NREL
NATIONAL RENEWABLE ENERGY LABORATORY

The U.S. Wave Energy Resource

California Ocean Renewable Energy Conference

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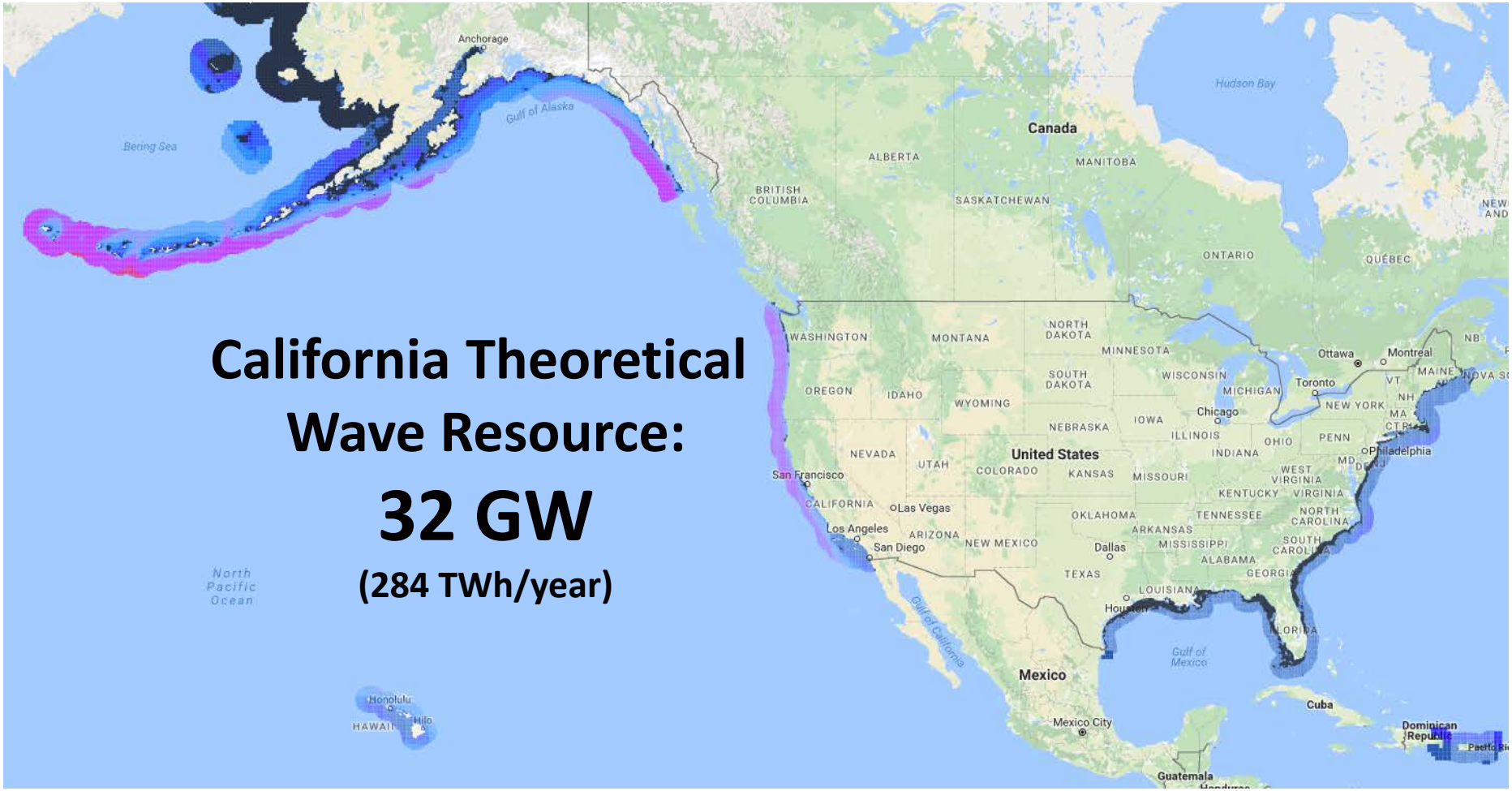
The U.S. Wave Energy Resource



Theoretical Resource: Total wave energy incident on coastline (no exclusions)

