FRAGILITY OF FLOATING DOCKS FOR SMALL CRAFT MARINAS

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Outline

- What is a Tele-Tsunami?
- Fragility Curves Methodology
- Post-Tsunami Damage Assessment
- Conclusions

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California Tele-Tsunamis

- Tele-Tsunamis: a tsunami that originates from a distant source, defined as more than 1,000 km away or three hours travel from the area of interest, sometimes travelling across an ocean.
- Sources:
  - 2010 Magnitude 8.8 Chile Event (Historical)
  - Magnitude 9.0 Cascadia Scenario
  - 2011 Magnitude 9.0 Japan Event (Historical)
  - Magnitude 9.4 Chile North Scenario
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Is this what a tsunami looks like in California? Ummm…nope.

Source: http://www.bustle.com/

Santa Cruz Harbor 2011 Tohoku Tsunami

- Many ports, harbors, and maritime facilities along the U.S. West Coast were adversely affected by surges and currents induced by the tsunami (Wilson et al. 2013; Wilson et al. 2012).
- In Santa Cruz, all docks sustained some level of damage.
- 30 boats broke free from the docks, several of them sinking and a number sustaining serious damage.
- There are two components in a floating dock system primarily believed to cause damage within the harbor: cleat and pile guide failure.

Source: Santa Cruz Harbor District

Tsunamis *ARE* a natural hazard.

Tsunamis *DO* cause damage.

Tsunamis *ARE NOT* what Hollywood makes of them.

For California, damage from tsunamis IS caused by high flow speed, *NOT* massive waves.

MOTIVATION

- **The Problem:** Existing methodologies to expose tsunami based vulnerably to small craft harbors are limited.
- **The Need:** Develop a robust method to quantitatively estimate the impact of tele-tsunamis to small craft harbors.

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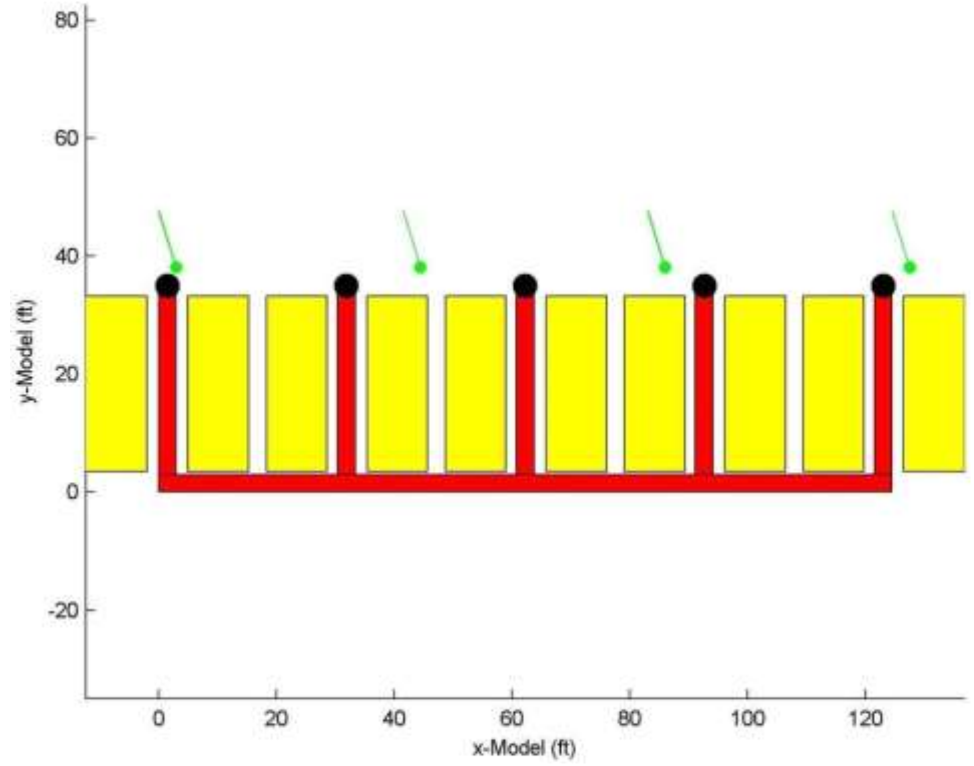
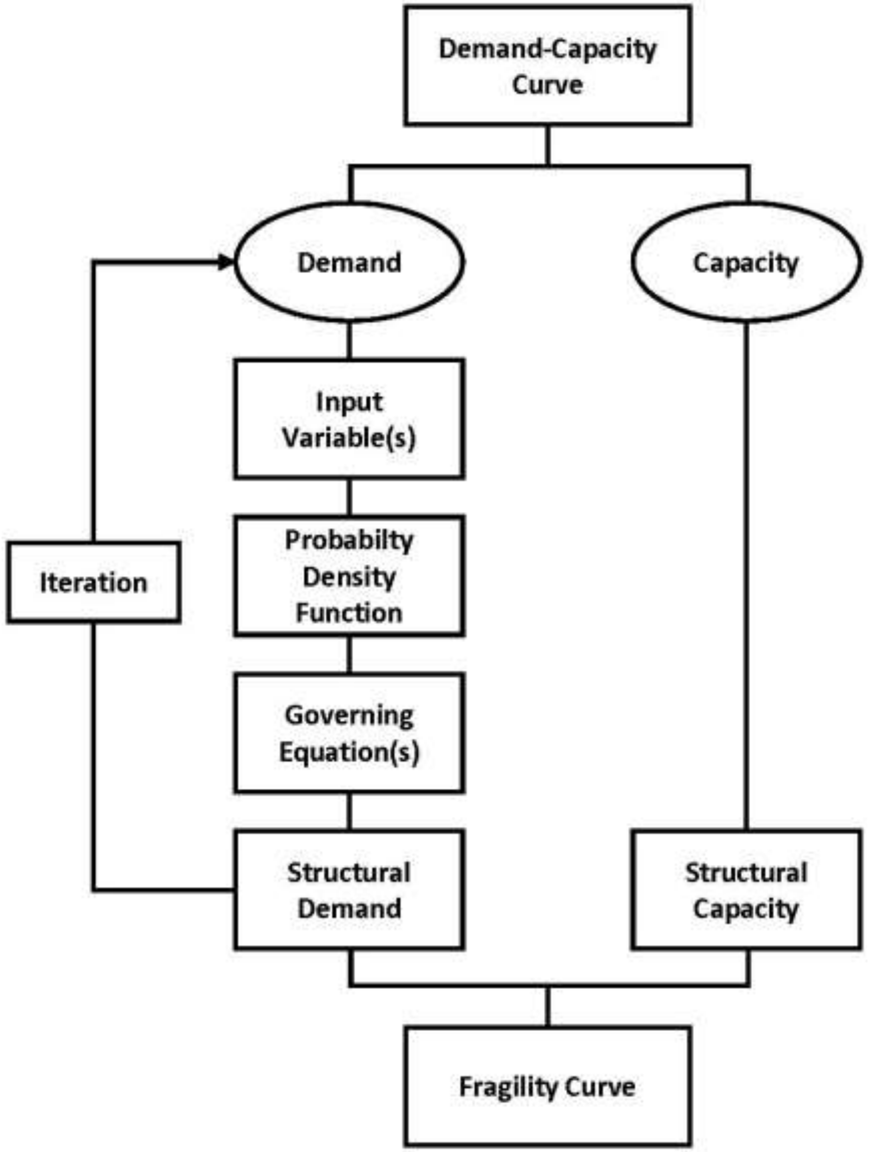
- **Propose:** A physics and Monte-Carlo based approach to fragility curves.





