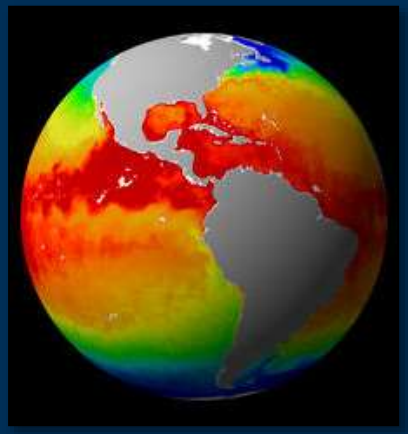
Changing climate, changing coasts: implications for the Cape and Islands

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Concepts

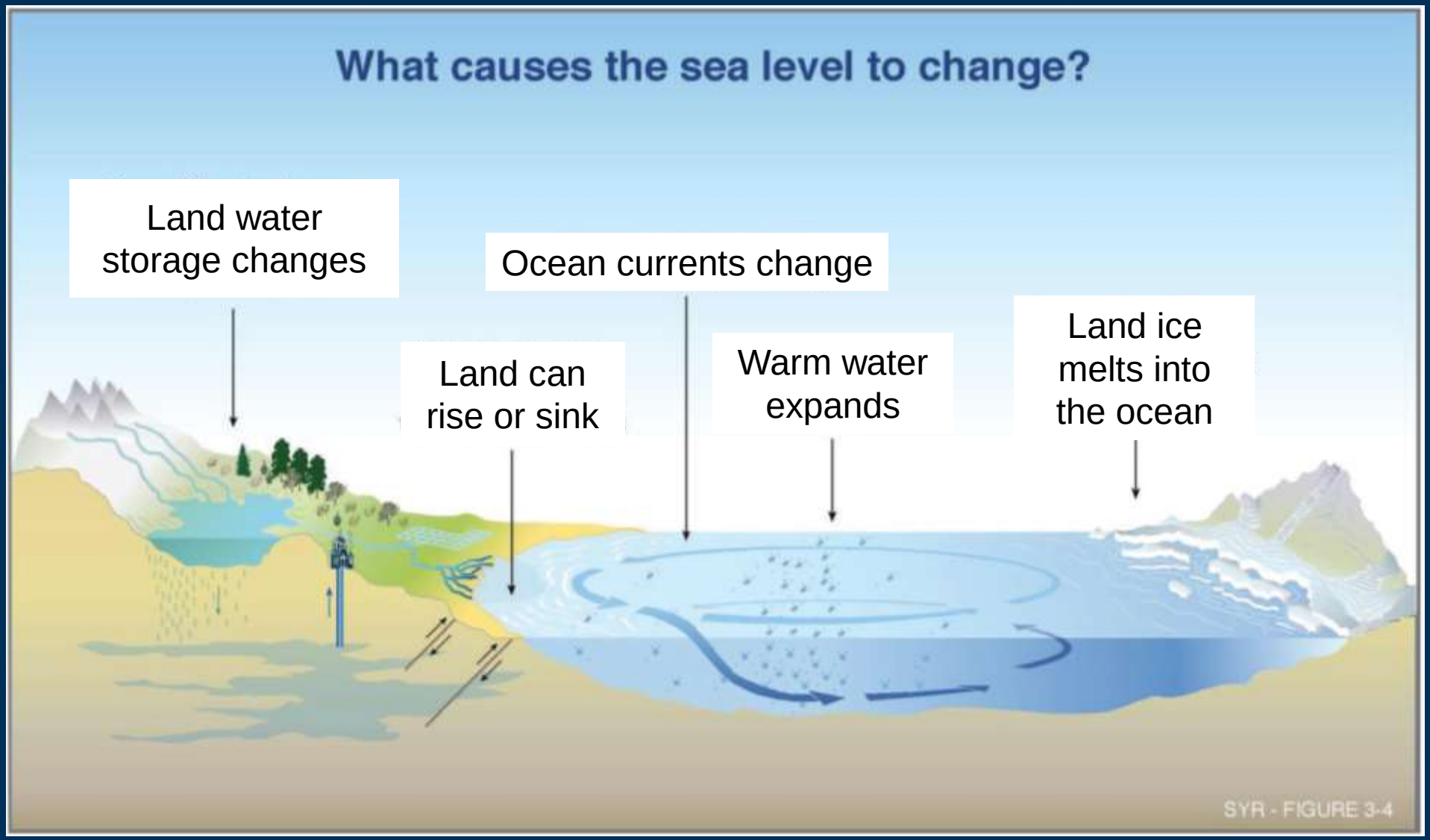
- Sea-level rise is one of the most certain impacts of climate change.
- Recent projections suggest that sea-level will rise between 1 foot and 8.2 feet by 2100.
- The coast does not flood like a bathtub. Coastal change will be much more exciting (and challenging).
- Effective adaptation to rising sea level will require changing approaches to coastal management.

We need better science* to prepare our local responses to climate change, especially in our coastal areas.
(David Carter, Delaware Coastal Management)



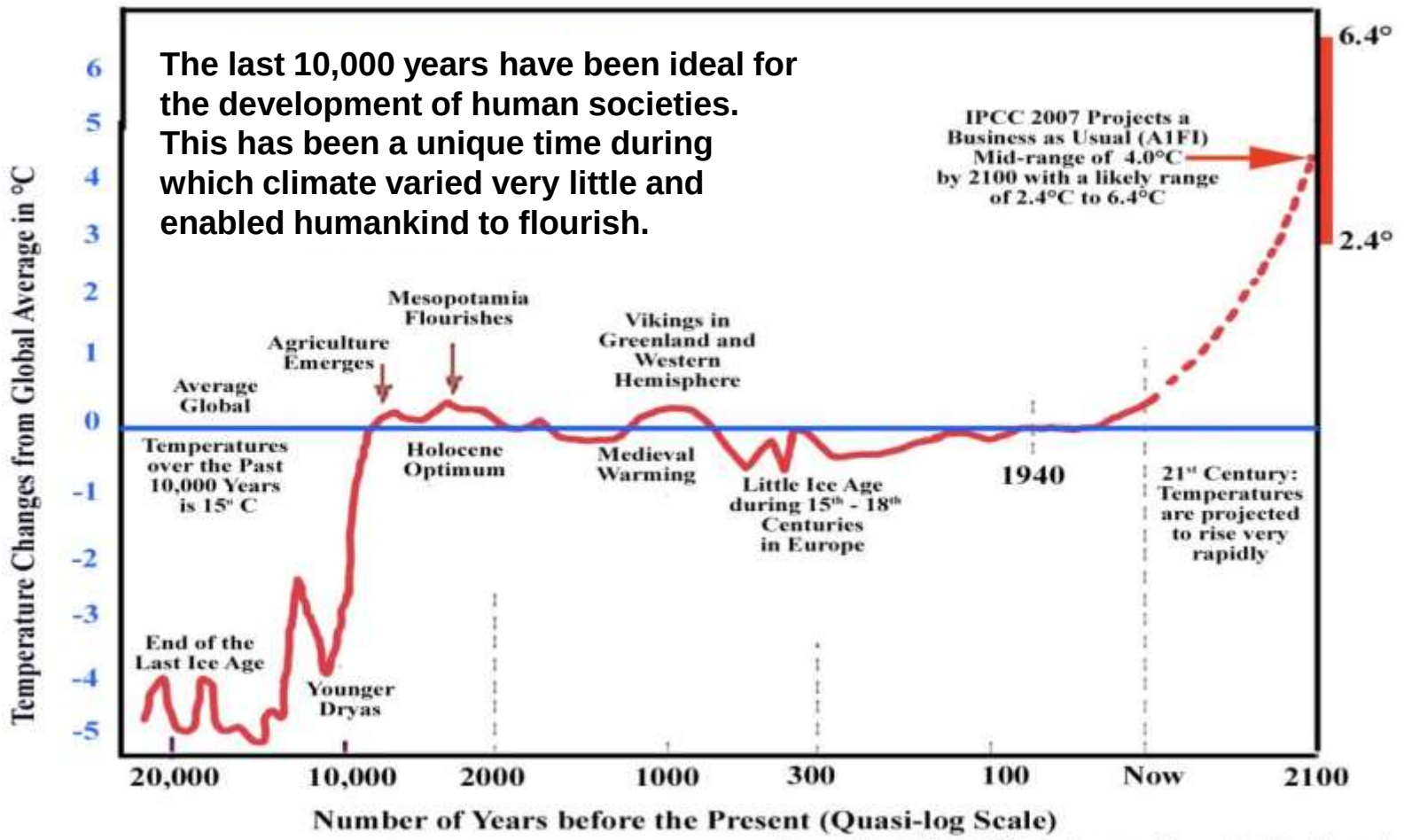


*science = better understanding of processes + better situation awareness


What causes the sea level to change?
Land water storage changes
Land can rise or sink
Ocean currents change
Warm water expands
Land ice melts into the ocean
SYR - FIGURE 3-4