Wave Energy Site/Market Identification

Large Markets

		Region	Resource [kW/m]	Market [MW]		Range [km]	Shipping [$/ton]	Depth [m]	Score
1	Oregon	West Coast	31	5,400	L	4.2	0	78	10.0
2	N. California	West Coast	31	1,400	L	5.4	0	99	9.7
3	Washington	West Coast	30	620	T	4.7	0	87	9.5
4	C. California	West Coast	25	2,500	R	6.0	0	92	9.4
5	S. California	West Coast	22	1,300	R	6.0	0	51	9.0
6	Oahu	Pacific	23	350	R	6.7	89	96	8.6
7	Maui	Pacific	20	140	L	8.5	96	134	7.8
8	Kauai	Pacific	23	52	L	8.2	97	150	7.7
9	Hawaii	Pacific	13	140	L	5.2	103	127	7.5
10	Puerto Rico	Caribbean	7	340	R	8.3	40	128	6.7

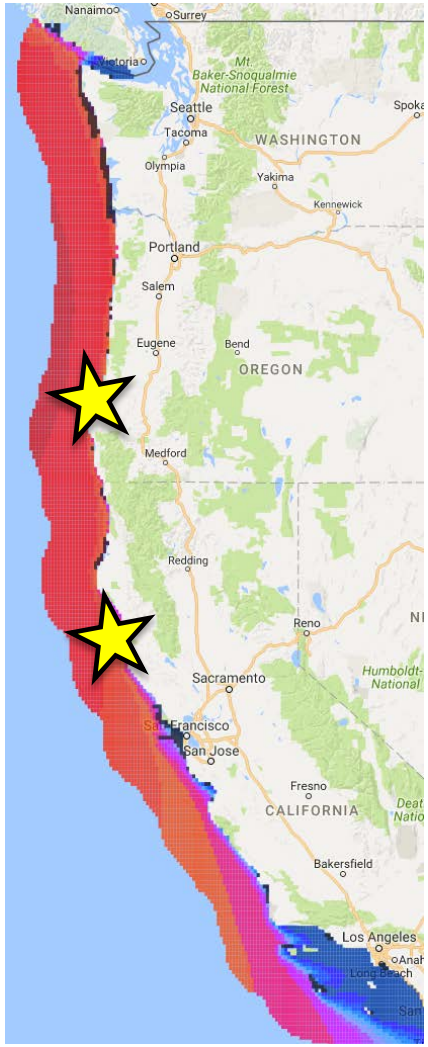
Early Markets

		Region	Resource [kW/m]	Market [MW]		Energy Cost [$/kWh]	Range [km]	Shipping [$/ton]	Depth [m]	Score
1	Oahu	Pacific	23	350	R	0.28	6.7	89	96	8.0
2	Kauai	Pacific	23	52	L	0.36	8.2	97	150	7.6
3	N. California	West Coast	31	1,400	L	0.11	5.4	0	99	7.6
4	Maui	Pacific	20	140	L	0.31	8.5	96	134	7.5
5	C. California	West Coast	25	2,500	R	0.11	6.0	0	92	7.4
6	Hawaii	Pacific	13	140	L	0.34	5.2	103	127	7.4
7	S. California	West Coast	22	1,300	R	0.11	6.0	0	51	7.1
8	Oregon	West Coast	31	5,400	L	0.06	4.2	0	78	7.0
9	Majuro	Pacific	18	7.0	L	0.36	5.0	271	100	6.5
10	Washington	West Coast	30	620	T	0.04	4.7	0	87	6.4

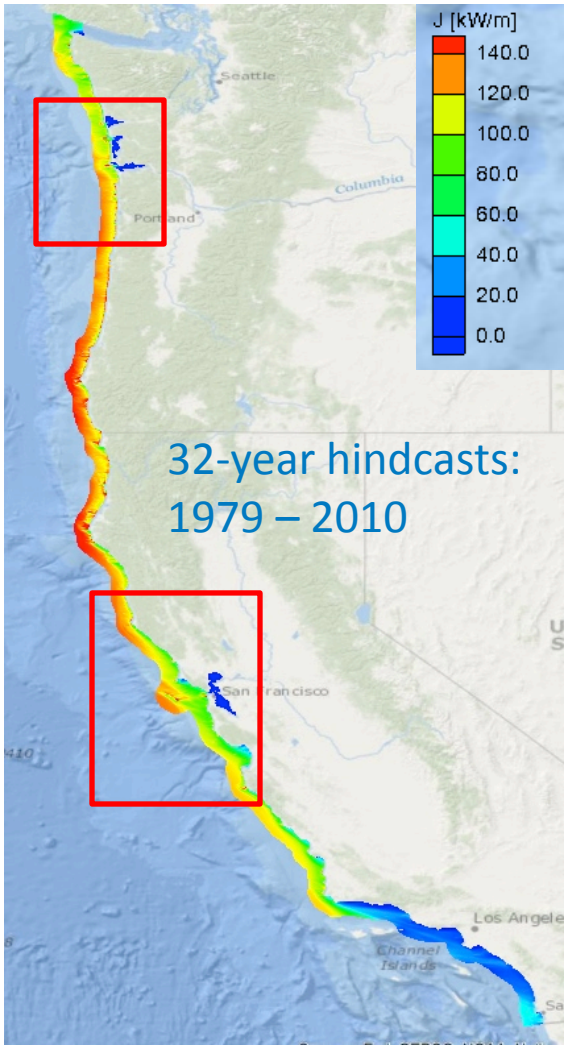
http://www.nrel.gov/docs/fy17osti/66038.pdf

