Sea Level Rise in California Policy in Practice

CMANC Annual Winter Meeting

January 17, 2020

Presenter: Aaron Holloway, PE

aholloway@moffattnichol.com

moffatt & nichol

State Sea Level Rise Guidance Documents

Long-term Planning Documents

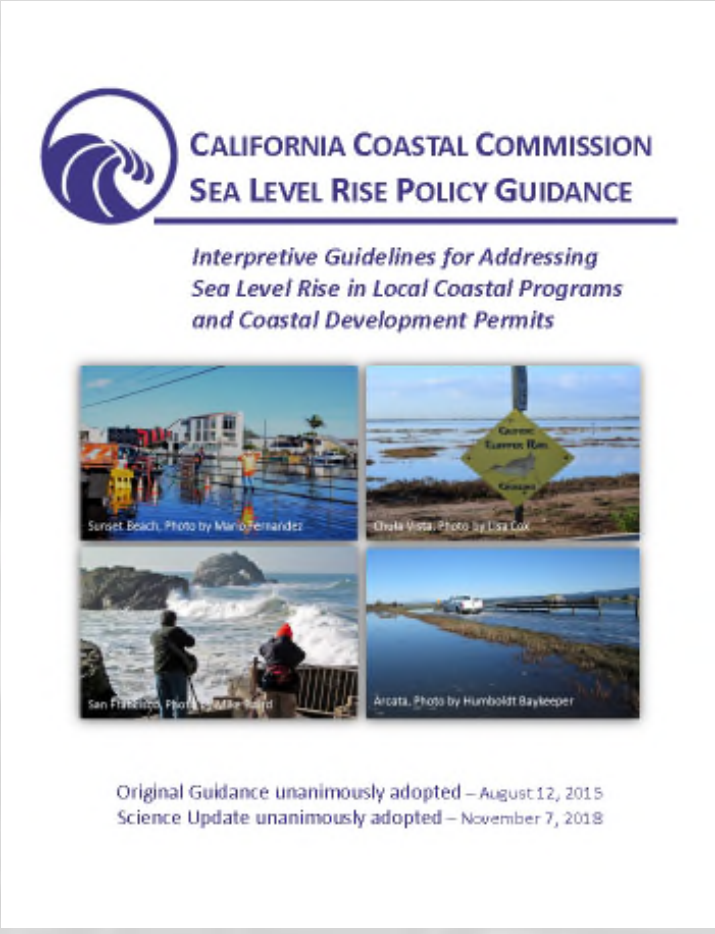
- Port Master Plan
- General Plan
- Local Coastal Program