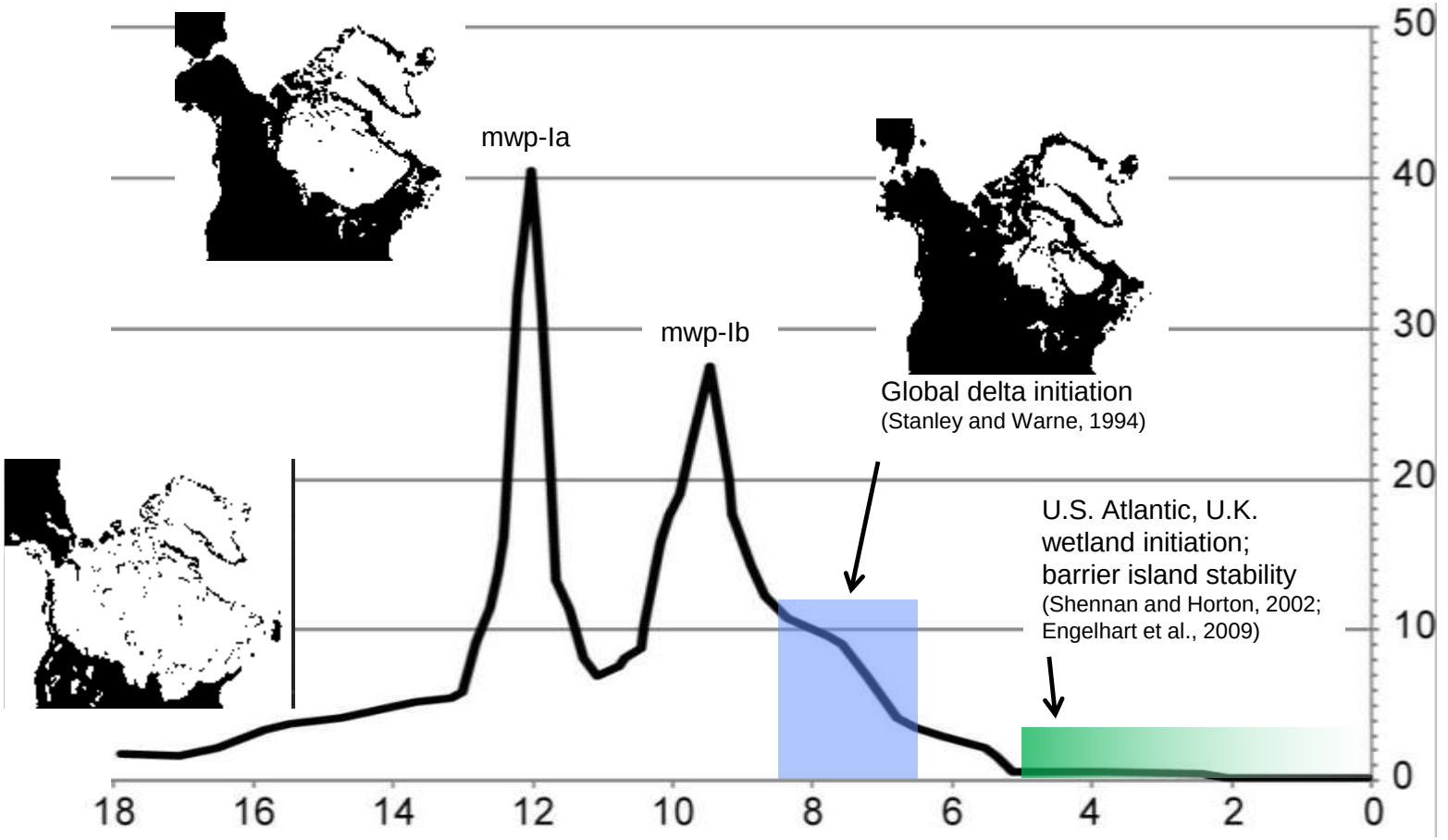
(IPCC, 2001)

Past, Current and Projected Global Temperature



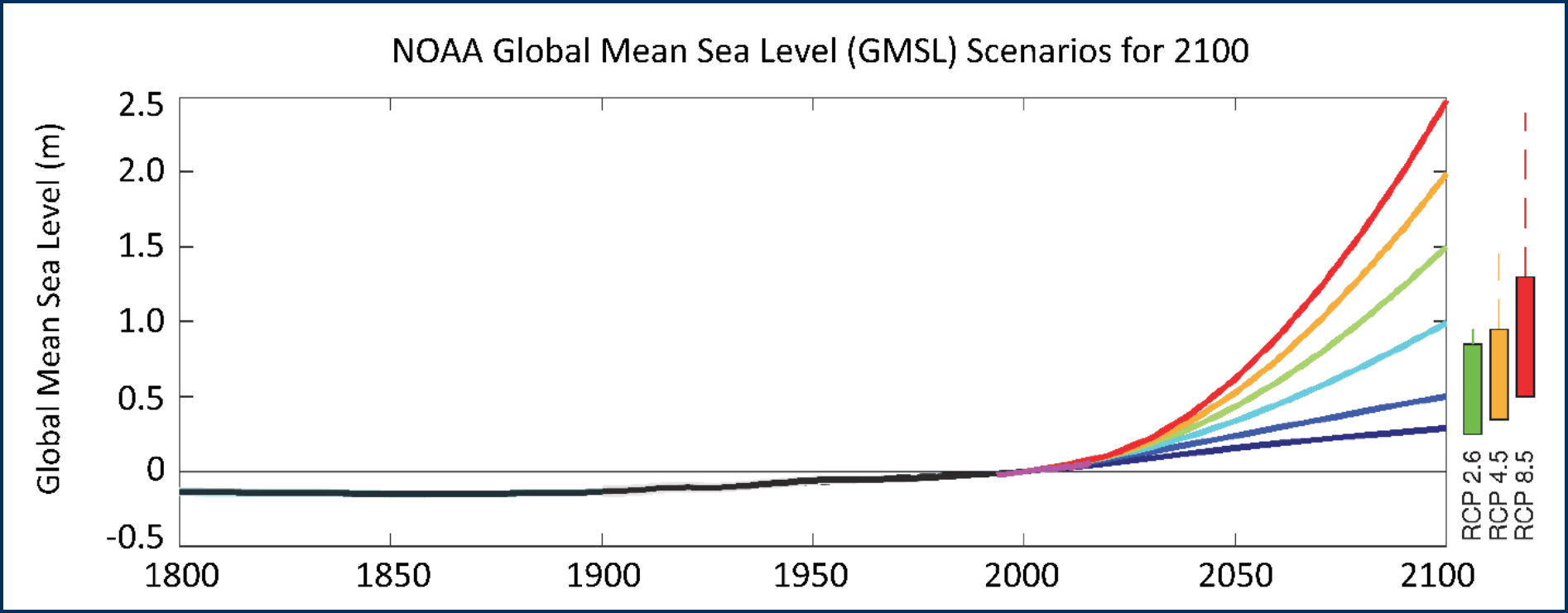
Source: Adapted from "Climate change and human health - risks and responses" published by WHO in collaboration with UNEP and WMO 2003 and more recent data from IPCC 2007.