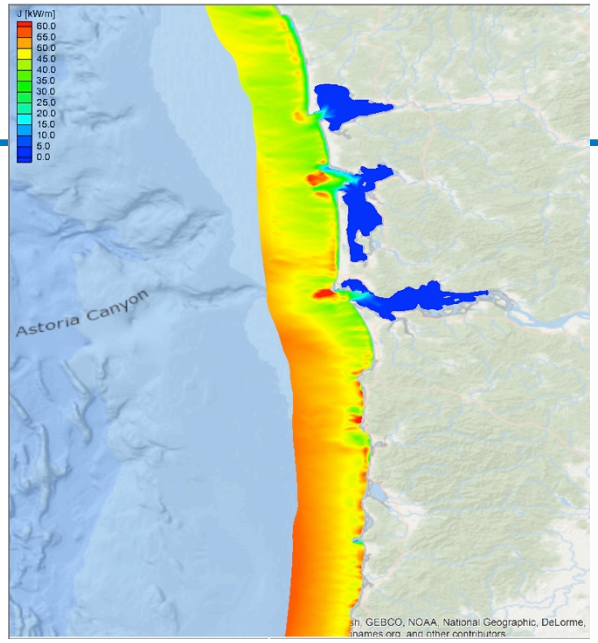
West Coast Wave Resource

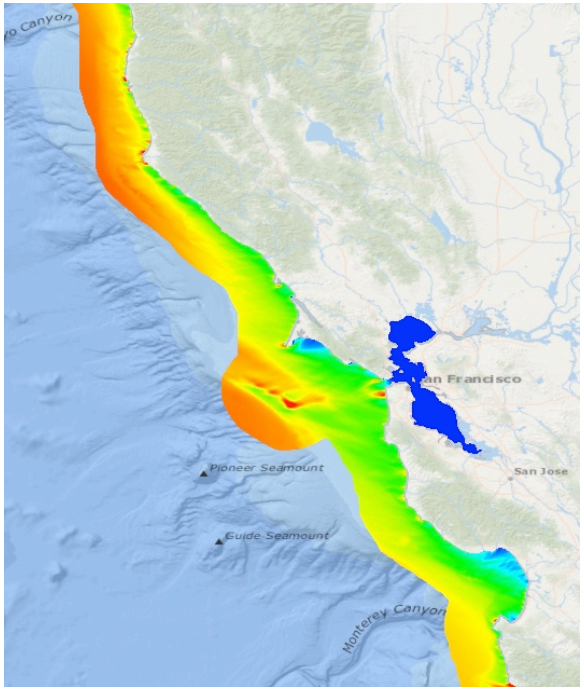
December (EPRI, 4'x4')



Dec, 2009 (PNNL, 12"x12")