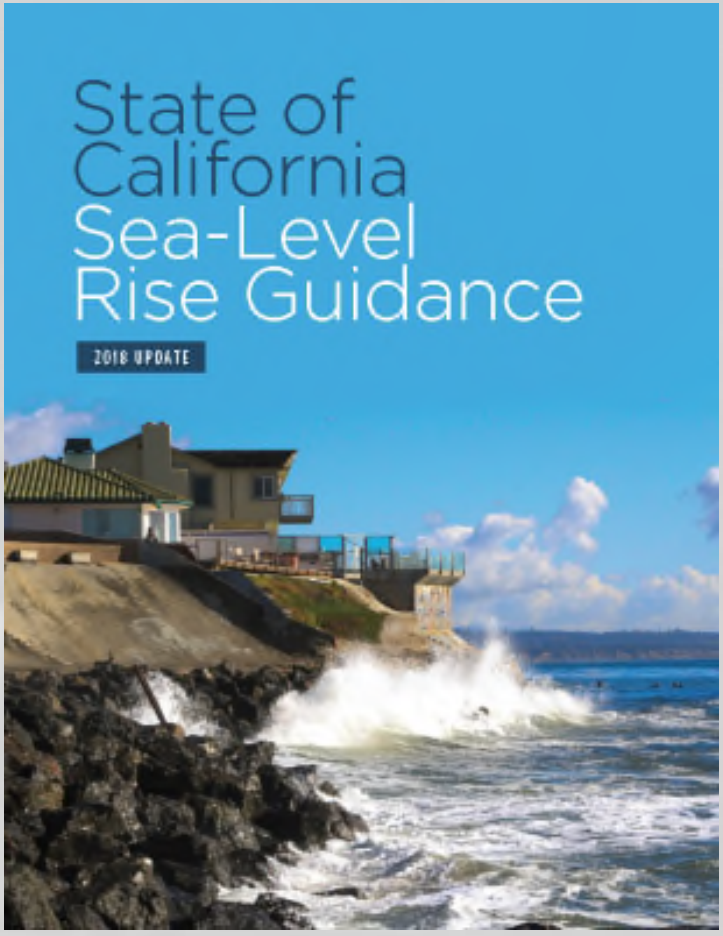
Assembly Bill 691

- Tidelands SLR assessment

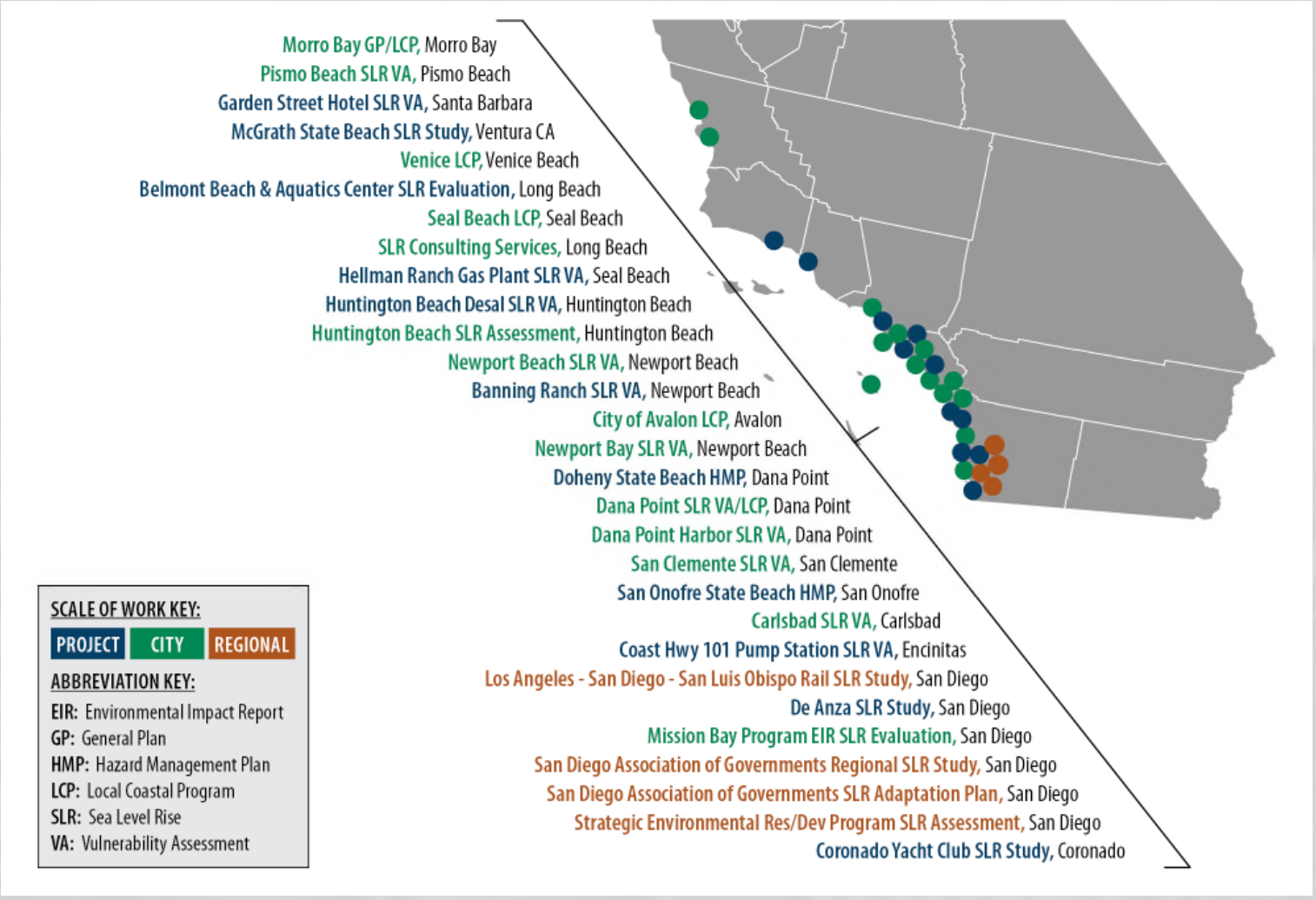
Coastal zone projects

- Coastal Development Permit





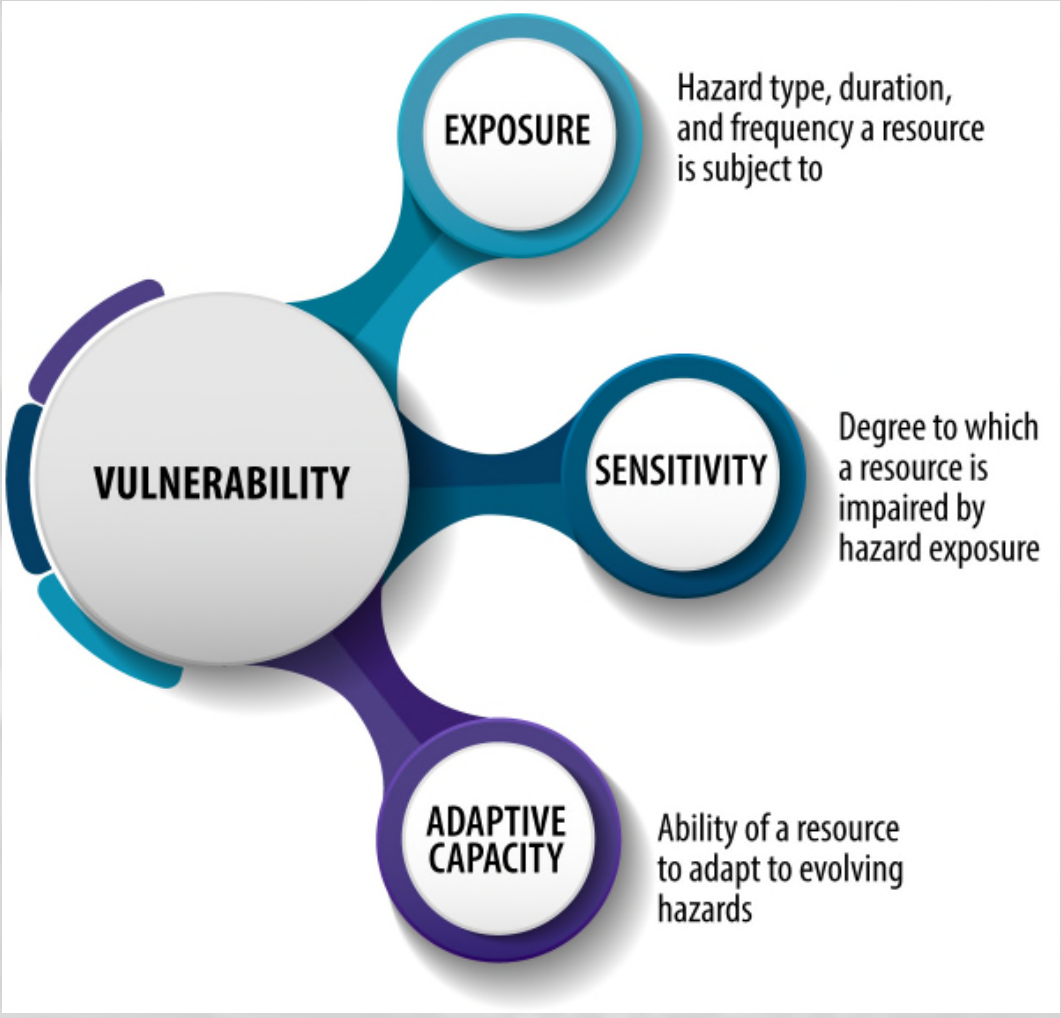
Recent SLR experience in Southern California



Sea Level Rise Vulnerability Assessment (Step 1)

Key objectives:

- Identify hazards of concern (storm and non-storm)
- Identify thresholds or tipping points where SLR becomes an issue
- Evaluate risk based on probability of these thresholds
- Prioritize adaptation strategies according to risk and timing



Adaptation Strategies (Step 2)

