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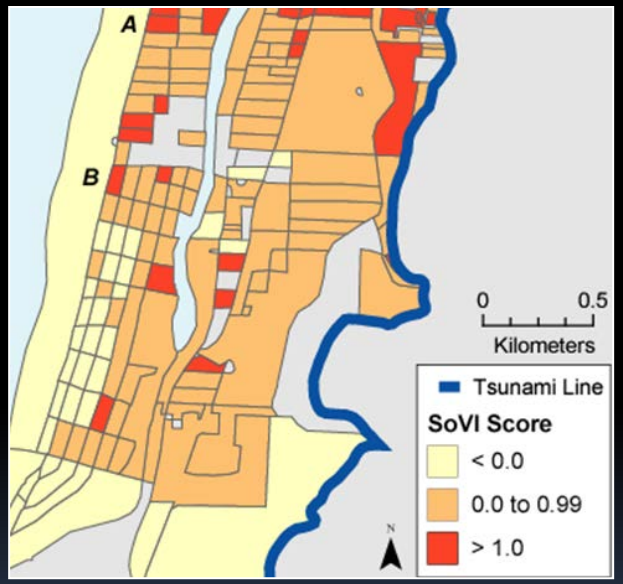
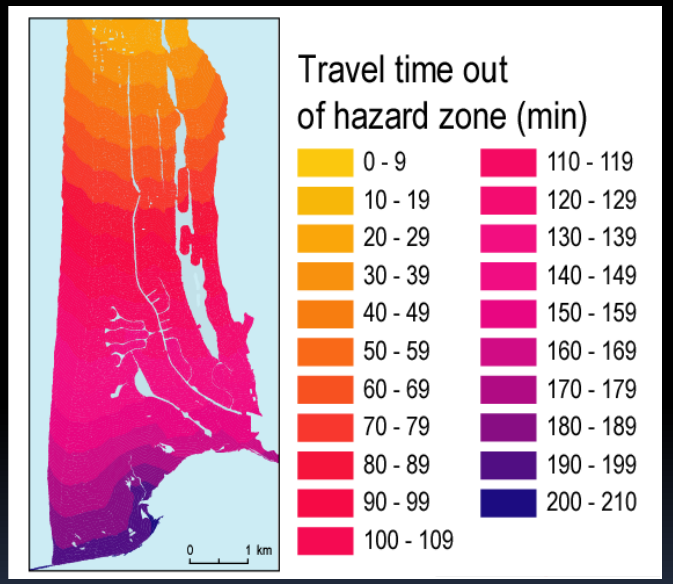
Societal vulnerability to tsunamis

