Ocean Observatories Initiative

Coastal Surface Piercing Profiler (CSPP)

- WHOI Cable Modeling
- Presented at uCSPP CDR
- Sept. 10, 2013

Operating Environment Requirements

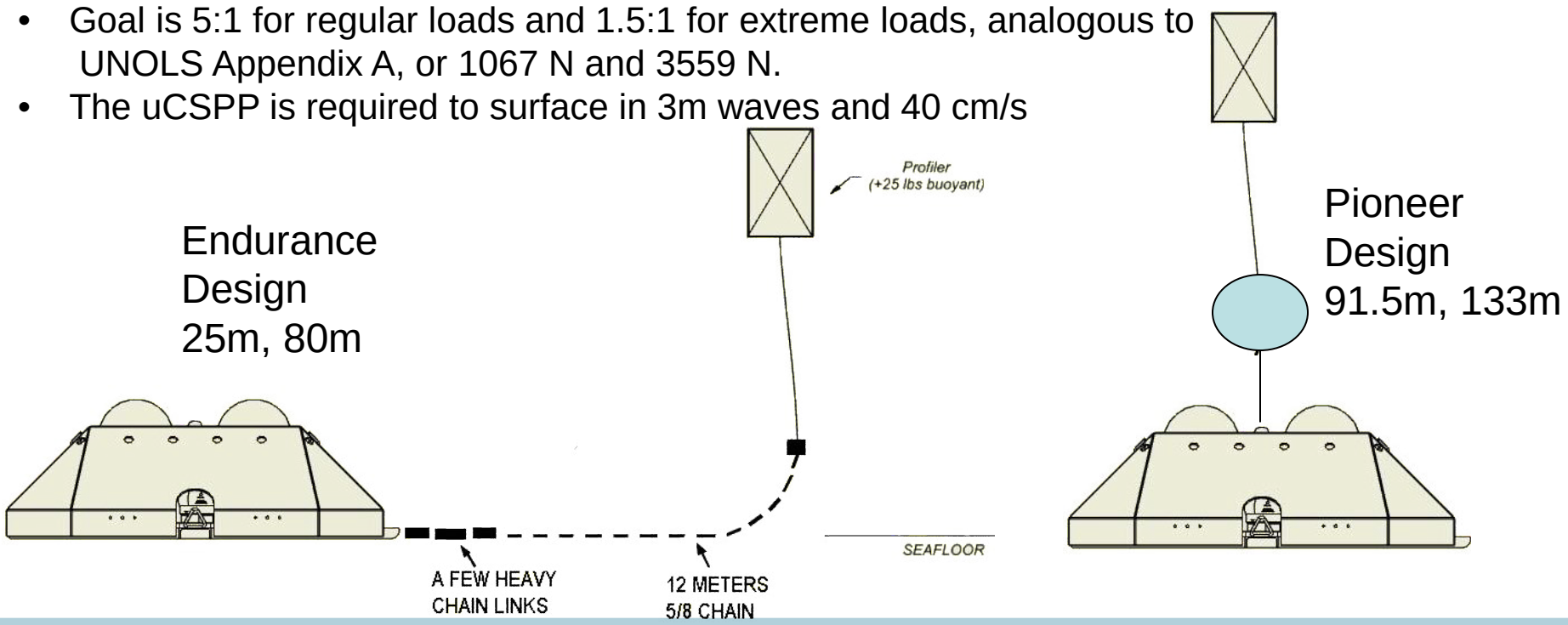
- OPEN-002: The coastal surface piercing Profiler shall have the capability to reach the surface in conditions of winds of 10 m/s and maximum significant wave heights of up to 3 meters.
- OPEN-006: The coastal surface piercing Profiler should have the capability to reach the surface in conditions of winds up to 20 m/s and maximum wave heights up to 8 meters. This is an objective.
- COTS:
  - Previous deployments of the system have proven the ability of the AMP to meet the threshold requirement, but not the objective.
- Development:
  - Numerical modeling with WHOI Cable was done to show that the uCSPP could meet the threshold requirement.
- Analysis: No further work needed
  - The anchor test part of the First Article Test will validate the WHOI Cable results