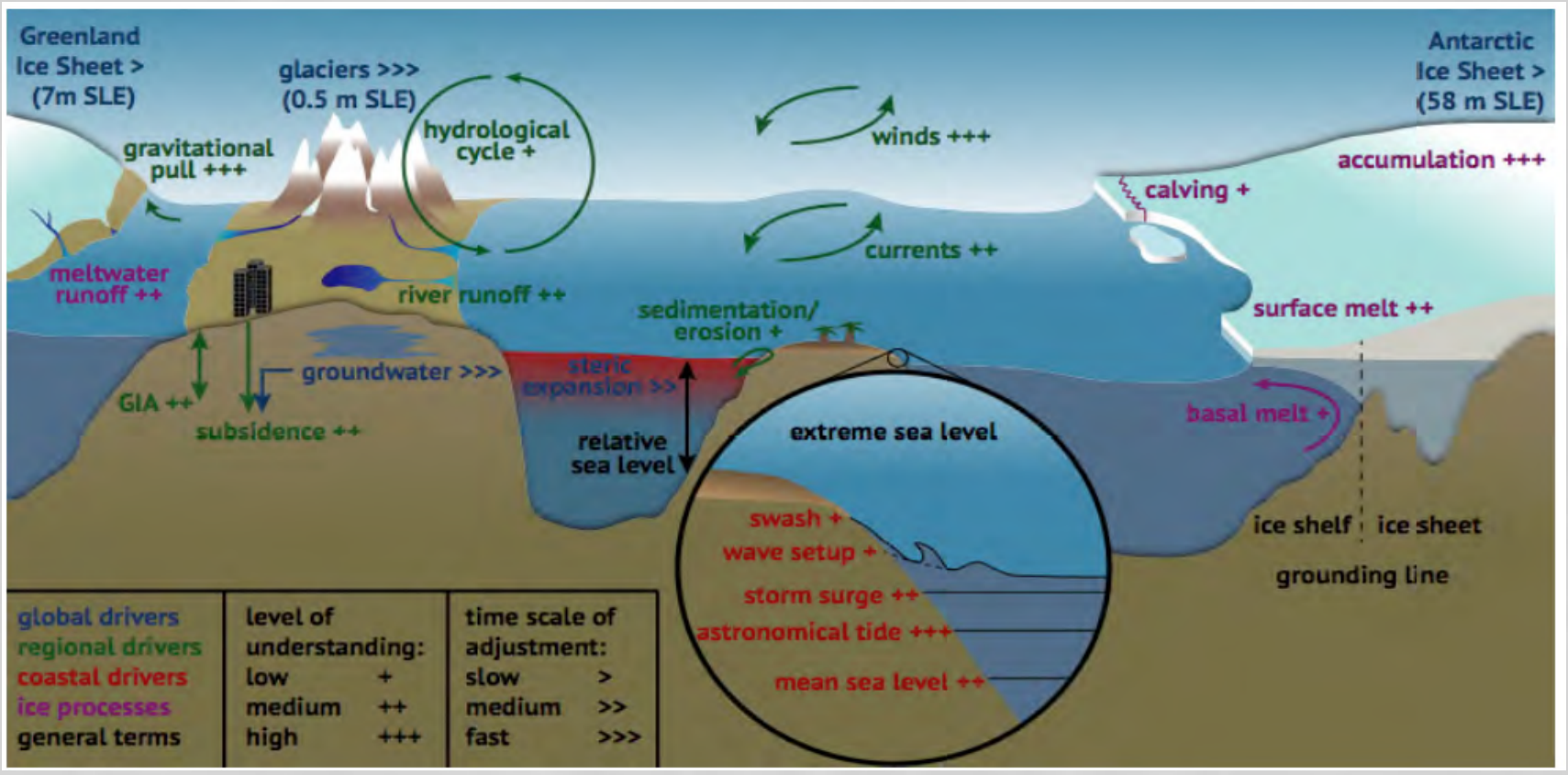
Project Level

- What to do now or in the future?
- Guided by cost-benefit analysis and permitting process
- Design measures to build in adaptive capacity
- Adaptation plan to describe potential responses to future hazards

Planning Level

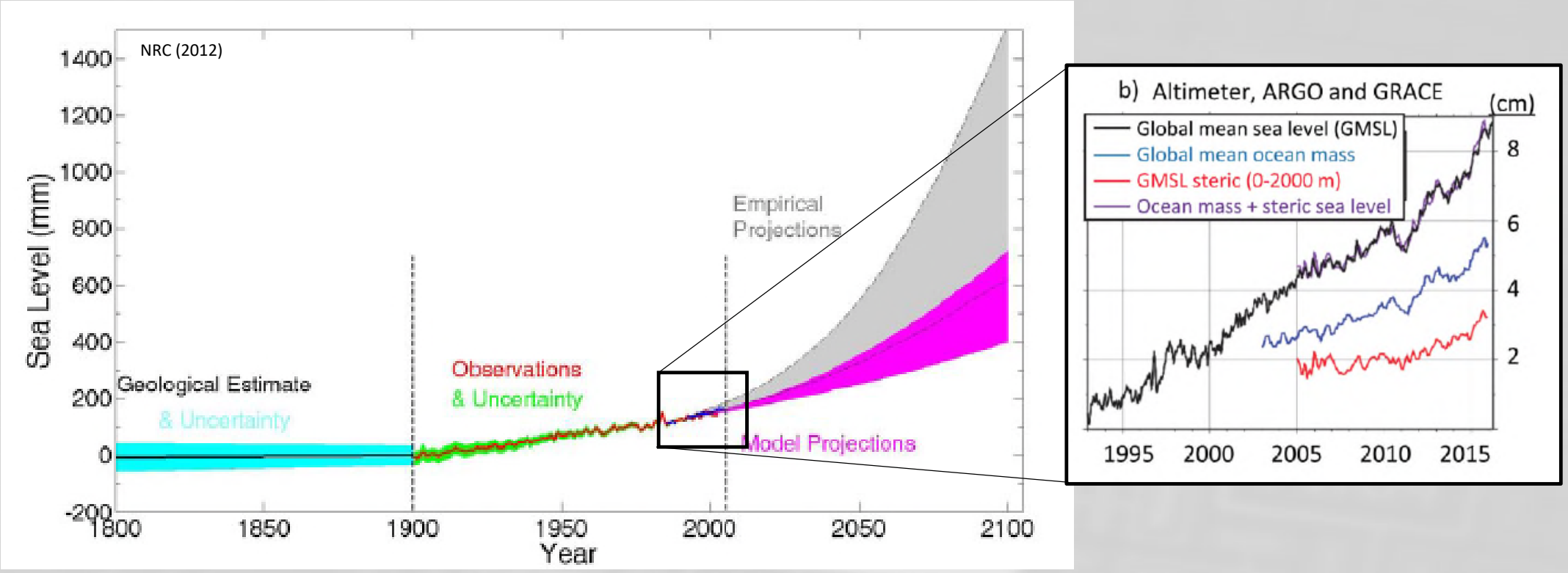
- Community outreach
- Land use designations
- Policies for existing & new development
- Trigger based adaptation strategies
- Monitoring

Sea Level Rise – Overview of regional and global factors



Global and regional factors contributing to sea level rise (IPCC, 2019)

Historic Sea Level Rise



Global trends from IPCC (2019):

1901 – 1990	1.4 mm/yr	4.8” total SLR
1993 – 2015	3.2 mm/yr	2.8” total SLR
2006 – 2015	3.6 mm/yr	1.3” total SLR

Local trends from NOAA (2019):

Port San Luis	~1 mm/yr	1945 - 2018
Los Angeles	~1 mm/yr	1923 - 2018
San Diego	~2.2 mm/yr	1906 - 2018

2018 OPC Guidance – SLR projections for California

Important concepts:

- Probability of occurrence
- Design life/planning horizon
- Risk tolerance

"Recommended" risk aversion categories:

- Low (17% probability)
- Med-high (0.5% probability)
- Extreme (H++ scenario)

