# MEASUREMENT OF LONG-TERM AMBIENT NOISE AND TIDAL TURBINE LEVELS IN THE BAY OF FUNDY

**11th European Conference on Underwater Acoustics, 3 July 2012**

Bruce Martin[1], Andrew Gerber[2], Christopher Whitt[1], Murray Scotney[3]

1 – JASCO Applied Sciences, Halifax NS

2 – University of New Brunswick, Fredericton NB.

3 – OTMS, Halifax NS.

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# Tidal Turbine Acoustic Impacts

- We expect rotating mechanical equipment in tidal turbines to emit continuous tones into the water, potentially at levels that may harm or harass marine life[1][2].
- To predict possible impacts we must measure the differences between the soundscapes with and without the turbine in place – soundscape – "sound or combination of sounds that forms or arises from an immersive environment"
- Ideally recordings should be made in all seasons, weather and tidal states.

[1] Polagye, B, Van Cleve, B, Copping, A, Kirkendall, K (eds). Environmental Effects of Tidal Energy Development. Proceedings of a Scientific Workshop (March 22-25 2010). NMFS F/SPO-116, 2011.

[2] Stein, P. Radiated Noise Measurements in a high current environment using a drifting noise measurement buoy. Marine Hydrokinetics Webinar Series, Session 3, 14 September 2011.

# Turbines and Noise Levels

- Frequencies from shaft rate, blade rates, and gearing ratios (if there are any) – 1 Hz – 100's Hz.
- SPL Disturbance thresholds for continuous noise
  - Marine Mammals – 100 - 140 dB RMS [3]
  - Fish, turtles – 150 dB RMS [4]
- 10 Hz and up
- Assuming we recording at 100 meters & 20 log R spreading, we need to 'hear' tones at 100 dB

[3] Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R.J. Greene, D. Kastak, D.R. Ketten, J.H. Miller, *et al.* 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* 33(4):411-521

[4] Fisheries Hydroacoustic Working Group, Interim Criteria, 2009.

# Making Acoustic Measurements

- Hydrophones measure changes in pressure from:
  - Acoustic waves
  - Changes in hydrostatic pressure (depth) due to hydrophone movement; may be from time-varying knock-down in current or mooring cable strumming.
  - Changes in pressure due to flow around the hydrophone creating eddies
- Sources besides acoustic waves are pseudo-noise which must be minimized by the *mooring*.

# Hydrophone Moorings

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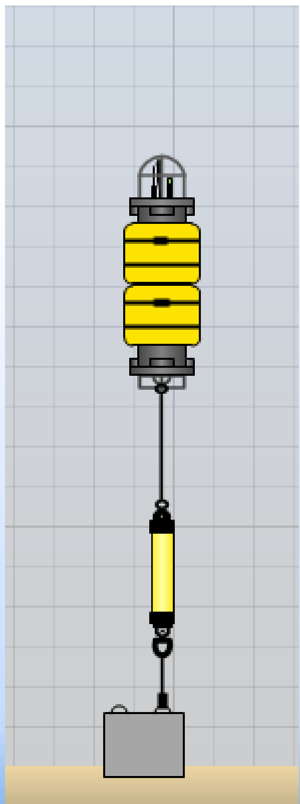
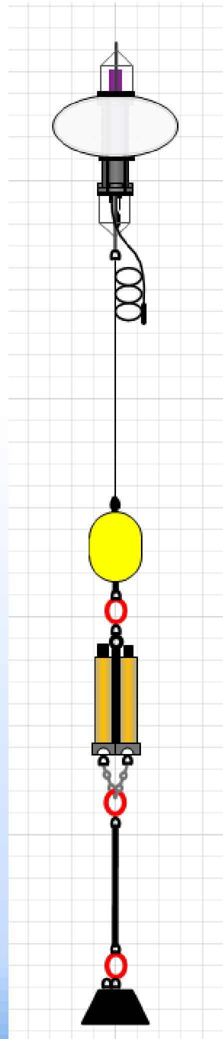
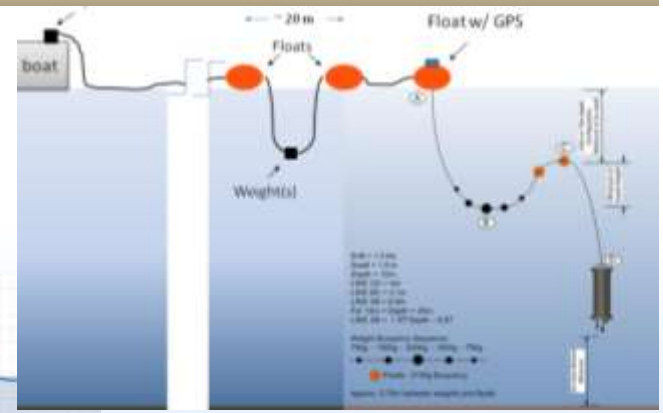
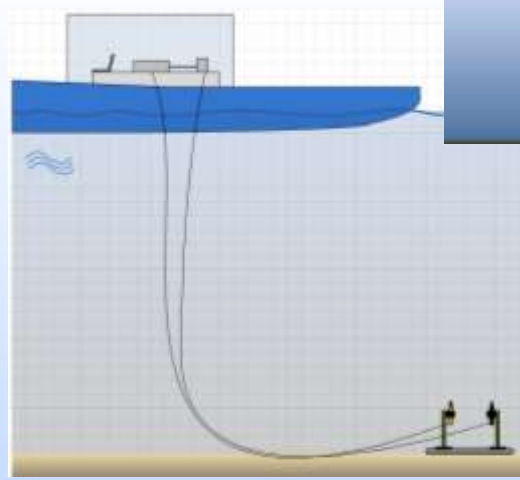
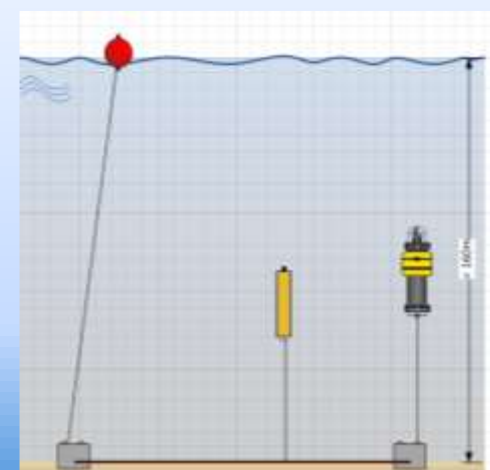




