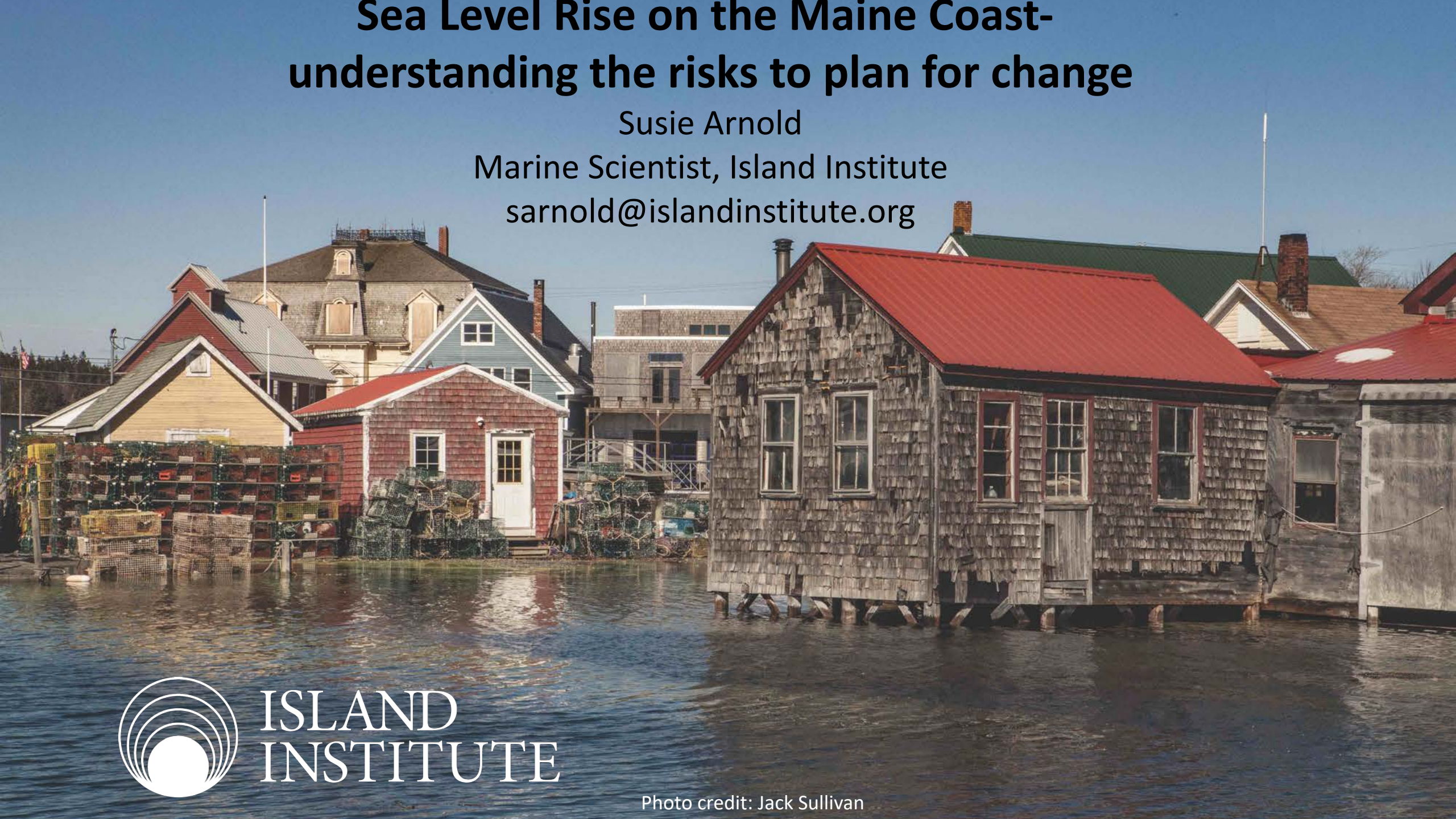
Sea Level Rise on the Maine Coast- understanding the risks to plan for change

Susie Arnold
Marine Scientist, Island Institute
sarnold@islandinstitute.org



ISLAND INSTITUTE

Photo credit: Jack Sullivan

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www.islandinstitute.org

Strong LEADERSHIP

- Leadership Framework
- Fellows
- Education
- Inclusion and Equity

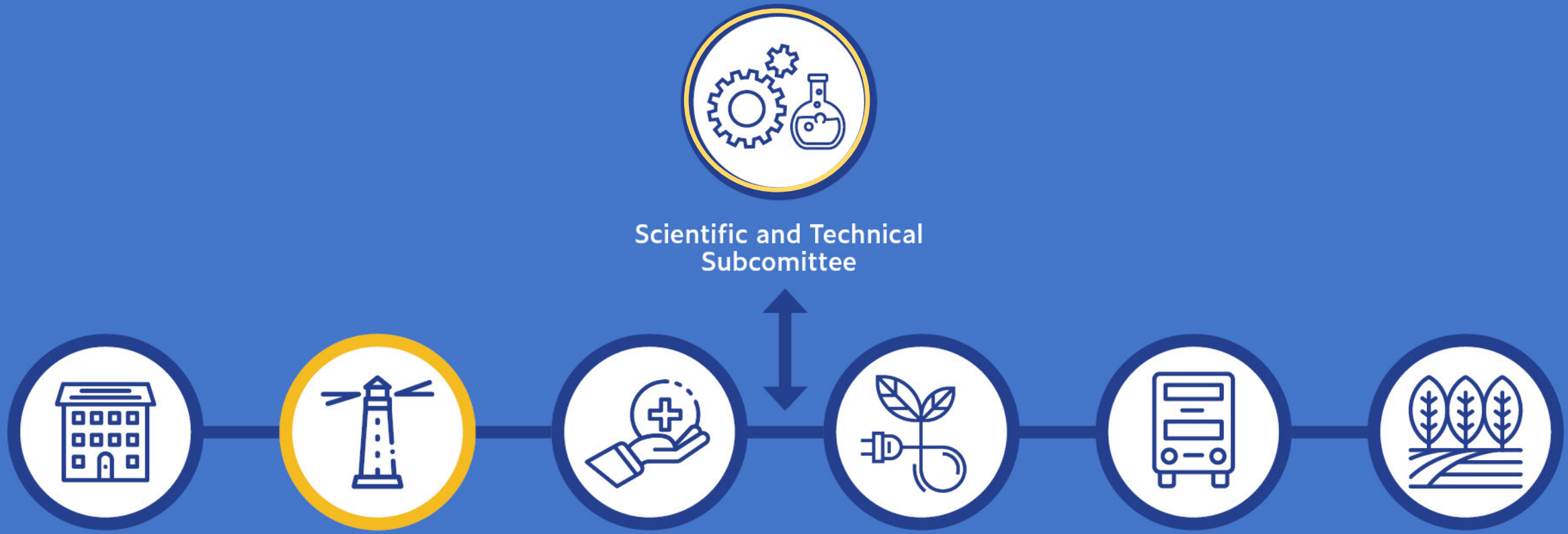
CLIMATE *Solutions*

- Clean Energy
- Sea Level Rise
- Ocean Acidification

Resilient ECONOMIES

- Marine Economy
- Sustainable Seafood
- Working Waterfronts
- Small Business
- Broadband
- Creative Economy

Maine Climate Council



Scientific Assessment of Climate Change and Its Effects in Maine

A REPORT BY
THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE
OF THE MAINE CLIMATE COUNCIL

Ivan Fernandez [1, 3] and Robert Marvinney [1,4]
(EDITORS AND CO-CHAIRS)

Cassaundra Rose
(GOVERNOR'S OFFICE OF POLICY INNOVATION AND THE FUTURE)

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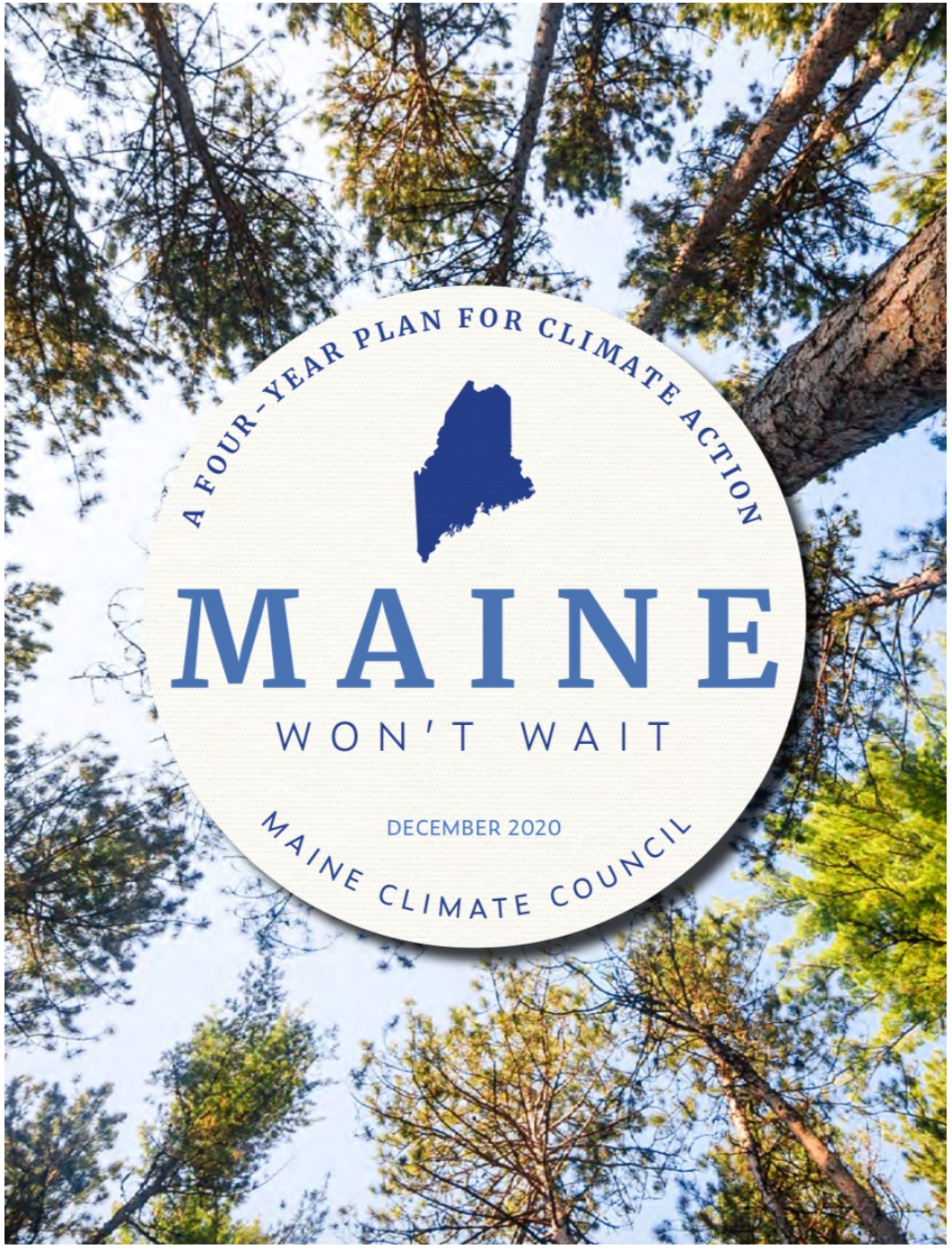
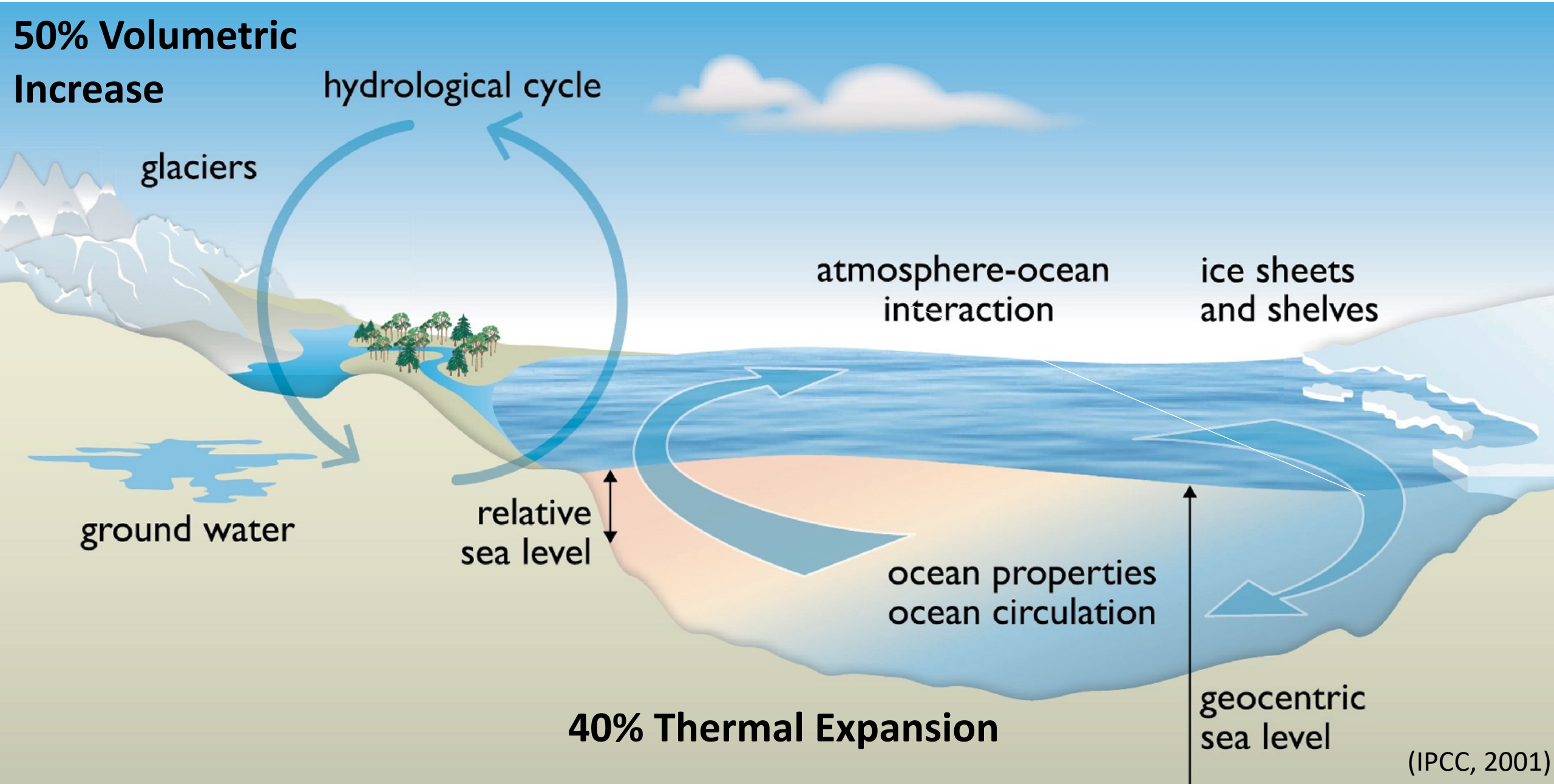
AUGUST 2020



