Empirical Method for Estimating Surf Heights

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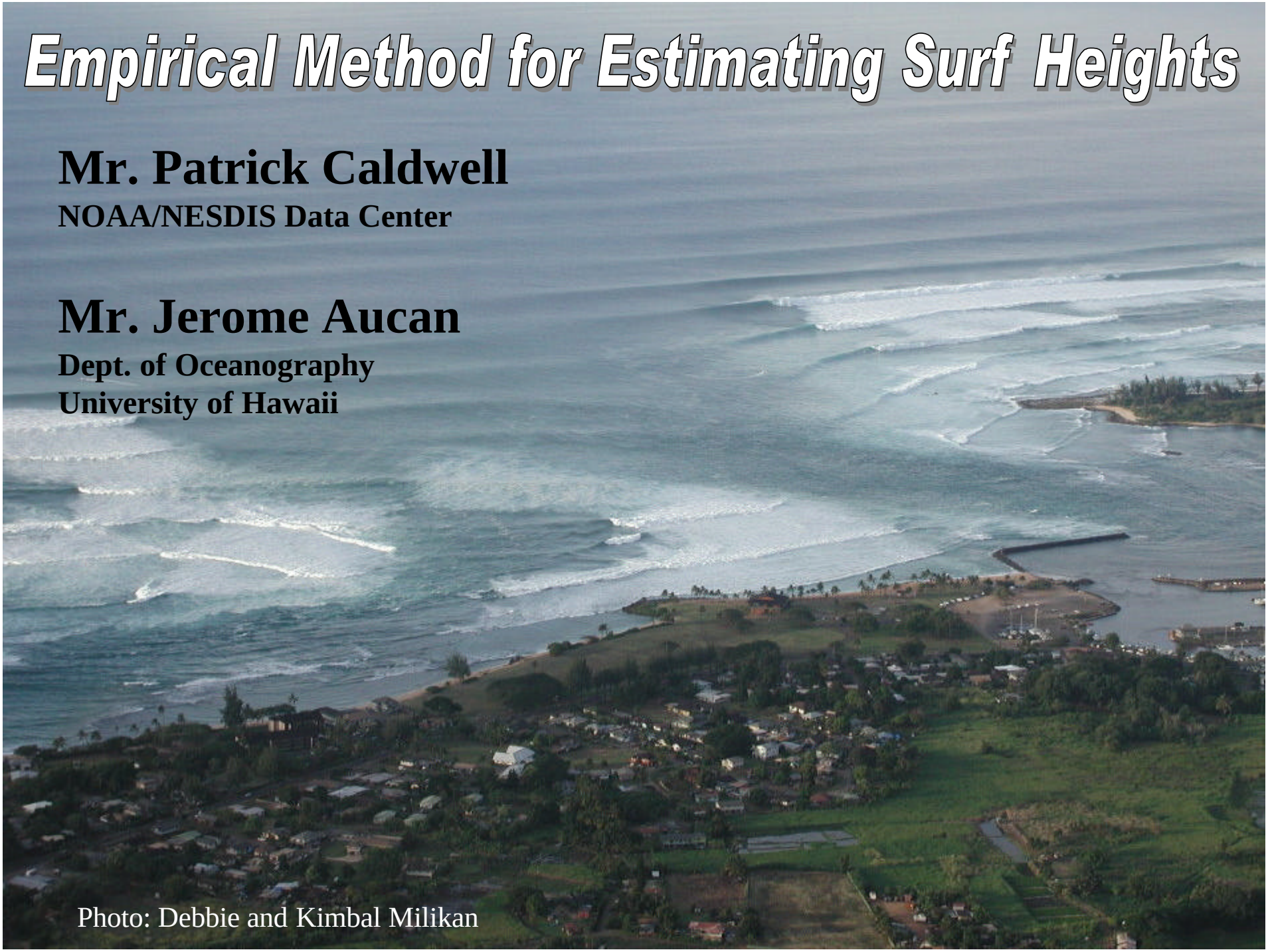
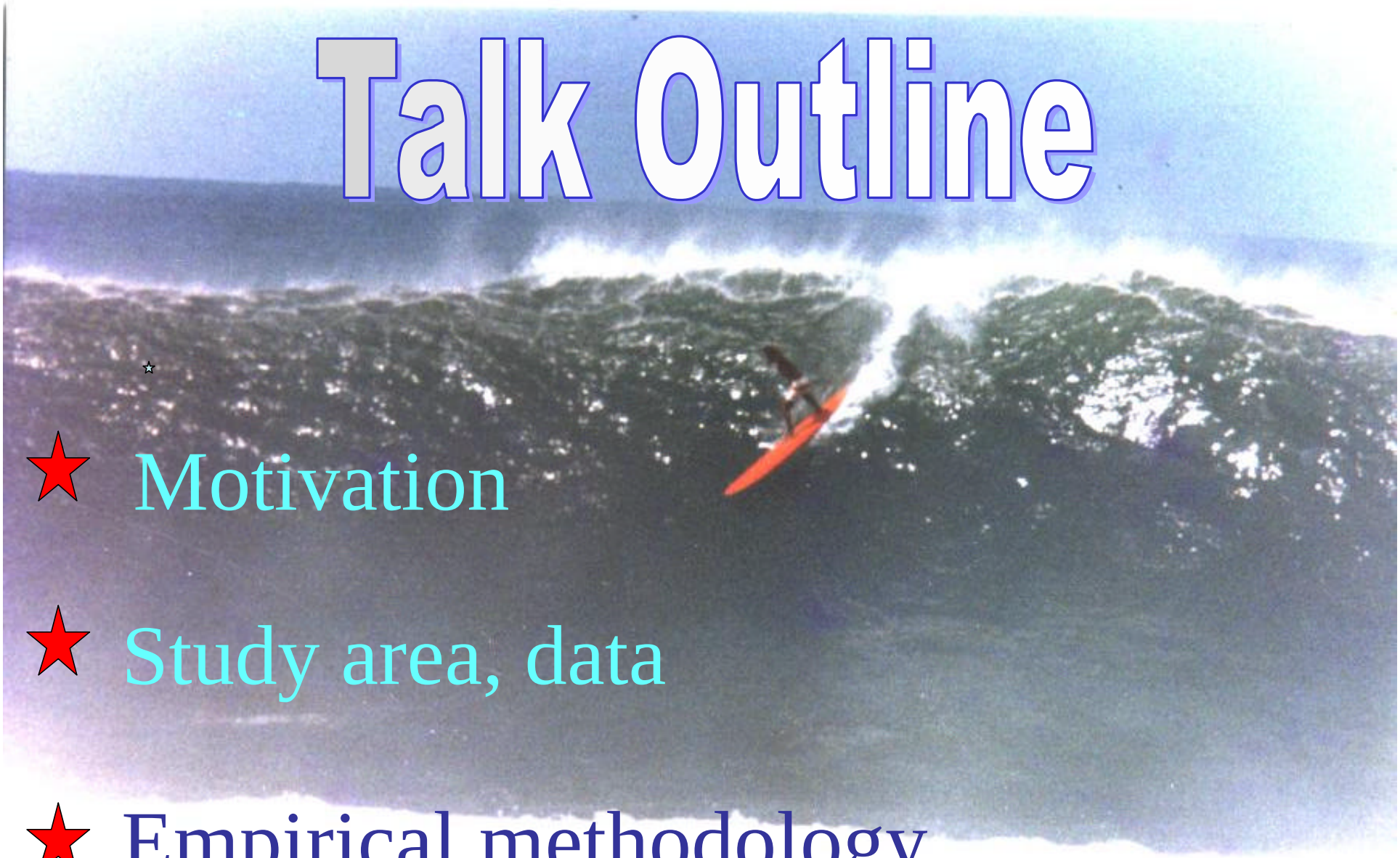


