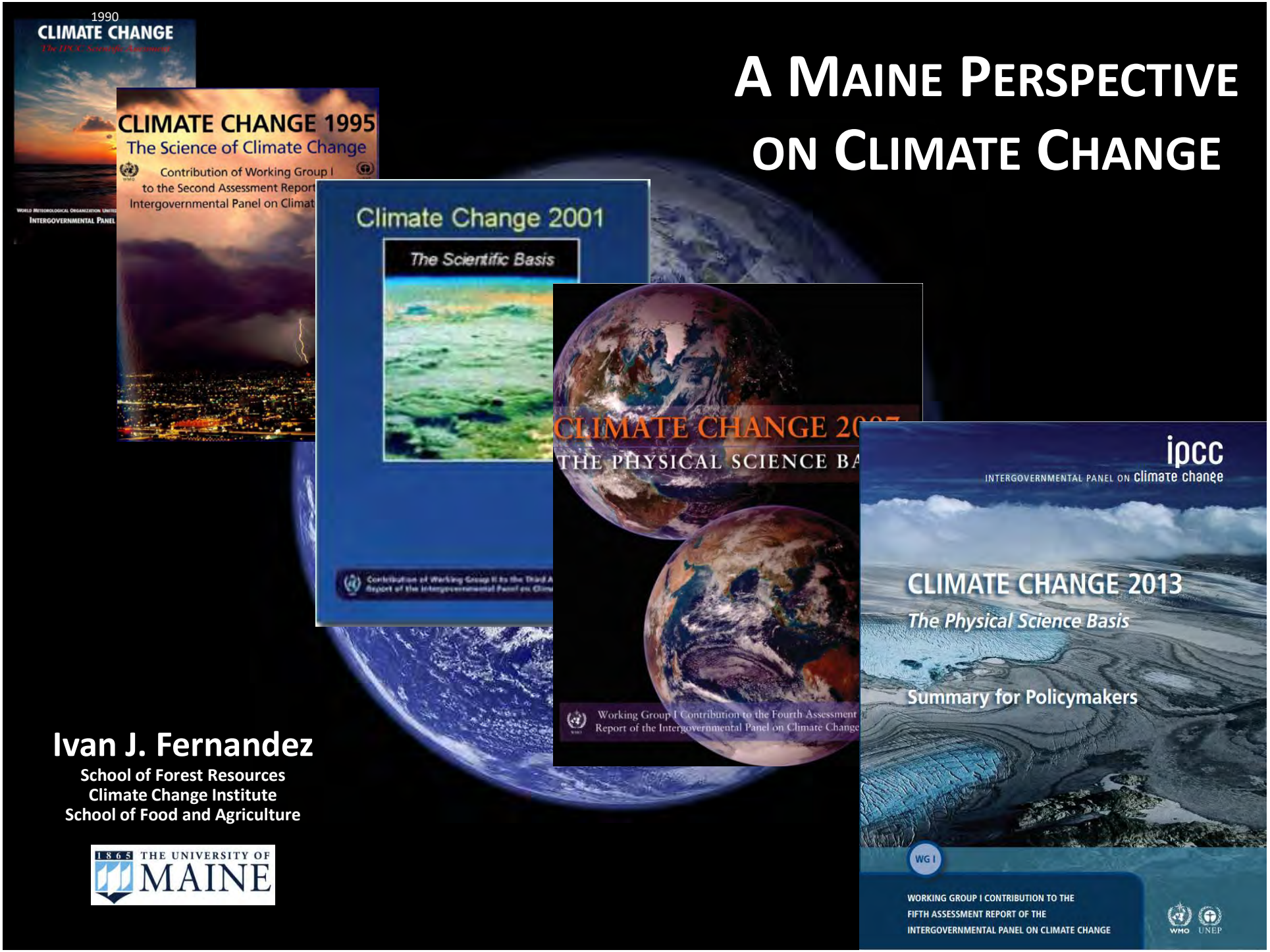
A Maine Perspective on Climate Change



Ivan J. Fernandez
School of Forest Resources
Climate Change Institute
School of Food and Agriculture

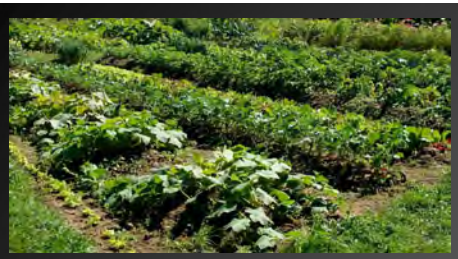
1865 THE UNIVERSITY OF MAINE

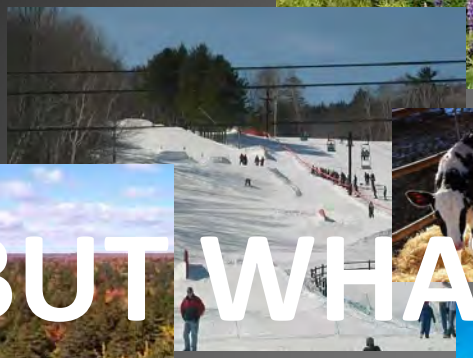
E&E NEWS
ENVIRONMENT

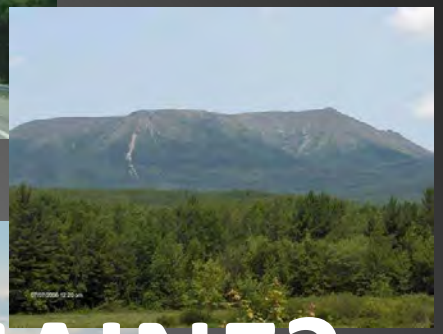
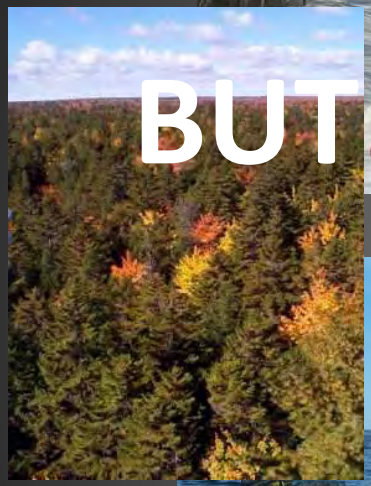
CO2 Emissions Reached an All-Time High in 2018

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 >>!)

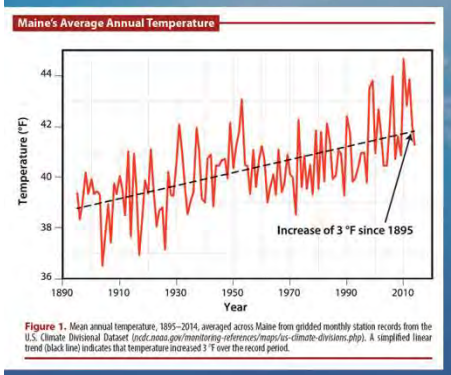
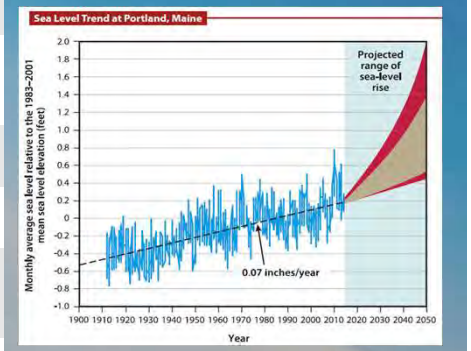


Figure 1. Mean annual temperature, 1895–2014, averaged across Maine from gridded monthly station records from the U.S. Climate Divisional Dataset (ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php). A simplified linear trend (black line) indicates that temperature increased 3 °F over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



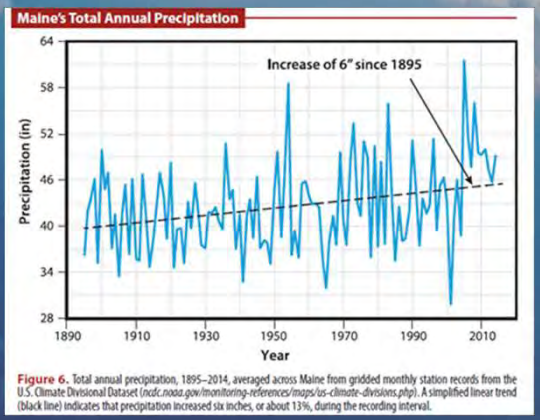


Figure 6. Total annual precipitation, 1895–2014, averaged across Maine from gridded monthly station records from the U.S. Climate Divisional Dataset (ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php). A simplified linear trend (black line) indicates that precipitation increased six inches,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

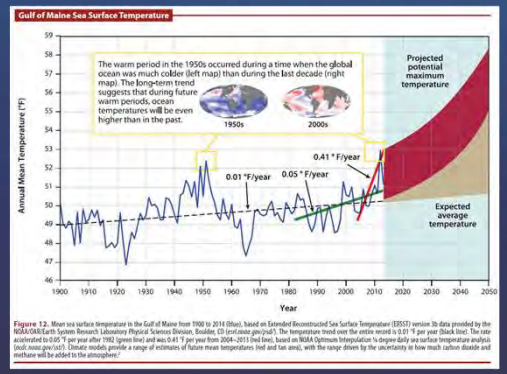


Figure 12. Mean sea surface temperature in the Gulf of Maine from 1900 to 2014 (blue), based on Extended Reconstructed Sea Surface Temperature (ERSST) version 3b data provided by the NOAA/OAR/Earth System Research Laboratory Physical Sciences Division, Boulder, CO (esrl.noaa.gov/psd/). The temperature trend over the entire record is 0.01 °F per year (black line). The rate accelerated to 0.05 °F per year after 1982 (green line) and was 0.41 °F per year from 2004–2013 (red line), based on NOAA Optimum Interpolation ¼-degree daily sea surface temperature analysis (esrl.noaa.gov/psd/). 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.

