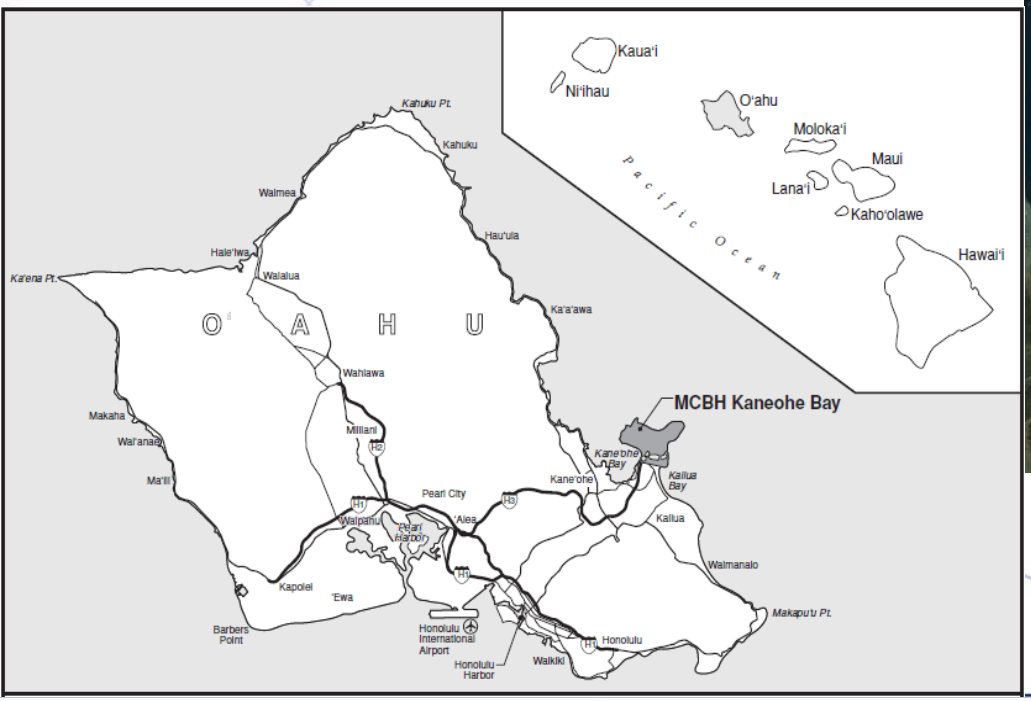
Wave Energy Test Site

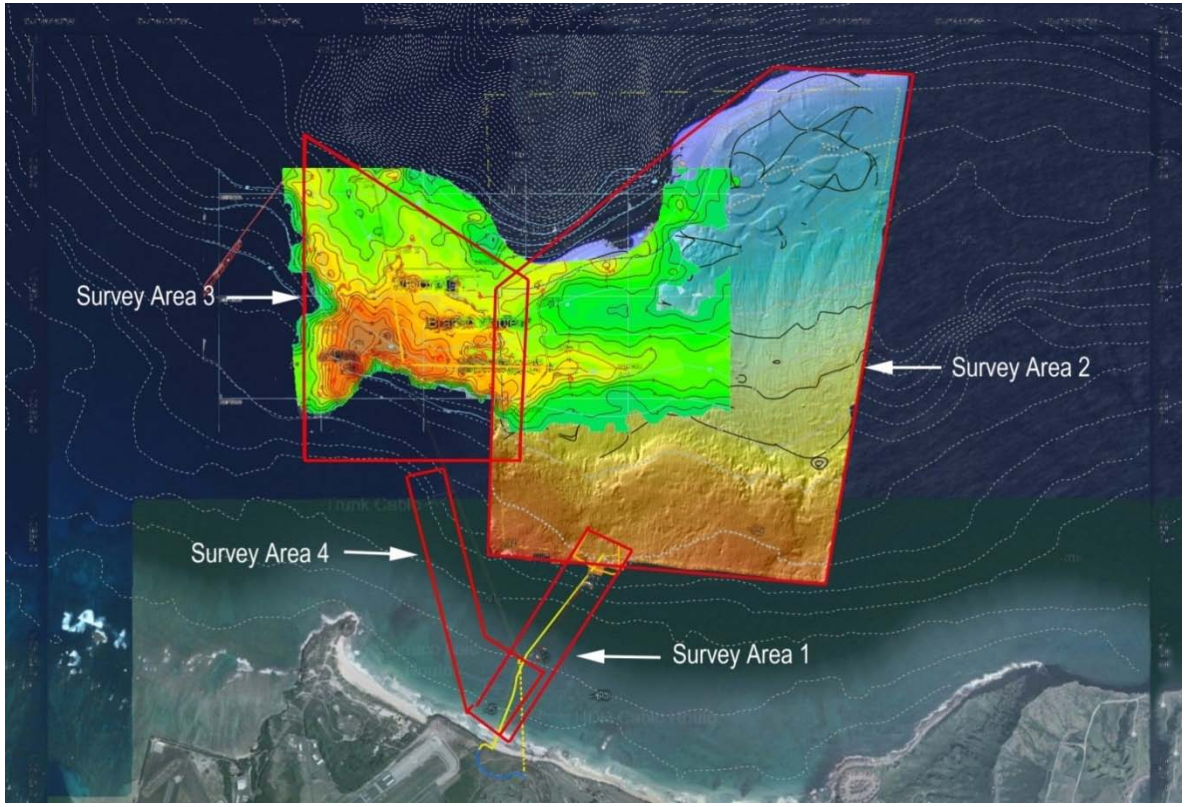
Kaneohe, HI



Alexandra De Visser, NAVFAC EXWC
Dr. Luis A. Vega, HNEI, University of Hawaii
June 2014

Wave Energy Test Site (WETS)