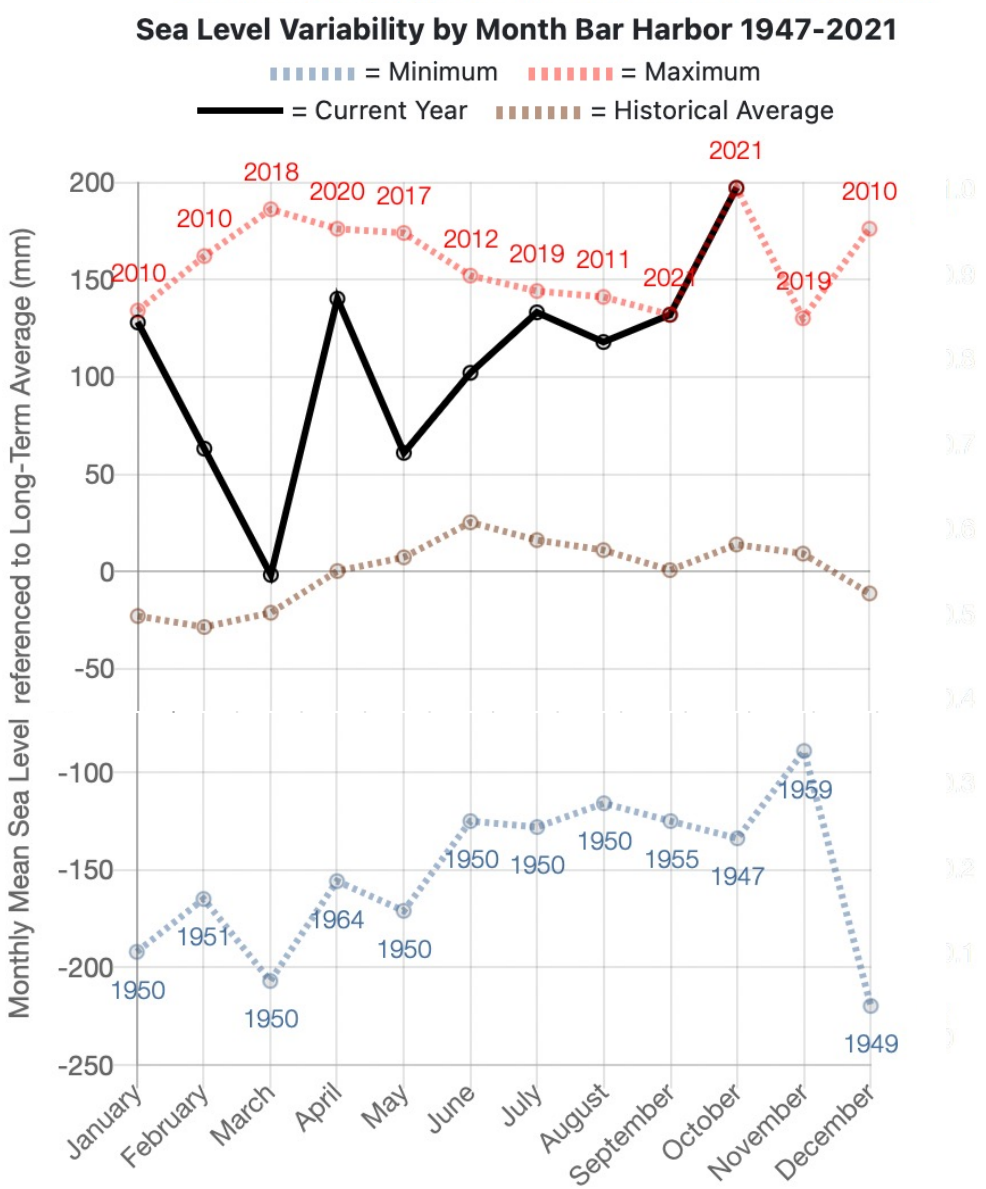
Causes of Sea Level Change

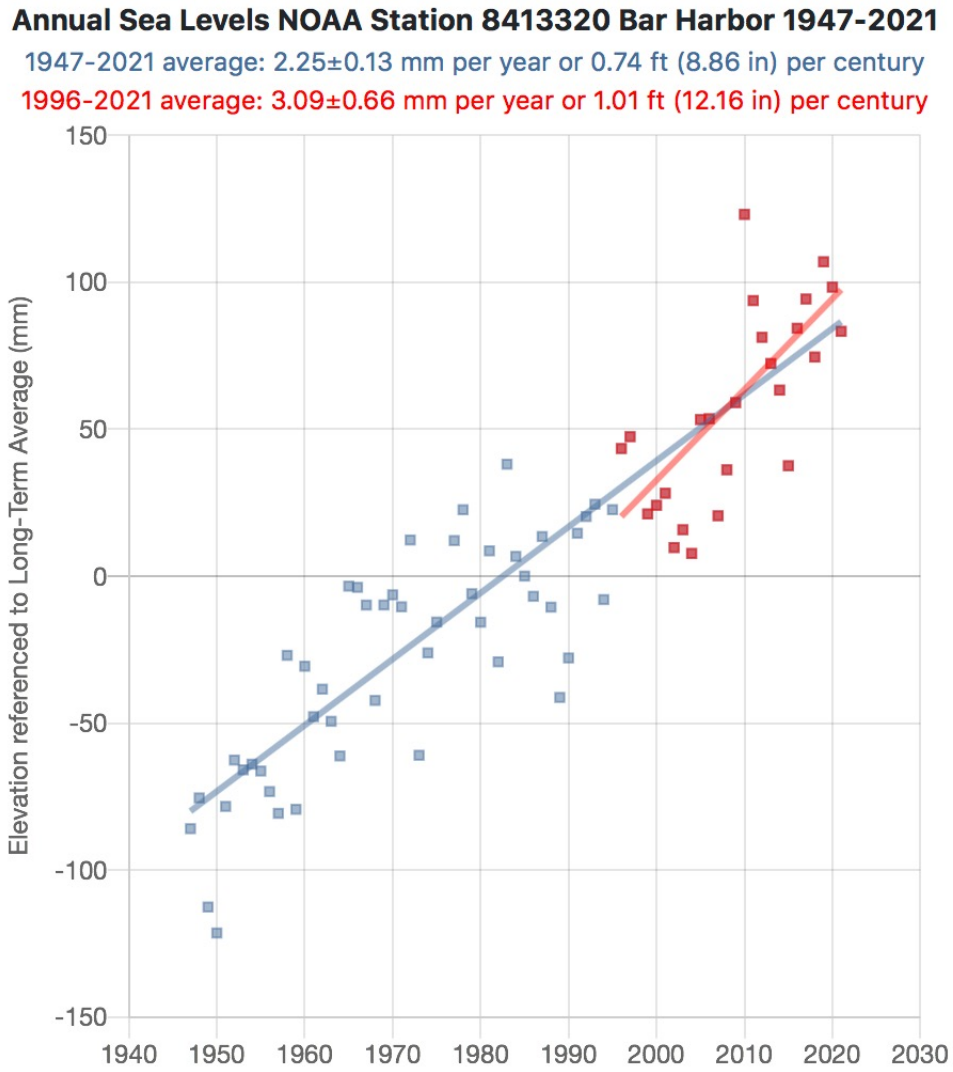


(IPCC, 2001)

Maine Sea Level Rise Dashboard

Select Station: Bar Harbor





https://www.maine.gov/dacf/mgs/hazards/slr_ticker/slr_dashboard.html

Month		Highest Average Monthly Sea Level (through November 2021)				
	Seavey Island	Wells	Portland	Bar Harbor	Cutler	Eastport
	1930-2021*	2005-2021	1912-2021	1947-2021	2011-2021	1929-2021
January	2021	2021	2010	2010	2021	2019
February	1978	2010	2010	2010	2020	2010
March	1958	2018	2010	2018	2018	2018
April	2021	2020	2020	2020	2020	2020
May	1960	2017	2017	2017	2017	2017
June	1998	2012	2012	2012	2018	2011
July	2020	2019	2009	2019	2019	2011
August	2021	2021	2011	2011	2011	2011
September	2021	2021	1996	2021	2021	2010
October	2021	2021	2021	2021	2021	2021
November	2021	2021	1970	2021	2019	2019
December	2020	2012	2010	2010	2019	2010

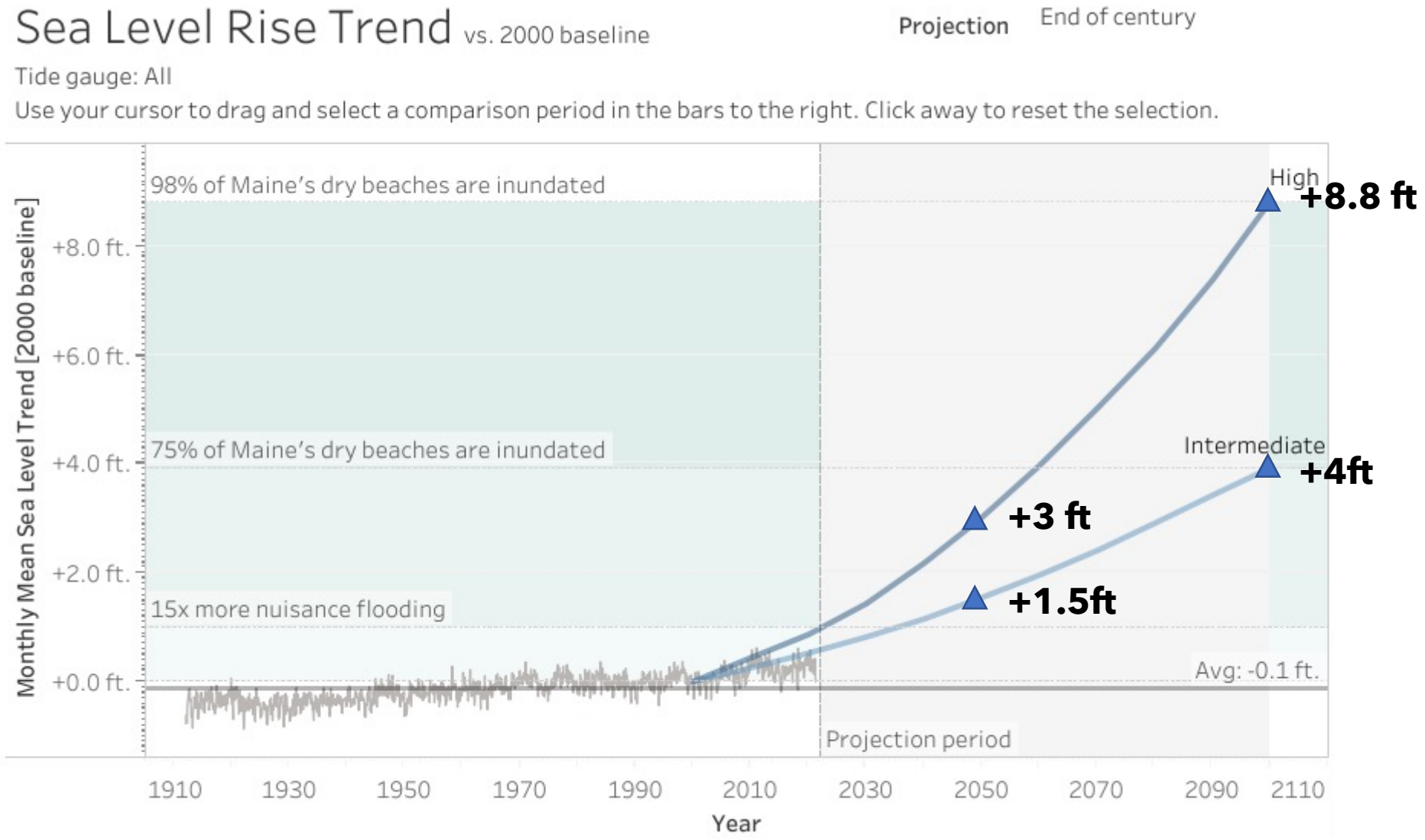
** Seavey Island, ME tide gauge was added to MGS SLR Ticker in December 2021; it has data gaps from 1987-1998 and 2001-2019*

SEA LEVEL RECORDS SET IN 2021:

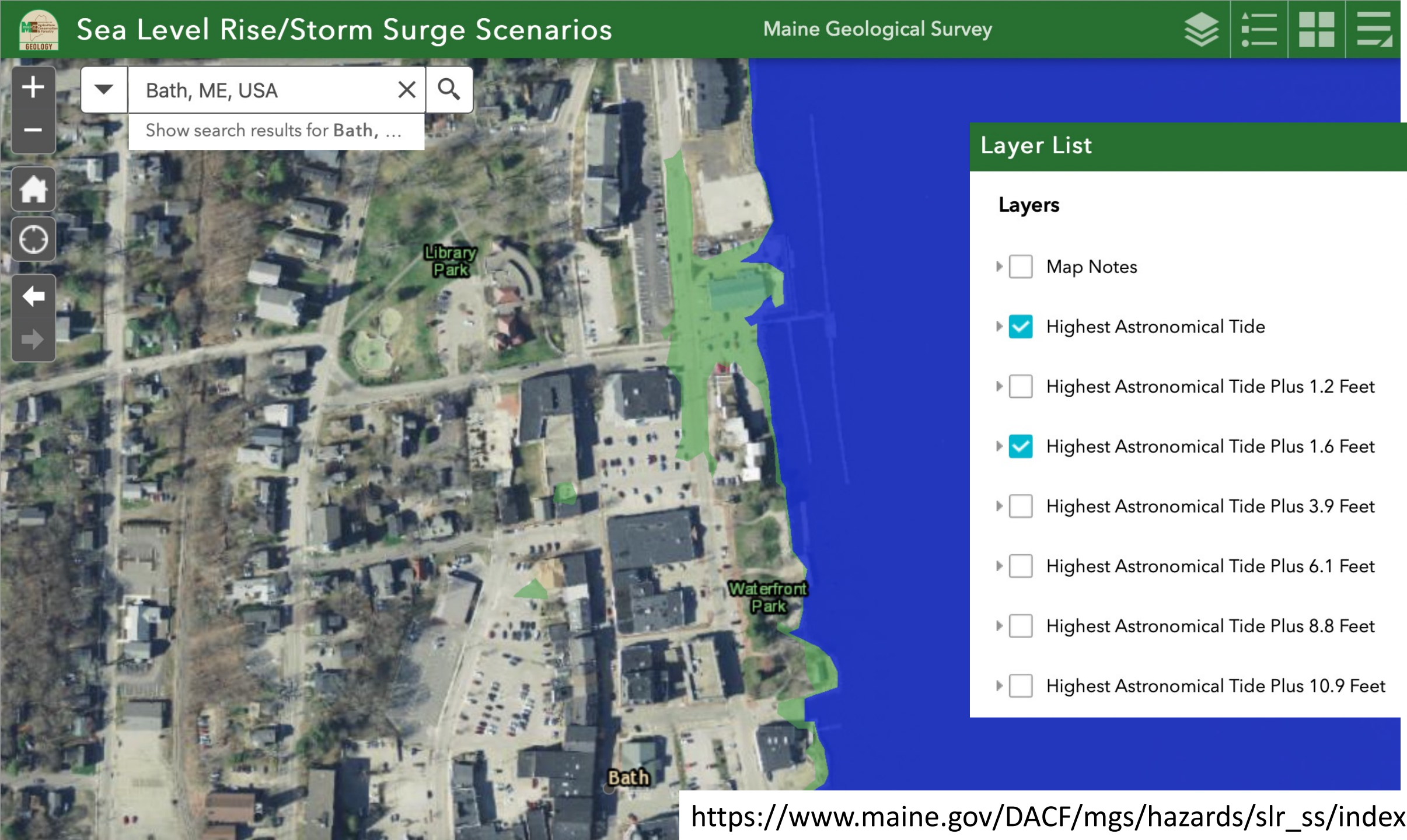
- Eastport: 2nd highest November since 1929 (and 2021 so far is 3rd highest average annual sea level)
- Cutler 2nd highest November since 2011 (and 2021 so far is highest average annual sea level)
- Bar Harbor: 1st highest November since 1947 (and 2021 so far is 2nd highest average annual sea level)
- Portland: 5th highest November since 1912 (and 2021 so far is 3rd highest average annual sea level)
- Wells: 1st highest November since 2005 (and 2021 so far is highest average annual sea level)
- Portsmouth: 1st highest November since 1930 (and 2021 highest average annual sea level, realizing there are a few gaps in the record)

Future Sea Level Rise Scenarios

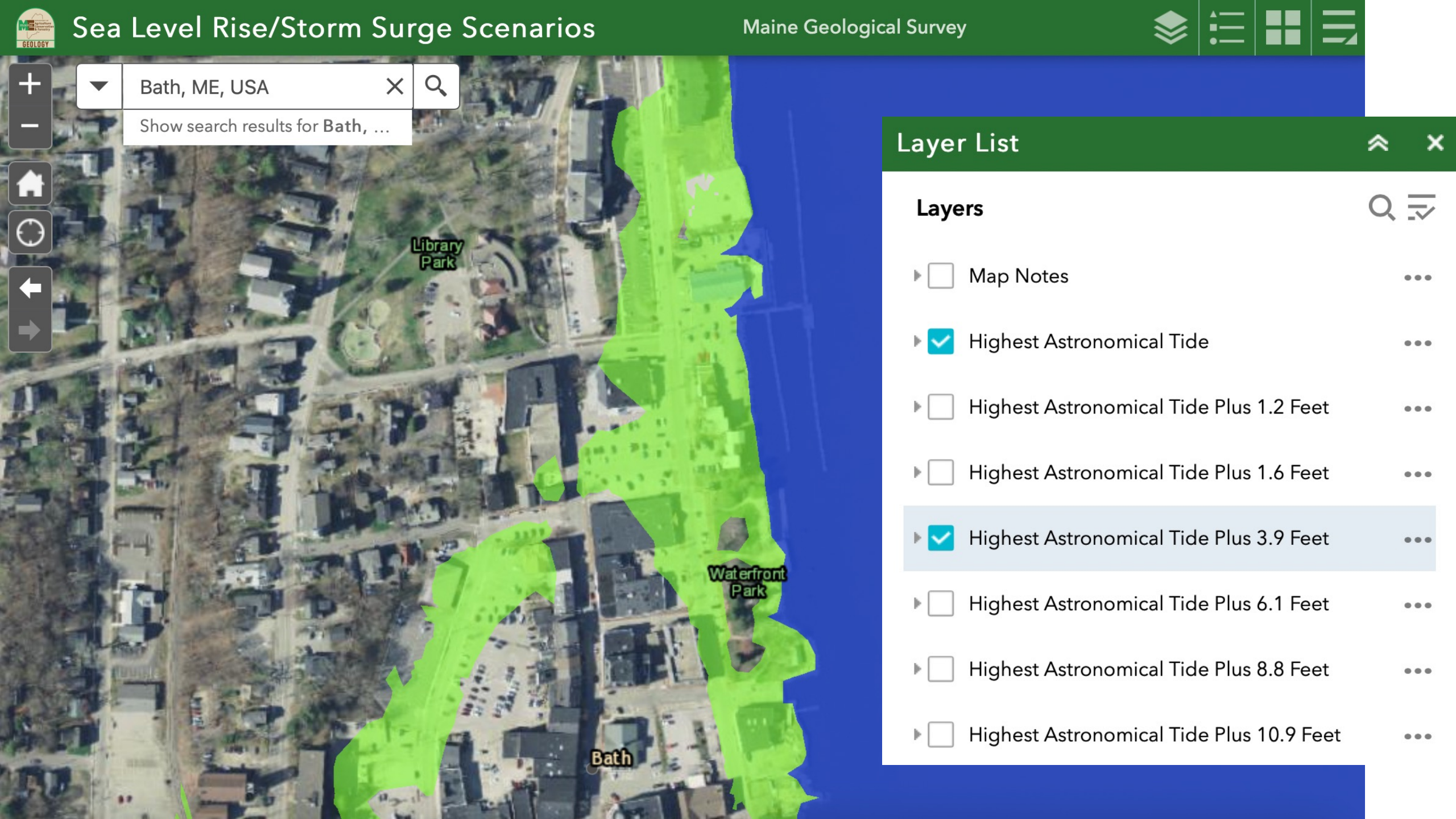
The State of Maine is planning for the intermediate scenario of 1.5 feet of relative sea level rise by 2050 and 4 feet of SLR by 2100.

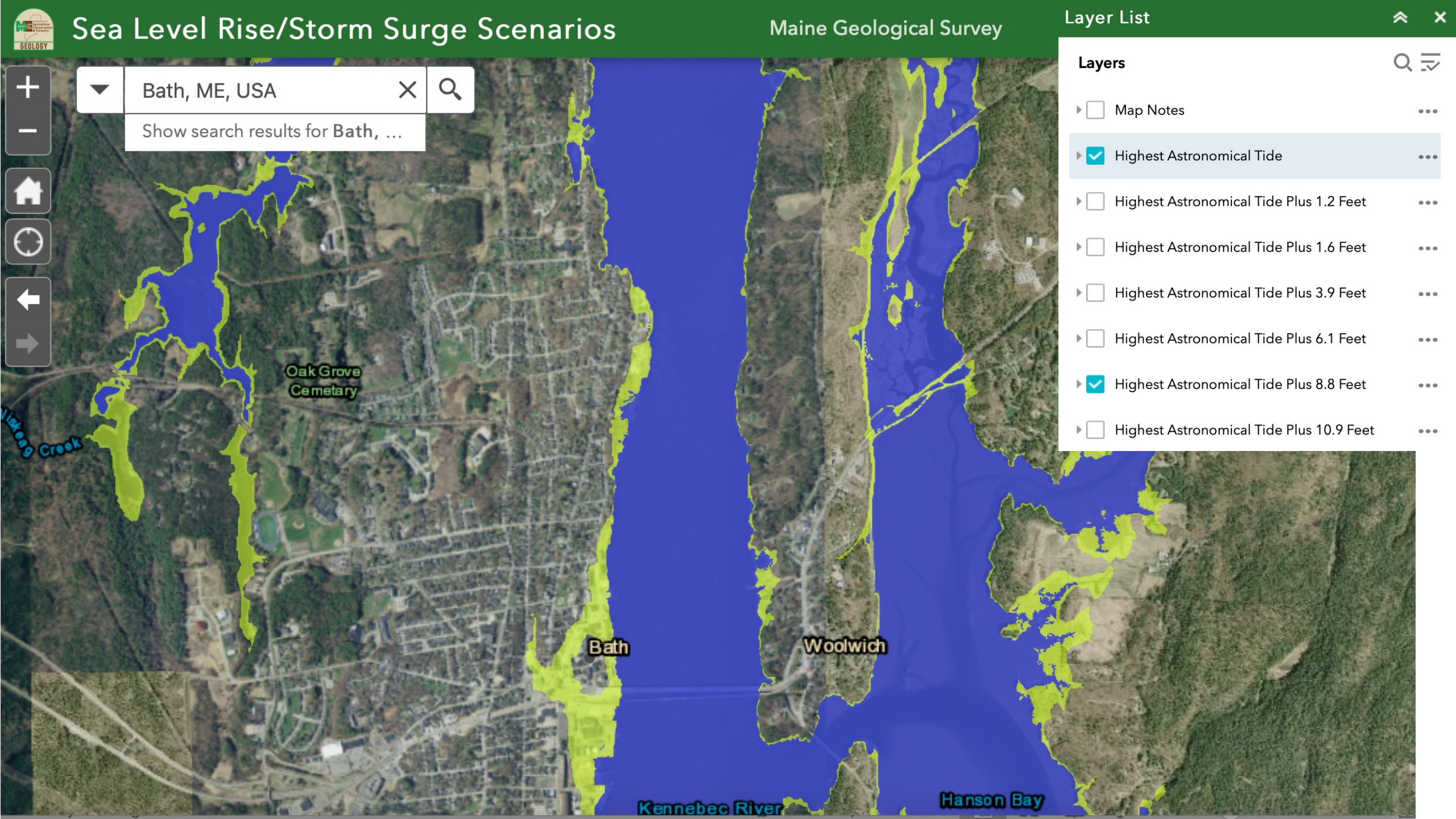


SOURCE: NOAA (monthly tide gauge readings); Army Corps of Engineers (projections). MaineWontWait.org



https://www.maine.gov/DACF/mgs/hazards/slr_ss/index.shtml


Sea Level Rise/Storm Surge Scenarios
Maine Geological Survey
Bath, ME, USA
Show search results for Bath, ...
Library Park
Waterfront Park
Bath
Layer List
Layers
Map Notes
Highest Astronomical Tide
Highest Astronomical Tide Plus 1.2 Feet
Highest Astronomical Tide Plus 1.6 Feet
Highest Astronomical Tide Plus 3.9 Feet
Highest Astronomical Tide Plus 6.1 Feet
Highest Astronomical Tide Plus 8.8 Feet
Highest Astronomical Tide Plus 10.9 Feet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Highest Astronomical Tide Plus 8.8 Feet
Highest Astronomical Tide Plus 10.9 Feet
Oak Grove Cemetary
Bath
Woolwich
Kennebec River
Hanson Bay

Coastal Resilience Maine

The Nature Conservancy

Find address or place

Coastal Risk Explorer

Rising sea levels will impact Maine's coast in many different ways. One important effect will be the inundation of roads, which will prevent access to homes and businesses as roads are flooded. Use this tool to explore how rising sea levels will affect roads in coastal cities and towns, see where road networks will be inaccessible to emergency responders, and how that relates to the overall social vulnerability of the community. Social vulnerability is provided for each coastal block group, based upon 17 socioeconomic and demographic factors.

Choose a Town to Explore: Bath

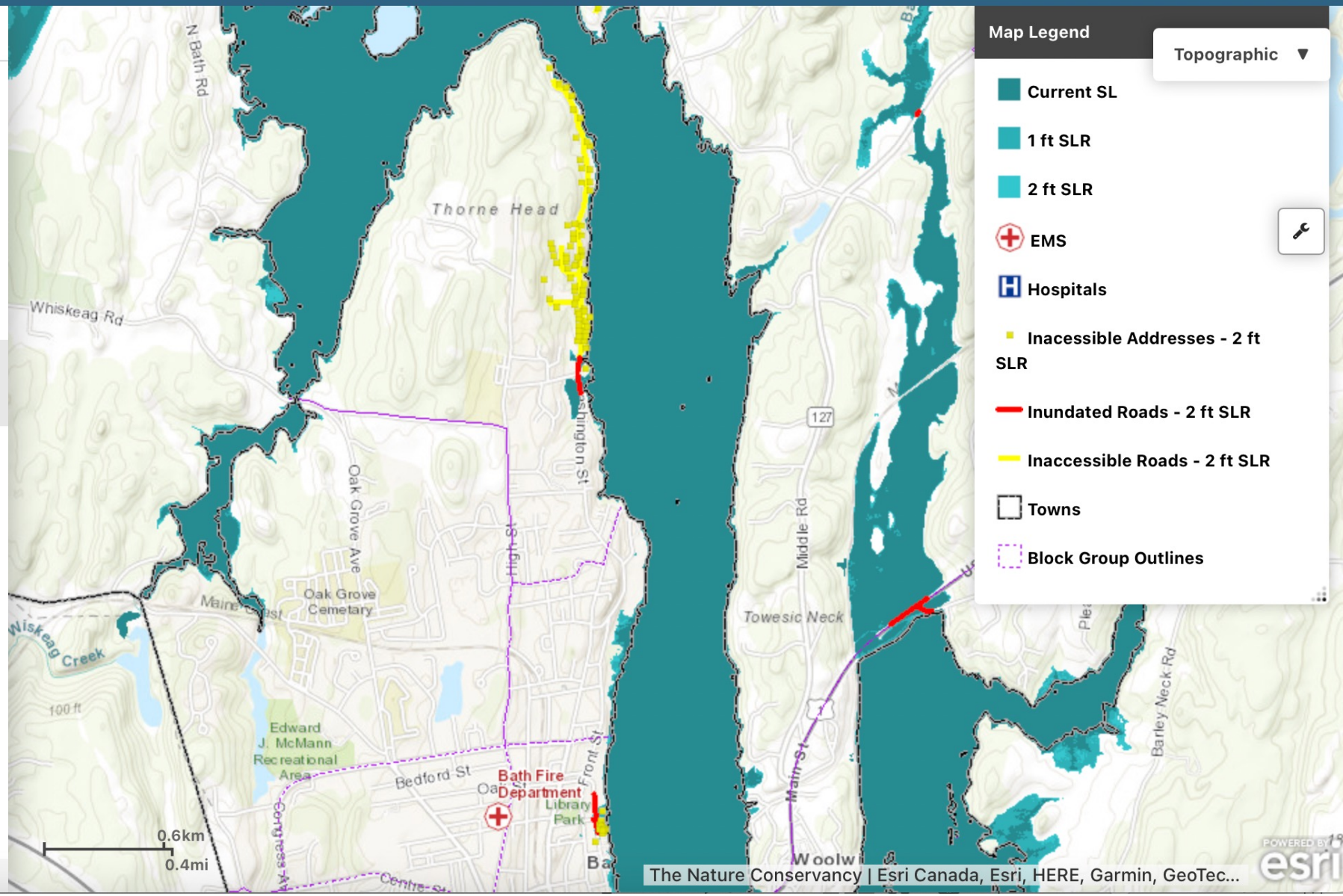
Block Group 3

Coastal Roads Inaccessible to Emergency Services

Sea Level Rise Prediction

Current | 1 ft | 2 ft | 3.3 ft | 6 ft

NUMBER OF ADDRESSES INACCESSIBLE TO EMERGENCY SERVICES	APPROXIMATE COST TO UPGRADE INUNDATED ROADS
91	$590,000
TOWN TOTAL	TOWN TOTAL
2	$140,000
BLOCK GROUP TOTAL	BLOCK GROUP TOTAL



https://maps.coastalresilience.org/maine/

Coastal Resilience Maine

Coastal Risk Explorer

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Choose a Town to Explore:

Georgetown

Coastal Roads Inaccessible to Emergency Services

Sea Level Rise Prediction

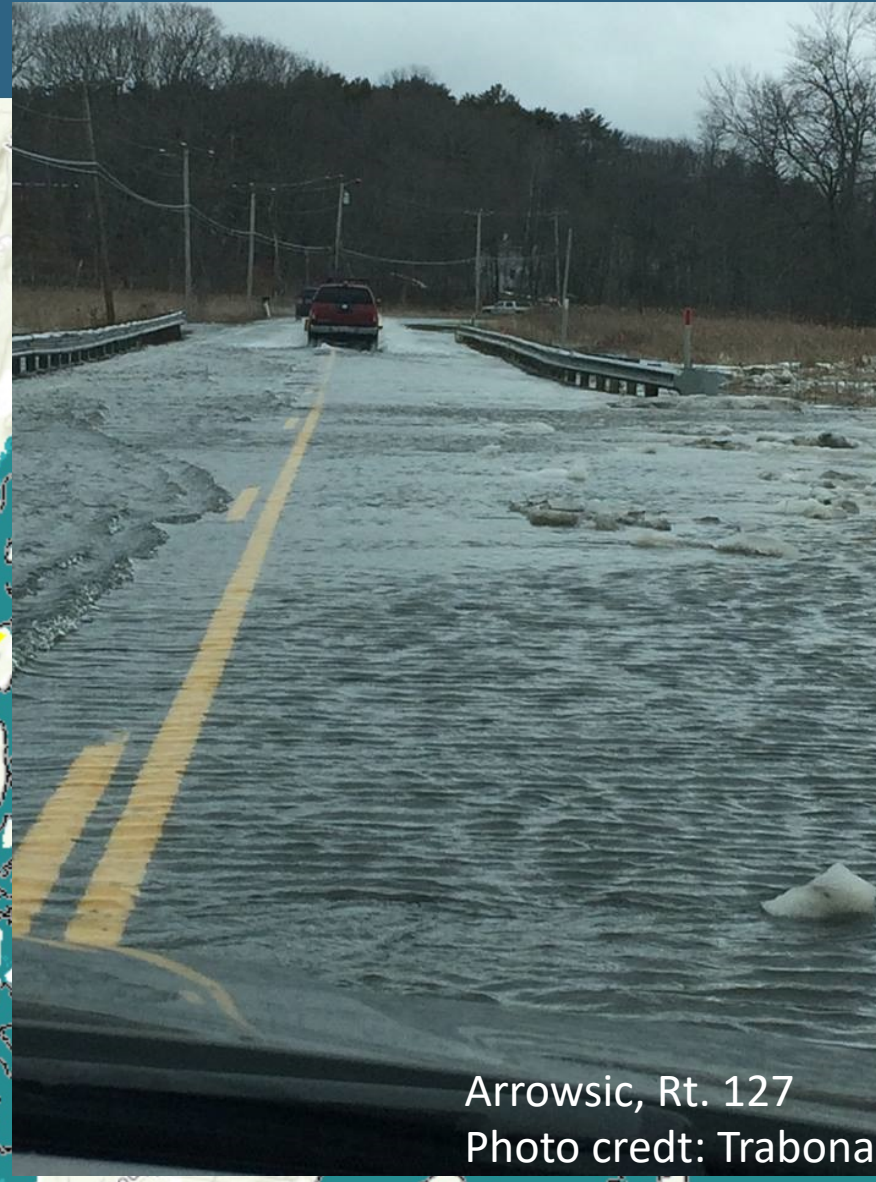
Current 1 ft 2 ft 3.3 ft 6 ft

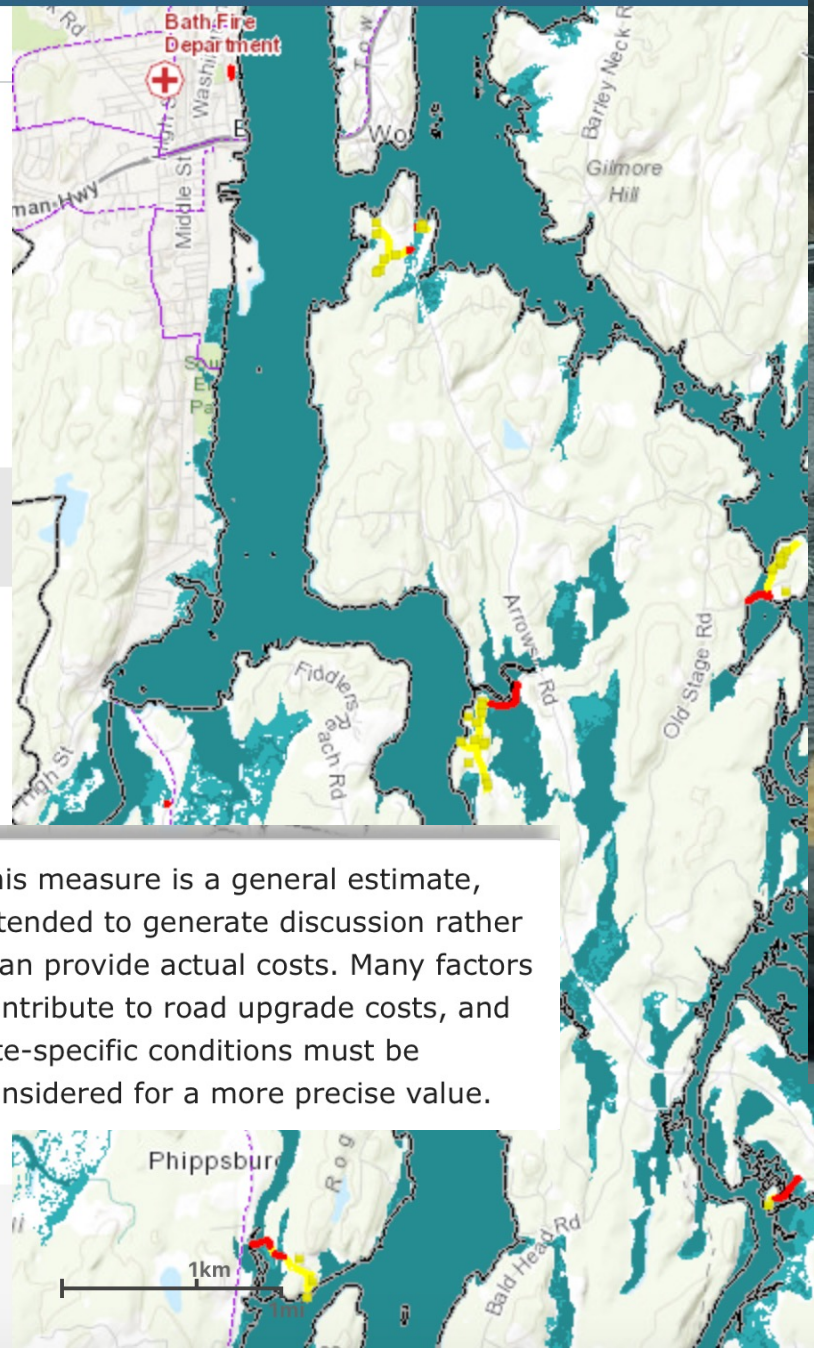
NUMBER OF ADDRESSES INACCESSIBLE TO EMERGENCY SERVICES	APPROXIMATE COST TO UPGR INUNDATED ROADS
4	$1,070,000
TOWN TOTAL	TOWN TOTAL
--	$--
BLOCK GROUP TOTAL	BLOCK GROUP TOTAL

This measure is a general estimate, intended to generate discussion rather than provide actual costs. Many factors contribute to road upgrade costs, and site-specific conditions must be considered for a more precise value.

Social Vulnerability Ranking

Least Vulnerable Most Vulnerable





Tour

Coastal Resilience Maine

Find address or place

Coastal Risk Explorer

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Choose a Town to Explore:

Georgetown

Coastal Roads Inaccessible to Emergency Services

Sea Level Rise Prediction

Current | 1 ft | 2 ft | 3.3 ft | 6 ft

NUMBER OF ADDRESSES INACCESSIBLE TO EMERGENCY SERVICES	APPROXIMATE COST TO UPGRADE INUNDATED ROADS
932	$1,710,000
TOWN TOTAL	TOWN TOTAL
--	$--
BLOCK GROUP TOTAL	BLOCK GROUP TOTAL

Social Vulnerability Ranking

Least Vulnerable — Most Vulnerable

Tour

Map Legend — Topographic

- Current SL
- 1 ft SLR
- 2 ft SLR
- EMS
- Hospitals
- Inacessible Addresses - 2 ft SLR
- Inundated Roads - 2 ft SLR
- Inaccessible Roads - 2 ft SLR
- Towns
- Block Group Outlines

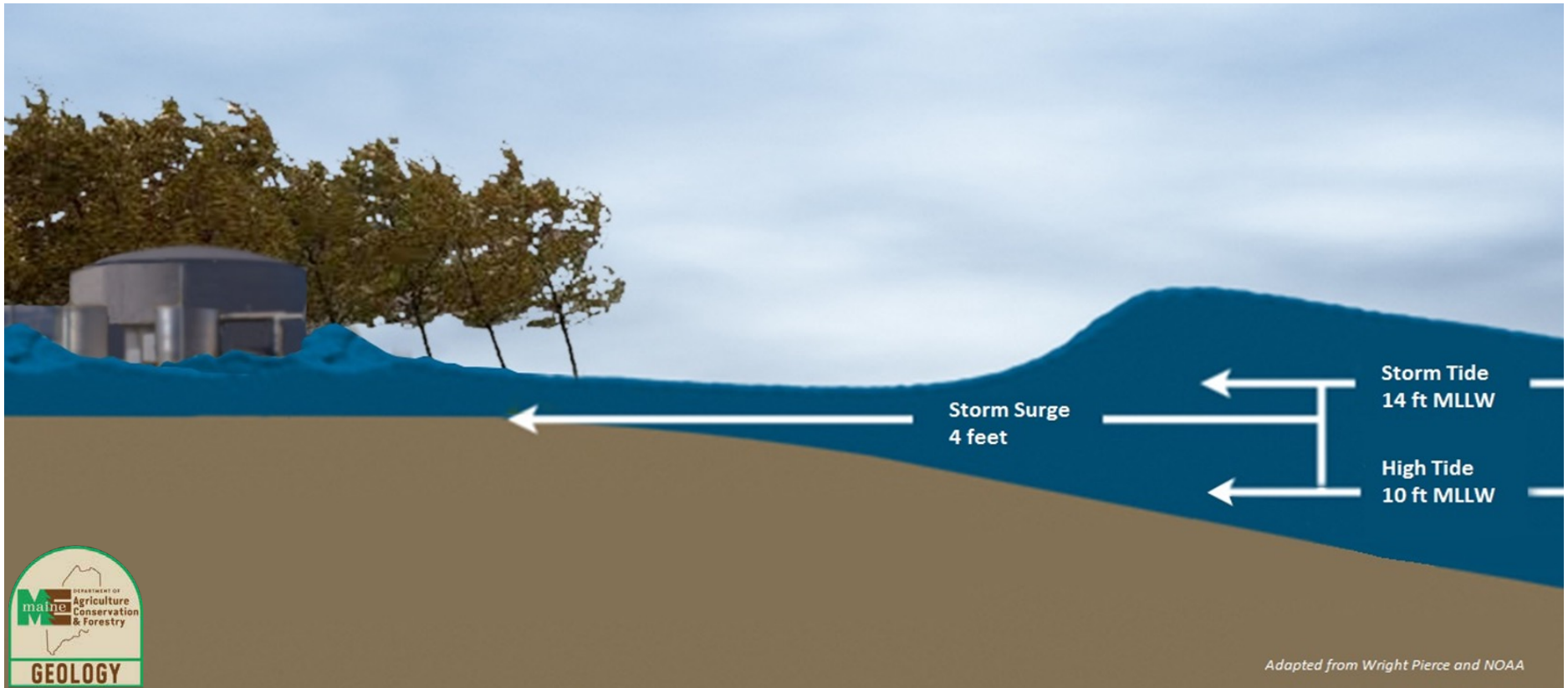
Bath Fire Department
Gilmore Hill
Fiddlers Reach Rd
Pitchpine Hill
Cutting Creek
Rogers Neck
Brook Point
Isle of Springs
Macmahan Island
Phippsburg
1km

The Nature Conservancy | Esri Canada, Esri, HERE, Garmin, INCRE...

POWERED BY esri

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).



Deer Isle Causeway

Woolwich

A Superstorm in Maine?