WHOI Cable

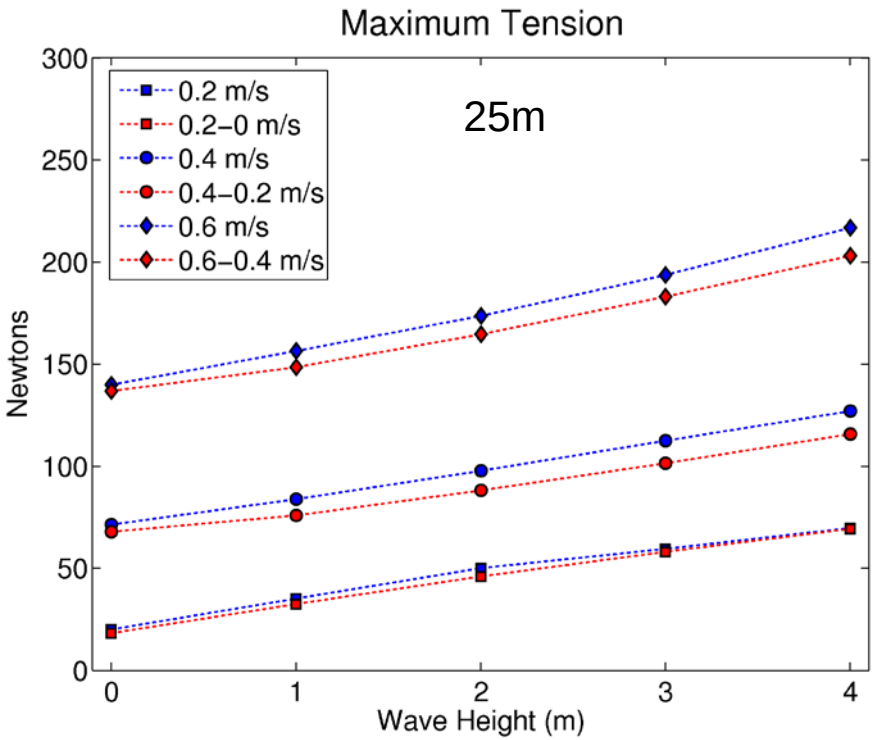
by Jason I. Gobat and Mark A. Grosenbaugh, 2000

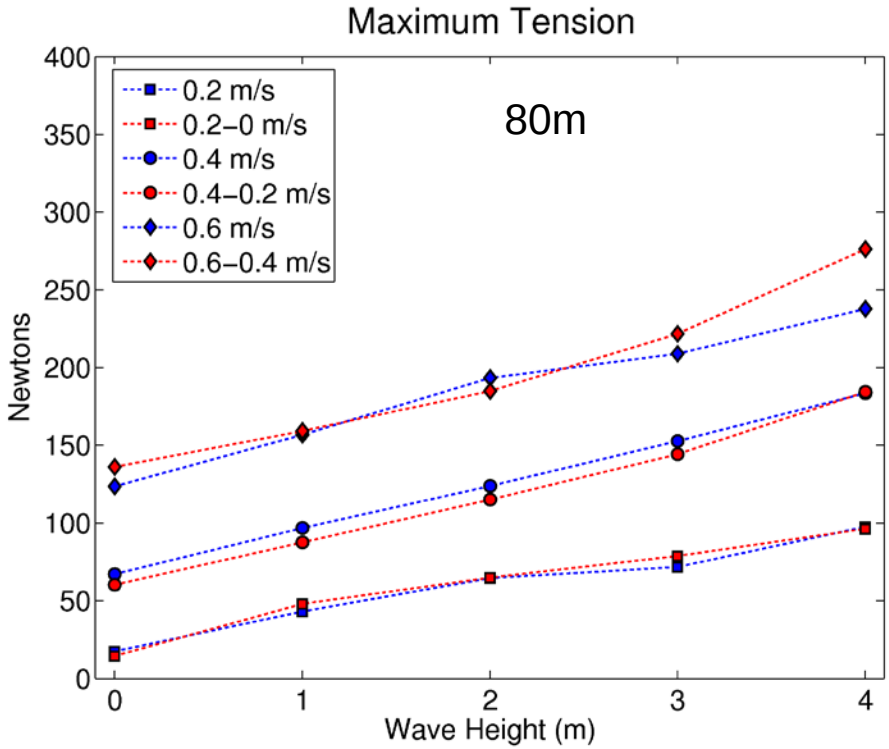
- Models mooring motion and line tension as a function of waves and currents
- Has been used to model other OOI moorings

- The AMP winch rope new is rated at 1400 lbs.
- After deployments, WET Labs has measured breaking strengths of 1200 lbs. = 5338 Newtons
- Goal is 5:1 for regular loads and 1.5:1 for extreme loads, analogous to UNOLS Appendix A, or 1067 N and 3559 N.
- The uCSPP is required to surface in 3m waves and 40 cm/s