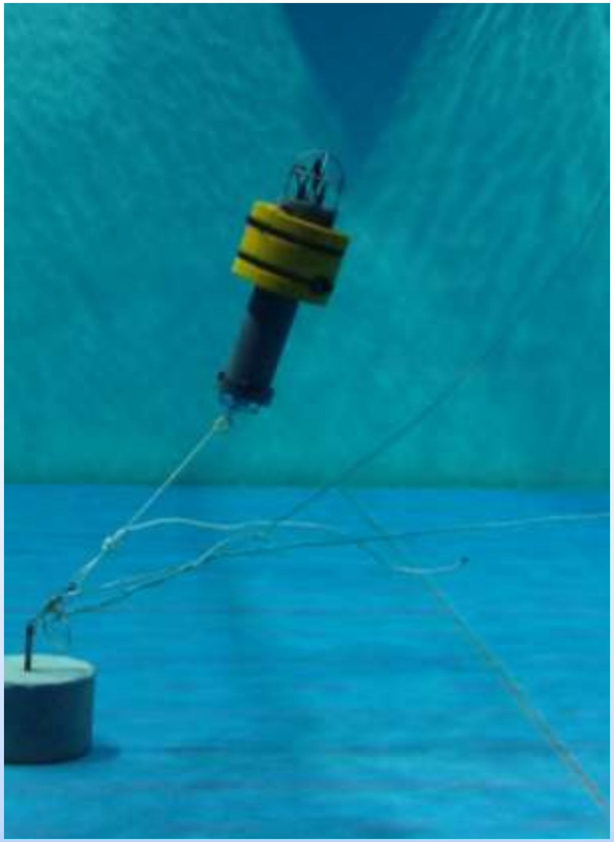


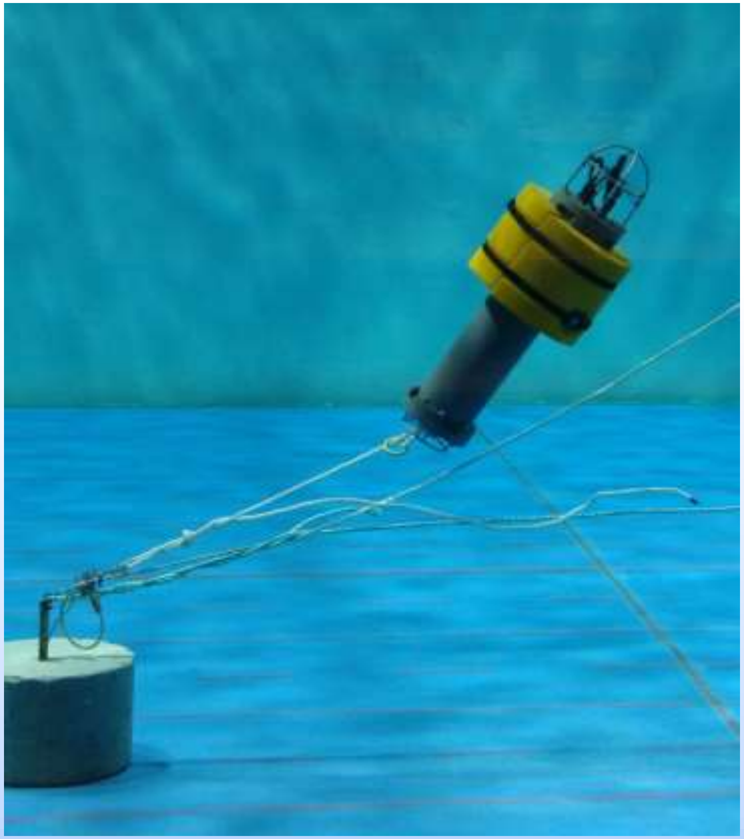


# Knockdown & Strum

**0.2 m/s current**



**0.8 m/s current**



Measurements performed at Center for Sustainable Aquatic Resources, Memorial University, St John's NFLD.

# Common Wisdom …

- Float-on-a-rope won't work due to knock-down and strum
- Bottomed moorings:
  - are too difficult to handle if they are big enough to stay in place
  - Likely to only record bottom noise
  - Still have flow-noise issues

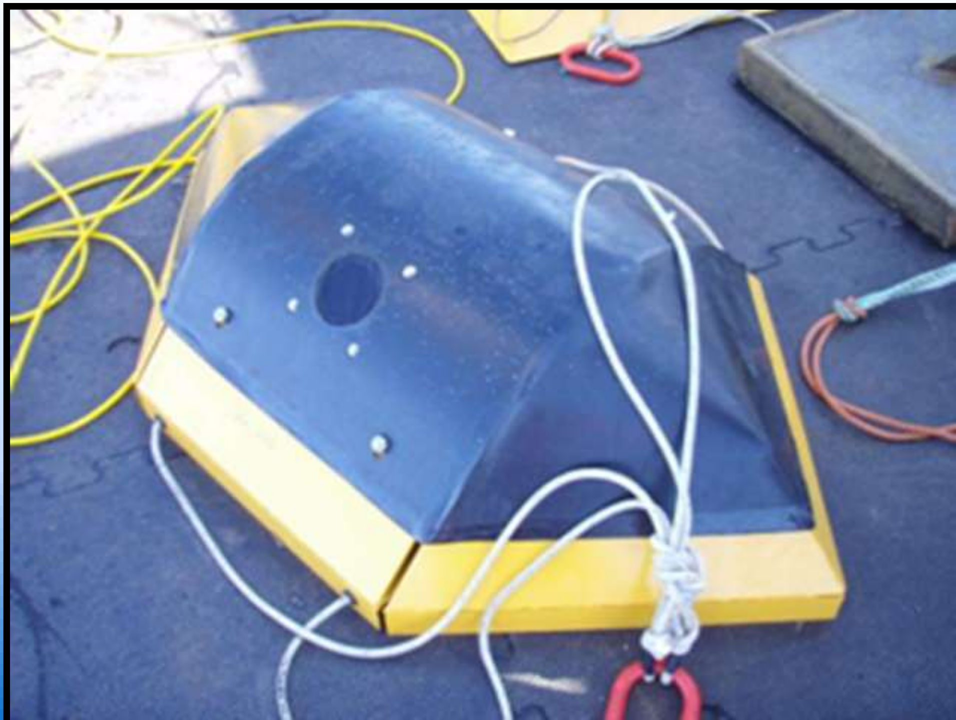
- Drifting measurements only ones likely to produce good data[5]

[5] Stein, P. Radiated Noise Measurements in a high current environment using a drifting noise measurement buoy. Marine Hydrokinetics Webinar Series, Session 3, 14 September 2011.

# Results Summary

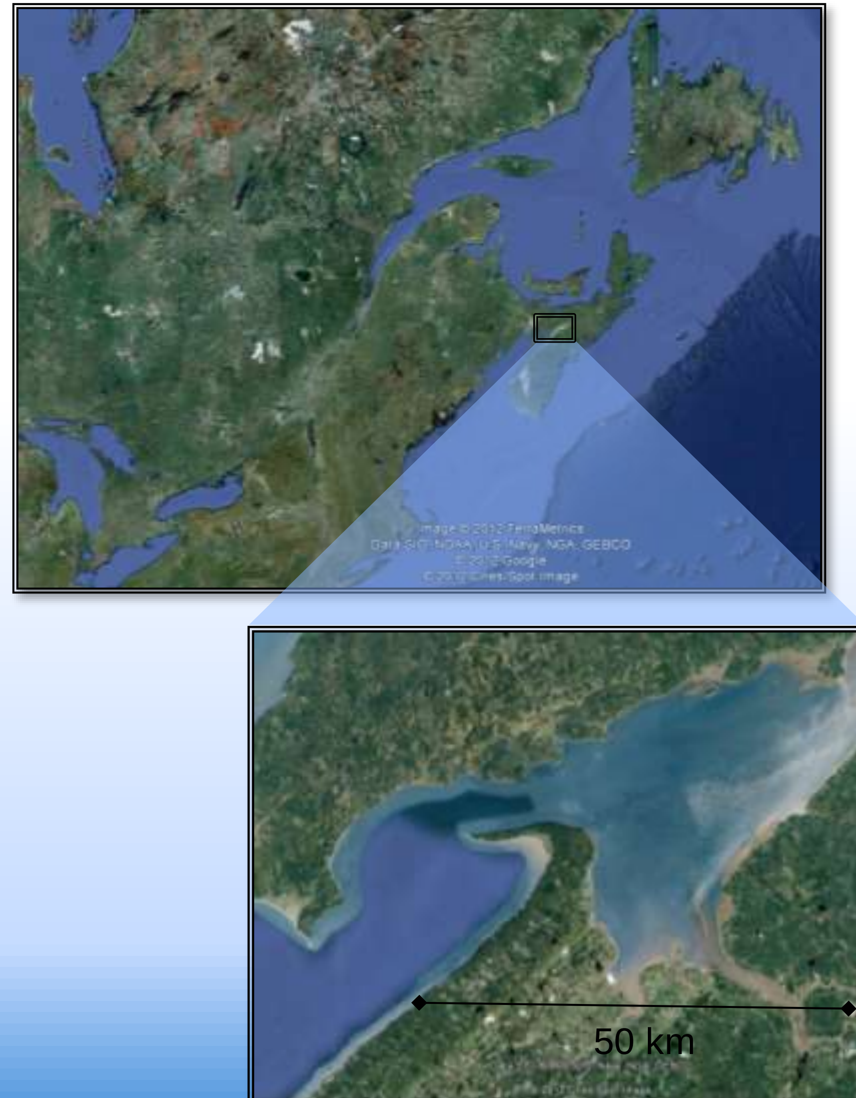
- A carefully designed bottom mooring will stay in place and is manageable from a reasonably equipped fishing vessel.
- Flow noise can be mitigated allowing for ambient noise measurements, even in very high flow conditions.

