Part 1: Long-range active acoustic detection, localization, tracking and classification for offshore renewable energy applications
and
Part 2: Radiated noise measurements in a high-current environment using a drifting noise measurement buoy

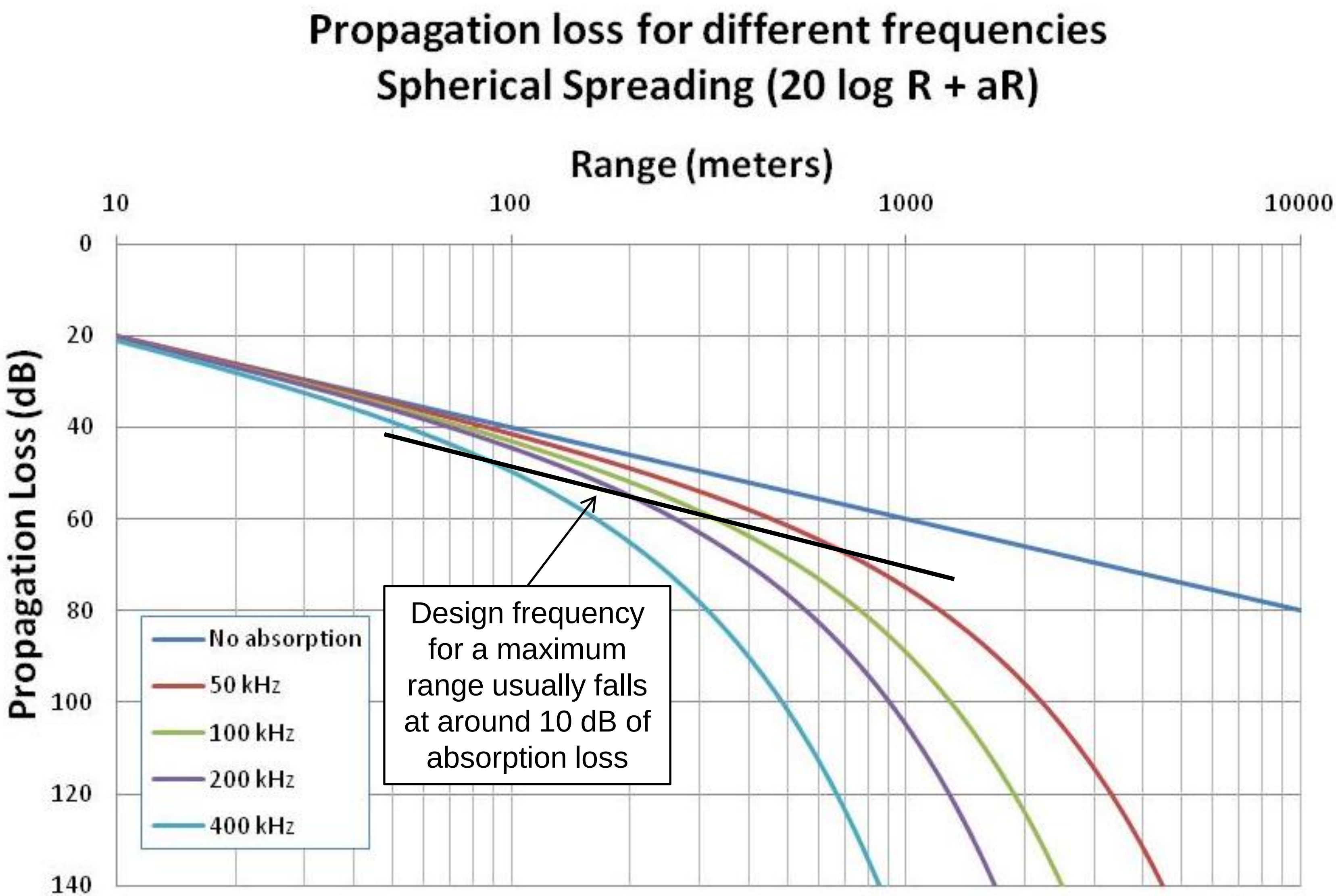
Dr. Peter J. Stein

Scientific Solutions, Inc.

PART 1: Active acoustics: Why and why not?

- **Why?**
  - **If you really want/need to detect, localize, and track an underwater object active acoustics (i.e. active sonar) is the most robust method**
- **Why not?**
  - **The effects of the active acoustic transmissions on marine life**
  - **Systems often don’t work that well for a variety of reasons**
  - **Systems that work well are generally very expensive and have limited coverage**

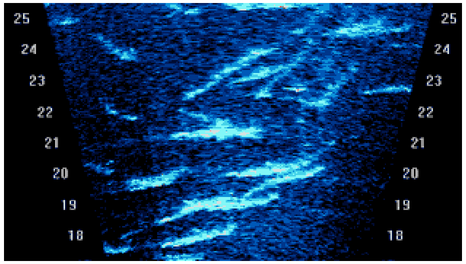
One-way propagation loss

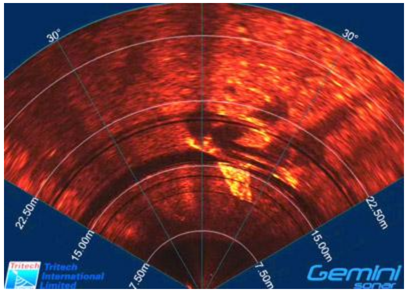


Common systems for bi-acoustic rdserach

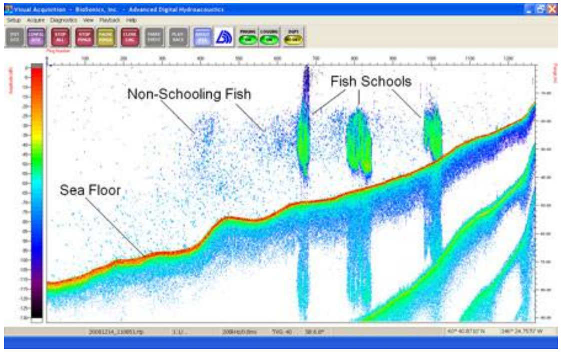
Different categories roughly depending on frequency

Imaging
Generally >400 kHz
Classification possible

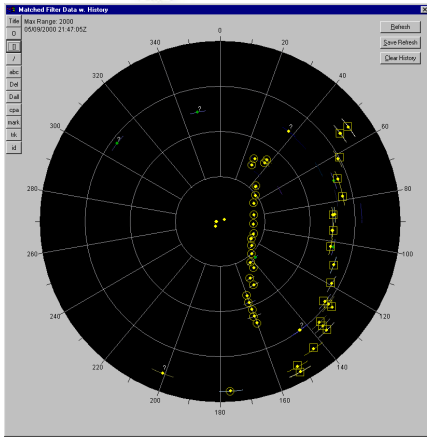




Fish-finding
Generally 50-200 kHz
Location and estimation of bio-mass possible



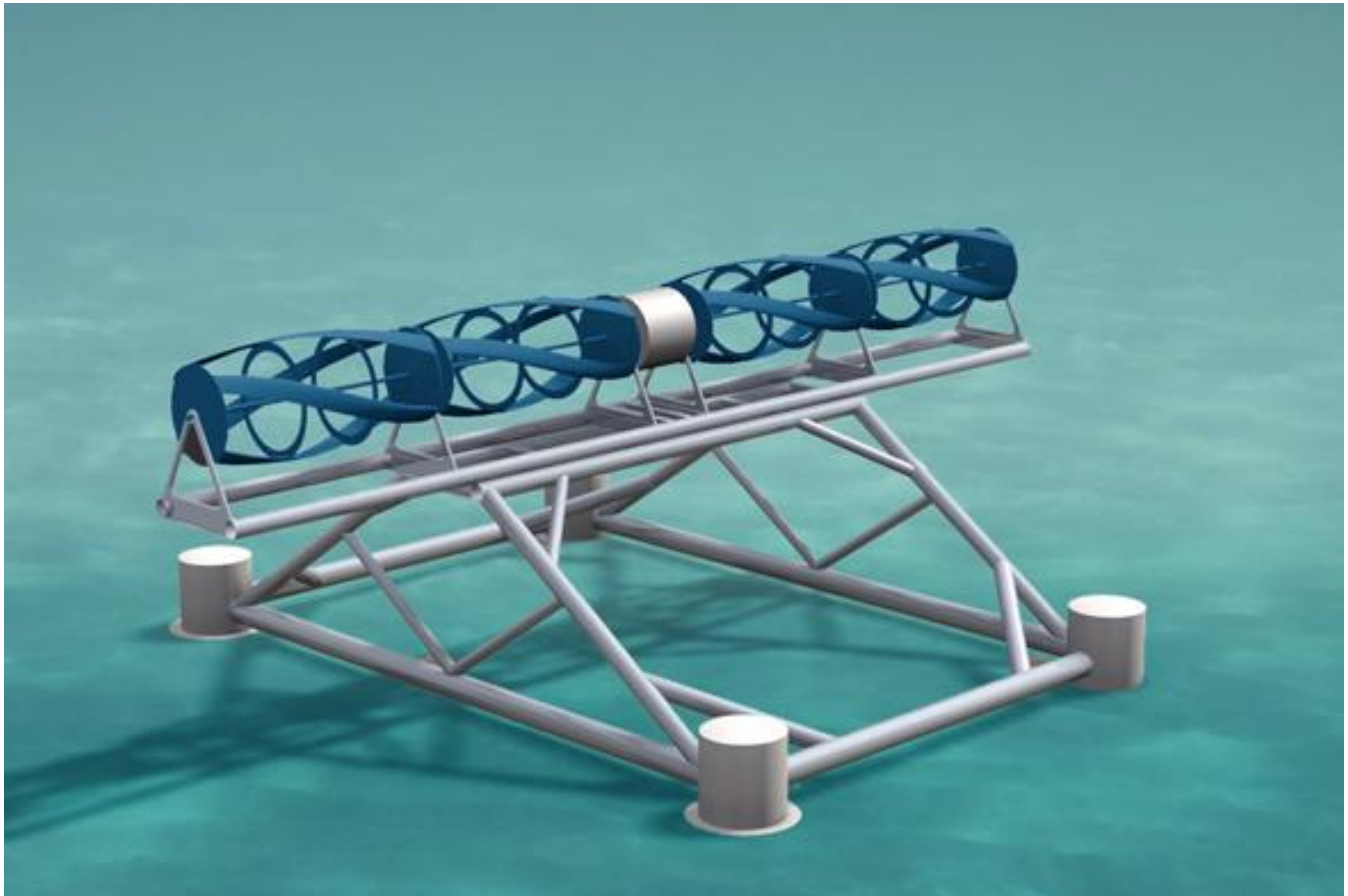
Longer range detection, localization, and tracking (30-100 kHz)
Robust classification not there yet, bigger targets



