ICOE 2016
INTERNATIONAL CONFERENCE ON OCEAN ENERGY

- U.S. Marine Corps Base Hawaii, Kaneohe
- 30m, 60m, 80m berths in place, grid-connected
- First device deployed, second Feb 2016, third Sep 2016
- HNEI role
  - Acoustic, EMF, ecological, sediment transport 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

ONR Science & Technology

U.S. Navy Wave Energy Test Site – Research Update

Patrick Cross, Hawaii Natural Energy Institute (HNEI)

Hawaii Natural Energy Institute

Alternative Fuels: Biomass and biofuels; methane hydrates

Electrochemical Power Systems

Fuel Cells, Batteries

Renewable Power Generation

Ocean Energy

Photovoltaics

Energy Efficiency

Building technology

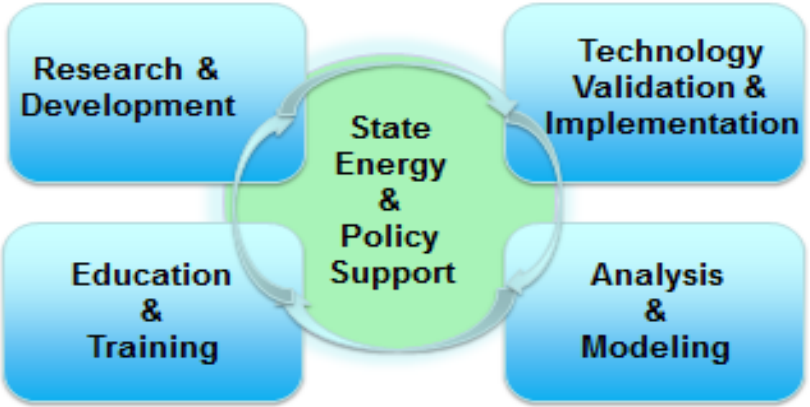
Sea Water Air Conditioning

Systems Integration

Grid modeling and analysis

Smart grid development

Grid-scale storage

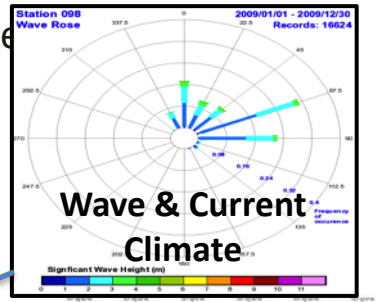


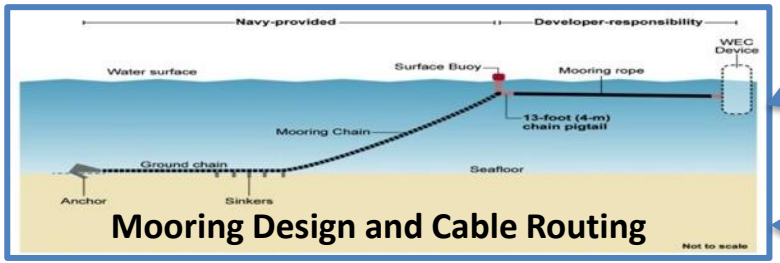
Funding Sources for WETS Support

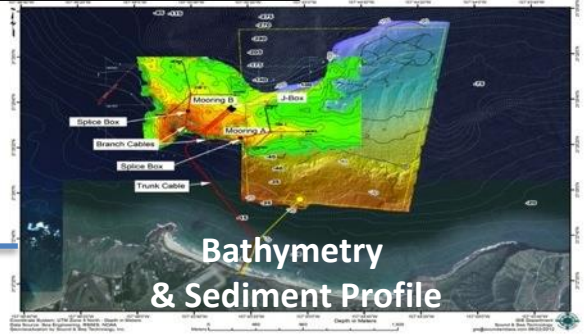
- US Department of Energy
- US Navy – Naval Facilities Engineering Command
- Office of Naval Research
- State of Hawaii

Progress to Date

- Site Design and Environmental Assessment(60m and 80m be
  - 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, Finding of No Significant Impact
  - HNEI served in advisory role with NAVFAC, NOAA, DOE, Marine Corps for over 2 years
  - Authorizes point absorber and OWC devices, subject to CATEX
- > 1 Year of Environmental Measurements
- First WEC (Azura) deployed May 2015, Second (Lifesaver) Feb/Mar 2016

WETS Layout

80m

Waverider

Waverider

60m

30m

Bunker

Cable Capacity

30m Berth – 250kW

60/80m Berths – 1MW

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

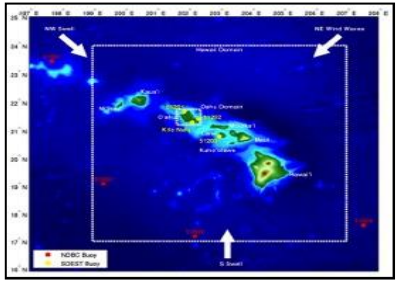
Coordinate System: UTM Zone 4 North - Depth/Elevation in Meters
Data Source: UofH, RSIMS, NOAA
Geovisualization by Sound & Sea Technology, Inc.