METHODOLOGY: GOVERNING EQUATIONS

Demand to Capacity Equations for Cleats

$$F_{yc} = \frac{1}{2} \rho_w \, V_c^2 \, L_{wl} \, T \, C_{yc} \sin\theta$$

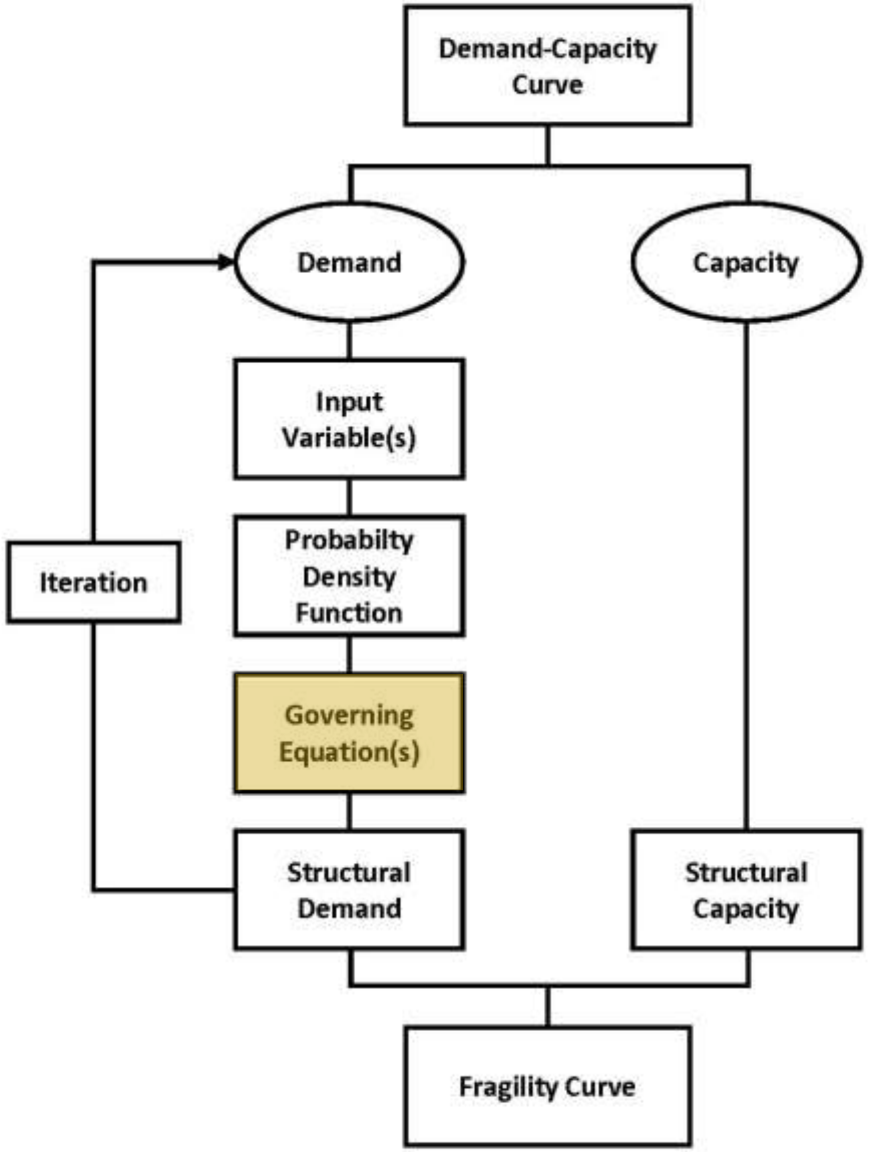
$$F_{xc} = F_{x\,FORM} + F_{x\,FRICTION}$$