Scientific Solutions, Inc.
Innovative Research and Engineering

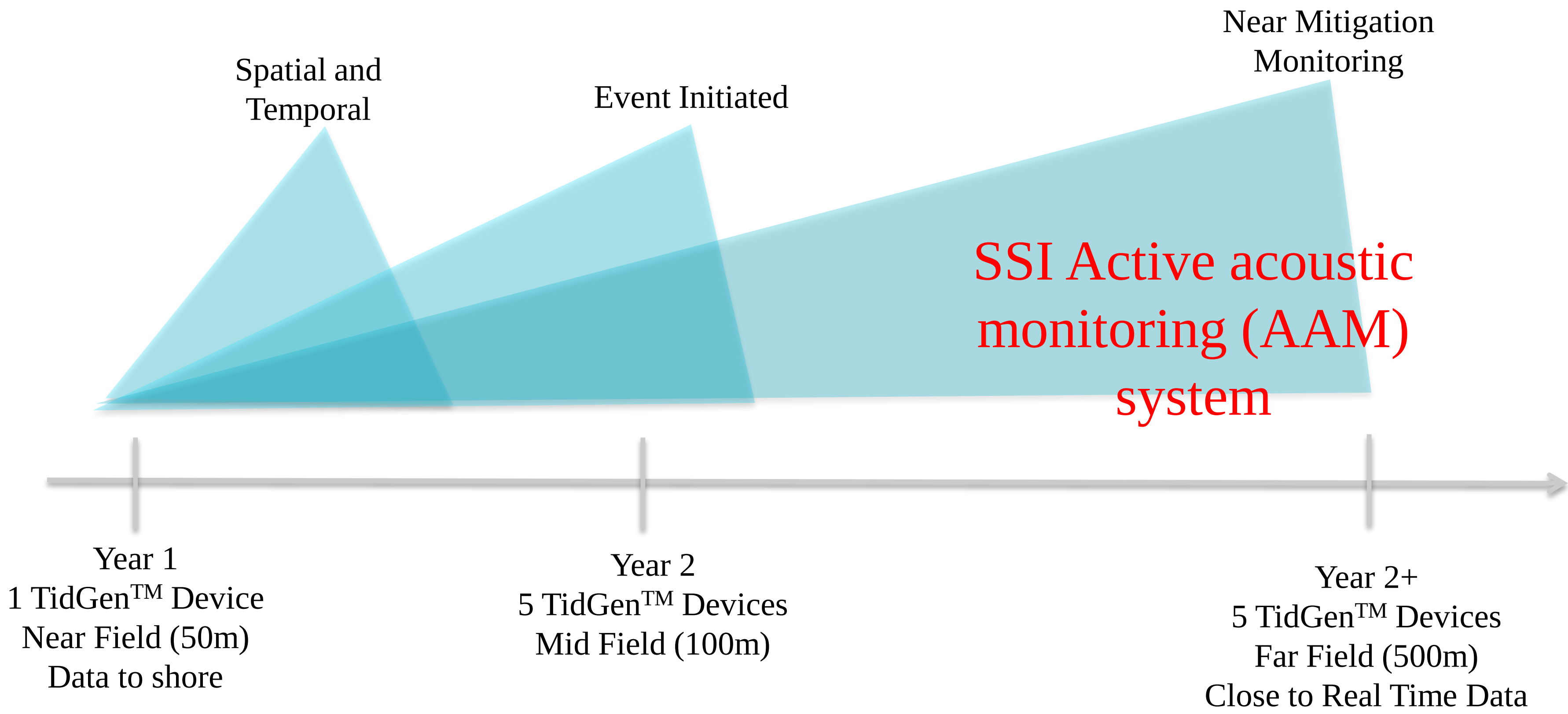
Application

Evaluating and mitigating risks of marine hydroturbines



TidGen™ unit being installed off Eastport, Maine by the Ocean Renewable Power Company (ORPC)

Plan: Integrated Near-field and Far-Field Systems

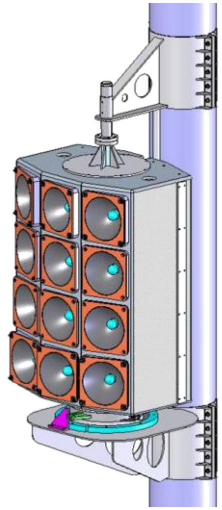


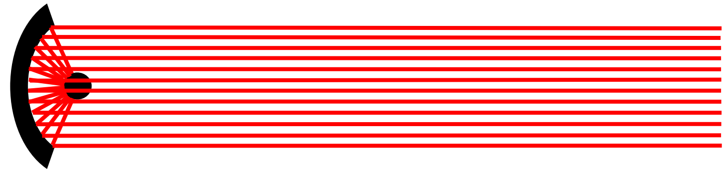
Scientific Solutions, Inc.
Innovative Research and Engineering

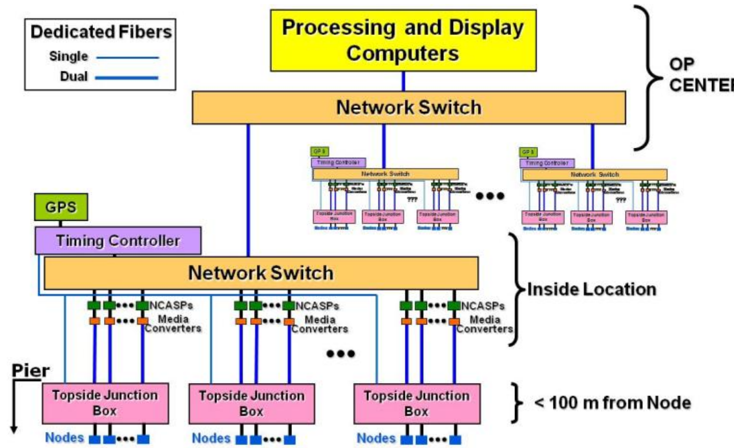
Swimmer detection systems as a basis for AAM

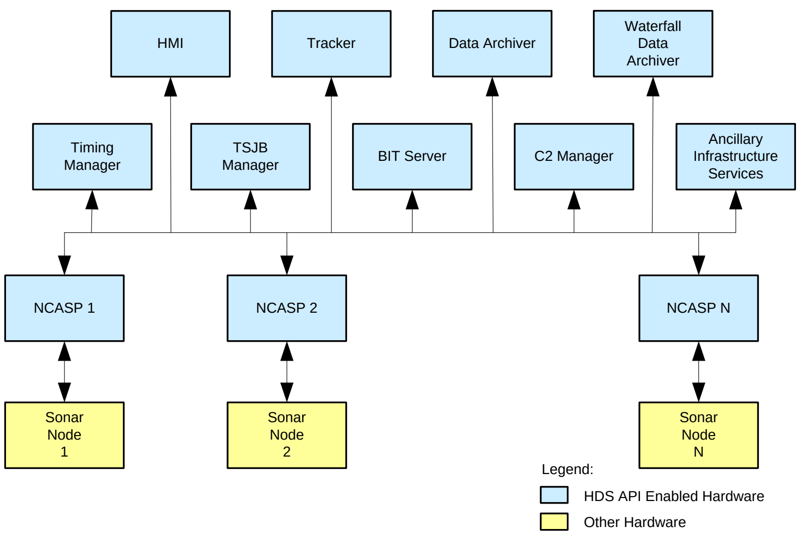
- An effective AAM for offshore renewable energy applications has pretty much the same requirements as swimmer detection sonar
  - Automatic detection, tracking, localization, and classification of low target strength objects in a shallow water harbor environment
- Swimmer detection sonar systems are fairly well developed, however most are very expensive and classification is still an issue
- SSI has been working since 2002 to develop a cost effective swimmer detection sonar system based on networking simple inexpensive sonar “nodes”
- The SSI/ORPC AAM program is based on leveraging the on-going SDSN development

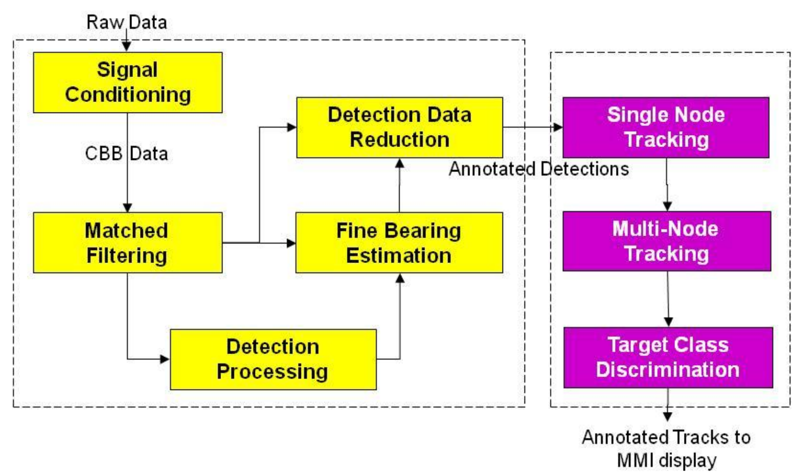
Swimmer Detection Sonar Network (SDSN)