Sea-level rise rates since the Last Glacial Maximum

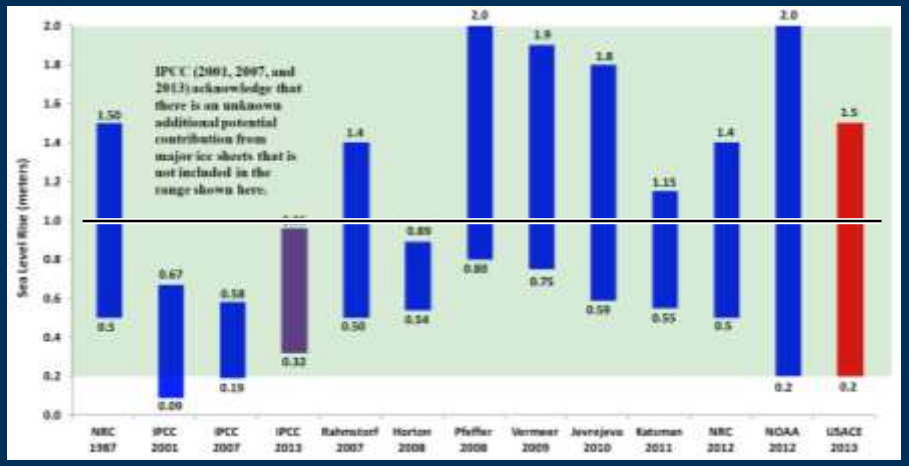


(SLR rate based on Fairbanks, 1989; ice extent from Dyke, 2004)

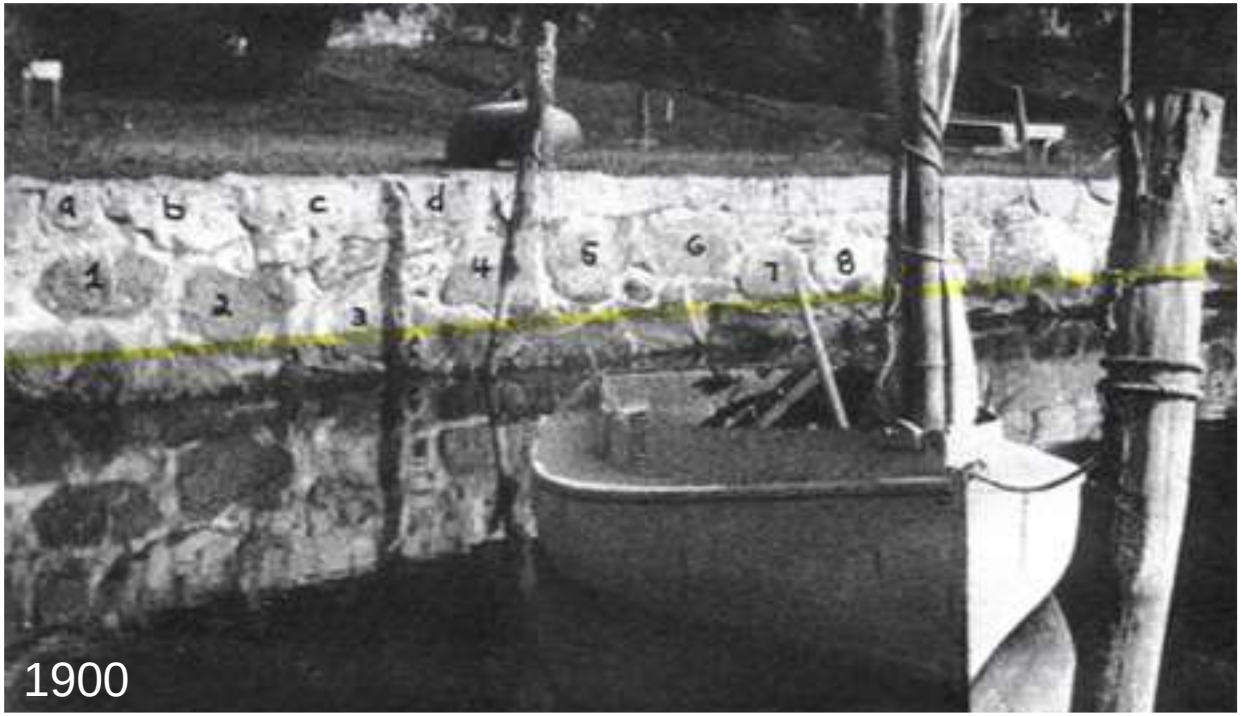
Sea-level Rise Projections



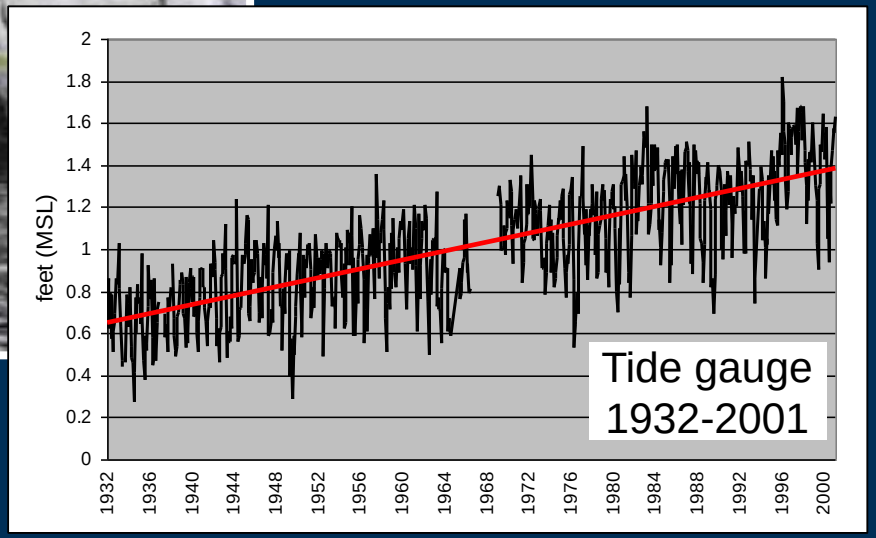
(Sweet et al., 2017)



(USACE, ETL 1100-2-1, 2014)