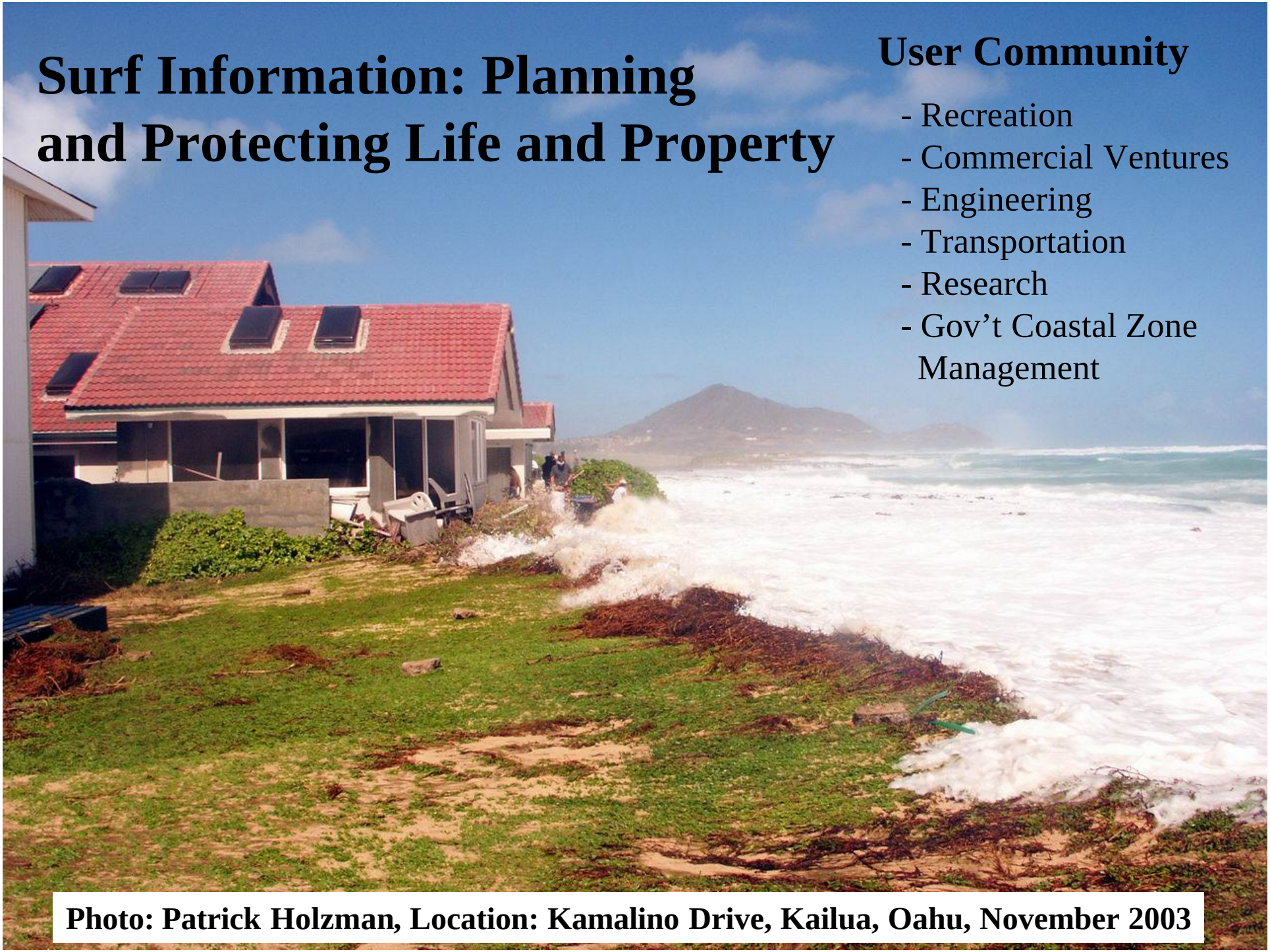
Photo: Debbie and Kimbal Milikan



Talk Outline

- Motivation
- Study area, data
- Empirical methodology and discussion

Surf Information: Planning and Protecting Life and Property



User Community

- Recreation
- Commercial Ventures
- Engineering
- Transportation
- Research
- Gov't Coastal Zone Management

Photo: Patrick Holzman, Location: Kamalino Drive, Kailua, Oahu, November 2003

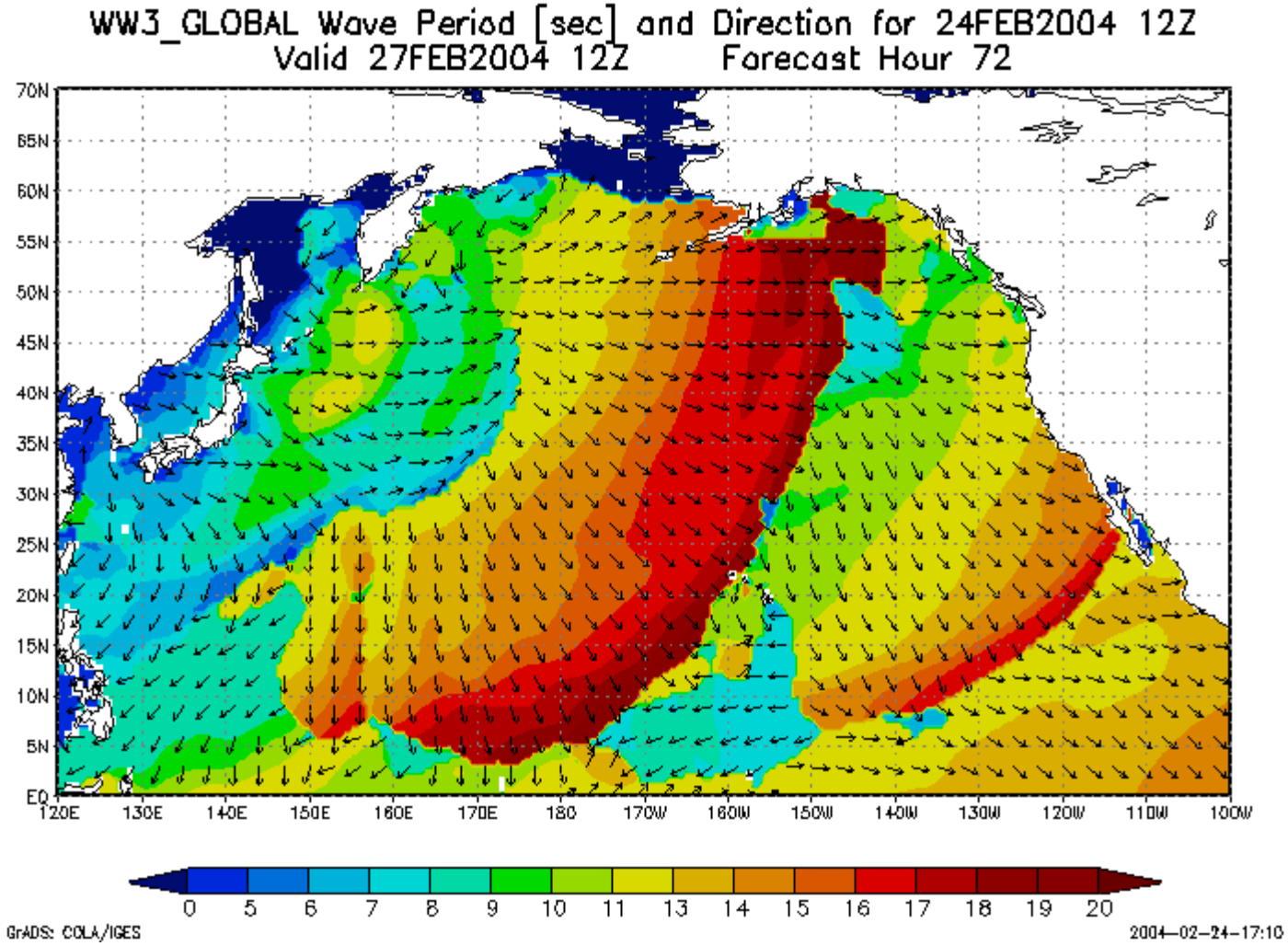
Surf forecasts issued by the NOAA Honolulu National Weather Service Forecast Office as “full face” or **trough-to-crest** heights

Validation:

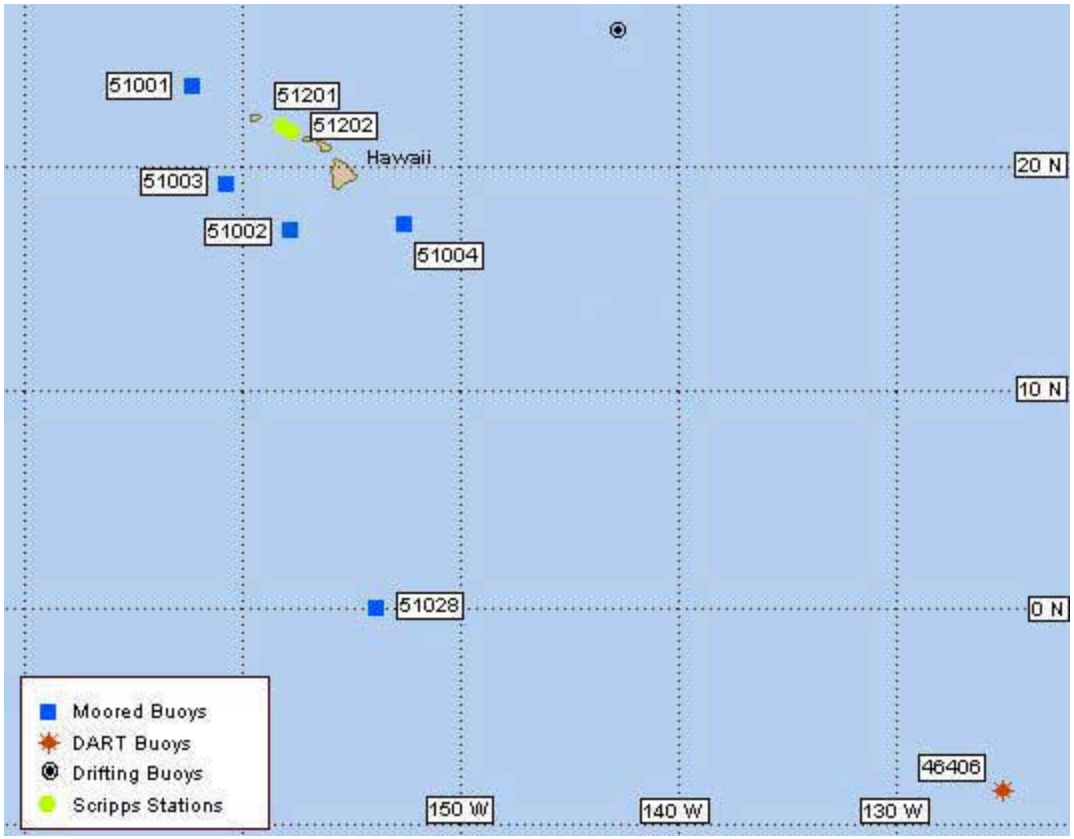
- Buoy readings
- Visual surf observations