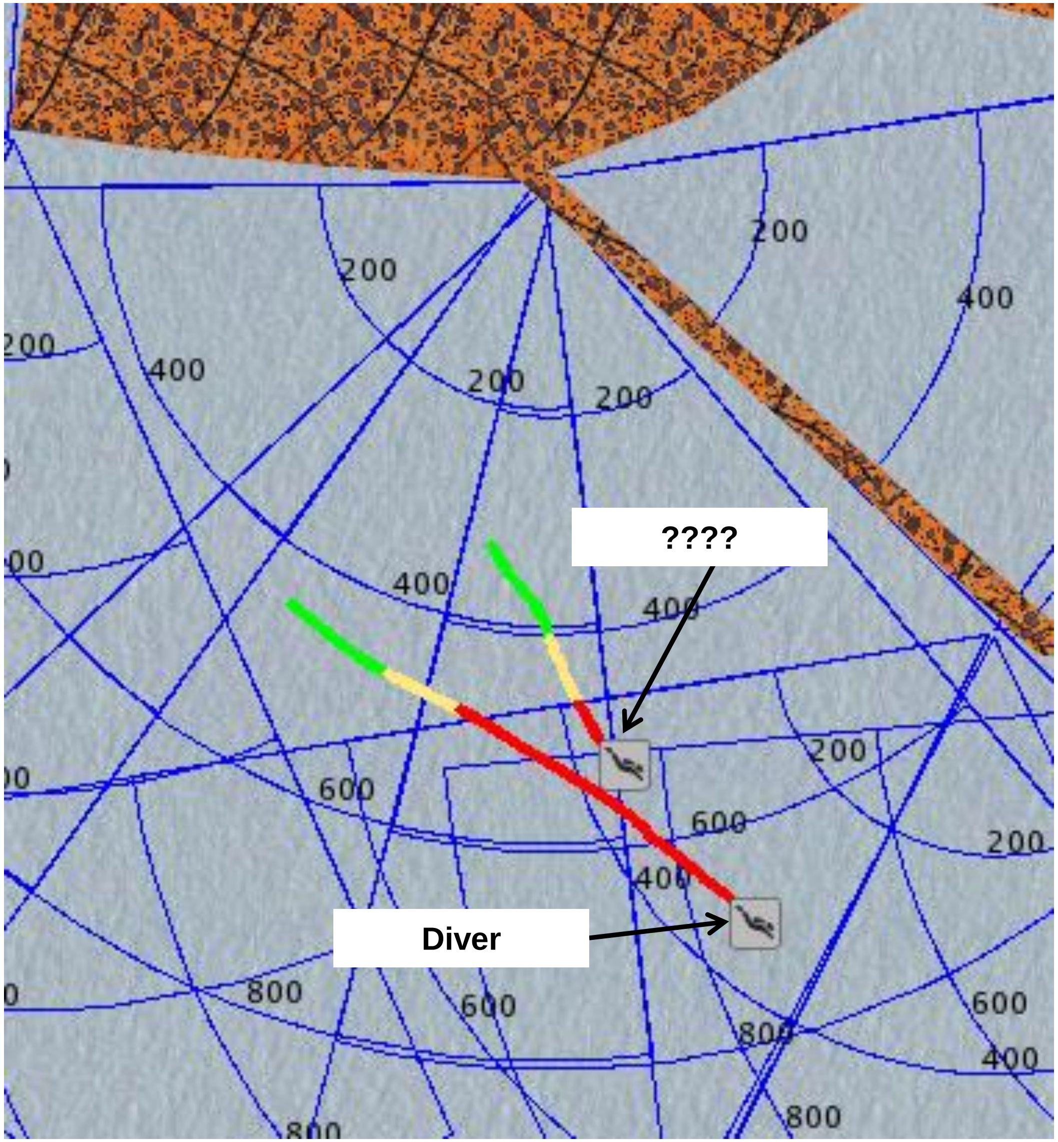






SCIENTIFIC SOLUTIONS, INC.
INNOVATIVE RESEARCH AND ENGINEERING

Recent Trial Results

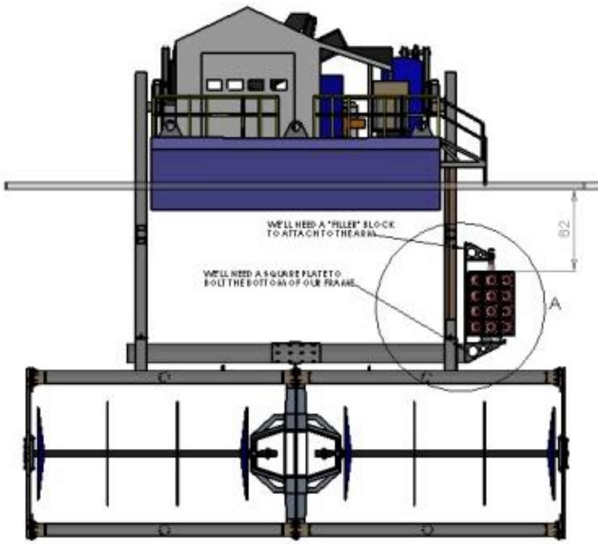


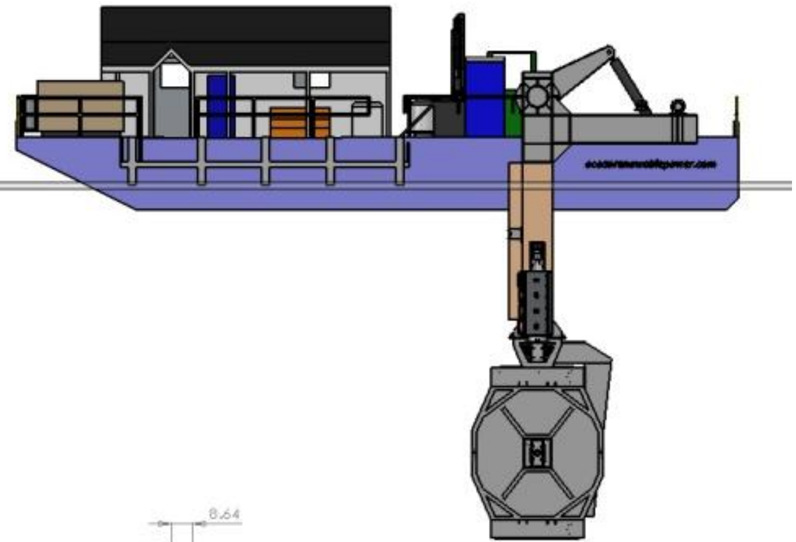
SCIENTIFIC SOLUTIONS, INC.
INNOVATIVE RESEARCH AND ENGINEERING

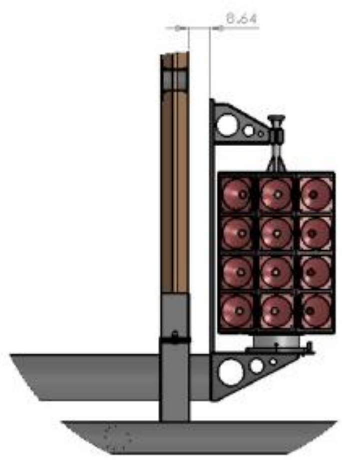
Major uncertainties

- Will longer range detection, localization, and tracking systems work in the required environment?
  - High currents?
  - Variable sound speed field?
  - Potentially rocky bottom?
- That is, will it work off Eastport, Maine?

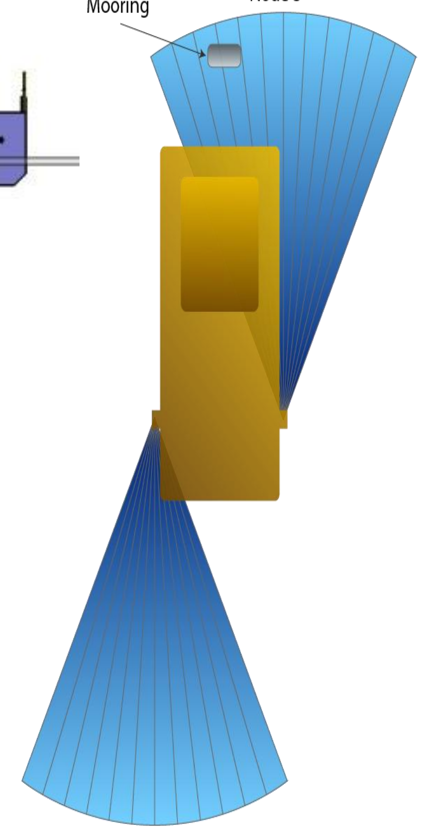
Test installation using existing nodes and ORPC beta







DETAIL A
SCALE 1 : 20

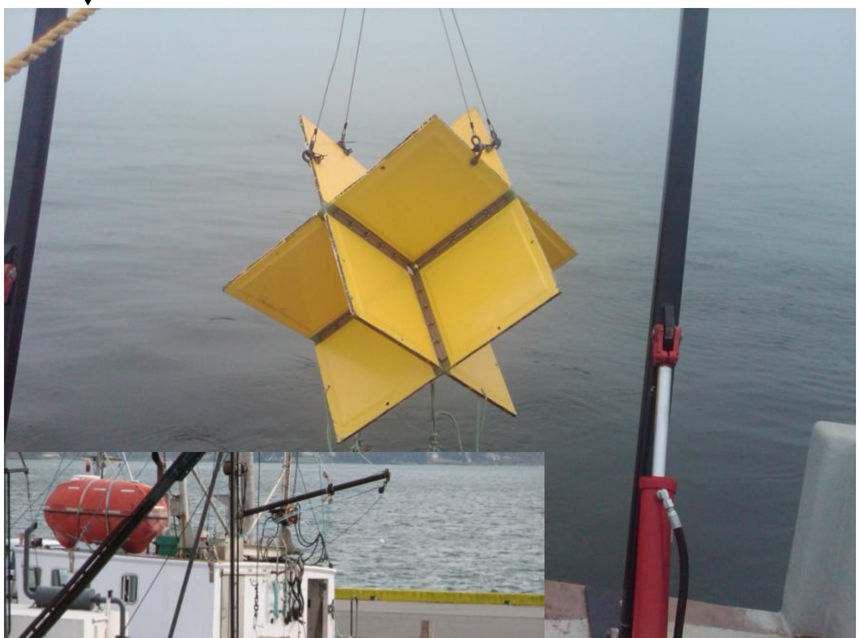


Eastport Testing of Current Node – September 2010

SCIENTIFIC SOLUTIONS, INC.
INNOVATIVE RESEARCH AND ENGINEERING

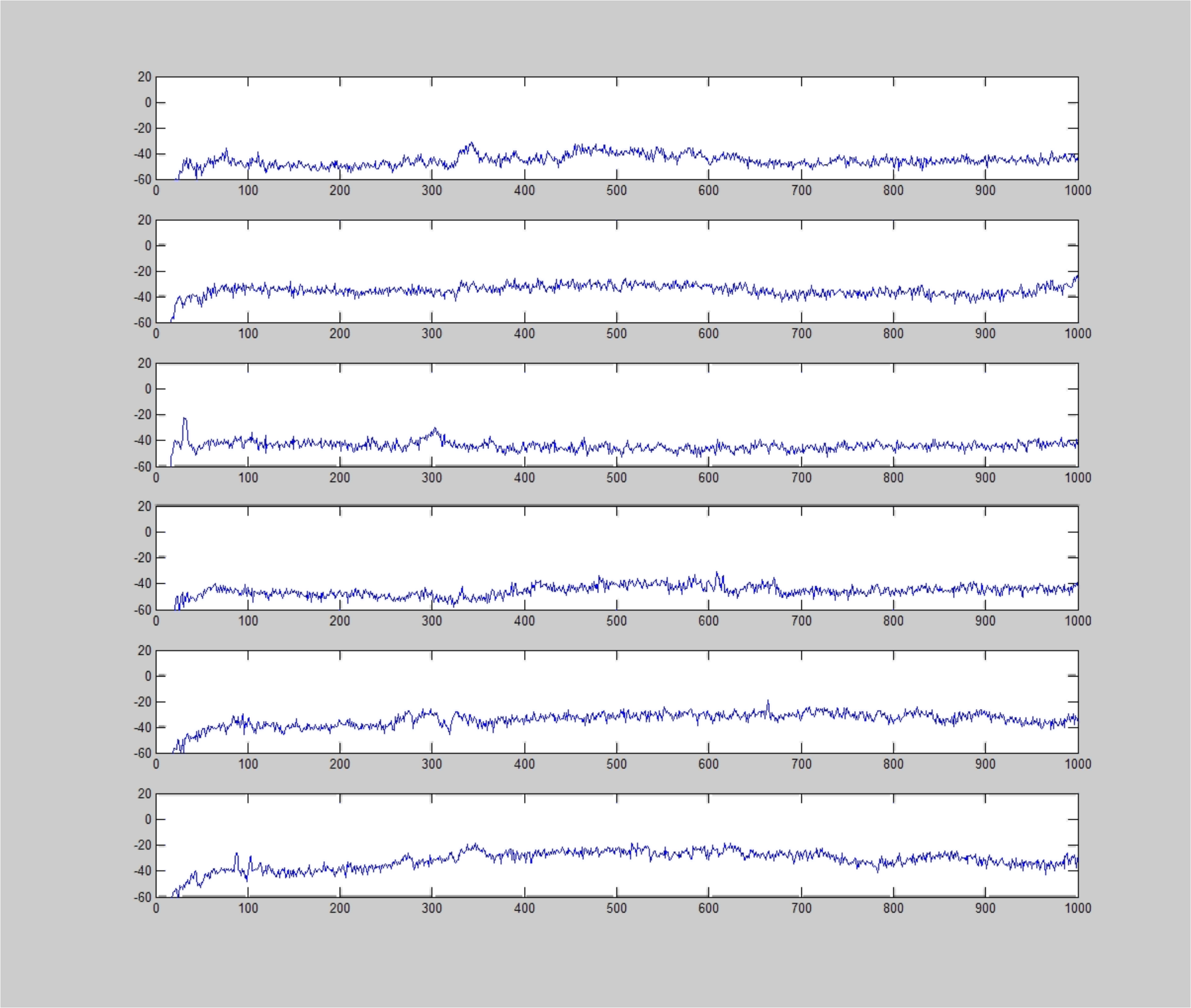
Eastport Drift/Tow Tests

- **Two targets:**
  - **TS = -5 to +5 dB re 1 m (mid-size whale)**
  - **TS = -20 to -15 dB sphere (small odonocete/pinneped)**