Overview and relationship to national risk analysis





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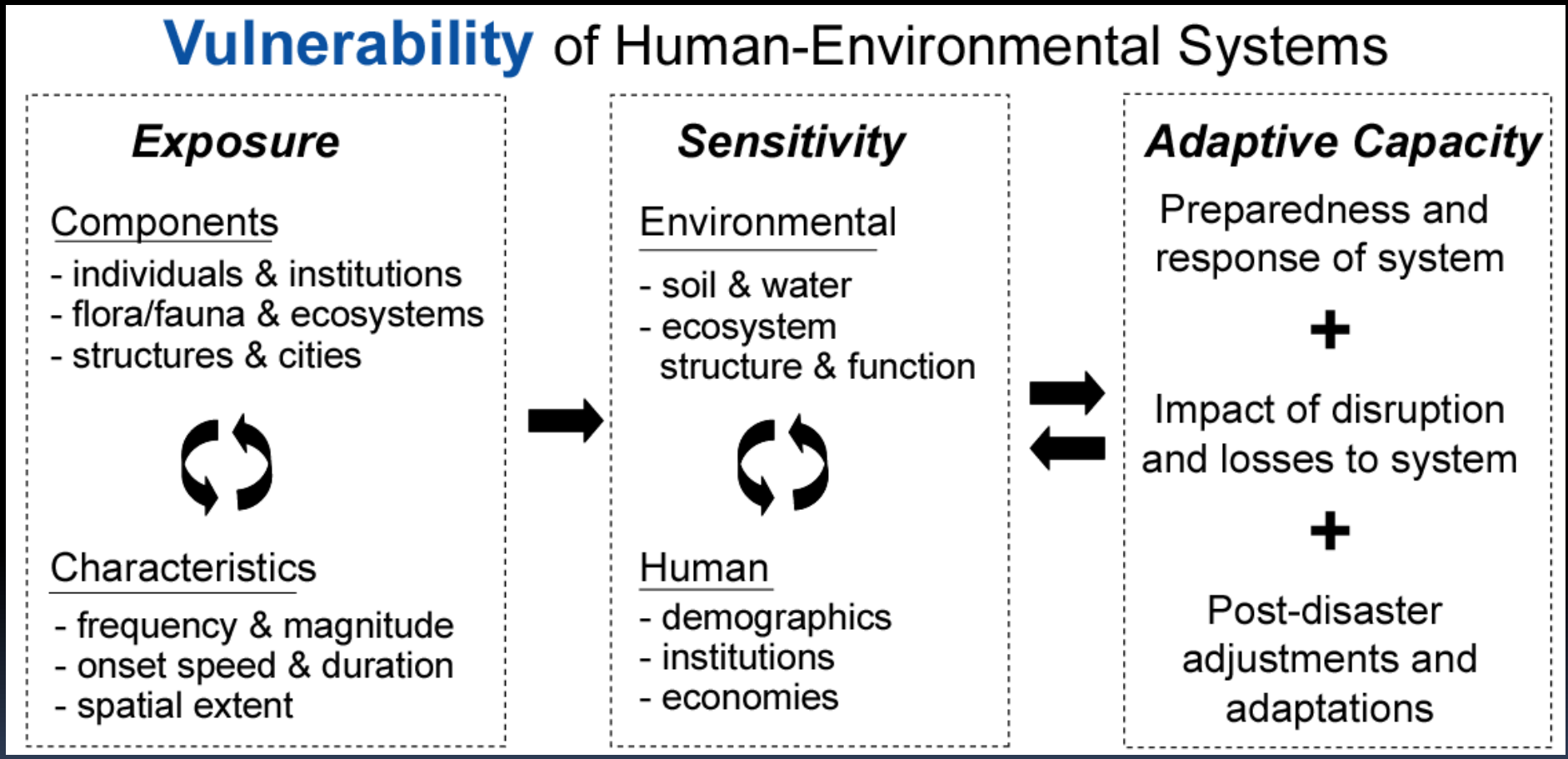
Vulnerability

Combination of physical, social, economic, ecological, and political components that influence the degree to which a system is threatened by a particular hazard



Potential for coming into contact with an environmental condition

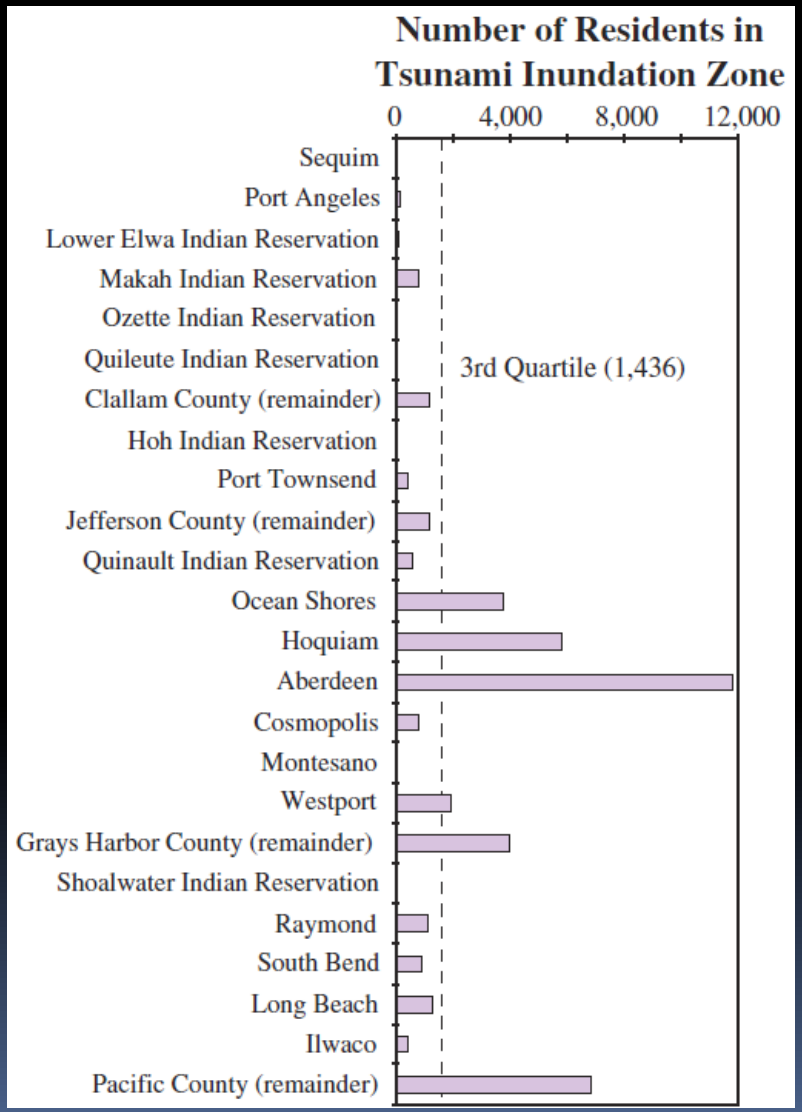
Internal characteristics of exposed system that amplifies potential for loss