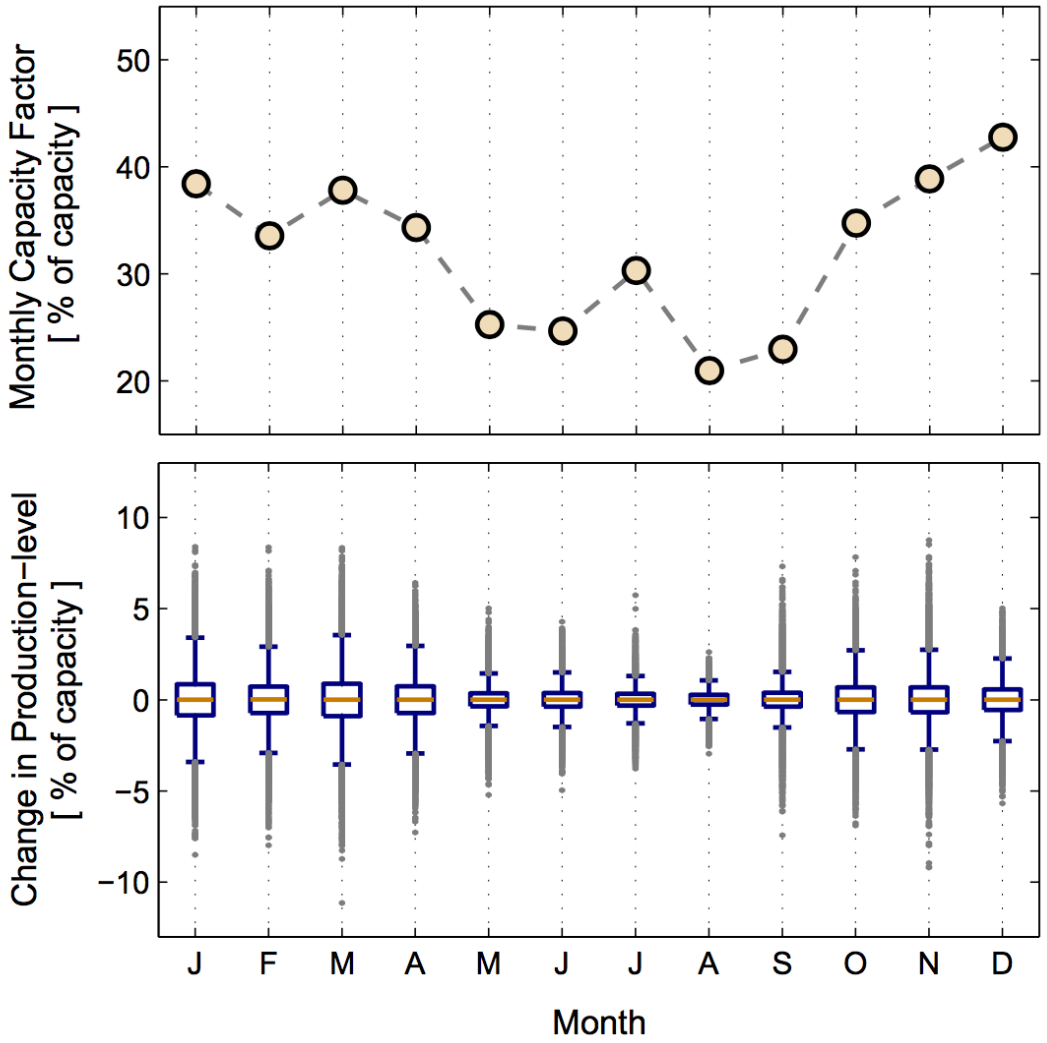




West Coast Simulated Wave Energy Generation

- 5 arrays of 100 1MW devices = 500 MW total capacity
- 2010 resource data

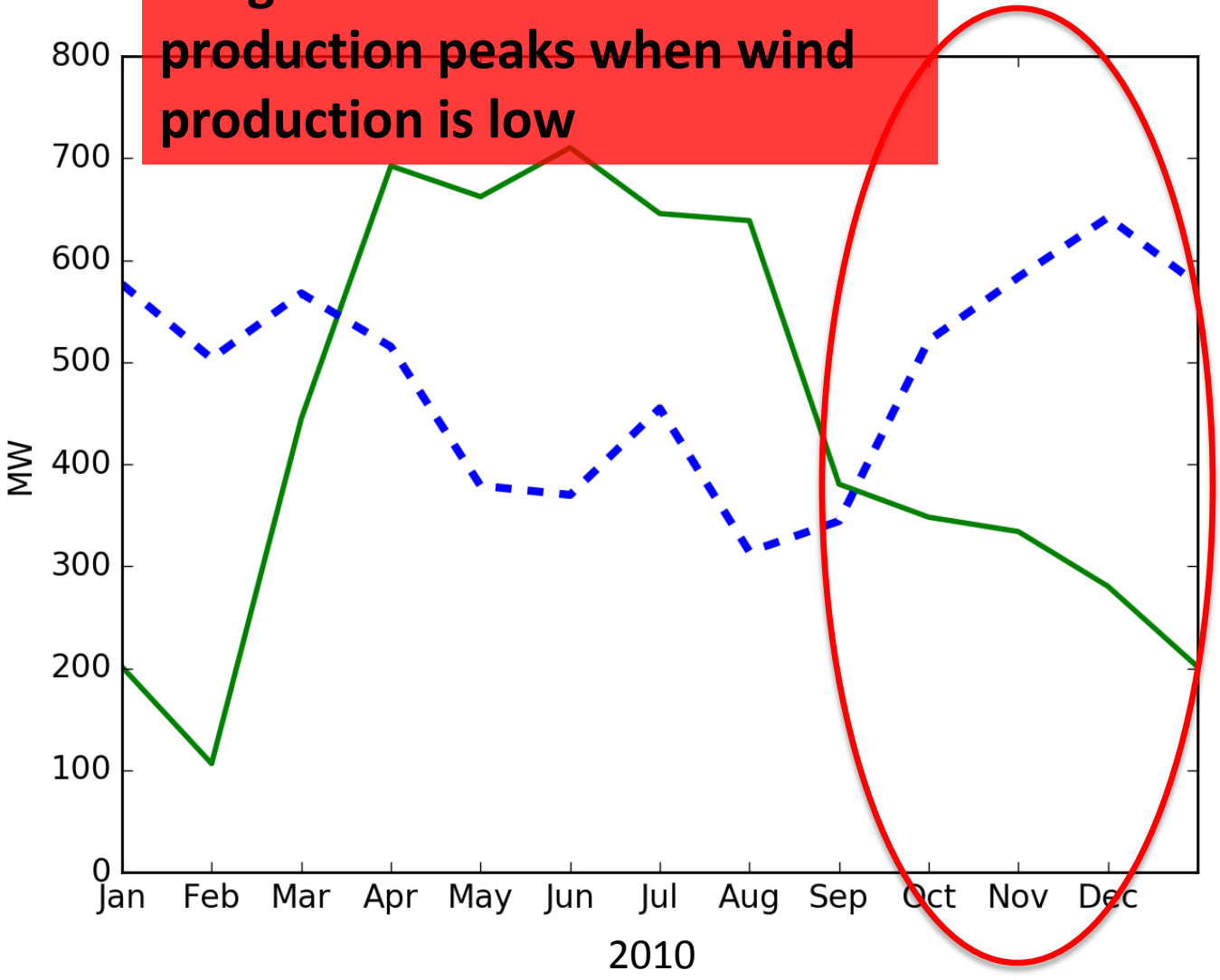
- **Highest generation in winter**
- **Low minute-by-minute variability**