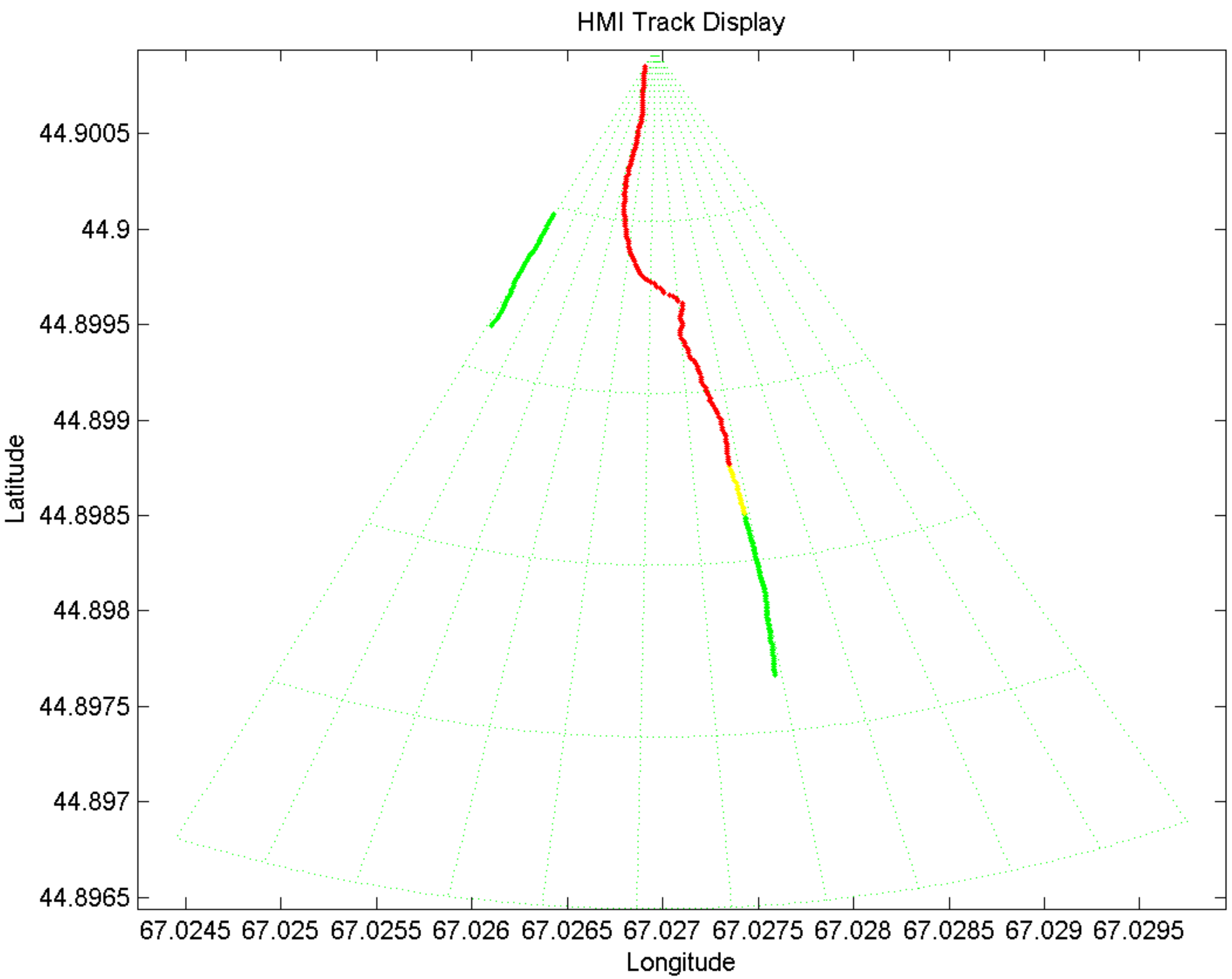


SCIENTIFIC SOLUTIONS, INC.
INNOVATIVE RESEARCH AND ENGINEERING

Large target run



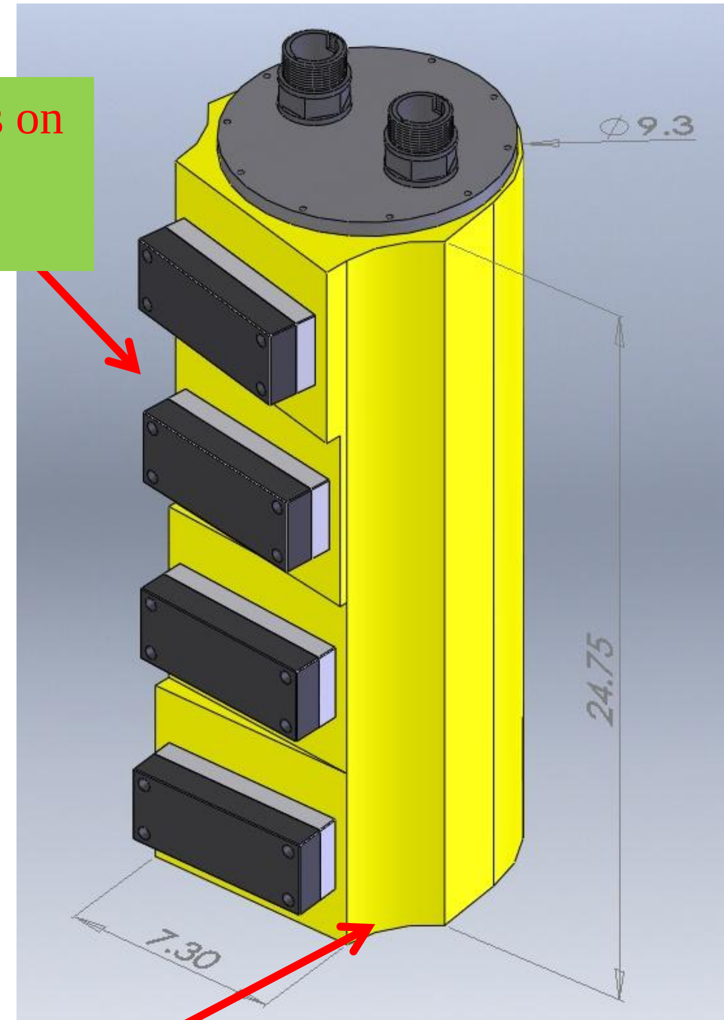
Small target tracker results



New Node

45-75 kHz Assembly

90-120 kHz Assembly



HF Transducers on Electronics Enclosure

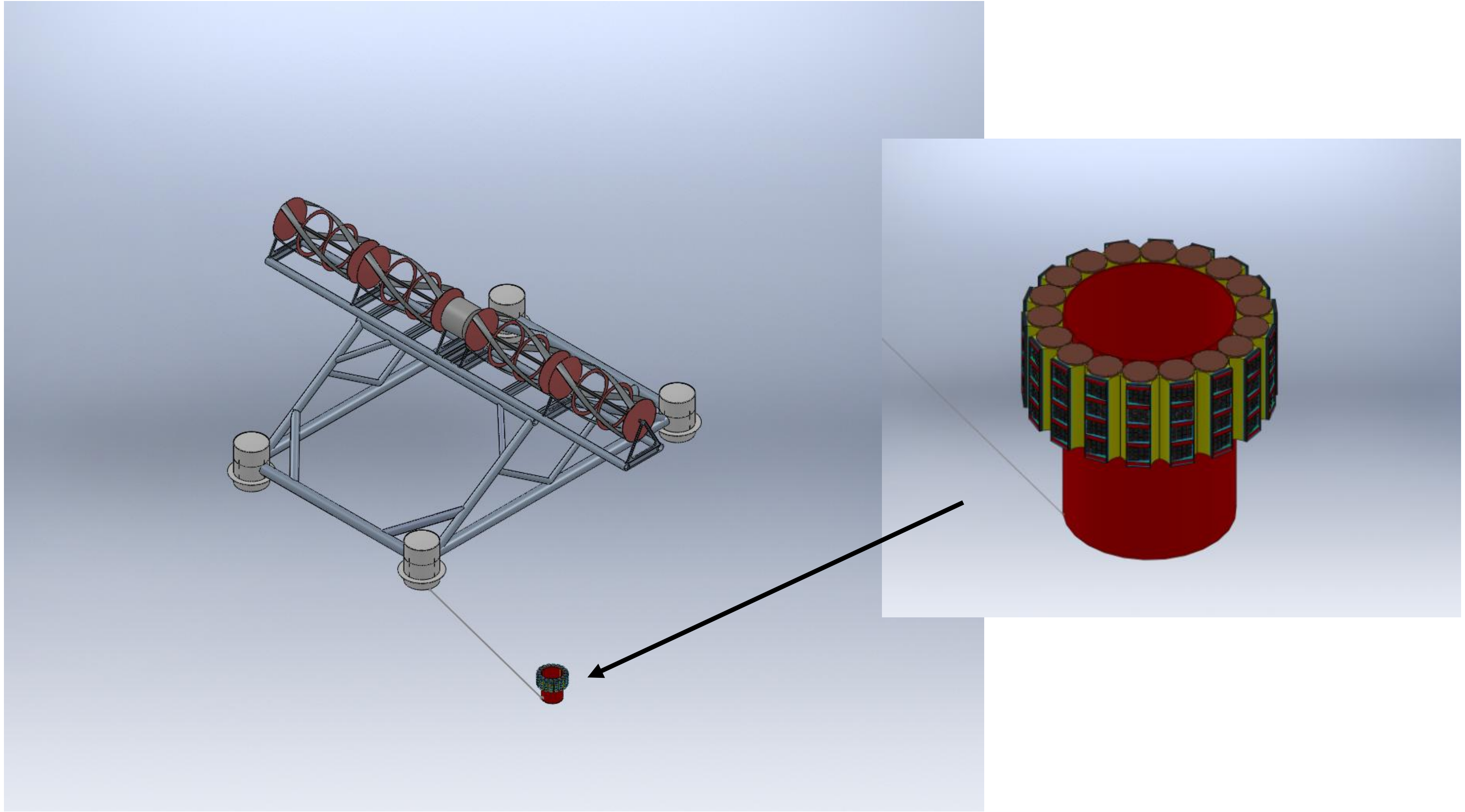
LF Transducers

Electronics

SCIENTIFIC SOLUTIONS, INC.
INNOVATIVE RESEARCH AND ENGINEERING

AAM Installation on (near?) ORPC TidGen^{TM} Unit

SSI is now teamed with ORPC to develop AAM for marine hydrokinetic energy applications