- How did we get there?
- Acoustic results



# Project Site - Minas Passage NS

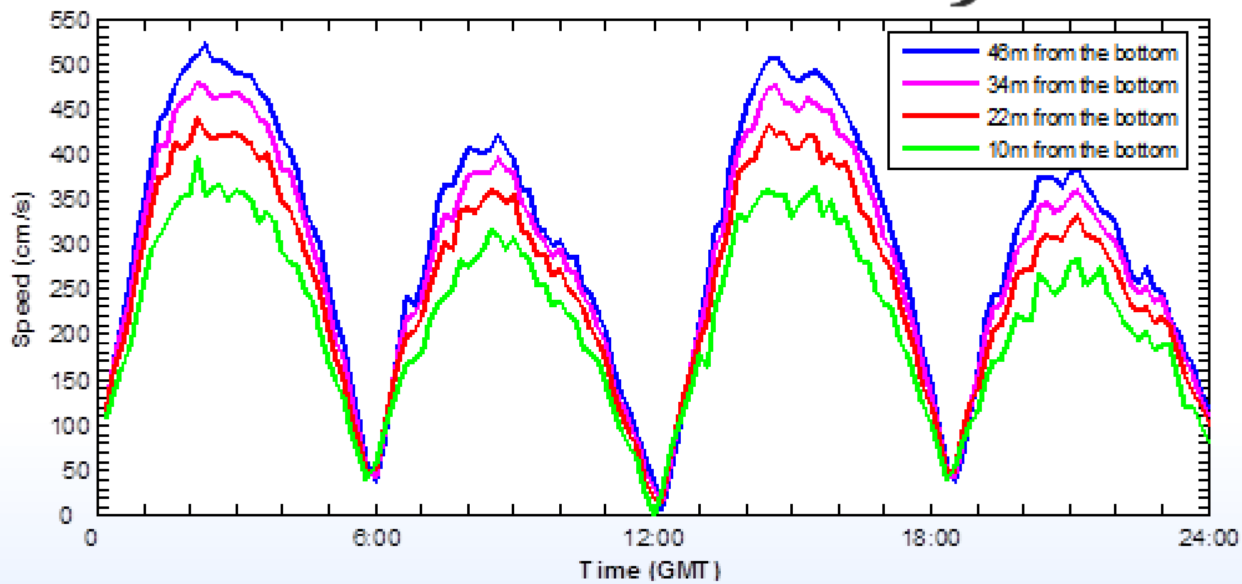
- Located between Cape Spear and Cape Split NS.
- 40 – 60 meters deep, 4.5 km wide at the FORCE site.
- Current at mid-tide moves 4.5 cubic kilometers of water per hour
- 14 billion tonnes of seawater moves per tide.
- Tidal variation 11 – 13 meters



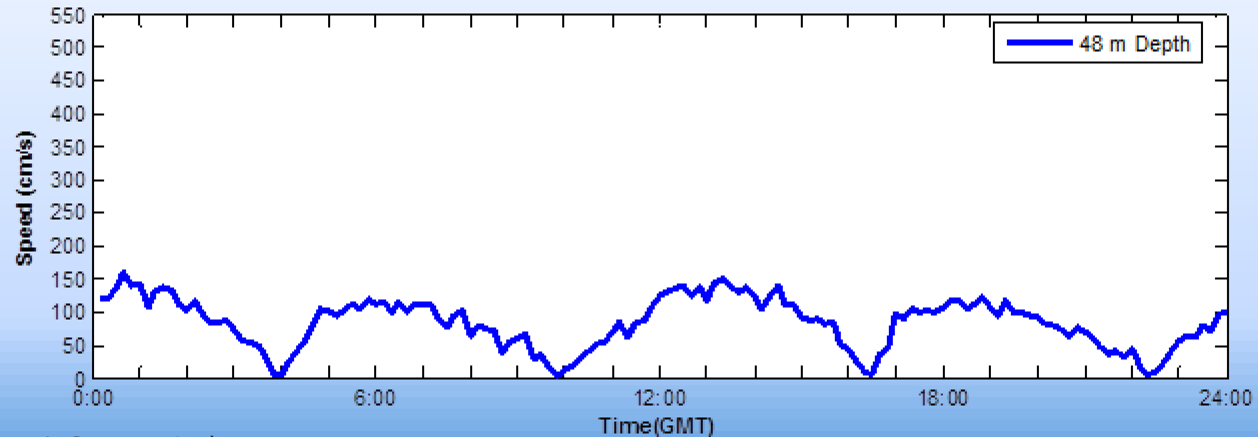

http://fundyforce.ca/testsite

# Current Profile

- Spring Tides, 7 May 2008. Flood stronger and shorter than ebb.