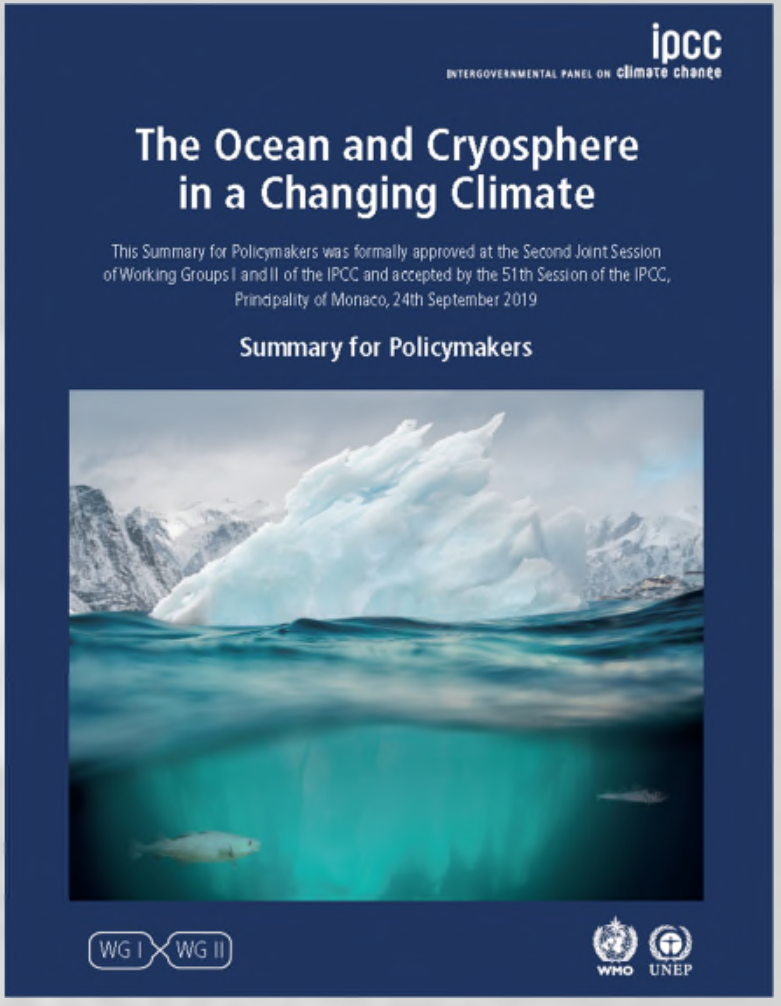
Why is "medium – high" a single category?

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...	5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
			Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.3	0.2 - 0.5	0.6	0.7	1.0
	2040	0.5	0.4 - 0.7	0.9	1.2	1.7
	2050	0.7	0.5 - 1.0	1.2	1.8	2.6
Low emissions	2060	0.8	0.5 - 1.1	1.4	2.2	
High emissions	2060	1.0	0.7 - 1.3	1.7	2.5	3.7
Low emissions	2070	0.9	0.6 - 1.3	1.8	2.9	
High emissions	2070	1.2	0.8 - 1.7	2.2	3.3	5.0
Low emissions	2080	1.0	0.6 - 1.6	2.1	3.6	
High emissions	2080	1.5	1.0 - 2.2	2.8	4.3	6.4
Low emissions	2090	1.2	0.7 - 1.8	2.5	4.5	
High emissions	2090	1.8	1.2 - 2.7	3.4	5.3	8.0
Low emissions	2100	1.3	0.7 - 2.1	3.0	5.4	
High emissions	2100	2.2	1.3 - 3.2	4.1	6.7	9.9
Low emissions	2110*	1.4	0.9 - 2.2	3.1	6.0	
High emissions	2110*	2.3	1.6 - 3.3	4.3	7.1	11.5
Low emissions	2120	1.5	0.9 - 2.5	3.6	7.1	
High emissions	2120	2.7	1.8 - 3.8	5.0	8.3	13.8
Low emissions	2130	1.7	0.9 - 2.8	4.0	8.1	
High emissions	2130	3.0	2.0 - 4.3	5.7	9.7	16.1
Low emissions	2140	1.8	0.9 - 3.0	4.5	9.2	
High emissions	2140	3.3	2.2 - 4.9	6.5	11.1	18.7
Low emissions	2150	1.9	0.9 - 3.3	5.1	10.6	
High emissions	2150	3.7	2.4 - 5.4	7.3	12.7	21.5

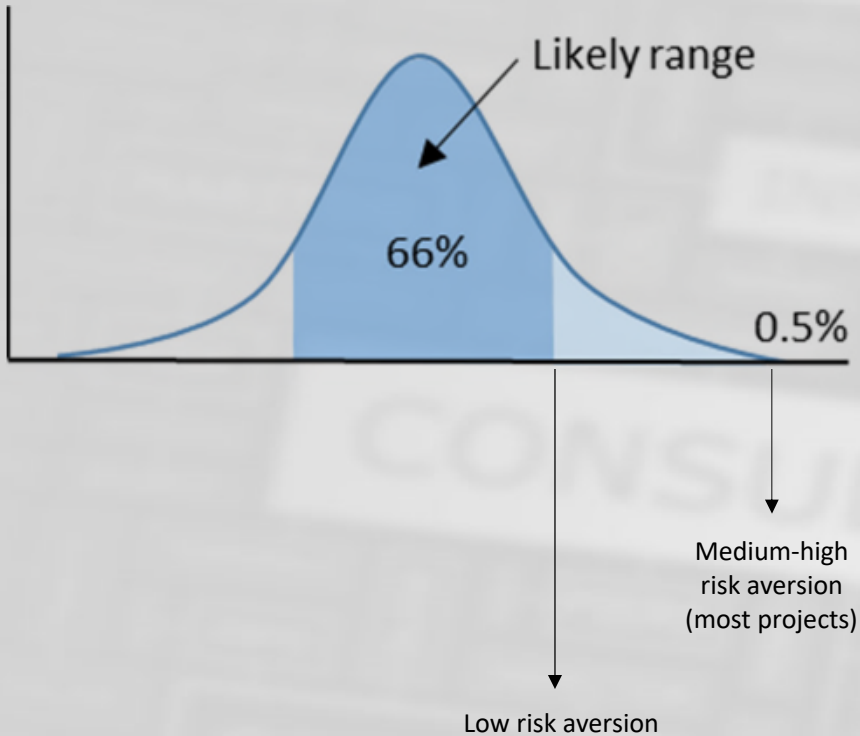
Oceans & Cryosphere in a Changing Climate (IPCC, 2019)