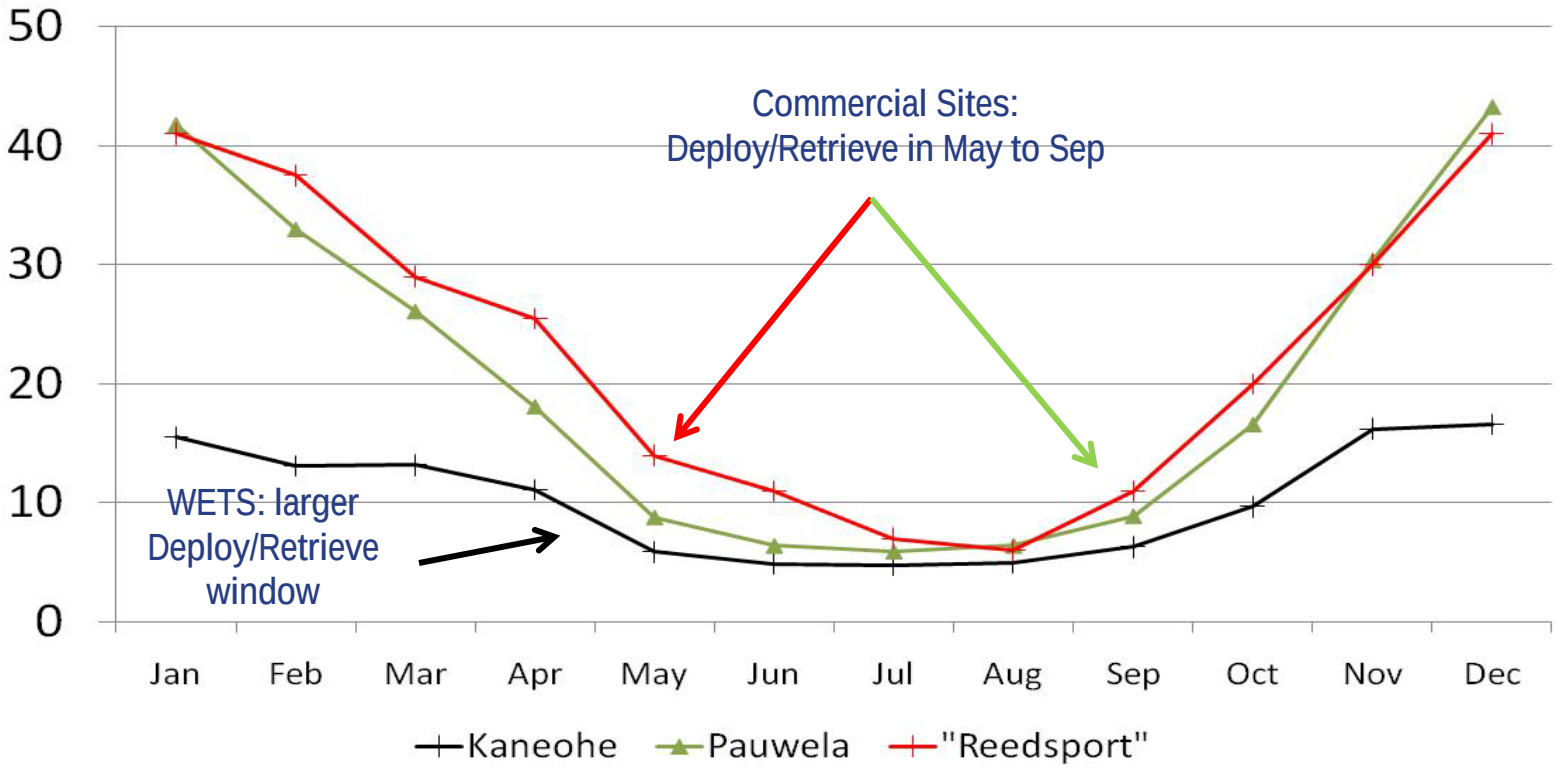
- **Objective:** Provide USA location for technical evaluation and environmental data collection studies of in-water WEC devices.
- **Approach:** Expand facility from one- to three-permitted berths (30m, 60m, and 80m water depths).