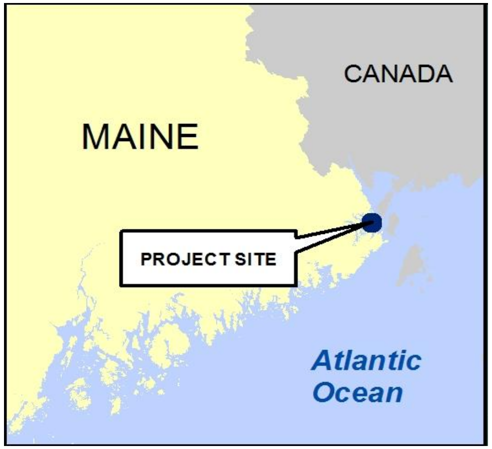
Conclusions (AAM)

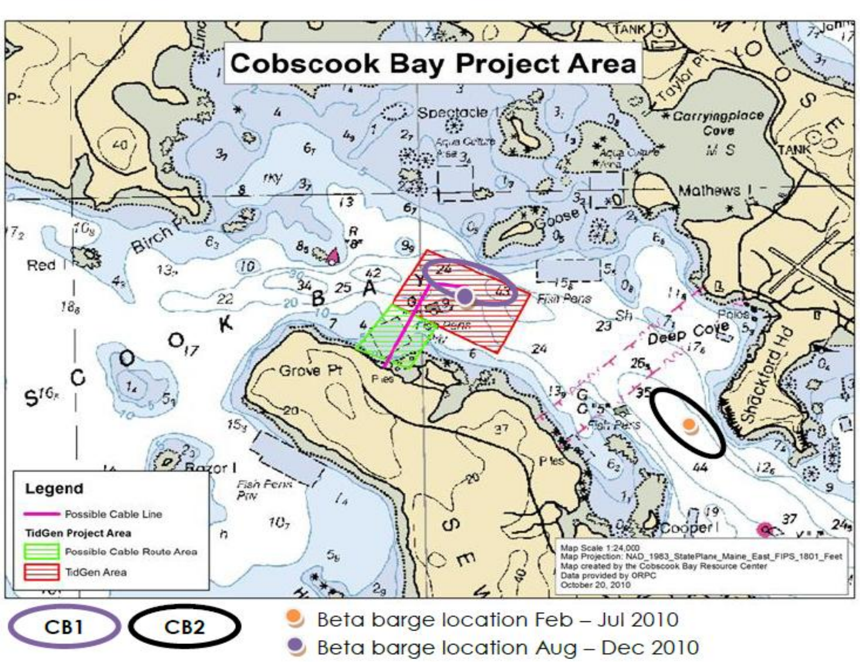
- **There are many active acoustic systems available for mitigation and monitoring**
  - **Generally high frequency imaging systems and thus limited coverage for the cost**
- **There is one operational system (I know of) for longer range DLTC of marine mammals (SURTASS LFA HF/M3 Sonar)**
- **AAM systems are under development which may eventually lead to robust longer-range DLTC of marine mammals and fish (classification will always be difficult)**
- **Integration of systems will lead to greatest advancements**
- **Issues related to marine mammal harassment need to be studied and evaluated**

PART 2: Radiated Noise Measurements In High Currents

Need to determine radiated noise impacts of tidal turbines

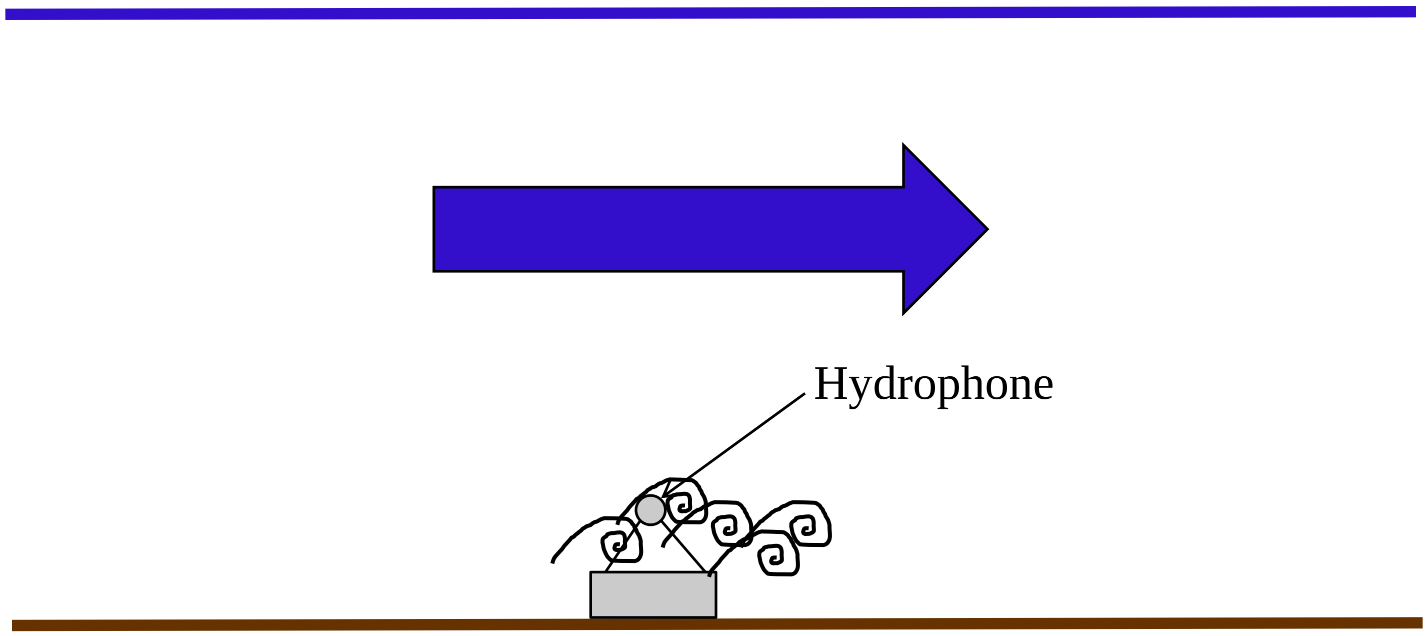
However, high currents make accurate noise measurements very difficult





Moored system

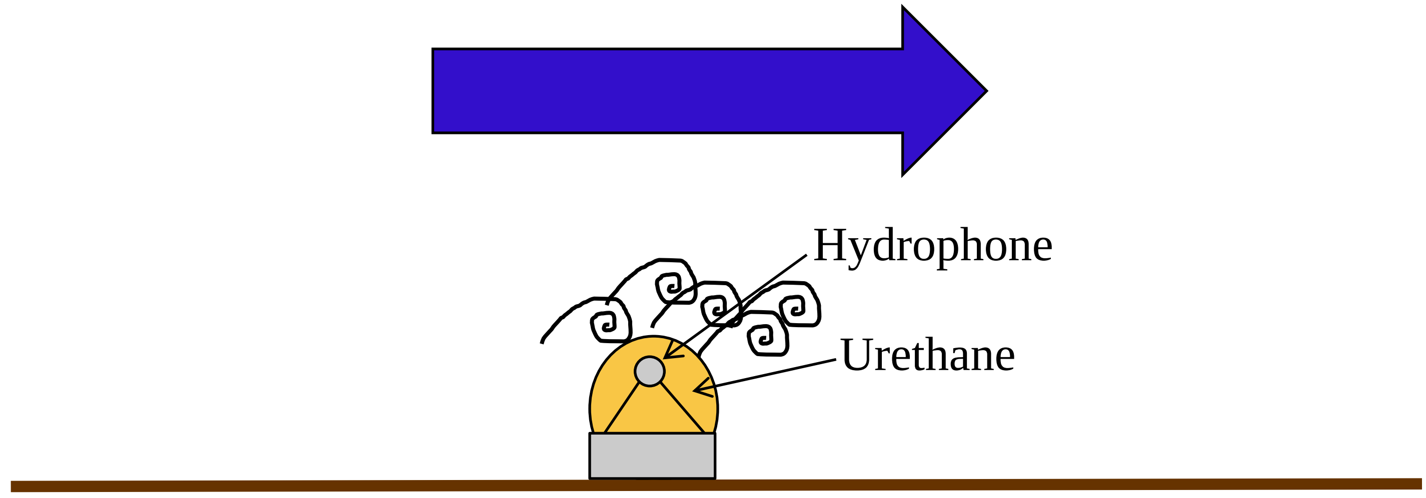
Will be contaminated by turbulent flow noise



Moored system – Flow noise isolation

Turbulent fluctuations stay away from hydrophone

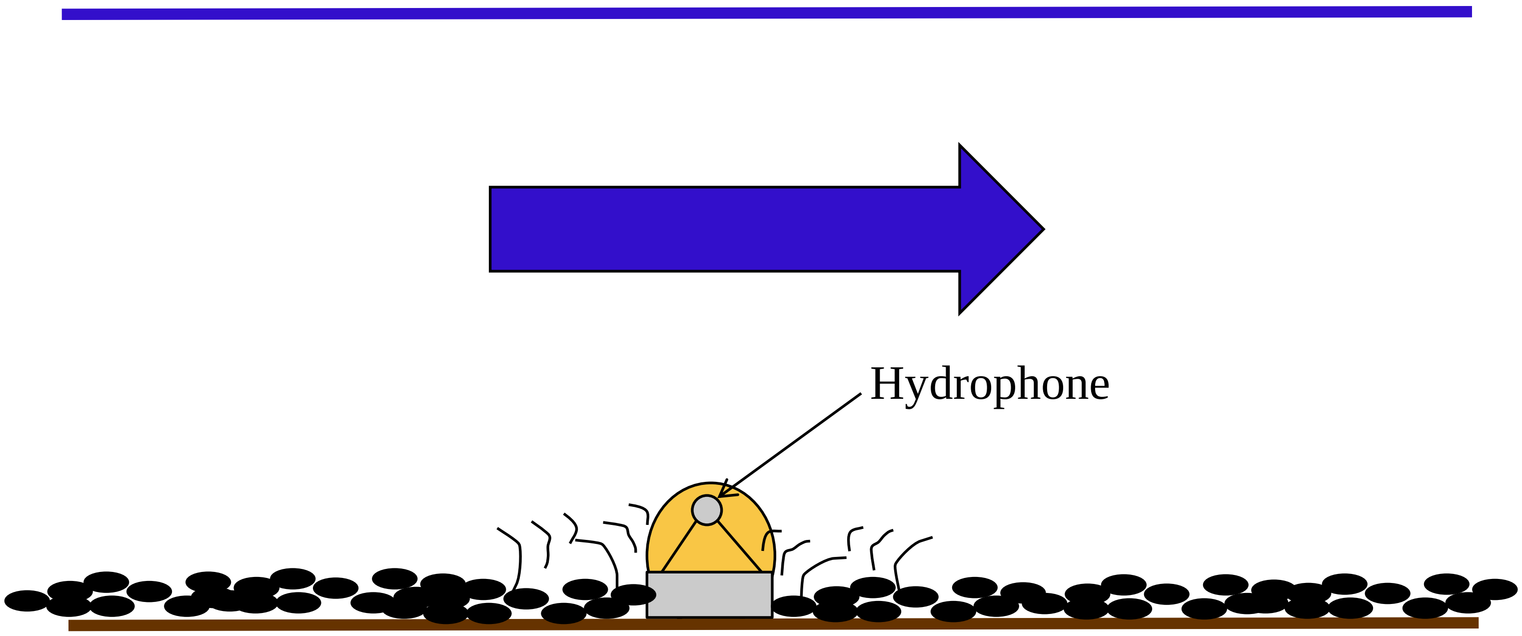
- But calibration gets very tricky due to added frequency dependence
  - Low frequency turbulence still gets through
  - High frequency sound of interest can get absorbed by urethane