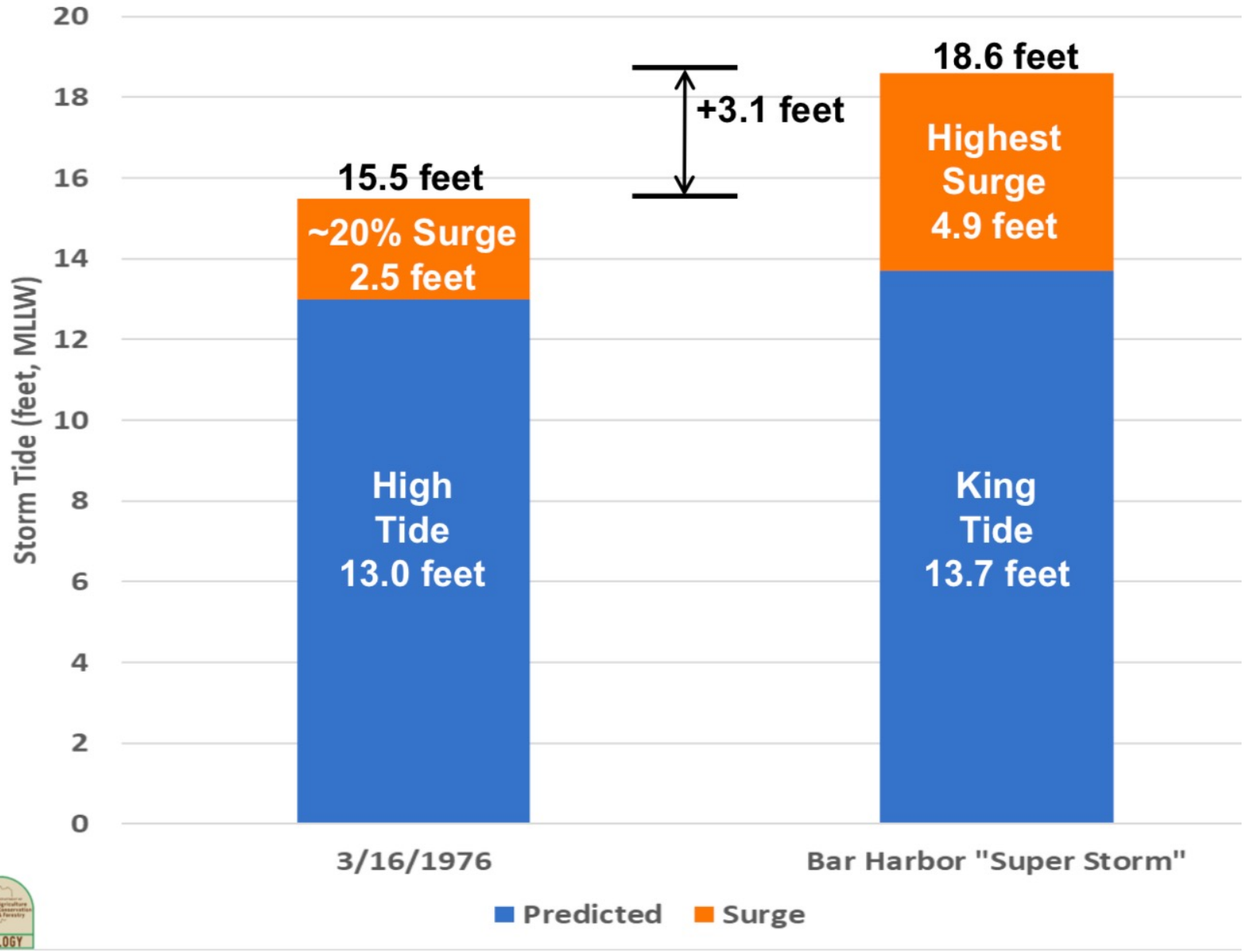


Figure from P.A. Slovinsky, Maine Geological Survey

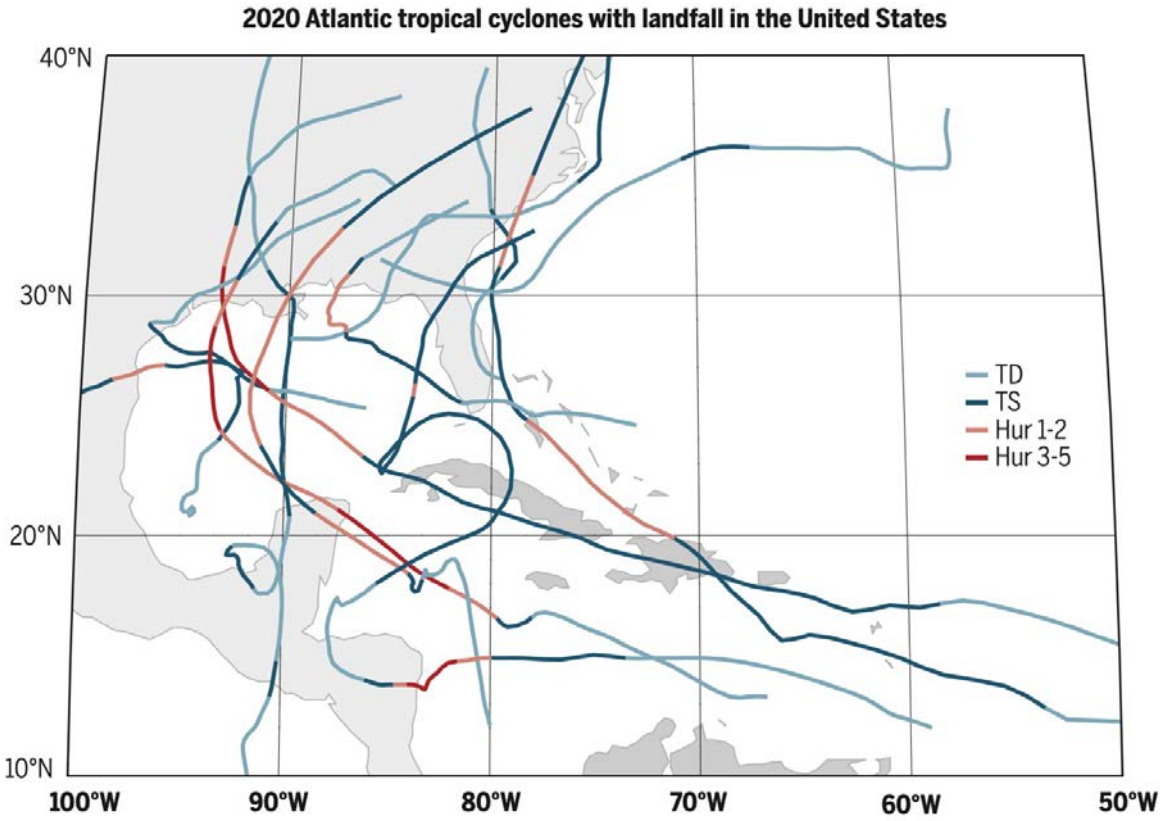
Changes in Storm Tracks and Activity

Background- Tropical Cyclone (TC) activity with warming

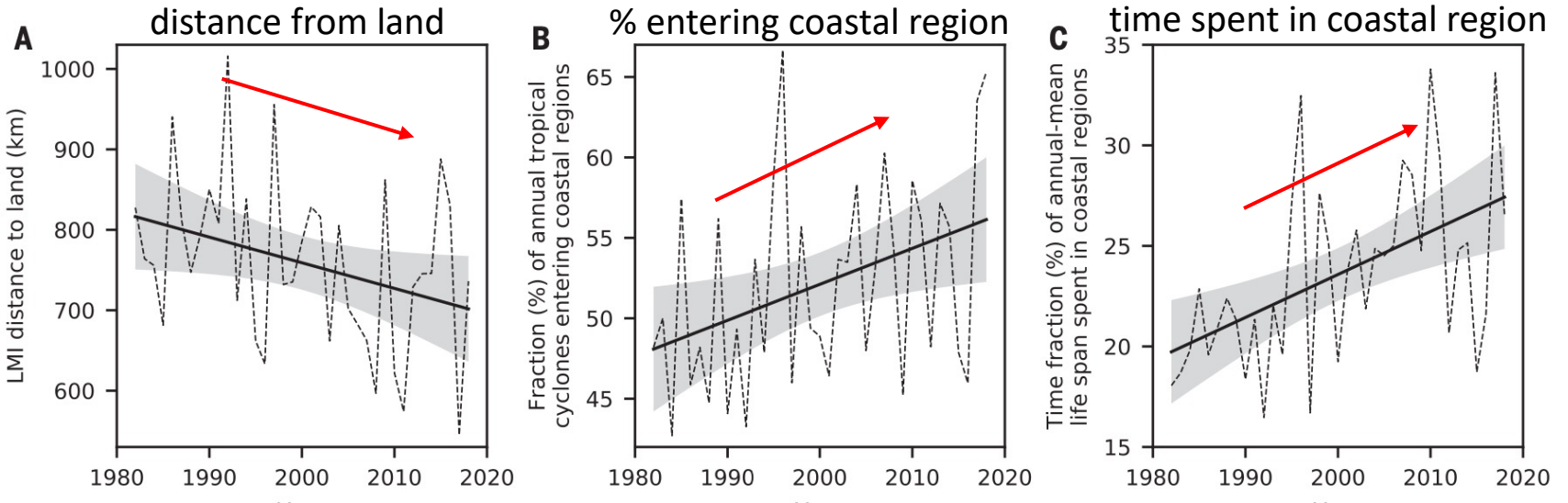
- ⬆ occurrence and intensity of most intense TC
- ⬆ precipitation associated with TC
- ⬆ storm surge flooding

New insights-

- Tracks shifting poleward and westward, potentially impacting unprepared regions not typically affected by intense TCs
- TC activity close to land is increasing, and seeing increased stalling of Atlantic TCs- with a substantial increase in risk to costal regions



Camargo & Wing 2021



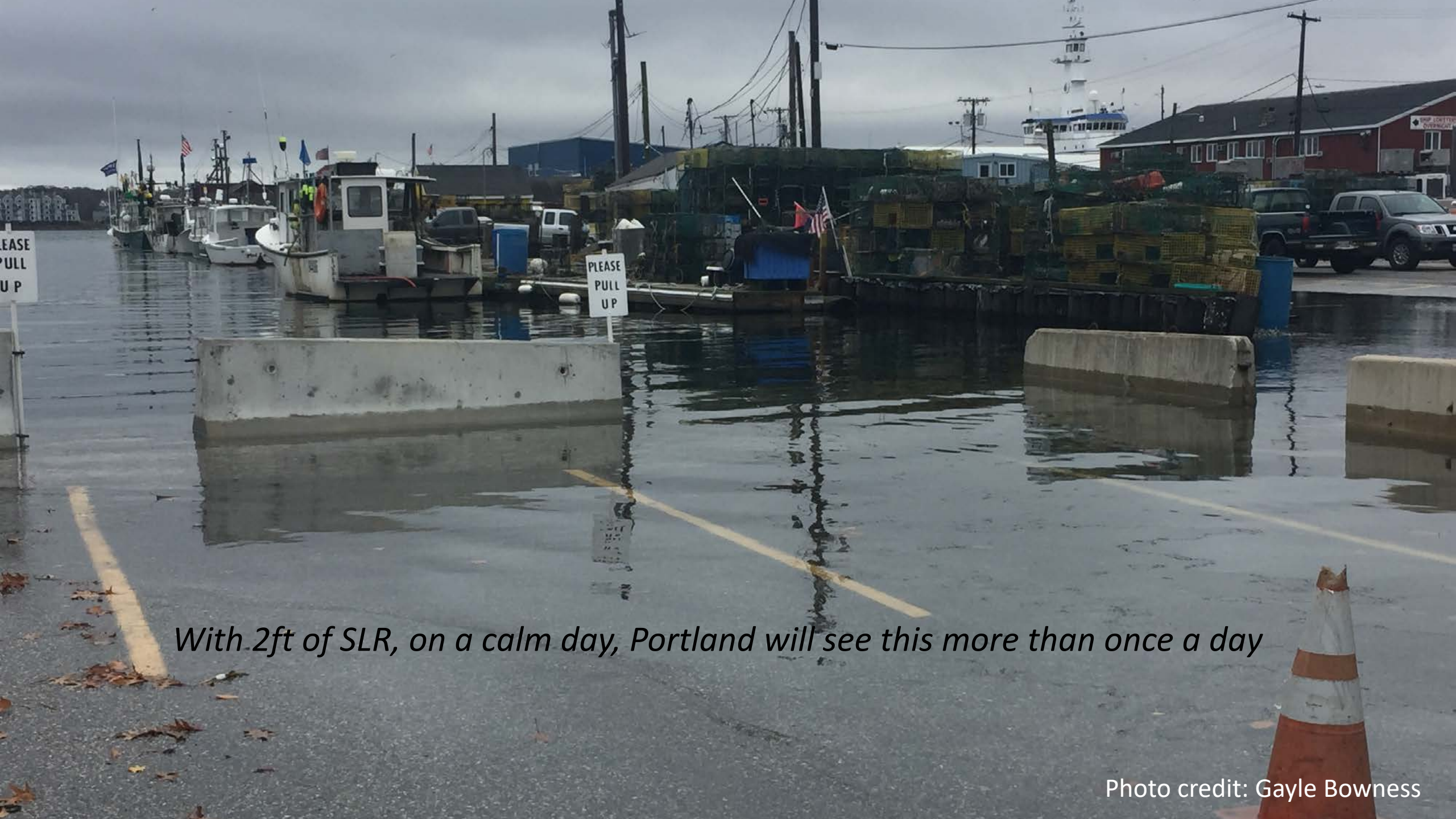
Wang & Toumi 2021

Changes in Annual Flooding Frequency with SLR (using 2006-2016 Average)

Scenario	Flood Stage (ft, MLLW)	# times per year	% of high tides
Existing	12	9.8	1.3%
+1 ft SLR	11	98	13.5%
+2 ft SLR	10	461	63.3%

Based on this, there could potentially be **a *tenfold increase in the frequency of flooding* in Portland** with **1 foot of sea level rise**.