Ability of a system to adjust and take opportunities

Adapted from Turner et al., 2003

Exposure Analysis

Location and number of people relative to tsunami-hazard zones



(Wood and Soulard, 2008)

Types of people in hazard zone:

- Residents
- Employees
- Visitors at public venues
  - Museums
  - Theaters
- Dependents
  - Child day care centers
  - Adult residential care
  - Hospital patients
- Patrons at community places
  - Churches and other religious organizations
  - Grocery stores
- Recreationists
  - Beaches visitors
  - Park visitors

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Exposure Analysis

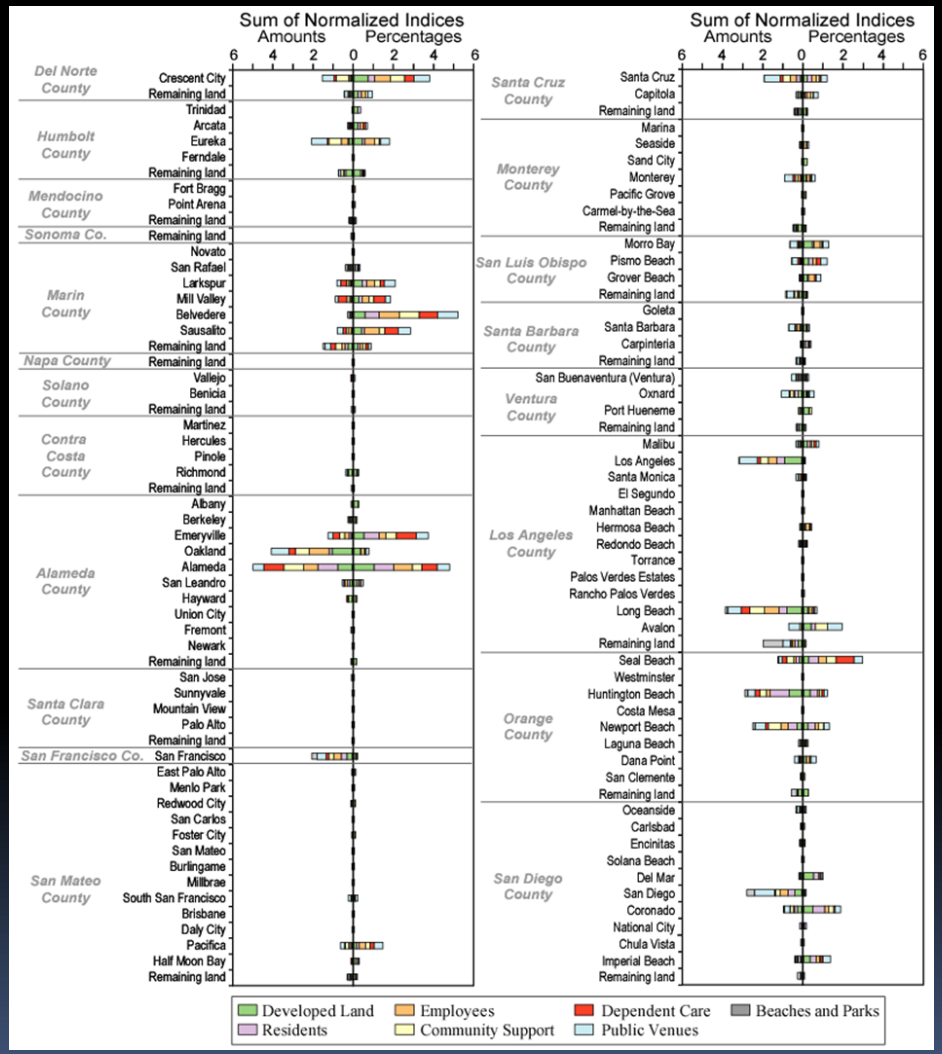
Relative rankings of community exposure to tsunami-hazard zones