Why WETS in Kaneohe, Oahu?

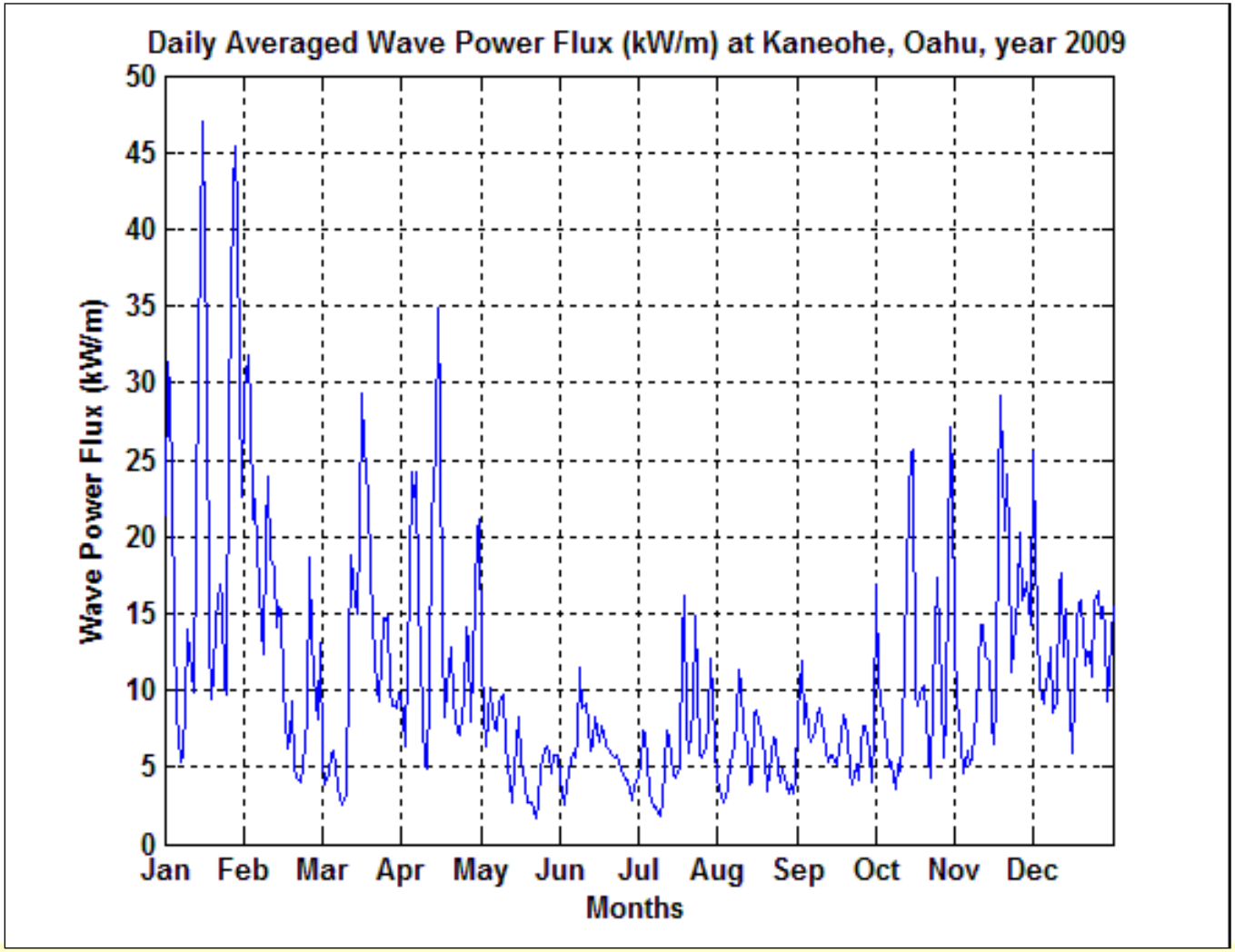
Wave Power Flux (kW/m) Monthly Average:

- **Commercial Sites (Reedsport, OR; Pa'uwela, HI)**
- **Test Site (Kaneohe, MCBH, Oahu)****



** *Year-round data collection in a wide range of wave conditions is possible!*

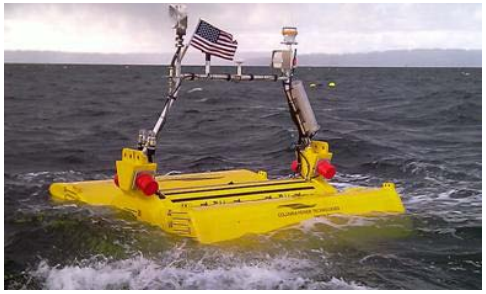
Daily Wave Power Flux



Device performance can be fully evaluated at WETS under all operational conditions.

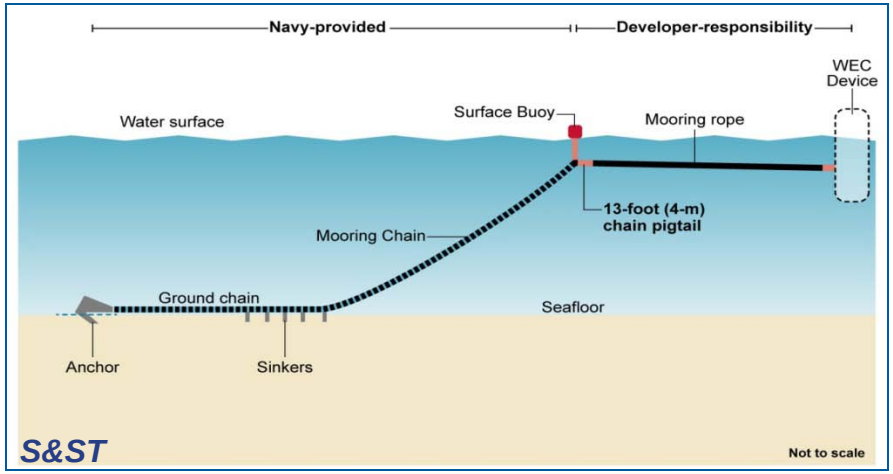
WETS Infrastructure Design Approach

- **Potential Users:** Industry surveys revealed that the most mature technologies were of two types.
  - **Point Absorber**
    (e.g., NWEI, Fred.Olsen Ltd, Columbia Power, Carnegie, OPT)