P.A. Slovinsky, Maine Geological Survey



With 2ft of SLR, on a calm day, Portland will see this more than once a day

Photo credit: Gayle Bowness

2011 King Tide, Bath, ME
Photo credit: Steve Dickson

Sea Level Rise Central Estimates for Planning in Maine (averaged for all of Maines' tide gauges)

Planning Scenario	"Commit to Manage"	"Prepare to Manage"
Year	Intermediate Scenario	High Scenario
2030	0.8	1.4
2050	1.5	3.0
2070	2.4	5.0
2100	3.9 ~4 ft	8.8 ~9 ft

Relative Sea Level Rise (feet) from 2000

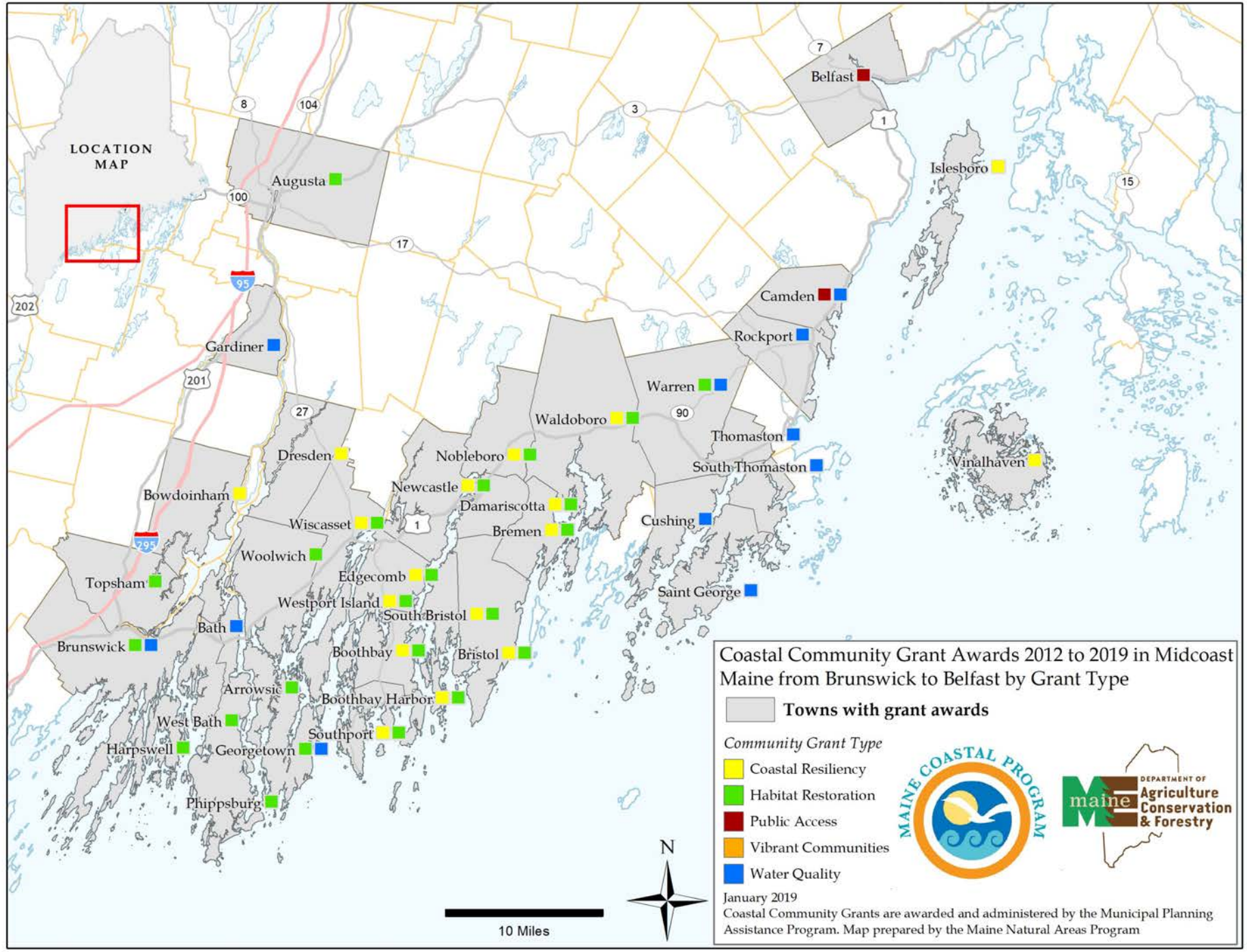
STS (2020) Table 7b

Stonington

Blue Hill

Progress towards improving coastal resilience

Credit: Kate Tagai, Island Institute


LOCATION MAP
Belfast
Islesboro
Augusta
Camden
Rockport
Gardiner
Warren
Waldoboro
Thomaston
Dresden
Nobleboro
South Thomaston
Vinalhaven
Newcastle
Bowdoinham
Damariscotta
Wiscasset
Cushing
Bremen
Woolwich
Edgecomb
Topsham
Saint George
Westport Island
South Bristol
Bath
Brunswick
Boothbay
Bristol
Arrowsic
Boothbay Harbor
West Bath
Southport
Harpswell
Georgetown
Phippsburg
N
10 Miles
Coastal Community Grant Awards 2012 to 2019 in Midcoast Maine from Brunswick to Belfast by Grant Type
Towns with grant awards
Community Grant Type
Coastal Resiliency
Habitat Restoration
Public Access
Vibrant Communities
Water Quality
MAINE COASTAL PROGRAM
maine DEPARTMENT OF Agriculture Conservation & Forestry
January 2019
Coastal Community Grants are awarded and administered by the Municipal Planning Assistance Program. Map prepared by the Maine Natural Areas Program

Funding For Climate Resilience

From the Federal Infrastructure Investment & Jobs Act (over five years):

- $1.3 billion for federal-aid highway apportioned programs and $225 million for bridge replacement and repairs – which can include climate resilience projects
- $390 million to improve water infrastructure across the state
- Additional competitive funds for cybersecurity, energy and climate resilience programs

From the Maine Jobs & Recovery Plan (federal American Rescue Plan Act):

- $20 million to support adaptation and resilience of infrastructure vulnerable to climate

Maine State Budget:

- $40 million in the biennial budget for land conservation (LMF Program)
- $4.75 million for local and regional planning grants to prepare for climate change effects, reduce carbon emissions, and transition to renewable energy.
- $3 million to upgrade municipal culverts at stream crossings
- $300k for eelgrass mapping; $200k for DEP rulemaking support; and $400k for forest carbon mapping.

Guidance Series for Maine Communities- *integrating climate adaptation measures into existing local policies*

MAINE'S REGIONAL PLANNING ORGANIZATIONS - LAND USE TECHNICAL ASSISTANCE TO MUNICIPALITIES

Municipal Climate Adaptation Guidance Series for Maine Communities

Inundation of Chebeague Island's Stone Pier

REGIONAL PARTNERS

Androscoggin Valley Council of Governments
Greater Portland Council of Governments
Hancock County Planning Commission
Kennebec Valley Council of Governments
Lincoln County Regional Planning Commission
MidCoast Council of Governments
Midcoast Regional Planning Commission
Northern Maine Development Commission
Washington County Council of Governments
Southern Maine Planning and Development Commission

See http://www.maine.gov/dacf/municipalplanning/technical/regional_council.shtml

STATE PARTNERS

Maine Department of Marine Resources: *Maine Coastal Program*
Maine Department of Agriculture Conservation and Forestry:
Municipal Planning Assistance Program, *Maine Geological Survey*,
Maine Floodplain Management Program, *Maine Natural Areas Program*
Maine Department of Environmental Protection: *Sustainability*
Maine Department of Transportation: *Environmental Office*

1. Overview
2. Transportation
3. StreamSmart Crossings
4. Wastewater Management
5. Drinking Water
6. Storm Water
7. Comprehensive Planning
8. Shoreland Zoning Ordinance
9. Site Plan Review Ordinance
10. Subdivision Ordinance

Available at: www.maine.gov/dacf/municipalplanning/docs/CAGS_01_Overview.pdf

Maine Flood Resilience Checklist-

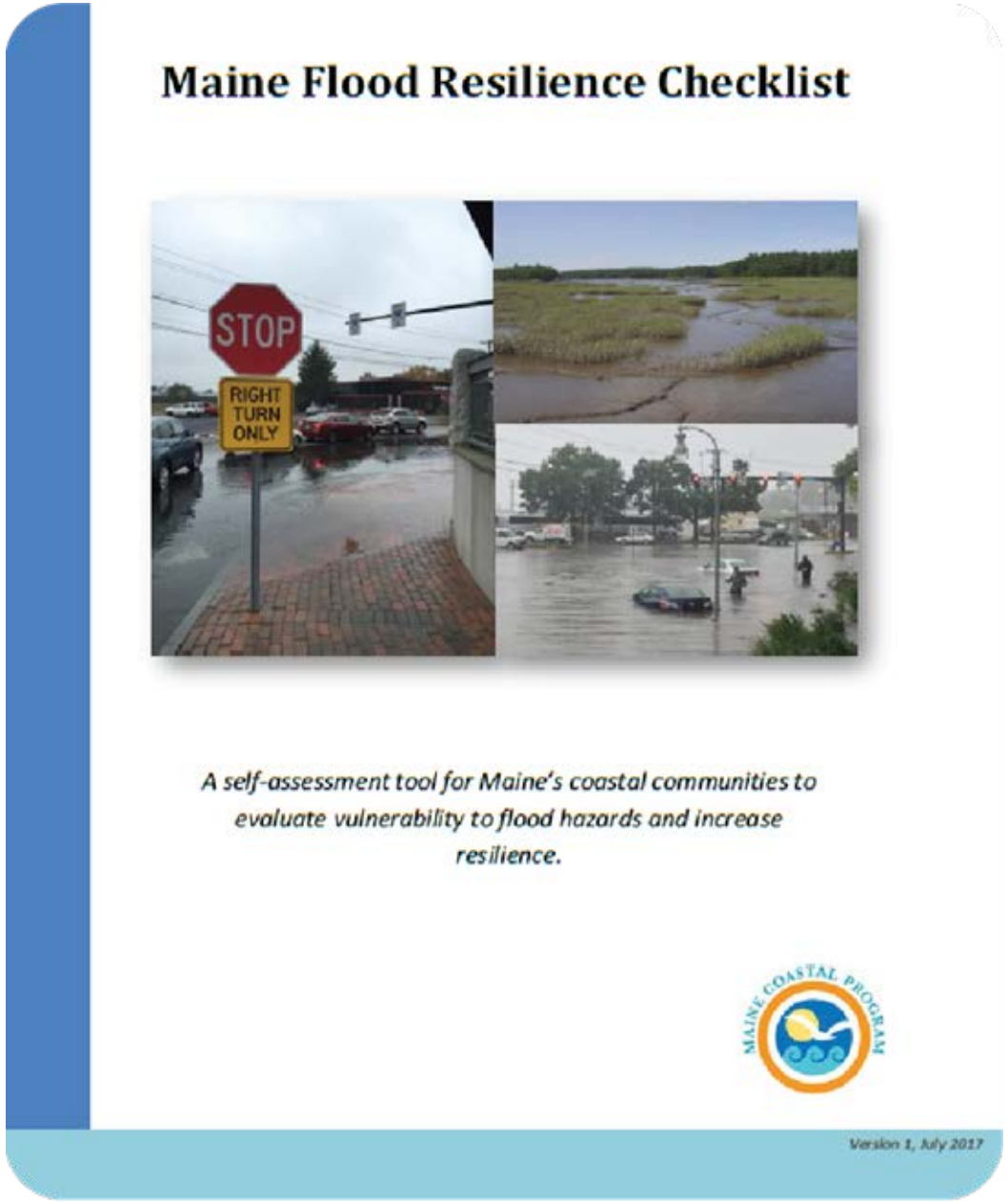
Top-down

Driven by State

Flood Resilience Checklist

Driven by community

Bottom-up



What Is It?

Practical self-assessment tool and integrated framework for…

- Examining local flood risk and preparedness
- Assessing vulnerability of the social, built, and natural environments
- Identifying strategies for increasing resilience

Who Should Use It?

Communities wanting to…

- Understand flood vulnerability and sea level rise
- Build flood resilience
- Enhance coastal hazard recovery

State of Maine
Governor's Office of Policy Innovation and the Future

COMMUNITY RESILIENCE PARTNERSHIP

Enrolling in the Partnership:

1. Complete a Community Resilience Self-Evaluation and **review the List of Community Actions** to assess existing progress and identify potential next steps;

Community resilience self-evaluation
List of community actions

2. Hold a public workshop(s) to review the self-assessment results and prioritize projects for implementation.
These workshops are an opportunity for communities to discuss their climate priorities and identify their top concerns.

3. Adopt a municipal resolution that establishes or designates either a citizen committee or a municipal employee to coordinate activities to reduce energy use and costs, transition to clean energy, and make the community more resilient to climate change

Community Action Grants- up to $50K for individual community
Once enrolled, communities may immediately apply for Community Action Grants.The 2022 grant deadlines are:

Deadlines for Communities Grant Applications	**Winter Awards**	**Summer Awards**
	March 22	September 20

City of Bath:
2019 Climate Action Plan

In 2019 the City of Bath:

- Pledged "*to take a leadership role to minimize the City's energy use and emissions and maximize efficiency and sustainability*"
- Established the Climate Action Commission "*to promote practices to reduce the effects of climate change through legislation, preparation and education*"

<u>March 10th 6:00 P.M - Auditorium of City Hall</u>
Community Workshop to discuss the Community Resilience Partnership and possible priority actions that the City may undertake to address climate change

BATH:BUILT TO LAST

BATH, ME • NOVEMBER, 2014

AIA Communities by Design

ENVISION. CREATE. SUSTAIN.

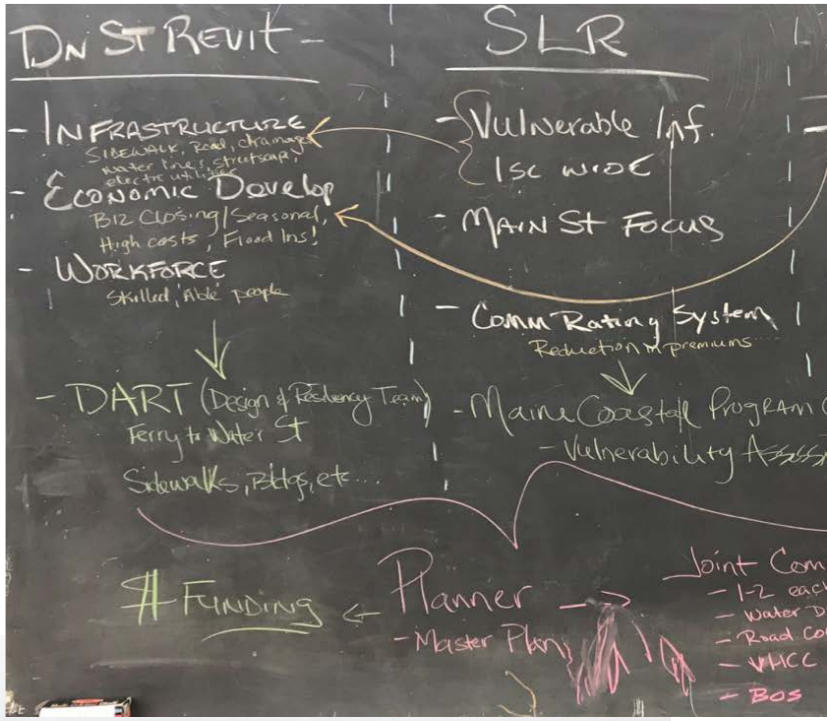
DESIGN AND RESILIENCY TEAM (DART) FINAL REPORT
A PILOT PROJECT OF THE AMERICAN INSTITUTE OF ARCHITECTS

The long-term vision for downtown includes a network of green streets and green/blue fingers. The primary green/blue finger is Elm Street and Water Street, which could be rebuilt to work with the water by including wetland systems and safe accommodation of temporary inundation during storm events. Relatively steep east-west streets connecting Front Street and Commercial Street should be improved to prioritize pedestrian traffic and include green infrastructure to slow and filter stormwater runoff before discharge to the river. Parking lots can also be green, and can include bioretention systems and permeable pavement.