$$F_{x\,FORM} = \frac{1}{2} \rho_w \, V_c^2 \, B \, T \, C_{xcb} \cos\theta$$

$$F_{x\,FRICTION} = \frac{1}{2} \rho_w \, V_c^2 \, B \, S \, C_{xca} \cos\theta$$

Demand to Capacity Equations for Pile Guides

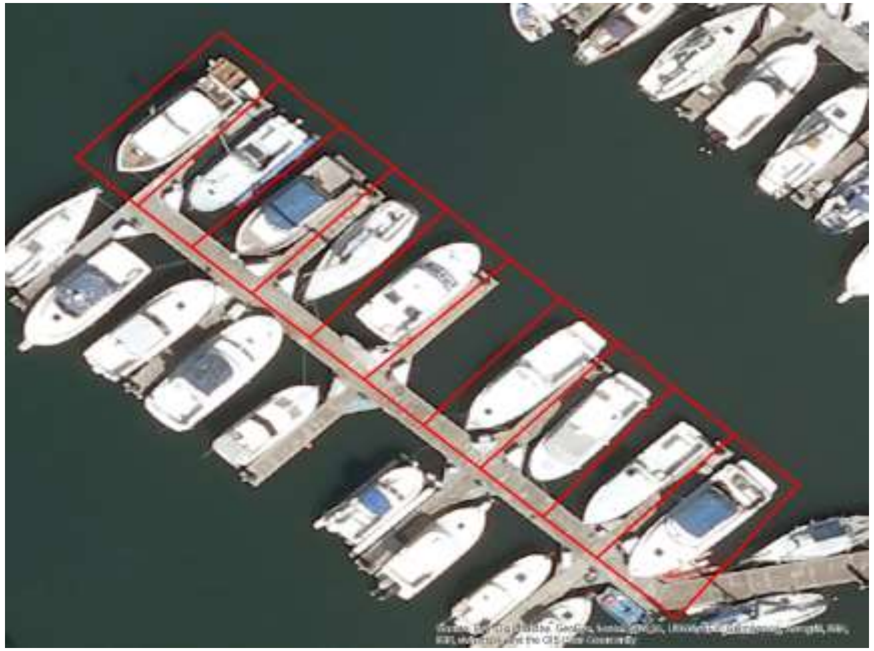
The equations to estimate pile guide demand are the same as cleats except they are **90 degrees out of phase**.

