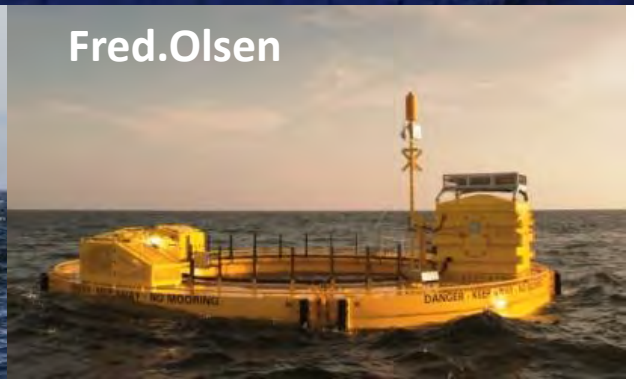
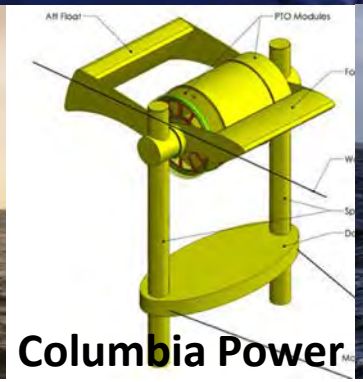
- U.S. Marine Corps Base Hawaii, Kaneohe
- 30, 60, and 80m berths now in and cabled to shore
- Grid connected
- HNEI role
  - Funded by DOE, US Navy, ONR, State of Hawaii
  - Acoustic, EMF, ecological, sediment xport measurements
  - Independent device durability and performance analysis
  - Site-dedicated support vessel/maintenance protocol development

NAVFAC Naval Facilities Engineering Command

APPLIED RESEARCH LABORATORY
UNIVERSITY OF HAWAI'I

NWEI





Columbia Power

Ocean Energy

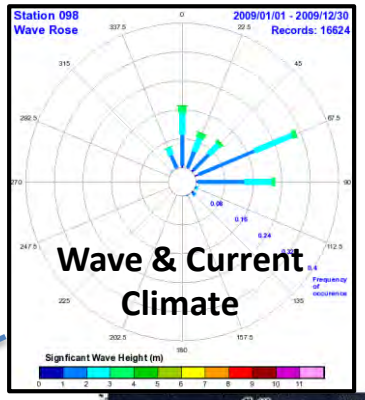
The Navy's Wave Energy Test Site

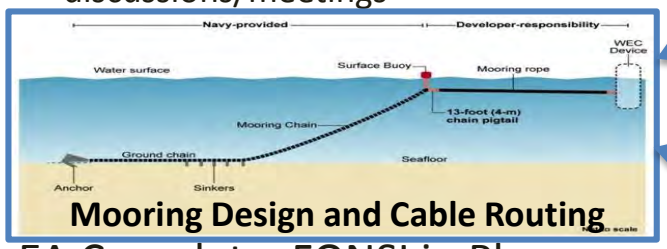
Patrick Cross, Hawaii Natural Energy Institute, University of Hawaii

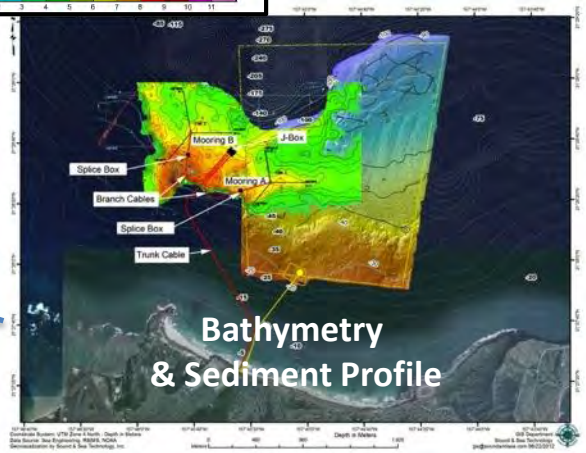
Ocean Renewable Energy Conference X – 16 July 2015

Progress to Date

- Site Design (60m and 80m berths) Complete
  - Design by Sound and Sea Technology for NAVFAC
  - HNEI Support
    - Wave/current analysis
    - Bathymetry and sediment survey
    - Participation in design planning discussions/meetings