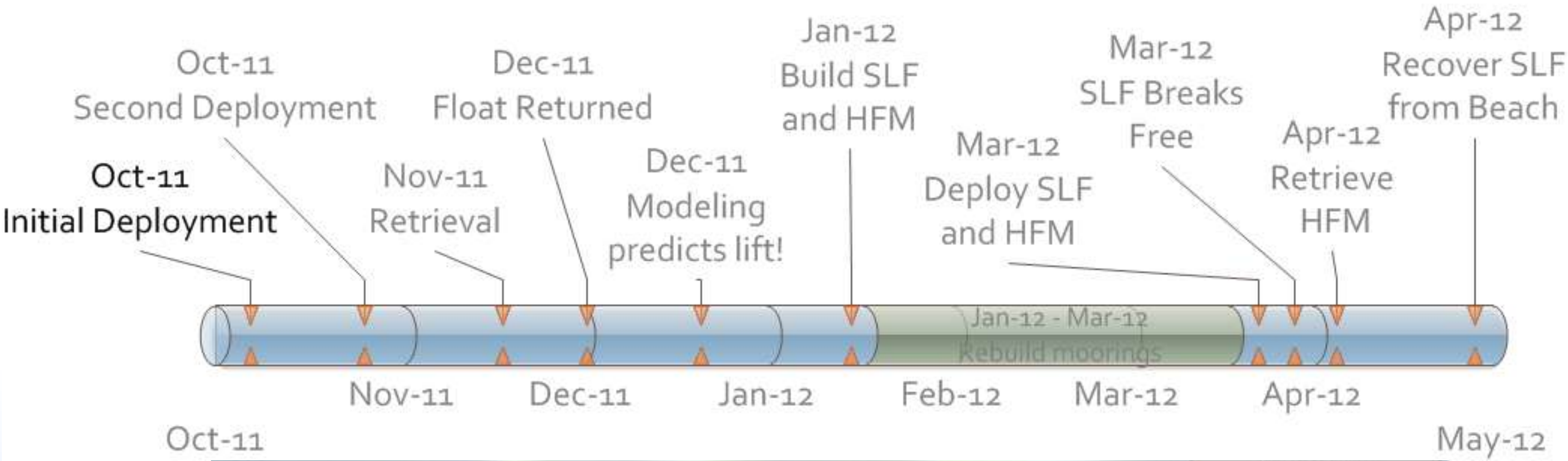


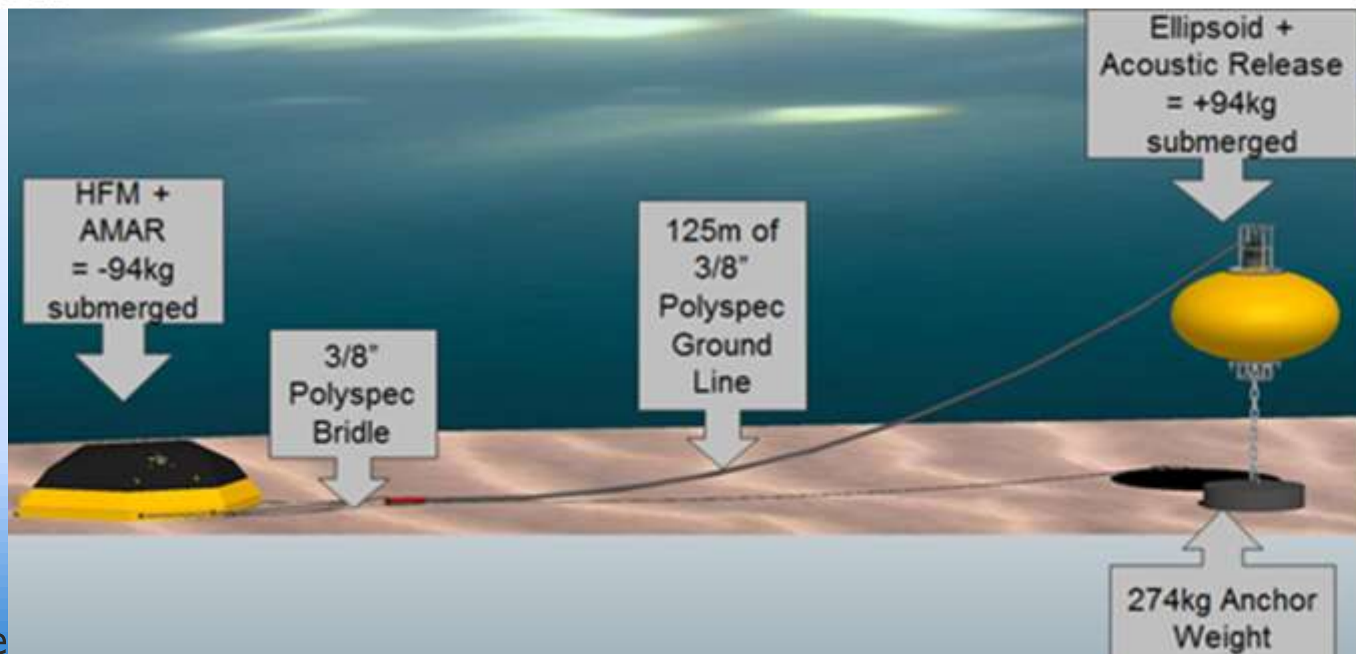

- InterOcean S4 data at 0.5 m above bottom, spring tides




Data courtesy of Minas Pulp and Paper & Oceans Ltd.

# Methods – Fieldwork Timeline



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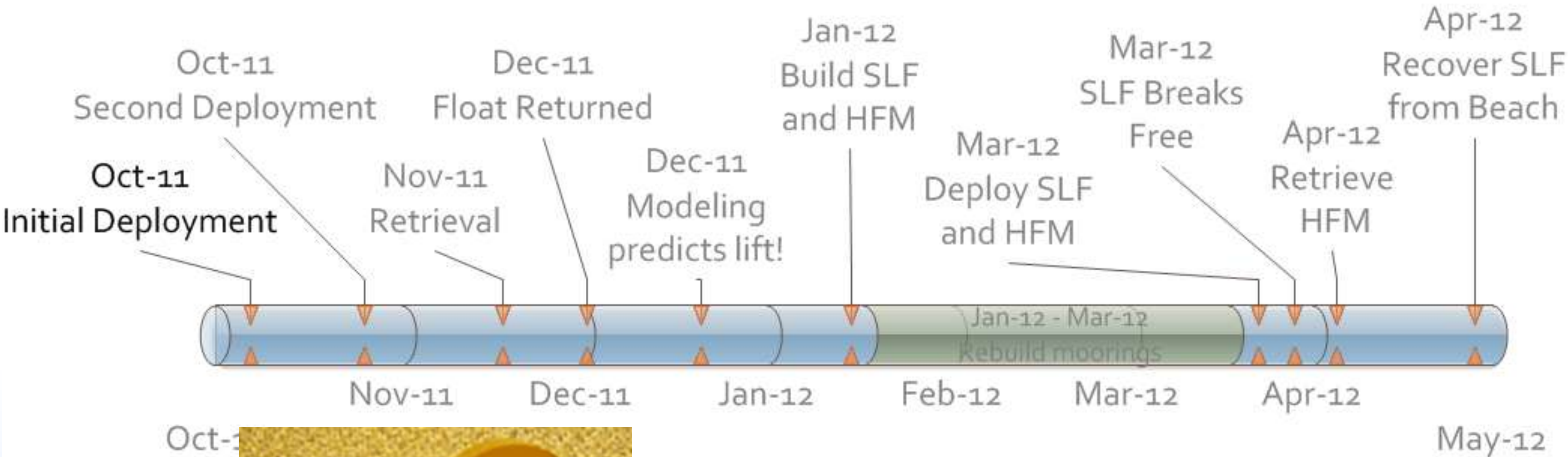
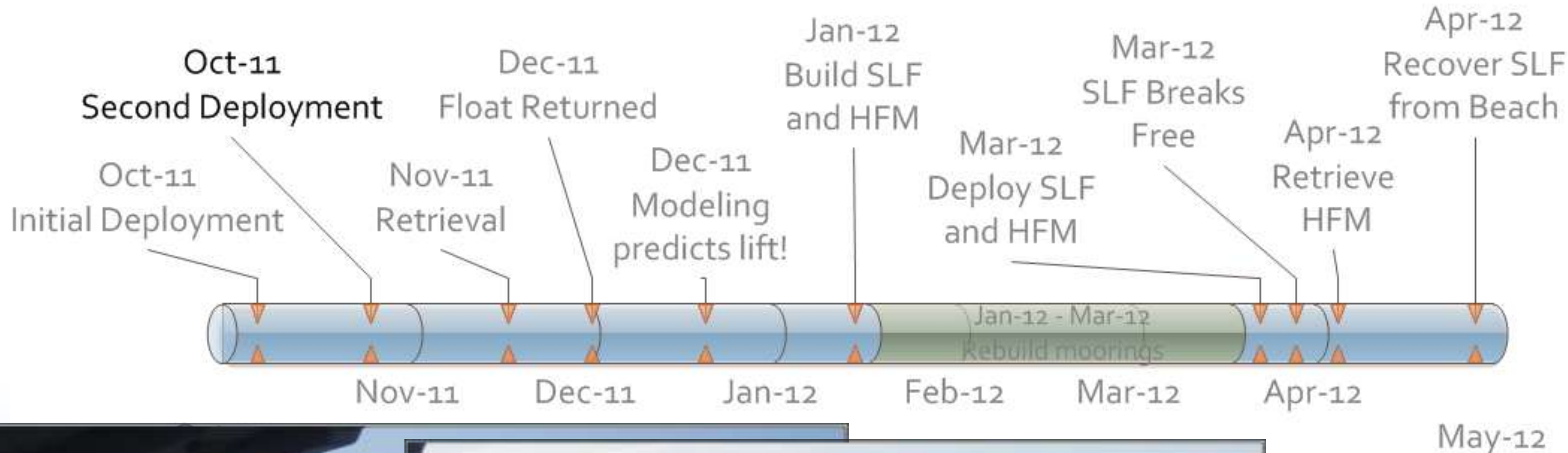
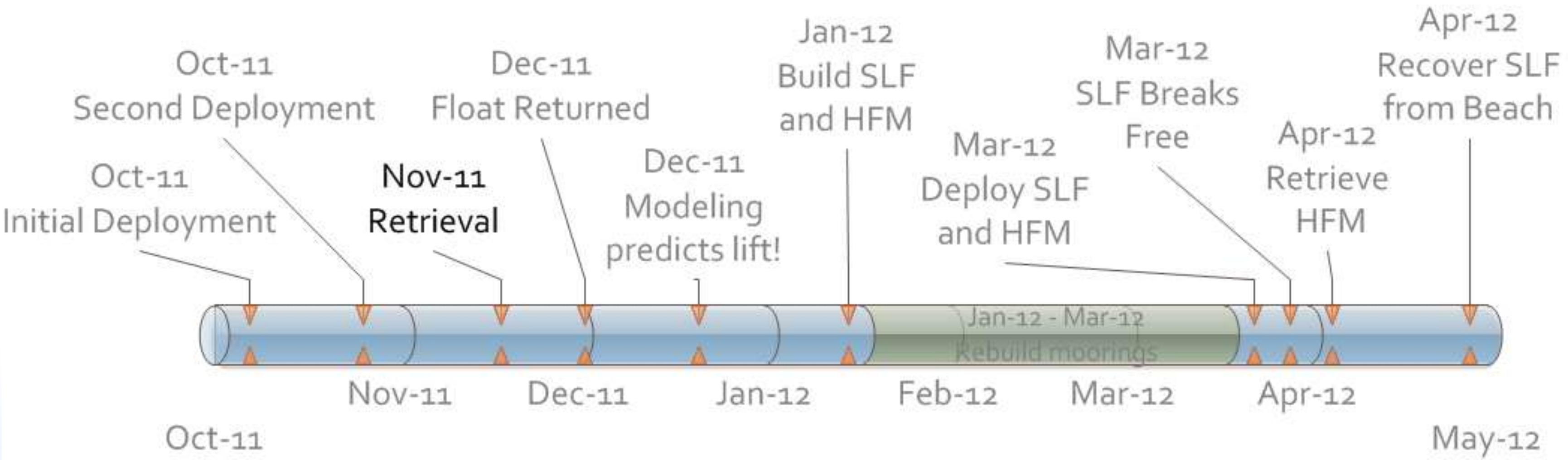