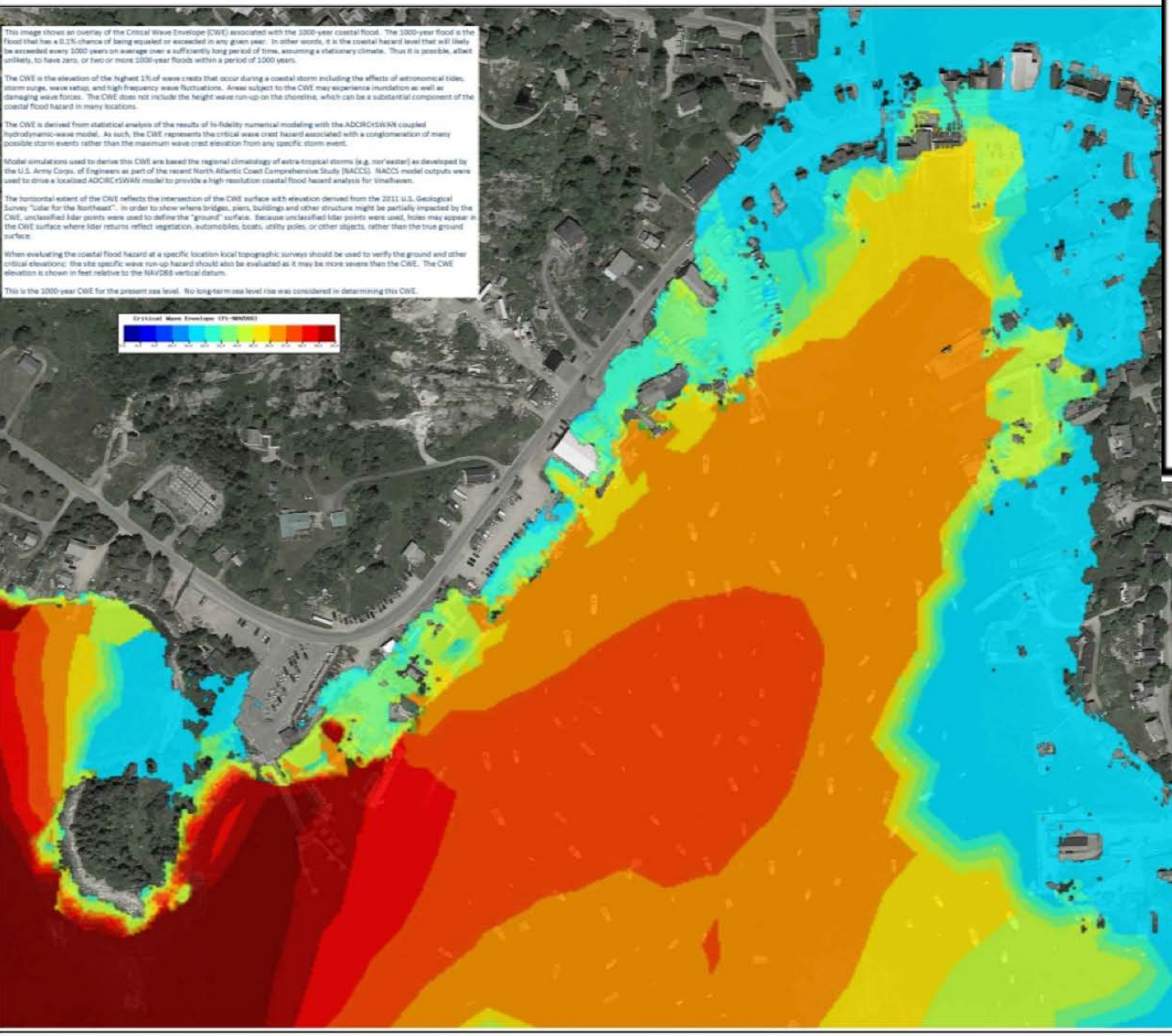
Vinalhaven “Downstreet”

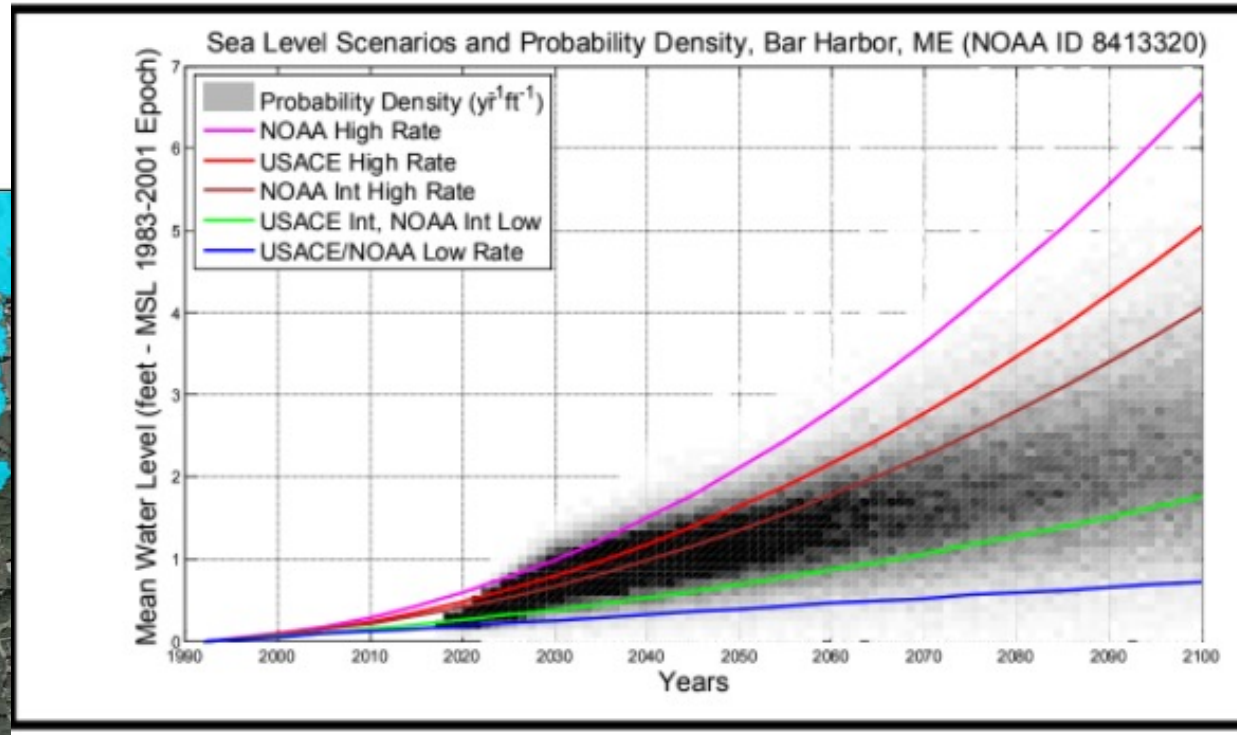
Economic Heartbeat

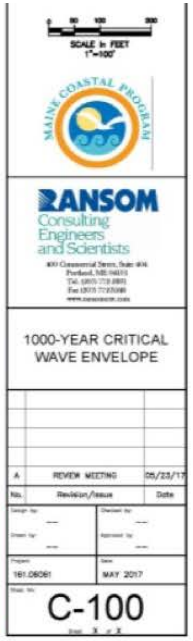
- 30+ businesses
- $13 million in RE value
- Emergency Services
- Boatyard
- Lobster Buyers
- Mixed Use



Critical Wave Envelope for the 1000-year storm event







Damariscotta Downtown

VE zone

AE zone

1ft SLR

3ft SLR

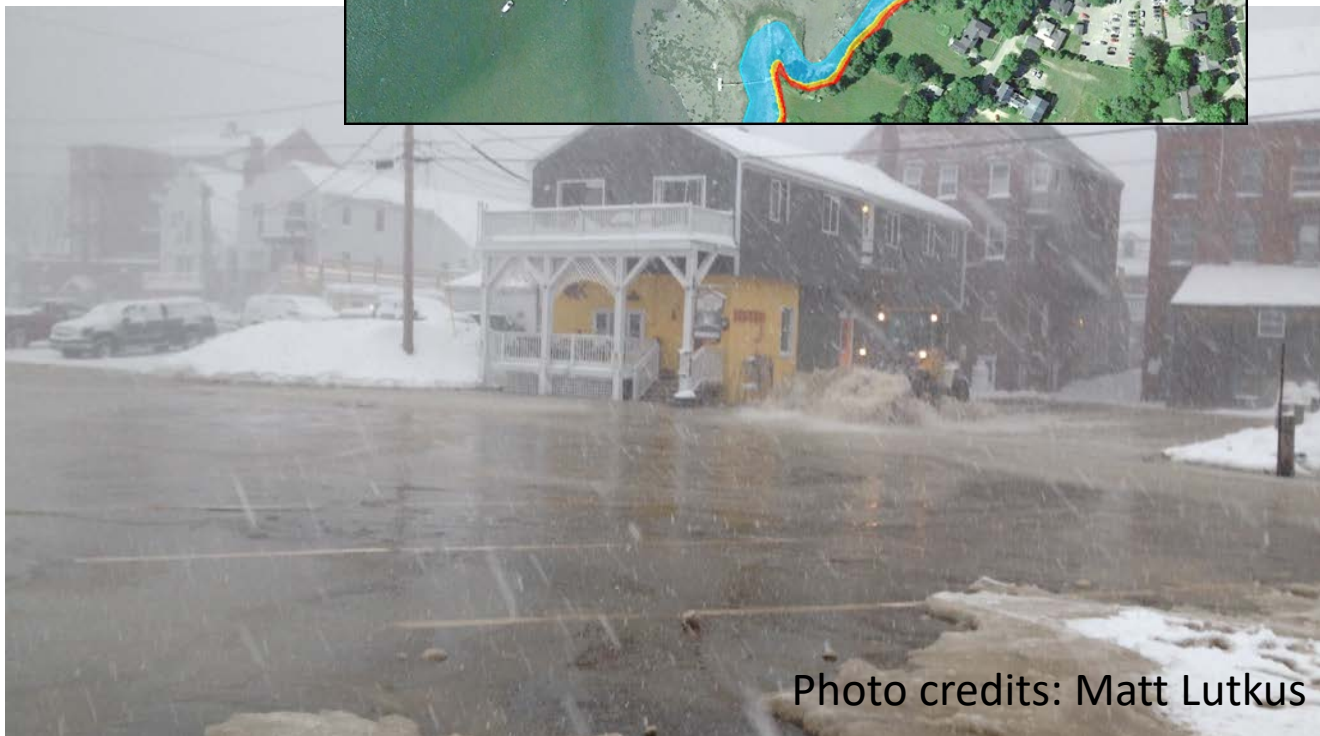


Photo credits: Matt Lutkus

ADAPTATION PLANNING STUDY
DOWNTOWN WATERFRONT AREA
DAMARISCOTTA, MAINE

DECEMBER 22, 2014
(REVISED FEBRUARY 2, 2015)

PREPARED FOR:
COASTAL COMMUNITIES GRANT OVERSIGHT COMMITTEE
DAMARISCOTTA, MAINE

PREPARED BY:
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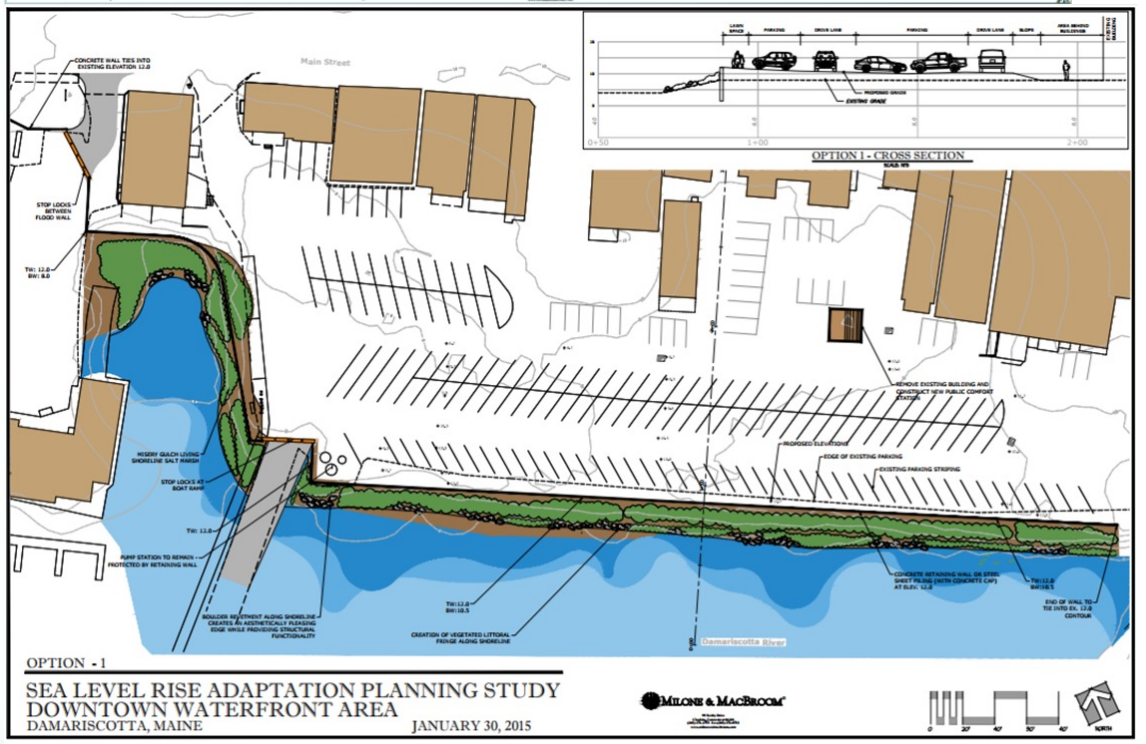
s memorandum was prepared by Milone & MacBroom, Inc. and the Town of Damariscotta under award CZM :13NOS4190045 to the Maine Coastal Program from the National Oceanic and Atmospheric Administration, U.S. Department Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily lect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

Option 2

Ground & Door elevations



Option 1

The Lincoln County News™

Damariscotta Wins $3M Grant for Waterfront Project

April 15, 2020 at 3:52 pm

A view of downtown Damariscotta from Newcastle on Saturday, April 18. The town of Damariscotta has won a $3 million grant for improvements to waterfront infrastructure. (Bisi Cameron Yee photo)

The town of Damariscotta will receive a $3 million grant from the federal Economic Development Administration to make flood-protection and infrastructure improvements to the downtown waterfront area.

