

So Many Earthquakes: What Has the Potential to Change the Way We Do Business?

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Geo-engineering Extreme Events Reconnaissance
Turning Disaster into Knowledge

www.geerassociation.org



Summary of Geotechnical Issues

Event	M_w
Haiti	7.0
Chile	8.8
New Zealand	7.1/6.2
Japan	9.0



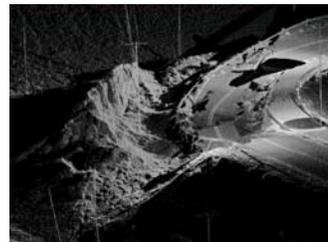
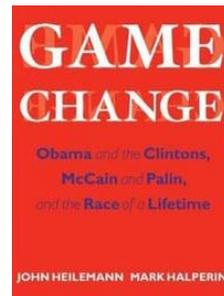
Summary of Geotechnical Issues

Event	M _w	No. of Records	Levees	Dams	Landslides	Damage Patterns	Topo. Effects
Haiti	7.0	0			✓ minor	✓	✓
Chile	8.8	~30		✓	✓ minor		
New Zealand	7.1/6.2	~30/20	✓		✓		
Japan	9.0	> 1000	✓	✓			

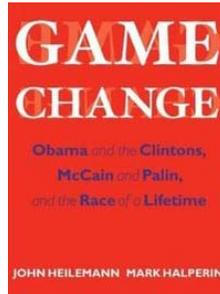


Game Change

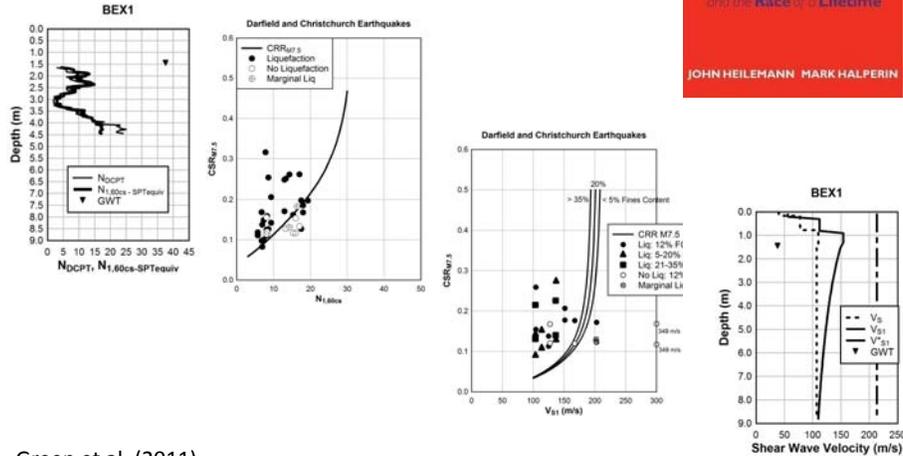
- Rapid site characterization during reconnaissance
 - MASW (Vs), DCP, LIDAR, mapping



Game Change

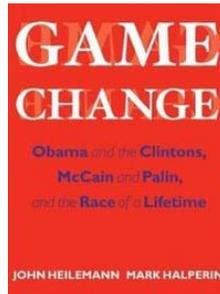


- Rapid evaluation of effects



Green et al. (2011)

Game Change

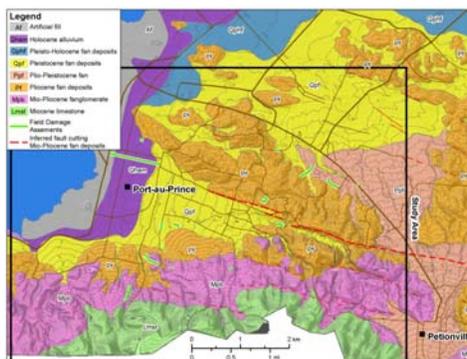
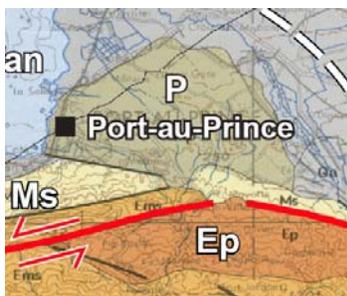
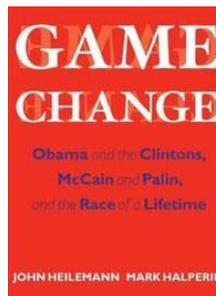