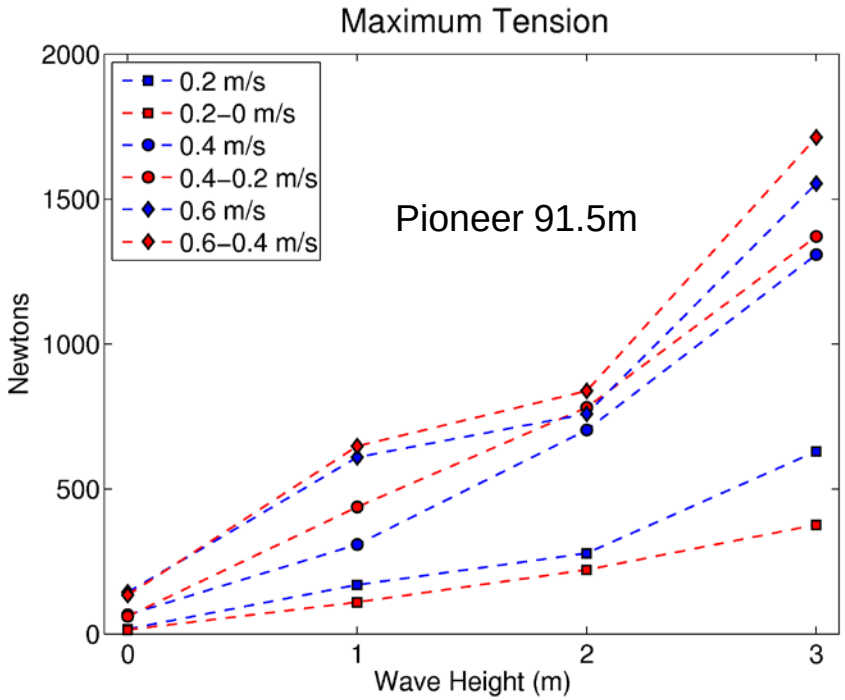
WHOI Cable Results for Top of Water Column





Endurance uCSPPs meet the 3 m requirement by over a factor of 5 (vs. 1067 Newtons)

WHOI Cable Results for Top of Water Column

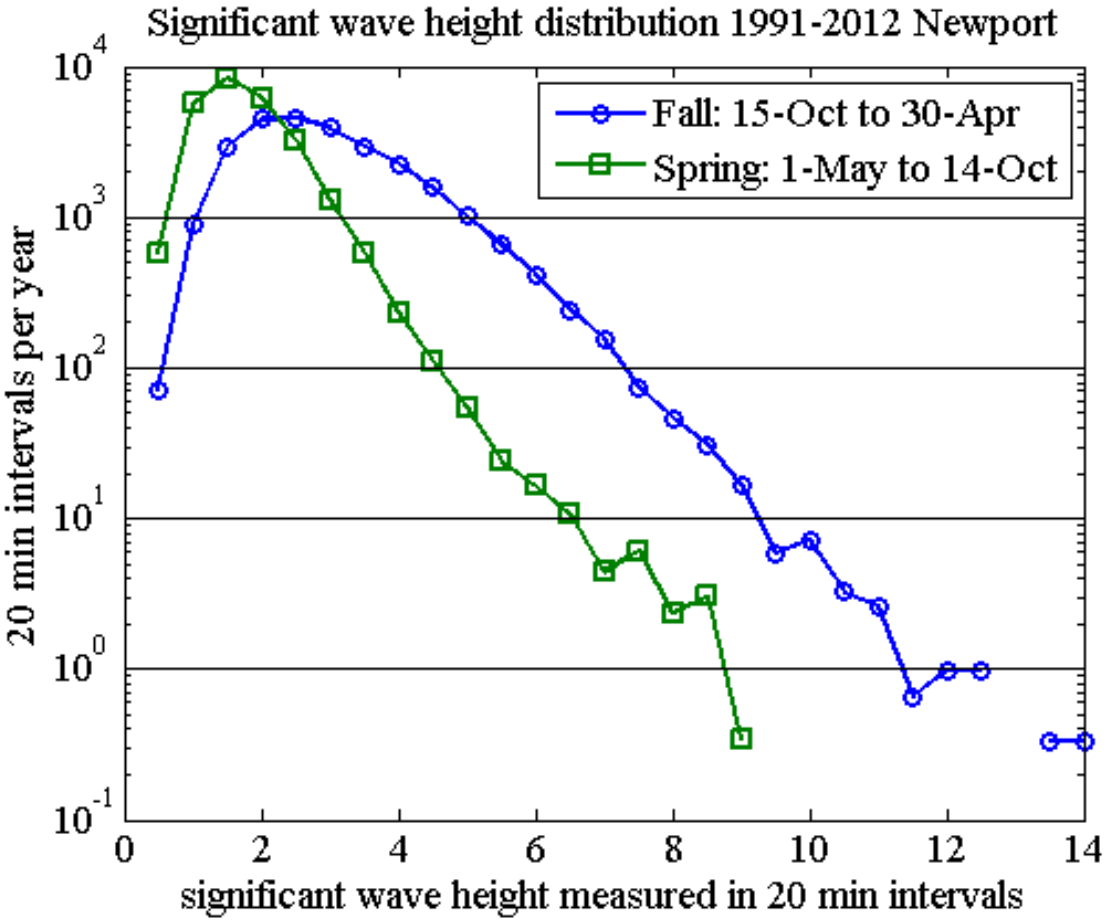


1. Pioneer uCSPPs does not meet the 5:1 tension goal and always meets the 1.5:1 goal
   (~1700N is 3:1 vs. 1067N for 5:1 and 3559N for 1.5:1)
2. Lack of a chain at bottom causes nearly a 10x increase in tension spikes
3. Keeping winch on at the surface can further reduce tension spikes
4. Model results will be tested in the First Article Test to validate these results
5. The Pioneer 133m uCSPP will experience slightly less tension than the Pioneer 91.5m uCSPP