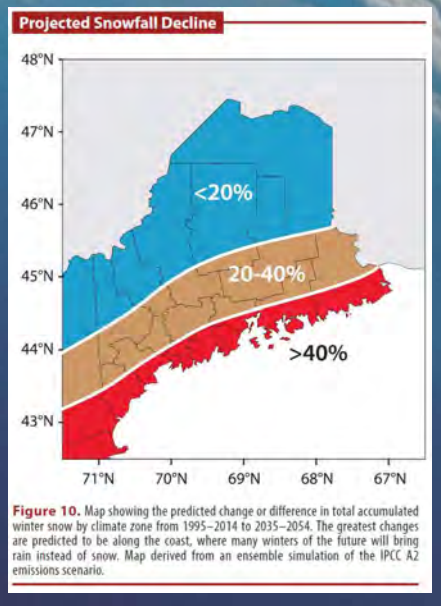
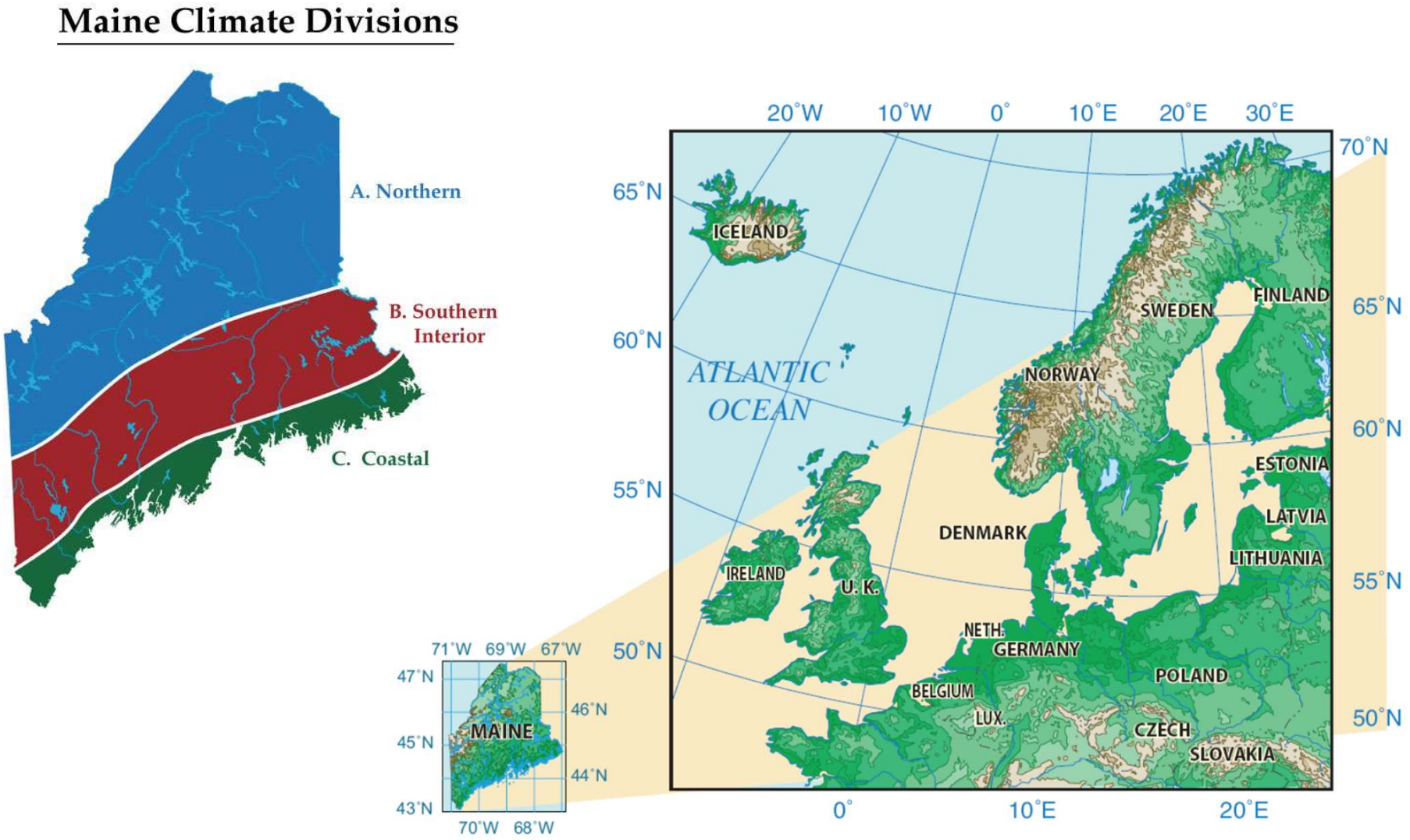


Figure 10. Map showing the predicted change or difference in total accumulated winter snow by climate zone from 1995–2014 to 2035–2054. The greatest changes are predicted to be along the coast, where many winters of the future will bring rain instead of snow. Map derived from an ensemble simulation of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

Fernandez et al. 2015

Temporal *and* Spatial Variability in Maine's Climate

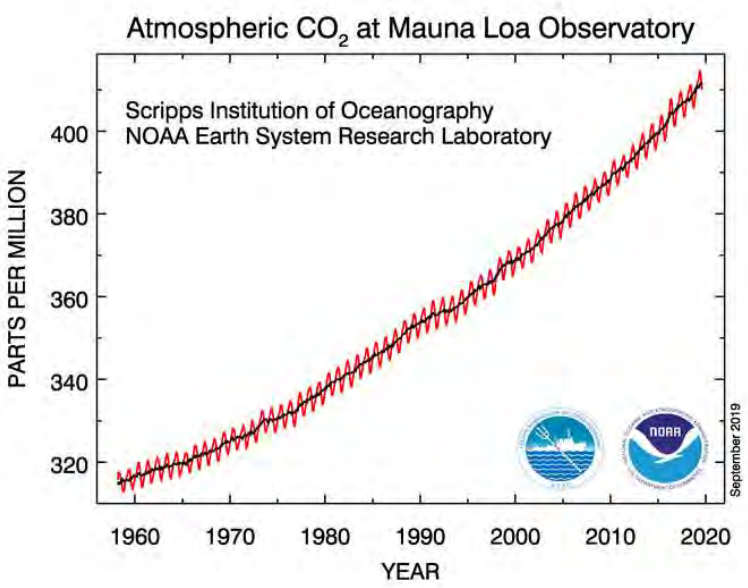


Jacobson et al. 2015

Does this affect Maine?

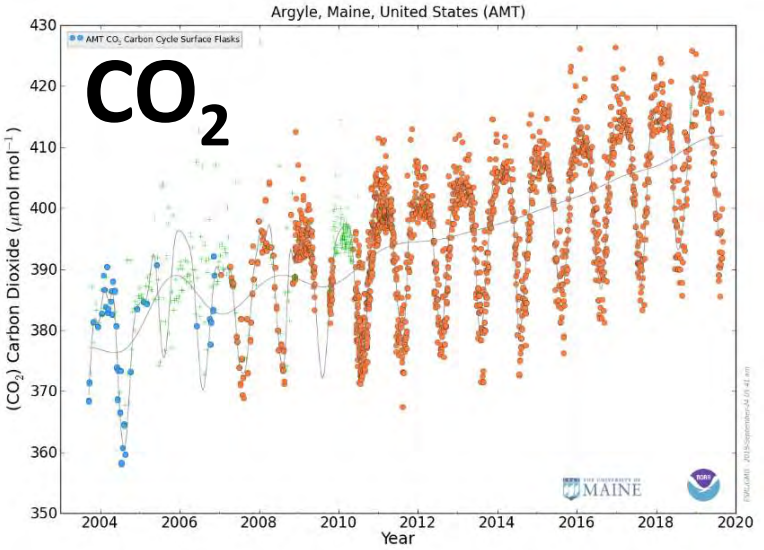

Agriculture
Recreation + Tourism
Forestry
Security
ADAPTATION and MITIGATION
Human Health
Businesses
Marine Fisheries
Communities

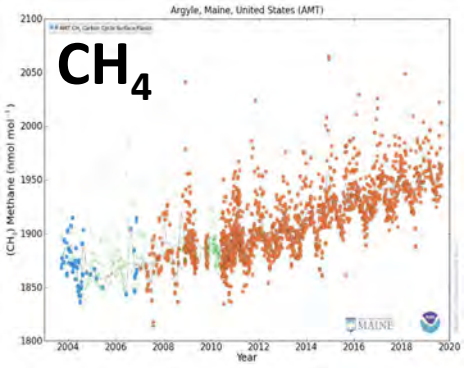
GREENHOUSE GASES

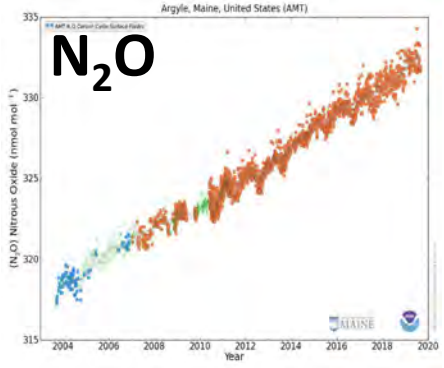


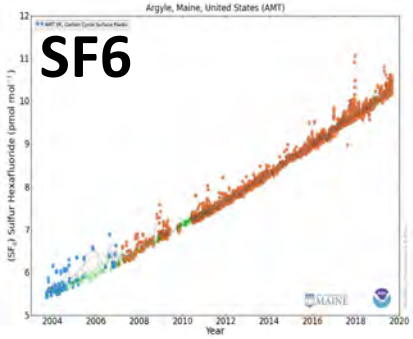
"The Keeling Curve"

http://www.esrl.noaa.gov/gmd/ccgg/trends/









NOAA Earth System Research Laboratory
Global Monitoring Division

ESRL GMD Tall Towers Site
Argyle, Maine (AMT)

https://www.esrl.noaa.gov/gmd/dv/iadv/graph.php?code=AMT&program=ccgg&type=tw

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.

SCHOOL OF FOREST RESOURCES
UNIVERSITY OF MAINE

THE UNIVERSITY OF MAINE
CLIMATE CHANGE INSTITUTE

SCHOOL OF FOOD AND AGRICULTURE

Melissa Law

Co-Owner and Flower Manager,

Bumbleroot Organic Farm, Windham

Effects of Climate Change on Maine's Wildlife

Nathan Webb, Wildlife Division Director

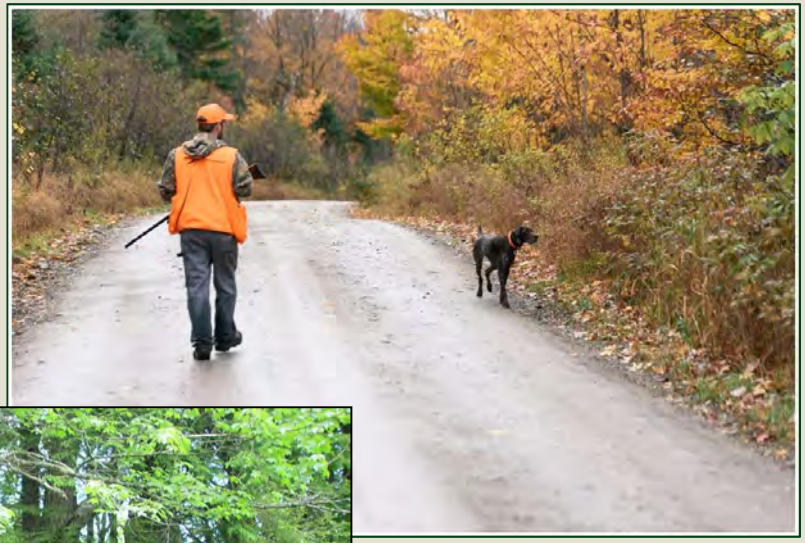
Amanda Shearin Cross, Beginning with Habitat and Wildlife Action Plan Coordinator