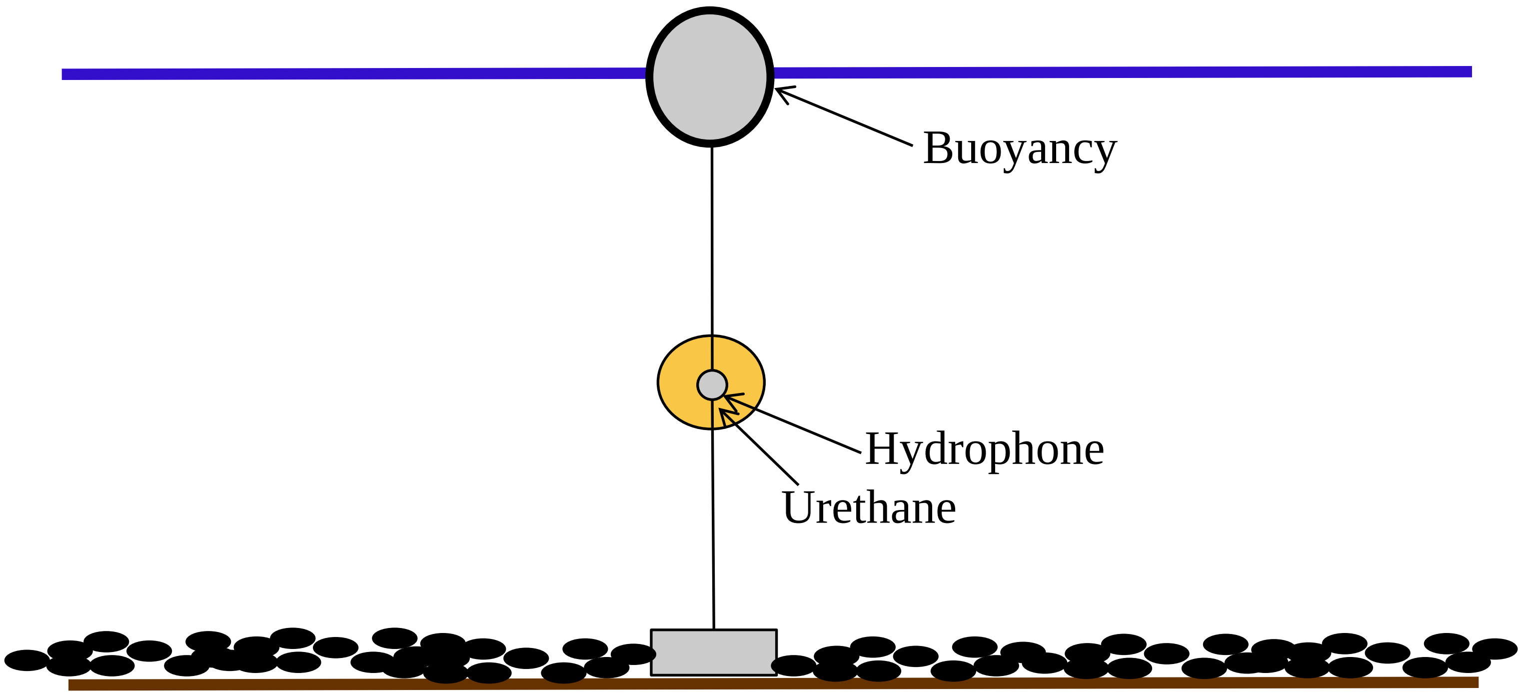
Further: Moored system subject to contamination