Photo: J.Ballenger, HawaiianWaterShots.com

Wave Watch III



Central Pacific/Hawaii Buoy Network



Needed: **Operational Method to Estimate Surf from Offshore Conditions**

Shoaling

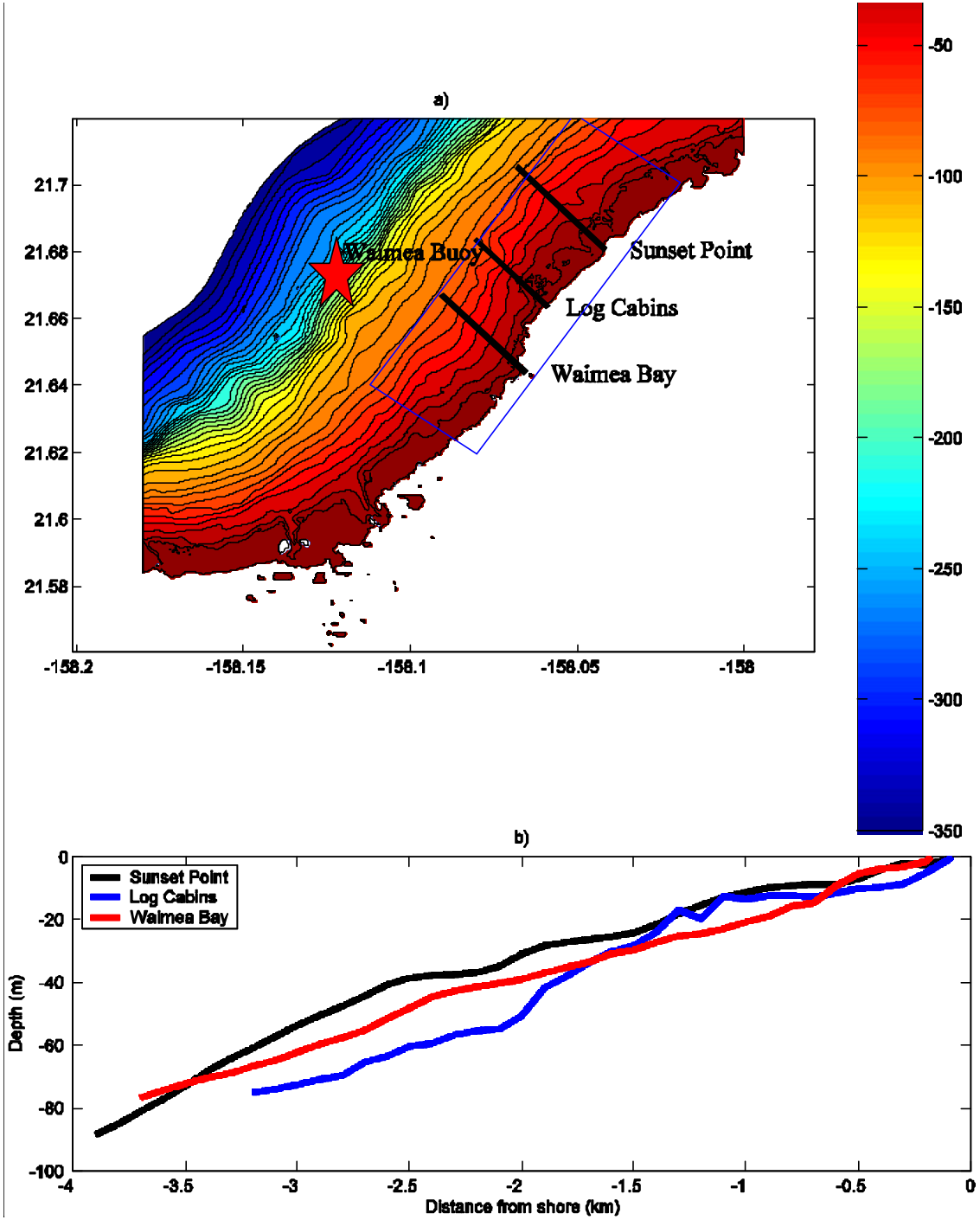
-Rayleigh: conservation of energy flux

Refraction

- direct ray method (Author, Munk, Isaacs, 1952)

-REF/DIF model (Kirby and Dalrymple, 1994)

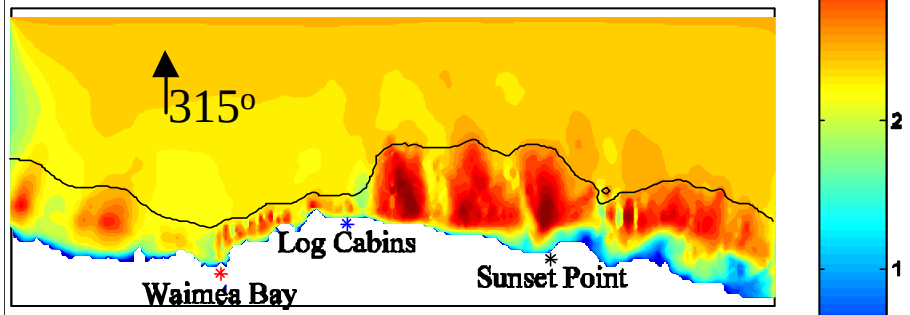
Study Area


a)
Waimea Buoy
Sunset Point
Log Cabins
Waimea Bay
21.7
21.68
21.66
21.64
21.62
21.6
21.58
-158.2
-158.15
-158.1
-158.05
-158
-50
-100
-150
-200
-250
-300
-350
b)
Sunset Point
Log Cabins
Waimea Bay
Depth (m)
0
-20
-40
-60
-80
-100
-4
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0
Distance from shore (km)

Simulating Waves Nearshore (SWAN) Model

- Includes wave generation by winds, propagation, shoaling, refraction, bottom friction, and breaking
- 50 m horizontal grid

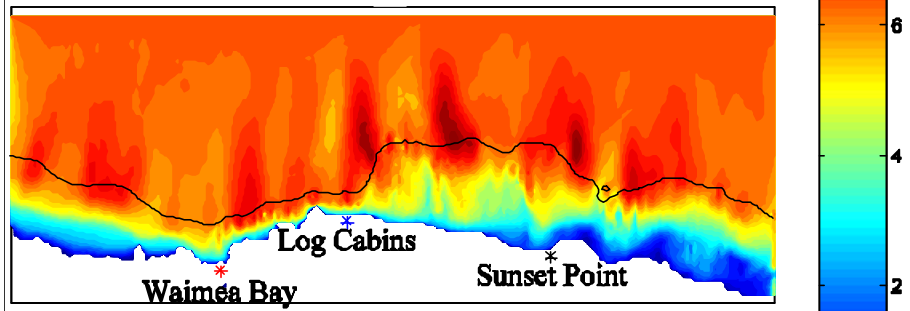
Incident 2.5 m, 14 second from 315°



20m isobath

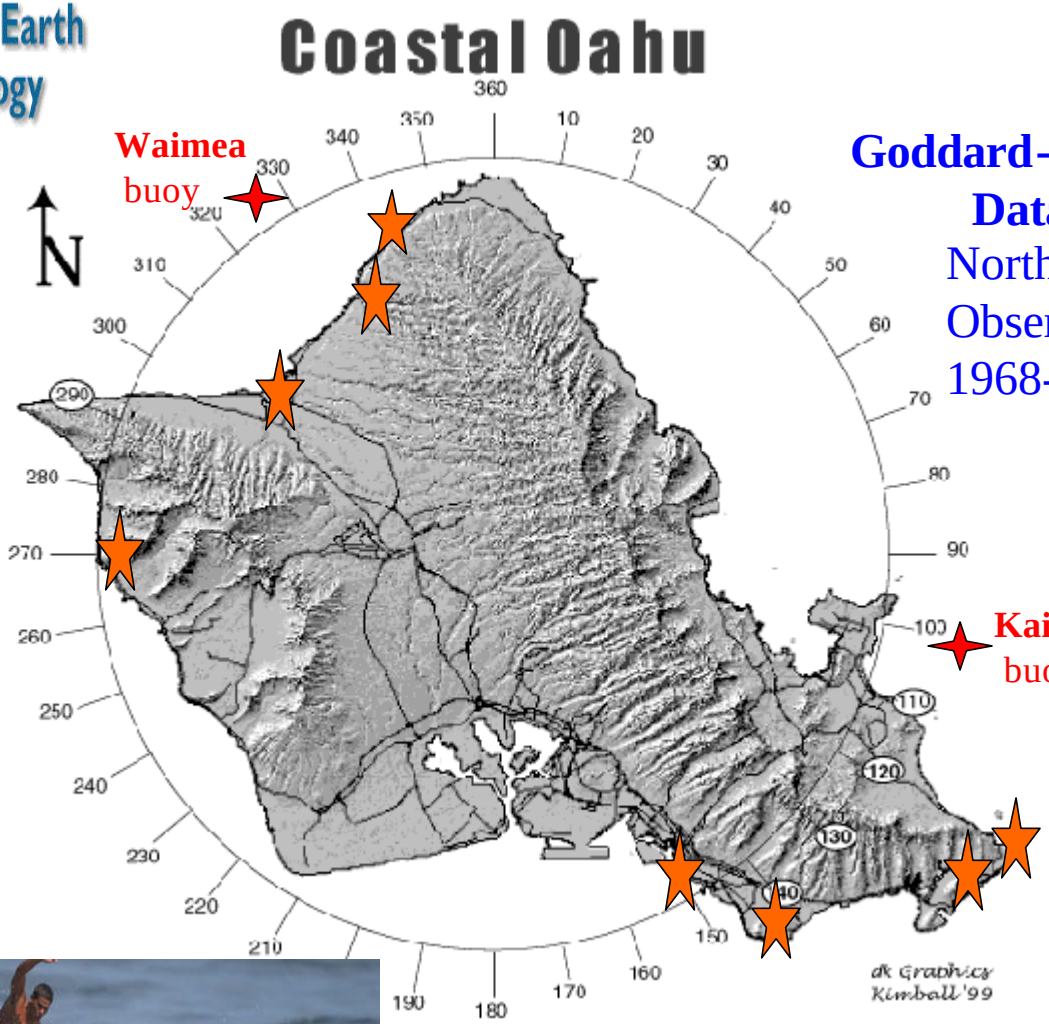
Height (m)