Sea-level rise in Woods Hole ~13” in 100 years



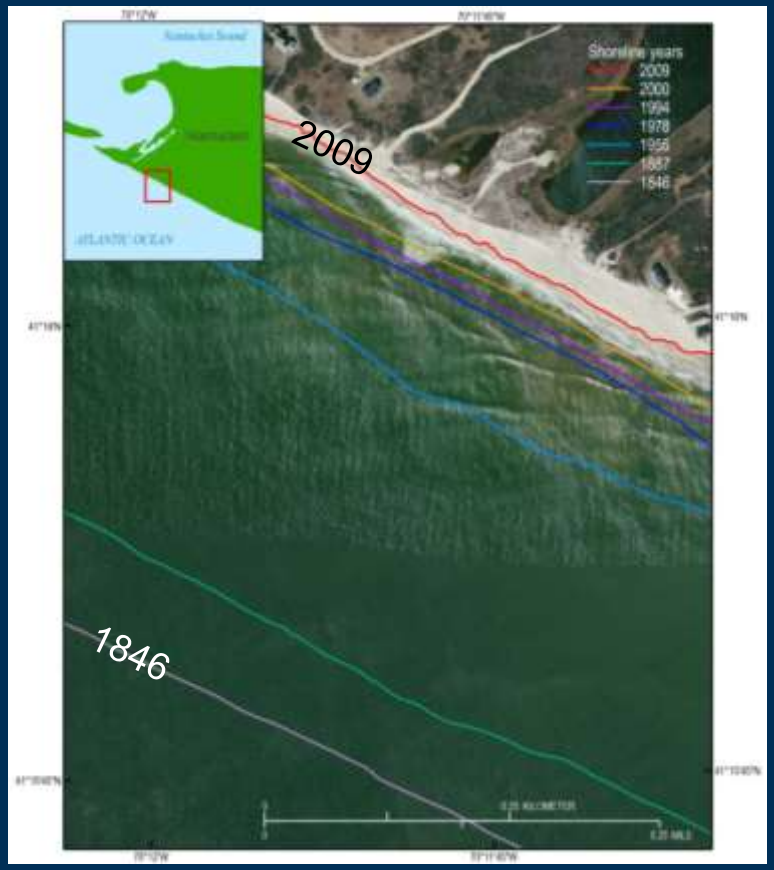
Coastal Flooding in Charleston, SC

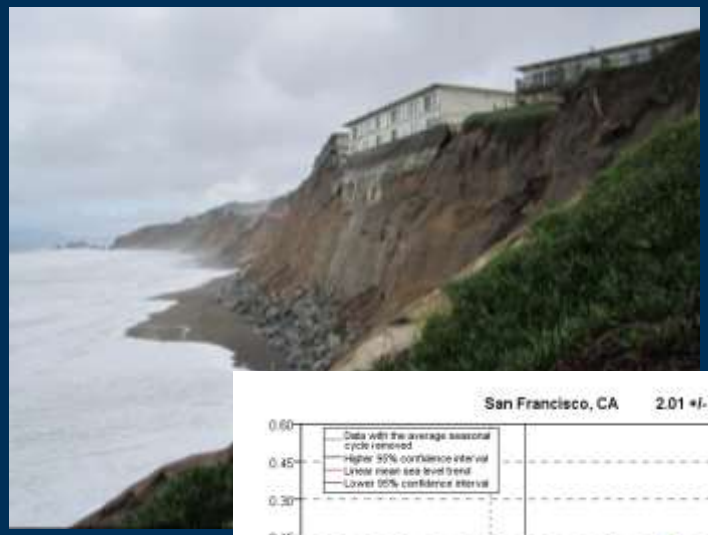
Built environment impacts

- NOAA NWS Charleston issues shallow coastal flooding advisories for 7 ft tides
- 7 ft tides typically predicted to occur twice a year
- With 1.6 ft of relative sea-level rise, this advisory could be issued 355 times

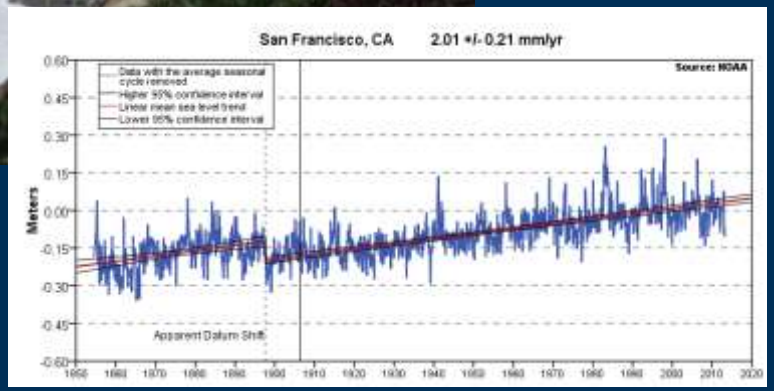
But… the coast is not like a bathtub

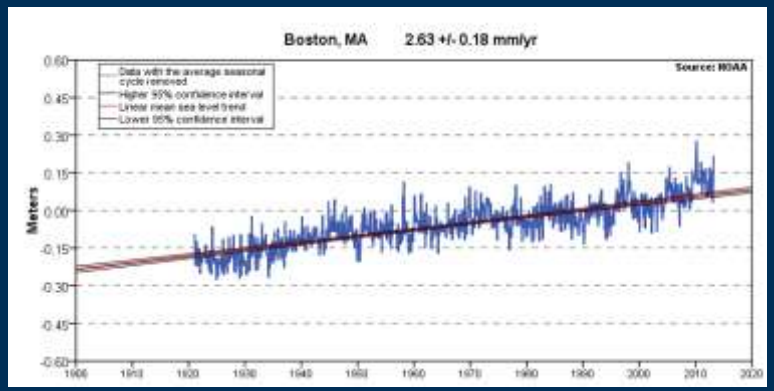
Nantucket, MA
~0.26 m SLR in 100 yr; 500 m shoreline retreat