Local bottom noise sources dominate

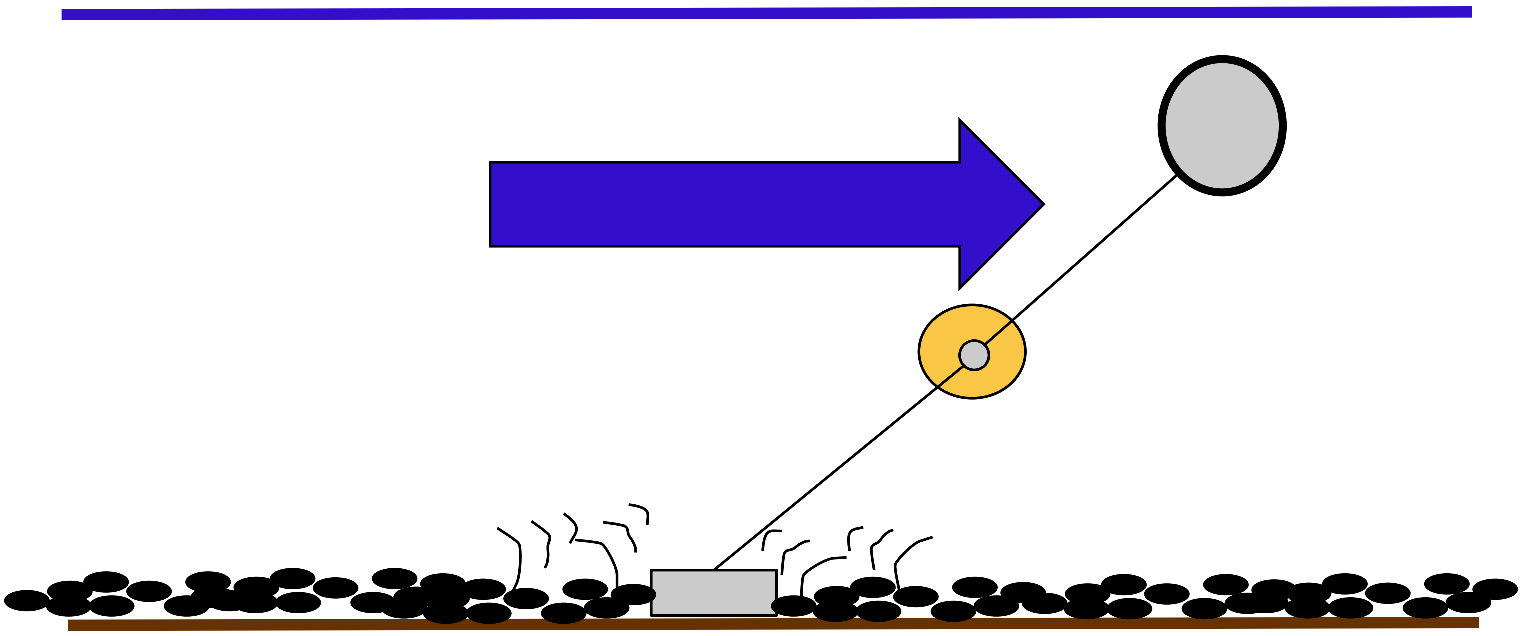
- i.e. noise is depth dependent



Maybe suspend hydrophone in water column

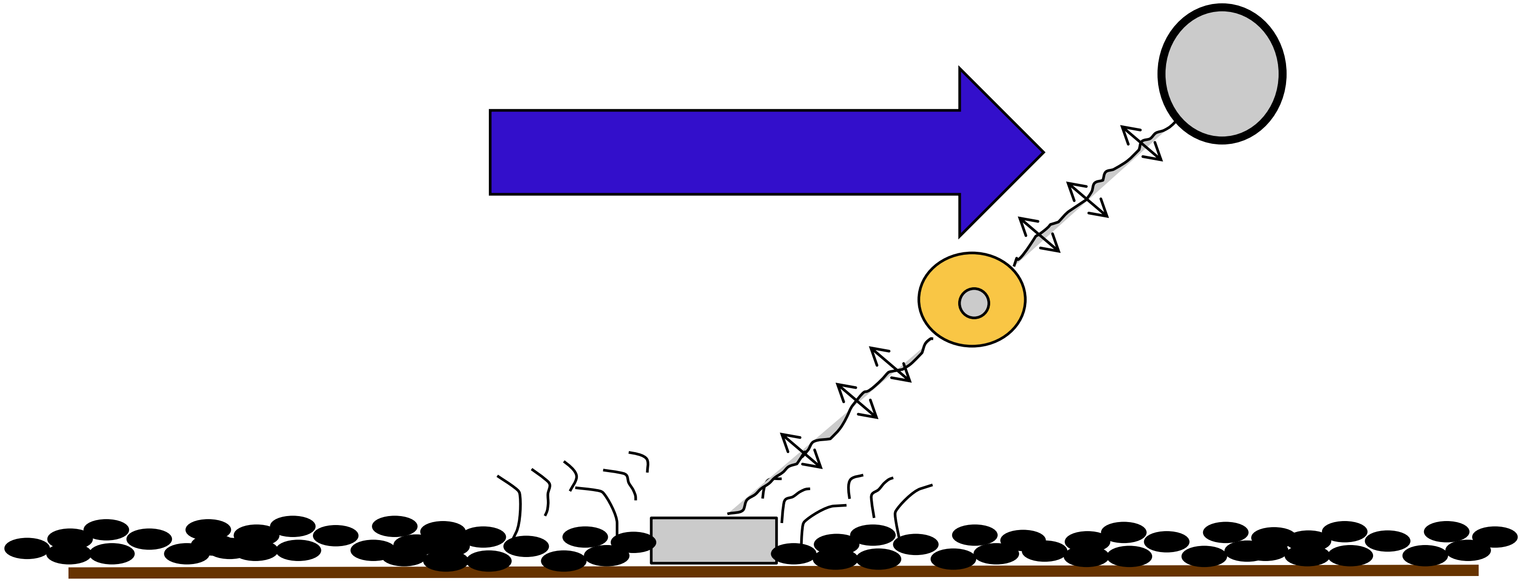


Besides getting a little scary



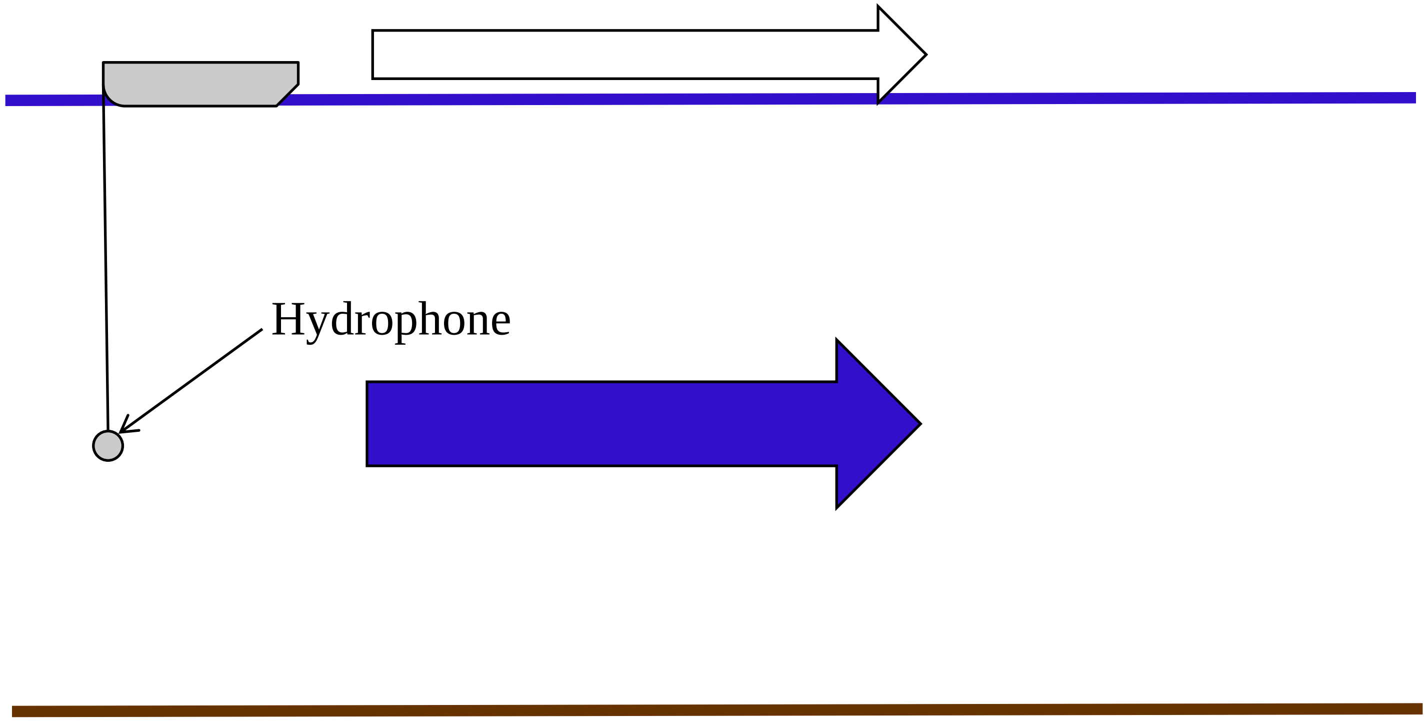
There is also cable strum

- Violent shaking of the cable
  - Noisy (shaking of hydrophone, couplings)
  - Change in depth due to cable shortening and lengthening can lead to pressure fluctuations usually enough to saturate preamplifiers

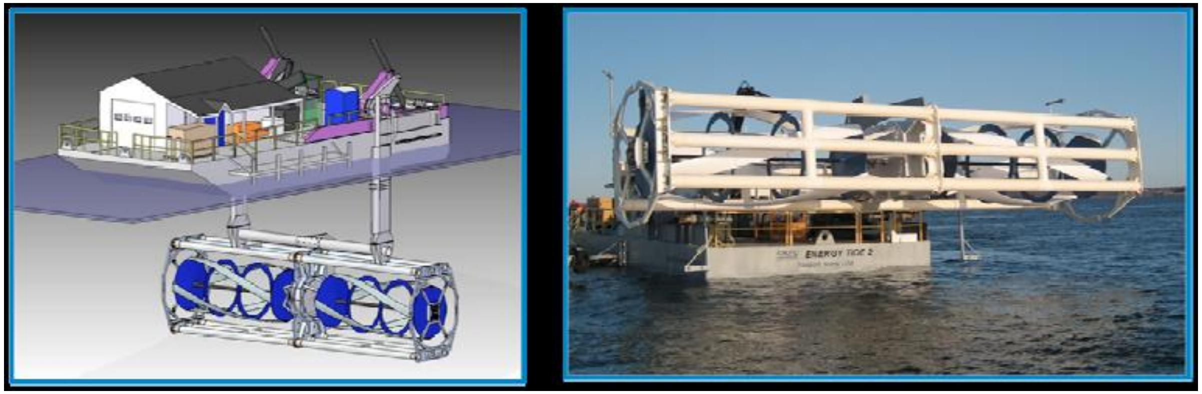


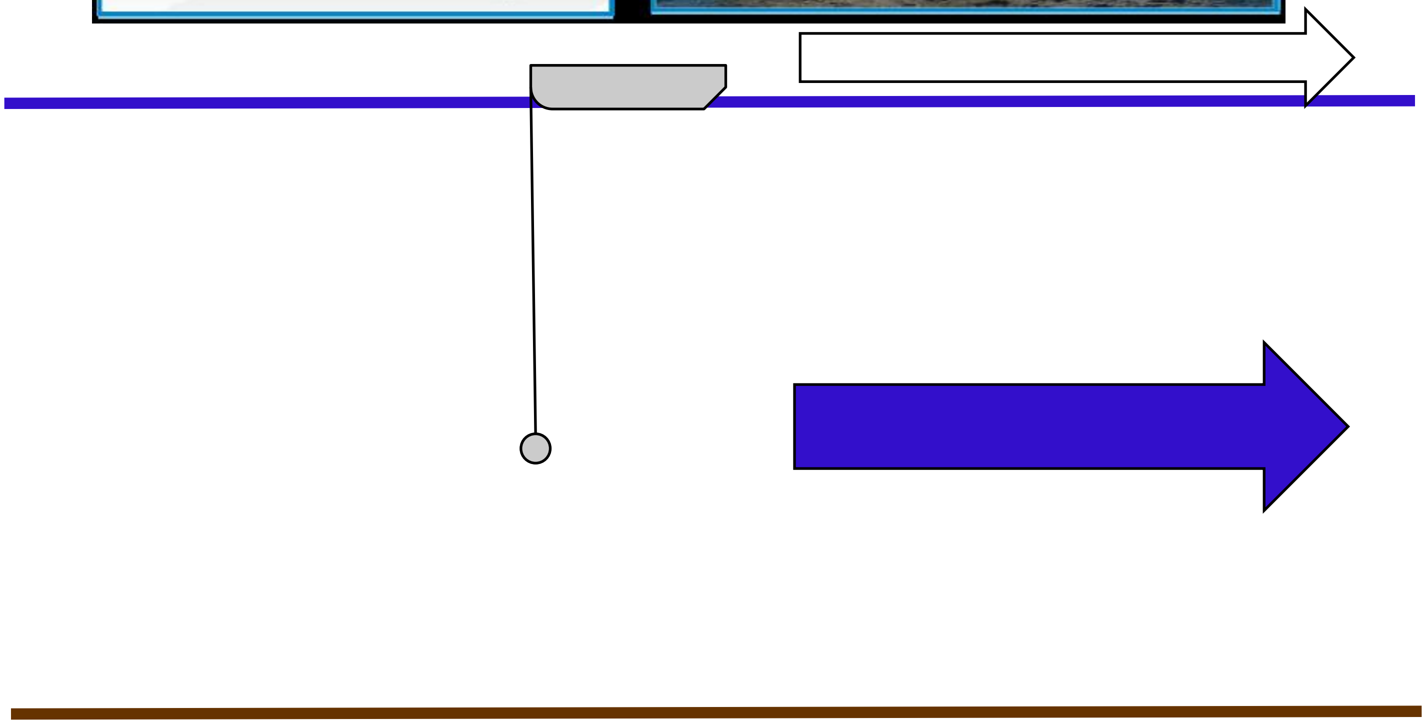
Solution

- Suspend hydrophone from a drifting platform
- Drift with and without the tidal generator in the path