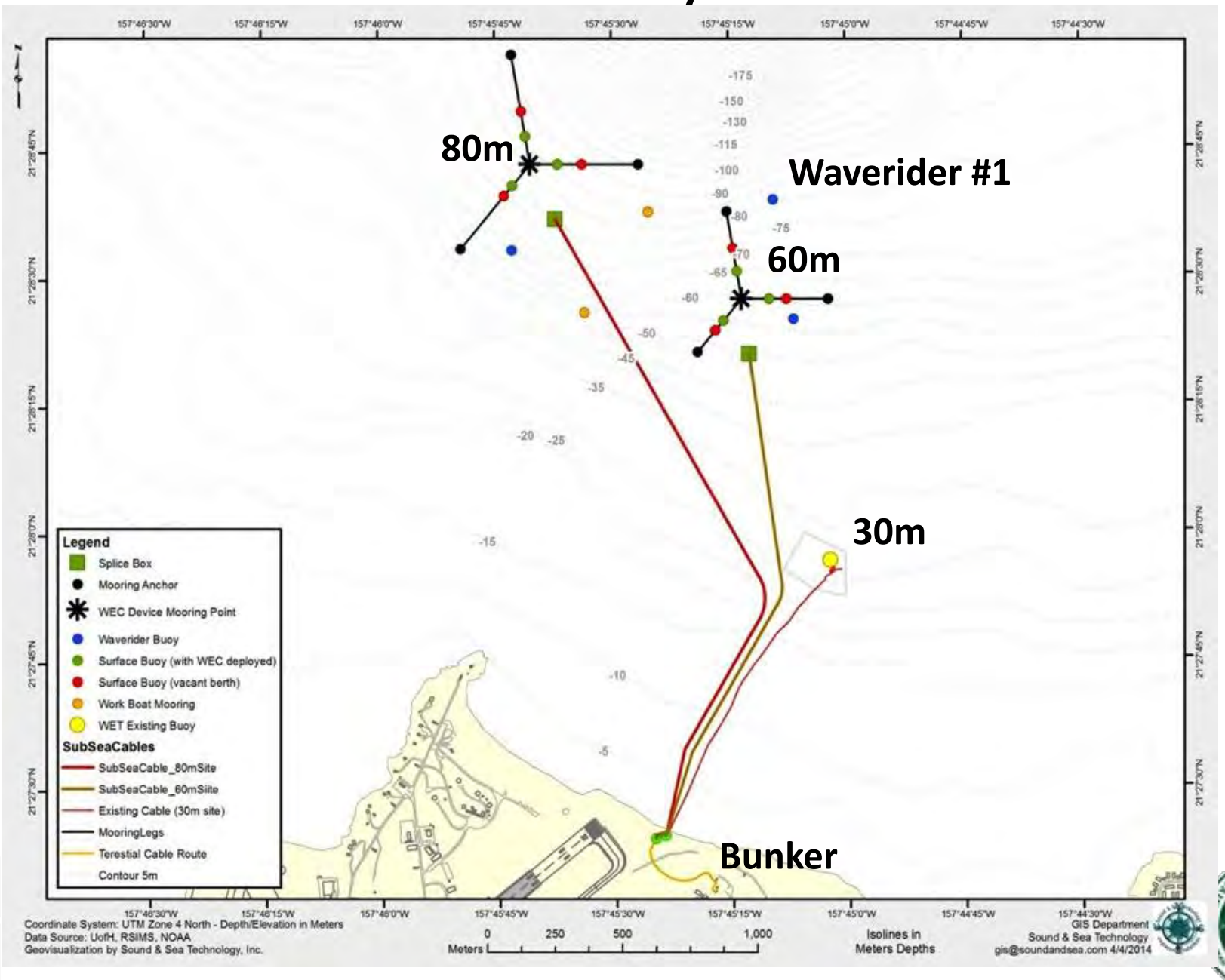




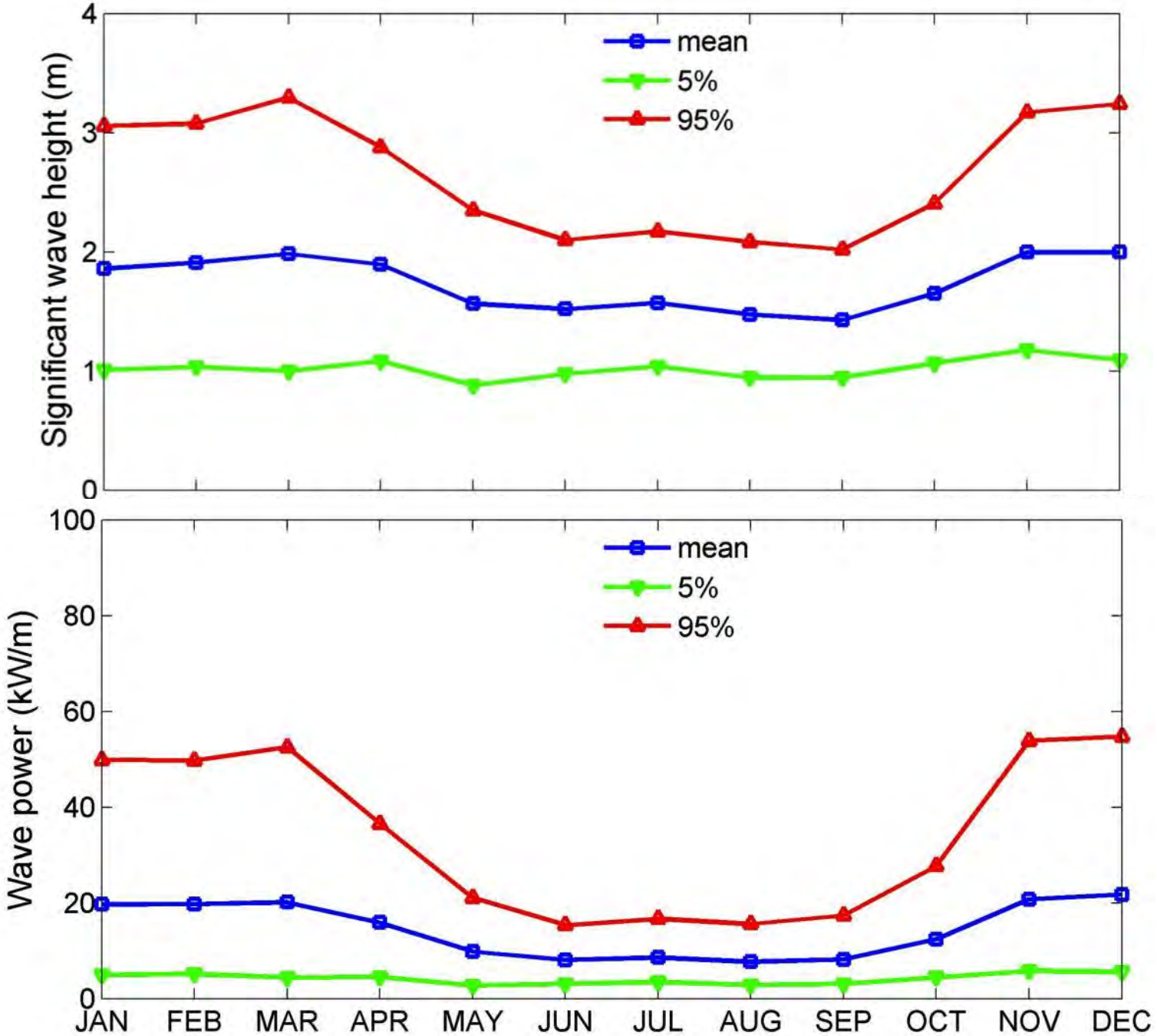


- Navy EA Complete, FONSI in Place
  - HNEI served in regular advisory role with NAVFAC, NOAA, DOE, Marine Corps for over 2 years
- Baseline Environmental Measurements Begun – Oct 2014
- NWEI device deployed at 30m berth – May 2015
- Cables laid to connect 60m/80m berths – June 2015

WETS Layout


80m
Waverider #1
60m
30m
Bunker
Legend
Splice Box
Mooring Anchor
WEC Device Mooring Point
Waverider Buoy
Surface Buoy (with WEC deployed)
Surface Buoy (vacant berth)
Work Boat Mooring
WET Existing Buoy
SubSeaCables
SubSeaCable_80mSite
SubSeaCable_60mSiite
Existing Cable (30m site)
MooringLegs
Terestial Cable Route
Contour 5m
Coordinate System: UTM Zone 4 North - Depth/Elevation in Meters
Data Source: UofH, RSIMS, NOAA
Geovisualization by Sound & Sea Technology, Inc.
0 250 500 1,000
Meters
Isolines in Meters Depths
GIS Department
Sound & Sea Technology
gis@soundandsea.com 4/4/2014