- Rapid site characterization during reconnaissance
 - Photos to point cloud



Game Change

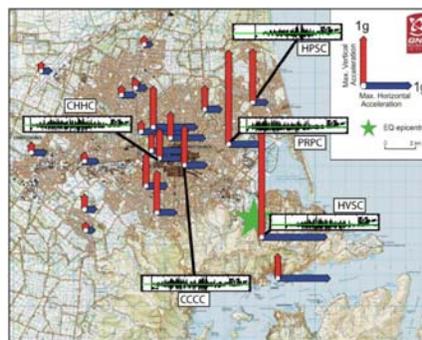
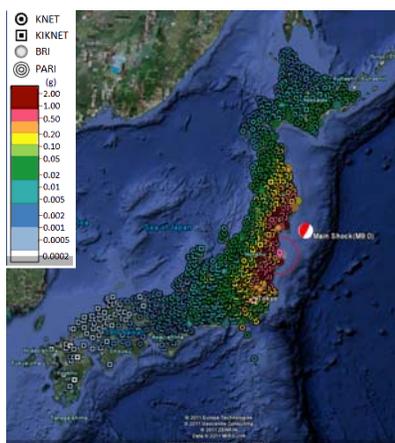
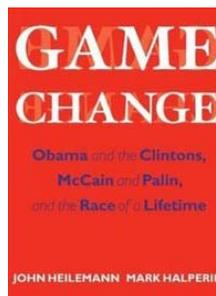
- Rapid mapping/microzonation

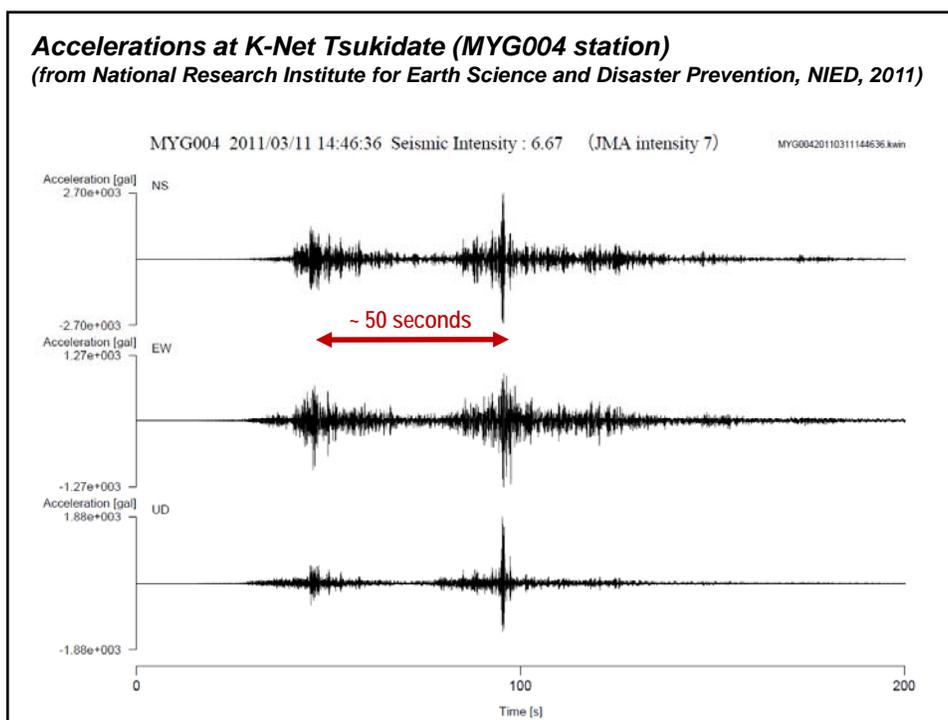
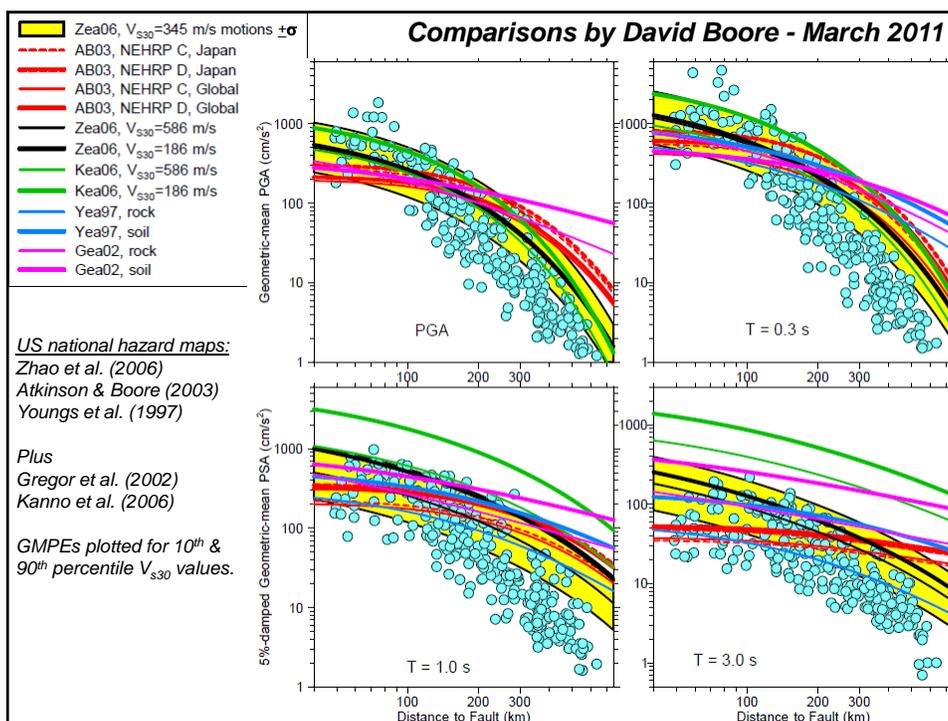