Phillip DeMaynadier, Reptile, Amphibian, and Invertebrate Group Leader

Maine Department of Inland Fisheries and Wildlife

Maine Department of Inland Fisheries and Wildlife

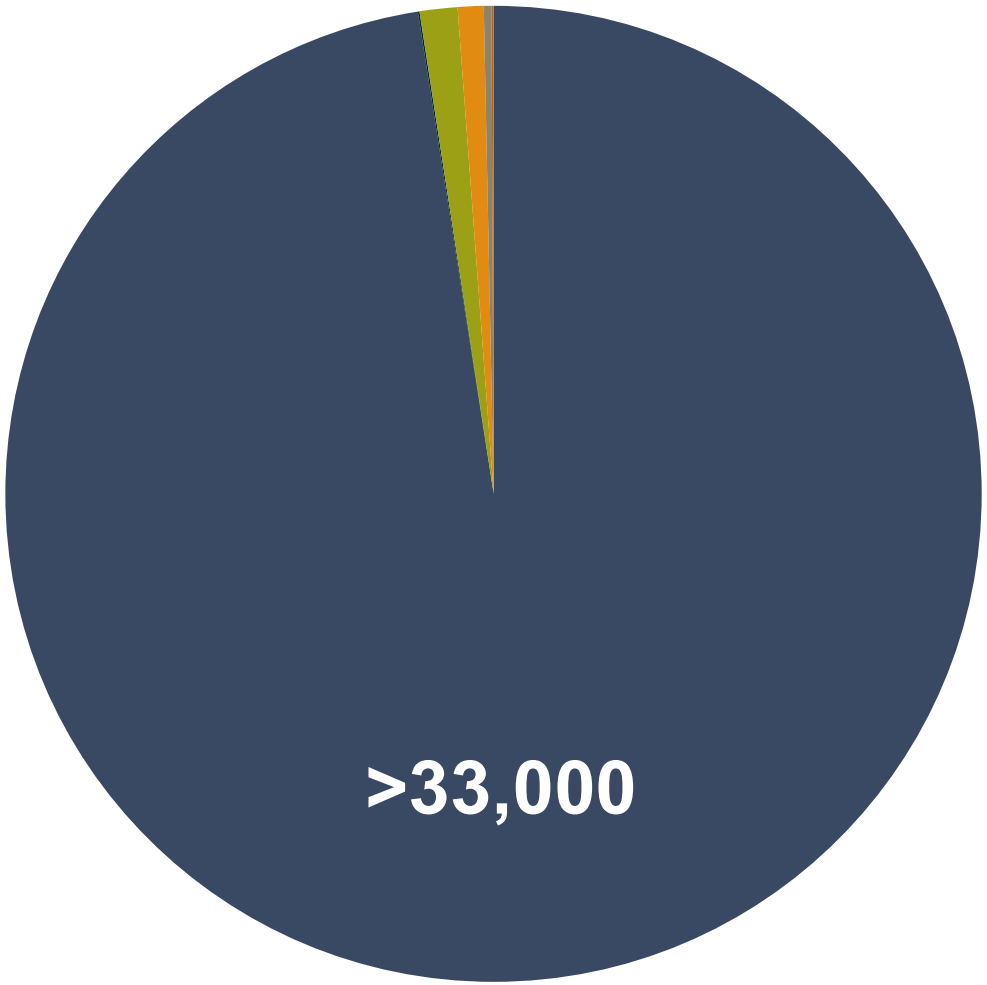
Species



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

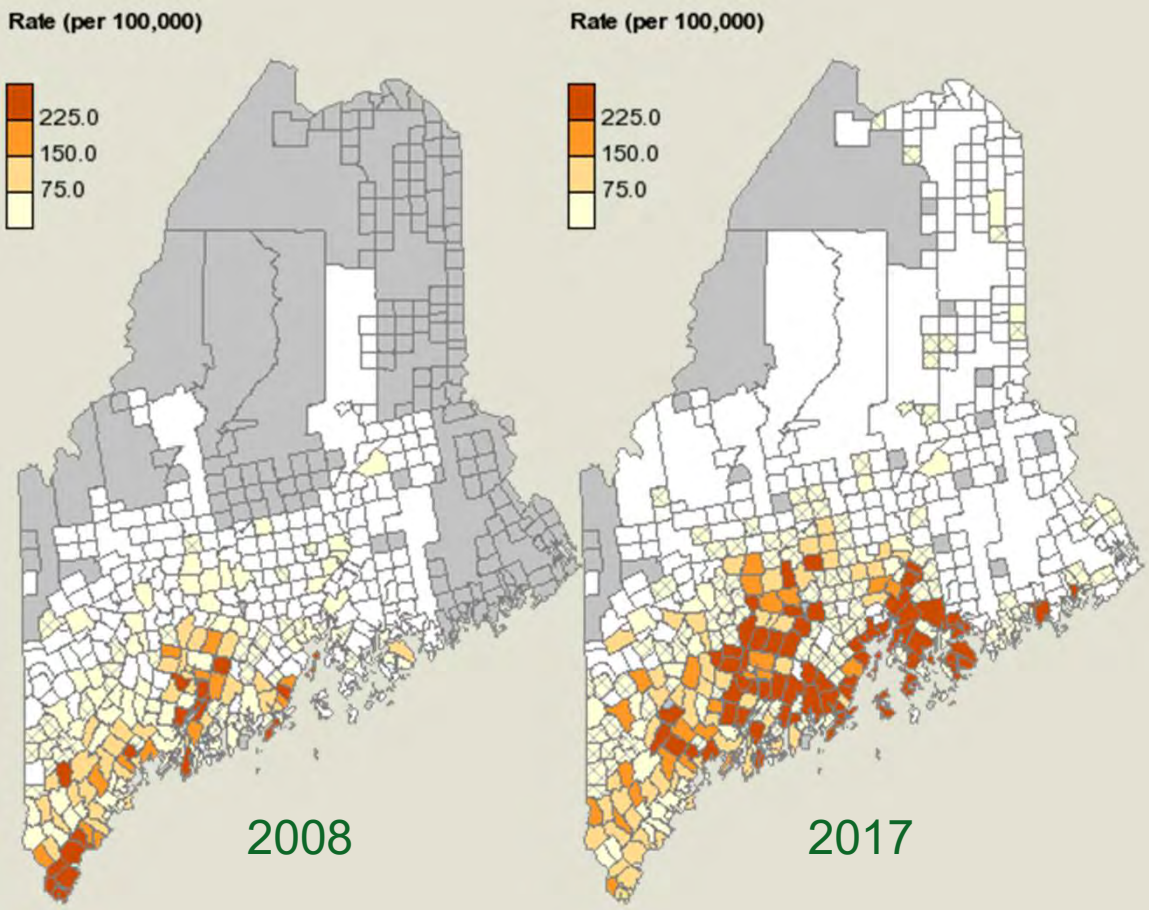
nps.org

Brook Trout & Water Temperature

Invasive Species

BDN

Ticks & Human Health



What Does Climate Change Mean for Maine's Wildlife?

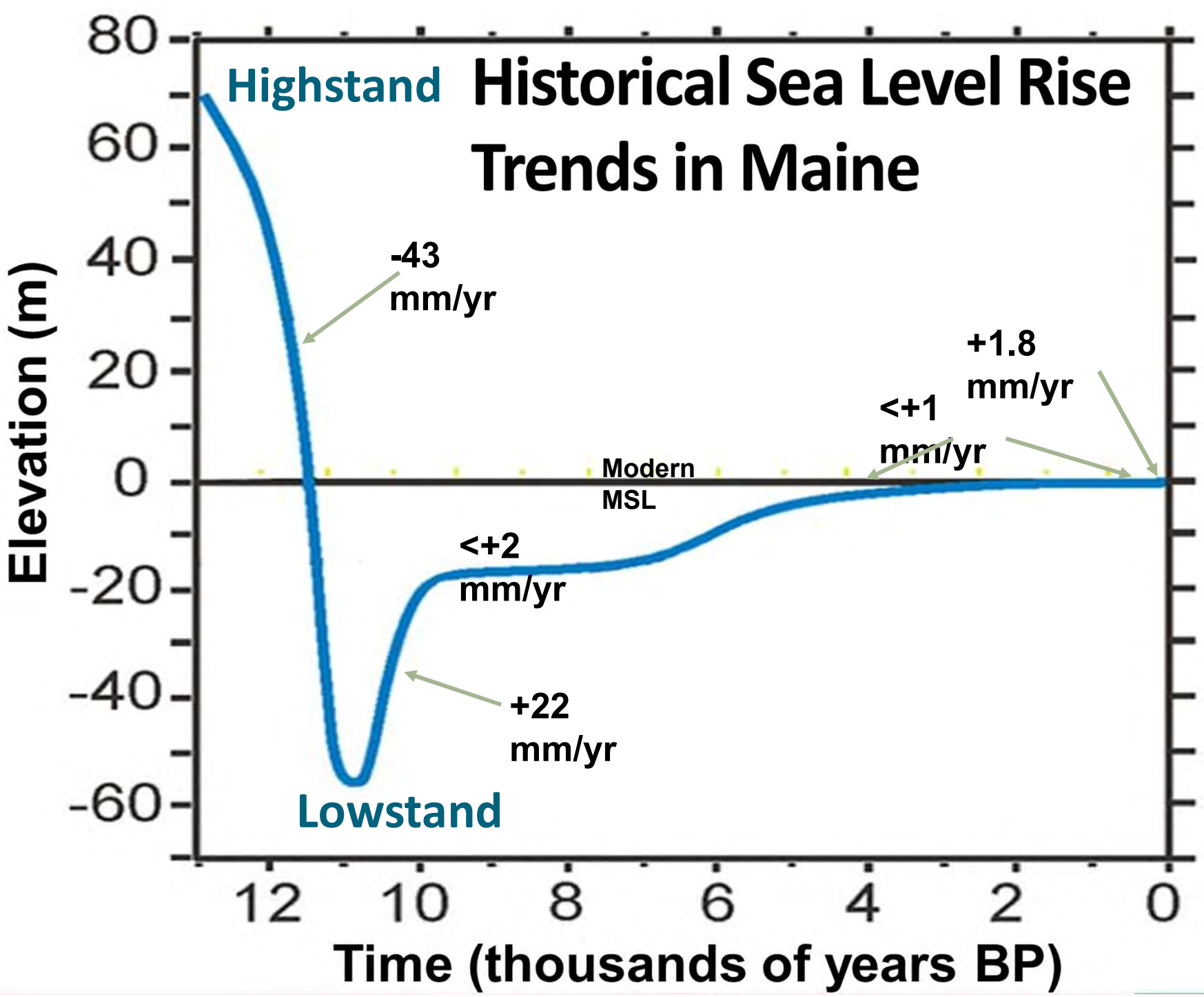
- Climate plays key role in distribution & abundance
- Large shifts in geographic distribution
- 'Winners' and 'Losers'
- Many winners will be weedy or invasive spp.
- Some species at southern edge of range will be lost
- Highest risk: species reliant on climate – vulnerable ecosystems