Incident 6.5 m, 19 second from 317°



Observational Network

soest School of Ocean & Earth Science & Technology
university of hawai'i



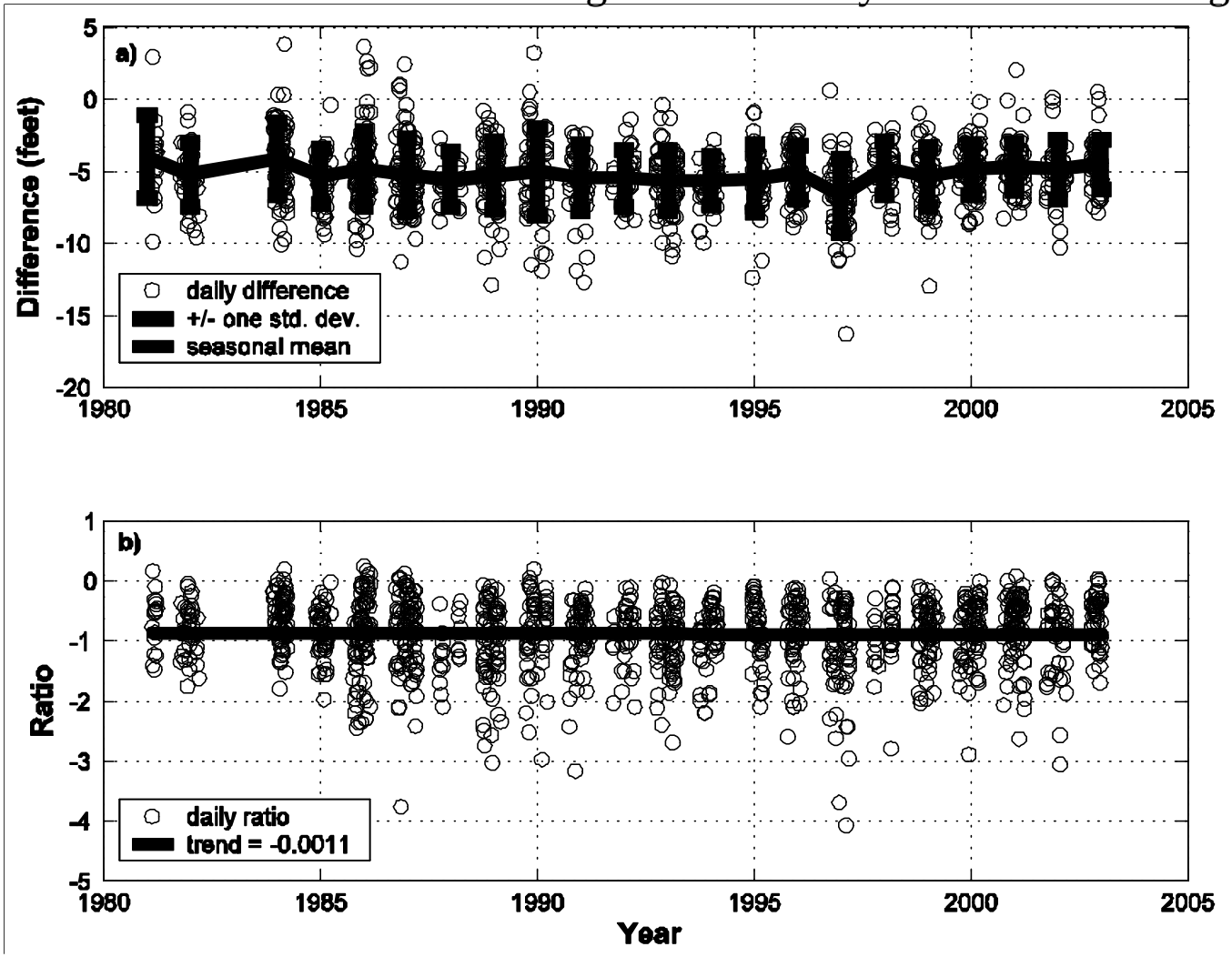
Goddard-Caldwell Dataset
North Shore Observations, 1968-present

OCEAN SAFETY LIFEGUARD CITY & COUNTY OF HONOLULU

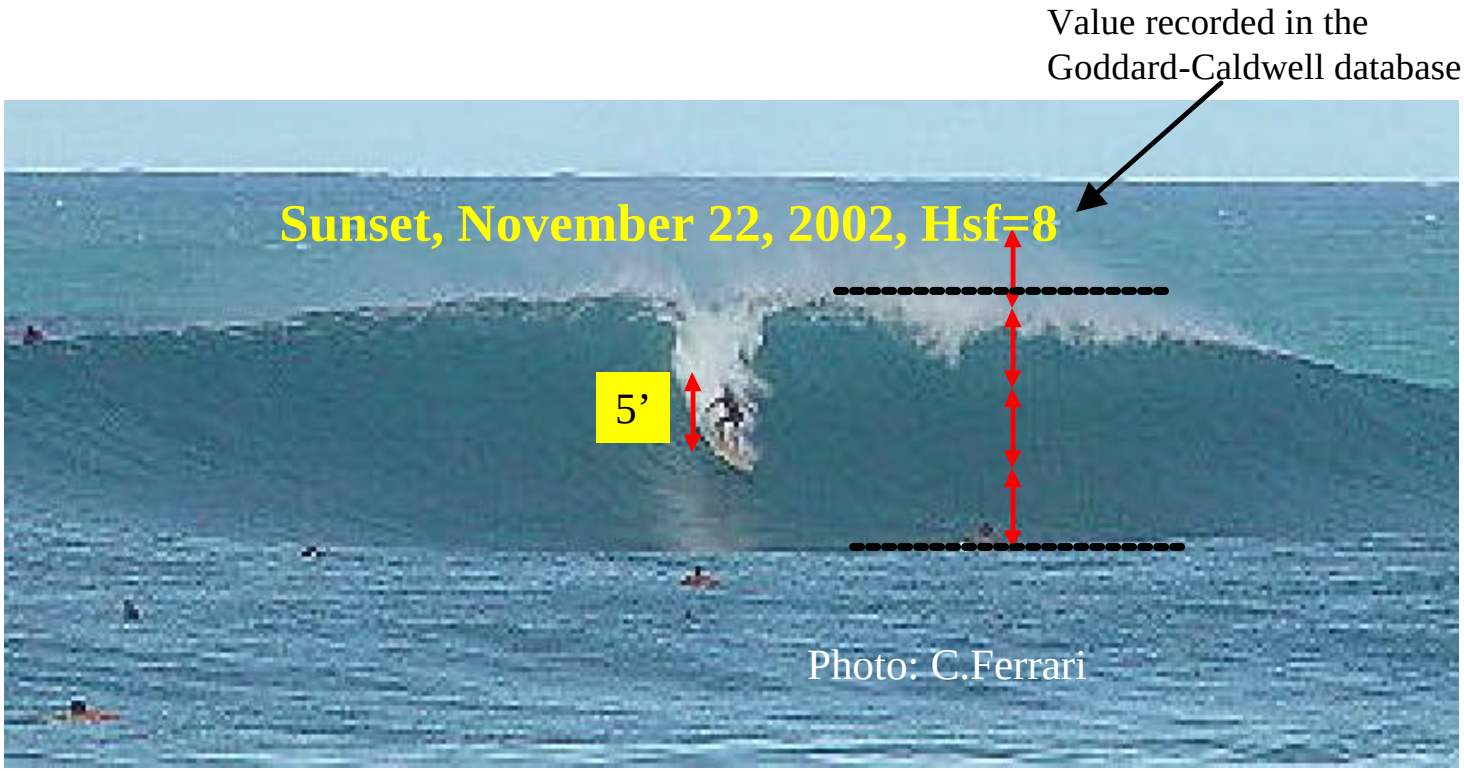
★ Primary reporting locations

Surf observations are temporally consistent

Surf observations minus shoaling-corrected buoy 51001 breaker height



Translation from Hawaii Scale to Trough-to-Crest Heights



The trough-to-crest surf height is defined as the vertical distance between the crest and the preceding trough at the moment and location along the wave front of highest cresting. For zones of high refraction with A-shaped peaks, the height refers to the center of the “A”.

Errors: - trough identification ~ 10% of height
- five-feet unit ~ +/- 6 inches or 10% of height

	Hawaii Scale Feet	*Trough to Crest Height (feet)*		*Number of Photos*	*Translation Factor*
		Mean	St. Dev.		
Non-Waimea Observing Locations	2	5.07	0.5	15	2.54
	3	7.44	0.63	15	2.48
	4	9.5	0.79	15	2.38
	6	12.9	0.99	15	2.15
	8	16.6	0.78	15	2.08
	10	20.28	1.64	15	2.03
	12	23.54	1.08	18	1.96
	15	28.4	4.16	8	1.89
Waimea Bay	15	25.73	1.27	8	1.72
	18	28.93	2.79	13	1.61
	20	31.69	2.59	16	1.58
	25	34.07	1.18	14	1.36
	27.5	38.5	1.14	11	1.4
	30	47.6	0.85	3	1.58
	35	51	0	1	1.46
Peahi (Jaws), Maui	18	35	2.78	5	1.94
	30	59.46	6.13	7	1.98
Oahu Outer Reefs	20	41.3	1.80	4	2.07
	27.5	50.1	1.24	4	1.82
	35	65.9	5	7	1.88

Table 1. Translation from Hawaii scale feet to trough to crest heights (feet). Non-Waimea refers to locations between Log Cabins and Sunset Point.

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- 50 m horizontal grid

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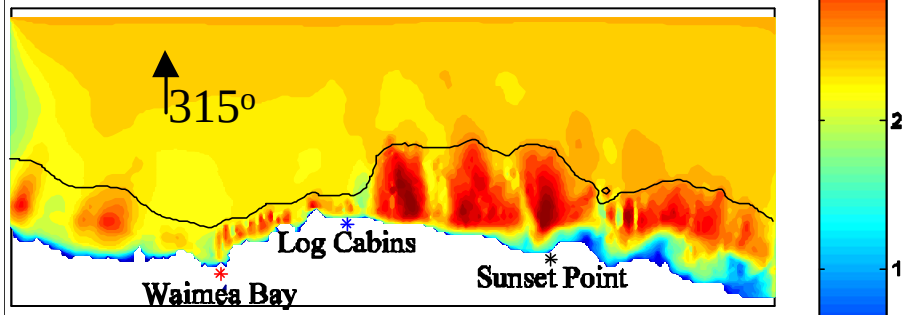