Operating Environment Requirements

- OPEN-003: The coastal surface piercing Profiler shall be designed to sustain 30 year return period extreme waves, winds, currents, and tides.
- OPEN-004: The coastal surface piercing Profiler shall be designed to survive 100 year return period extreme waves, winds, currents, and tides.
- COTS:
  - Engineering analysis based upon past deployments shows that the AMP design can meet these requirements at the 133, 91.5 and 80m sites, but not at the 25m sites. This includes mechanical integrity as well as methods that reduce functionality to achieve sustained operations.
- Development:
  - Numerical modeling with WHOI Cable was done to show that the AMP could meet this requirement at the 25m sites during the spring deployments but not fall ones
  - OSU and WET Labs agreed before starting CLIN 1 that meeting this requirement completely would be a low priority because of the large amounts of time and money needed to address it and the low probability of actually meeting it.
- Analysis: No further work needed
  - The anchor test part of the First Article Test will validate the WHOI Cable results

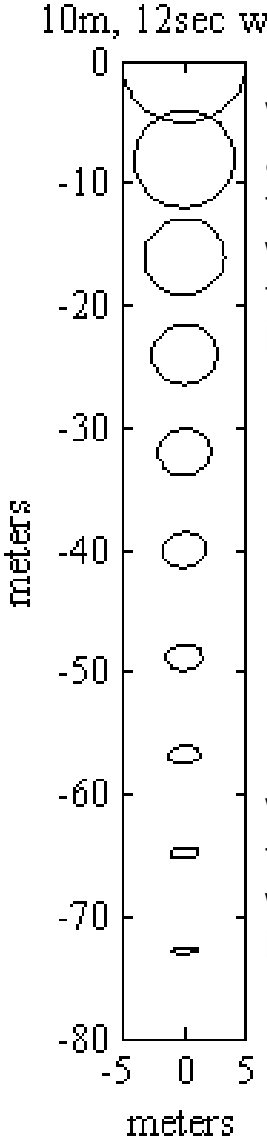
Implications of sustaining 30-year & surviving 100-year waves



9-10 m max waves Spring/Summer
14-15 m max waves Fall/Winter

Significant wave height is the mean height of the highest third of waves, traditionally measured over 20 minutes.

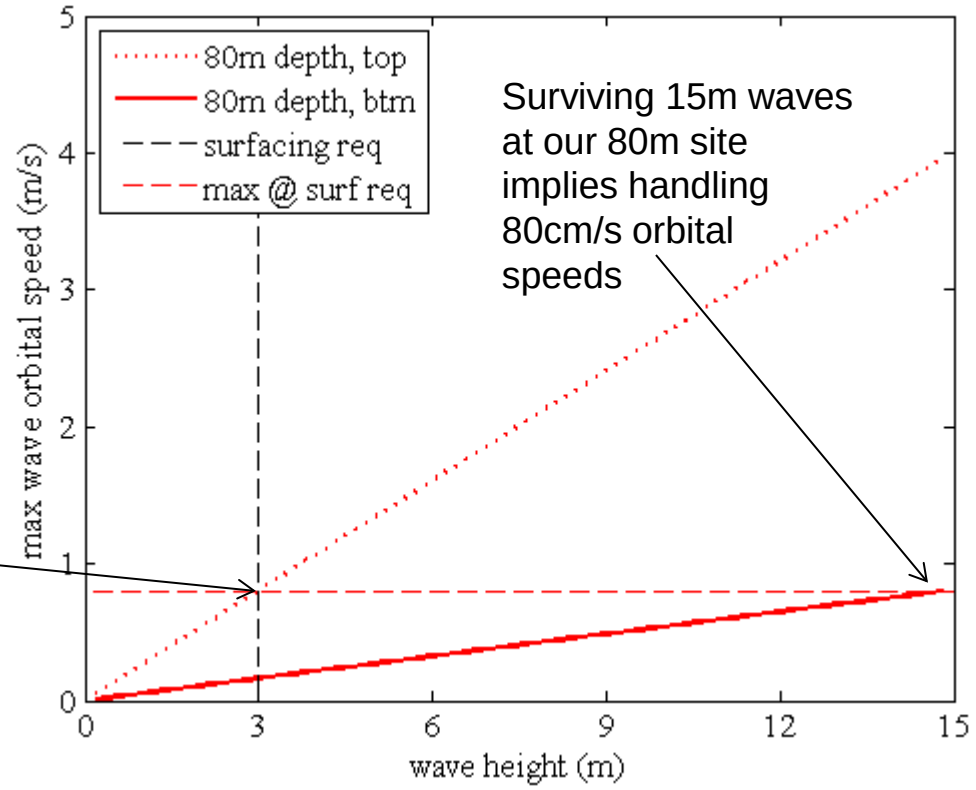
Implications of sustaining 30-year & surviving 100-year waves