Population indicators

- Developed land
- Residents
- Employees
- Public venues
- Dependent facilities
- Community support businesses
- Beach & park visitors

Normalized rankings

- Number of populations and facilities
- Percentage of community totals



Relative indices of the number and percentage of population-related attributes for communities in the California maximum tsunami-inundation zone (Wood et al., in press)

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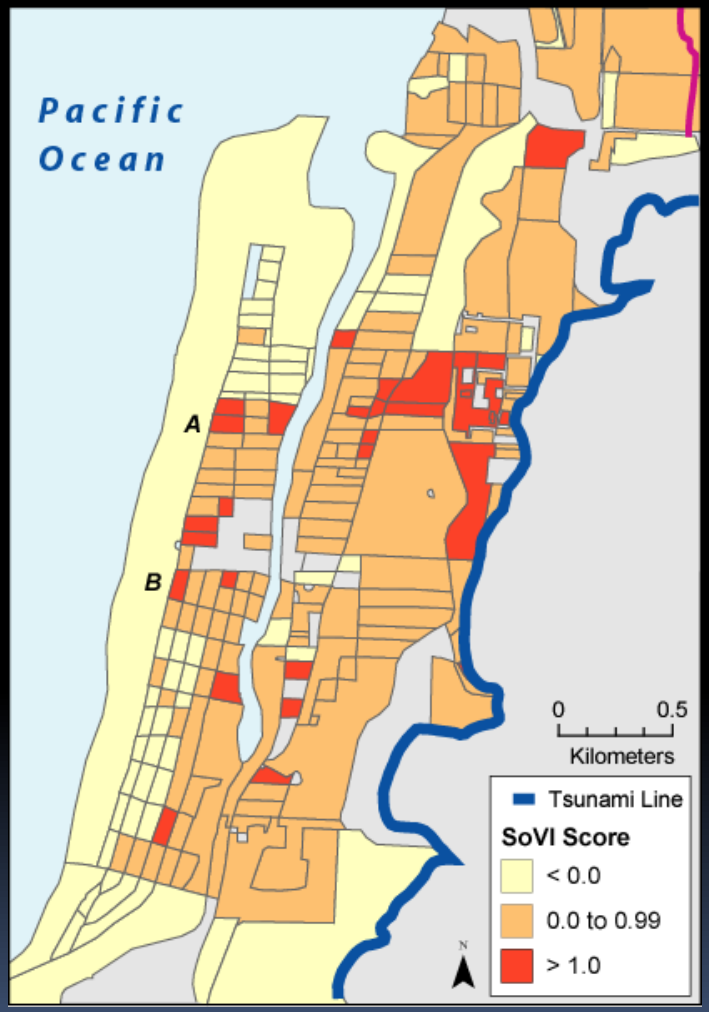
Sensitivity Analysis

Internal characteristics that inhibit preparedness for and response to tsunamis



Hot-spots of demographic sensitivity in Seaside, Oregon *(Wood et al., 2010)*

Demographic characteristics

- Age
- Gender
- Race and ethnicity
- Economic status
- Tenancy
- Ability to speak primary language
- Occupation
- Family structure
- Education
- Dependence on social services