WETS Monthly Averages from 34-year Hindcast

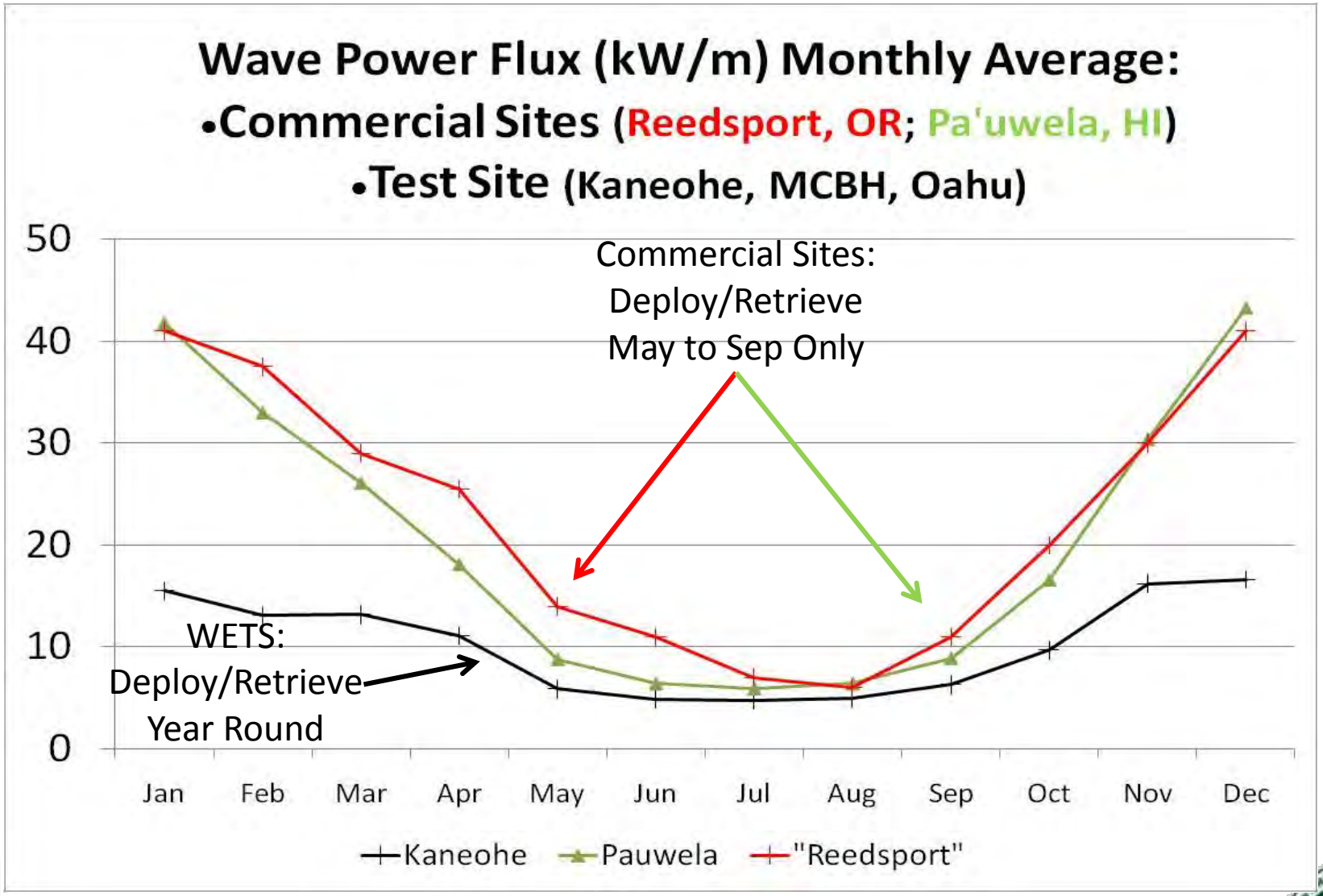


Who Does What at WETS

- NAVFAC
  - Permitted berths with primary mooring, submarine power, and data cables
  - Grid connection infrastructure + Interconnection Requirements Study
  - Device-specific permits (CATEX and ACOE permits)
  - Cooperative Research and Development Agreement or Navy contract
  - Host site (MCBH) coordination and office space in bunker
- Tenants
  - Obtain competitive selection for WETS testing through Navy BAA or DOE FOA
  - Deploy and retrieve device (connect to mooring and submarine cable)
  - Provide hawser for mooring connection and umbilical to Navy junction box
  - Subsystem parameter data collection
  - HECO Standard Interconnection Agreement (SIA) application
- HNEI
  - Independent evaluation of WEC power output as a function of wave conditions
  - WEC device, mooring system & power cable durability analysis
  - Environmental impact analysis (acoustics, EMF, eco. surveys, sediment transport)
  - Daily calibrated 7.5-day wave forecast
  - Device and array numerical modeling
  - Site-dedicated support vessel
  - Limited device maintenance response

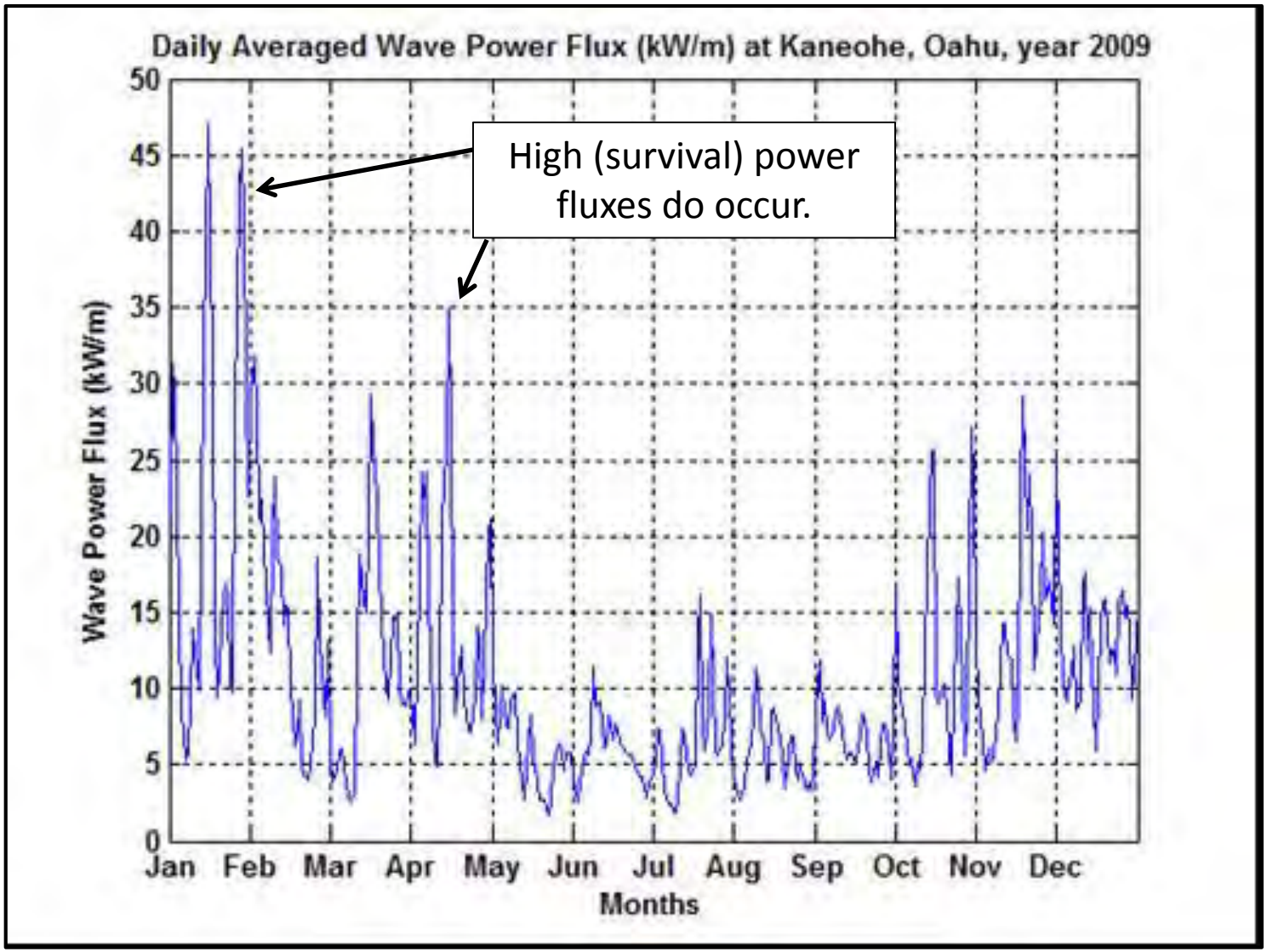
Questions?