Stonington-
Adaptation Report March 2021

GEI Consultants

Consulting Engineers and Scientists

Higher Priority

Lower Priority

Road	Approximate # of Residences/ Businesses for Which Road is Sole Access	Detour Length if Road Flooded or Closed	Minimum Elevation, ft NAVD88	Event That Will Cause Standing Water Flooding In:			Recommended Initial Amount to Raise Roads to Provide Protection from Most Flooding Scenarios Through 2050:	Approximate Segment Length for Recommended Elevation Action, ft	Total Cost	Estimated Costs to Elevate per Linear Foot of Roadbed
				2030	2050	2100				
Oceanville Road	100	No Detour Available	8.5	10-yr	HAT	MHW	2 ft	375	$260,000	$693
Whitman Road	28	No Detour Available	8.8	10-yr	10-yr	MHW	4 ft	780	$820,000	$1,051
Fifield Point Road	16	No Detour Available	9.1	10-yr	10-yr	MHW	4 ft	650	$360,000	$554
Ocean Street	8	No Detour Available	8.6	10-yr	HAT	MHW	3 ft	250	$180,000	$720
Moose Island Causeway	6	No Detour Available	8.1	10-yr	HAT	MHW	3 ft	475	$370,000	$779
Sand Beach Road	7	3+ miles	9	10-yr	10-yr	MHW	2 ft	600	$380,000	$633
Main Street	50	1.5 miles	11.3	NA	100-yr	HAT	3 ft	600	$340,000	$567
Atlantic Avenue	5	No Detour Available	13	NA	NA	10-yr	2 ft	200	$250,000	$1,250
Burnt Cove Road	3	5.5+	11	500-yr	50-yr	MHHW	2 ft	350	$220,000	$629
Bayview Avenue	5	No Detour Available	11.6	NA	500-yr	HAT	4 ft	500	$690,000	$1,380
West Main Street	25	0.2 miles	12.8	NA	NA	10-yr	2 ft	325	$250,000	$769
Colwell's Lane	NA	No Detour Available	8.4	10-yr	HAT	MHW	0 - 3 ft	0 - 100	$0 - $390,000	$0 - $3,900
Rhode Island Ave	3	No Detour Available	10	50-yr	10-yr	MHW	0 ft	0	$0	$0

A CLIMATE OF CHANGE:

SEA LEVEL RISE

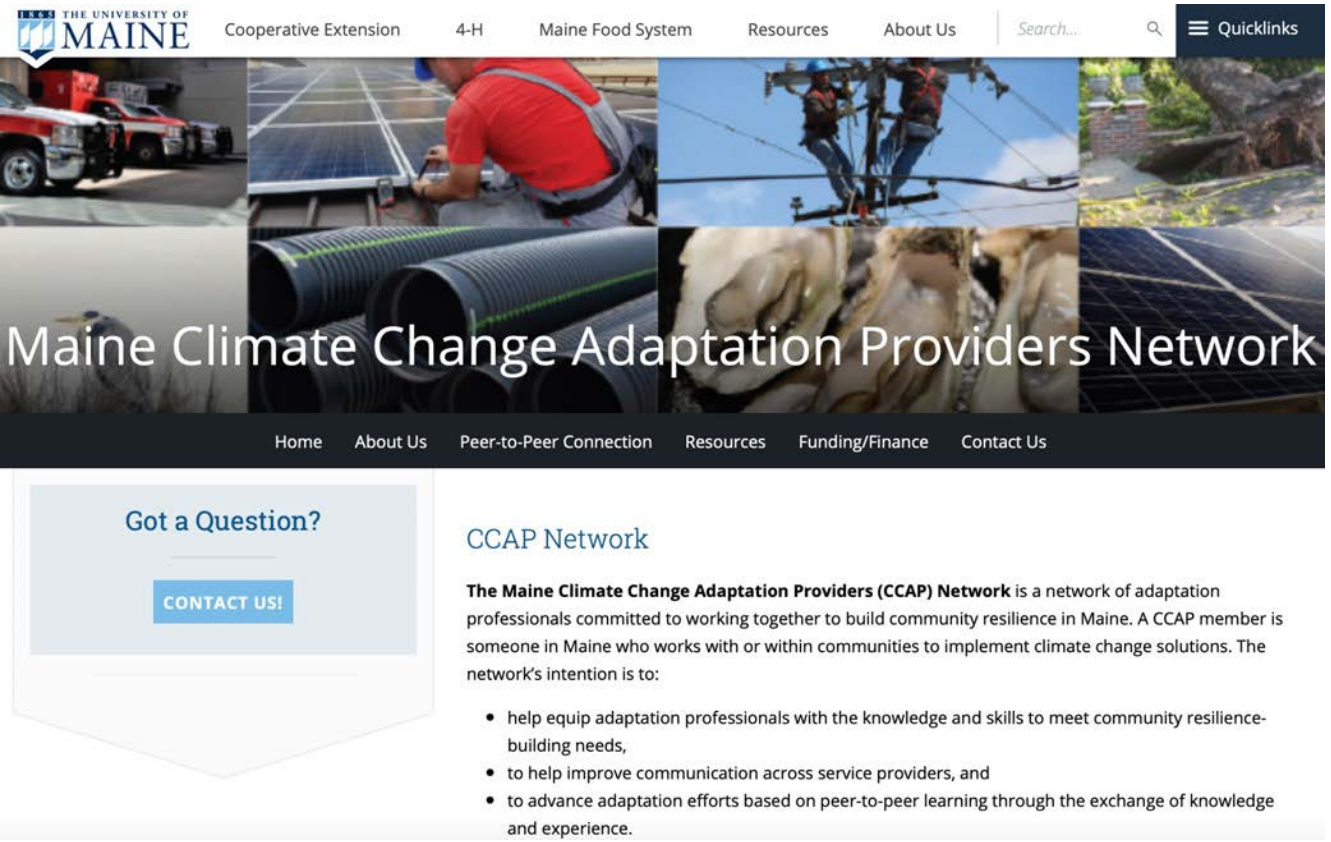
Produced by Beechwood Film

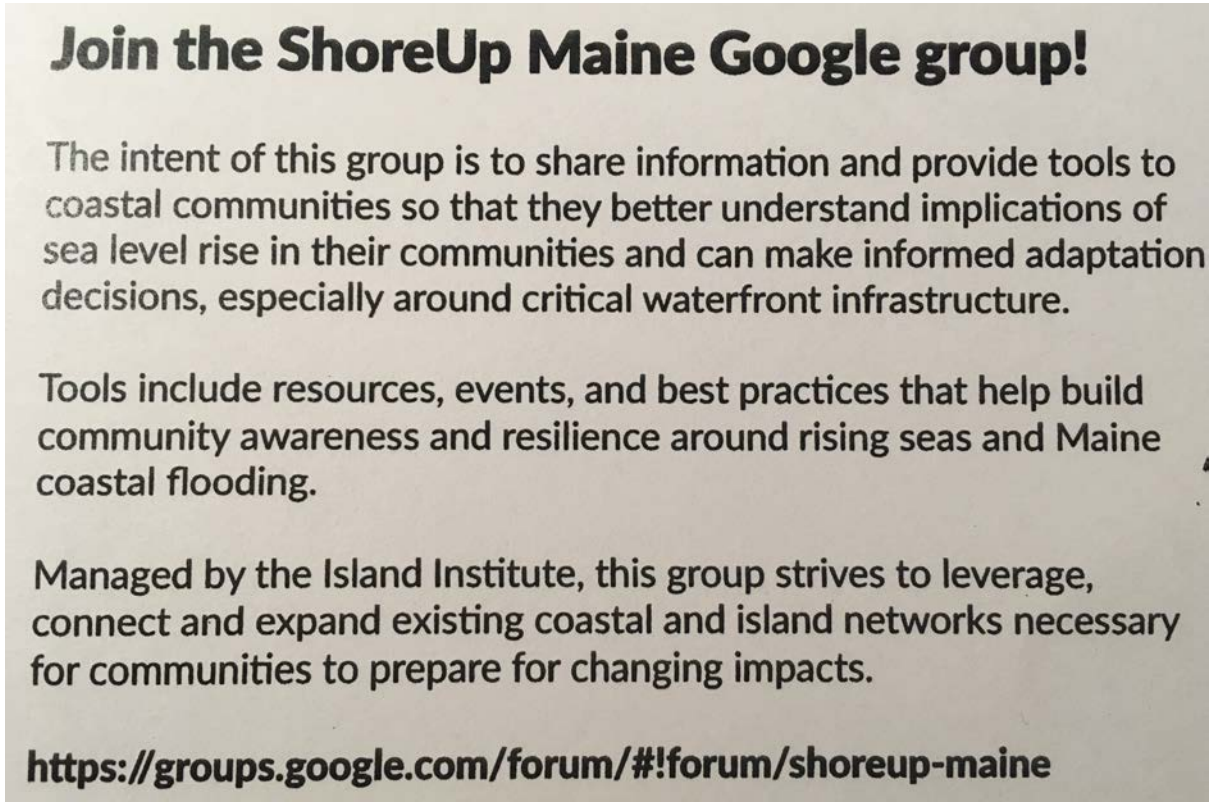
https://www.islandinstitute.org/priorities/climate-solutions/sea-level-rise/

How you can stay connected and get involved:

Follow the Maine Climate Council: climatecouncil.maine.gov

https://extension.umaine.edu/climatesolutions/who-we-are/





Report to the Joint Standing Committee on
the Environment and Natural Resources

Result of Analysis Required by 2021 Public Law, Chapter 67, Resolve, *To Analyze the Impact of Sea Level Rise*

January 2022

https://www.maine.gov/dep/publications/reports/index.html

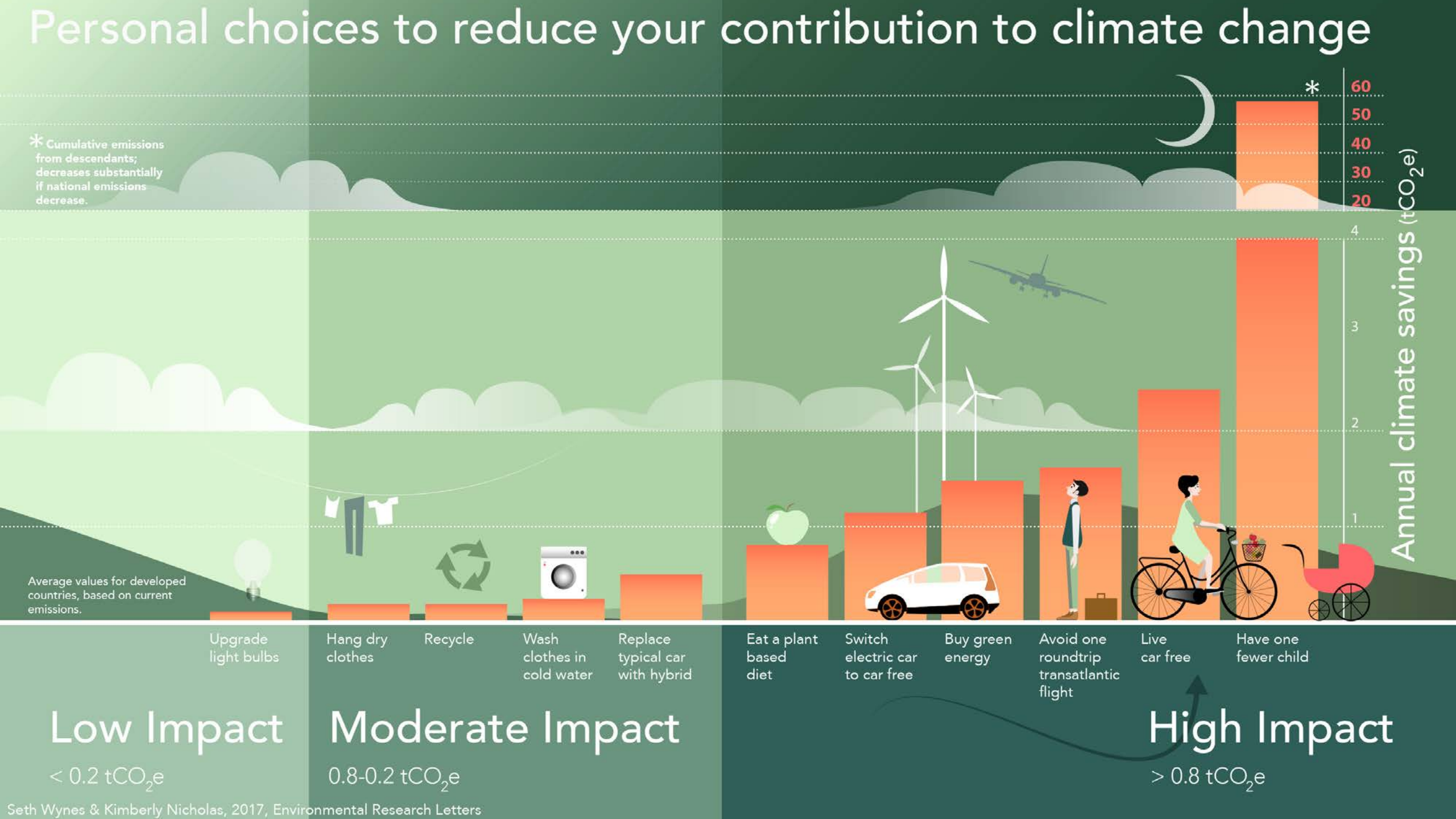
130th Maine Legislature, Second Regular Session

An Act To Implement Agency Recommendations Relating to Sea Level Rise and Climate Resilience Provided Pursuant to Resolve 2021, Chapter 67

Referred to Committee on Environment and Natural Resources **on** Feb 10, 2022.
Latest Committee Action: Voted, Mar 2, 2022, ANT. DIV. REP.
Latest Committee Report: Not Reported Out

http://www.mainelegislature.org/legis/bills/display_ps.asp?ld=1970&PID=1456&snum=130&sec3

Personal choices to reduce your contribution to climate change



Low Impact

< 0.2 tCO_2e

Moderate Impact

0.8-0.2 tCO_2e

High Impact

> 0.8 tCO_2e

Seth Wynes & Kimberly Nicholas, 2017, Environmental Research Letters

Thank you. Questions?

Susie Arnold
Marine Scientist
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