| Bay Of Fundy | JASCO |
|---|---|
| + 2 Anchors | 0 |
| | |
| | |

# Second Deployment – Success!

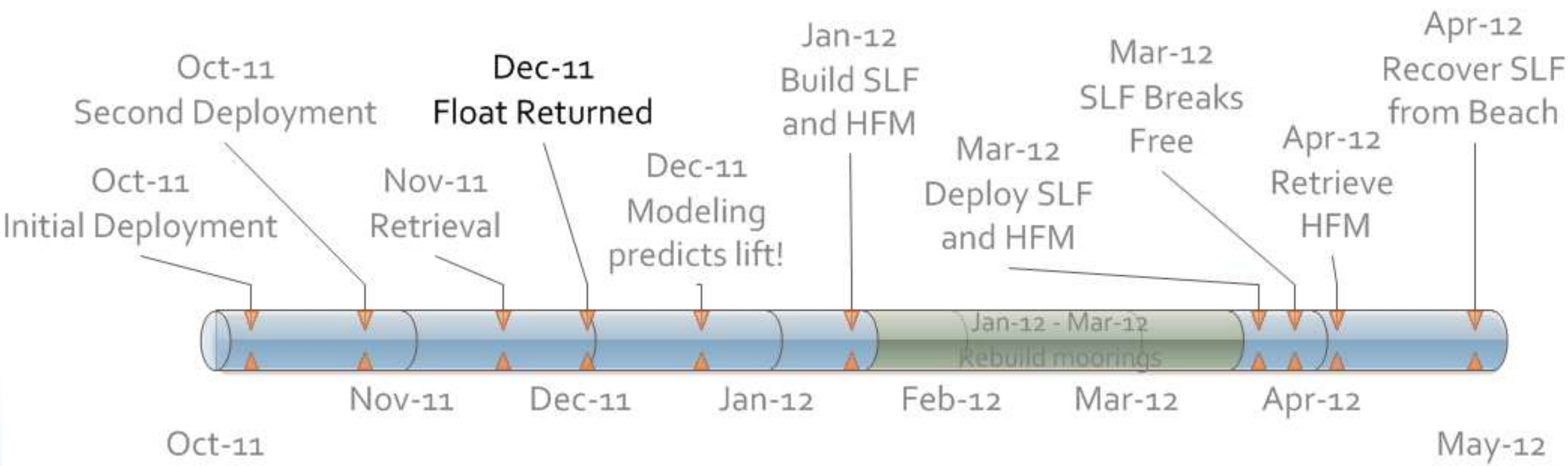


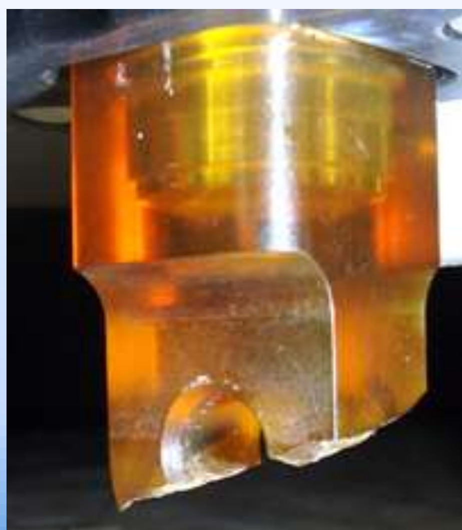

# Nov-11 Retrieval




| Bay Of Fundy | JASCO |
|---|---|
| + 2 Anchors | 0 |
| + 2 HFM, 2 AMARs, 2 PORT-LF releases, 2 elliptical floats | 0 |
| | |