Why WETS?



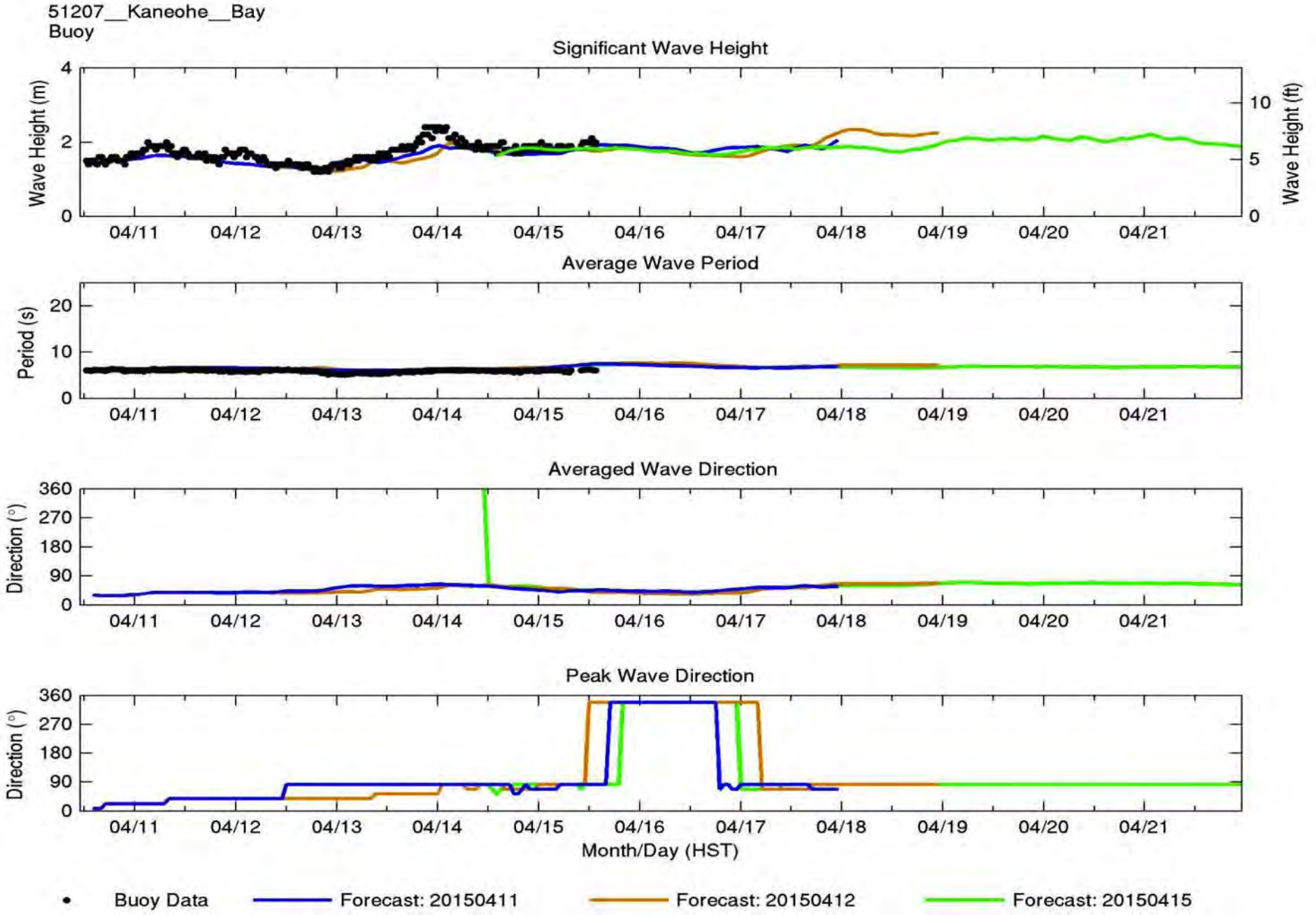
Year-round data collection in a wide range of wave conditions is possible.