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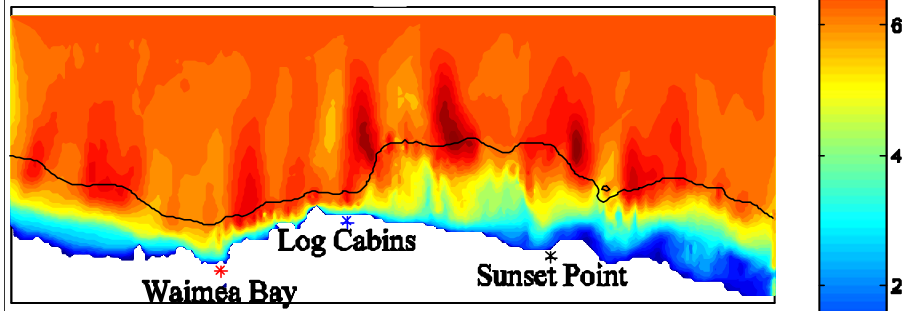
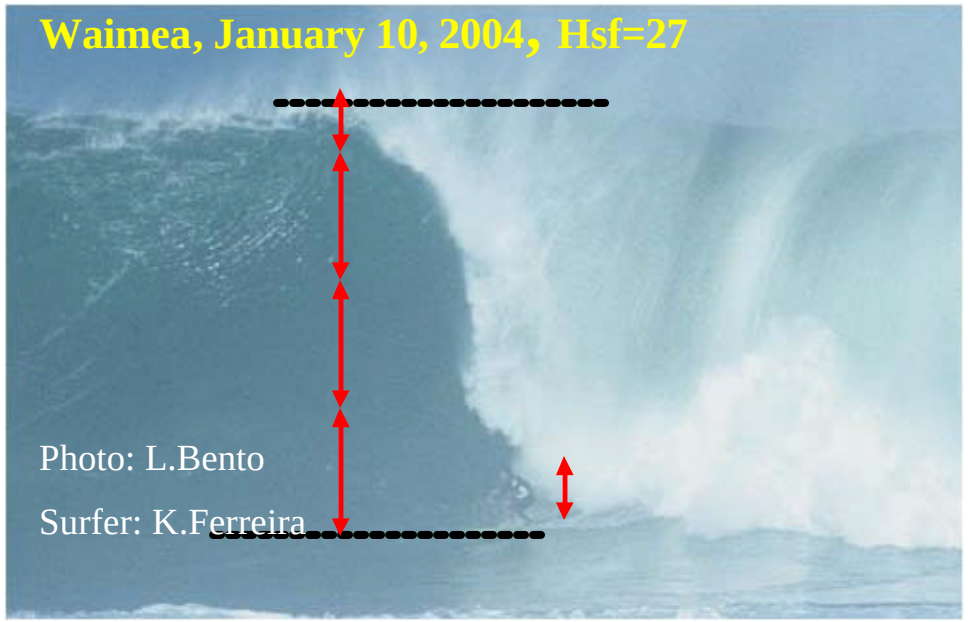
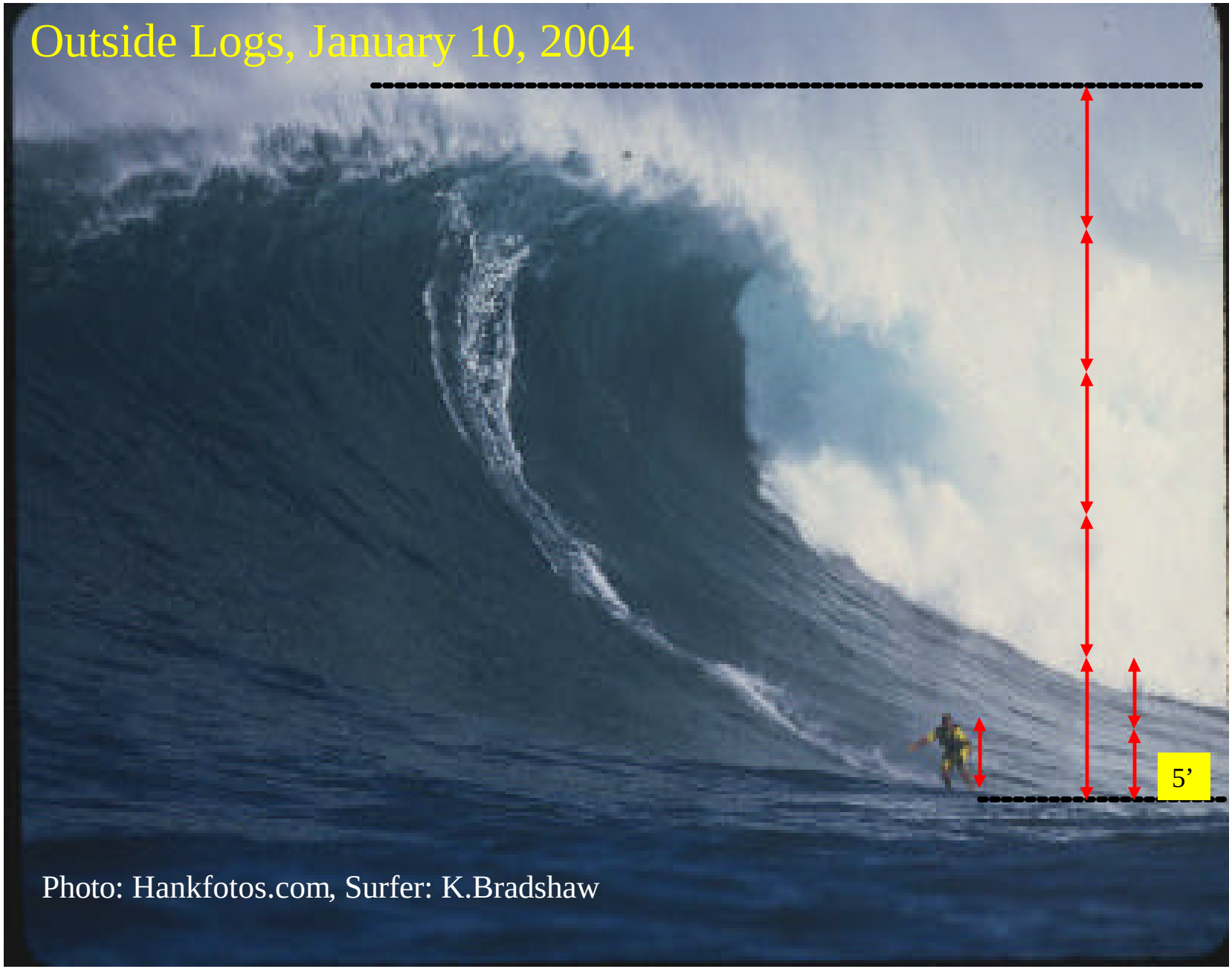
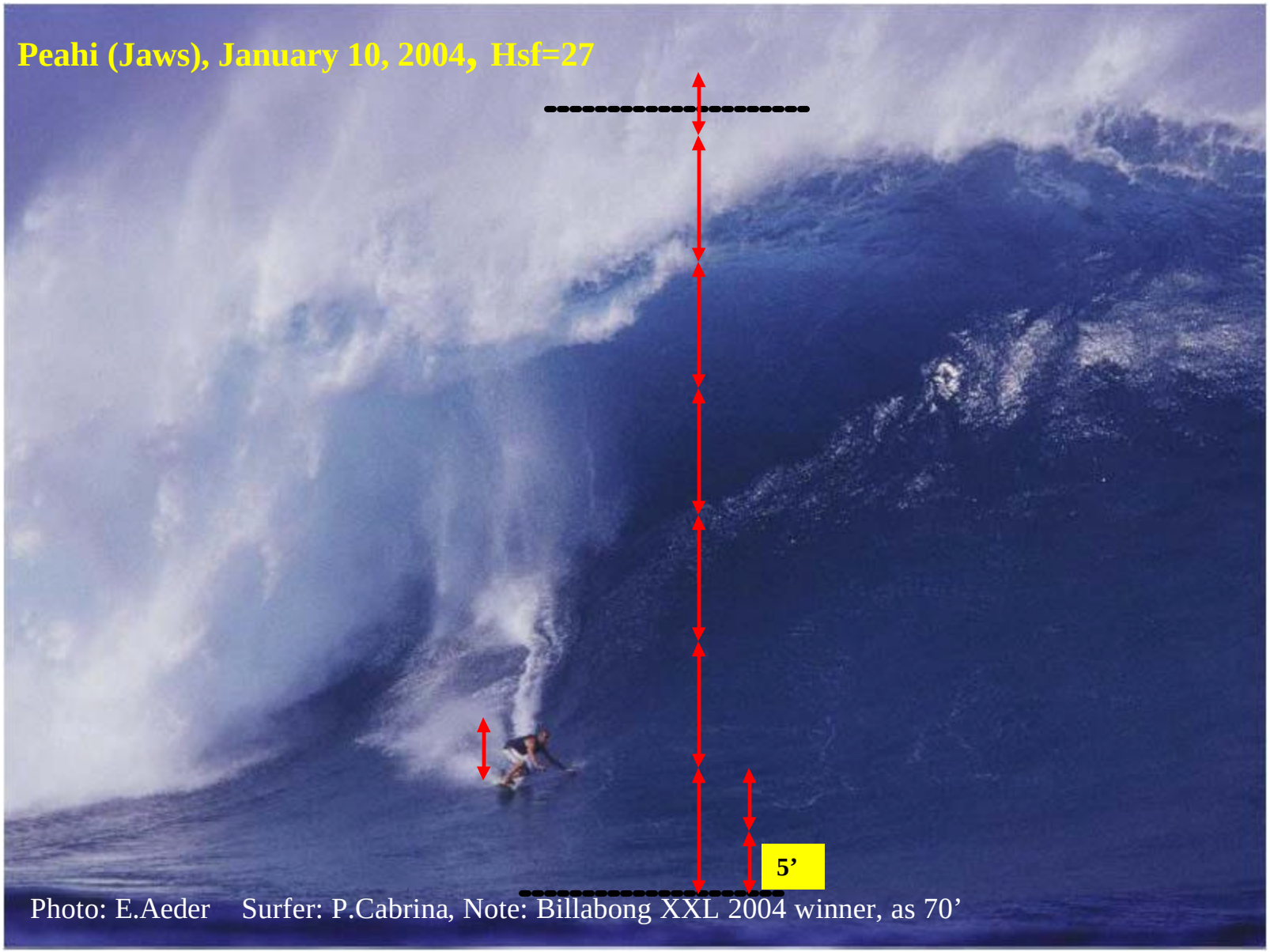
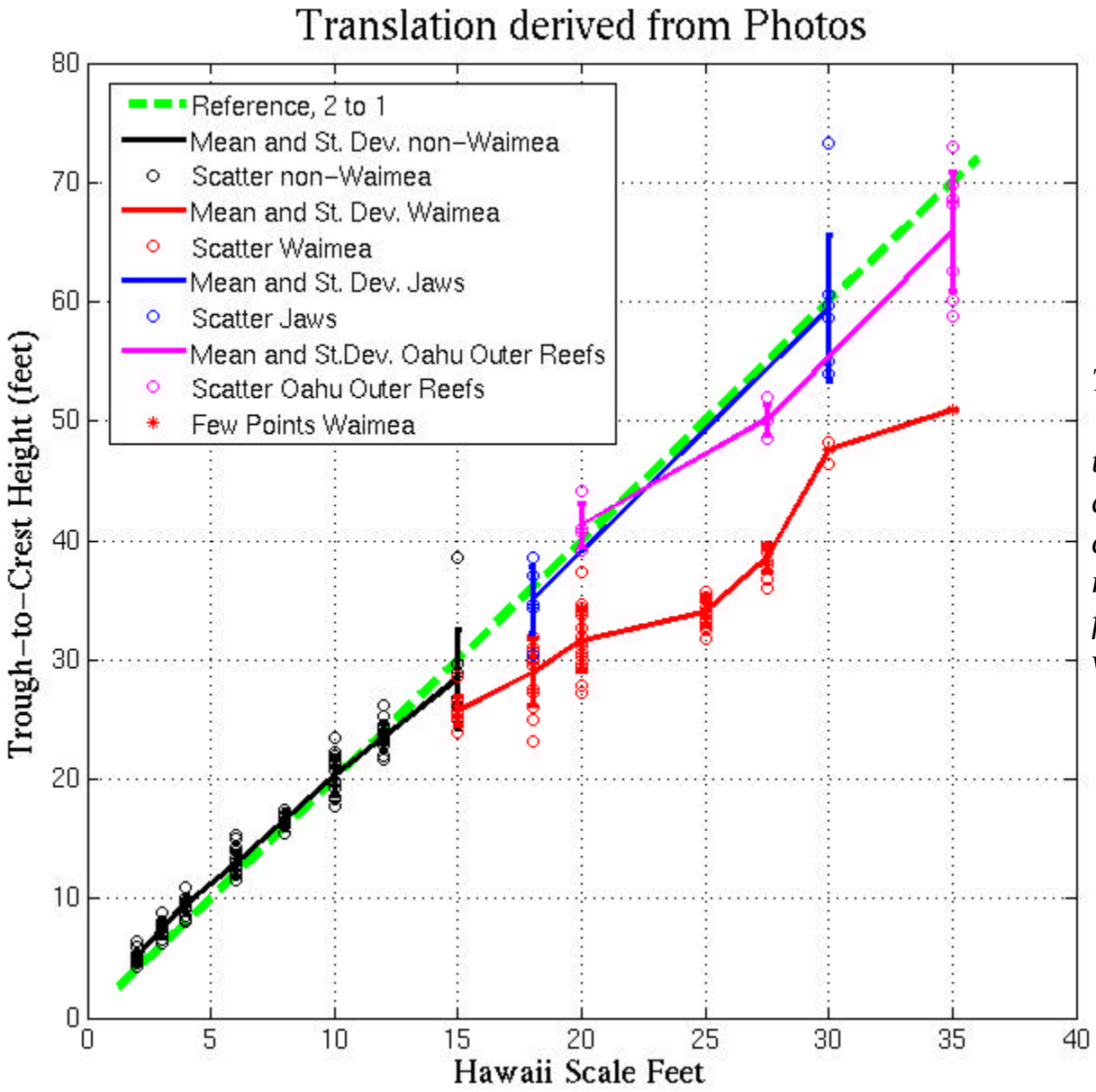