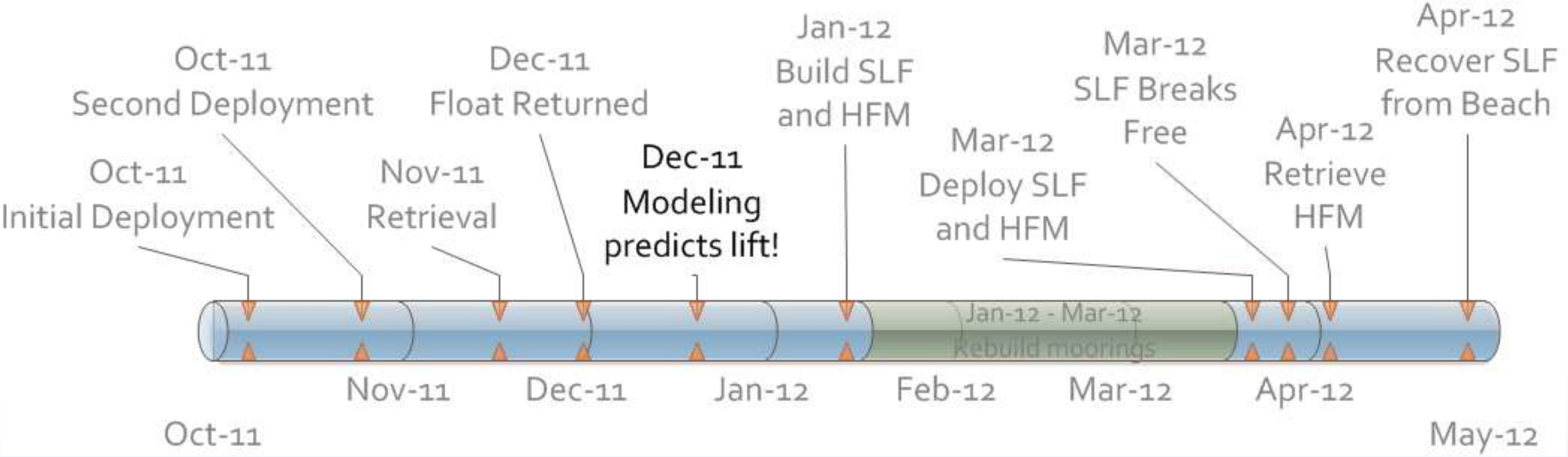
# Float Found …



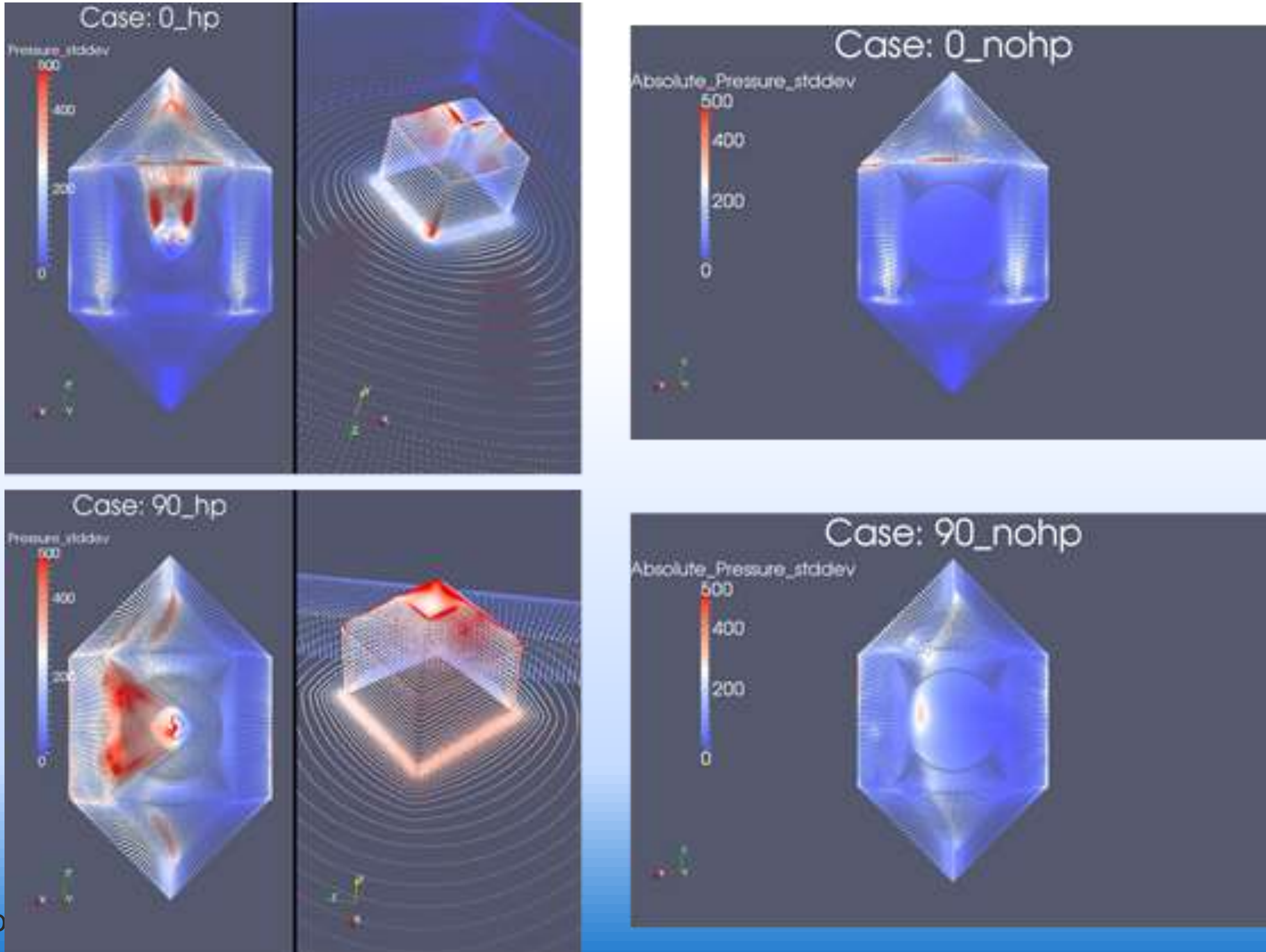
| Bay Of Fundy | JASCO |
|---|---|
| + 2 Anchors | 0 |
| + 2 HFM, 2 AMARs, ~~2~~ 1 PORT-LF releases, ~~2~~ 1 elliptical floats | 0 |
| | |

# CFD – Computational Fluid Dynamics Models



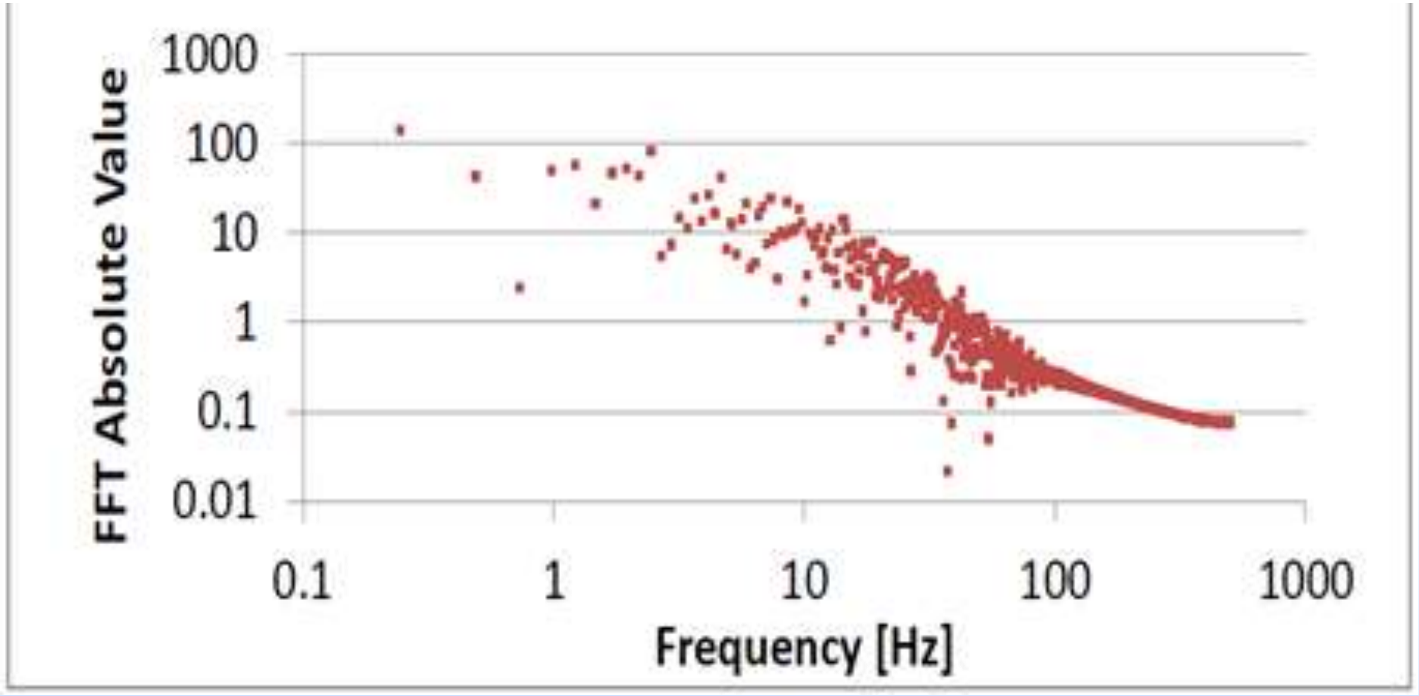

- Performed under an Engage Grant by UNB
- Created a mesh representation of the HFM, then modeled using Detached Eddy Simulations to solve the Navier-Stokes equations and obtain time-varying pressures for the surface.
- Model indicated HFM produces lift in the current and required more weight to keep stationary.
- Predicted noise levels from flow over the surface.