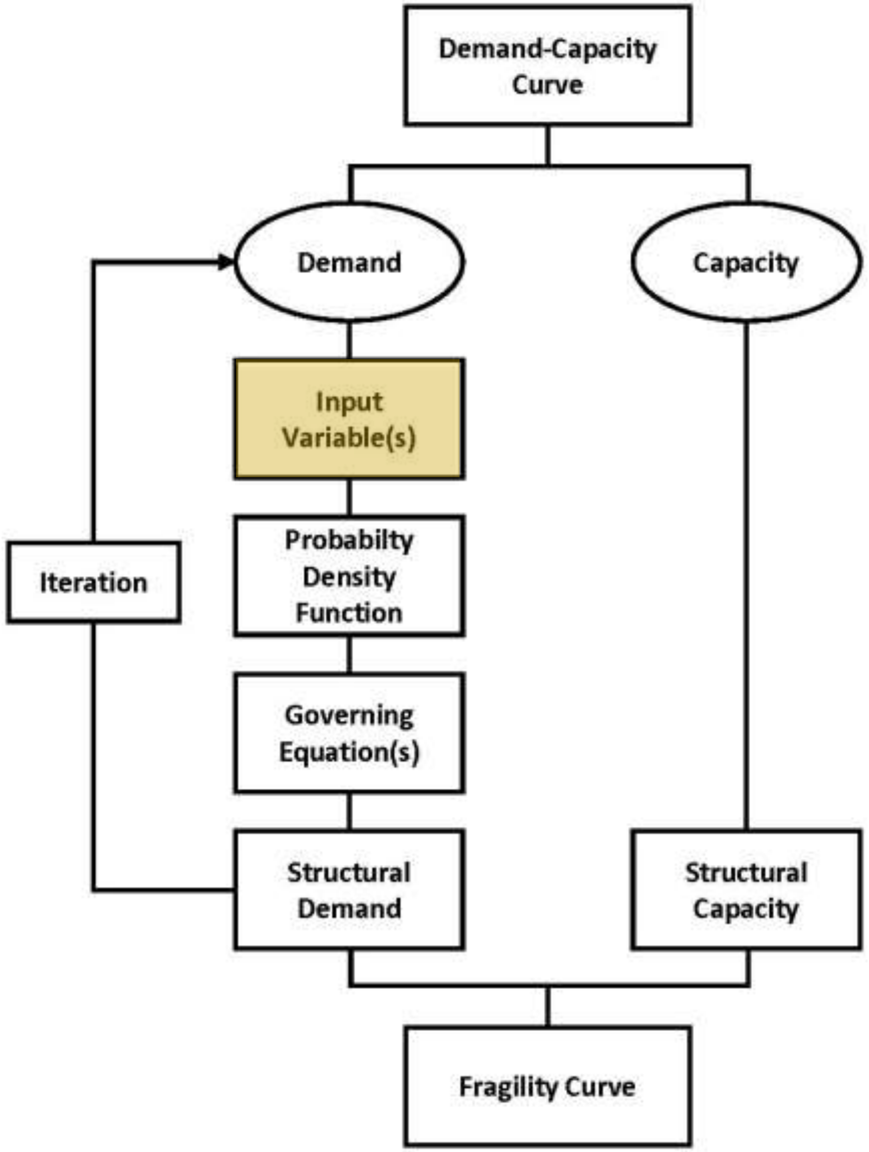


METHODOLOGY: INPUT VARIABLES

From the **aerial images** we get:

- Vessel length, draft
- Finger and walkway length/width, num. of slip/piles

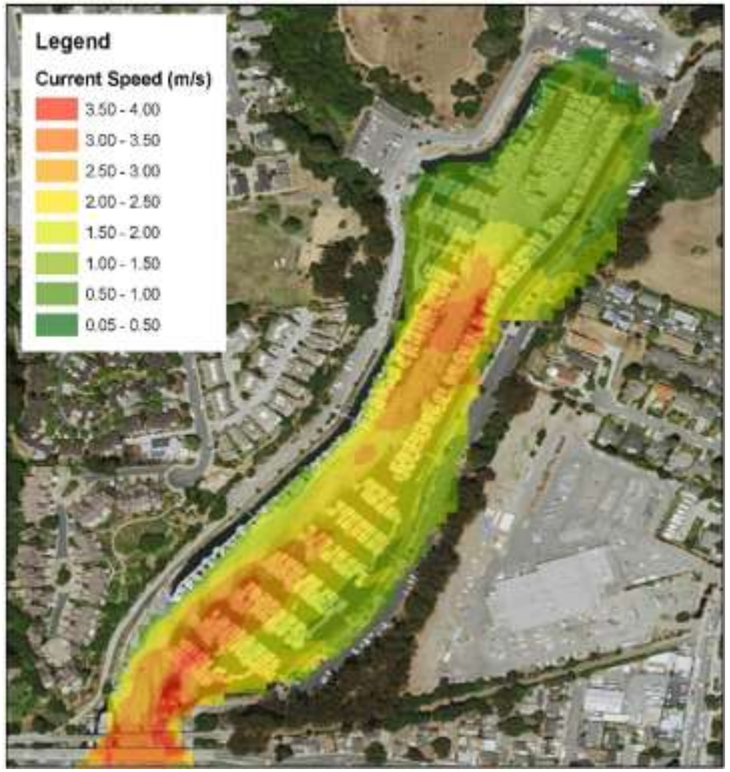


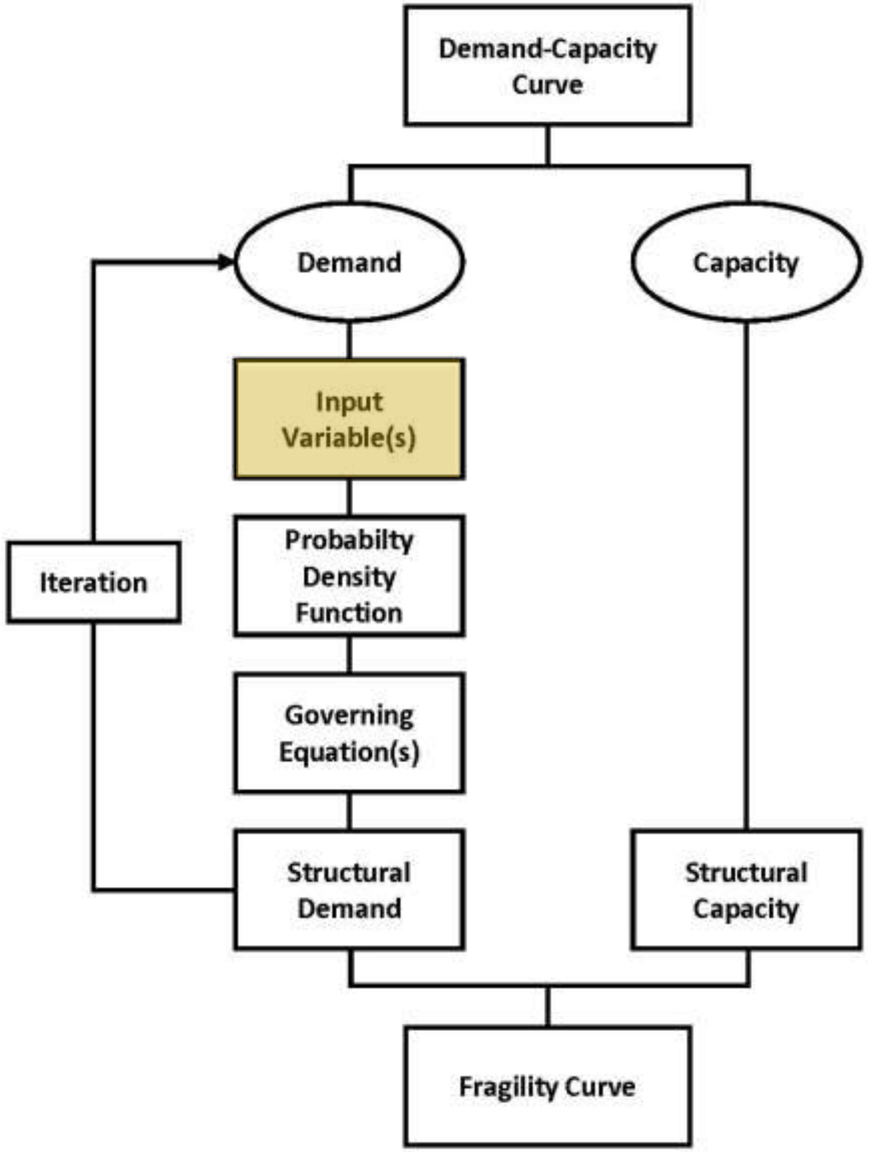


Methodology: Input Variables

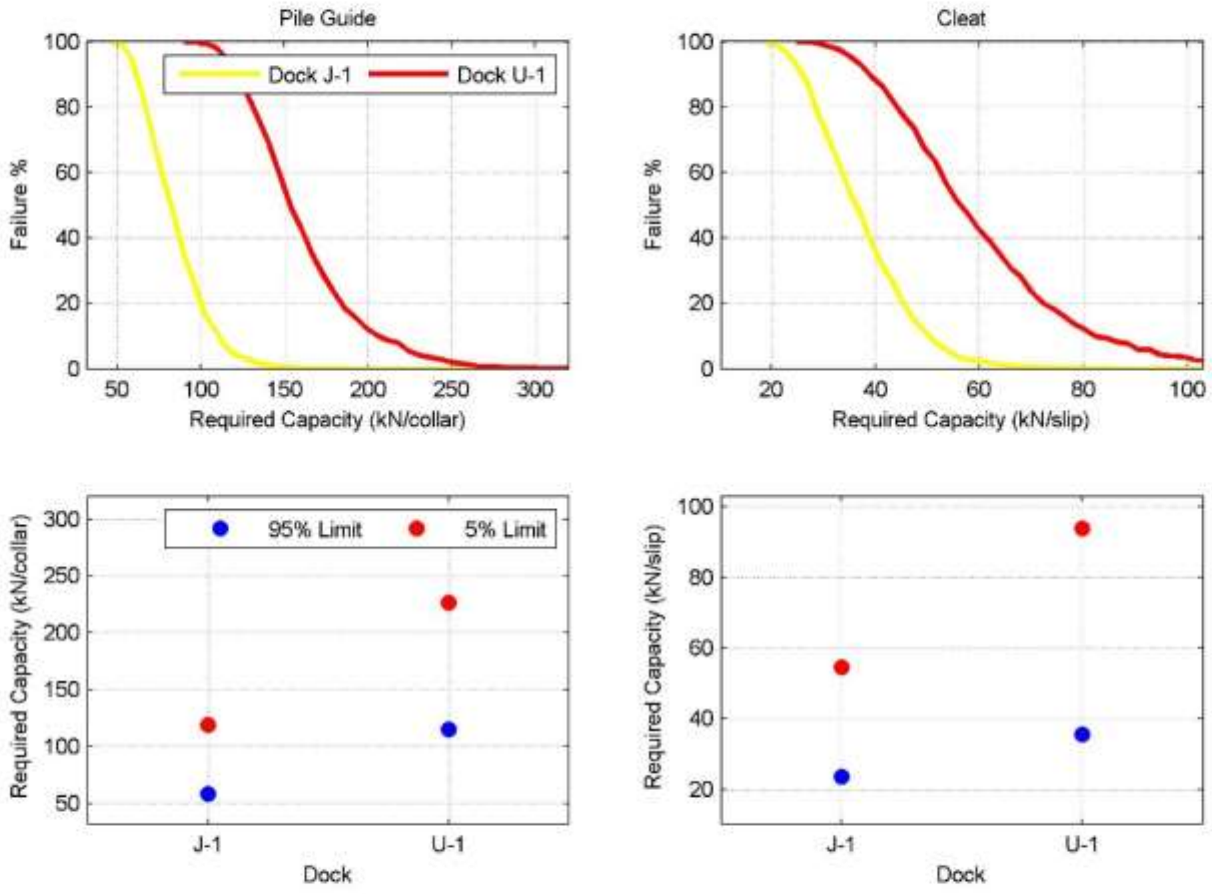
From the **numerical model** we get:

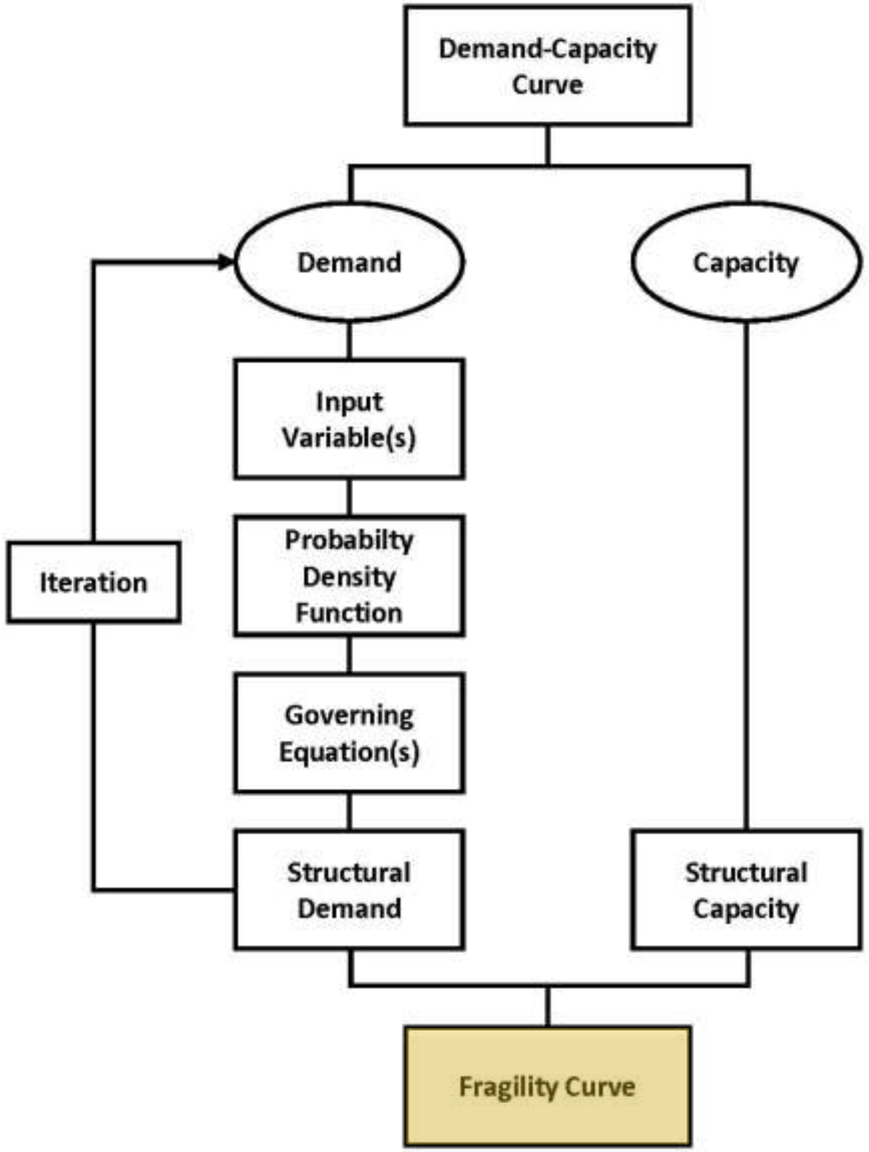
- Current speed/direction/water depth





Methodology: Fragility Curve





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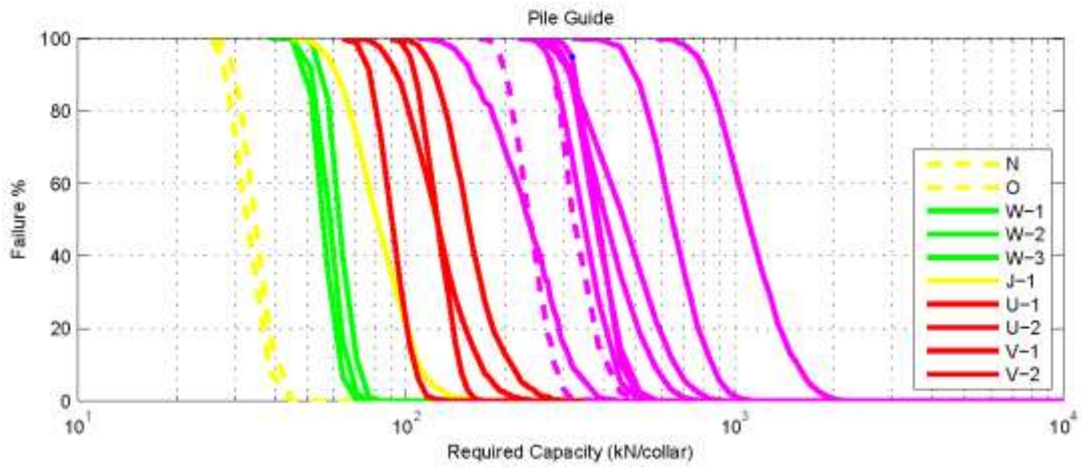
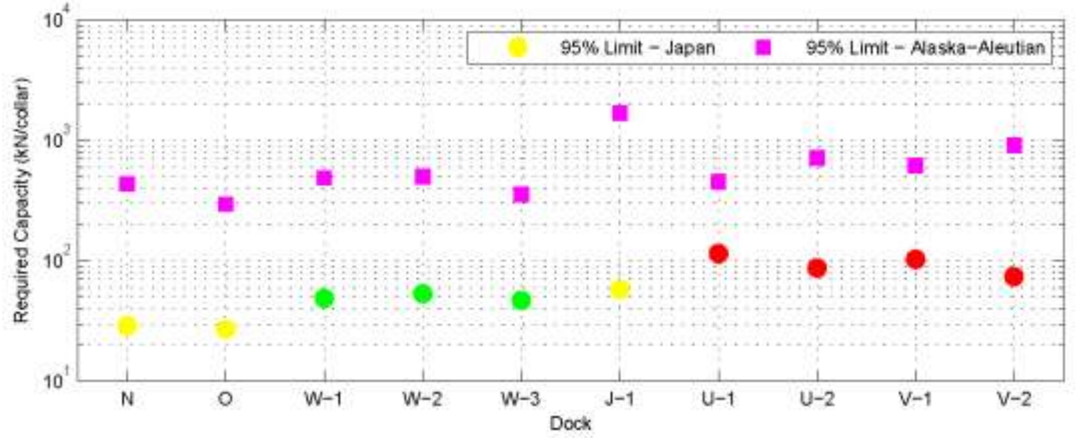
POST-TSUNAMI DAMAGE ASSESSMENT: SANTA CRUZ

- Every floating dock within Santa Cruz sustained damage
- Mesiti-Miller Engineering Inc. conducted a damage evaluation