Waimea, January 10, 2004, Hsf=27
Photo: L.Bento
Surfer: K.Ferreira


Outside Logs, January 10, 2004
5’
Photo: Hankfotos.com, Surfer: K.Bradshaw


Peahi (Jaws), January 10, 2004, Hsf=27
5’
Photo: E.Aeder Surfer: P.Cabrina, Note: Billabong XXL 2004 winner, as 70’



Translation is a **factor of two**
For the full range of breaker sizes
Encountered in Hawaii within the
10-20% margin of error.

This assumes the height is defined as the highest height reached in the vertical from the trough to crest at any point along the wave front during breaking and zones of high refraction (outer reefs) are included for extreme days when Waimea Bay was the reporting location.

Empirical Method:

Following Komar and Gaughan, 1973

$$H_b = H_o^{4/5}\left[(1/\sqrt{g})(gP/4\pi)\right]^{2/5} \quad (1)$$

where:

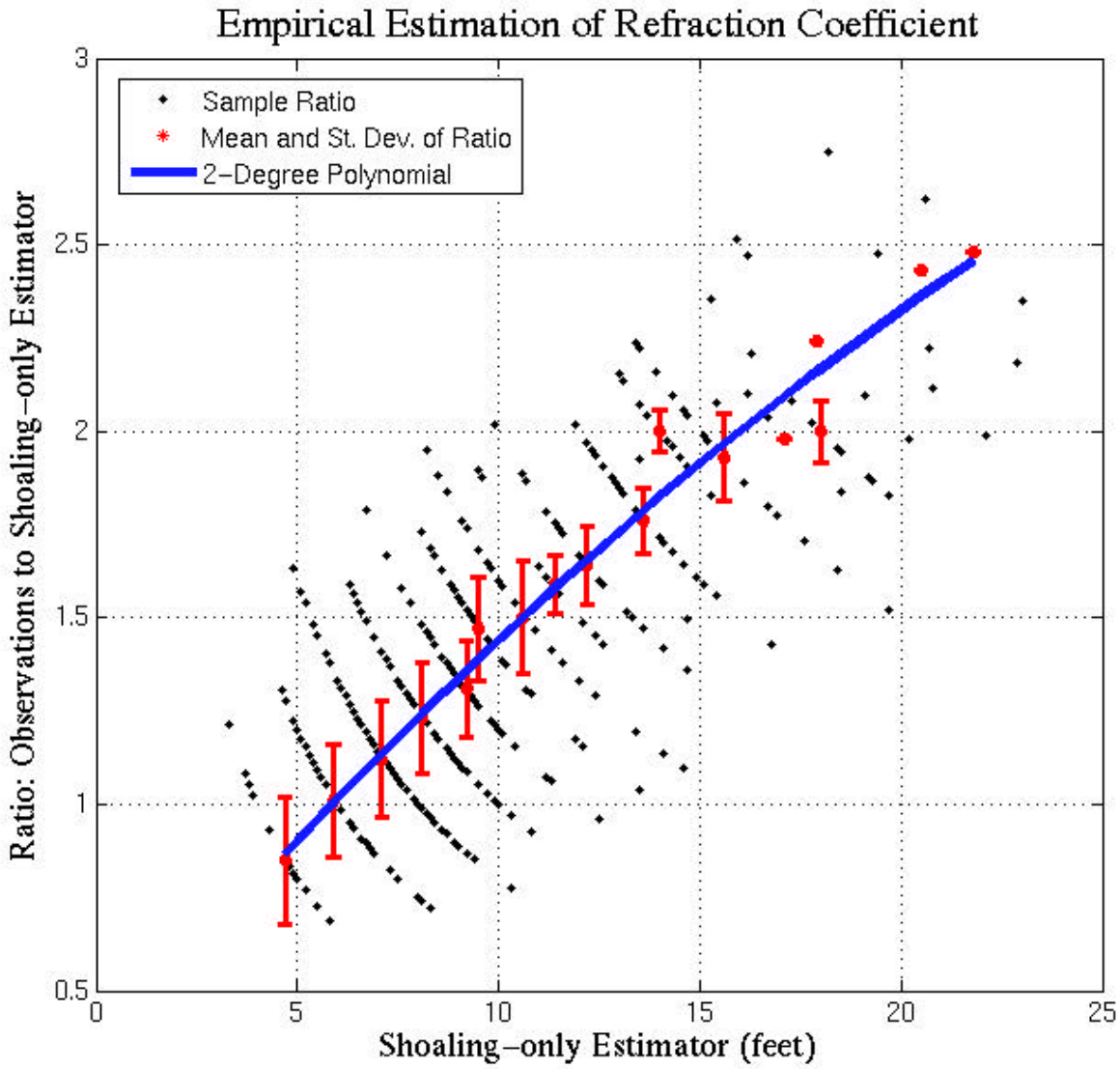
H_b = shoaling-only predicted wave height at breaking
H_o = deep water significant wave height
P = dominant wave period
g = gravity

* Conservation of energy flux
* Ignores refraction, diffraction, bottom friction, currents, wave-wave interactions, and wind

Data: - Daily Surf Observations
(HSF * 2)
- Waimea Buoy
maximum between 7am-5pm

Days removed from data:

