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Reducing Disaster Vulnerability of Coastal Communities on the Salish Sea

Stephanie Chang
University of British Columbia, stephanie.chang@ubc.ca

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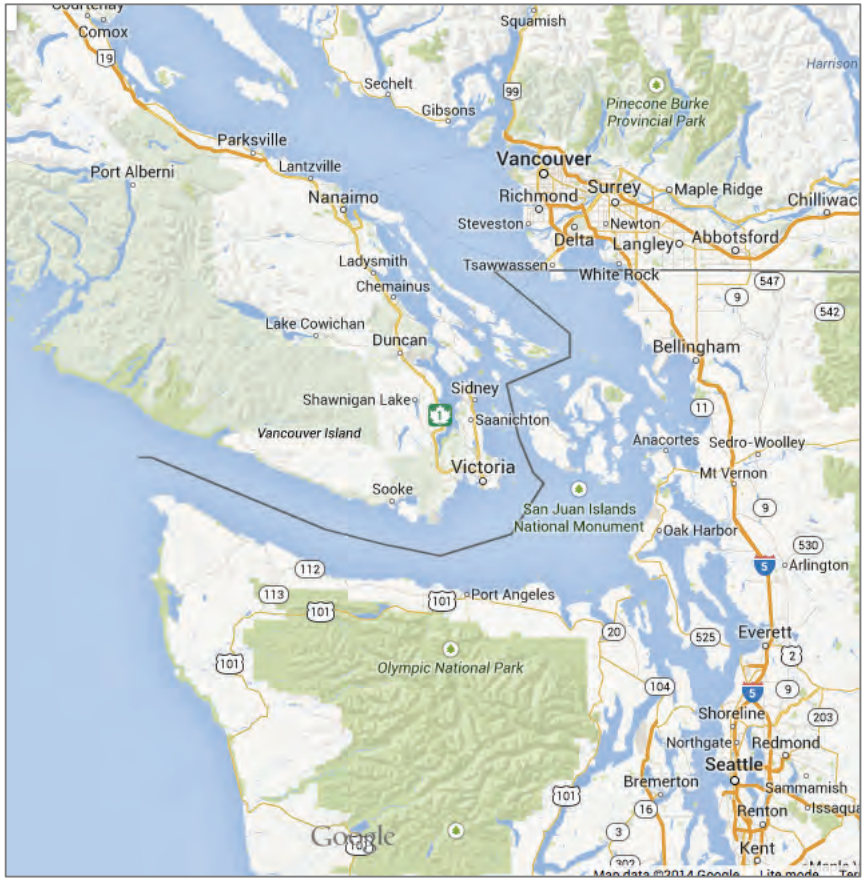
MEOPAR

With: J. Yip, R. Chaster, S. van Zijll de Jong, A. Lowcock, C. Carter

Coastal Hazards in Metro Vancouver

- Earthquake
- Tsunami (incl. undersea landslide)
- Storm surge, coastal flooding
- Freshet flooding
- Sea level rise-related
- Oil spills
- …



Coastal Disasters

earthquake… tsunami…

- >30% probability of damaging earthquake in 50 years
- M9.0 Cascadia event (IBC 2013)
  - C$62 b. direct loss, C$75 b. with indirect, C$20 b. insured
- M7.3 Georgia Strait (Chang et al. 2012; Chang and Lotze 2014)
  - 51,000 pop. in significantly damaged buildings
  - Up to 88% business disruption in DNV