- Transformed Post Tsunami Damage Assessment: Santa Cruz ratings from A-F to Low-High damage ratings

POST-TSUNAMI DAMAGE ASSESSMENT: PILE GUIDES

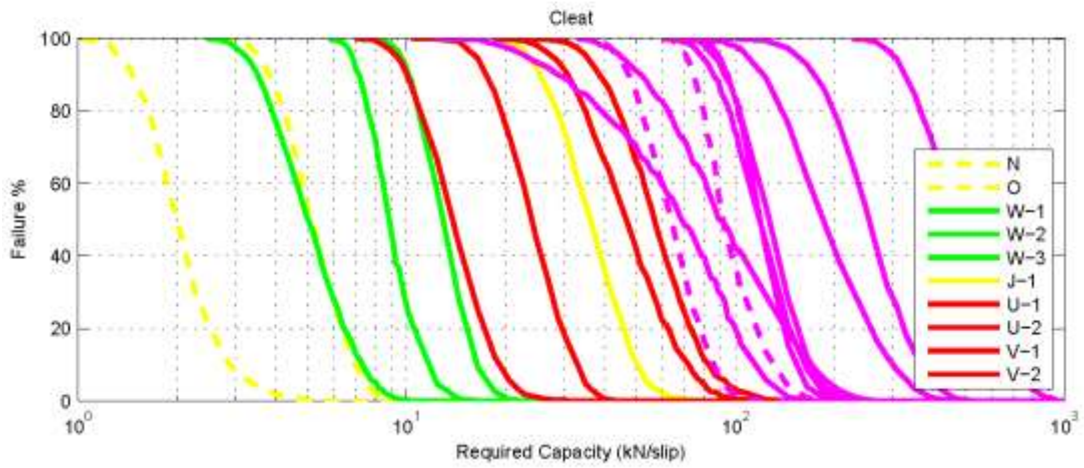
- Results w.r.t. required capacity, can be interpreted as capacity needed to resist the tsunami demand.
- Fragility curves correspond to low (green), medium (yellow), and high (red) levels of damage from damage report
- Damaged components have a relatively large capacity; components that weren't damaged small capacity.