# Pressure Standard Deviation Surfaces

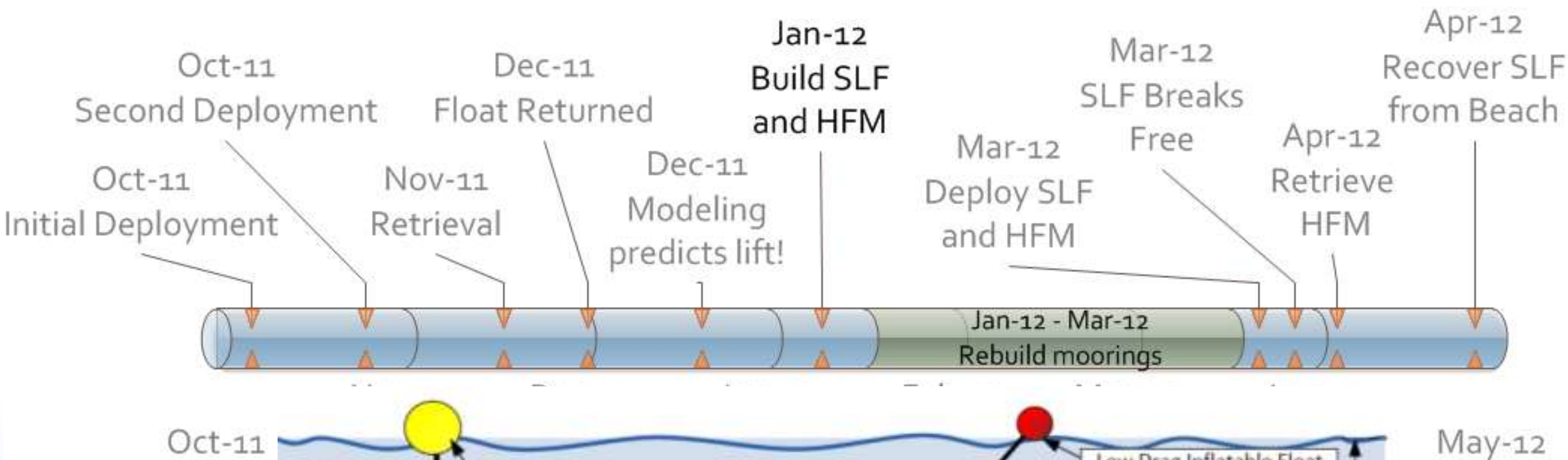


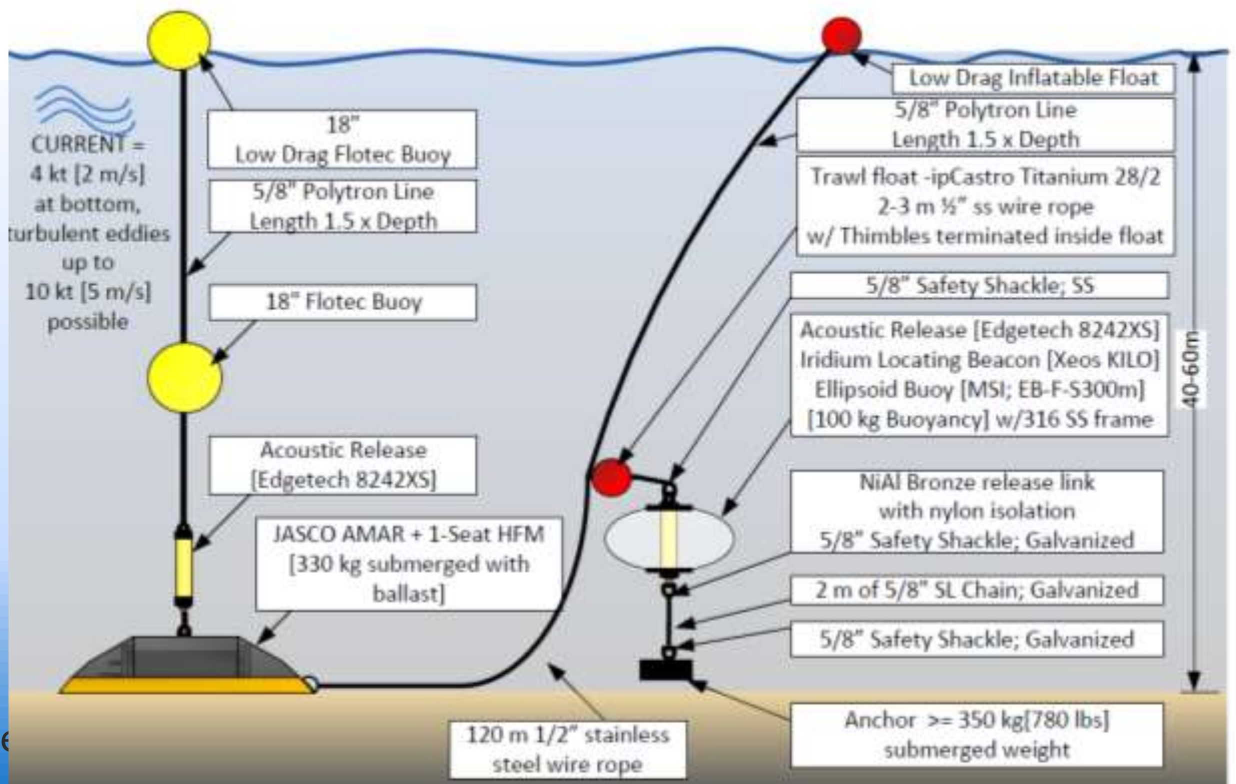

So

# Frequency Dependence of Noise

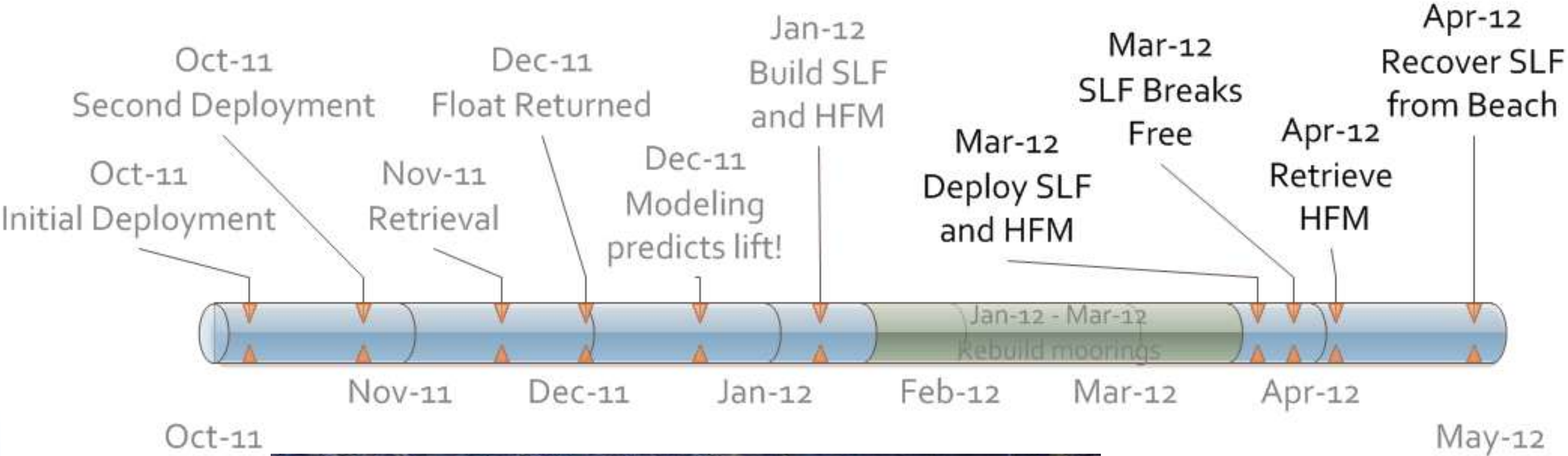


# Changing Mooring Designs

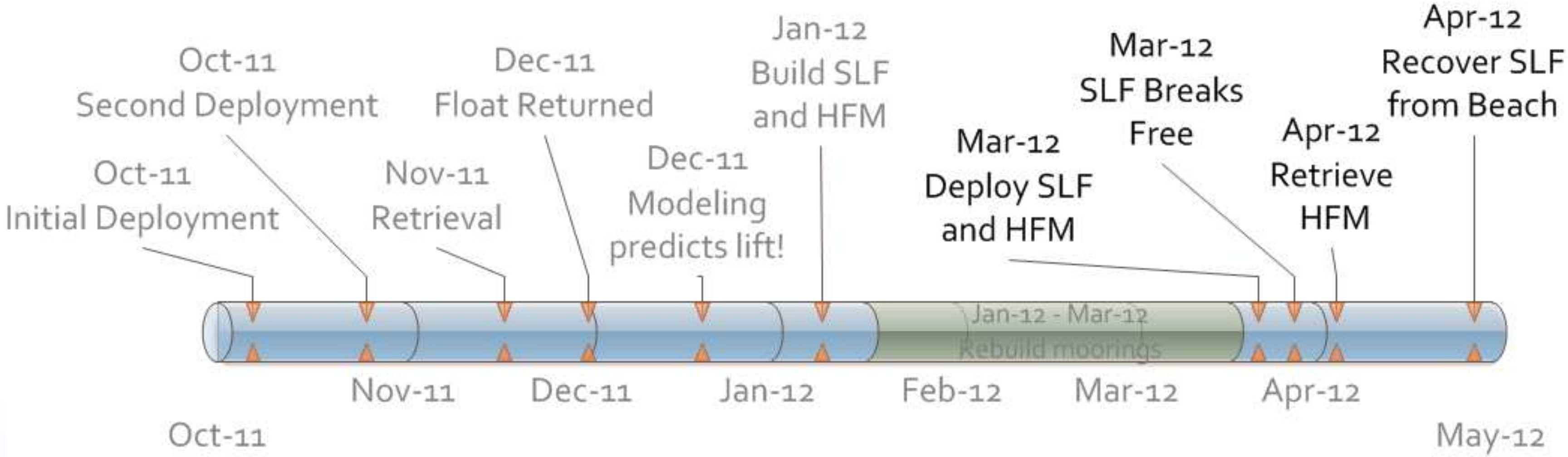