0 250 500 1,000
Meters

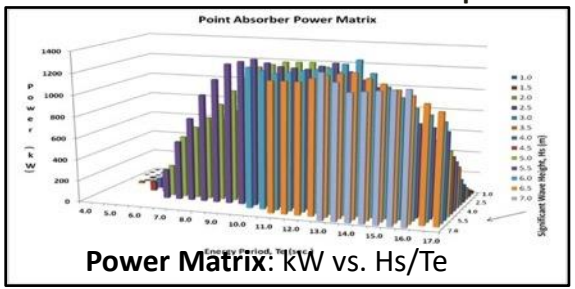
Isolines in Meters Depths

GIS Department
Sound & Sea Technology
gis@soundandsea.com 4/4/2014

HNEI WEC Device Performance Studies

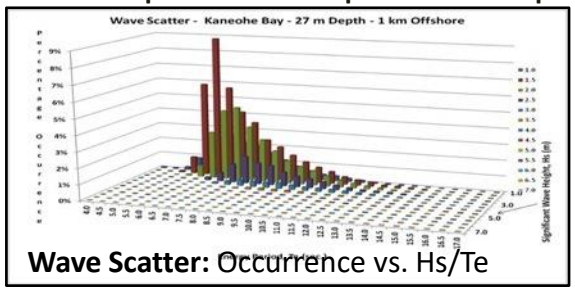


- Wave Measurements with Waverider Buoys and ADCP
  - WETS Waverider #1 deployed Oct 2012, #2 in early 2016
- Daily 7.5-day Wave Forecasts with High-res Model
  - Calibrated w/Waverider data
- Wave 34-year Hindcast Database Developed
- Regular ROV and diver-based device and mooring inspections to analyze durability and develop operational and maintenance protocols
- Power matrix development – wave input versus power output



