

# A Novel Approach to Remove Ocean Wave Loading Noise: The Horizontal Pressure Gradient

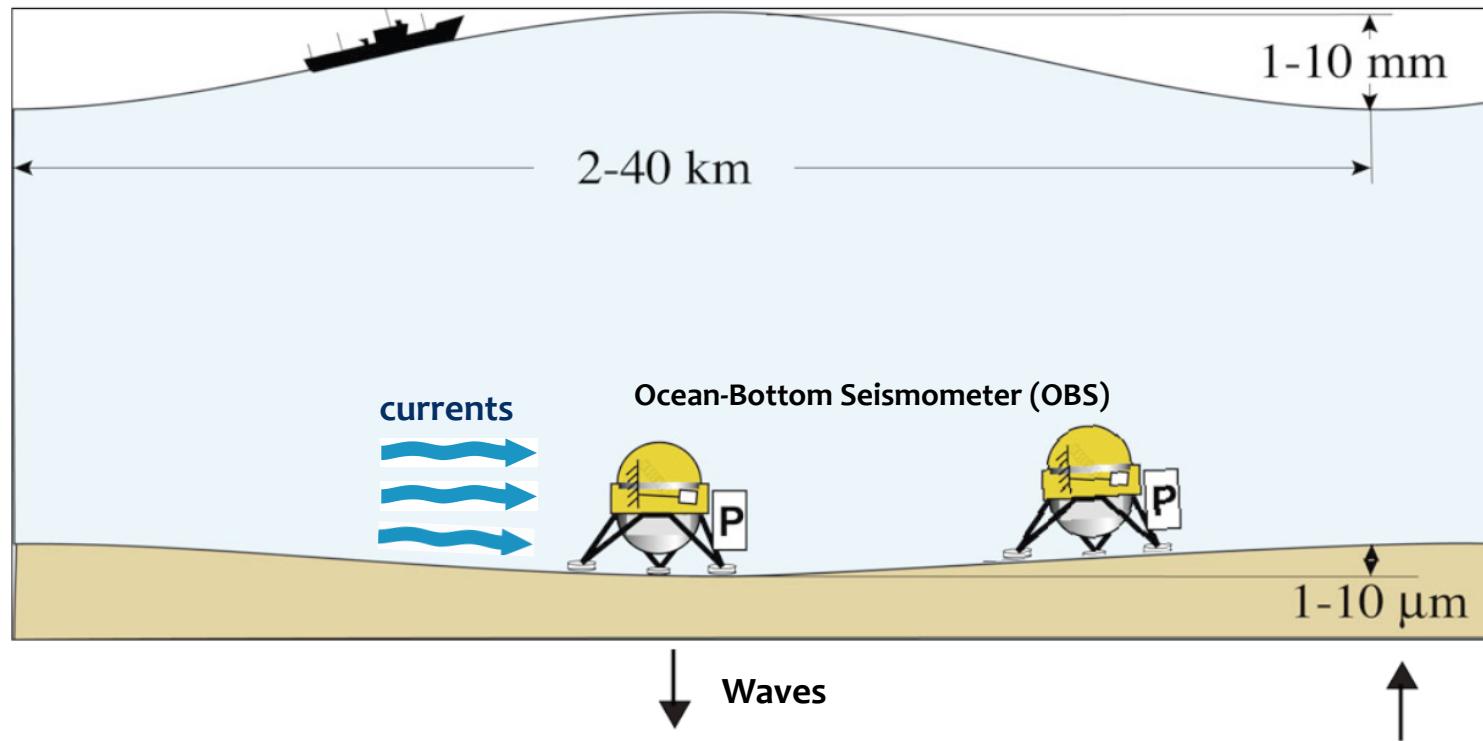


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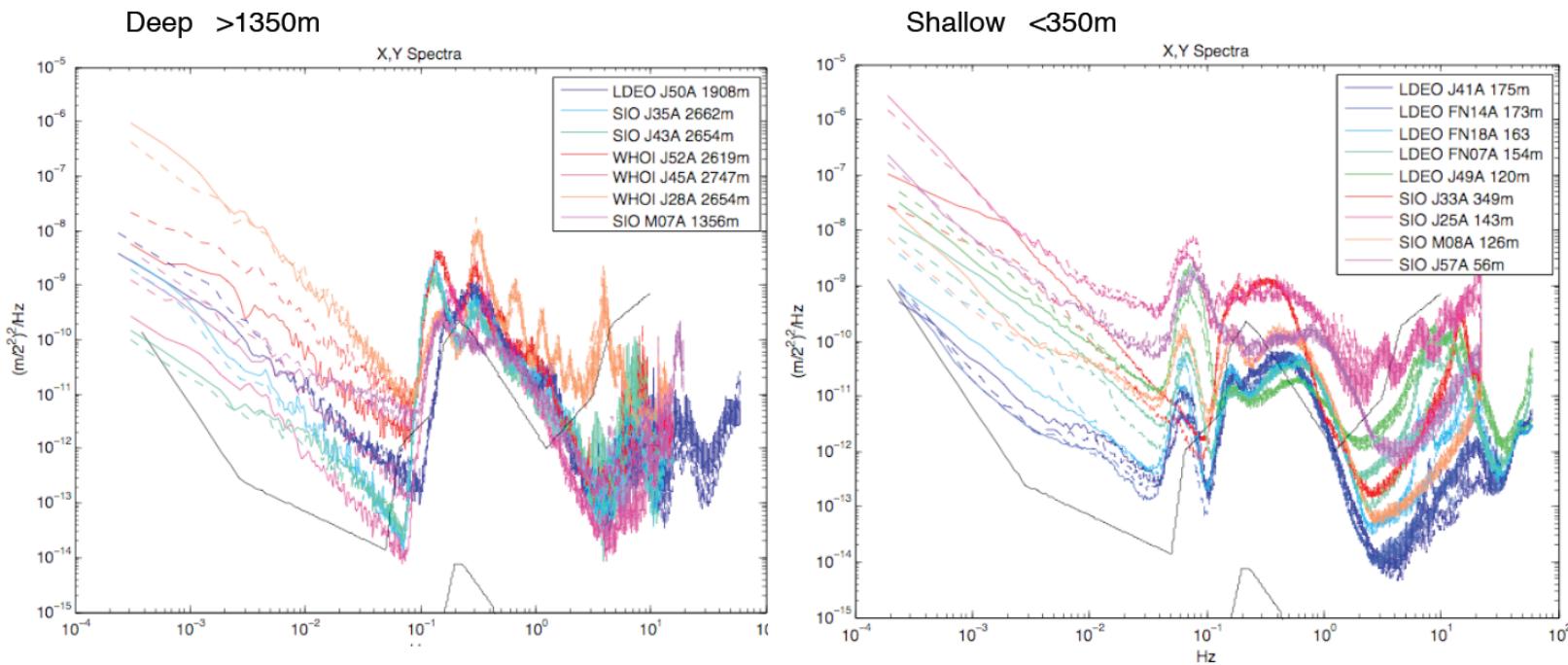