Wave orbitals are higher at the top of the water column than the bottom

Wave orbitals flatten in shallow water near the bottom

Surfacing in 3m waves at our 80m site implies operating in 80cm/s orbital speeds

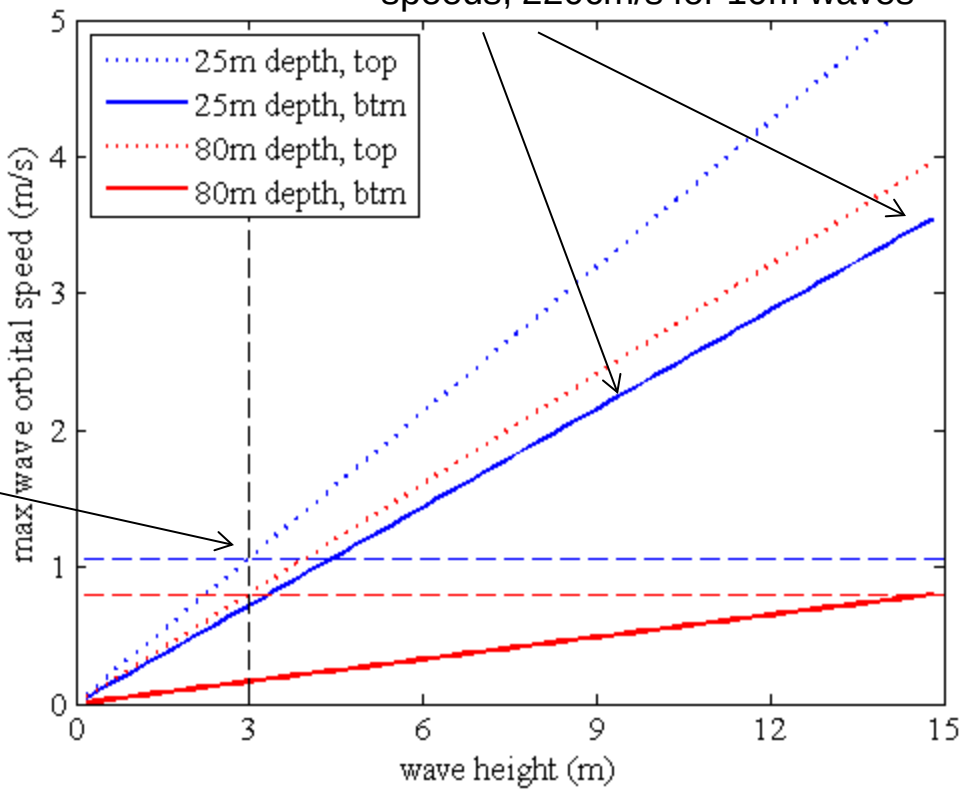


Surviving 15m waves at our 80m site implies handling 80cm/s orbital speeds

Implications of sustaining 30-year & surviving 100-year waves

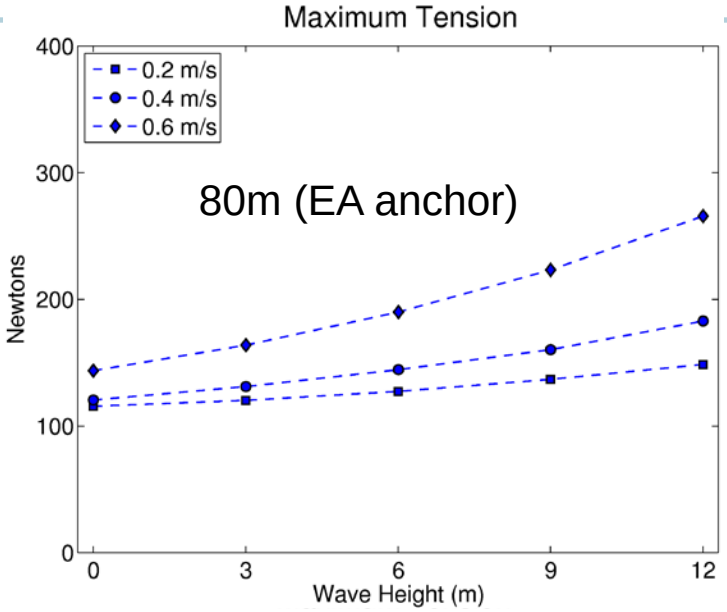
Surviving 15m waves at our 25m site implies handling 360cm/s orbital speeds, 220cm/s for 10m waves