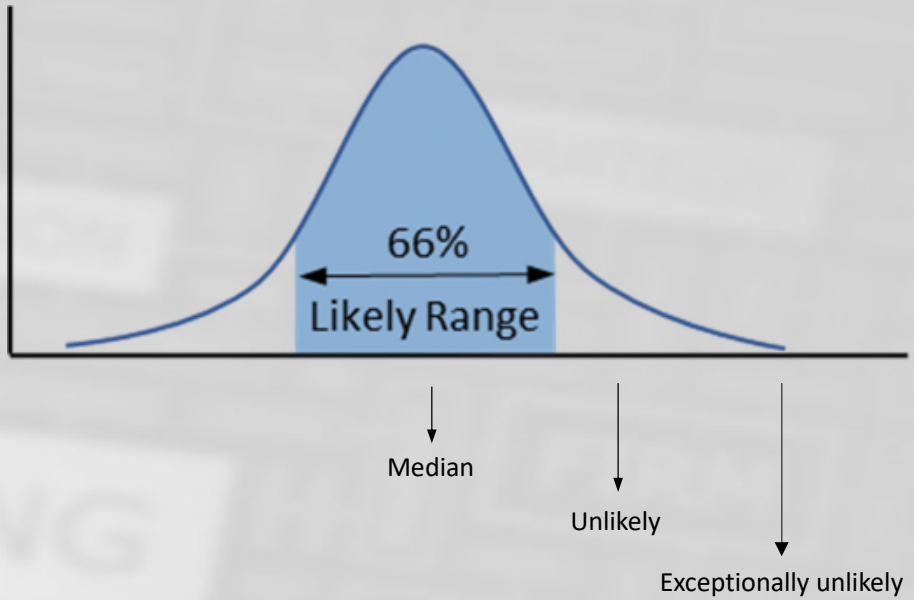
- Updated global SLR projections
- Likely range of SLR similar to OPC, revised upward since previous IPCC report (AR5)
- H++ scenario excluded from projections
  - DeConto & Pollard (2016) assumption related to MICI "remains unproven and characterized by deep uncertainty"
  - Deep uncertainty: Limited knowledge of processes & lack of agreement in scientific community
- Probability (likelihood) language

Likelihood Language	Statistical Level (assessing change)	Statistical Range (assessing range)
Virtually certain	greater than 99%	
Extremely likely	greater than 95%	
Very likely	greater than 90%	5-95% range
Likely	greater than 66%	17-83% range
More likely than not	greater than 50%	25-75% range
About as likely as not	33-66%	
Unlikely	less than 33%	<17% and >83% (both tails)
Very unlikely	less than 10%	<5% and >95% (both tails)
Extremely unlikely	less than 5%	
Exceptionally unlikely	less than 1%	

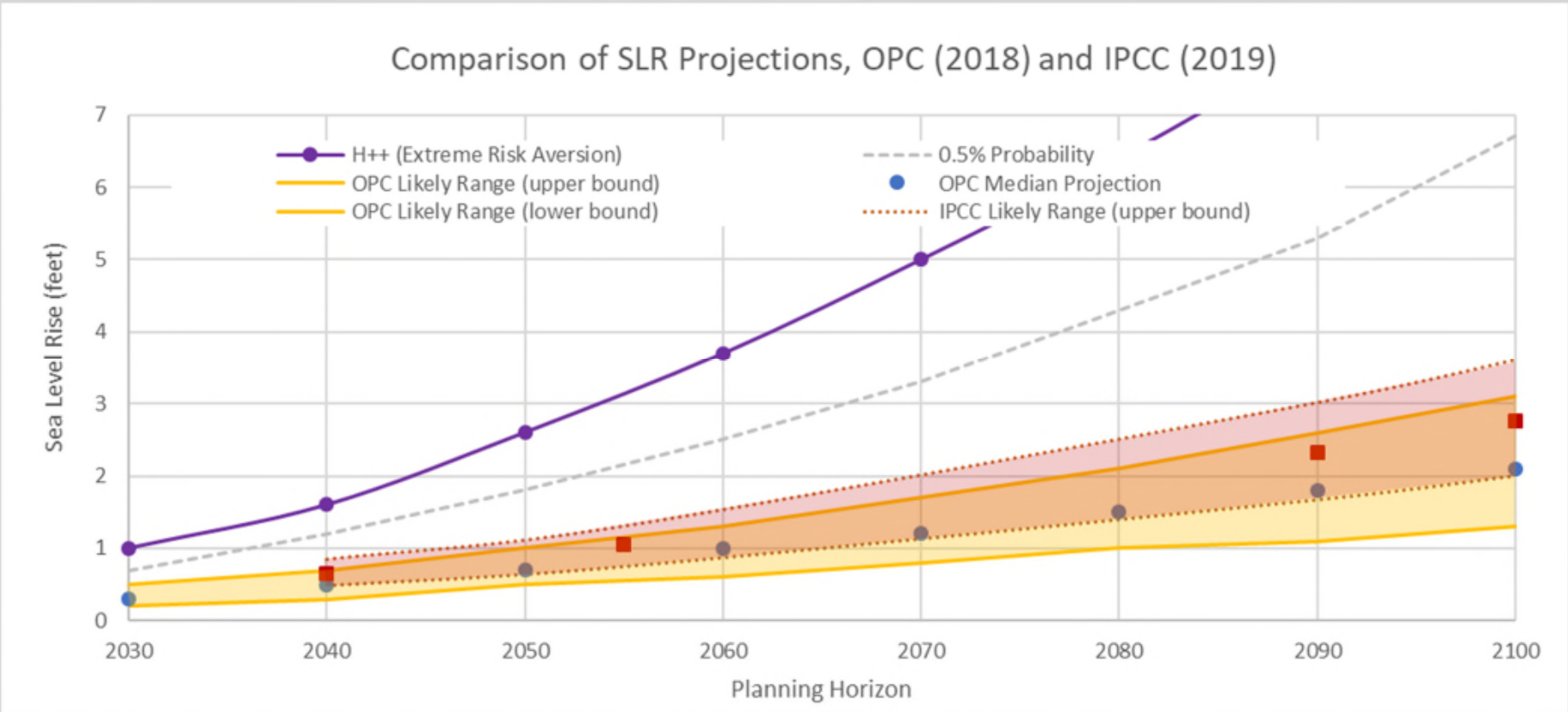


OPC Guidance vs IPCC (2019)