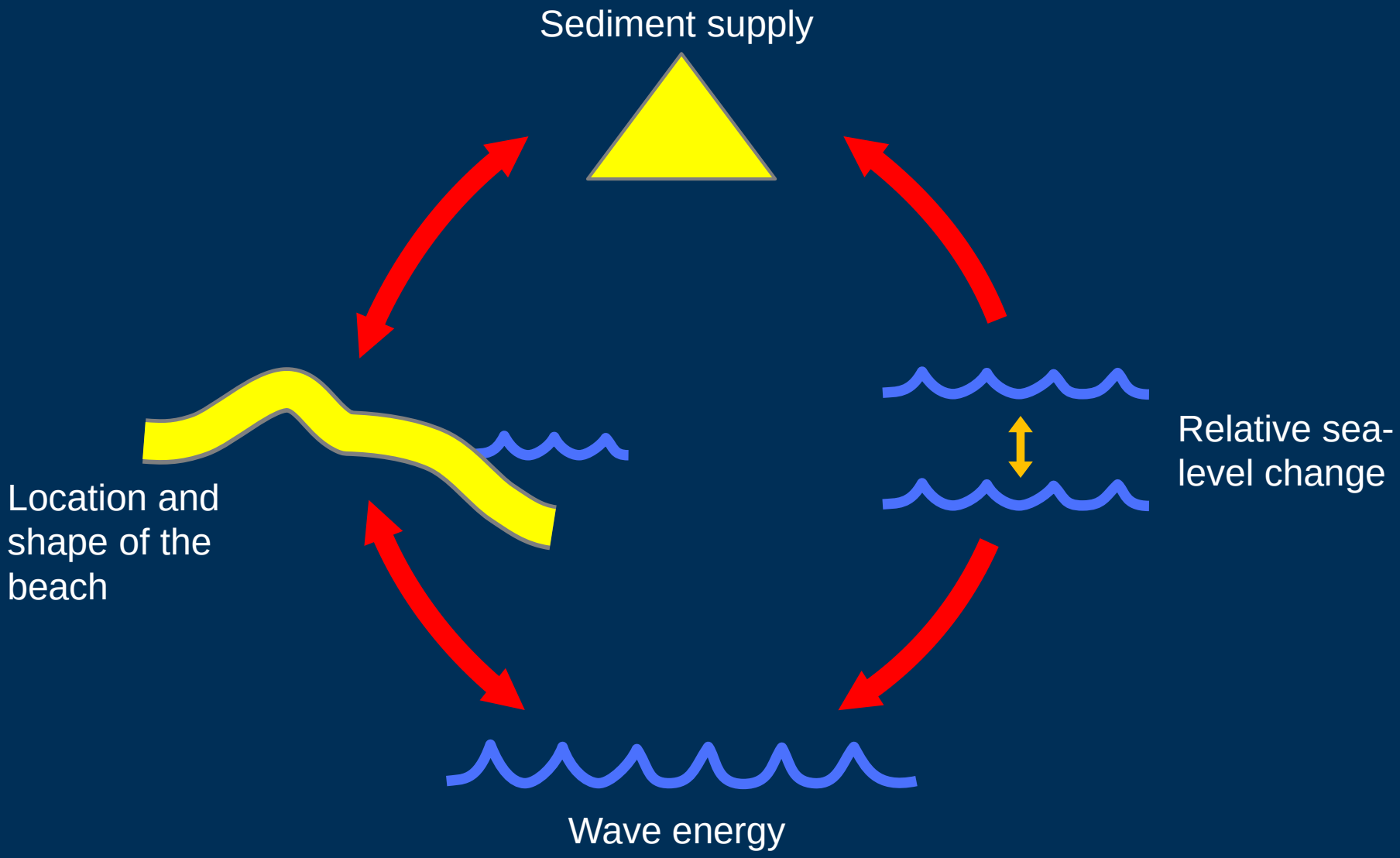


Pacifica, CA
~0.2 m SLR in 100 yr; long-term cliff erosion and retreat





Dynamic Equilibrium of Beaches



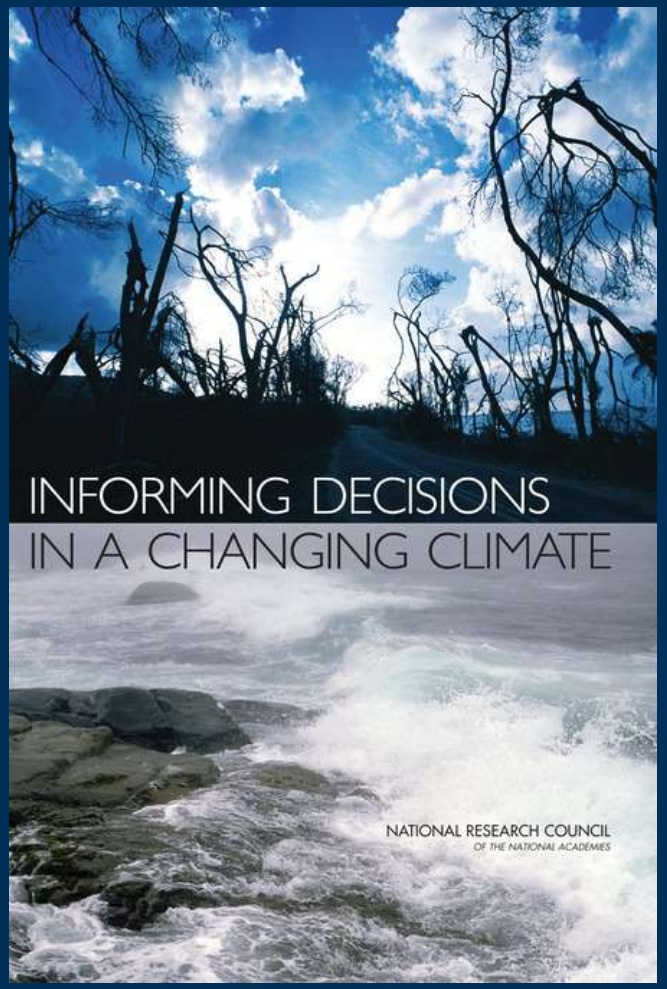
So, what can happen?

Informing Decisions in a Changing Climate

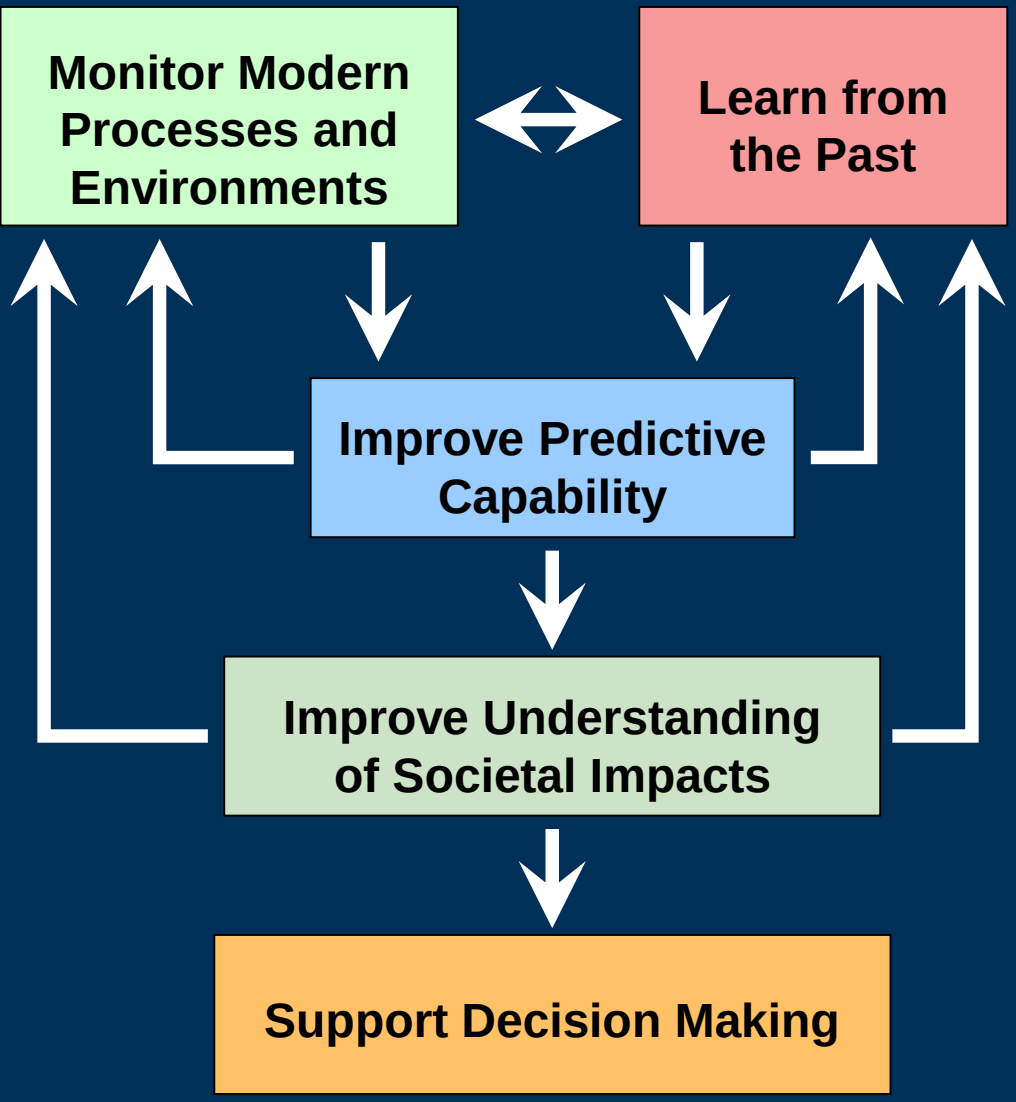
National Research Council (2009)

The end of “Climate Stationarity” requires that organizations and individuals alter their standard practices and decision routines to take climate change into account.

- Decision makers must expect to be surprised.
- An uncertainty management framework should be used.



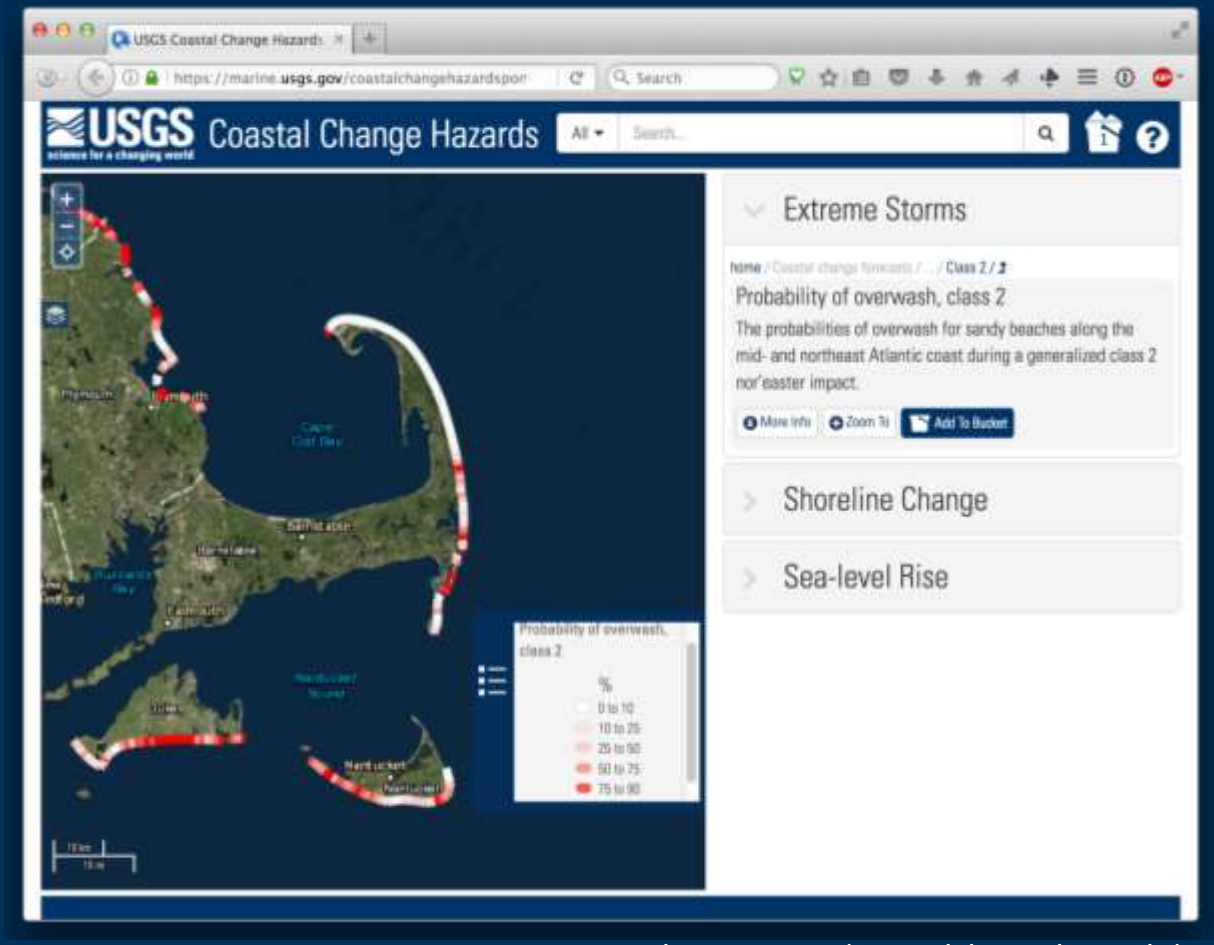
Science strategy to address the challenge of climate change and sea-level rise