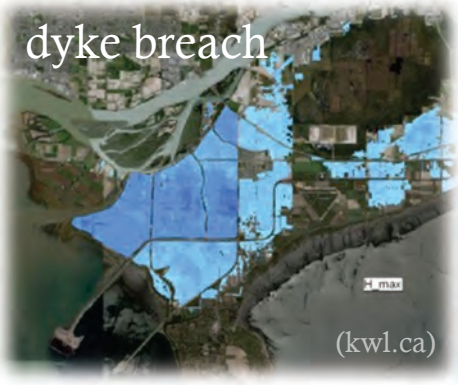
Coastal Disasters

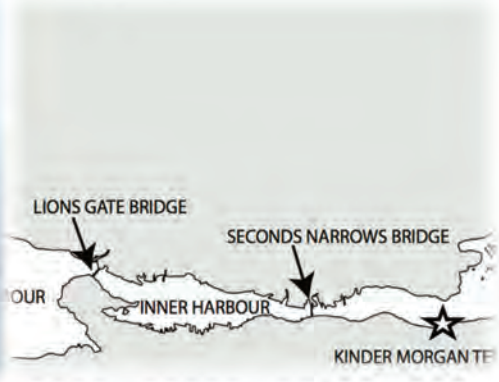
flood… oil spill…

- Sea-level flooding events (Forseth/ACT 2012)
  - 7 events, 1960-2011
  - C$11 m. damage in 1982 & 2006 events
- SLR C$2.1~7.6 b. damage in BC by 2050 (NRTEE 2012)

- Oil spills
  - No experience in region
  - Kinder Morgan proposal increase 650 tankers/year
  - Clean-up costs & economic impacts (Allo and Loureiro 2012)
    - Valdez 2010$US 4.3 b
  - Health & social impacts


(Photo: K. Stallknecht, PNG)

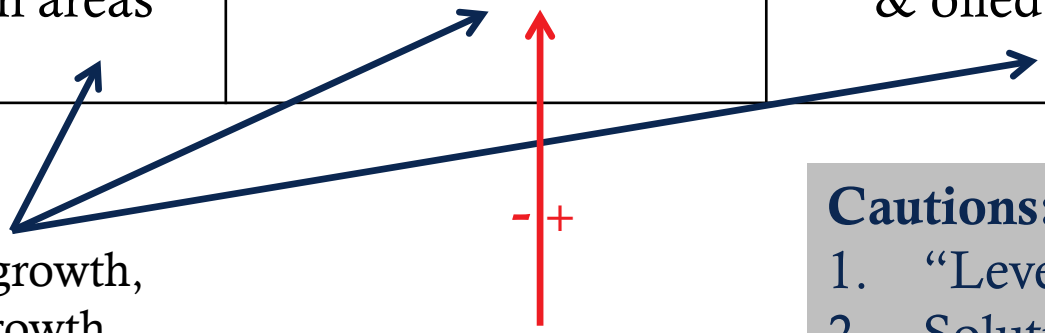




Vulnerability Factors

Exposure

Earthquake	Flood	Oil Spill
Pop. in shake zone & liquefaction areas	Pop. in flood zone	Pop. in local airshed & oiled shores



Population growth, economic growth, development patterns, land-use planning, transportation planning,…

Dykes, seawalls, Green infrastructure

Cautions:

1. "Levee effect"
2. Solutions need to be viable in multi-hazard environment

Vulnerability Factors

Susceptibility, Capacity

Earthquake	Flood	Oil Spill
Vulnerable buildings, maritime transport dep.	Vulnerable buildings, maritime transport dep.	Maritime transport dep.
Low income, low education,…	Low income, low education,…	Low income, low education,…
Small businesses, neighborhood effect,…	Small businesses, neighborhood effect,…	Small businesses, neighborhood effect,…
Declining economy, undiversified economy	Declining economy, undiversified economy	Declining economy, undiversified economy, "brand" sensitive econ.
Response capacity, assistance programs	Response capacity, assistance programs	Response capacity, assistance programs
Risk perception, preparedness, community cohesion, social capital	Risk perception, preparedness, community cohesion, social capital	Risk perception, preparedness, community cohesion, social capital

G.I.

Green Infrastructure for Disaster Risk Reduction

- **Flood protection mechanisms of coastal ecosystems:**
  - Tidal wetlands – reduce size and erosive power of waves
  - Floodplains – divert, hold, and slow flood water
  - Stabilizing sand dunes – sustain wave energy reduction mechanism
  - Oyster reefs and eelgrass beds – reduce wave energy, increase sedimentation
  - Mangrove forests – reduce tsunami velocities, wave heights; attenuate storm surge amplitude and winds


(TNC 2013)


(Mangrove Restoration Project, Thailand)

Effectiveness

Suppasri, A. et al. (2013) *Pure Appl. Geophys*. 170: 993-1018.