Rathje et al. (2011), Cox et al. (2011)

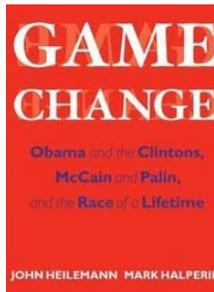
Game Change

- Ground motion recordings



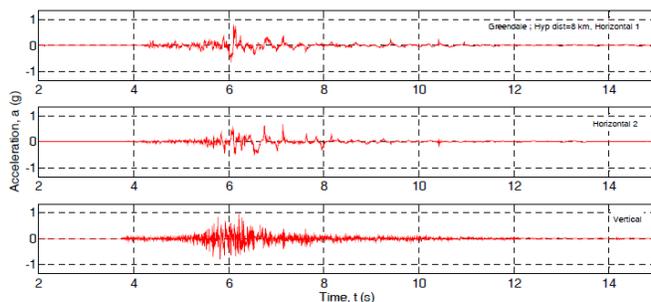


Game Change

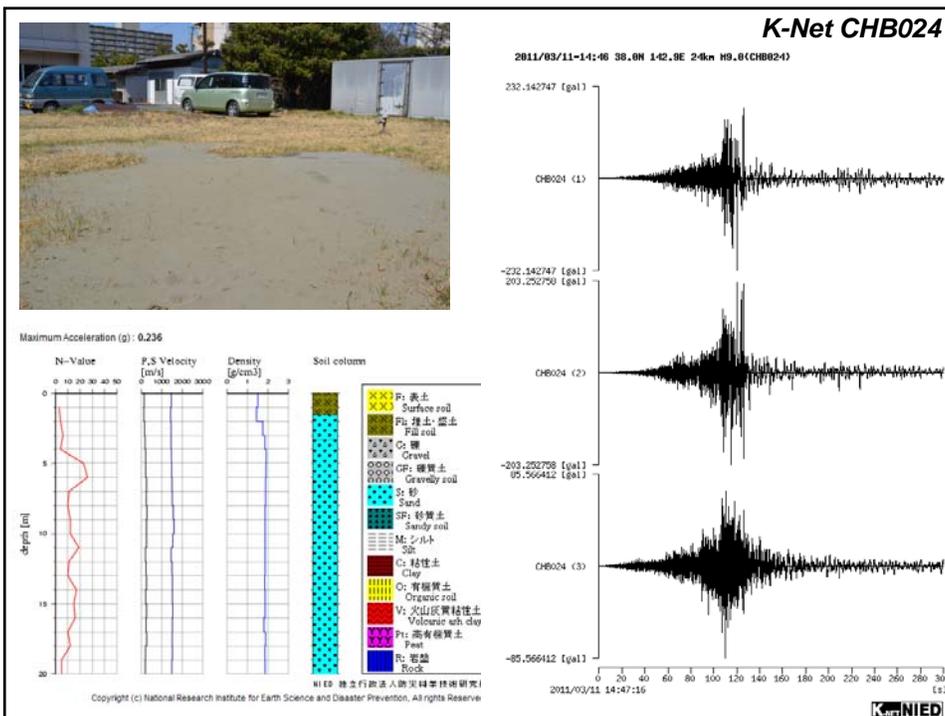


- Recordings at liquefaction sites

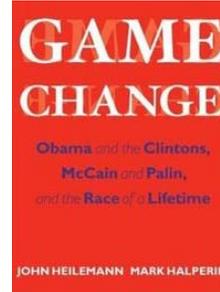
Greendale, Darfield EQ



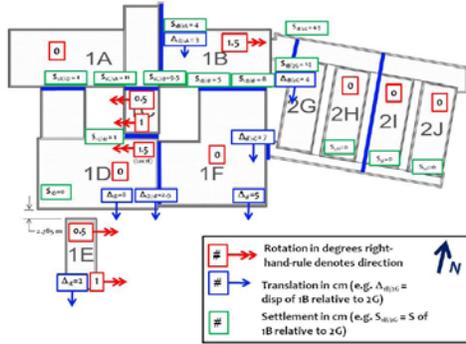
Bradley et al. (2011)



Game Change



- Liquefaction Consequences
 - Building Performance

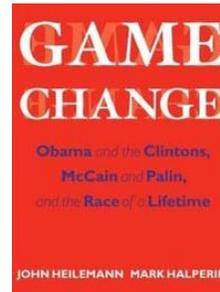


Bray et al. (2011)



Cubrinovski et al. (2011)

Game Change



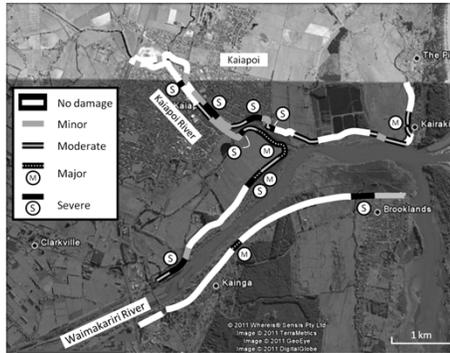
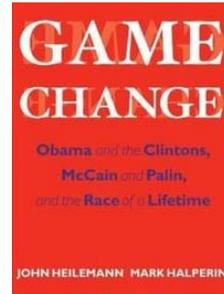
- Response during multiple events

Cubrinovski et al. (2011)

Event	Geometric Mean PGA (g)				Cyclic Stress Ratio CSR _{7.5} ^{a)}				Magnitude Scaling Factor MSF ^{b)}
	CBGS	CCCC	CHHC	REHS	CBGS	CCCC	CHHC	REHS	
4 SEP 10 M _w =7.1	0.158	0.224	0.173	0.252	0.089	0.127	0.098	0.142	1.15
26 DEC 10 M _w =4.7	0.270	0.227	0.162	0.245	0.097	0.082	0.058	0.088	1.80
