National Research Council Sea Level Rise Study

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A cooperative three-state and federal partnership for the West Coast

Why the Study?

- California 2008 Executive Order on adaptation, inclusion of NRC study motivated by reactions to SLR estimates published in IPCC AR4
- West Coast Governors Agreement on Ocean Health (2006), impetus for Oregon, Washington, federal agencies to join in supporting study

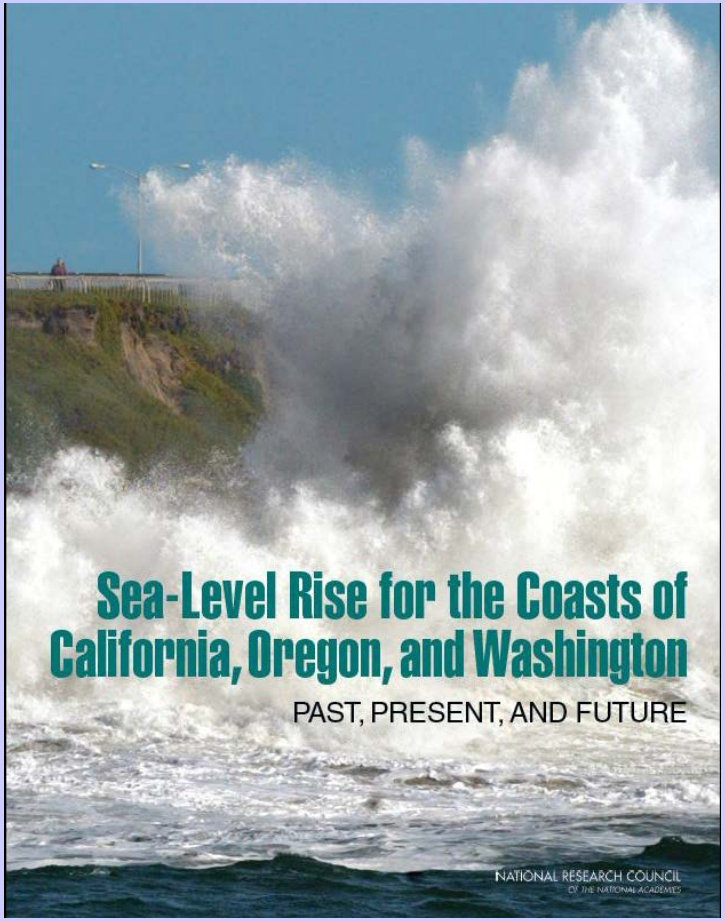
Participating State & Federal Agencies

- California: Department of Water Resources, Ocean Protection Council, California Energy Commission, Caltrans, State Water Resources Control Board
- Oregon: Watershed Enhancement Board
- Washington: Department of Ecology
- Federal: USACE, USGS, NOAA

Scope of NRC Study

- Estimate the contributions to global sea-level rise and project global sea-level rise for 2030, 2050, and 2100
- Estimate the contributions to regional sea-level rise and project sea-level rise for California, Oregon, and Washington for 2030, 2050, and 2100
- Examine any changes in storminess and how it would affect regional sea-level rise
- Examine how sea-level rise affects the shoreline and protection provided by habitats and the natural shoreline

- Prepublication electronic copy released June 2012
- Final hard copies expected soon



Assessment of Components of Global Sea-Level Rise Since IPCC (2007)

- Thermal expansion of ocean water
  - Correcting biases discovered in ocean temperature measurements decreased estimates of the contribution of thermal expansion to about 35%
- Ice melt from ice sheets, glaciers, and ice caps
  - Ice loss rates are variable, but increasing overall, raising the land ice contribution to about 65%