- Storm surge attenuated at -1m per 14.5km marsh (Resio 2008)
  - Range 7~20km
  - So. Louisiana

FAO 2006 Coastal Protection Workshop:

1. Forests and trees can act as bioshields that protect people and other assets against tsunamis and other coastal hazards, but whether they are effective and the degree of their effectiveness depend on many variables;
2. Care must be taken to avoid making generalizations and creating a false sense of security that bioshields will protect against all hazards;
3. The use of bioshields should be considered within the framework of disaster management strategies, which also include effective early warning systems and evacuation plans.

Cost-Effectiveness

- In many cases, same level of risk reduction as gray infrastructure, at lower cost (TNC 2013)
- 1 ha wetland loss => $33,000 storm damage in specific storms (Costanza et al. 2008)
- Coastal ecosystem restoration in 3 cases: BCR >15 (Conathan et al. 2014)
- Netherlands CBA: higher, stronger dikes most cost-effective in dense area
  - land-use change and floodplain restoration justified over 100 yrs and w/other benefits (Brouwer et al. 2004)
- GI costs higher in urban areas (Jonkmann et al. 2013, Linham and Nicholls 2010)

The study found that the cost of raising and maintaining an existing bayshore levee was twice that of the cost to build and maintain a smaller levee behind a roughly 150-foot-wide restored marsh.

San Francisco Bay Horizontal Levee Concept

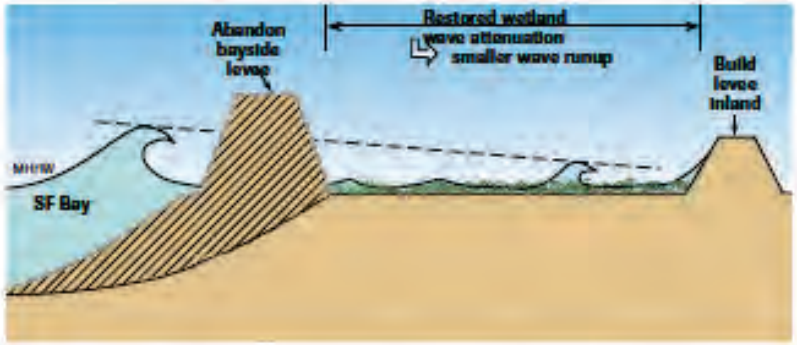
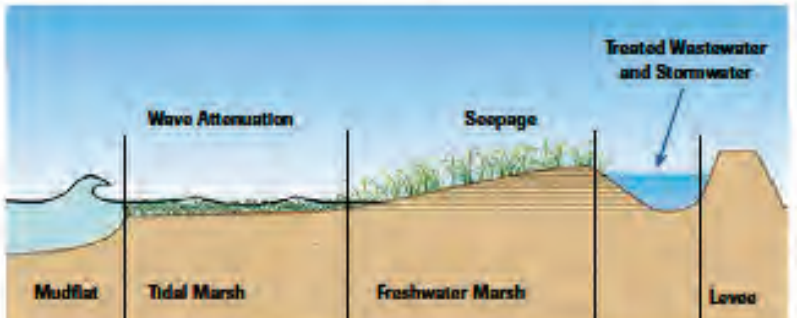


Figure 1: Tidal marshlands reduce wave energy substantially. Modeling results indicate that it would be cost-effective to abandon deteriorating bayshore levees in favor of smaller levees built landward of restored tidal marshes. This strategy would meet both ecological restoration and long-term flood risk management goals.



The Nature Conservancy. (2013) *Reducing Climate Risks with Natural Infrastructure*

Multiple Benefits

- Habitat, carbon sequestration, water quality, recharge aquifers, recreation, property values, jobs,… (TNC 2013)
- Community livability: aesthetics, recreation, sense of place and well-being, community cohesion (CNT 2010)
- Greenspace access as social equity, social well-being and participation, sense of place attachment, stress reduction and health (Barnhill and Smardon 2012)

Richmond: Dike upgrade with enhanced habitat value

- What types of G.I. could effectively reduce risk in the Salish Sea region?
- How cost-effective?
- Other benefits?