(Thieler et al., 2009)

Storm and coastal impact forecasting

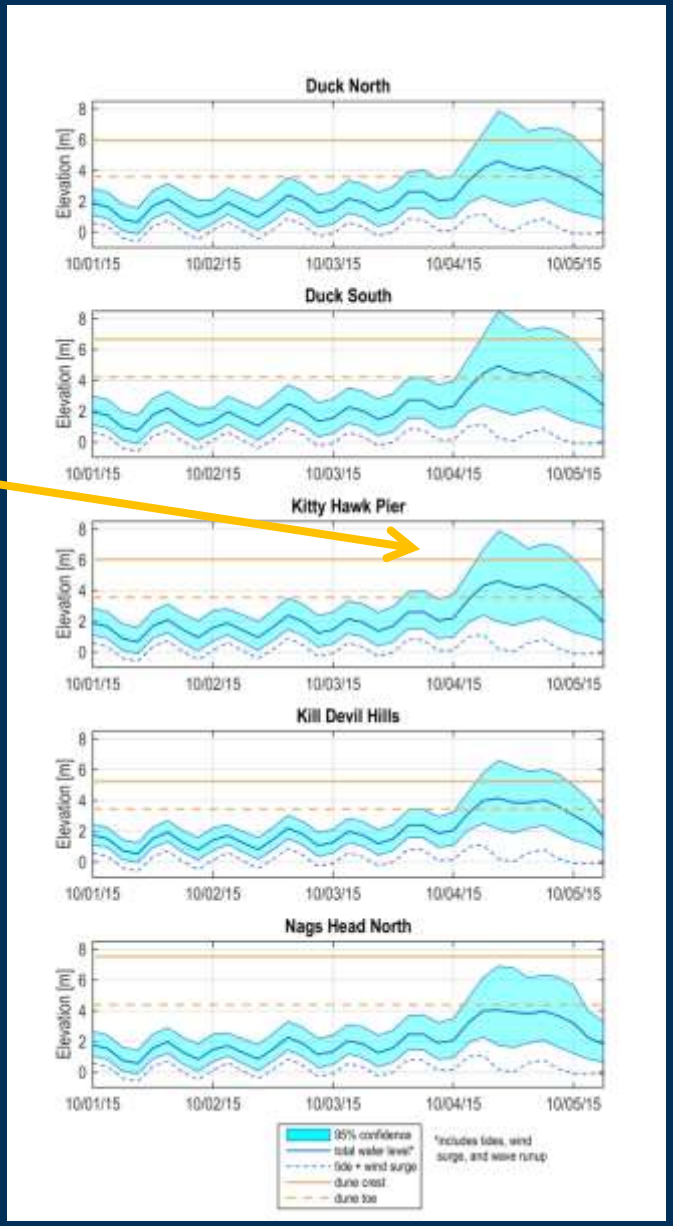
NOAA / NWS / TPC



marine.usgs.gov/coastalchangehazards/

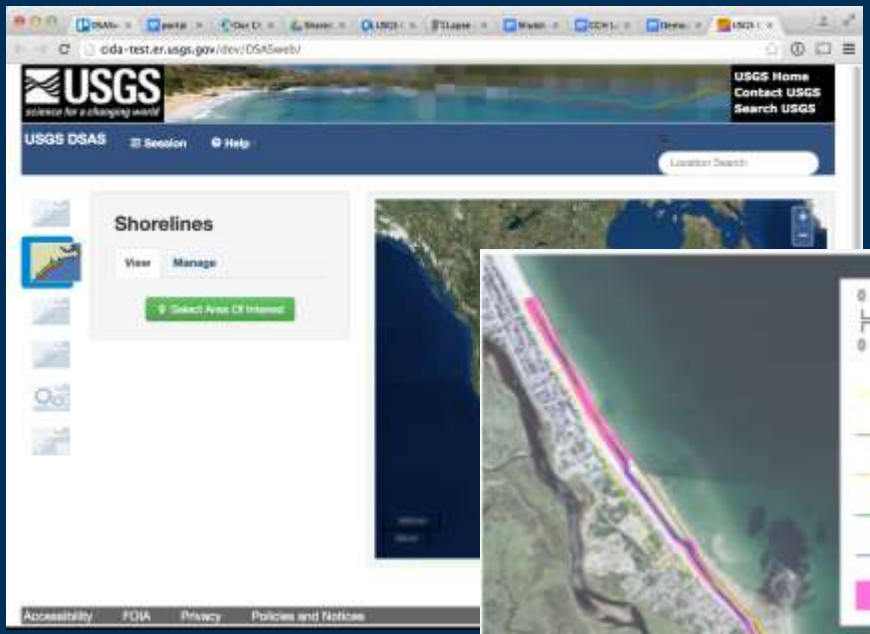
Storm impact forecasting (Hurricane Joaquin, 2015)

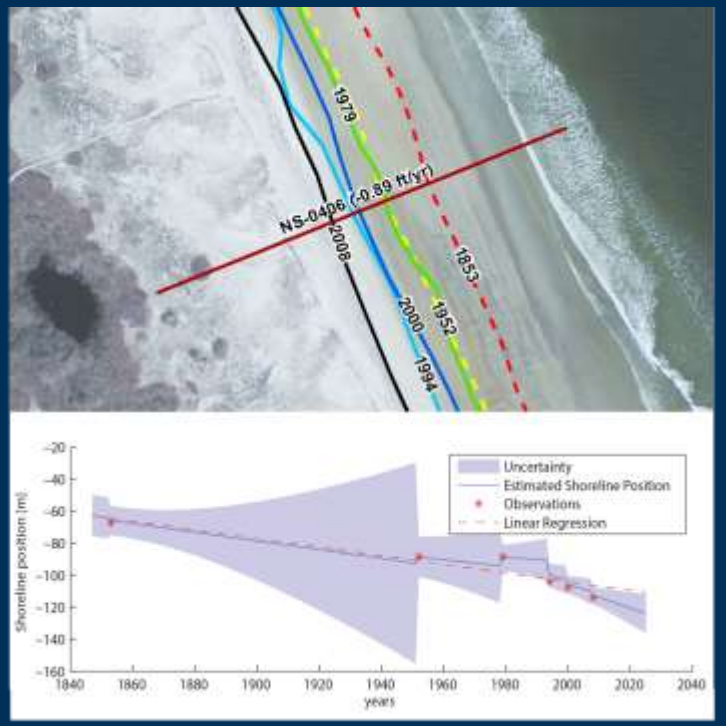
Photo credit: Dare County Emergency Management



Operational forecasts of total water levels can warn local officials of potential overwash, such as that observed along Hwy 12 in Kitty Hawk, NC.
(USGS collaboration with NOAA, NWS)