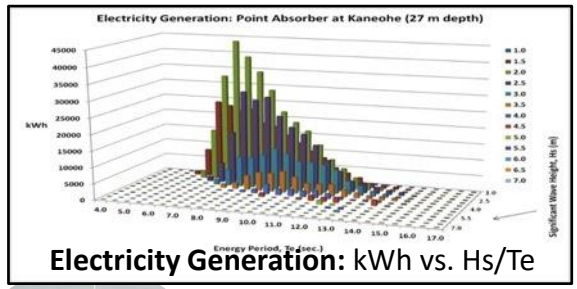
Power Matrix: kW vs. Hs/Te

X



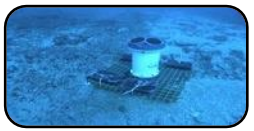
Wave Scatter: Occurrence vs. Hs/Te

=

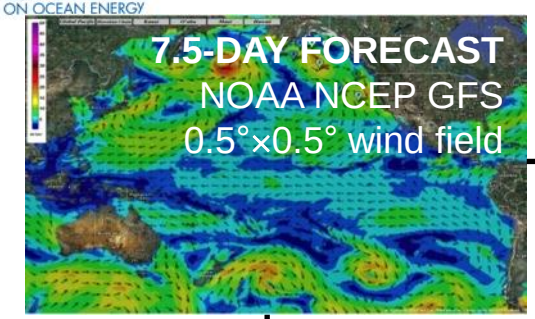


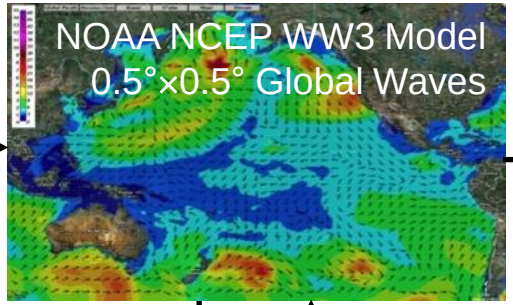
Electricity Generation: kWh vs. Hs/Te

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

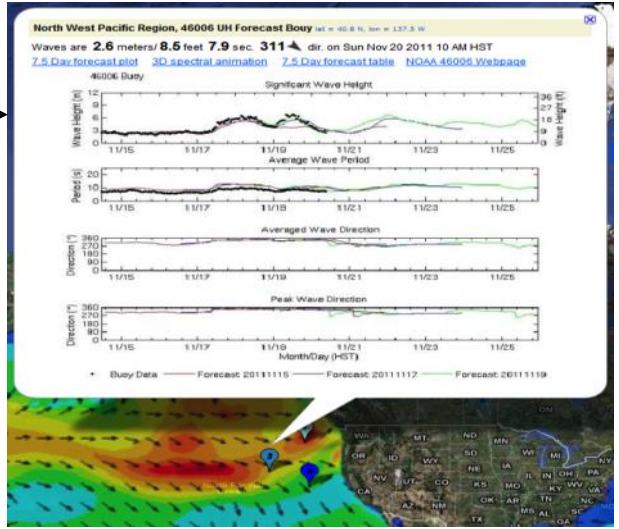


Wind and Wave Forecast System

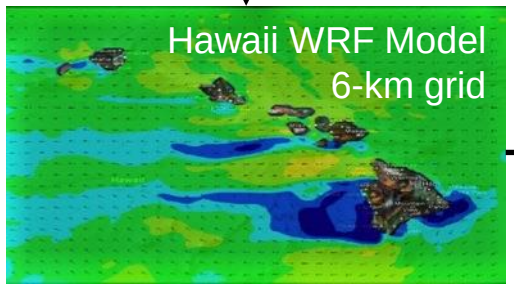


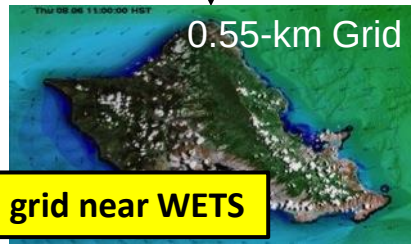


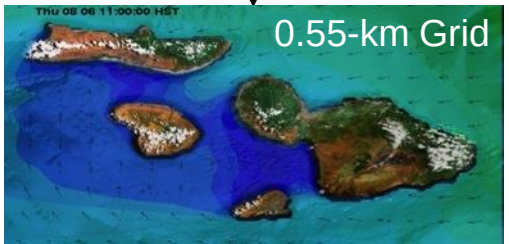
Available at oceanforecast.org

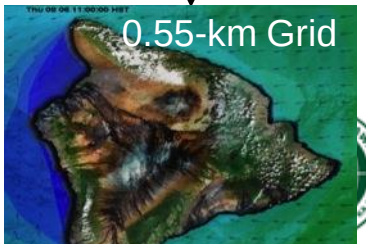


Real-time validation with buoy measurements







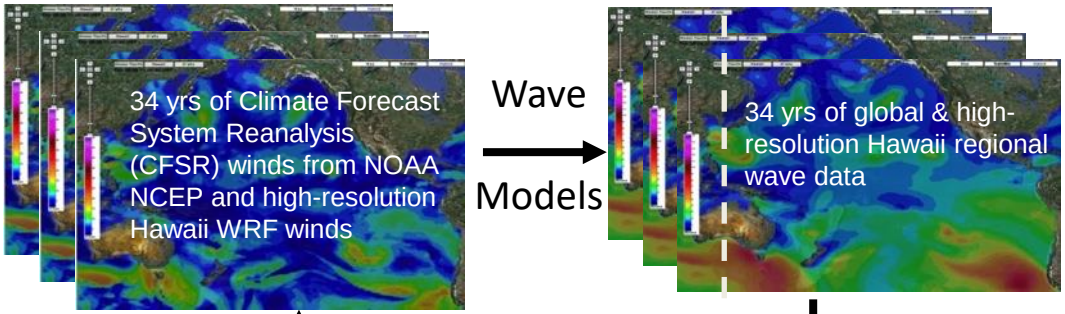


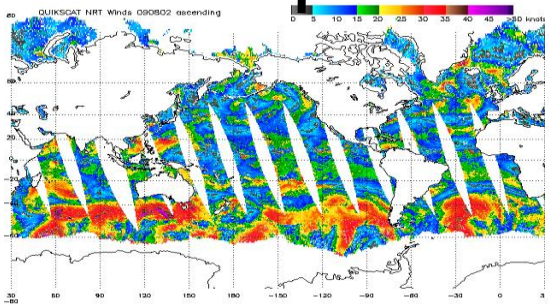
100m grid near WETS

Wave Hindcasting

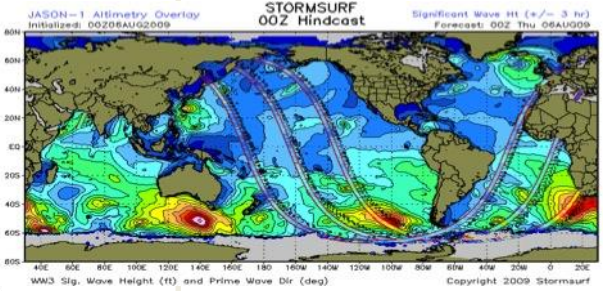
Hindcasting of global and Hawaii regional wave data for 1979 – 2013