Parkinson, Dragoon, Reikard, García-Medina, Özkan-Haller, and Brekken (2015), *Integrating ocean wave energy at large-scales: A study of the US Pacific Northwest*, Renewable Energy.

The Value of Resource Diversity

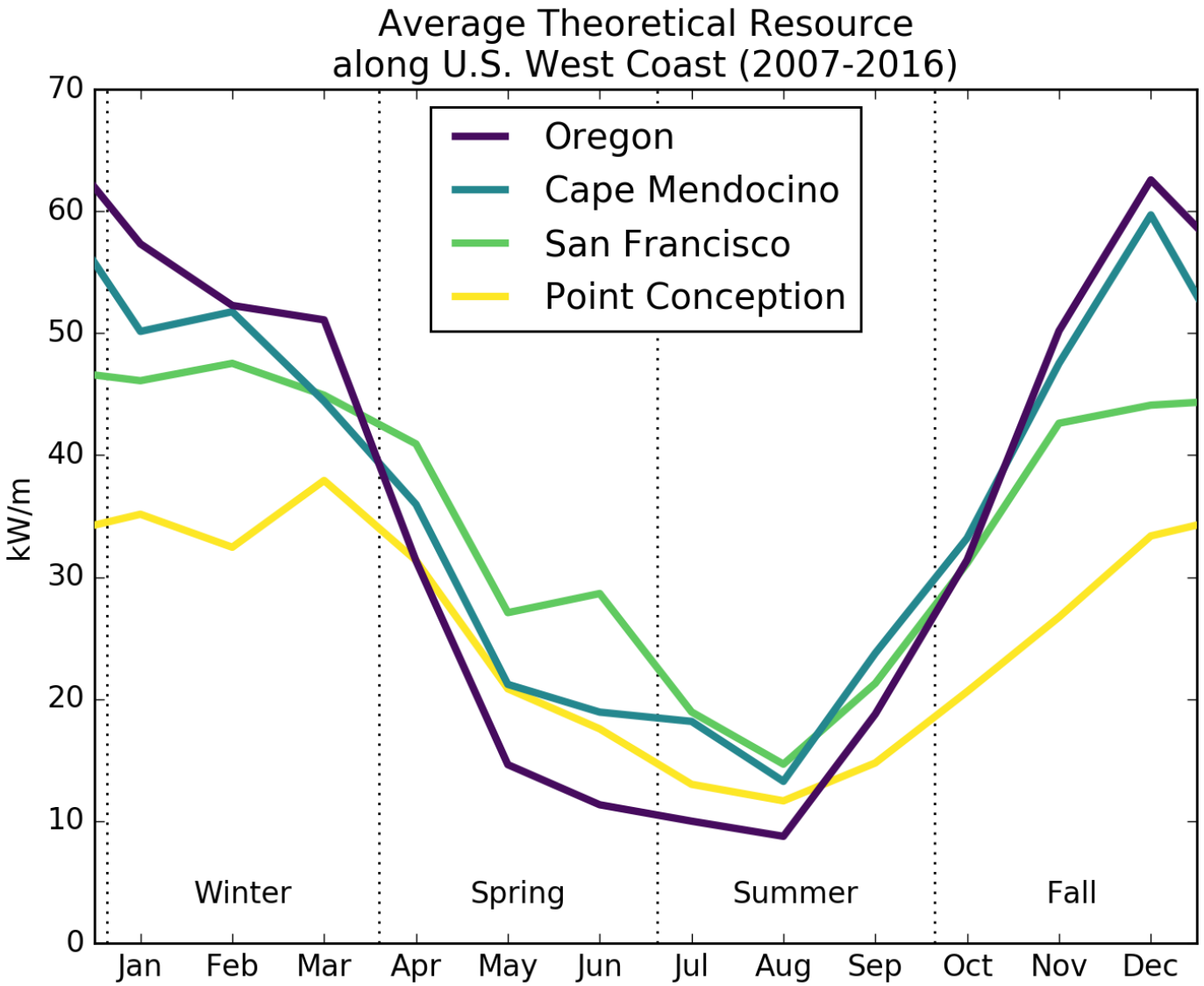
Oregon: simulated wave production peaks when wind production is low



