Local-Regional Linkages in South Bay Shoreline Flooding with Rising Sea Levels

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South Bay Shoreline Workshop
September 27, 2016
Coastal Flooding: The Emerging Nuisance

- Increasing frequency, increasing cost
Recent studies documented millions in the US (500 million worldwide) that are vulnerable to flooding from future sea level rise.

- Does not account for other disruptions to services
“Nuisance Flooding”: San Francisco Bay

- Tidal inundation already occurring along SF waterfront and at Tam Junction in Marin County
  - January (annual peak) high tides inundate currently
  - Future: daily high tides?
More than a “nuisance”

- Critical elements of regional, national and global transportation system disrupted
More than a “nuisance”

- Critical elements of regional, national and global transportation system disrupted

Rail and road links intermittently flooded
How to think about “Resilience”?  

- Coastal communities have adopted the mantle of being 'resilient' to sea level rise. 
  - Resilience connotes recovering from an event 
  - Sea Level Rise is not an event from which you recover 

- Instead, need to think about adapting to sea level rise 
  - Resilience is more properly applied to the actual inundation events, which are shaped by other forcings 

- Framework: Long-term sea level rise is reducing the resilience of communities to coastal flooding events. Communities must adapt to this trend in order to preserve resilience
Accommodation or Containment

- Tidal dynamics and sea level rise define conditions
- Inundation results from interaction with protective infrastructure
  - Containment acts to prevent events from occurring
  - Accommodation allows inundation but minimizes impacts
- Question of how shoreline infrastructure feeds back to alter forcing
Accommodation in an urban estuary

- Hydrodynamics depend mostly on placement of barriers
  - Details of landuse of secondary importance
Regional connections or interactions

• Similarities in future flood risks
• Influences of actions on tidal hydrodynamics
• Transportation/Utility network disruptions
• Social and ecological systems
• Governance and decision-making
Regional connections or interactions

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Preliminary Inundation Analyses: Area based

- Community-scale metrics for inundation
  - Initial analysis based on area only
  - Work towards more nuanced analysis of 'risk'
Preliminary Sea Level Rise Physics Network

- Link if threat occurs at similar sea level (based on formal correlation in change of inundation area)
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Tides in basins: Amplification v. Dissipation

• Tides can be amplified in basins
  – Set by interplay of tidal forcing and bathymetry and shorelines

• Friction and interaction with perimeter dissipate tidal energy
  – Wetlands, topography and shallow regions

• San Francisco Bay experiences both
  – South Bay: Amplified
  – North Bay: Dissipated
Examples: SF Bay

5' Range

7.5' Range

11' Range
Shoreline Scenarios (Illustrative)

- Accommodation or Containment
  - Accommodation: Allow inundation without altering shorelines
  - Containment: Preserve current shorelines with infrastructure

- Scenarios
  - Accommodation Everywhere
  - Accommodation Nowhere
  - Accommodation South Bay only
  - Accommodation South of Narrows only
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• Difference in high water between containment everywhere and accommodation everywhere
Accommodation in South Bay

- Difference between containment everywhere and accommodation in South Bay
Accommodation South of Dumbarton

- Difference between containment everywhere and accommodation only South of Narrows
Analyzing Spatial Influences: Simplified Model

\[ \frac{\partial \eta}{\partial t} = -\frac{1}{W} \frac{\partial Q}{\partial x} \]

\[ \frac{\partial Q}{\partial t} = -gA \frac{\partial \eta}{\partial x} - \frac{Q}{A} \frac{\partial Q}{\partial x} - K \frac{QW}{A} \]
Idealized Model

- First, rectangular model to understand effects of accommodation
Idealized Model

- First, rectangular model to understand effects of accommodation
Accommodation by Segment

- Setback levees by 2 meters (vertical) in 5 km segment
  - Track effects at head of estuary
Regional connections or interactions

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Transportation disruption

- Intermittent, localized events create regional impacts

Flooding jams streets and highway as Novato logs 4 inches in 12 hours

Author: Nels Johnson njohnson@marinj.com @nelsjohnsonnews on Twitter
Date: December 3, 2014
Publication: Marin Independent Journal (San Rafael, CA)
Torrential rains that dumped as much as 4 inches on Novato in 12 hours triggered flooding across Marin Wednesday, jamming the freeway when water closed two southbound lanes at Marin City.
Regional connections or interactions

- Similarities in future flood risks
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Social and Ecological Systems

- Geographic distribution of housing and habitats sets spatial interactions
Regional connections or interactions

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- Social and ecological systems
- Governance and decision-making
Governance System

- Many players involved with shoreline decision making
Summary and Questions

- Decisions about shoreline structures and placement define the resilience of the region to coastal flooding events
  - Containment: Minimize chances of event, but impacts are severe and require other infrastructure for recovery
  - Accommodation: Allow events to occur regularly, but minimize disruptive impacts
- Local-regional interactions should be examined as a part of developing a regional strategy
- What are the potential mixes of accommodation and containment for the South Bay shorelines?
  - What might land use look like in front of or behind the protective infrastructure?
Influence Diagram: Effects of Widening

Green: action at one location reduces water level at connected location
Red: action at one location increases water level at connected location

- South of Narrows: Actions protective down-estuary
- Actions at mouth: negatively influence up-estuary
Influence Diagram: Effects of Narrowing

Green: action at one location reduces water level at connected location
Red: action at one location increases water level at connected location

- South of Narrows: Negative local influences
- Actions at mouth: protective up-estuary
- Actions at narrows: protective up-estuary (choke)