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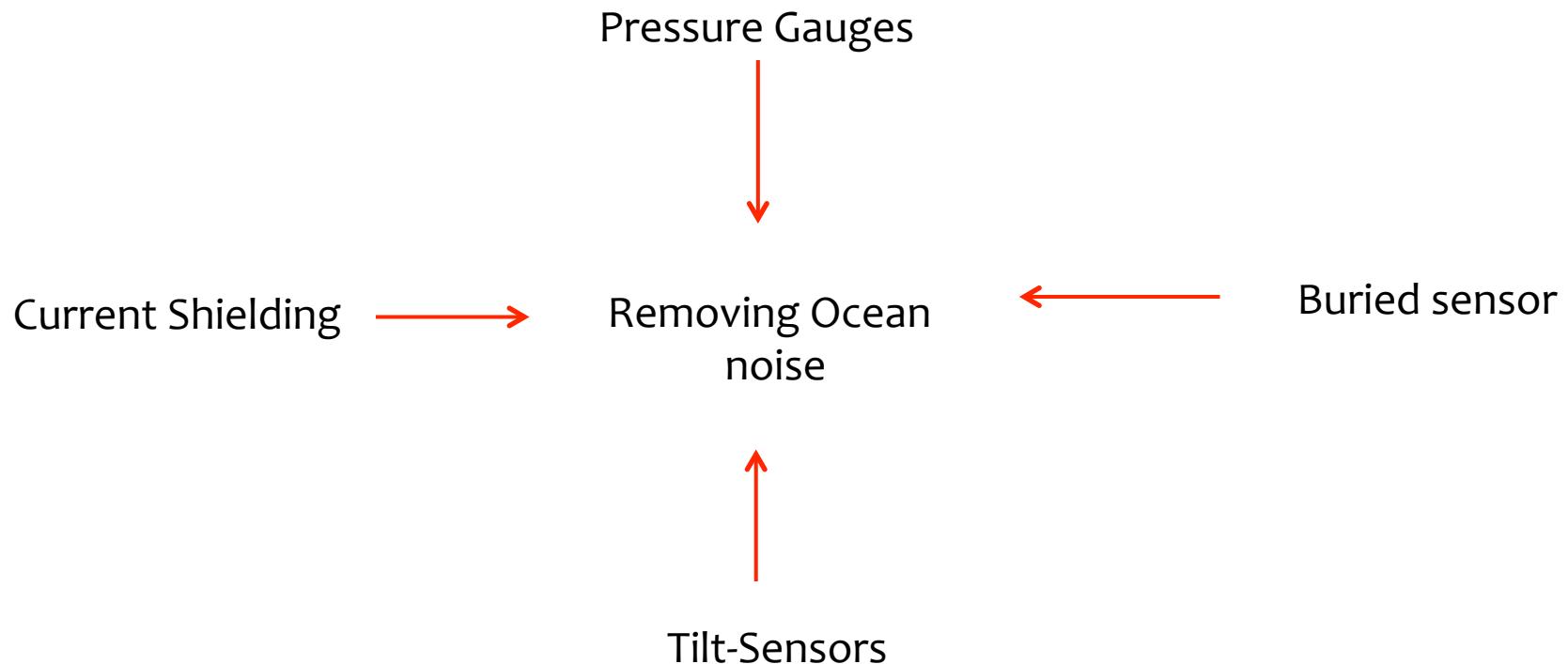
# Wave Pressure Noise and Wave Loading