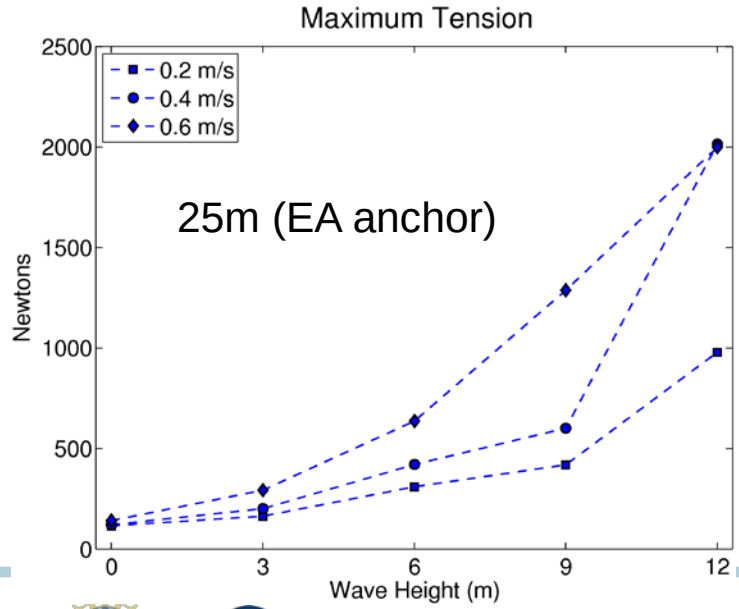
Surfacing in 3m waves at our 25m site implies operating in 100cm/s orbital speeds

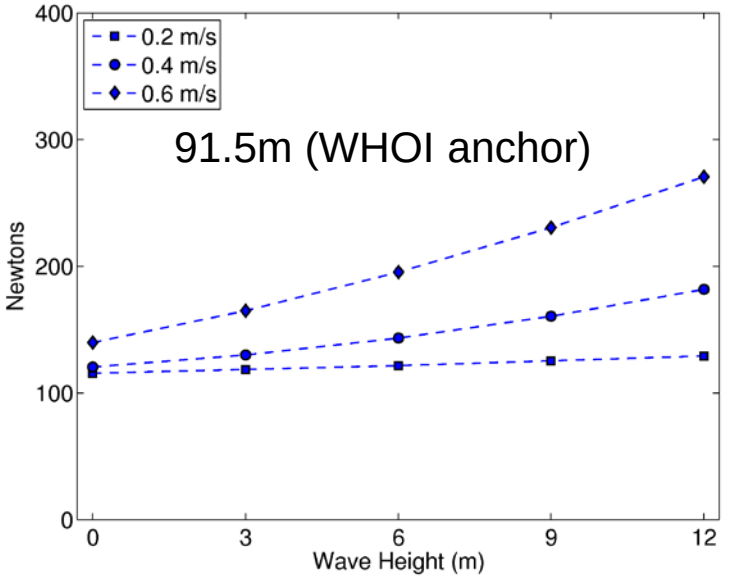


WHOI Cable Tension Results Near the Sea Bed

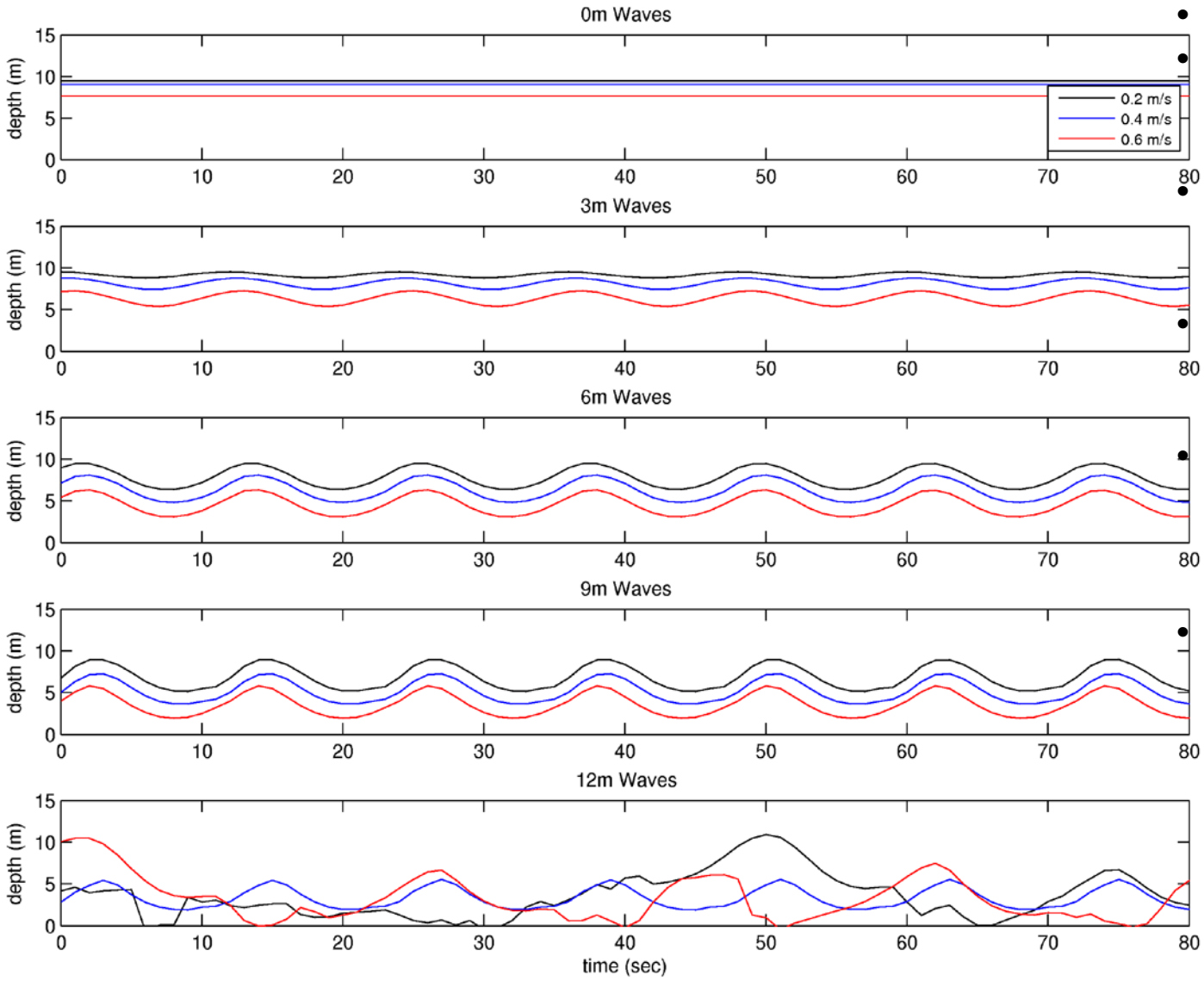
1. The Pioneer and EA 80m uCSPP meet the 5:1 goal (1067N).
2. The EA 25m uCSPP does not meet the 5:1 goal in spring/summer (~3:1 for ~10m max wave, ~0.8m/s max currents)
3. The EA 25m uCSPP may not meet the 1.5:1 goal (3559N) during fall/winter (~15m max wave, ~1.0m/s).
4. WHOI Cable is not stable over 12m. This is not a problem with WHOI Cable. See time series on next slide.