Trends in coastal flooding and sea-level rise in Maine

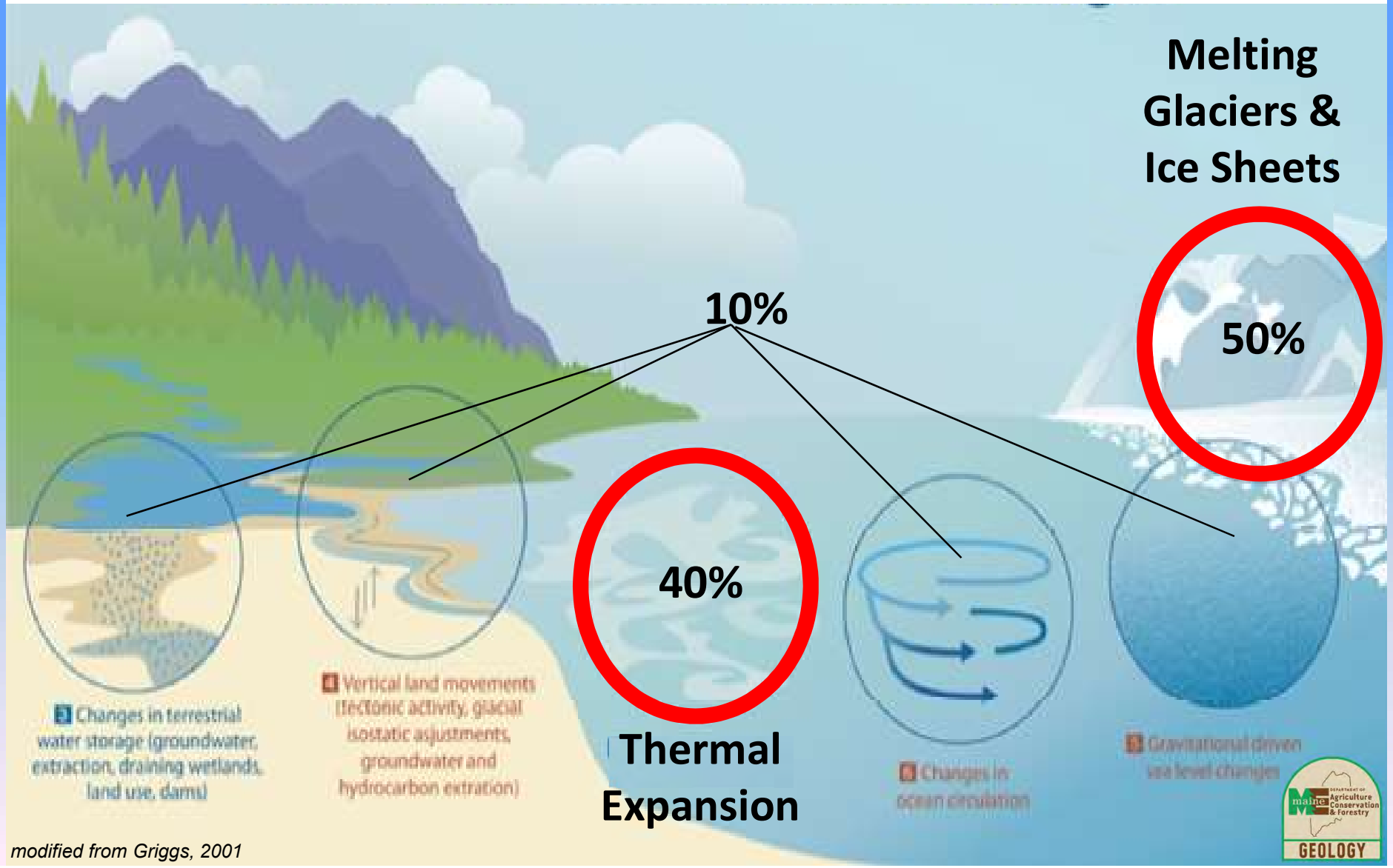
Robert G. Marvinney, State Geologist
Peter A. Slovinsky, Marine Geologist
Maine Geological Survey

DEPARTMENT OF Agriculture Conservation & Forestry
maine
GEOLOGY

Image from Chebeague.org

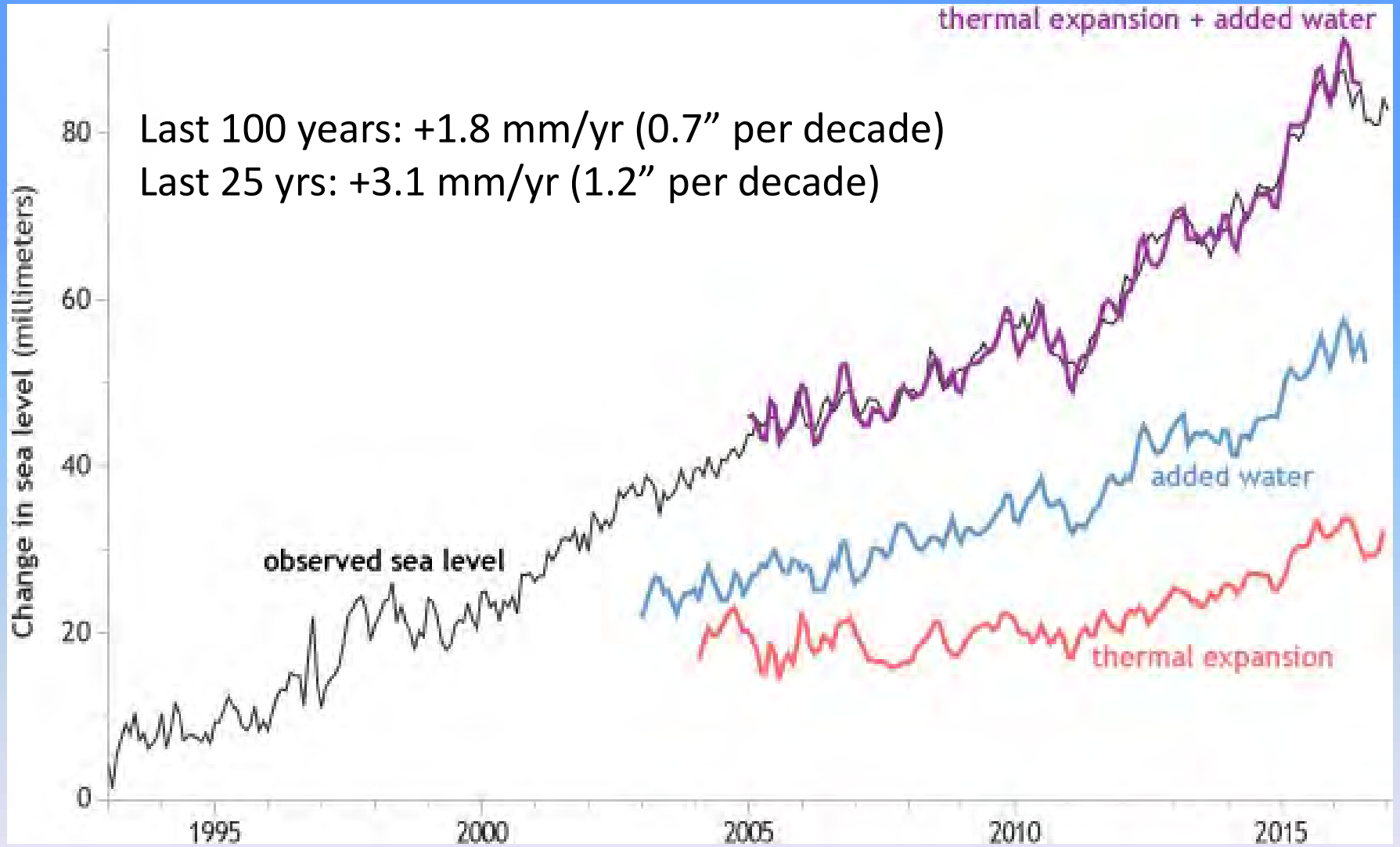

Historical Sea Level Rise Trends in Maine
Highstand
Lowstand
-43 mm/yr
+22 mm/yr
<+2 mm/yr
<+1 mm/yr
+1.8 mm/yr
Modern MSL
Elevation (m)
80
60
40
20
0
-20
-40
-60
12
10
8
6
4
2
0
Time (thousands of years BP)

What causes the global sea level changes we see today?



modified from Griggs, 2001

Global sea level rise observations

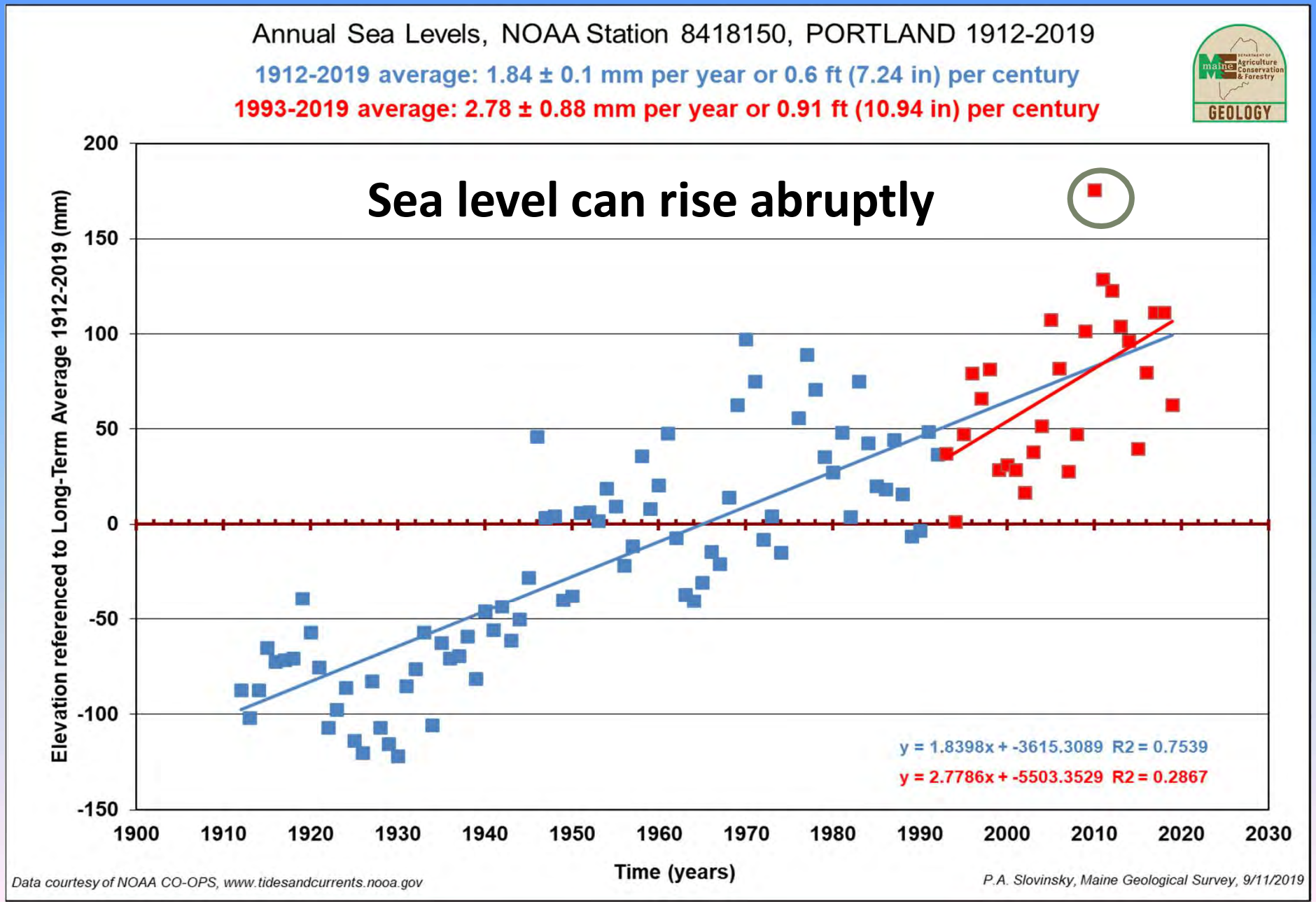


Combined independent totals from **thermal expansion and glacier/land-based ice sheet input** match **satellite** measurements