NRC Approach to Global Projections

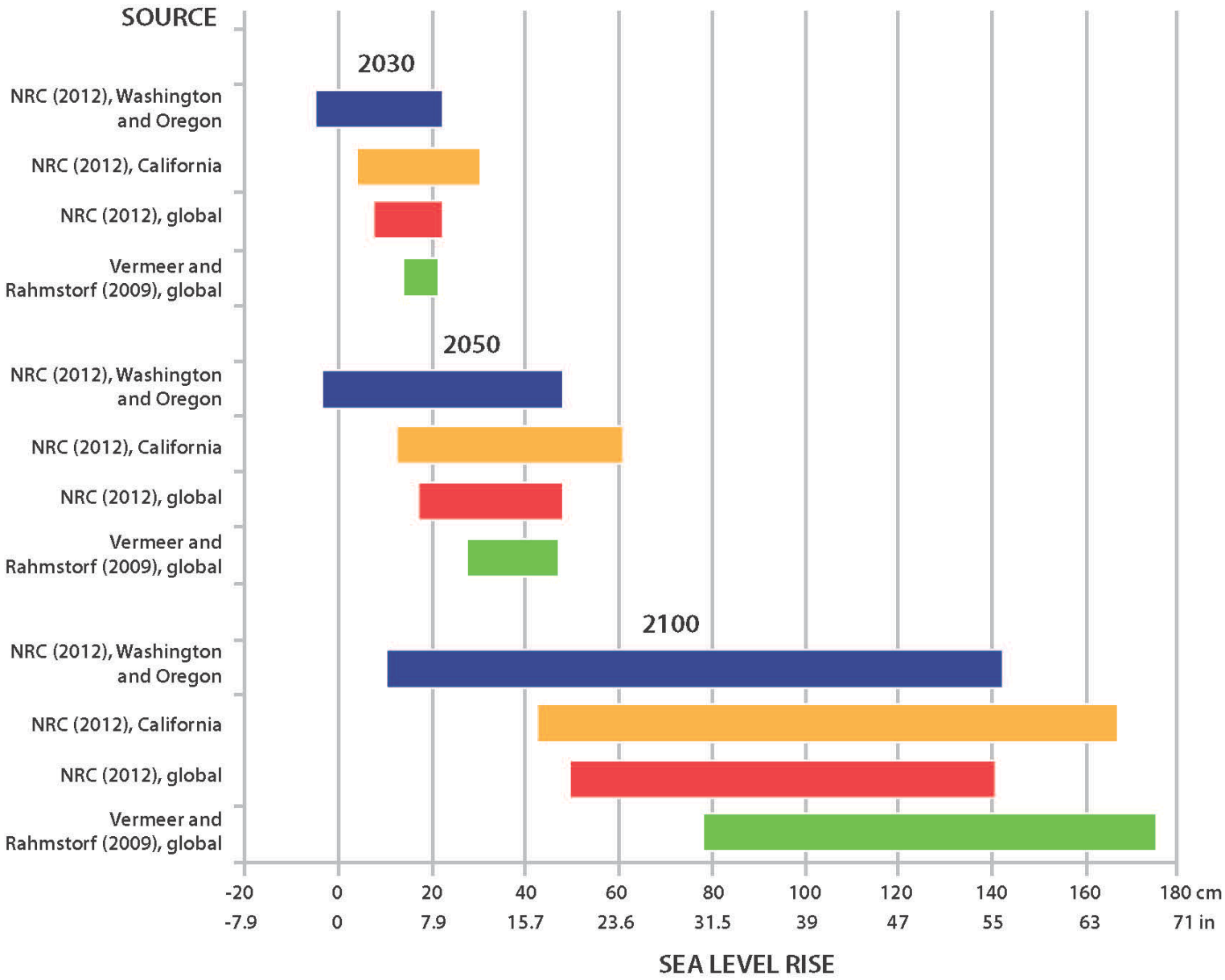
- Thermal expansion (steric) contribution determined from IPCC (2007) global climate models
  - Range due to different greenhouse gas scenarios
- Cryosphere contribution extrapolated from 1992-2010 trends in observed ice loss
  - Range includes added rapid dynamic response

Factors that Affect <u>West Coast</u> Sea-Level Rise

- Global sea-level rise
- Atmosphere-ocean circulation patterns in the northeast Pacific, which affect ocean levels
- Melting of modern and Ice Age glaciers and ice sheets, which affect ocean and land levels
- Tectonics and fluid withdrawal/recharge, which affect land levels
- *Local sea level rises if the ocean rises and/or the land sinks*

Committee Approach to Projections for California, Oregon, and Washington

- Northeast Pacific Ocean steric and wind-driven component was obtained from global climate models
- Global cryosphere component was adjusted for sea-level fingerprint effects, then extrapolated forward
- Vertical land motions were extrapolated from trends in GPS coastal observations
- Regional averages were determined for areas to the north and to the south of Cape Mendocino