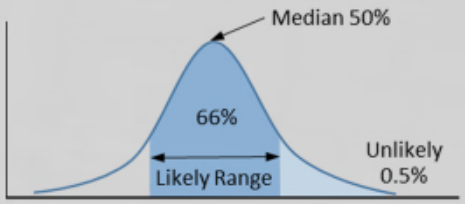


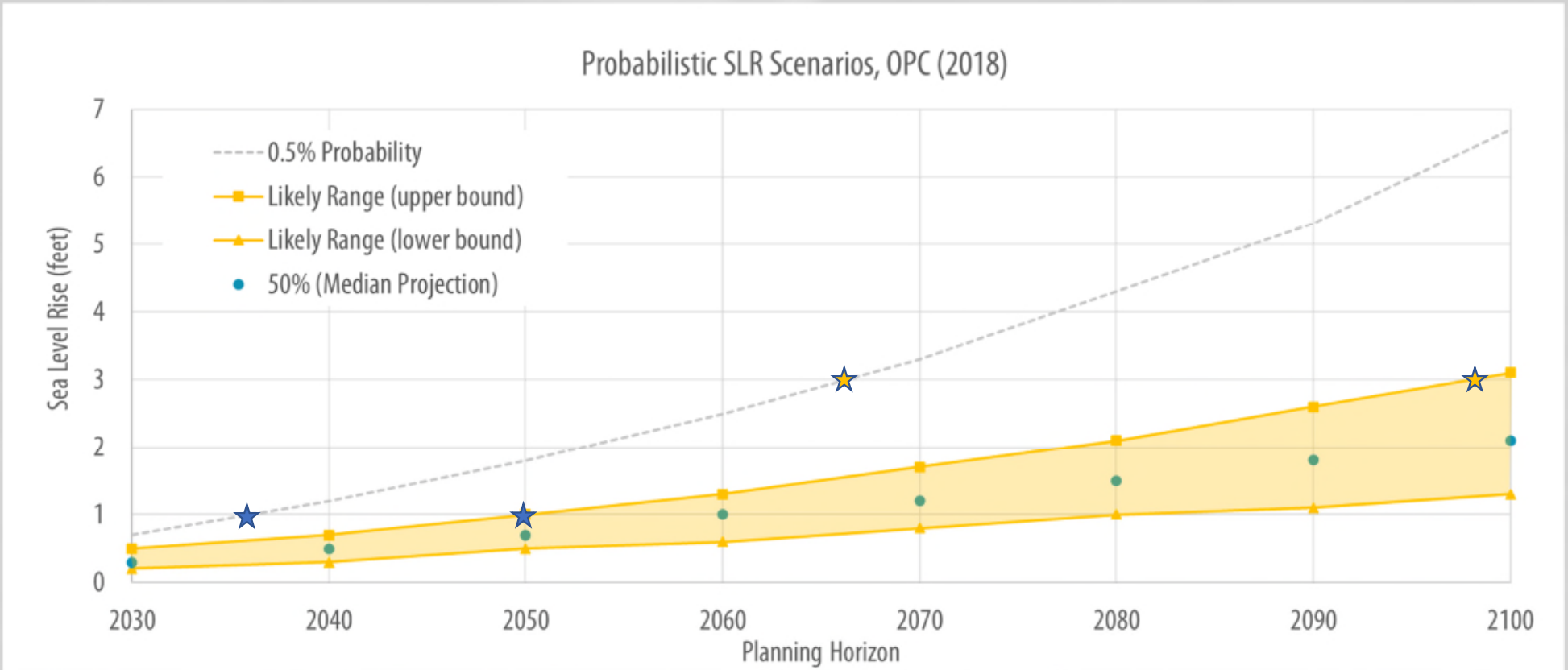
OPC Guidance vs IPCC (2019)



What is your risk tolerance and design life?

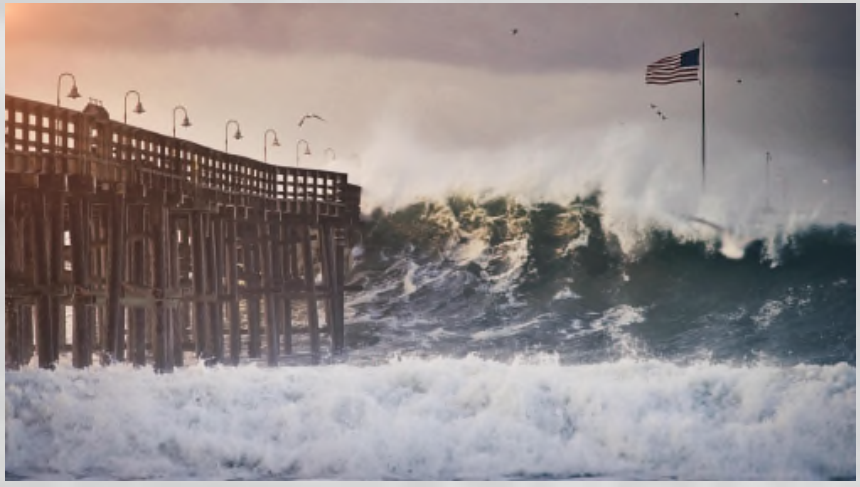
Default: “medium-high” risk aversion and 75-100 years for most development





Joint Probability – SLR is only one piece of the puzzle

- Non-storm hazards
  - Tidal flooding
  - Chronic erosion
- Coastal storm hazards
  - Extreme water levels
  - Wave runup/impact forces
  - Storm erosion
- Riverine flooding
- Groundwater table
- Tsunami



Typical example:
New development

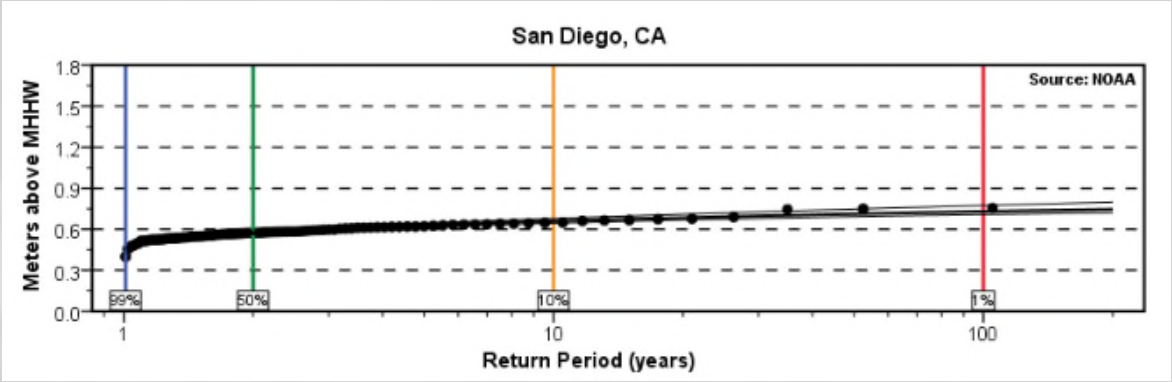
- 75-100 year design life
- Medium-high risk aversion (0.5% probability)