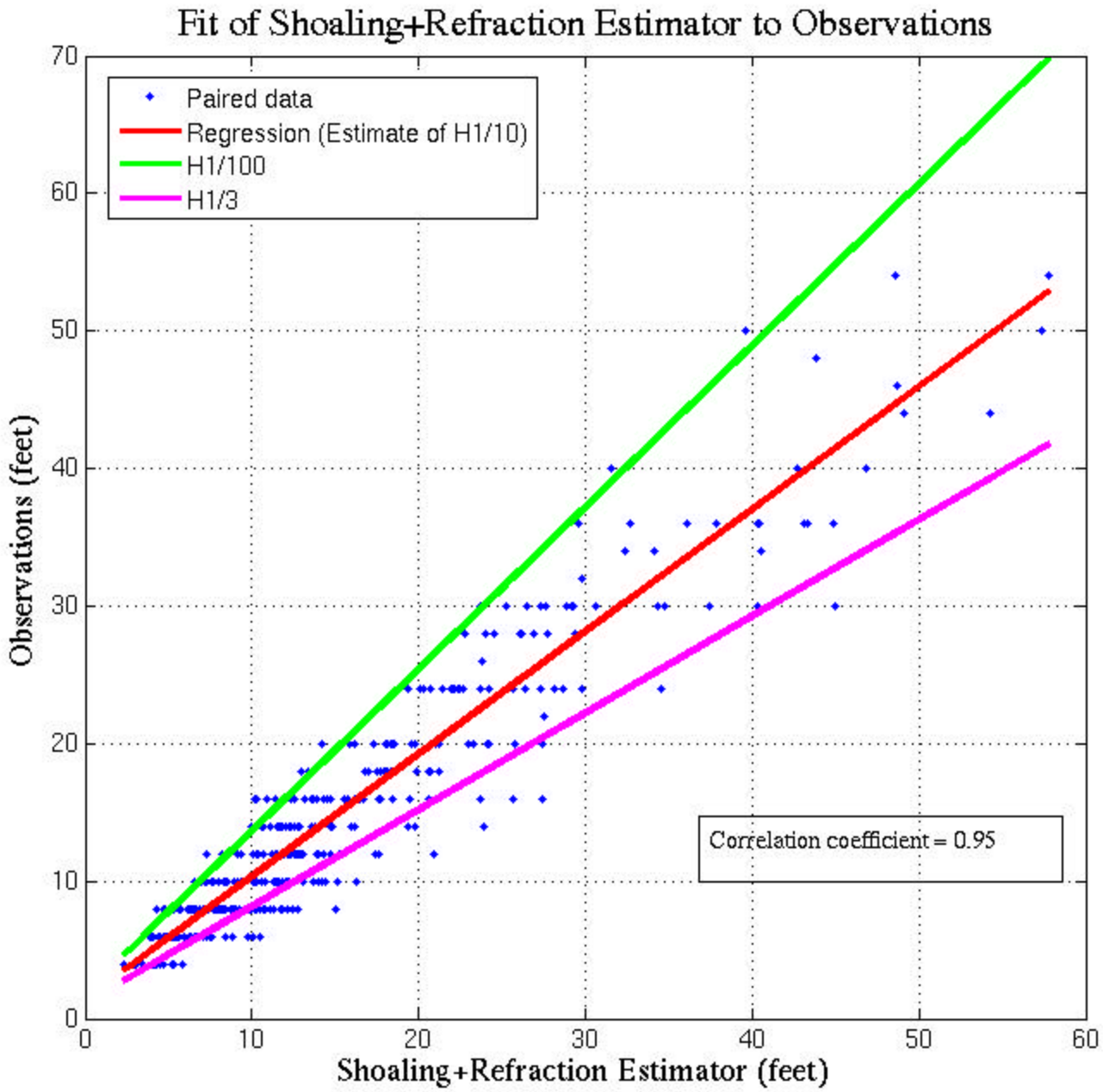
- strong trades
- moderate or stronger onshore winds
- 10^o < wave direction < 270^o



$K_r(H_b) = -0.0013*H_b^2 + 0.1262*H_b + 0.3025$

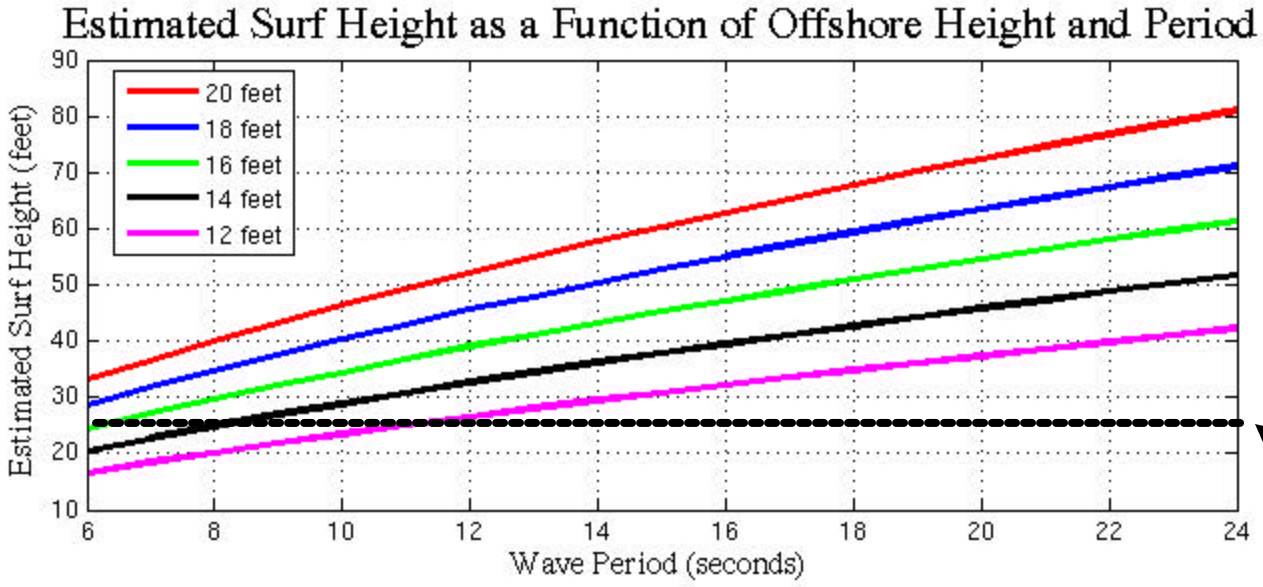
$K_{surf} = H_b * K_r(H_b)$

K_r: coefficient of refraction
H_b: shoaling only estimator
H_{surf}: estimated surf height (shoaling + refraction)