Feasibility test conducted last fall

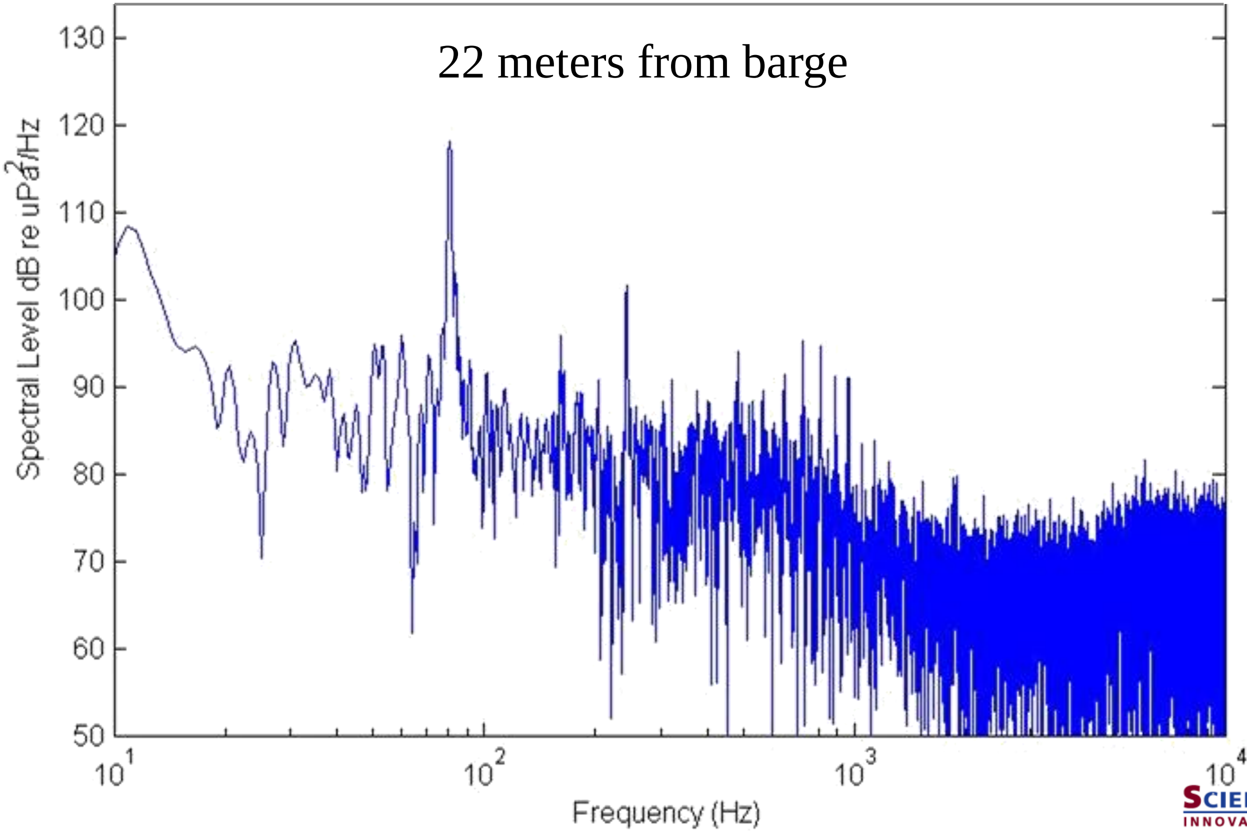




SCIENTIFIC SOLUTIONS, INC.
INNOVATIVE RESEARCH AND ENGINEERING

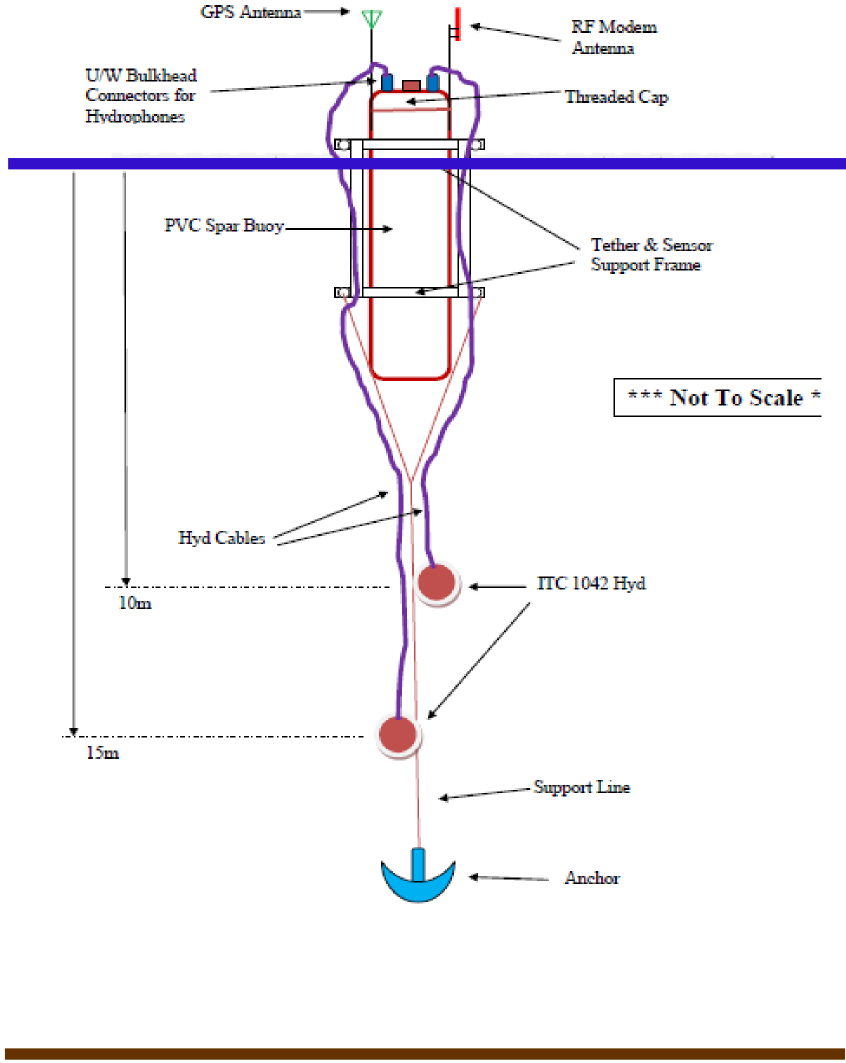
Data: Hydrophone suspended from drifting platform

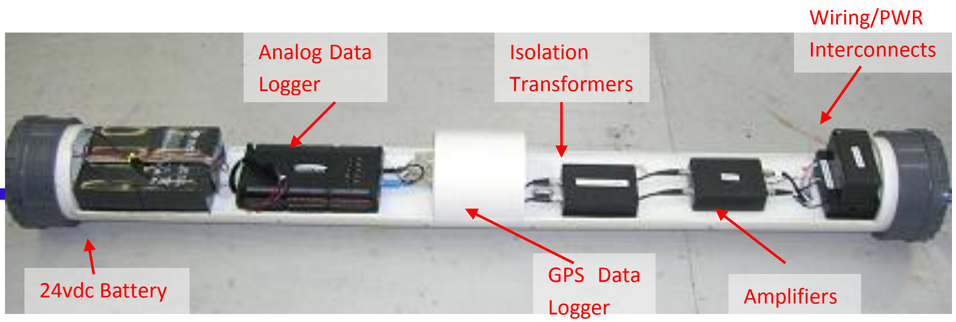
- Very promising, but data still contaminated
- Boat rocking caused noise and hydrophone heave
- Some cable strum due to some differential motion between boat and current (wind also drives the boat)
- A lot of sifting to get even small chunks of good data



SCIENTIFIC SOLUTIONS, INC.
INNOVATIVE RESEARCH AND ENGINEERING

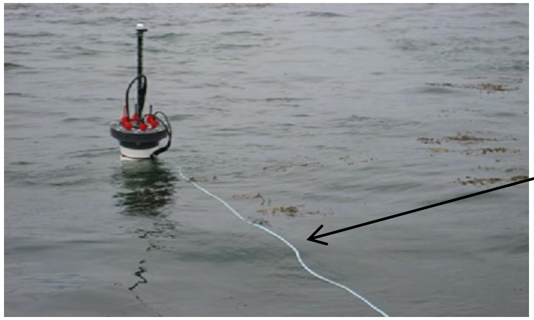
Designed and built spar buoy to remove last issues





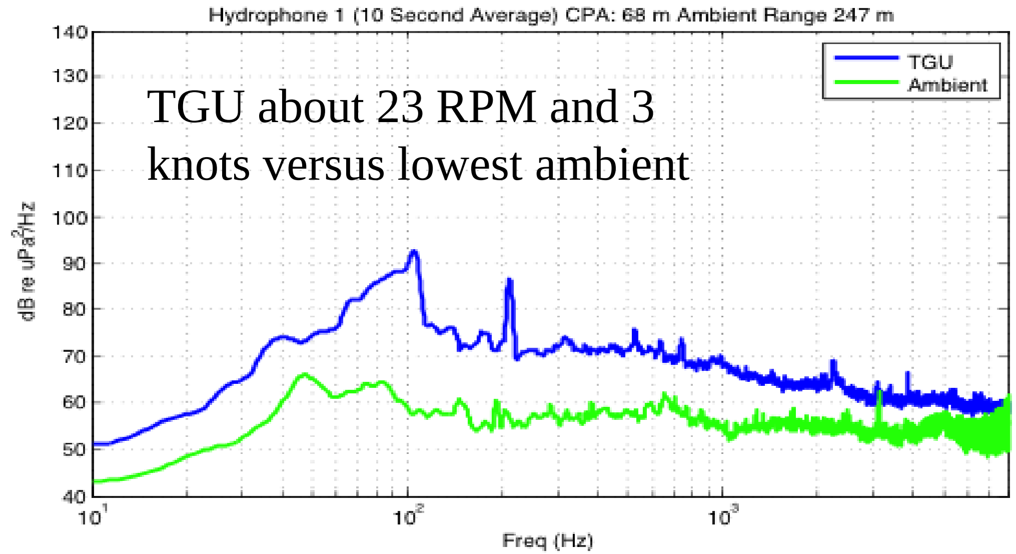
Hydrophones in faired cable

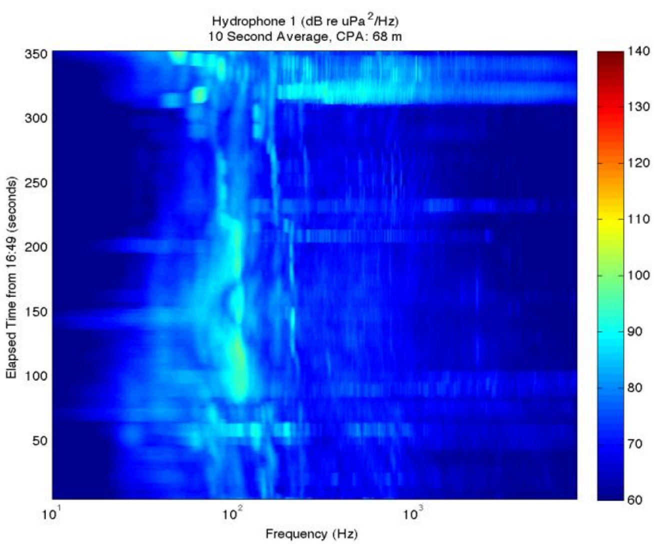
GPS antenna

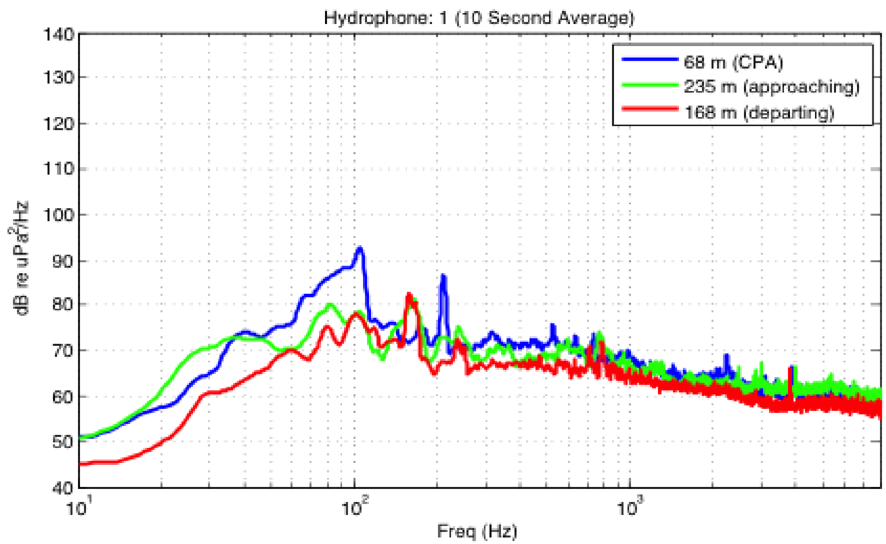


Tag line

Tests with spar buoy conducted in July







Conclusions

- High current noise measurements can be made from a drifting spar buoy
- It is very labor intensive and not feasible for continuous long-term monitoring
- OPRC turbine is very quite
    - No incidental harassment authorization (IHA) required
- Plan for tidal generator is to install accelerometers on the unit
    - Radiate noise will be correlated with accelerations
    - Accelerometers will then provide long-term monitoring of noise levels (also failure detection)