adapted from Figure 3.15a in *State of the Climate in 2016*

maine Department of Agriculture Conservation & Forestry
GEOLOGY

Long- and short- term sea level rise

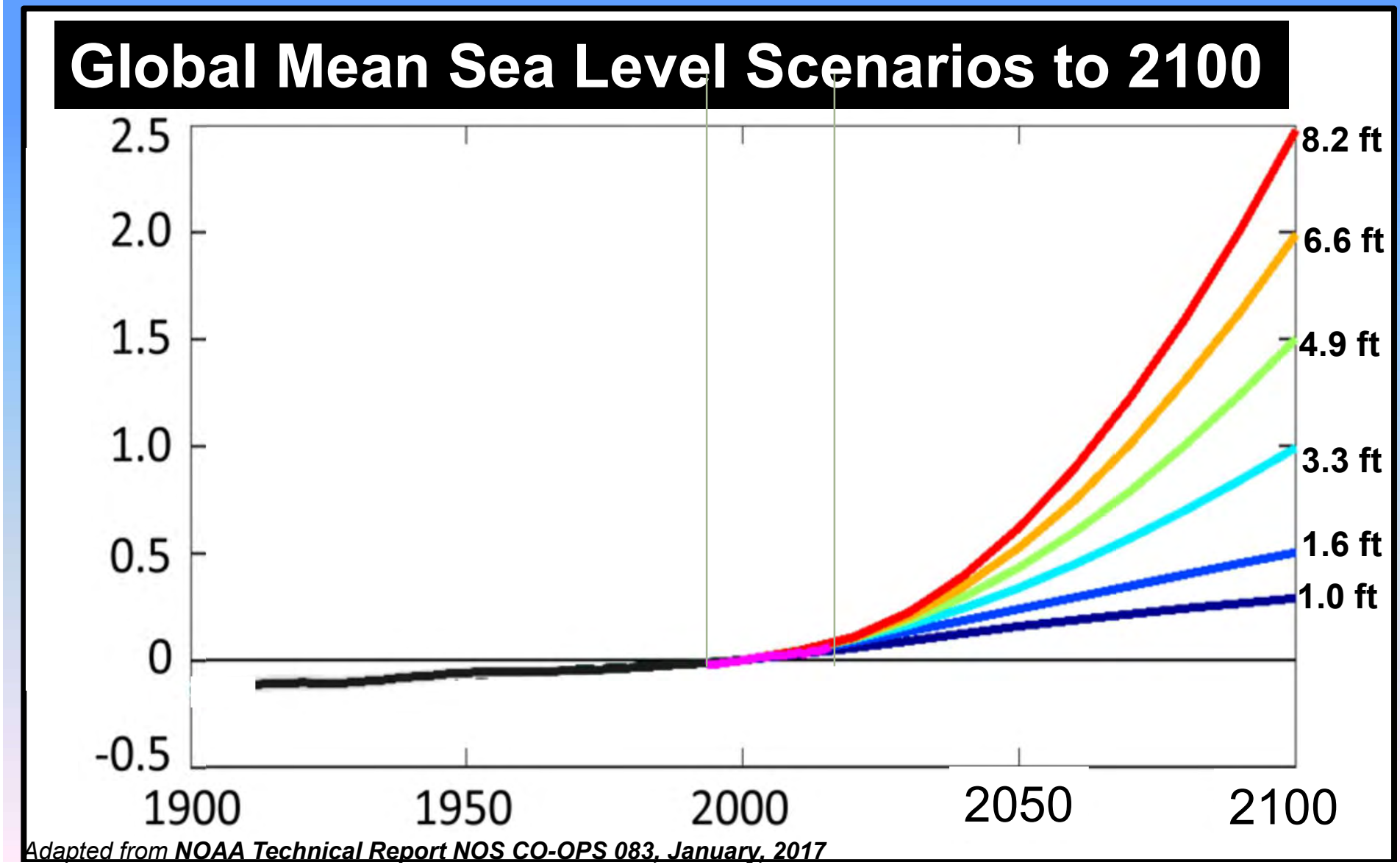


Slightly higher sea levels, combined with storm events, lead to *much higher levels of erosion* as witnessed in winter 2010

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

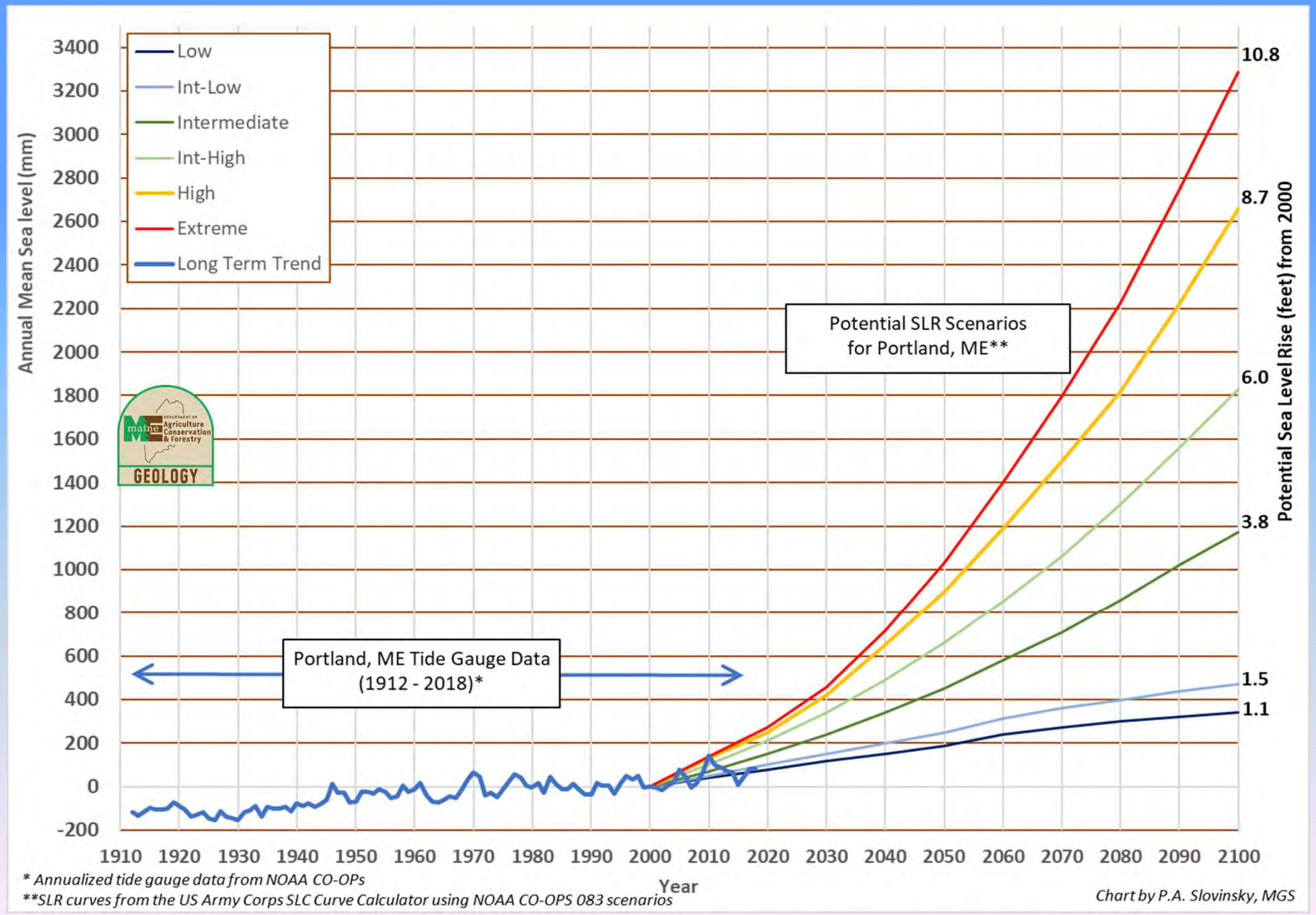
maine DEPARTMENT OF Agriculture Conservation & Forestry
GEOLOGY

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



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

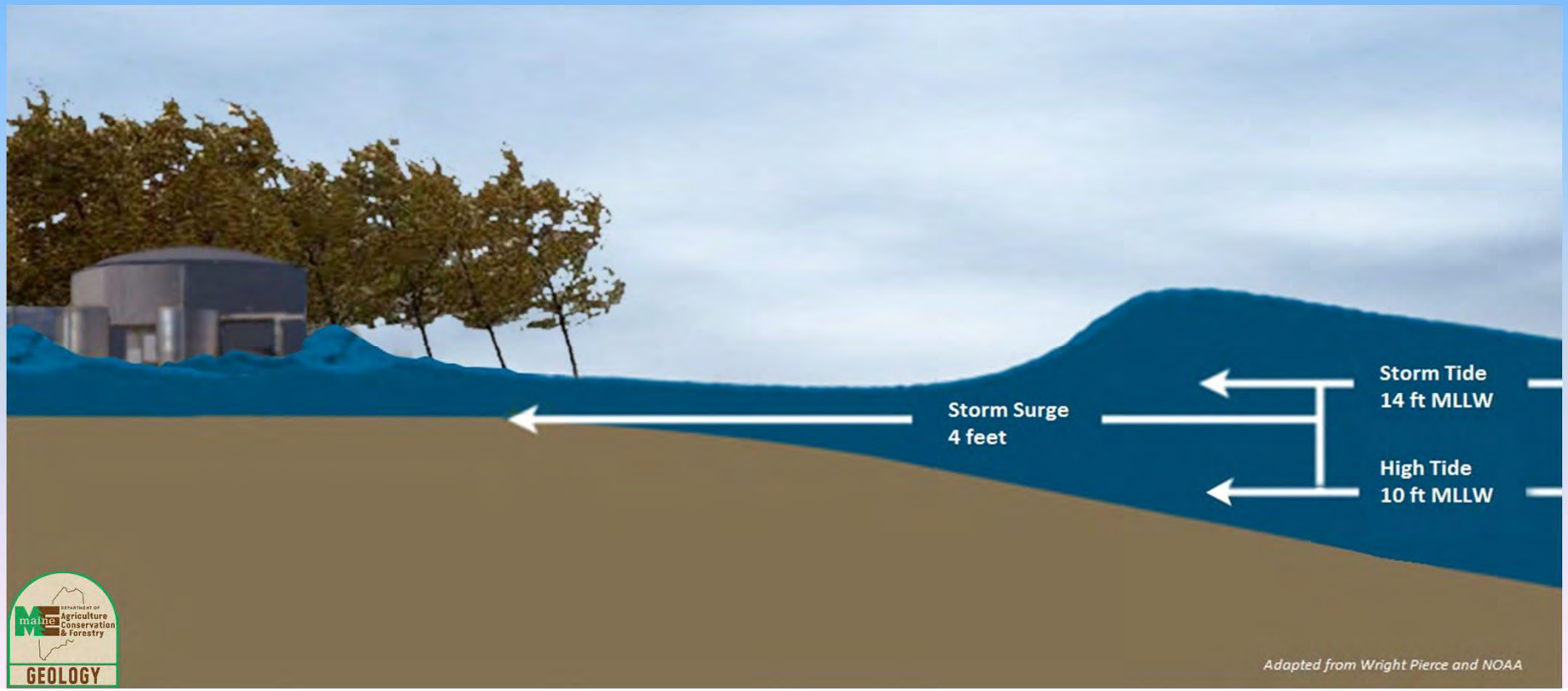
…and in Maine, could potentially rise *higher than* global averages.