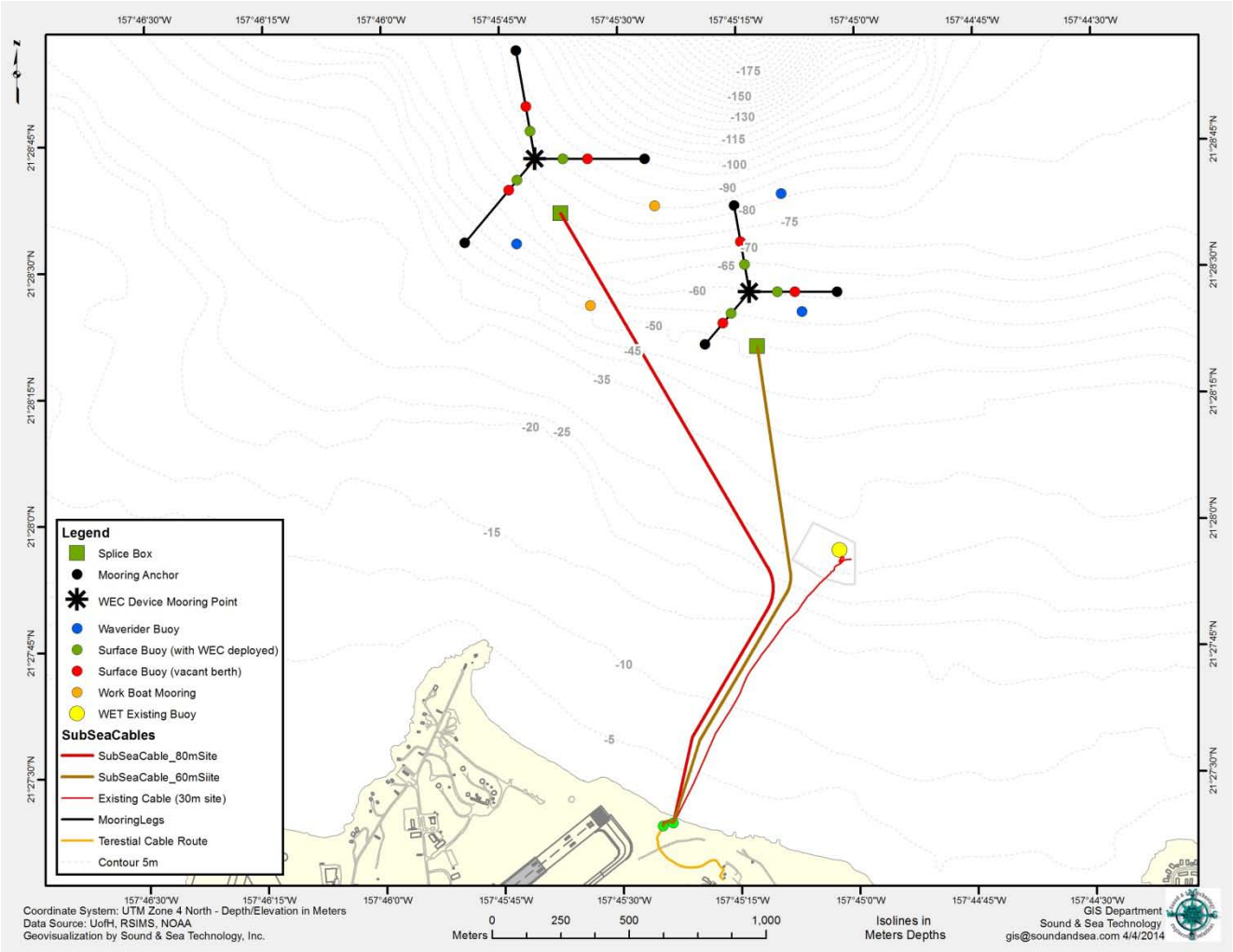


  - **Oscillating Water Column**
    (e.g., Ocean Energy)

- **Approach:** Expand facility from one- to three-permitted berths (30m, 60m, and 80m water depths).