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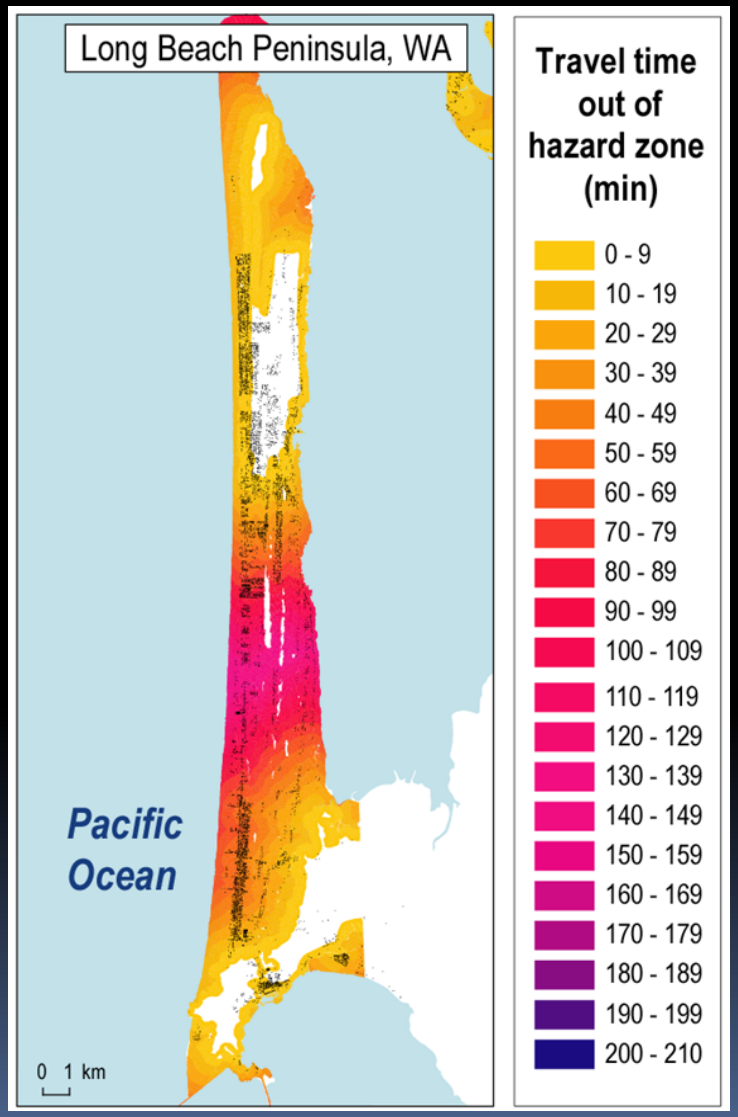
Adaptive Capacity Analysis

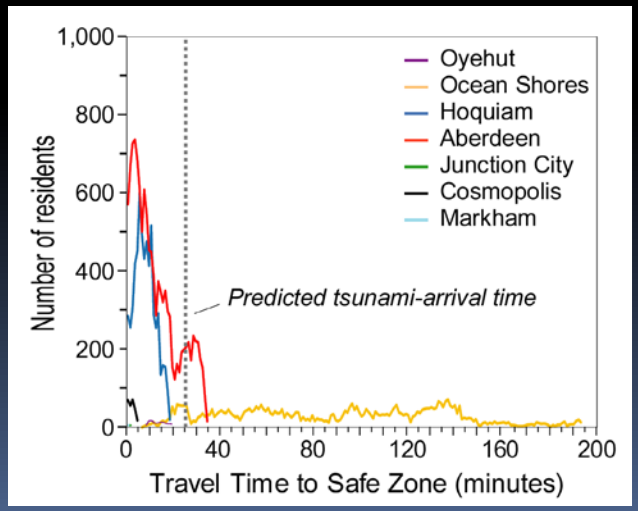
Ability of a system to adjust and take opportunities given a predicted tsunami



Life safety from a near-field tsunami threat is a question of geography and human behavior and not just structural integrity

Examples of Adaptive Capacity Research

- **Pre-event**
  - Preparedness levels
  - Perceptions and risk tolerance
  - Willingness to pay for adaptation
- **Response**
  - Pedestrian evacuation potential



Potential pedestrian evacuation times out of tsunami-hazard zones (anisotropic, path distance modeling)

from Wood and Schmidtlein, 2012

Risk – what is it and how do we assess it?