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!

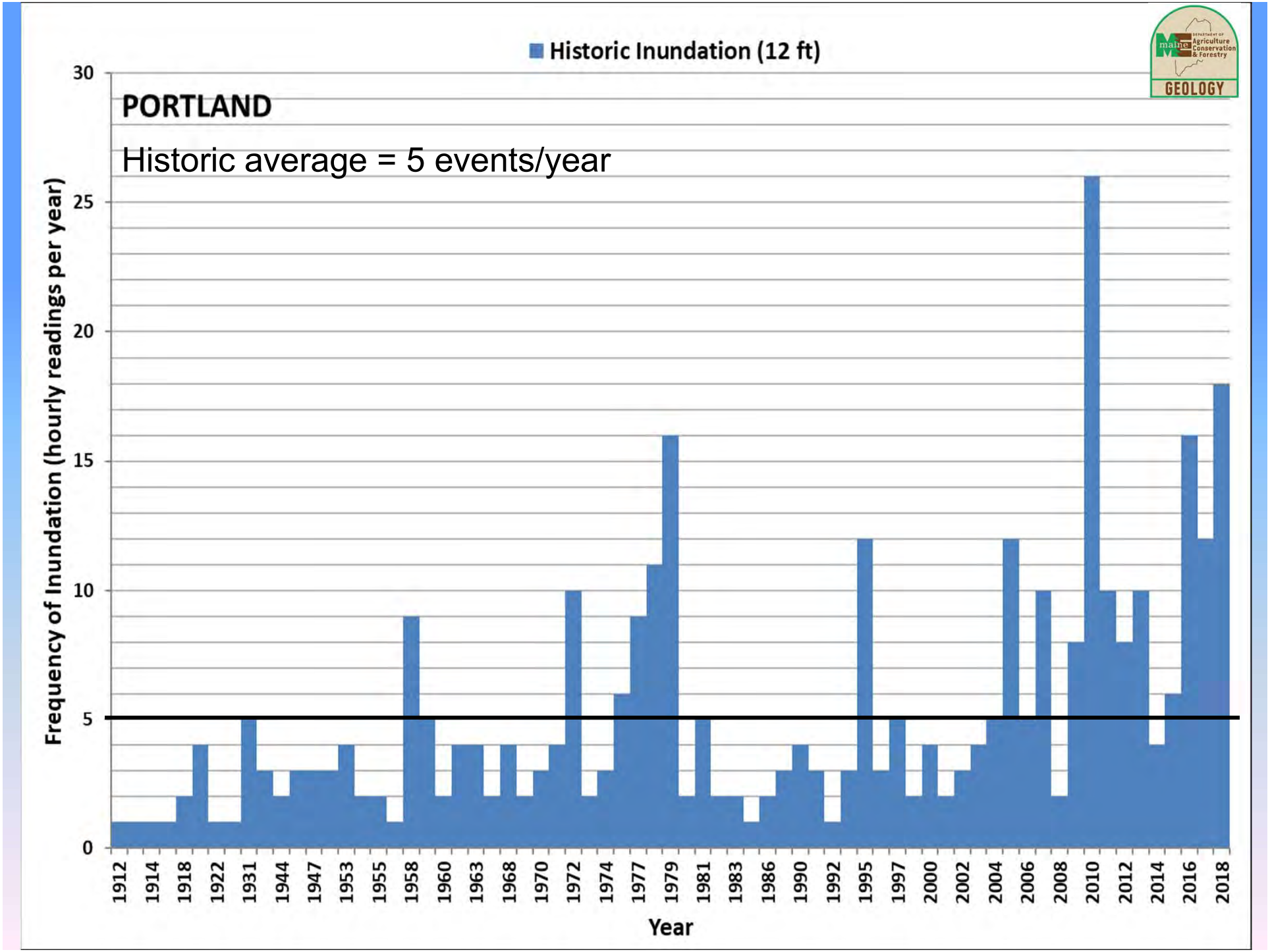
Highest recorded storm tide was 14.1 feet on 2/7/1978

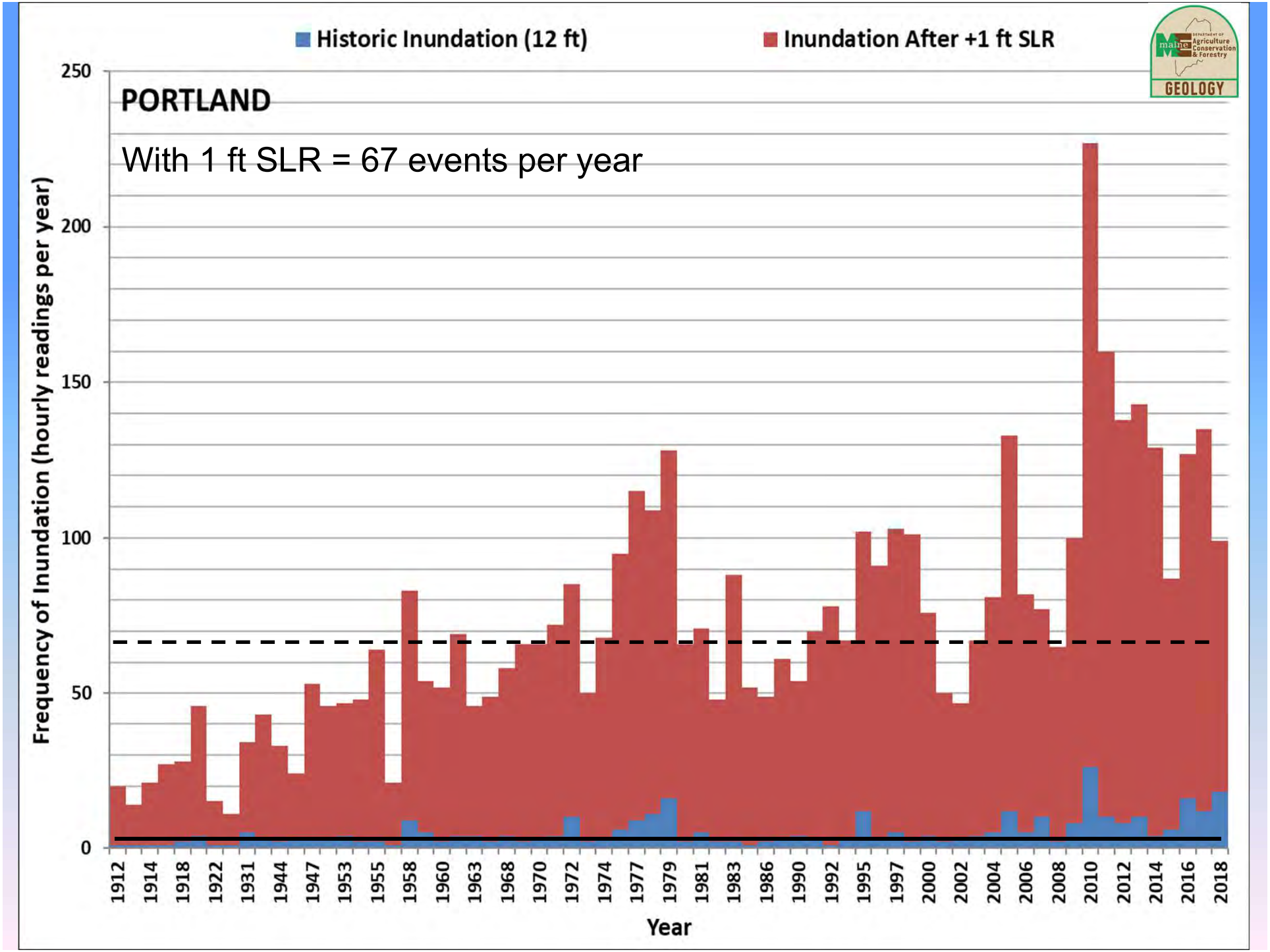
"King Tide" Marginal Way, October 25, 2016
A. Sherwin, MCP

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

maine Department of Agriculture Conservation & Forestry
GEOLOGY

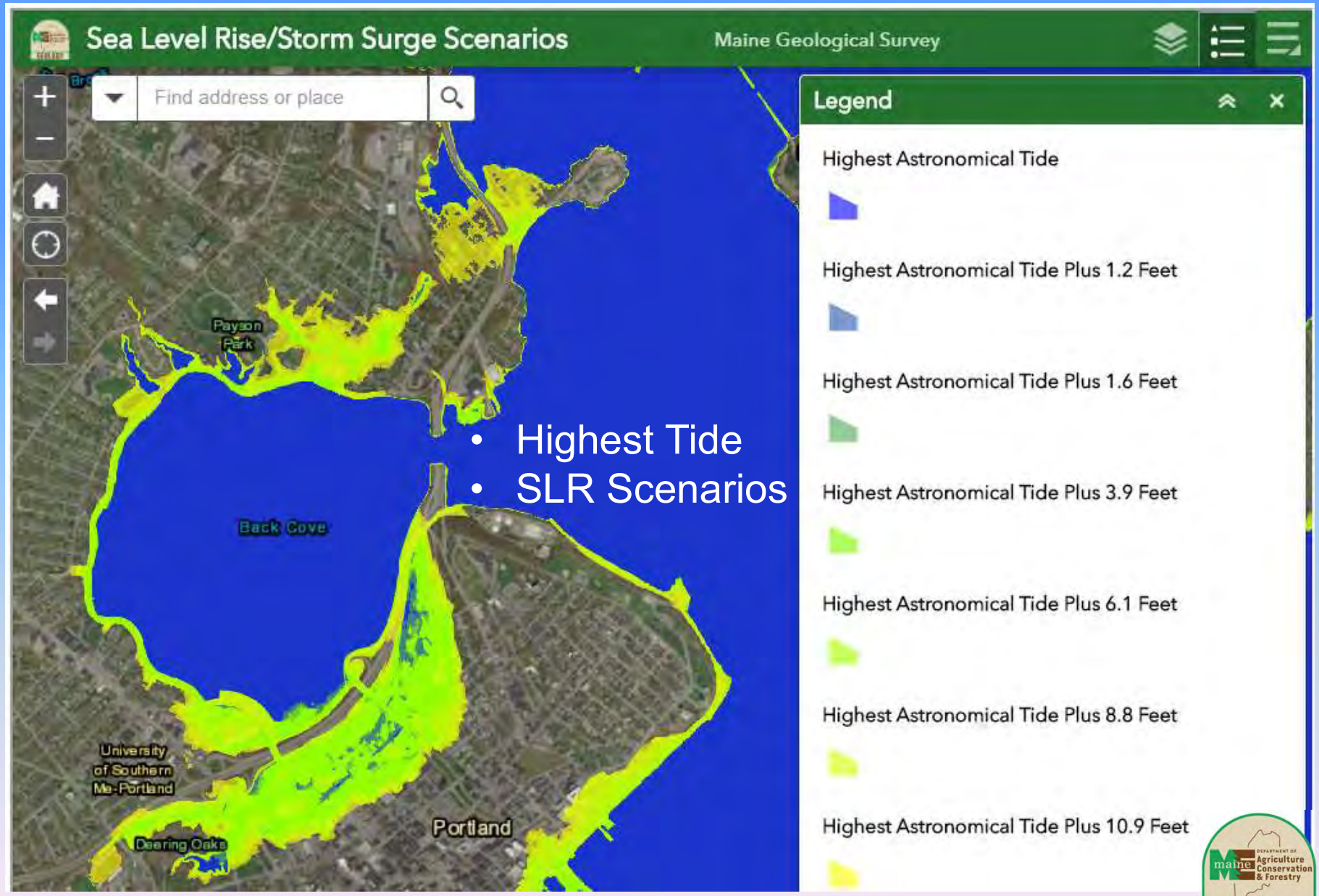

Historic Inundation (12 ft)
PORTLAND
Historic average = 5 events/year
Frequency of Inundation (hourly readings per year)
Year
0
5
10
15
20
25
30
1912
1914
1918
1922
1931
1944
1947
1953
1955
1958
1960
1963
1968
1970
1972
1974
1977
1979
1981
1983
1986
1990
1992
1995
1997
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
maine Department of Agriculture Conservation & Forestry
GEOLOGY


Historic Inundation (12 ft)
Inundation After +1 ft SLR
maine Department of Agriculture Conservation & Forestry
GEOLOGY
PORTLAND
With 1 ft SLR = 67 events per year
Frequency of Inundation (hourly readings per year)
250
200
150
100
50
0
1912
1914
1918
1922
1931
1944
1947
1953
1955
1958
1960
1963
1968
1970
1972
1974
1977
1979
1981
1983
1986
1990
1992
1995
1997
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year

Sea-level rise inundation scenarios for Maine

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

Sea Level Rise Mapping



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

Thank you!