Decadal-scale shoreline change forecasting



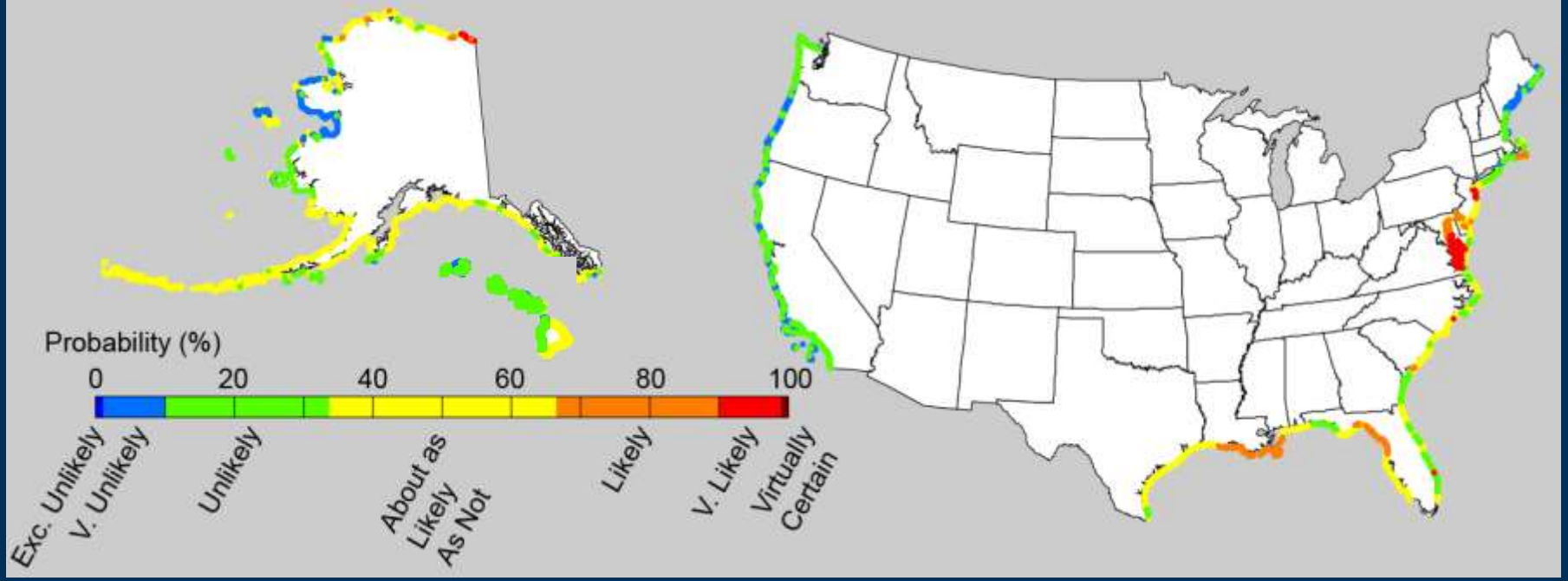


(Massachusetts Coastal Erosion Commission, 2015)

Forecasting sea-level rise impacts

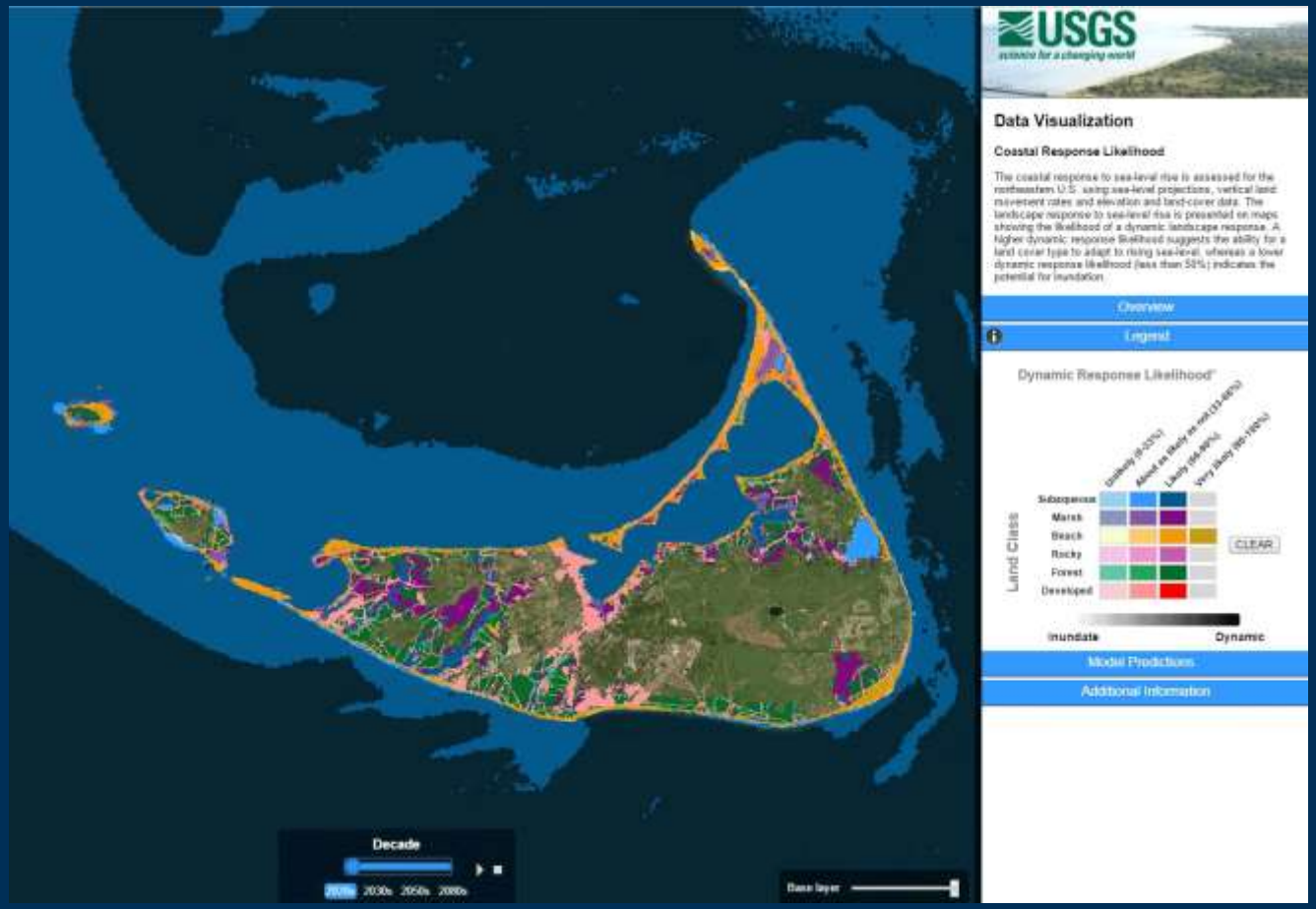
- Bayesian Network uses climate forcing and geologic constraints
- Prediction and uncertainty maps identify where better information is needed (input data, process understanding)
- Provides scientific knowledge context for decision makers
- Can use to focus research resources

Probability of coastal erosion >1 m/yr



(Gutierrez et al., 2011; USGCRP, 2014)

Modeling coastal response to sea-level rise



(Lentz et al., 2015; 2016)

Flooding potential in New York City (as an example…)