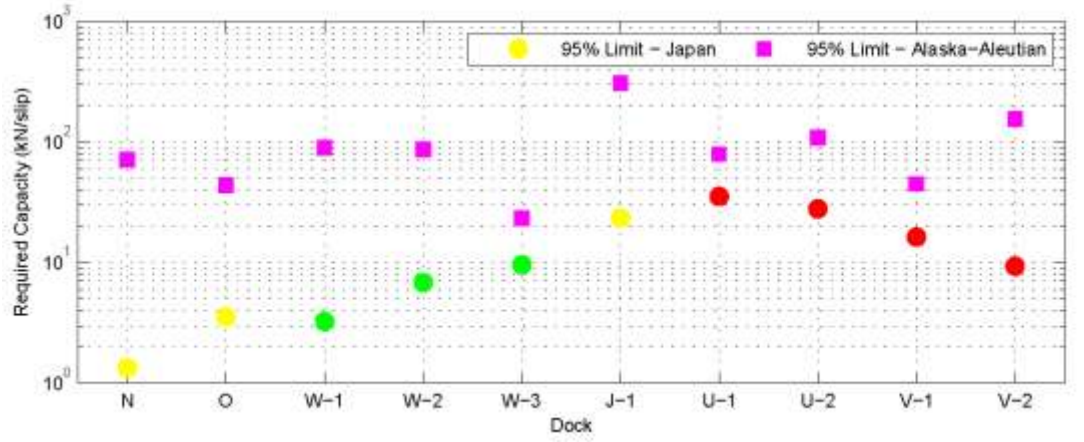




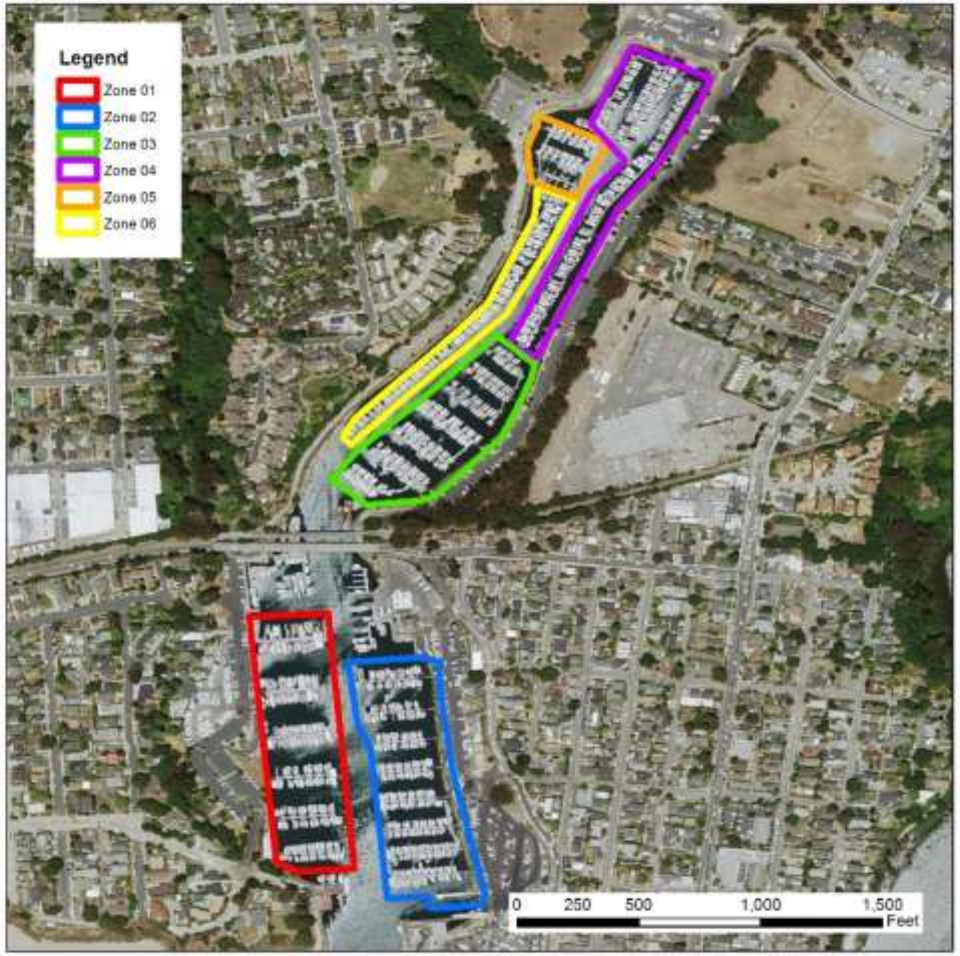
Post-Tsunami Damage Assessment: Cleats

- Results w.r.t. required capacity, can be interpreted as capacity needed to resist the tsunami demand.
- Difference between the north (solid) and south (dashed) harbor basins indicate age has an influence on capacity
- Cleat fragility curves order of magnitude lower than pile guide curves





PRE-TSUNAMI DAMAGE ASSESSMENT



Tsunami Event	Zone					
	1	2	3	4	5	6
2010 Magnitude 8.8 Chile Event (Historical)	Low	Low	Low	Low	Low	Moderate
Magnitude 9.0 Cascadia Scenario	Moderate	Moderate	Moderate	Moderate	Low	High
2011 Magnitude 9.0 Japan Event (Historical)	Moderate	Low	High	Moderate	Low	Moderate
Magnitude 9.4 Chile North Scenario	Moderate	Moderate	High	Moderate	Moderate	Moderate
Magnitude 9.2 Eastern Aleutian-Alaska Scenario	High	Moderate	Moderate	Moderate	Moderate	High

Keen, A.S., P.J. Lynett and A. Ayca (In Prep.). "Observation Based Estimates of Cleat and Pile Guide Capacities for Small Craft Harbors in California." Journal of Waterway, Port, Coastal, and Ocean Engineering.

Conclusion

- Developed a **robust method** to quantitatively estimate the impact of tele-tsunamis to small craft harbors.

- Method was able to capture variably in structural capacity for both **cleats** and **pile guides**.

- Can be used as a **predictive tool** to estimate future tsunami risk for small craft harbors.

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