# Tilt & Wave Loading: A common source of seismometer noise

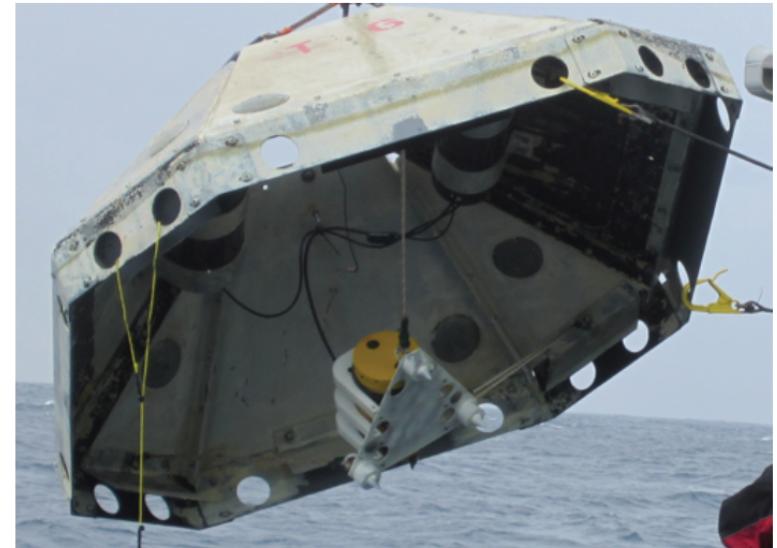


# Battling the Ocean: Waves + Currents



# Battling the Ocean: Currents (and trawling)

- Buried sensor
- Current Shielding



# Battling the Ocean: Waves

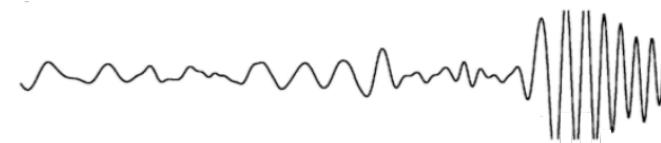
Pressure → Vertical Acceleration → Vertical displacement

Pressure = Force/Area  
Acceleration =  $\delta t^2$  (displacement),

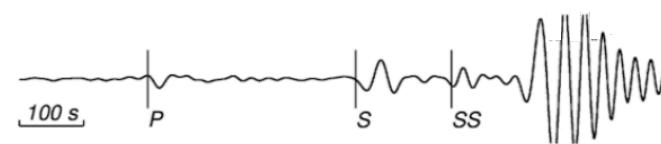
-Pressure



Vertical  
Displacement



Vertical  
Displacement  
Cleaned



# Pressure Gauges

## Differential Pressure Gauge (DPG)

- S
  - P
  - D
  - capillary tube
  - cl
  - u
  - a
  - Clip
  - seis
  - (<3
  - P
  - O
- 
- electrical connector
- capillary tube
- sensor
- overpressure relief valves
- Reference Chamber filled with oil
- oil filled outer chamber
- bottom is rubber diaphragm

## Absolute Pressure Gauge (APG)

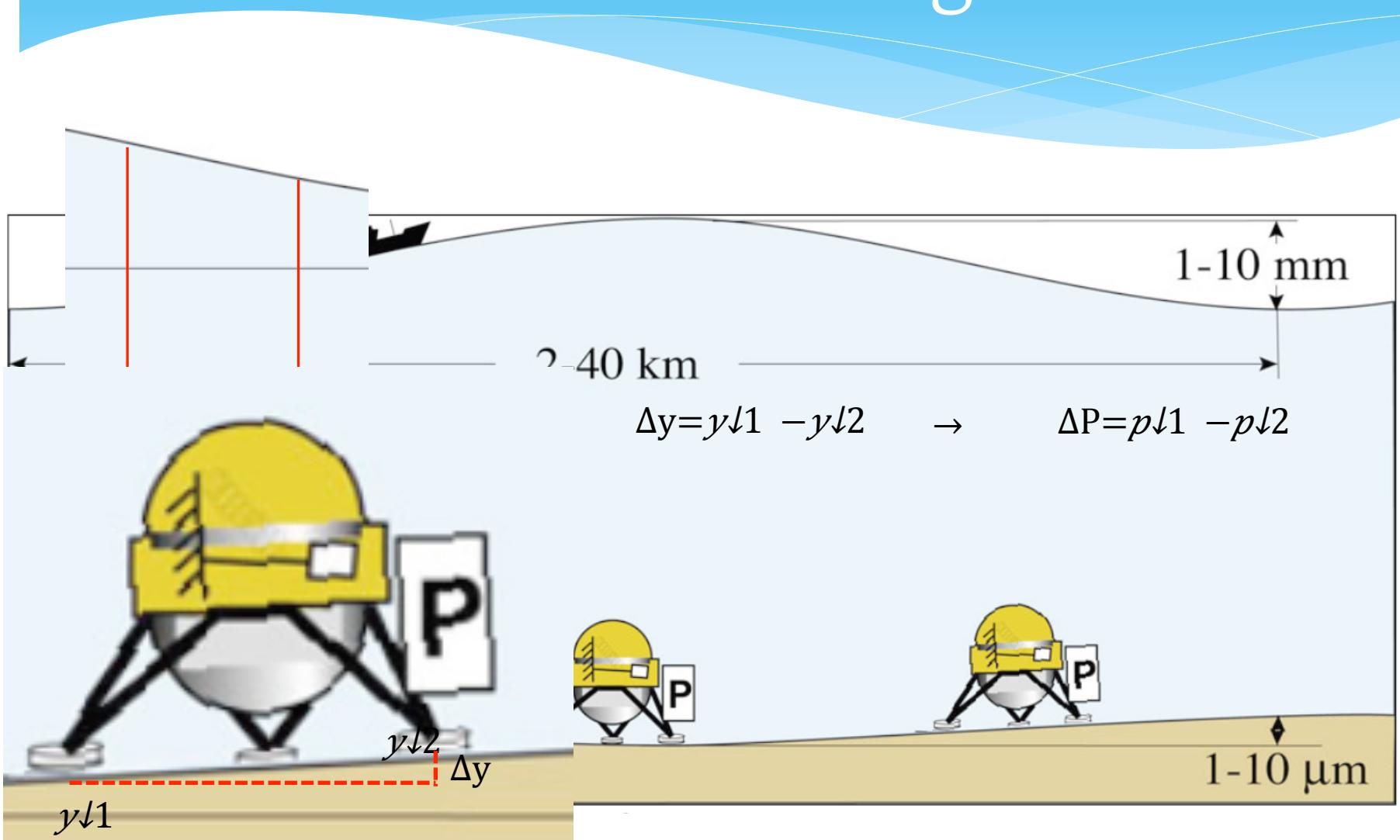
- Measure absolute pressure (includes water depth).