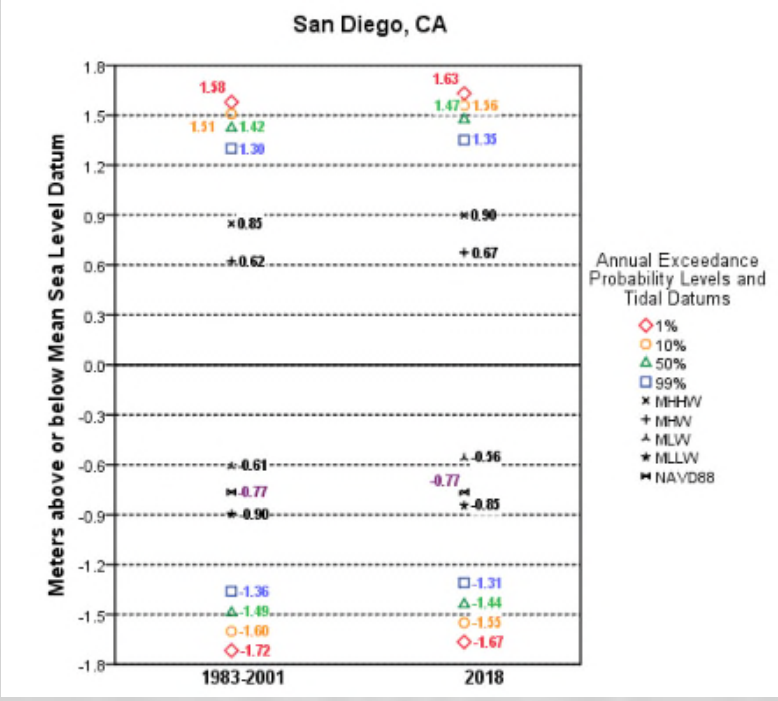
What if….100-yr coastal storm occurs?
Joint probability:
P = 0.005 x 0.01 = 0.00005
1 in 20,000 chance

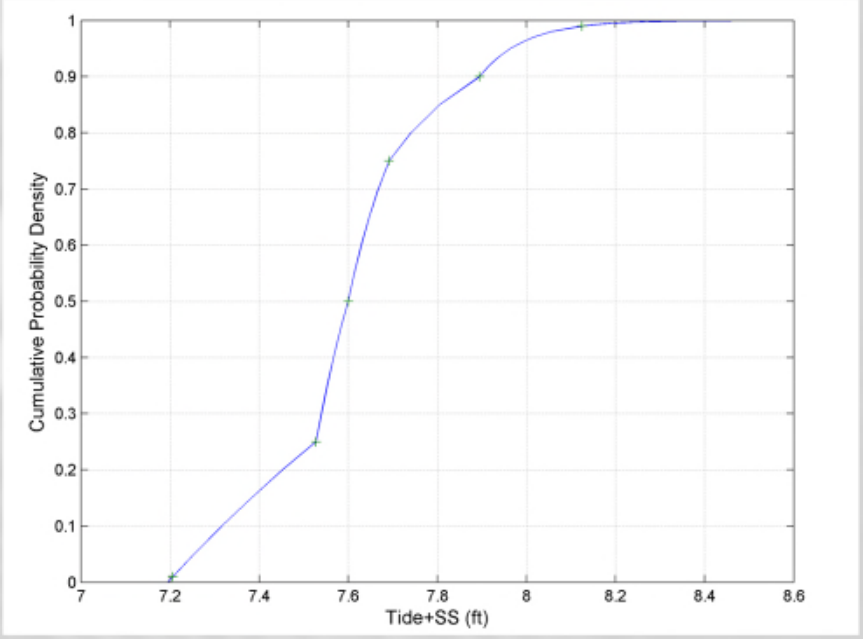
What if…..extreme tsunami occurs, at high tide?