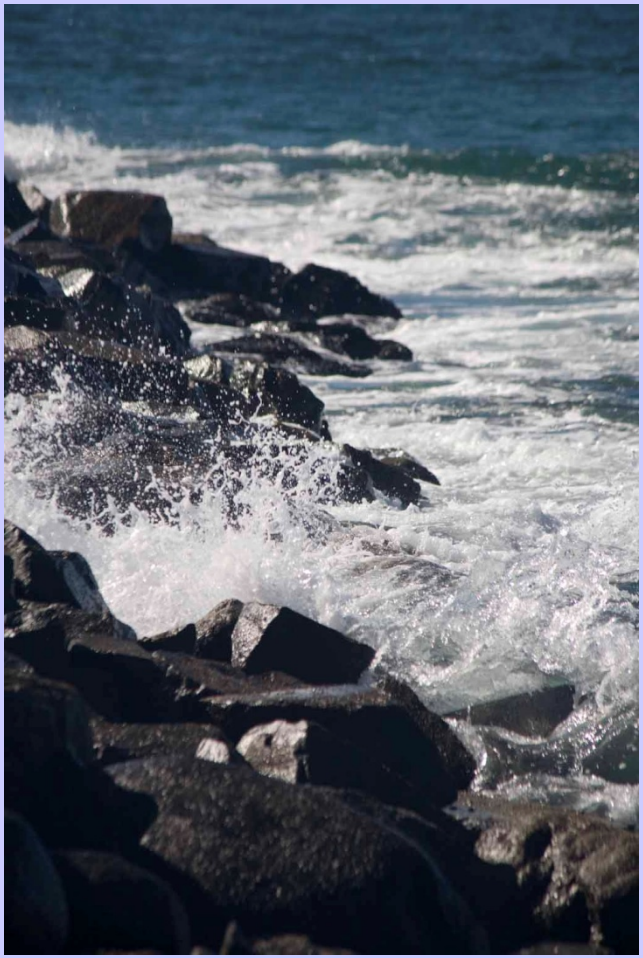
Modified from NRC (2012), Sea Level Rise for the Coasts of California, Oregon, and Washington

Summary of Regional Projections

- Sea level along the California coast south of Cape Mendocino is expected to rise nearly 1 m by 2100, about the same as global sea-level rise
- The projected rise is lower in Washington, Oregon, and California north of Cape Mendocino, about 60 cm, because the land is rising as seismic strain builds up
- A great earthquake (magnitude 8 or larger) along the Cascadia Subduction Zone would cause immediate subsidence and sea-level rise of an additional 1-2 m

Coastal Storminess

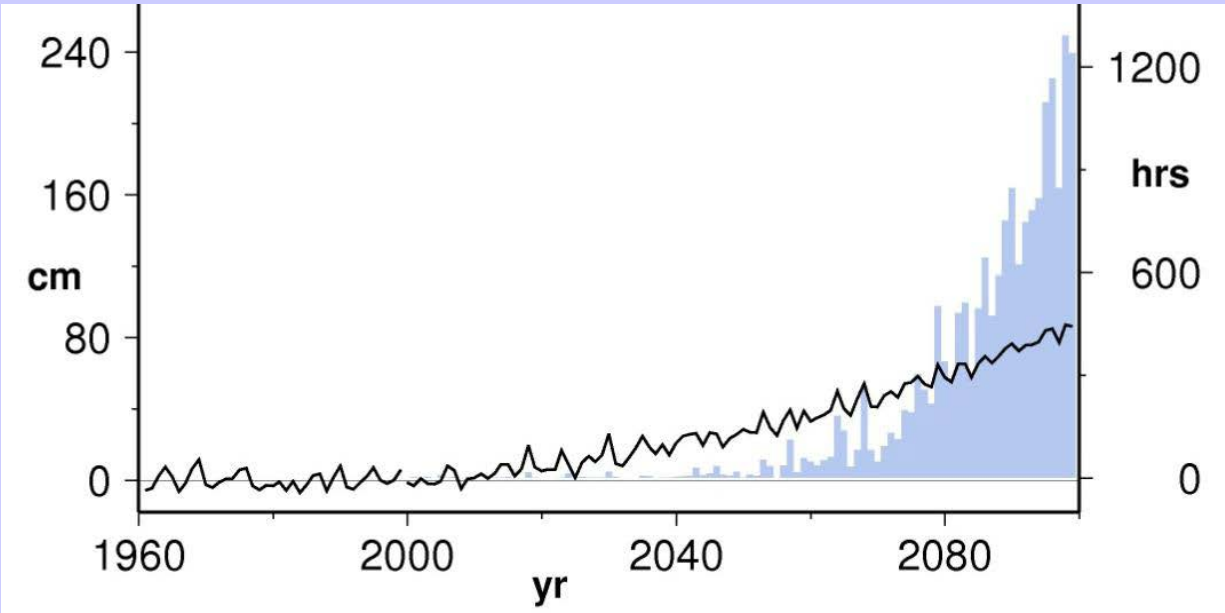
- Most coastal damage is caused by the confluence of large waves, storm surges, and high astronomical tides during a strong El Niño
- Water levels during these events can exceed projections for 2100



Future Storminess

- No consensus among climate models whether the number & severity of NE Pacific Storms will change
- Observational records not long enough to determine if storm tracks are shifting
- Some observational studies report that largest waves getting higher, winds getting stronger
- Records too short (35 years) to determine if changes are long-term trend or natural variability