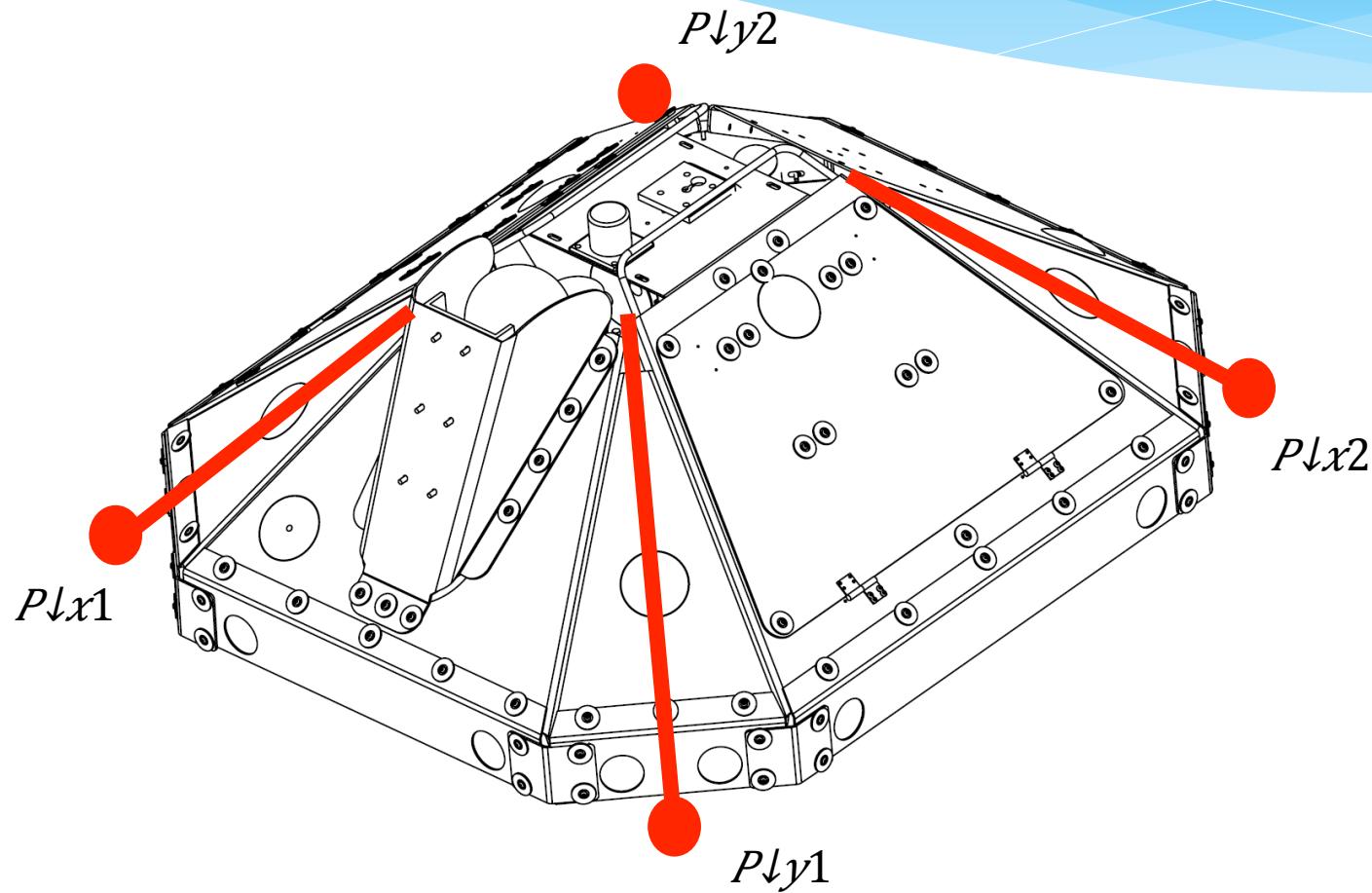
relatively high noise level at high frequencies.  
Solution: Augment with hydrophone.

- Useful for oceanography. Tides, currents and wave height

# What about Horizontal Tilt Due to Wave Loading



# A Horizontal Pressure Difference?



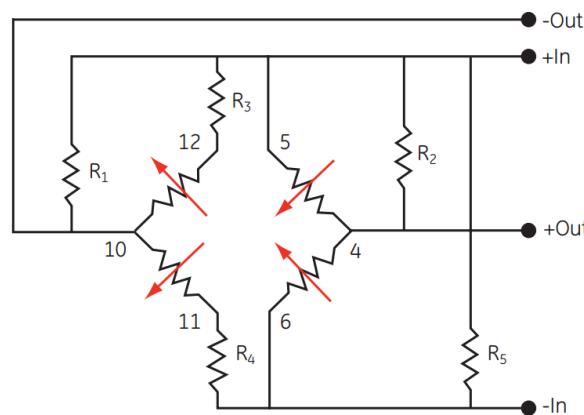
# Design Considerations

- Sensitivity to pressure differential
- Pressure port design
- Trawl-resistant mount (TRM)
- Two seismometers
- APG