WHOI Cable Depth Results Near the Sea Bed



- 25m depth
  Profiler moored 10m above the bottom
- Currents knock down the profiler (red below blue)
- Waves knock down profiler (oscillations)
- Profiler slams against the ground in waves >10m.
- Therefore, the profiler will not survive fall/winter extreme waves, but it will survive spring/summer extreme waves.

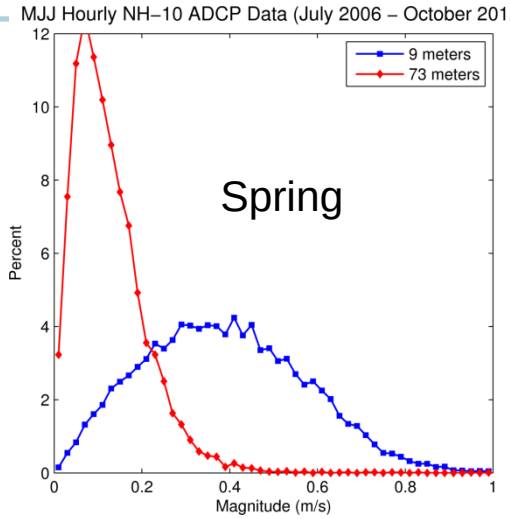
UCSD UNIVERSITY of WASHINGTON

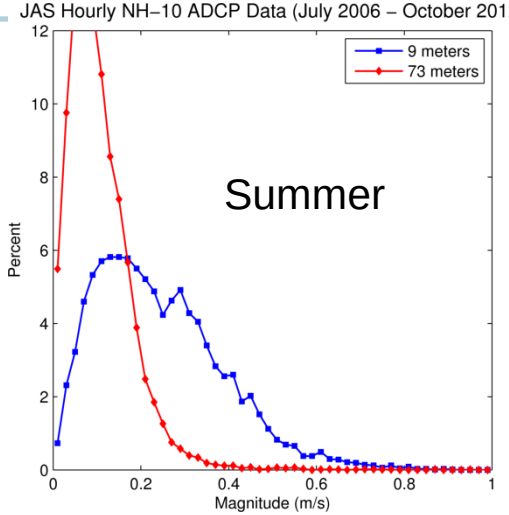
Operating Environment Requirements

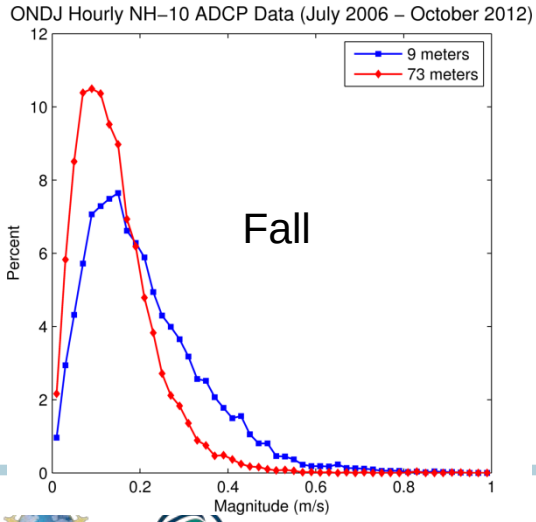
- OPEN-005: The coastal surface piercing profiler shall have the capability to reach the surface in the presence of a uniform current of 40 cm/sec between the surface and 200m depth.
- COTS:
  - Previous deployments of the system have proven the ability of the AMP to meet this requirement.
  - Previous power and rope length calculations are based upon 40cm/s current speed with a velocity profile of top 1/3 of water column equal to the max. Current and the bottom 2/3 of water column equal to 1/4 of the current.
- Development:
  - Numerical modeling with WHOI Cable was done to show that the uCSPP could meet this requirement (results shown on earlier slides).
- Analysis: No further work needed
  - The anchor test part of the First Article Test will validate the WHOI Cable results

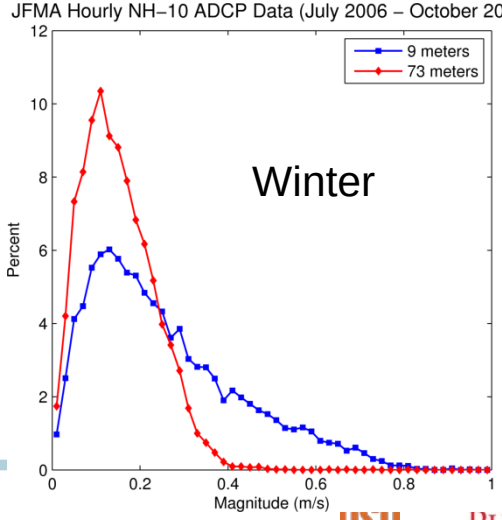
Basis of the Modeled Current Range

NH-10 (80m) Current Speeds

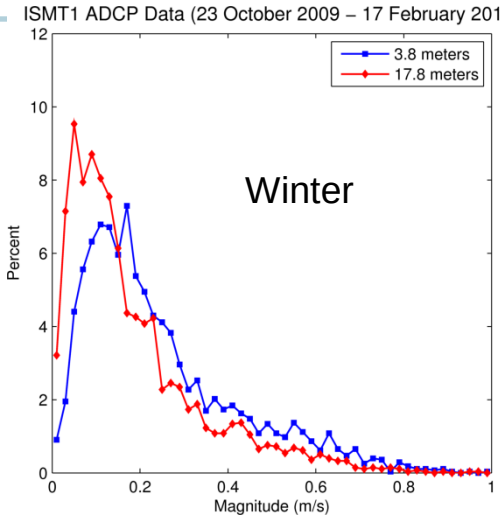








ISMT1 (25m) Current Speeds



- Can avoid high currents at 80m site by staying near the bottom.