Risk = Probability of event **x** Probability of Asset Damage or Loss **x** Number and Value of Exposed Assets

Broader risk definition may be more useful for policy

- Traditional definition useful for structures
- Risk is a social engagement
  - *perceptions, tolerance, willingness to pay for adaptation*
- Not all risks fit nicely in the joint probability paradigm
- Perhaps a national vulnerability assessment could be beneficial as a first step

"Risk is actuarial, whereas vulnerability is actual"

Challenges in applying traditional risk analysis to tsunamis

Tsunamis can be a “Black Swan” Problem

Unexpected events of large magnitude and consequence that dominate history but are considered outliers in risk assessment

http://en.wikipedia.org/wiki/Black_swan_theory

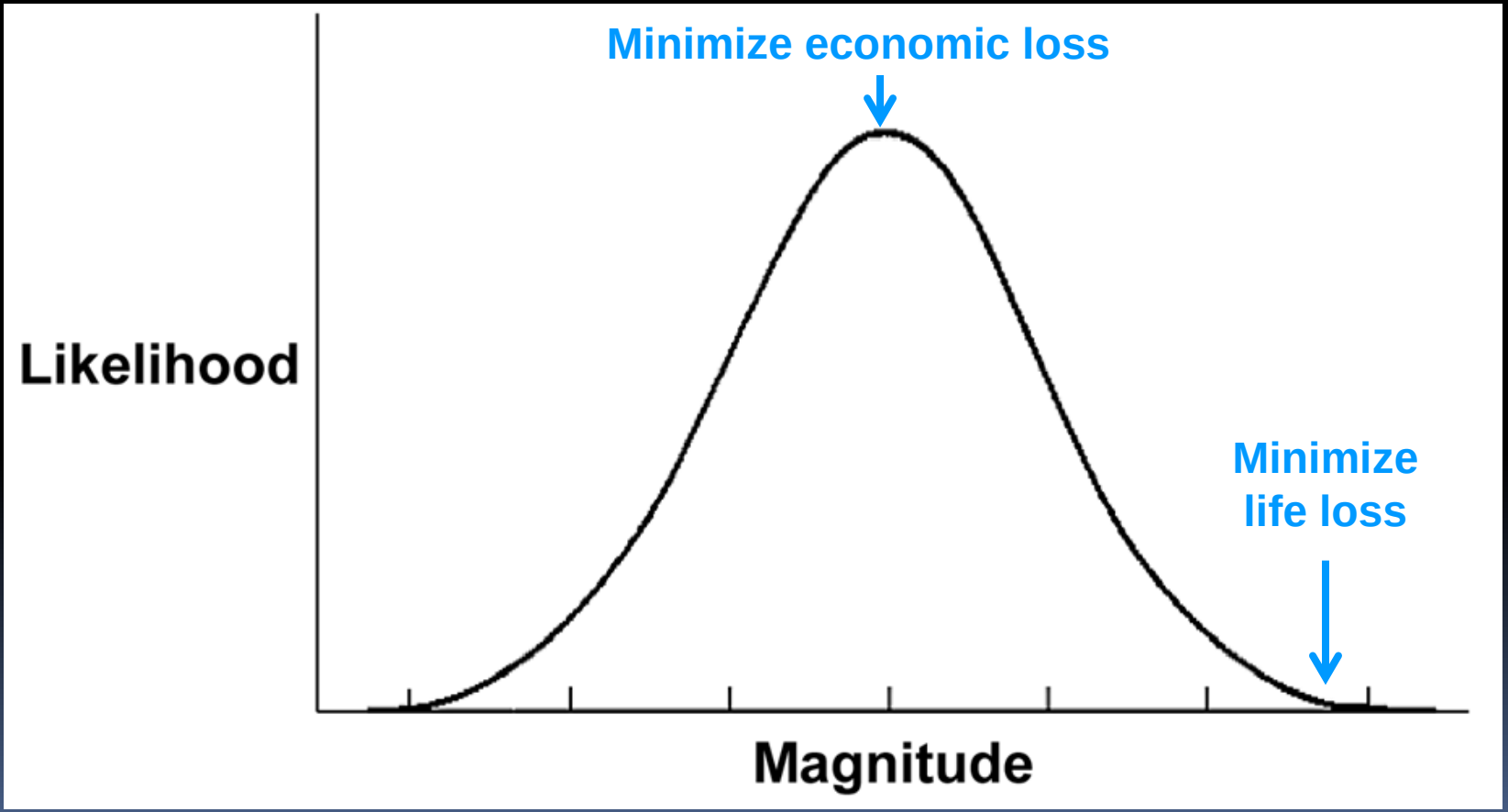
“Black Swan” Criteria

- The event is a surprise (to the observer)
- The event has a major impact
- After the event, it is rationalized by hindsight, as if it could have been expected. Relevant data were available but unaccounted for in risk mitigation programs

Challenges in applying traditional risk analysis to tsunamis

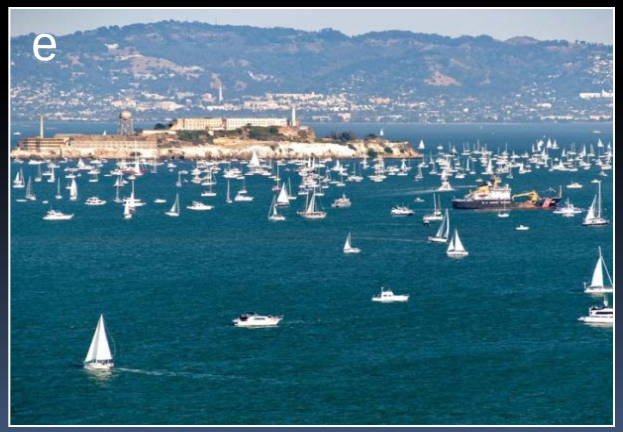
Difficulty handling multiple societal objectives

Possible tsunami scenarios



Challenges in applying traditional risk analysis to tsunamis

Difficulty handling high magnitude, highly dynamic service populations



Photograph credits – (a) City of Huntington Beach
(b, c, and f) Adelman and Adelman
(d) Catalina Island Chamber of Commerce, 2012.
(e) Bay Citizen, 2012

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Challenges in applying traditional risk analysis to tsunamis

Difficulty making distinctions between societal context of far-field and near-field tsunamis

- **Traditional risk focus just on damage and life loss**
- **Societal context and adaptation different**