- Validation with satellite and buoy measurements
- Long-term wave hindcast for nearshore facility design and wave energy resource assessment

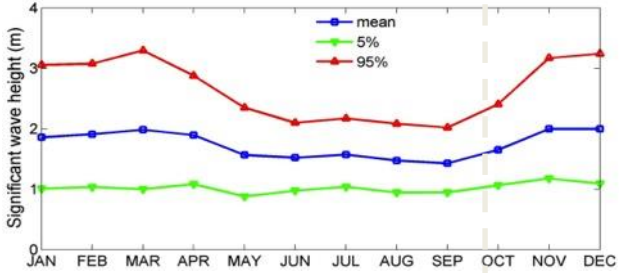




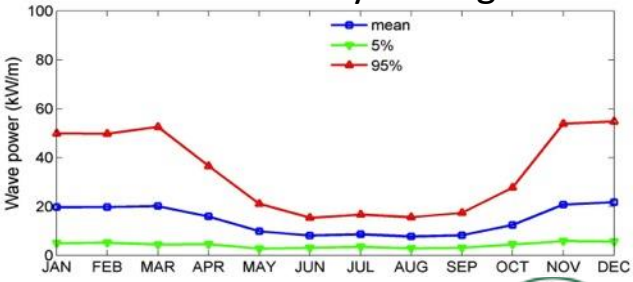
Satellite and in-situ observations



Altimetry and buoy observations

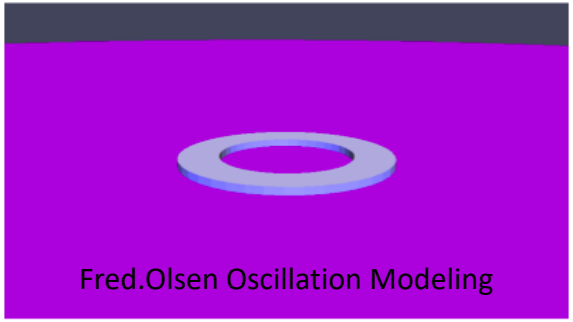


WETS Monthly Averages

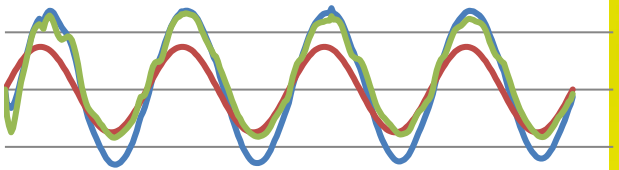


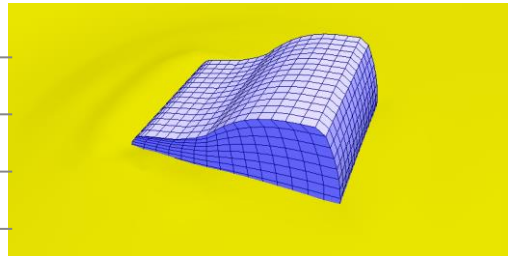
WEC Numerical Modeling

- Provide state-of-the-art numerical modeling assistance to WEC developers planning/conducting tests at WETS, as desired
  - Prediction of power performance matrix
  - Validation of predicted power matrix versus measured
- ➢ Provide insights into device modifications for performance enhancement
- Modeling tools employed by HNEI:
  - Mid-fidelity: WECSIM, WAVEDYN, WAMIT
  - High-fidelity: FLOW-3D, OpenFOAM