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

maine Department of Agriculture Conservation & Forestry
GEOLOGY

Judy Cooper East

Executive Director, Washington Council of Governments

Washington County Council of Governments

Machias Incorporated 1784 Shire Town 1790

GIS SERVICE CENTER

MAINE COASTAL PROGRAM

In Partnership With:

BAKER DESIGN CONSULTANTS
Civil, Marine, & Structural Engineering

RANSOM
Consulting Engineers and Scientists

West Falls Surveying
Machias, Maine

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

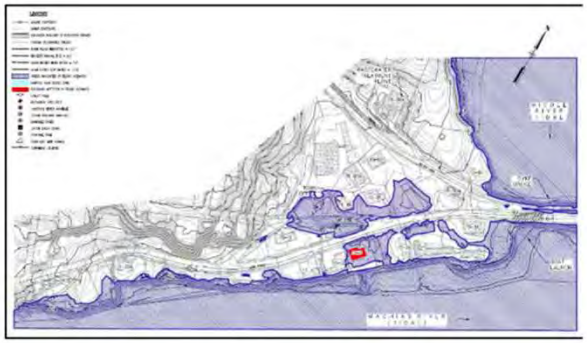


Figure 5 – Effective Base Flood Elevation;

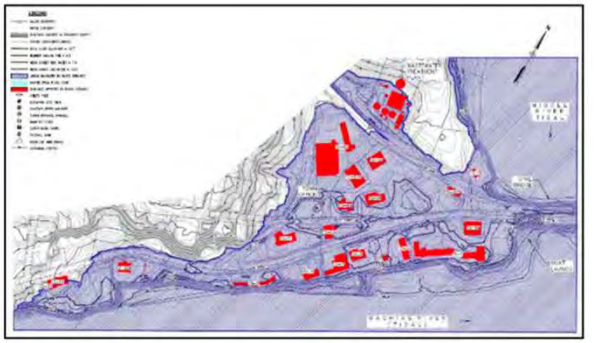


Figure 7 – Base Flood Elevation plus 4-FT

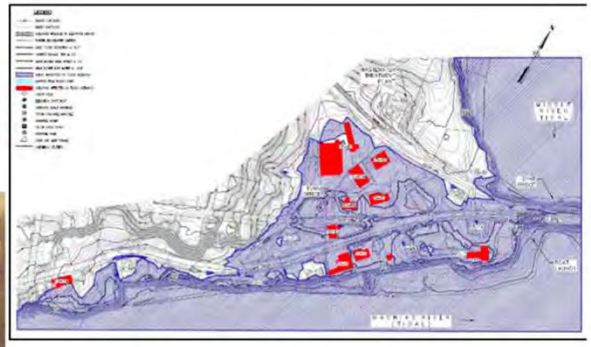


Figure 6 –Base Flood Elevation plus 2-FT

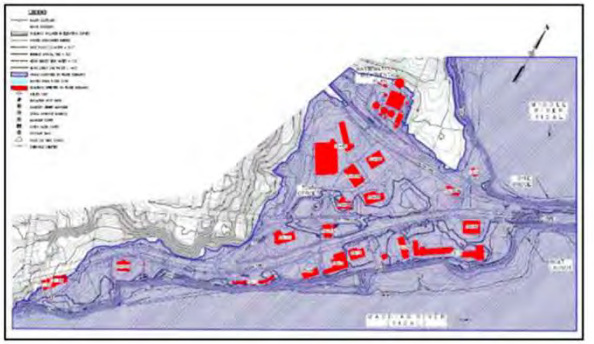


Figure 8 – Base Flood Elevation plus 6-FT

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 +

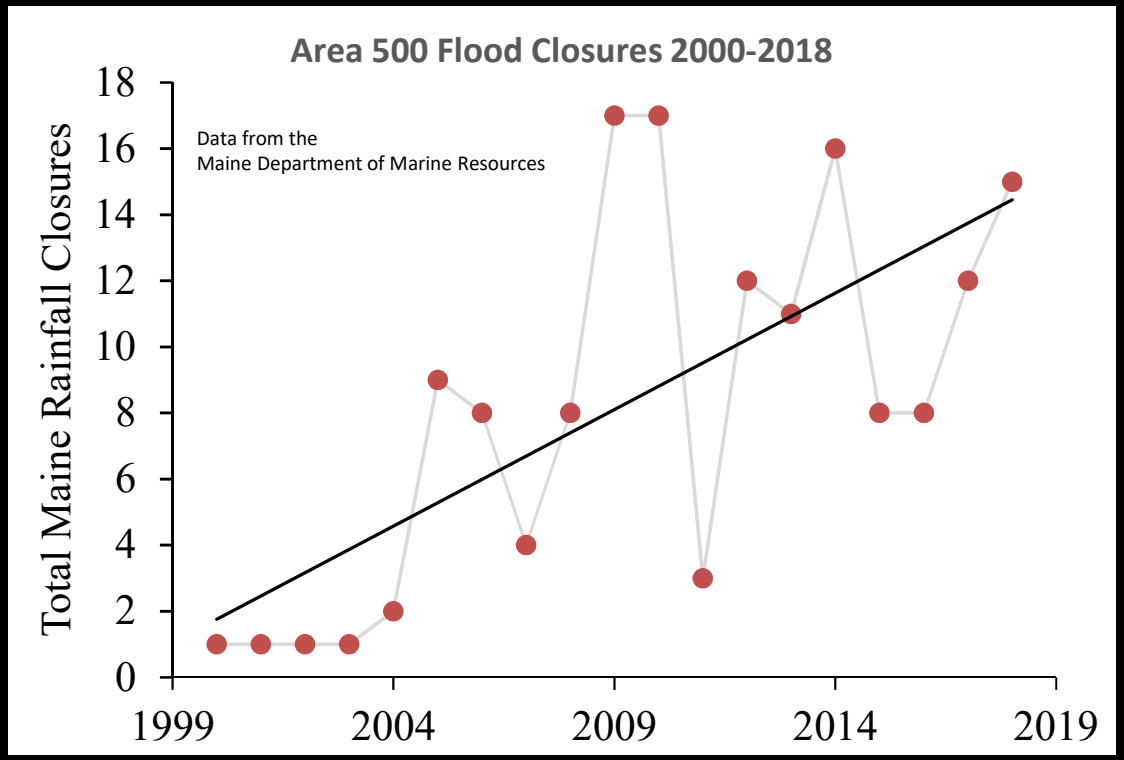
www.wccog.net/machias-resilience.htm

Bill Mook

Founder,

MOOK SEA FARM

Our world is your oyster!



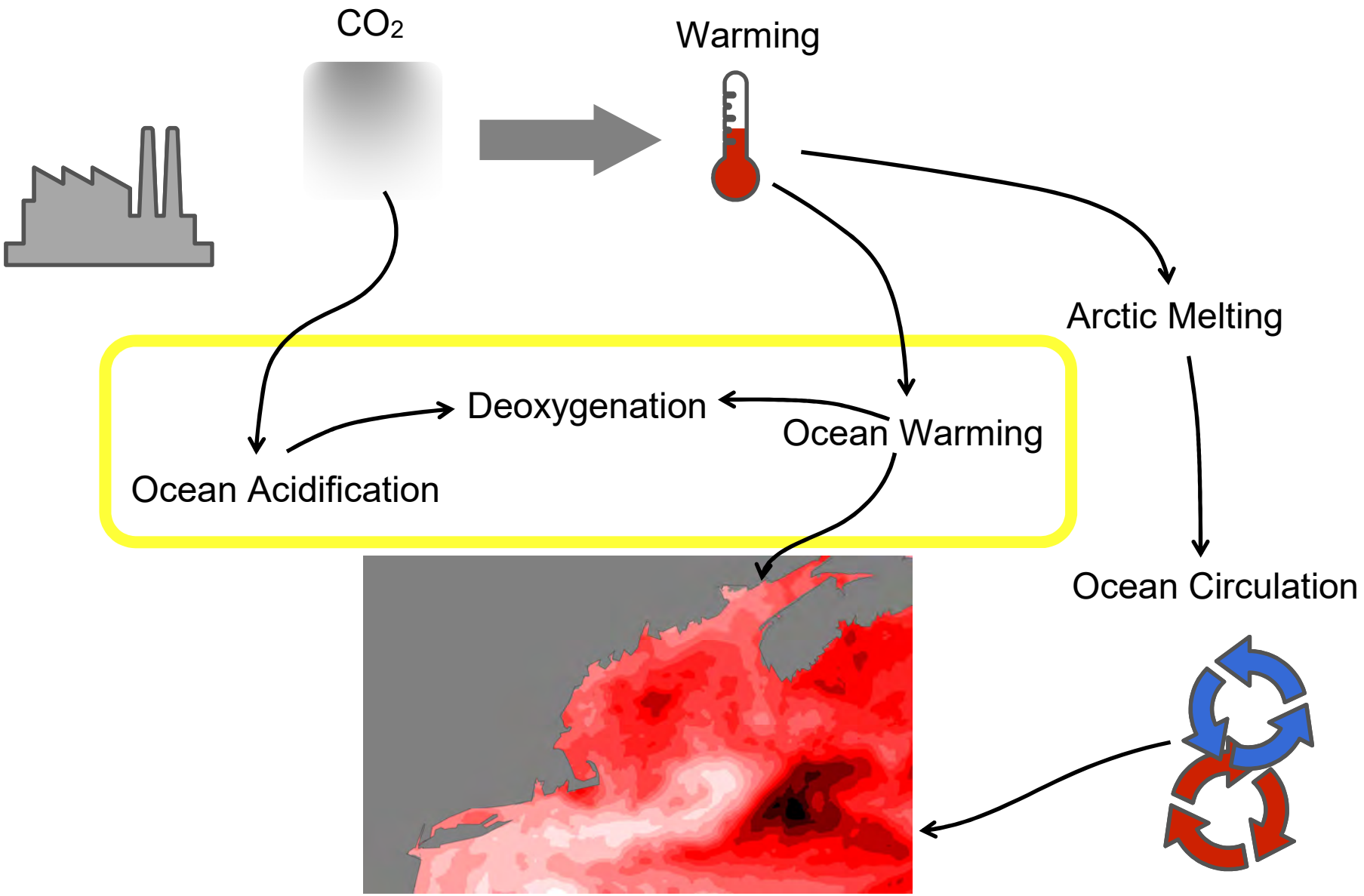
Climate Impacts on the Gulf of Maine

Andrew Pershing
apershing@gmri.org
@sci_officer

Gulf of Maine Research Institute
Science. Education. Community.