NOAA data provides daily and extreme water levels in San Diego Bay

https://tidesandcurrents.noaa.gov/datums.html?id=9410170

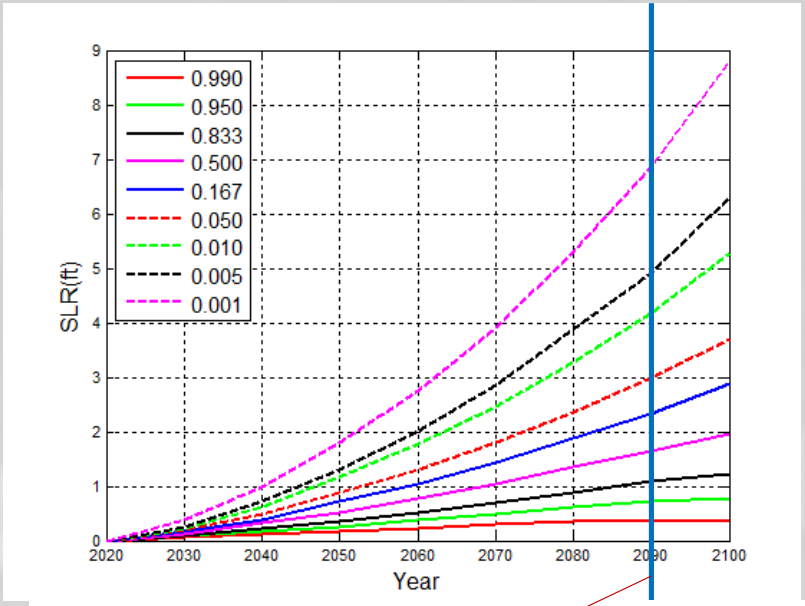


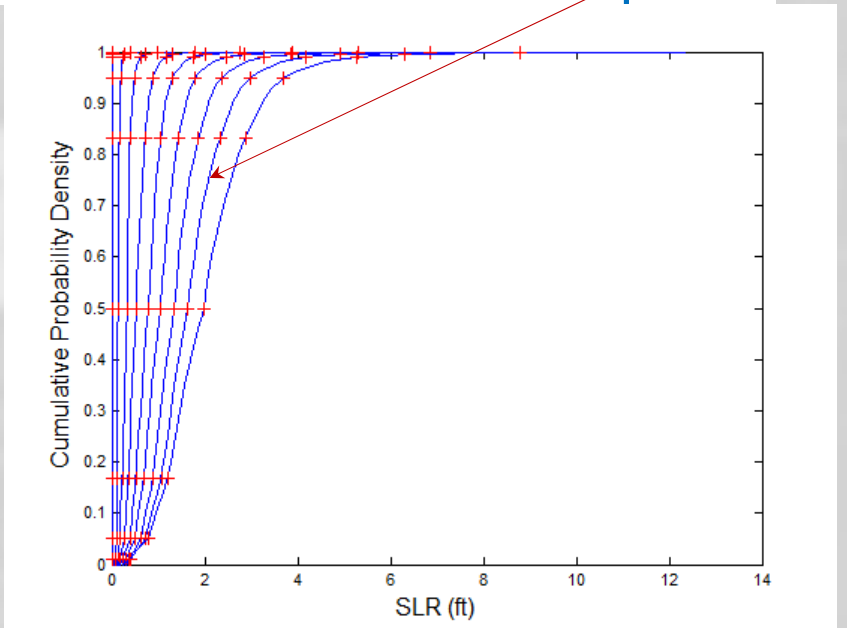


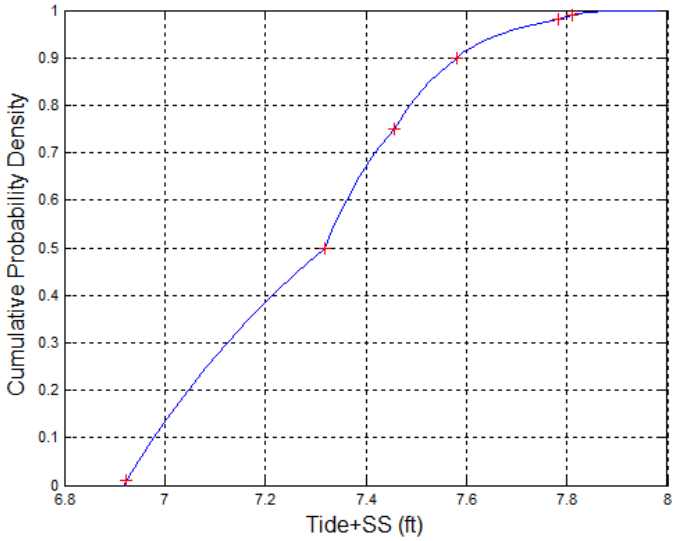


Sea Level Rise

Projections from OPC SLR Guidance, 2018; Kopp et at, 2017

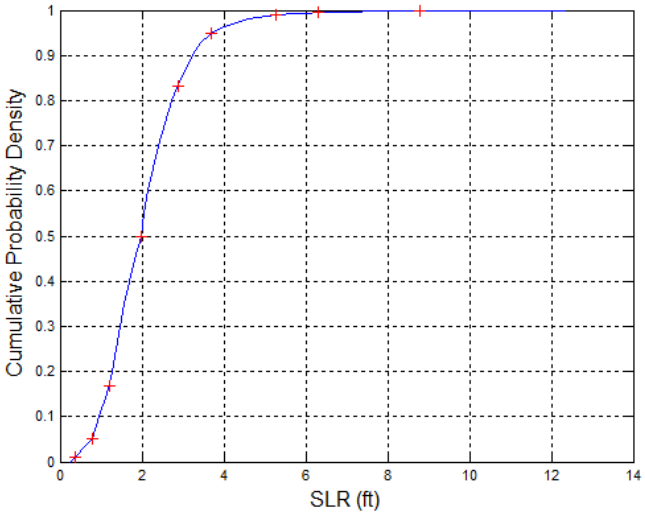




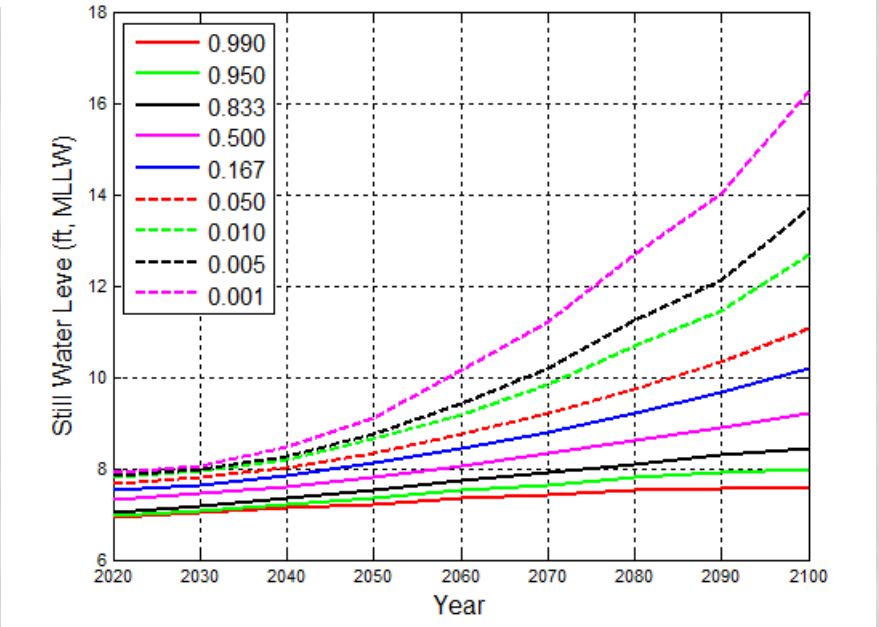


Tide + Storm Surge

Monte Carlo Simulation



Sea Level Rise



Probabilistic still water levels

Summary Table – Still Water Level exceedance versus site elevation and time horizon

Site Elevation in ft, MLLW

Time Horizon

	8	9	10	11	12	13	14	15	16	17	18	19	20
2030	14.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2040	49.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2050	83.0%	1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2060	95.2%	10.7%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2070	96.8%	35.8%	2.3%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2080	97.9%	62.2%	9.9%	1.5%	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2090	98.5%	79.4%	24.7%	4.6%	1.3%	0.4%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
2100	98.7%	87.1%	44.5%	13.5%	3.6%	1.4%	0.6%	0.3%	0.2%	0.1%	0.0%	0.0%	0.0%

Note, this analysis could be augmented to account for wave setup and runup along the project site.

Asset vs System Resilience

Interconnectivity of systems

- Federal infrastructure (breakwater)
- Local & regional infrastructure (wharves, docks, roads)
- Private (utilities, terminals)

Who is responsible for the most significant vulnerability?

Regional coordination & consistency become very important

Hurricane Michael
Mexico Beach, FL
(October 2018)

“Near-term” Adaptation Strategies (1-2 ft SLR)

- Identify SLR hazard zones
- Public outreach and education
- Port Master Plan/Local Coastal Program Updates
  - Apply consistent planning & development policies
- Capital Improvement Plan (CIP)/Operations & Maintenance programs
  - Incorporate SLR probability and coastal hazards into existing budgeting & planning process
  - Parcel scale SLR adaptation strategies can be incorporated into a variety of projects
- Support Regional Adaptation Planning
  - Local Hazard Mitigation Plan (LHMP) and Coastal Regional Sediment Management Plan (CRSMP)

Challenges in applying the guidance

- Design life & risk tolerance decisions
- Specific strategies to address improbable and long-term vulnerabilities
- Defining key terms:
  - existing development, coastal dependent uses, etc.
- Policies addressing existing development (permitted or not)
- Large scale adaptations impractical for small-scale projects & Cities
  - Need collaboration & partnerships among cities & agencies

Suggestions from lessons learned

- Apply the science, not the guidance
- Asset Managers:
  - Establish expected design life for range of facilities
  - Establish acceptable risk tolerance for range of facilities
- Asset versus system resilience
  - Regional coordination & consistency
- Integrate adaptation into existing management programs
  - Capital Improvement Plan
  - Operations & Maintenance

moffatt & nichol

Creative People, Practical Solutions.®

THANK YOU!

moffattnichol.com