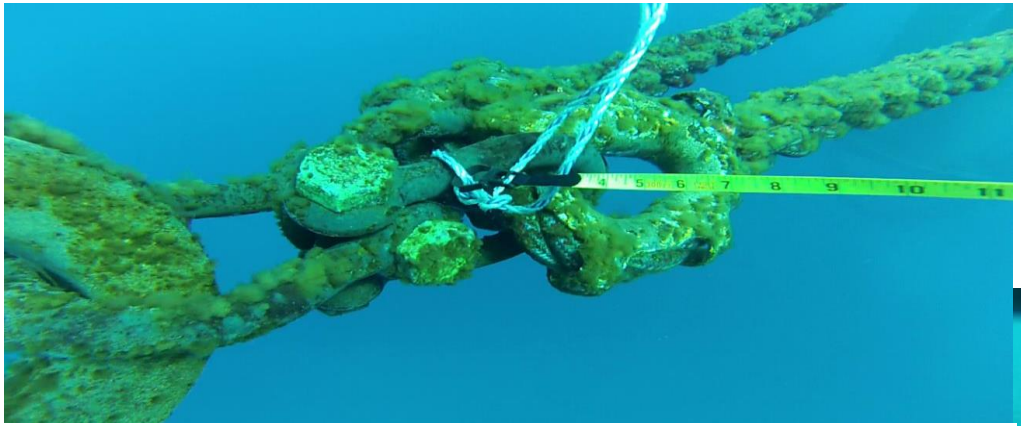

Fred.Olsen Oscillation Modeling

Azura Heave Oscillation Tests from OpenFOAM

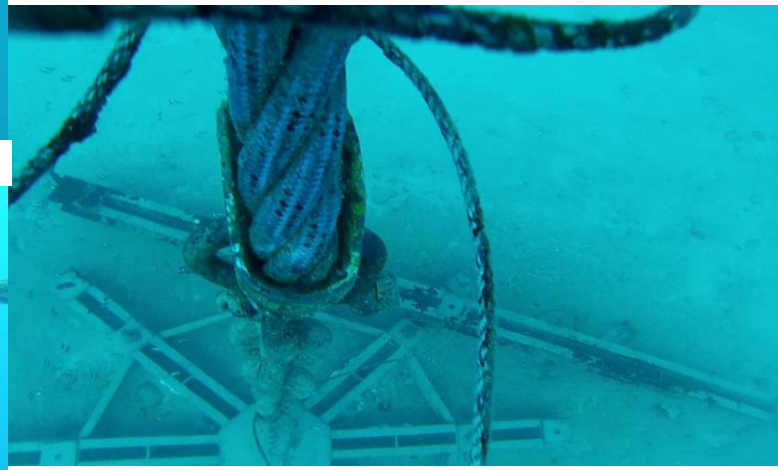




Device and Mooring Durability Assessment



- Quarterly surface and diver/ROV inspections of WEC devices and mooring infrastructure
- Document maintenance issues and develop protocols



Environmental Data Collection

- Measurements to support regulatory and stakeholder databases
- Device acoustic signatures
  - Bottom-mounted and drifting hydrophone systems
  - Regular deployments to build database
  - Assess device signatures and ambient noise
- Electromagnetic fields
  - Partner with OSU to periodically deploy system for measurement of EMF
- Sediment transport
  - Baseline and periodic measurements to detect 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, at-sea operations, and periodically from shore