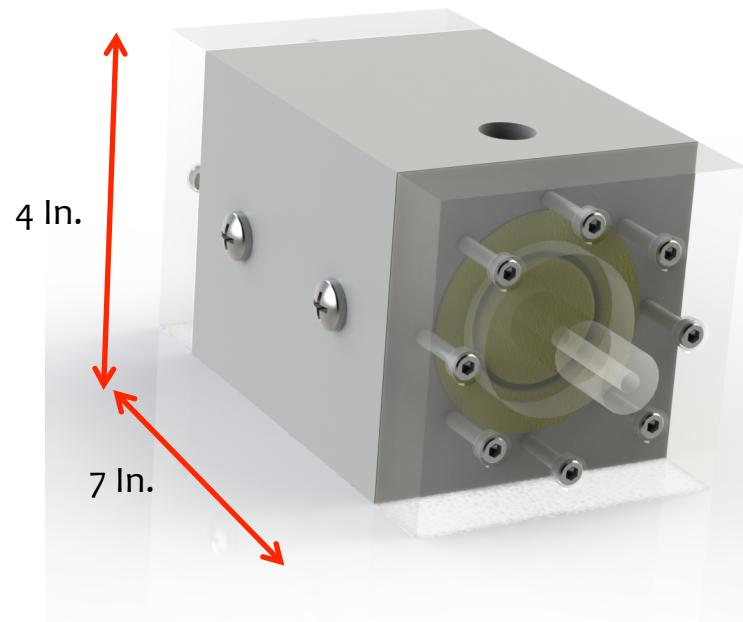
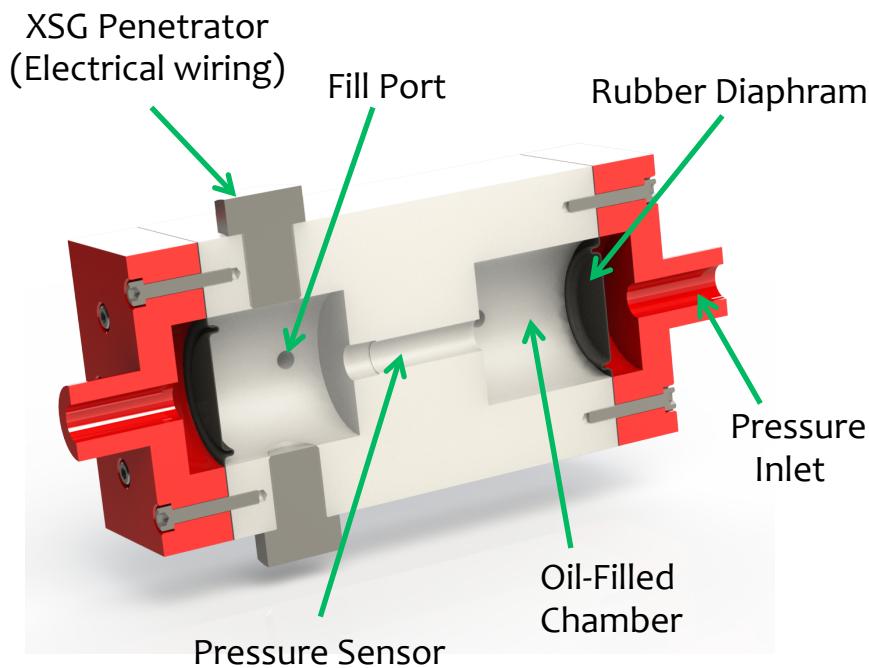
# Design Considerations: Sensitivity to pressure differential

## NPH Series

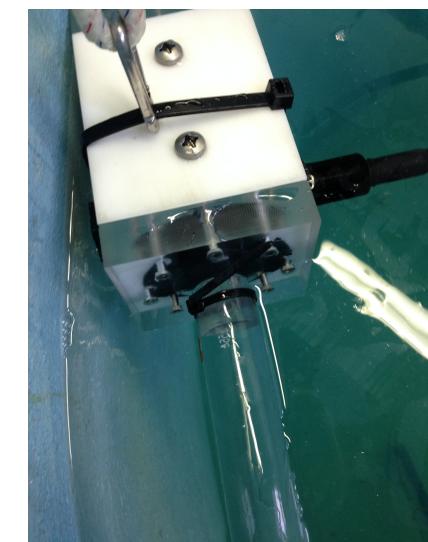
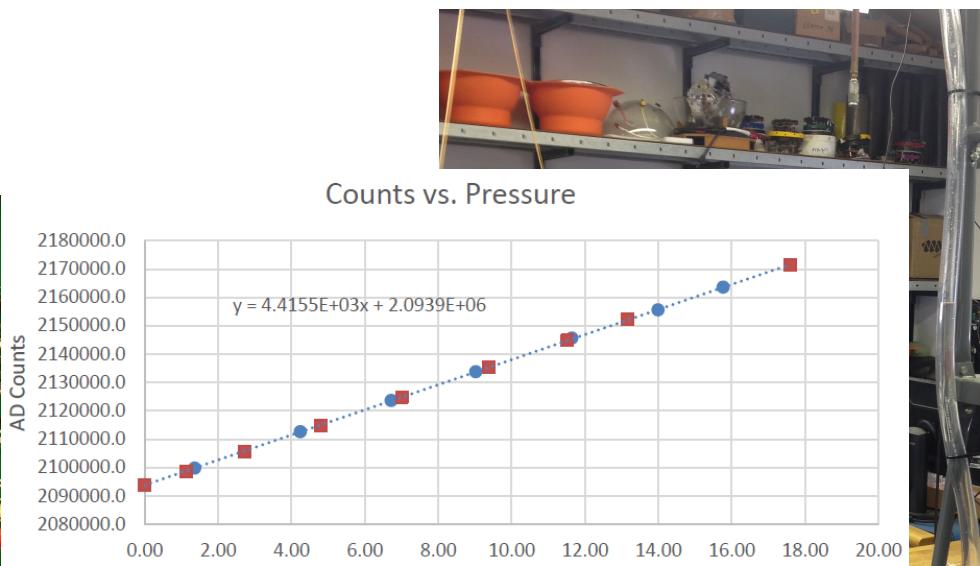
NovaSensor Solid State  
Medium Pressure Sensors