Climate Change & the Ocean

Gulf of Maine Research Institute



FOURTH NATIONAL CLIMATE ASSESSMENT

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

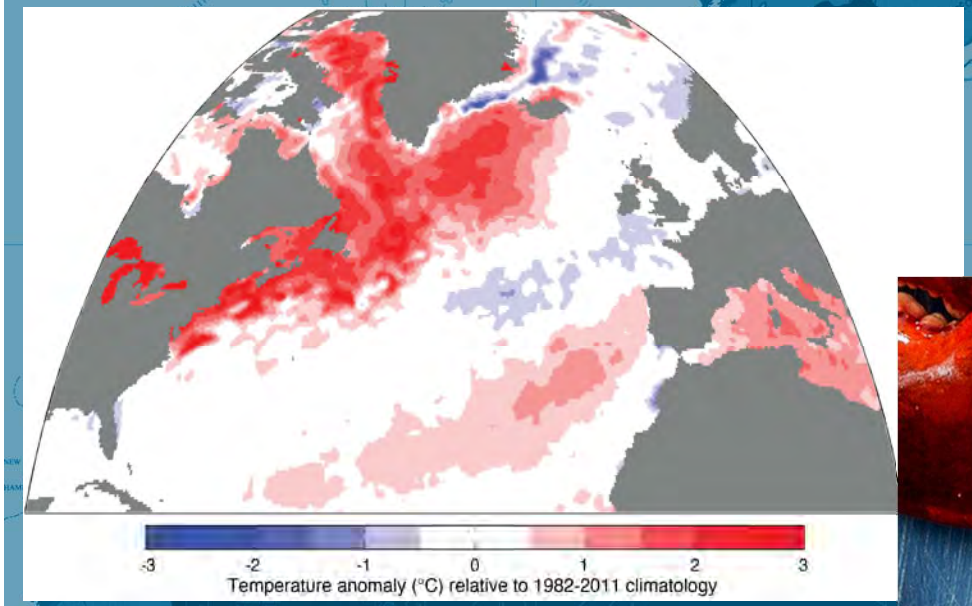
The National Climate Assessment (NCA) assesses the science of climate change and variability and its impacts across the United States, now and throughout this century.

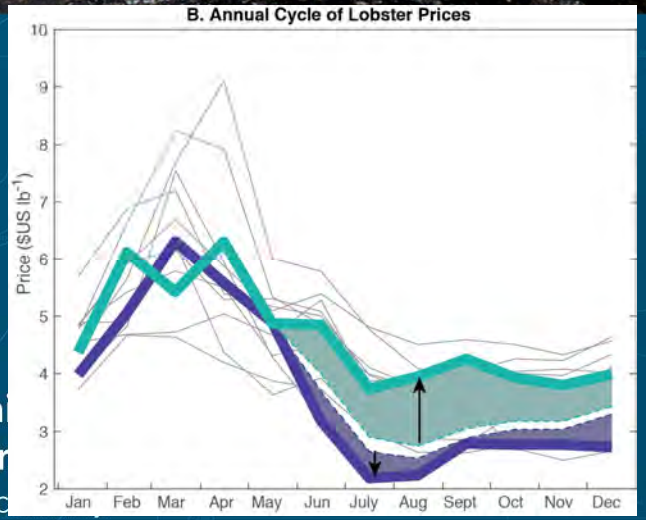
Extreme events

nca2018.globalchange.gov

Gulf of Maine Research Institute
Science. Education. Community.

Extreme Events





Gulf of Ma
Research In
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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

Fisheries

nca2018.globalchange.gov

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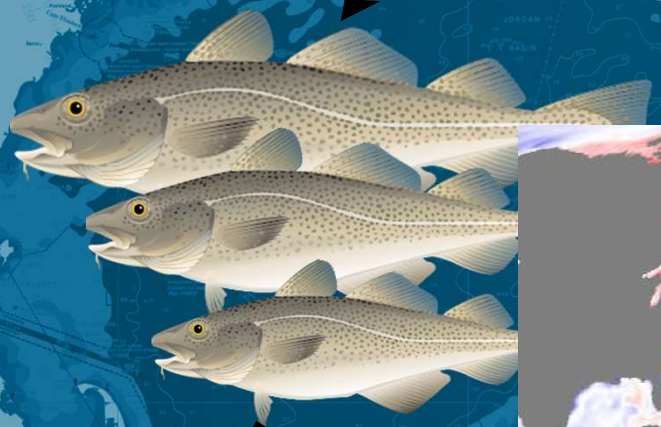
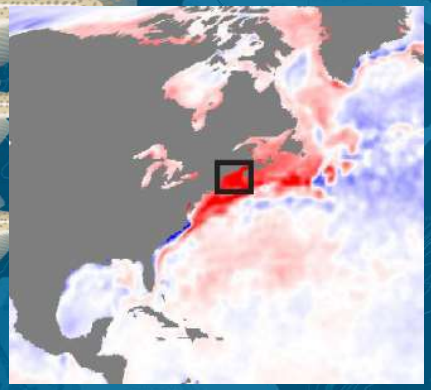
Fisheries





Fishery Management

Stock Assessment

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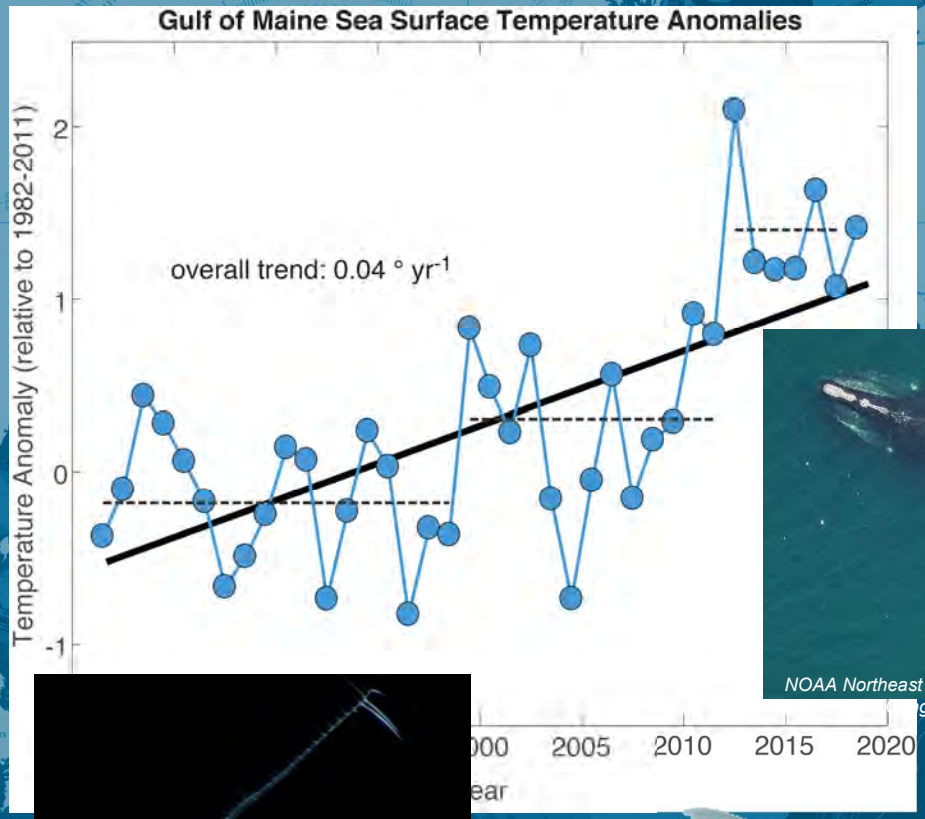
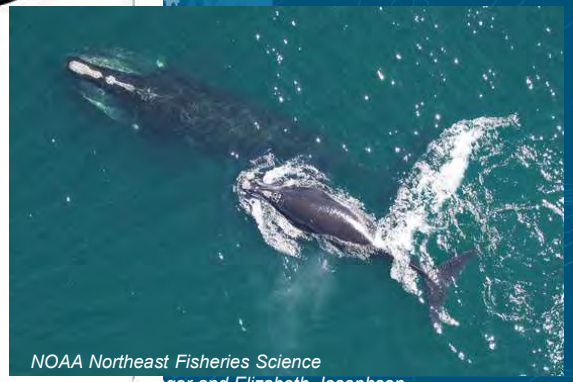
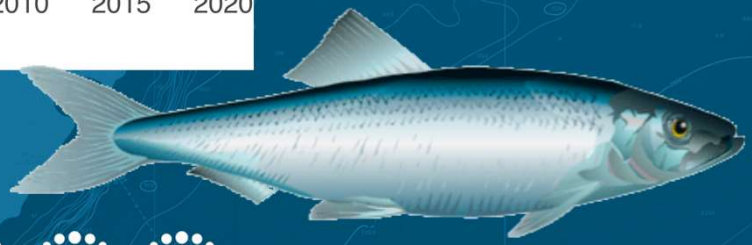
Ecosystem Disruption





NOAA Northeast Fisheries Science
ger and Elizabeth Josephson.



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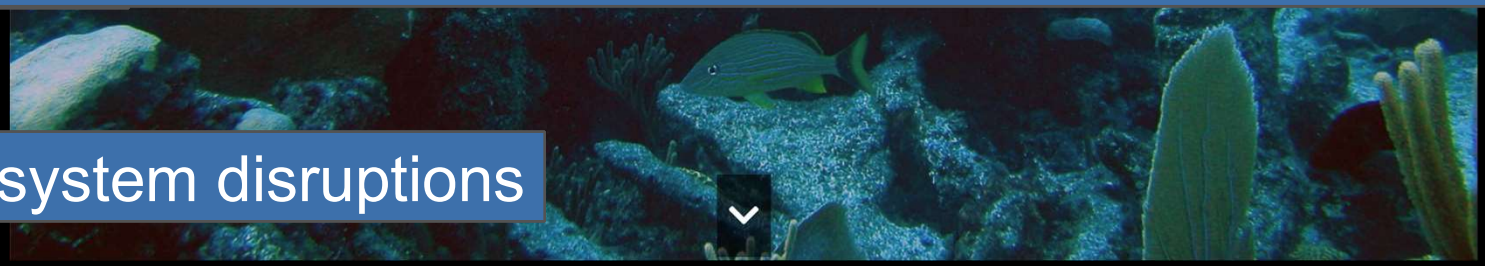

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In the absence of significant reductions in **carbon emissions, transformative impacts** on ocean ecosystems cannot be avoided.