SLR Magnifies Impacts of Storm Surge/High Waves

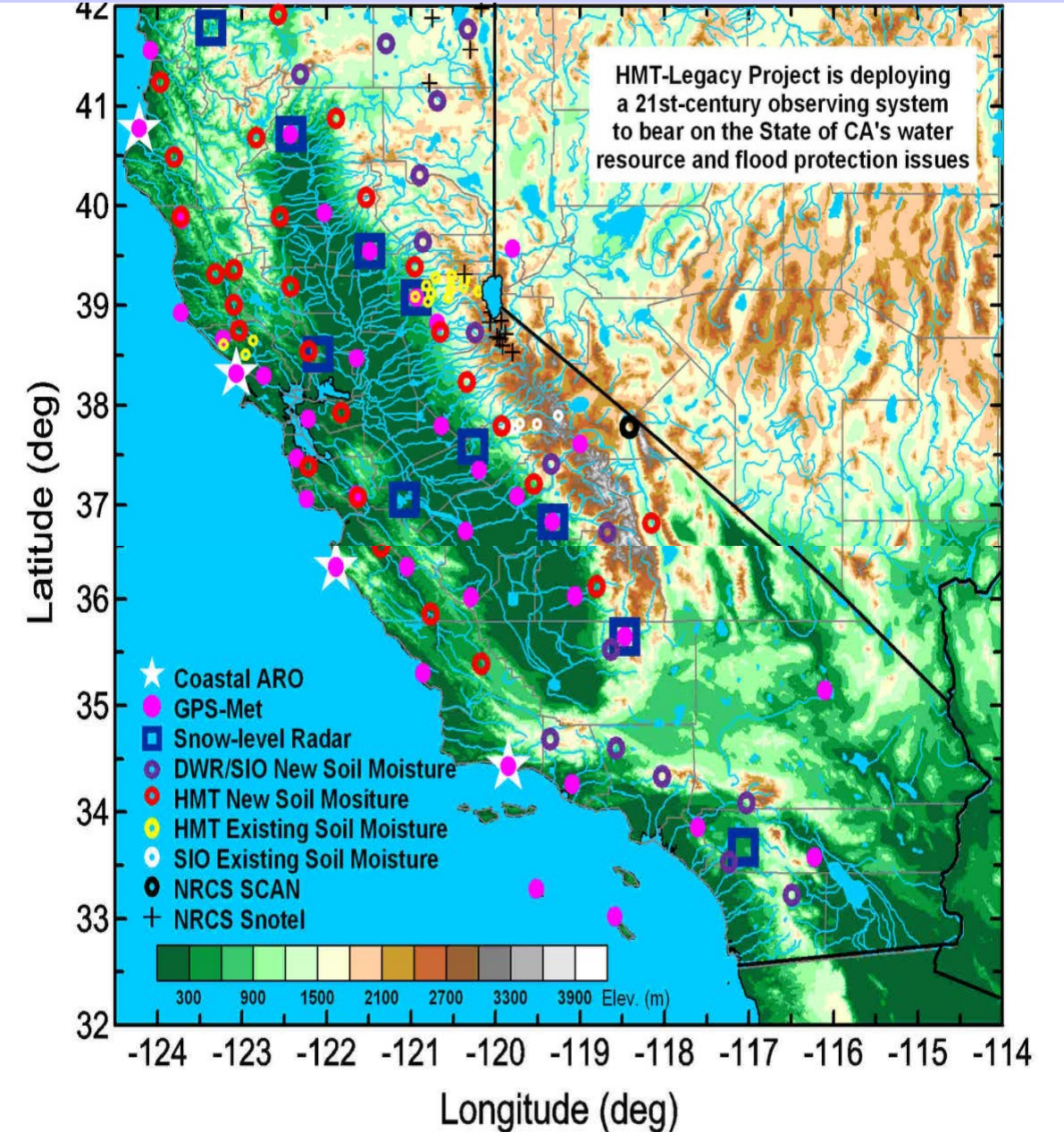


Hours of extremely high sea level at SF Bay projected to increase substantially

Bottom Line – Now to 2050

- Coastal inundation driven by winter storms, exacerbated by high tides, El Niño conditions
- Longer-term adaptation tools include land use planning, relocation/hardening of coastal infrastructure
- Nearer-term tools include improved weather forecasting/emergency response, updating coastal floodplain mapping

Improved Observing Systems for Extreme Precipitation

- NOAA Hydrometerology Testbed (HMT) program in California
- Monitor & forecast Atmospheric River storms
- First coastal atmospheric river observatory being installed in Bodega Bay in November

DWR Appreciates CWC's Support of the HMT Project