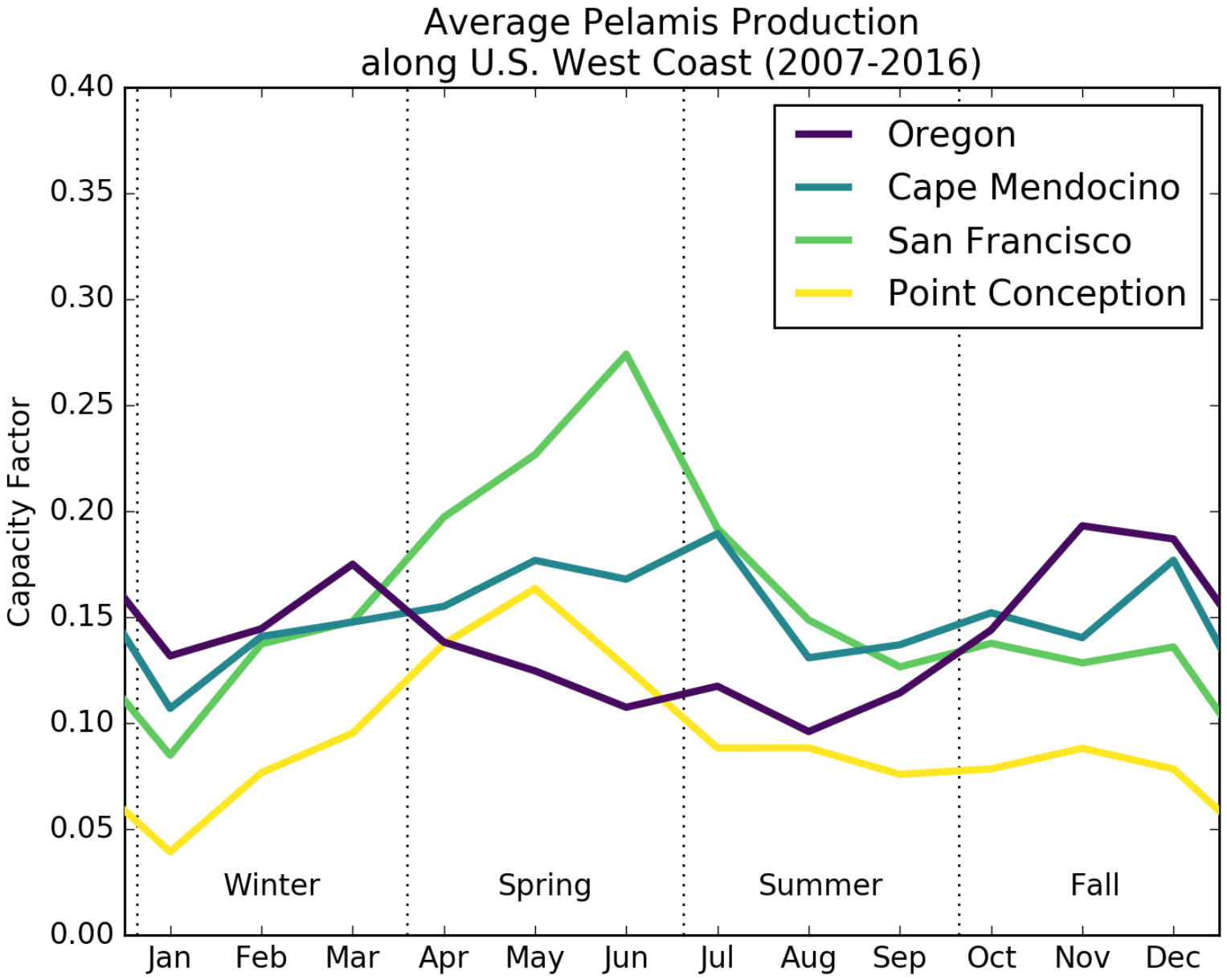
Wind: U.S. Energy Information Administration (eia.gov)