- Surfacing in only 40 cm/s is required.
- Less data available at the 25m site.
- 60+ cm/s bottom currents possible during winter at 25m

WHOI Cable: Time domain numerical modeling of moored oceanographic systems

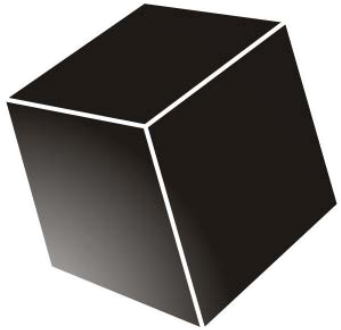
Jason I. Gobat and Mark A. Grosenbaugh

- Standard OOI mooring modeling software
- Analyzes the statics and dynamics of oceanographic cable structures
- Features a nonlinear solver that includes the effects of geometric and material nonlinearities, bending stiffness for seamless modeling of slack cables, and a model for the interaction of cable segments with the sea floor
- Solves, amongst other things, surface and subsurface single-point mooring problems
- Forcing includes waves, currents, and winds

J.I. Gobat, M.A. Grosenbaugh, WHOI Cable v2.0: Time domain numerical simulation of moored and towed oceanographic systems, Technical Report WHOI-2000-08, Woods Hole Oceanographic Institution, July 2000

J.I. Gobat, M.A. Grosenbaugh, The dynamics of shallow water oceanographic moorings: experimental and numerical results, in: Proceedings of Oceans '99, vol. 1, Seattle, WA, 1999, pp. 107–112

WHOI Cable Model Parameterization



- Waves: 12 sec period
- Forcing-method for surface runs = wave-follower
- Forcing-method for bottom runs = morison
- Buoy = float (hgt=1.52m, diam=.56, mass=373kg, bouyancy=11.34kg)
- Line = 1/8th inch spectra
- 5/8th chain, 10" panther float, 7/16" shackles
- Line out at the bottom = 10 m
- Line out at the surface = 1.5 * water depth