22 FEB 11 M _w =6.3	0.501	0.429	0.366	0.522	0.208	0.178	0.152	0.217	1.56
13 JUN 11 M _w =5.3	0.183	-	0.199	0.188	0.066	-	0.072	0.068	1.80
13 JUN 11 M _w =6.0	0.163	-	0.215	0.264	0.060	-	0.079	0.097	1.77

Game Change

- Liquefaction Consequences
 - Levee performance (NZ)

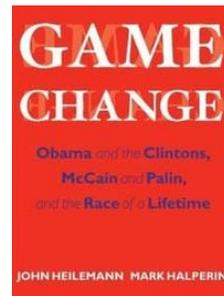


Green et al. (2011)



Game Change

- Liquefaction Consequences
 - Levee performance (Japan)



From L. Harder, R. Boulanger

Levee Damage in the Tohoku Region (MLIT 2011)

River System	Type and Number of Levee Damage Sites Reported							
	Failure	Settlement	Slope Slumping	Levee Cracking	Revetment/Wall Damage	Gate Damage	Other	Total
Mabuchi	0	1	1	1	5	1	5	13
Kitakami	13	62	47	278	121	67	58	646
Naruse	9	27	25	183	56	26	37	363
Natori	1	2	1	26	2	2	1	35
Abukuma	2	26	16	73	2	10	3	132
TOTAL	25	118	90	561	186	106	104	1190

Summary

- Reconnaissance efforts
- Ground motion recordings
 - Effect of liquefaction
 - Site effects
- Liquefaction Consequences
 - Long duration shaking, multiple events
 - Effects on infrastructure