Daily Wave Power Flux

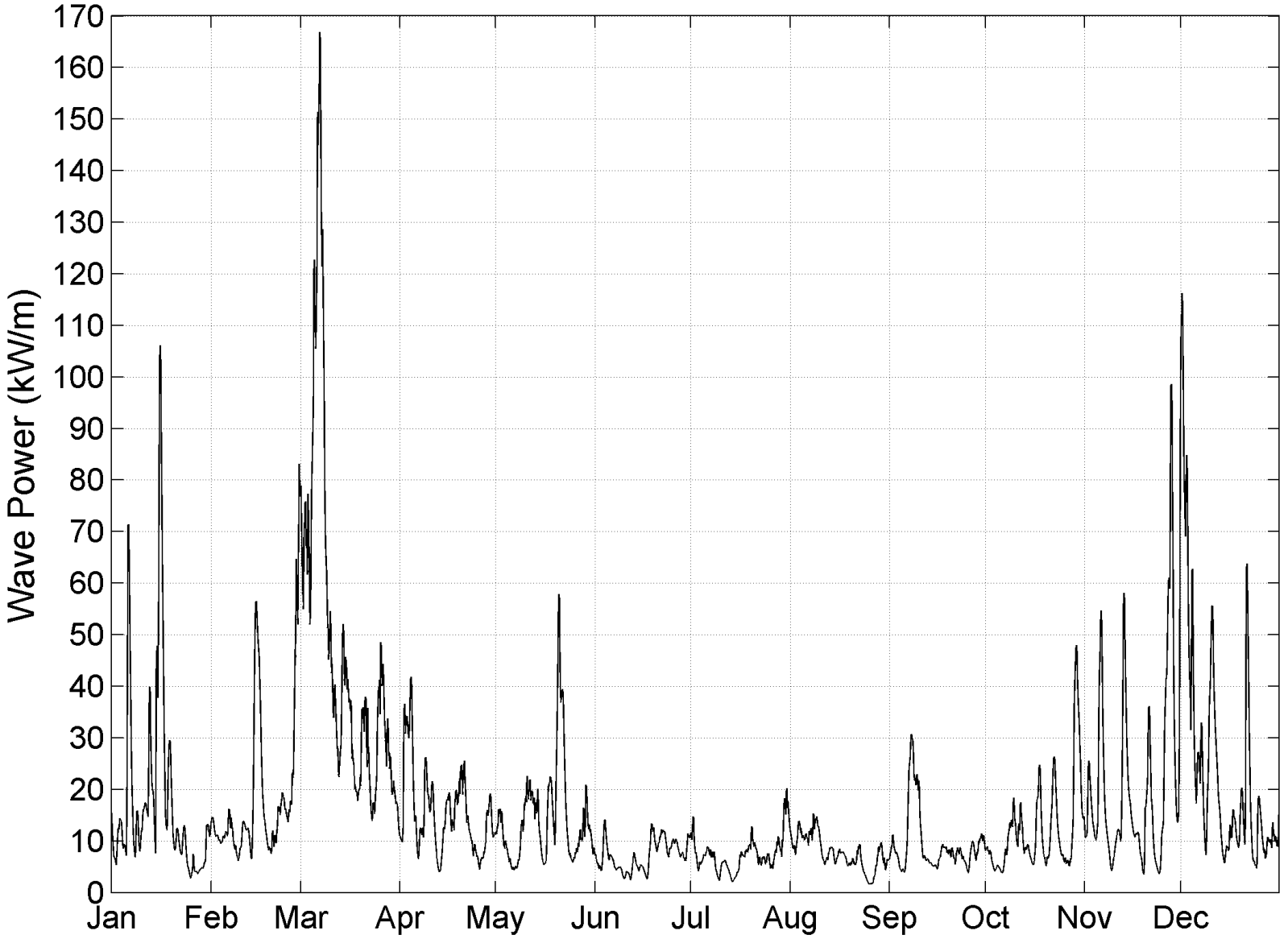


Device performance can be evaluated at WETS under wide ranging conditions.