Wave: Parkinson etal (2015).

Spatial variability



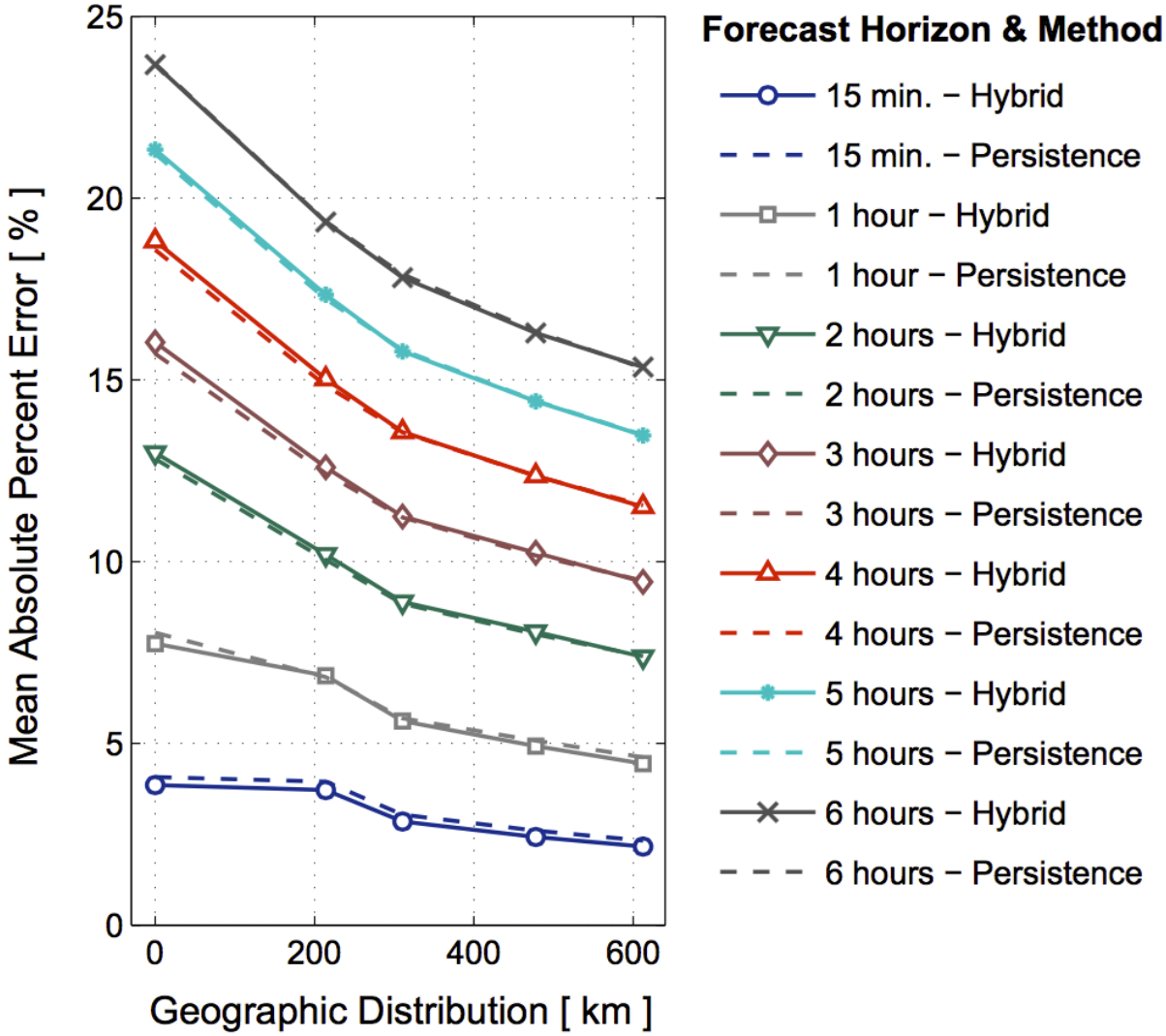
Device details change production



Wave energy is predictable

Low variability and high predictability suggests low integration costs

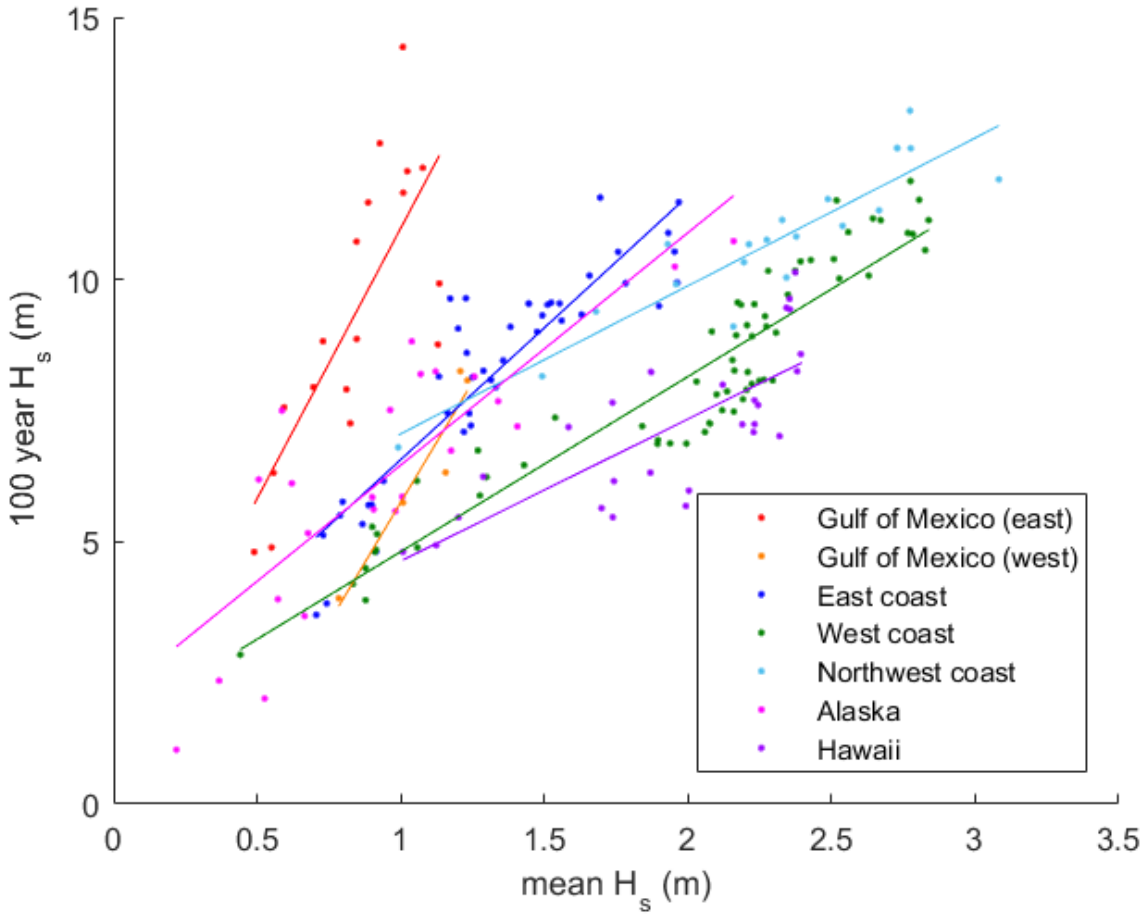
"You can see the waves coming."



Parkinson etal. (2015).

Extreme events

Hawaii and West Coast: small 100-year waves compared to average



Vince Neary, Kevin Hass, Sara Bredin
(Sandia National Lab & Georgia Tech)

Summary

The U.S. West Coast has an **abundant wave energy resource**:

- **Wave energy** may be able to **balance seasonal variability** of other renewables
- **Array siting** can help **meet seasonal demand** profiles
- **Low variability** and **high predictability** are expected to lead to low integration costs
- Pacific has a high 'mean-to-extreme' ratio

  "your steel will work for you"