WETS Notional Layout



Shore station facility

Moorings

- New 3-point moorings (60m & 80m)
- Existing 3-point mooring (30m depth)

Power cables

- One new trunk cable to one splice box for each deep site
- Existing subsea cable to 30m site

WETS Site Specific Parameters

Component	Shallow site	Deep sites
Water depth	One @ 30m	Two (60m and 80m)
Maximum transmitted power	250kW @ 4160V	1 MW @11,500V
3-point moorings	• three (3) sub-surface floats • two (2) rock-bolted anchor bases and one gravity anchor	• three (3) surface floats • three (3) drag embedment anchors

WETS Deep Site: Notional Parameters

Property	Point Absorber	Oscillating Water Column
Width	16 to 72 ft (5 to 22 m)	66 to 82 ft (20 to 25 m)
Length	16 to 82 ft (5 to 25 m)	49 to 164 ft (15 to 50 m)
Height	13 to 203 ft (4 to 62 m)	66 to 82 ft (20 to 25 m)
Height Above Water Line	5 to 30 ft (1.5 to 9 m)	7 to 36 ft (2 to 11 m)
Dry Weight	8 to 1,320 short tons (7 to 1,200 metric tons)	8 to 1,320 short tons (7 to 1,200 metric tons)
Power Take-Off	a) Vegetable-based hydraulics or gear drive connected to electrical generator; or b) Magnetic generator technology	Air turbine connected to electrical generator
Mechanical Operation	Two or three main components oscillate relative to each other	Oncoming waves force air through turbine via internal chamber
Power Output	10 to 1,000 kilowatt (kW)	500 to 1,000 kW

WETS Modus Operandi

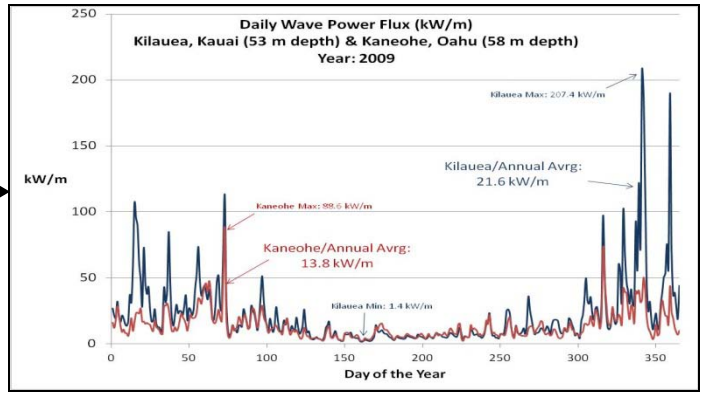
- **NAVFAC**
  - MCBH Kaneohe Bay, Site Host
  - Permitted berths with primary mooring, submarine power + data cables
  - Grid connection infrastructure + Interconnection Requirements Study
  - Device-specific permits (CATEX and ACOE permits)
  - Cooperative Research and Development Agreement or Navy contract
  - Office space
- **HNEI-UH**
  - Evaluate WEC system performance (power output as function of waves)
  - Mooring system & power cable life expectancy evaluation
  - Environmental impact (acoustics, EMF, ecological surveys)
  - Calibrated 7.5 days wave forecasting for operations planning
- **Tenants**
  - Deploy and retrieve device (connect to mooring and submarine cable)
  - Provide hawser for mooring connection and umbilical for connecting to splice box
  - Data acquisition of subsystem parameters
  - HECO Standard Interconnection Agreement (SIA) + Rule 14 Exhibit A application