# Pressure Sensor Design

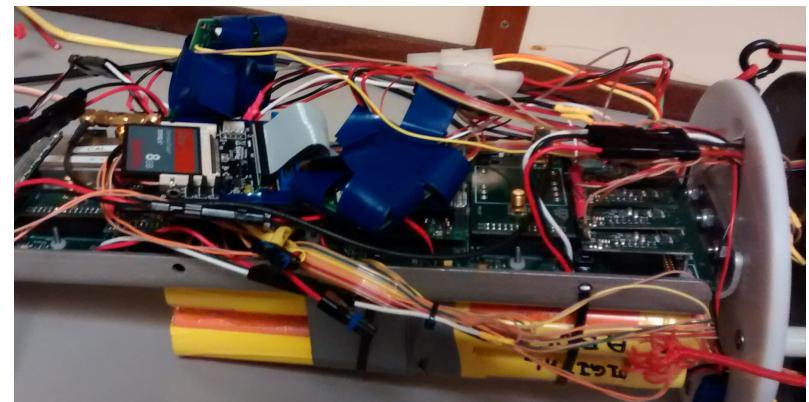
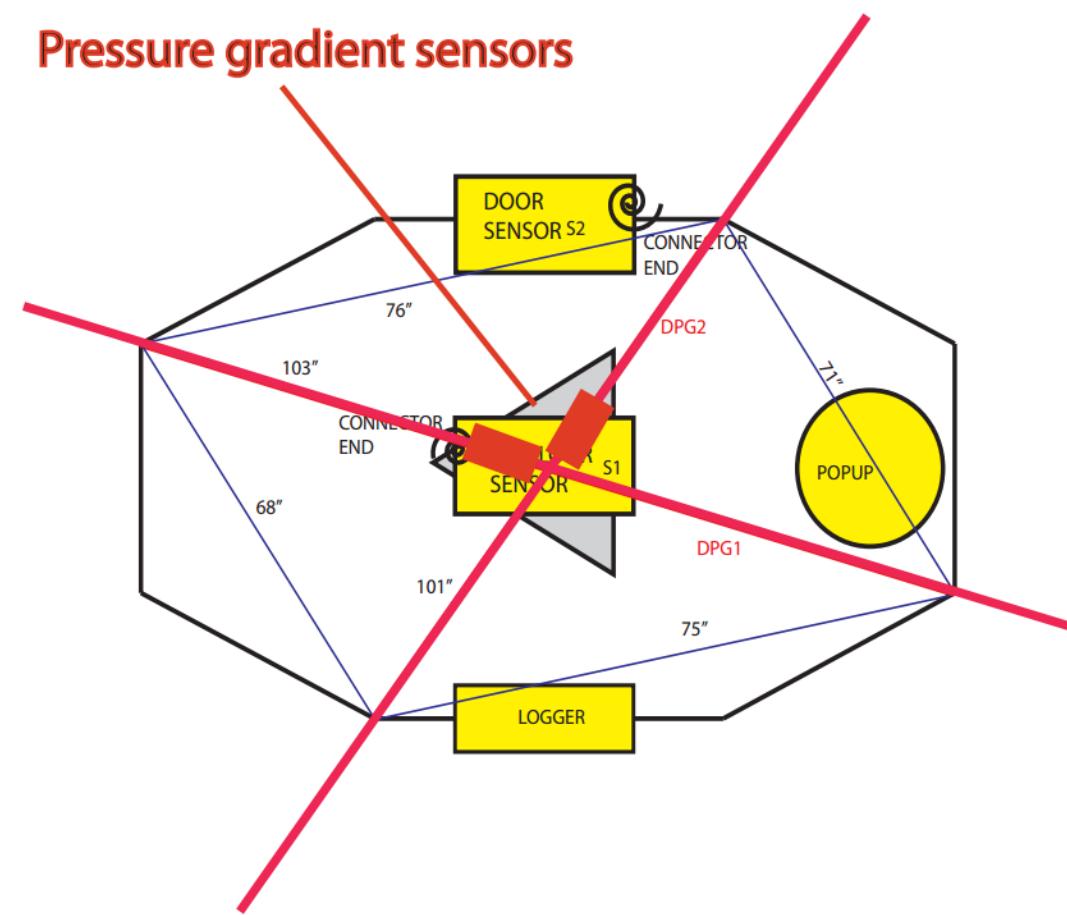