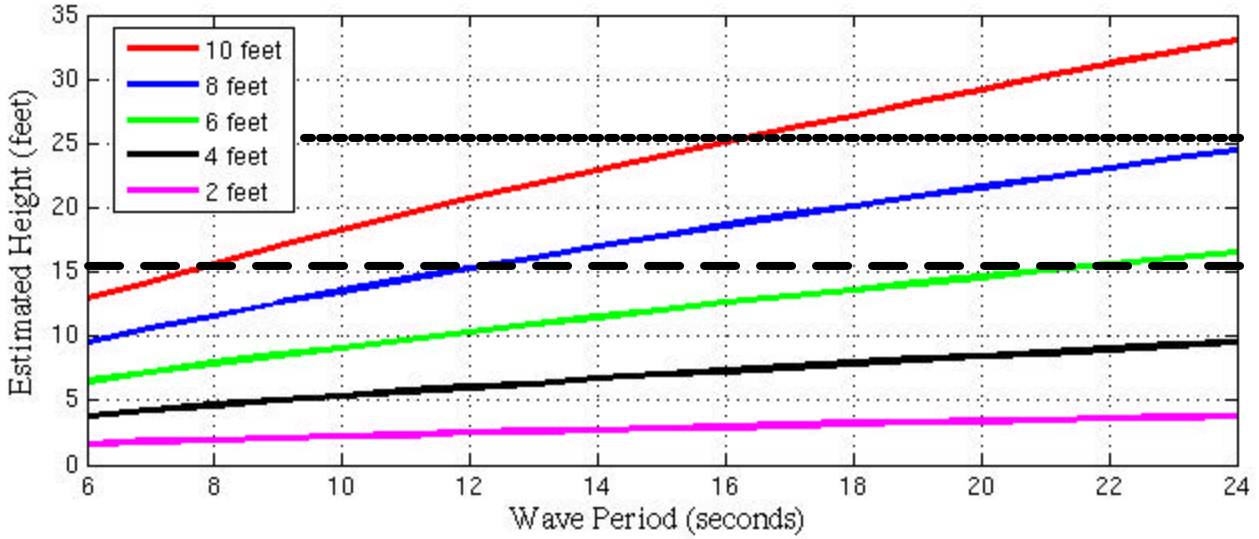


$H_{1/100} = 1.32 * H_{1/10}$

$H_{1/3} = 0.79 * H_{1/10}$



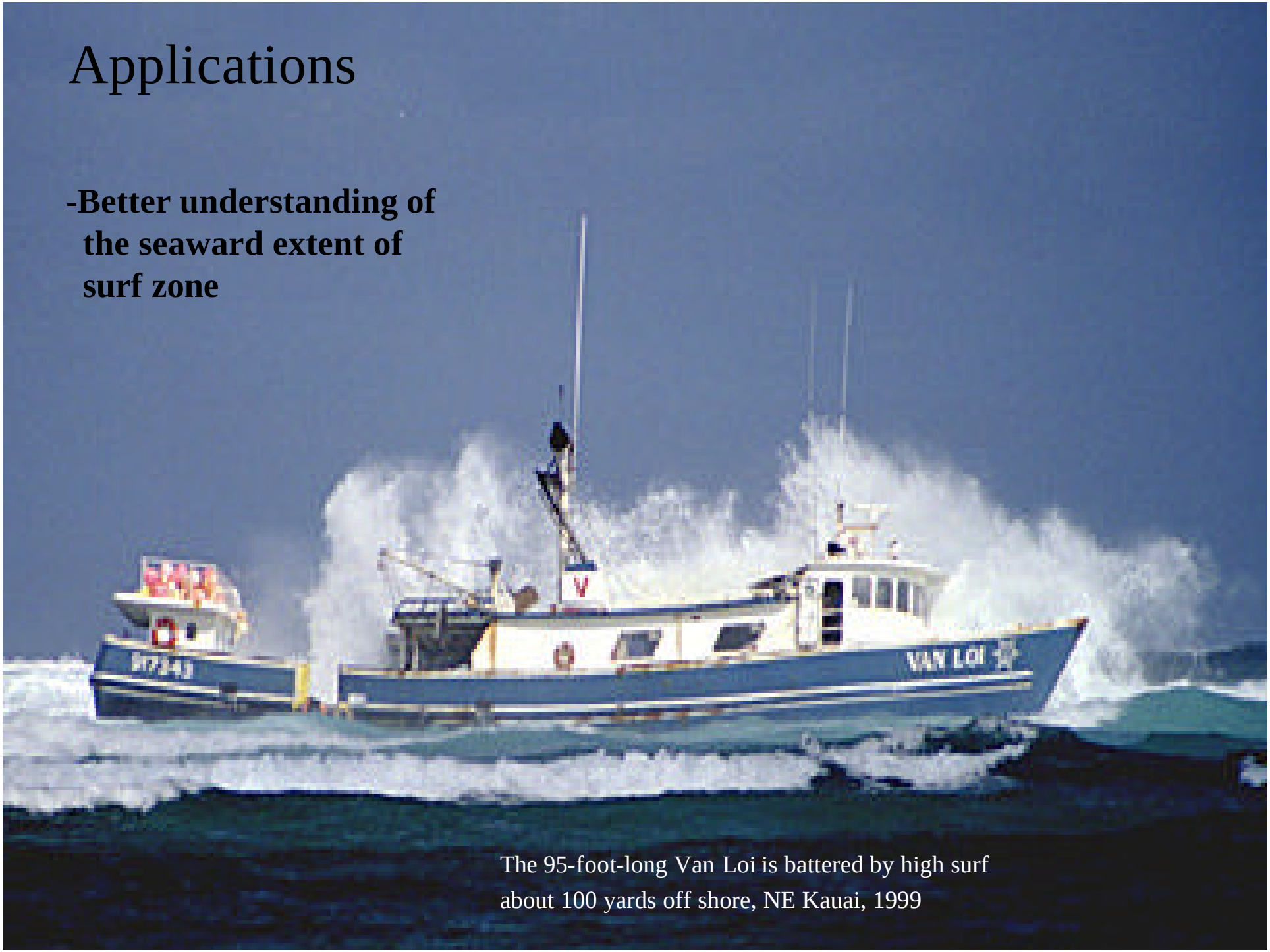
NWS
High surf
warning



NWS
High surf
advisory

Applications

-Better understanding of the seaward extent of surf zone

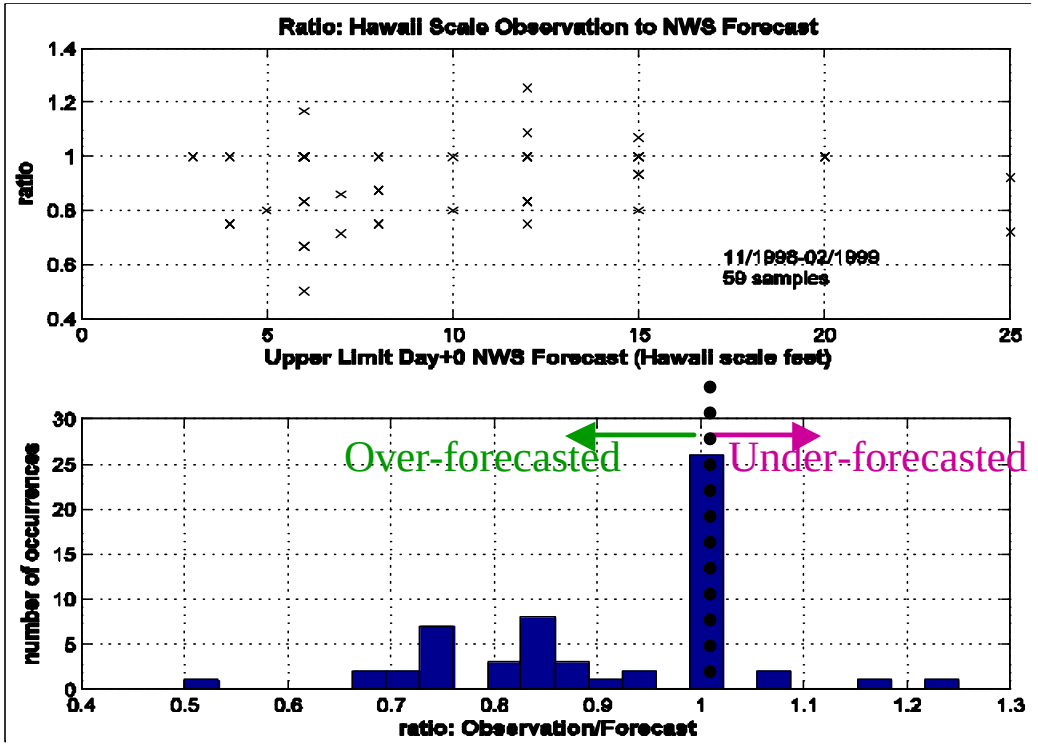


The 95-foot-long Van Loi is battered by high surf about 100 yards off shore, NE Kauai, 1999

Applications

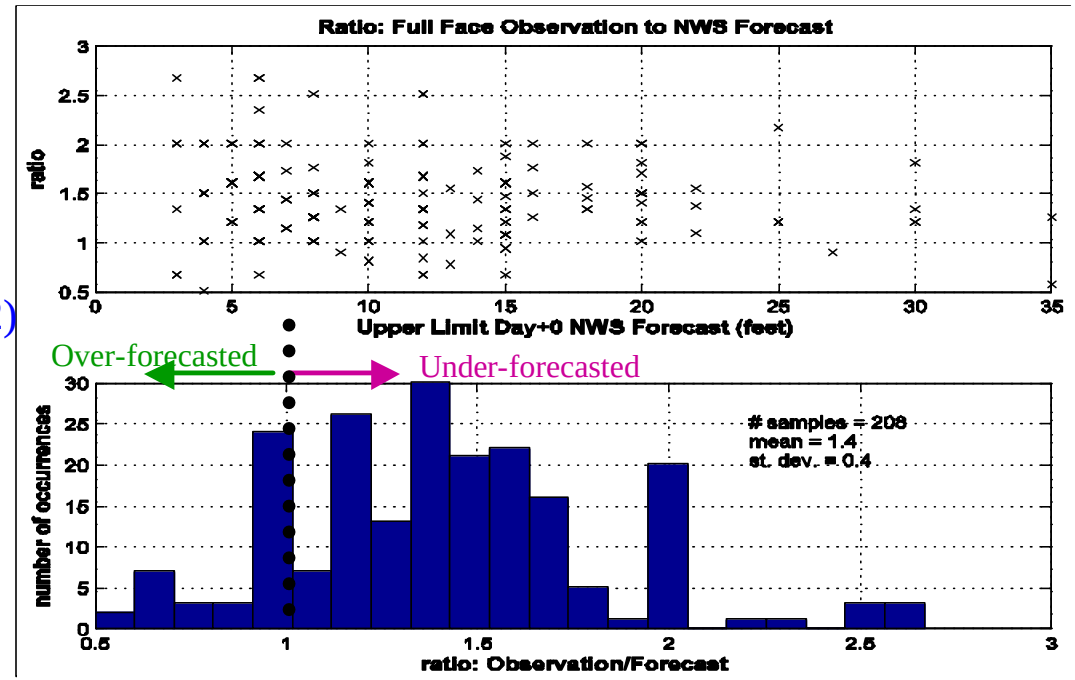
-Fine-tune NWS surf forecasts and validation

Forecasts/observations
In Hawaii Scale



April 2001

Forecasts/observations
in trough-to-crest heights
(observations are Goddard-Caldwell x 2)



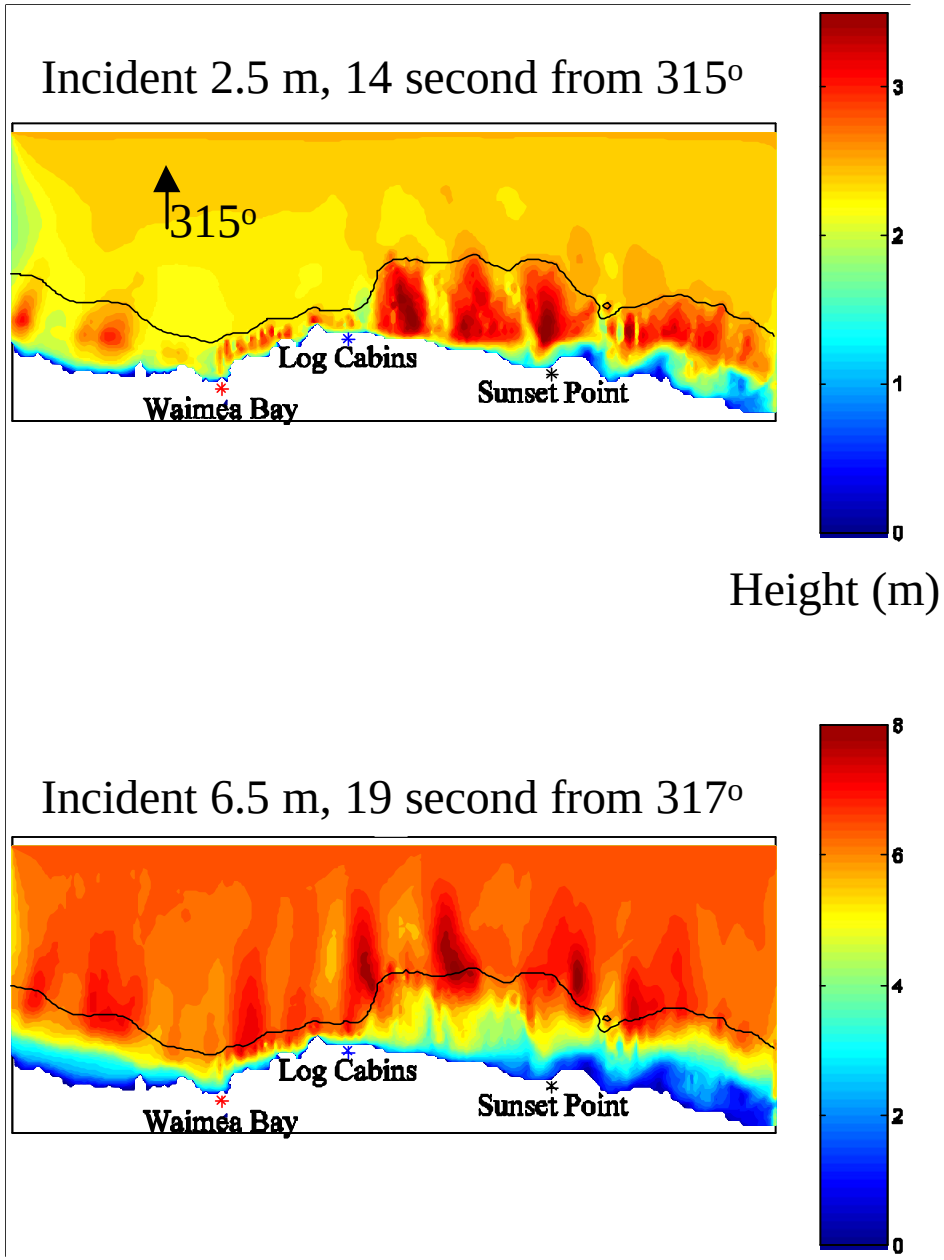
Why bias to under-forecast?

-validation/definition issue

-pre-April 2001 smaller sample size

Applications

Scale adjustments to the (SWAN) Model



Empirical output with 2.5m 14s gives H1/10 = 5.3m for zones of high refraction, compared to roughly 3.5 from SWAN


mahalo,
aloha,
a hui hou
Photo: Patrick Holzman