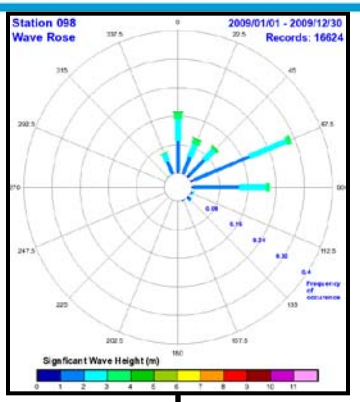
WETS Schedule

- **Existing 30m berth to be occupied by NWEI (*August 2014*)**
- **HNEI Waverider® buoy operational (*October 2012*)**
  - **Provides real-time wave data for WEC device performance and to calibrate models to provide 7.5 days of wave forecast info for test planning**
  - **CDIP Station 198**
- **WETS expansion for 60m and 80m berths**
  - **Engineering design by Sound & Sea Technology (*Jan 2014*)**
- **Signed FONSI and WETS Environmental Assessment (*Feb 2014*)**
- **Hardware procurement (*in process*)**
- **Deep water infrastructure construction (*Summer 2014*)**
- **Deep water berths operational (*Fall 2014*)**

HNEI-UH Team: Supporting NAVFAC in WETS Environmental Assessment and Design

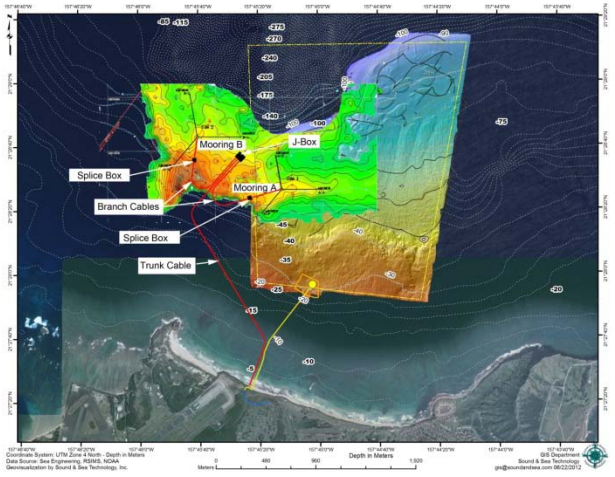
Wave & Current Climate

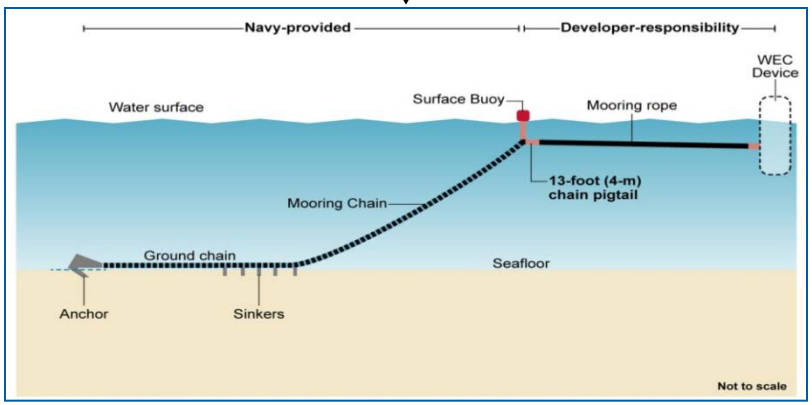




Waverider In-situ Measurements

Bathymetry & Sediment Profile



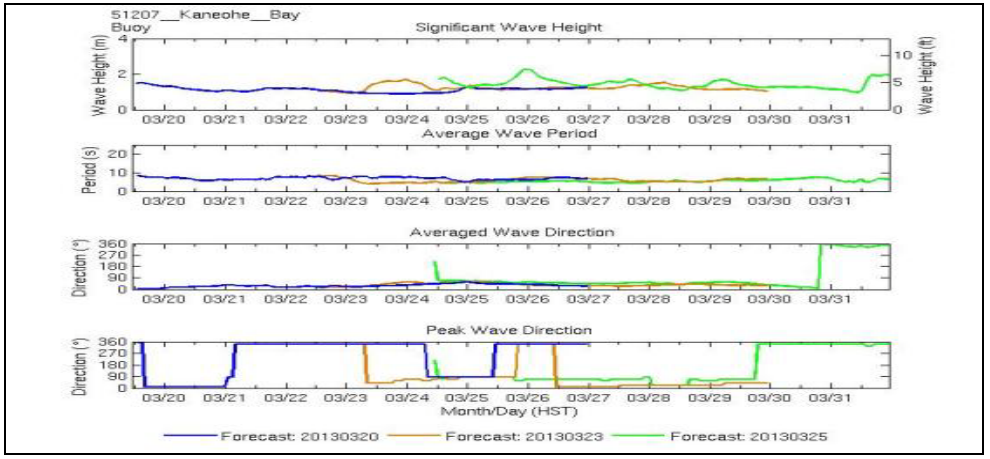


Output

- Mooring Design by SST
- Power cable routing