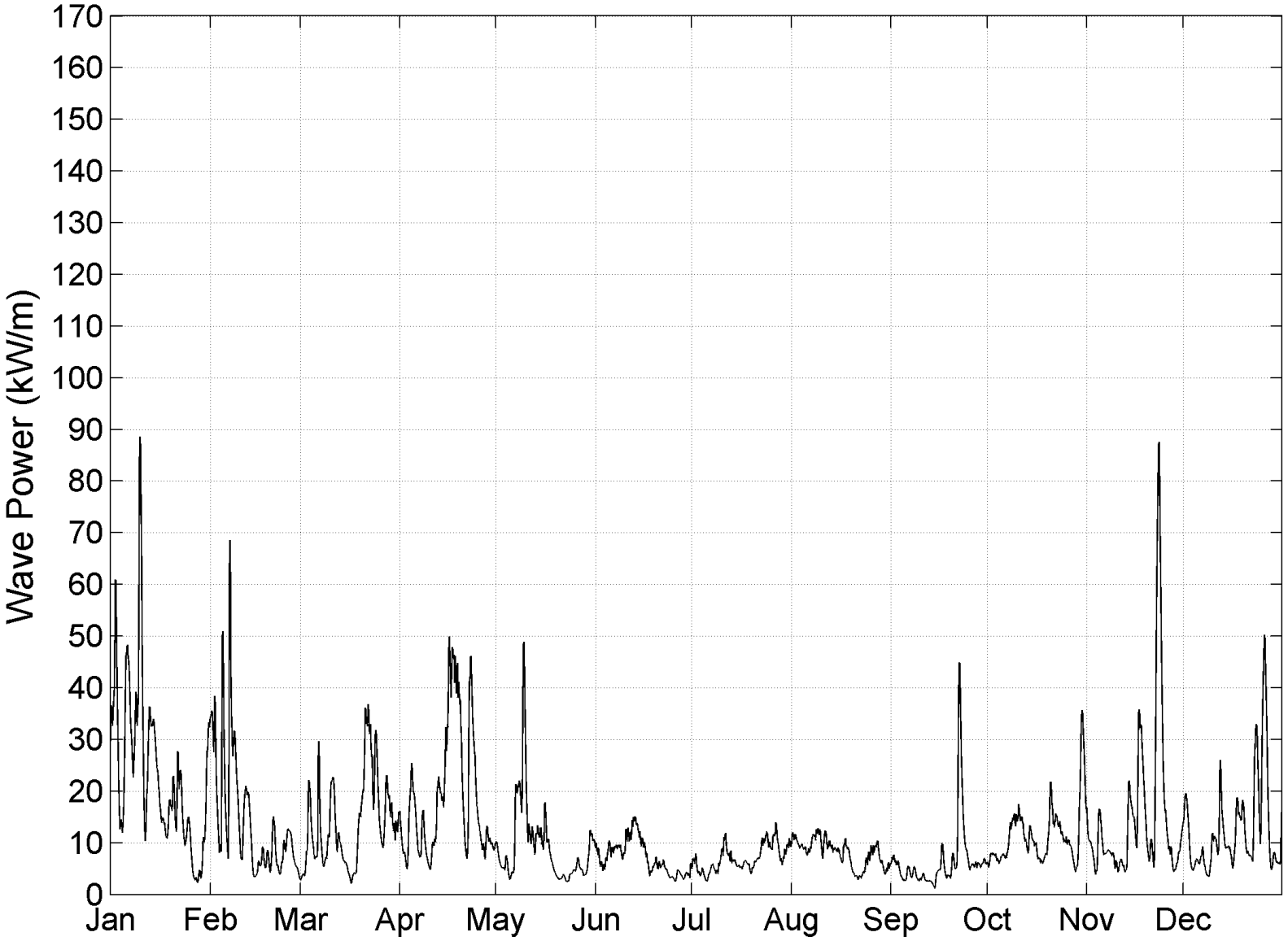
7.5-Day Daily Forecast



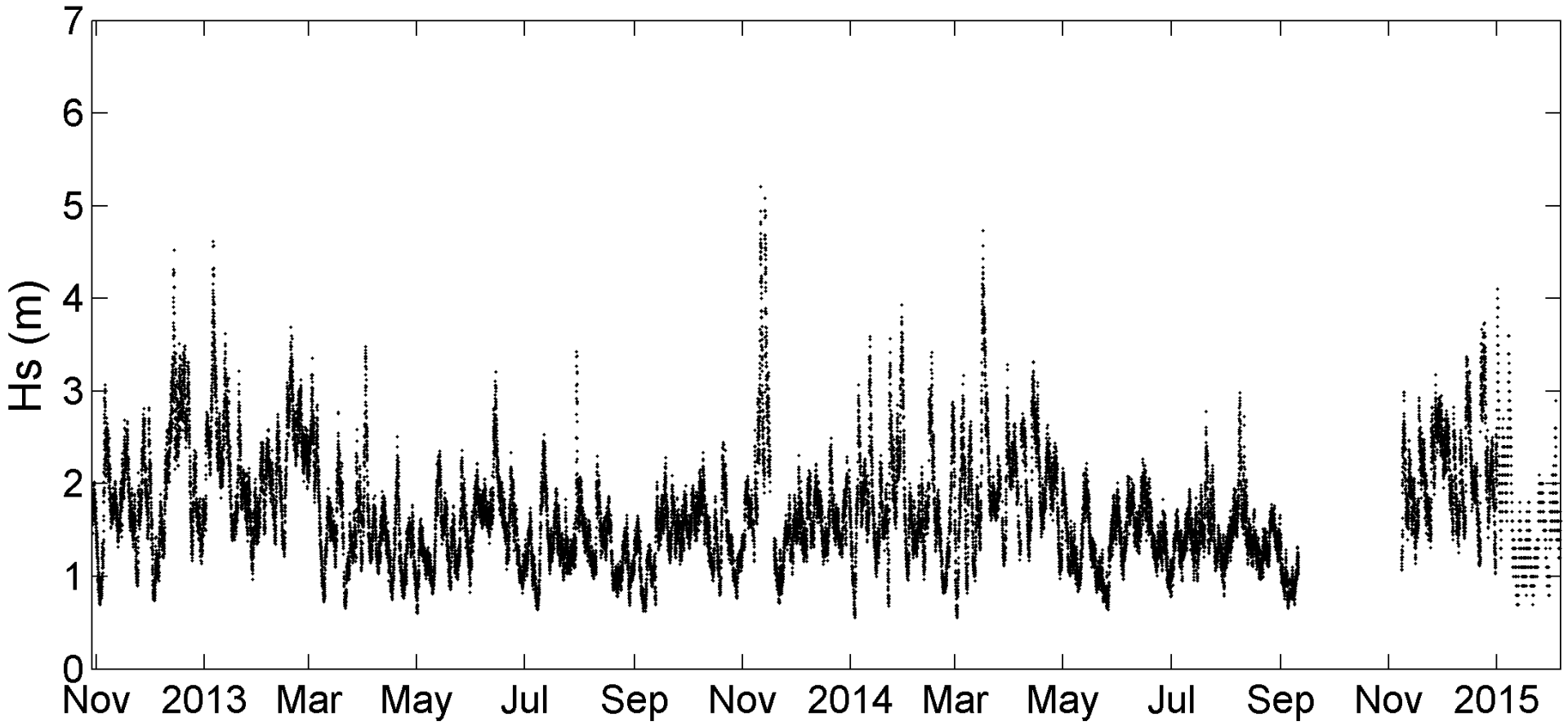
WETS Hourly Averaged Wave Power - 1985



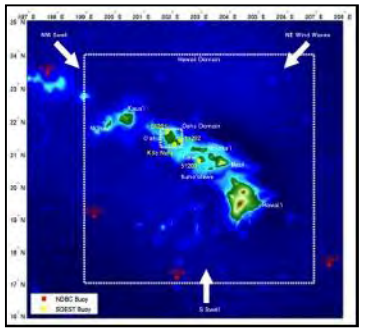
WETS Hourly Averaged Wave Power - 1995



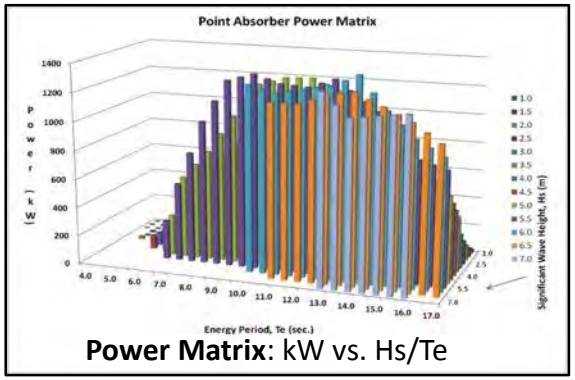
Wave Heights from NDBC Waverider, Station 51207, Kaneohe Bay, Hawaii (WETS)



HNEI WEC Device Performance Studies

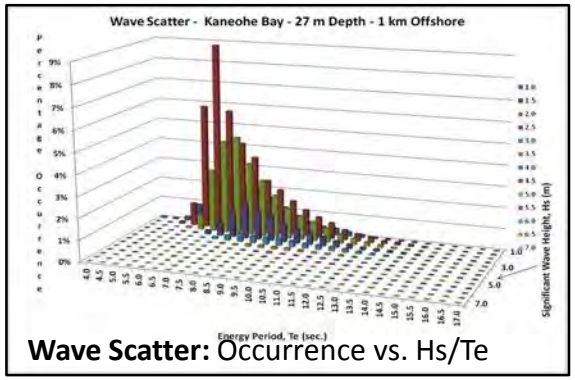


- Wave Measurements with Waverider Buoys and ADCP
- Wave Hindcast Database Developed, and Growing
- Daily 7.5-day Wave Forecasts with High-res Model
  - Calibrated w/WaveRider data from buoy deployed Oct 2012, 2 more in 2015
- Regular ROV and diver-based device and mooring inspections to analyze durability and develop operational and maintenance protocols
- Power matrix development – wave input versus power output



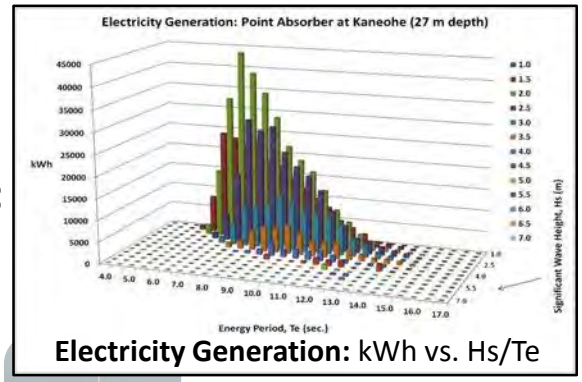
Power Matrix: kW vs. Hs/Te

X



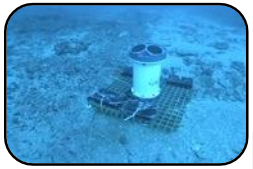
Wave Scatter: Occurrence vs. Hs/Te

=



Electricity Generation: kWh vs. Hs/Te

- Numerical Modeling
  - Device (w/non-linear physics)
  - Array (predict power extraction/area requirements)



Environmental Studies and Support Vessel

- Measurements to support regulatory and stakeholder databases
- Device acoustic signatures
  - Autonomous hydrophone station for each of 3 berths
  - Regular recoveries/redeployments to build database