  - Far-field – managed evacuations over several hours relying on effective communication between agencies
  - Near-field – self-evacuations relying on knowledge of at-risk individual and on distance to high ground
- **Assessing "risk" requires different approaches**
  - Far-field
    - Engineering and economic loss of assets
  - Near-field
    - Engineering and economic loss of assets
    - Perceptions, evacuation potential and behavior of at-risk individuals

Challenges in applying traditional risk analysis to tsunamis

Difficulty handling values for non-structural issues

- **Relatively easy to capture values**
  - Life loss from financial perspective
  - Structures – replacement cost, content loss
  - Regional economic losses – wages, sales volumes

- **Harder to capture values**
  - True impacts of loss of life
    - Psychological and sociological impact of lost loved ones
    - Impact of loss on public policy
  - Loss of livelihoods in context of pre-event conditions
  - Cultural assets
  - Loss of ecosystem goods and services
  - Post-tsunami landscape different (e.g., subsidence)

Things to consider for national risk analysis

- Distinction needed between near-field and far-field threats
  - Far-field threats – economic loss, infrastructure
  - Near-field threats – economic loss, infrastructure, population exposure, evacuation potential, perceptions, community recovery potential
- Different criteria needed for economic loss avoidance and for public safety
  - Economic loss avoidance – probabilistic approach maybe appropriate
  - Pubic safety - invoke precautionary principle; worst-case credible
- Consider intermediate, complementary products
  - Perhaps national vulnerability assessment would be first step to prioritize where detailed risk information is needed (at least for populations)