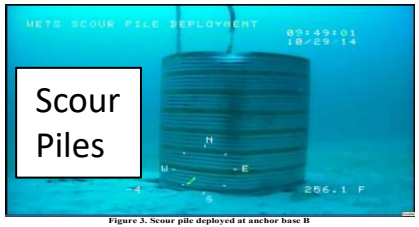


Figure 3. Scour pile deployed at anchor base B

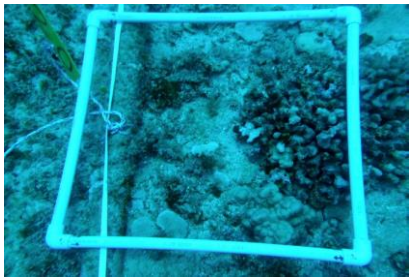
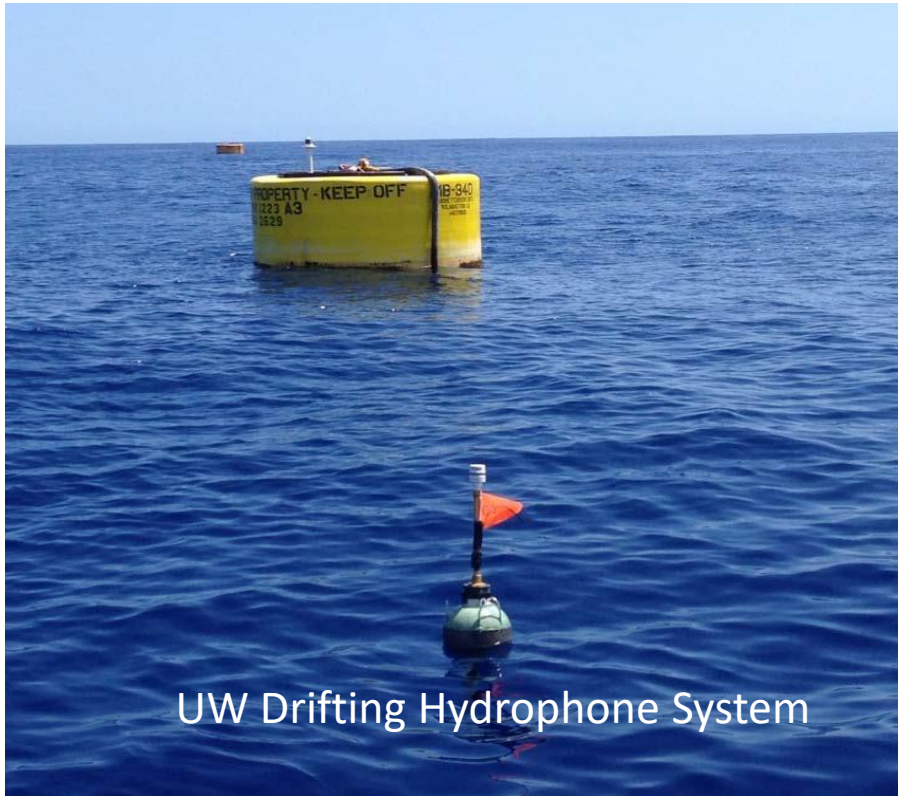


Figure 12. Deep Transect: 20m Location

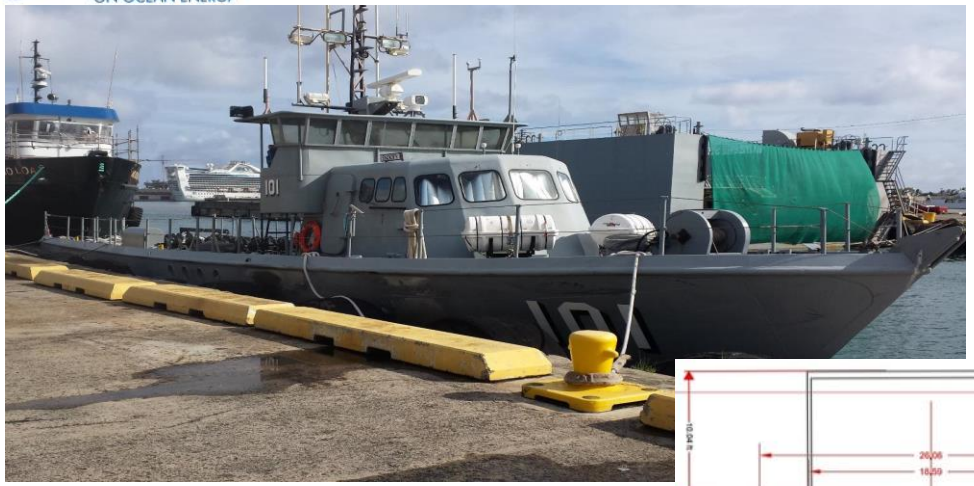
Acoustic Instrumentation Systems

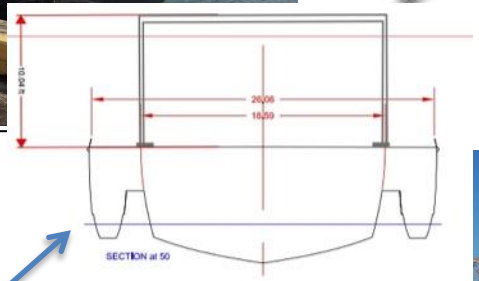
UW/UH Bottom-Mounted
3-hydrophone Station



UW Drifting Hydrophone System

WETS Site-Dedicated Support Vessel – Sea Engineering, Inc.





- 85 foot LOA
- 4-point mooring capability
- 10-ton lift capacity
- Deepwater dive spread
- ROV enclosure
- Reconfiguring w/added beam
- To be kept at boat harbor ~ 1hr away

Deployment of Azura – 28 May 2015


HUKI PAU

Launch of Lifesaver
28 August 2015

Questions?