  - Signal processing to assess device signatures
- Electromagnetic fields
  - Partner with OSU to periodically deploy system for measurement of EMF
- Sediment transport
  - Baseline and periodic measurements to detect any changes
- Ecological surveys and water chemistries
  - Regular diver and ROV surveys of marine ecosystems, including water samples
- Protected marine species monitoring
  - During WEC device deployments, other operations at sea, and periodically from shore
- Site-dedicated support vessel
  - A-frame, diver and ROV facilities, workspaces for tenants/UH
  - Kept at He'eia Kea small boat harbor ~ 1 hr transit from site
  - Can support future research initiatives at site

Figure 7. View inshore and above chain box AB

Figure 8. Close up of fish at chain box AB

Marine Mammals in Harmony with Wave Energy

WETS Schedule

Oct 2012	Waverider #1 operational
Jan 2014	Sound and Sea Technology 60/80m site expansion design finalized
Feb 2014	WETS EA and FONSI signed off
Jul 2014	NAVFAC/ARL task order approved, funding HNEI support through Jul 2018
Sep 2014	60/80m moorings deployed
Oct 2014	HNEI acoustic, sediment, ecological data collection begins
May 2015	NWEI device deployed at 30m berth
Late June 2015	60/80m berths cabled to shore
Summer 2015	Second Waverider deployed
August 2015 (?)	Fred.Olsen device deployed at 80m berth
Summer 2016	Ocean Energy device deployed at 60m berth
2017	Columbia Power/NWEI to occupy deep berths