HNEI-UH Team: Will Support Testing Operations and Provide Independent Assessment of Performance

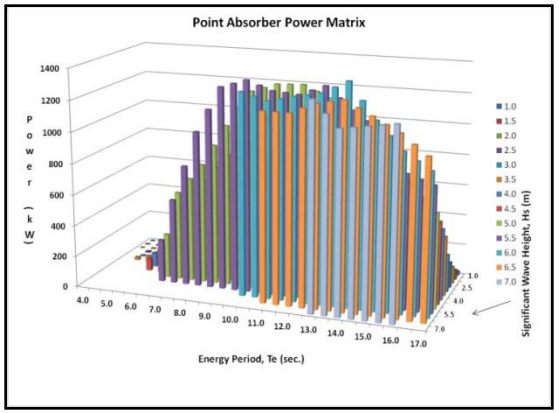
Wave & Current Climate



Device Power Performance:
- Electrical output vs. wave parameters

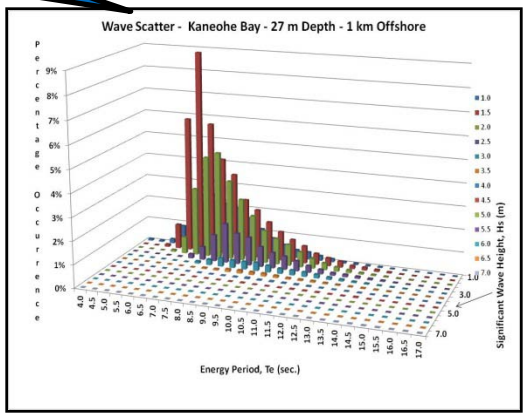
WEC Device Environmental Impact
– chemical & ecological site surveys
– acoustic & EMF signatures

→ **Database to address regulatory and stakeholder issues**



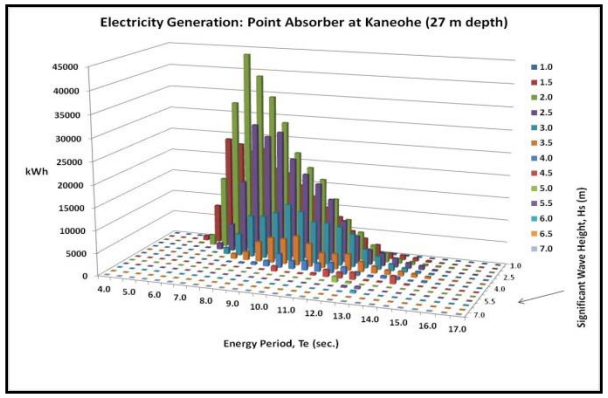
Power Matrix: kW vs. Hs/Te

X



Wave Scatter: Occurrence vs. Hs/Te

=



kWh vs. Hs/Te

Electrical Generation with Hypothetical "1 MW" Point Absorber

Site	Wave Scatter	Annual Po (kW/m)	Annual MWh	Max hour Po (kW/m)
Pauwela (Maui) 73 m Depth	Hindcast (1990-2009) 3 km offshore	23	1,560 CF: 0.18	350
Grays Harbor (WN) 40 m Depth	NDBC (1987-2008) 9 km offshore	31	2,025 CF: 0.23	1160
Col. Rvr Bar (WN/OR) 135 m Depth	NDBC (1999-2008) 40 km offshore	40	2,630 CF: 0.30	1420
		Theoretical Resource	**Technical Resource**	**Survival**

Can your WEC device survive 1300 kW/m?