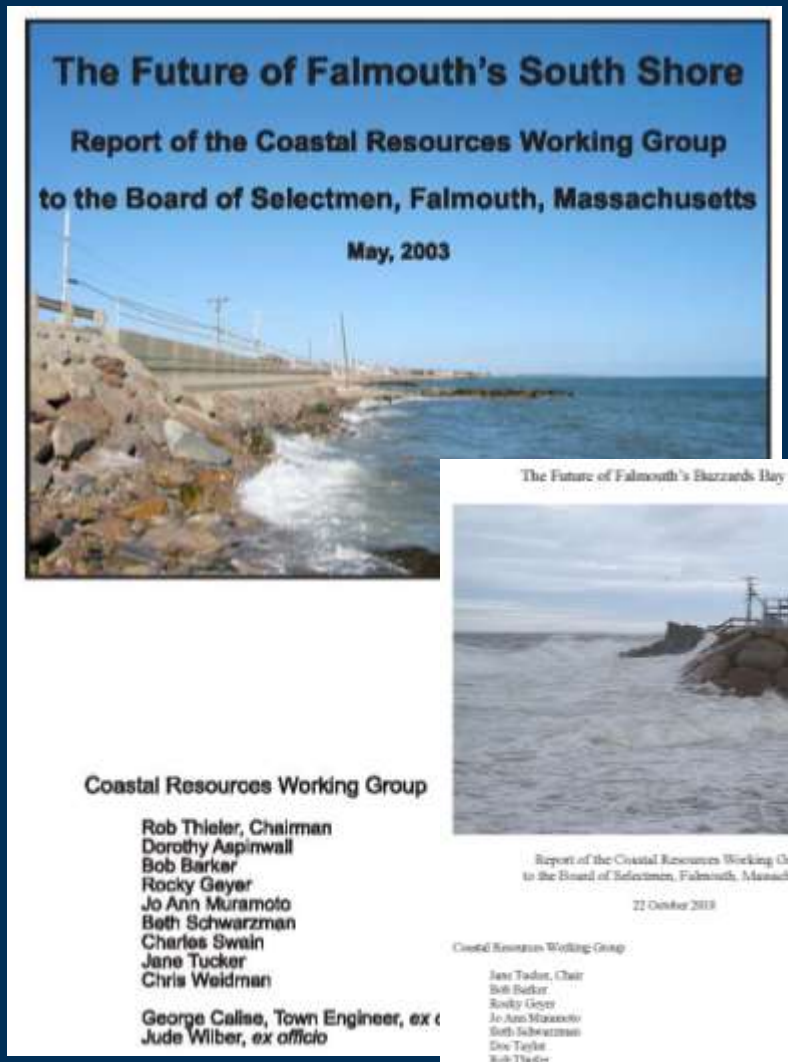
	1-in-10 Year Events				1-in-100 Year Events			
	No SLR	RCP2.6	RCP4.5	RCP8.5	No SLR	RCP2.6	RCP4.5	RCP8.5
2001-2030	3	4.8	4.7	4.9	0.3	0.4	0.4	0.4
2001-2050	5	11.8	11.8	12.7	0.5	0.9	0.9	0.9
2001-2100	10	50	53	56	1	4	6	9

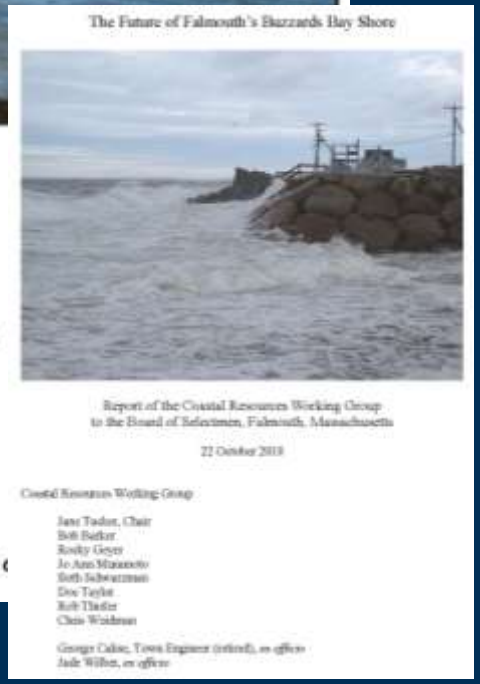
(Kopp et al., 2014)

Some things to consider…

- Options that maintain future flexibility
  - Magnitude and timing of future climate change and our responses to it are uncertain
- Holistic examination of potential impacts
  - Geologic, biologic, economic, social...
  - Expectations of your coastal zone (resources, tourism, aesthetics, navigation, etc.)
- Time horizon
  - How long should something last? Until you have a better plan to address the problem? The next big storm? Two feet of sea-level rise? Forever?
- Risk tolerance
  - Scale with size, value, time
  - Implications of failure, or over-planning/building
- Protocols for what happens after large events
  - Because there will be a "next time"

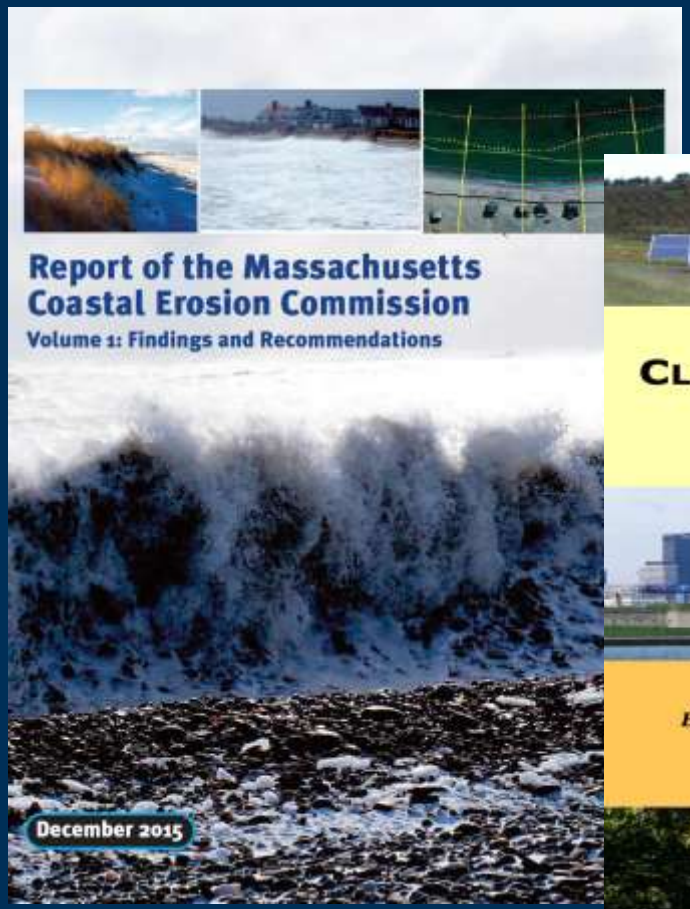
What's a community to do?

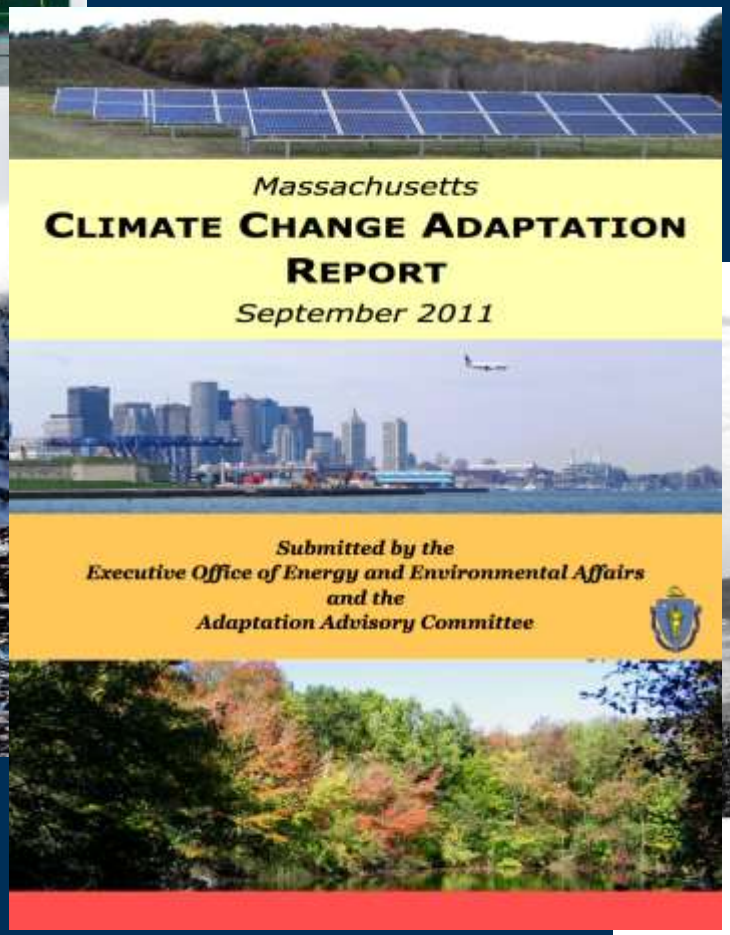




State resources are abundant and actionable

Here are just a few…





Summary

- The coast as we know it today is a product of sea-level rise; coastal erosion is an expected response
- Future sea-level rise is a **certain** impact
  - We have already made a commitment to several centuries of rise
- Future sea-level rise is an **uncertain** impact
  - Rates and magnitudes poorly constrained
  - Societal response unknown
- Major changes are occurring on the coast, as a result of human activity and changing climate
- Informed preparation is important
- Being uncertain is OK