# Testing Phase



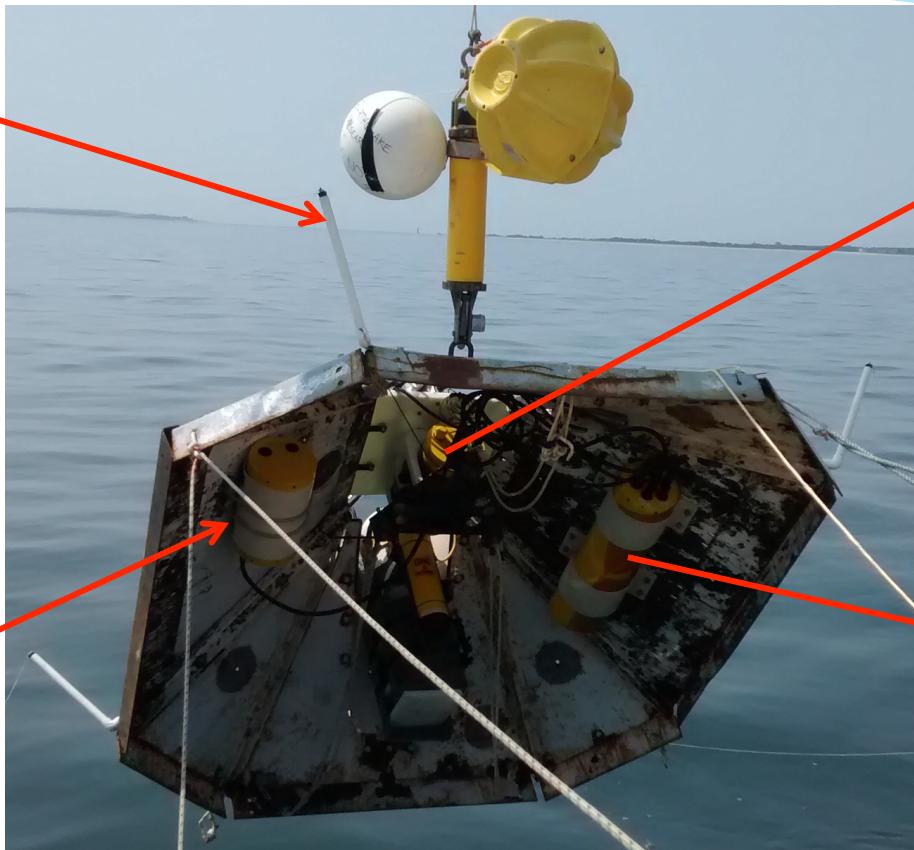
# It's All Coming Together

## Pressure gradient sensors



# Assy/Deployment

Inlet for  
Pressure Gradient  
measurement

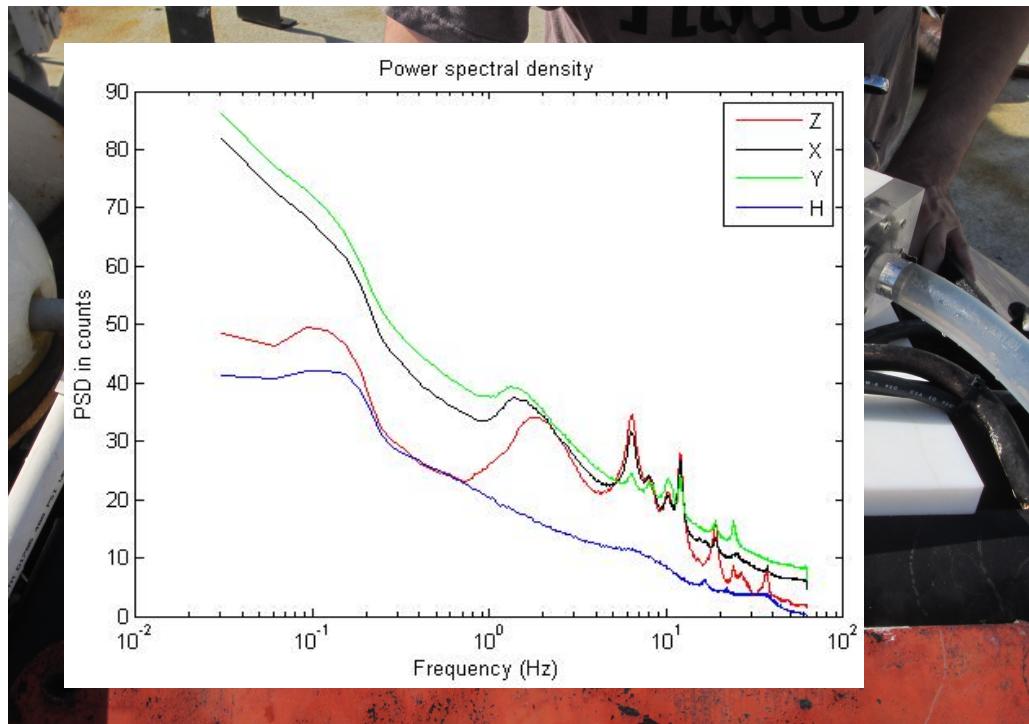


Seismometer  
drops onto  
seafloor

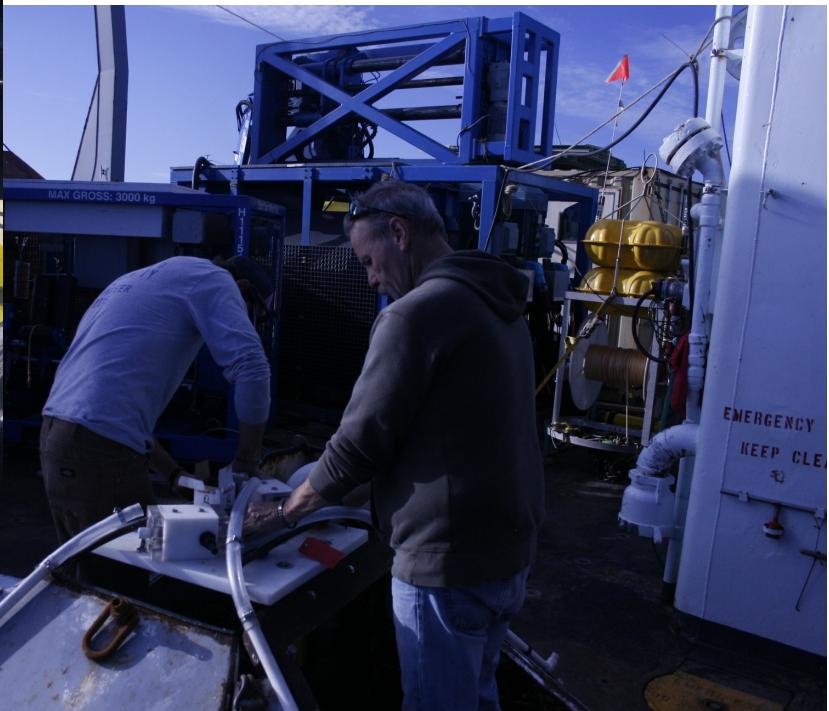
Seismometer  
Attached to  
frame

Absolute Pressure  
Gauge and  
Data Logger

# Lessons Learned from 1<sup>st</sup> Test

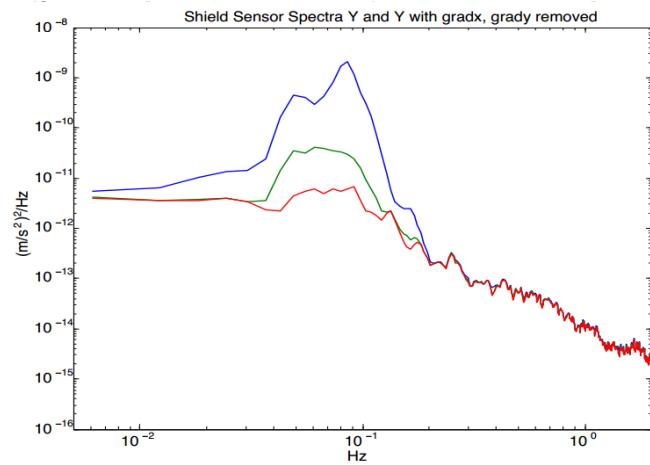
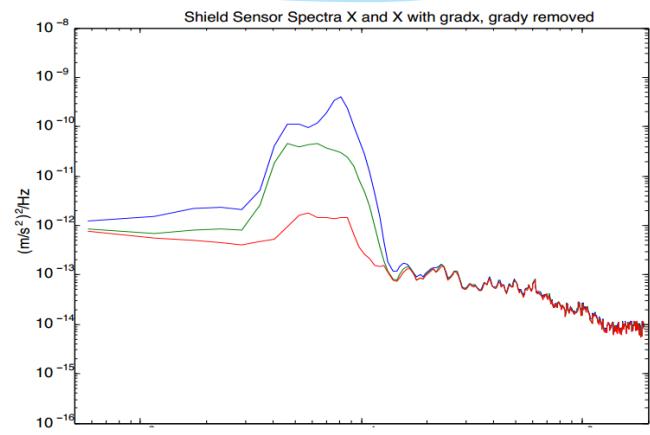
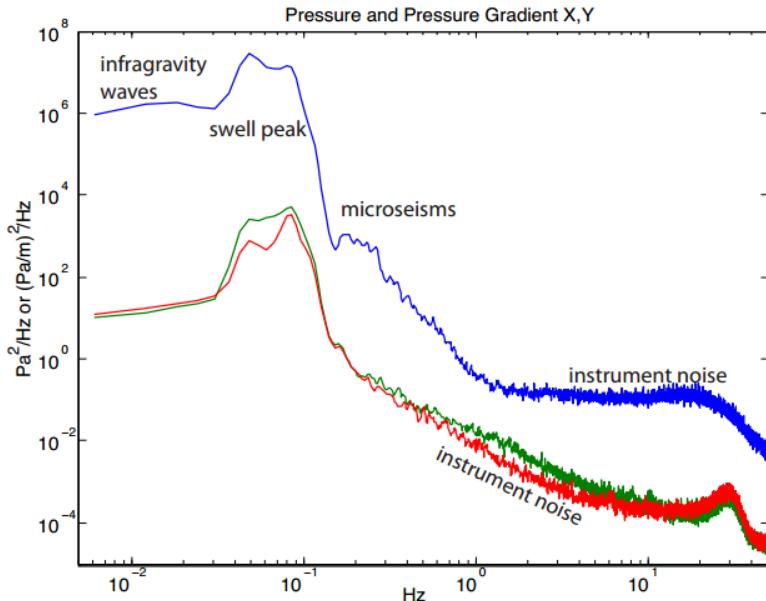


# 2<sup>nd</sup> Deployment



# Results

- \* Data is still being analyzed
- \* 25dB of noise suppression
- \* Instrument complexity



# Moving Forward And Conclusions

- \* The two components of the pressure gradient show potential to be used to partially remove the wave loading noise from the two seismic horizontal components, improving the signal to noise for long period signals for sensors on the shallow seafloor.
- \* The data set obtained is very short and it may be possible to obtain better results in future tests.
- \* Next deployment scheduled on the R/V Armstrong.