# March – April 2012



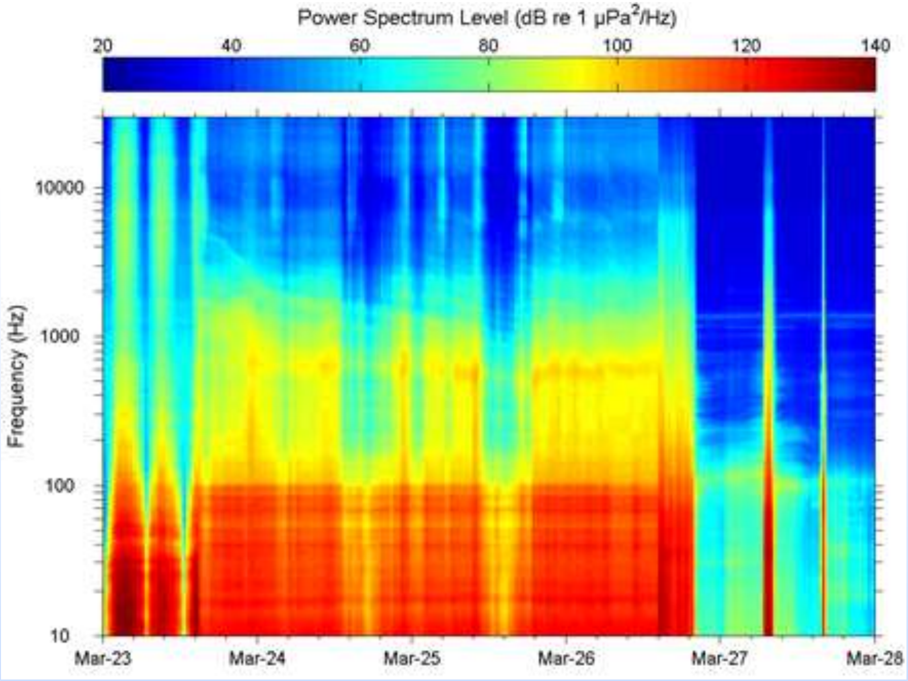

# March – April 2012



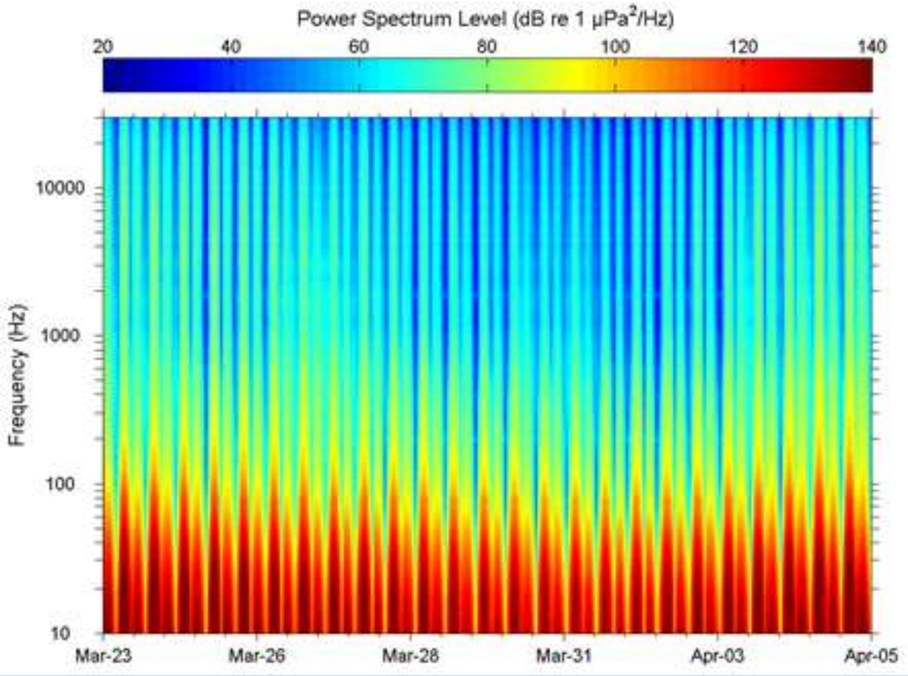

| Bay Of Fundy | JASCO |
|---|---|
| + 2 Anchors | 0 |
| + 2 HFM, 2 AMARs, ~~2~~ 1 PORT-LF releases, ~~2~~ 1 elliptical floats | 0 |
| + 2 ORE 8242 releases | DATA |
| | |

# Acoustic Data - Spectrograms

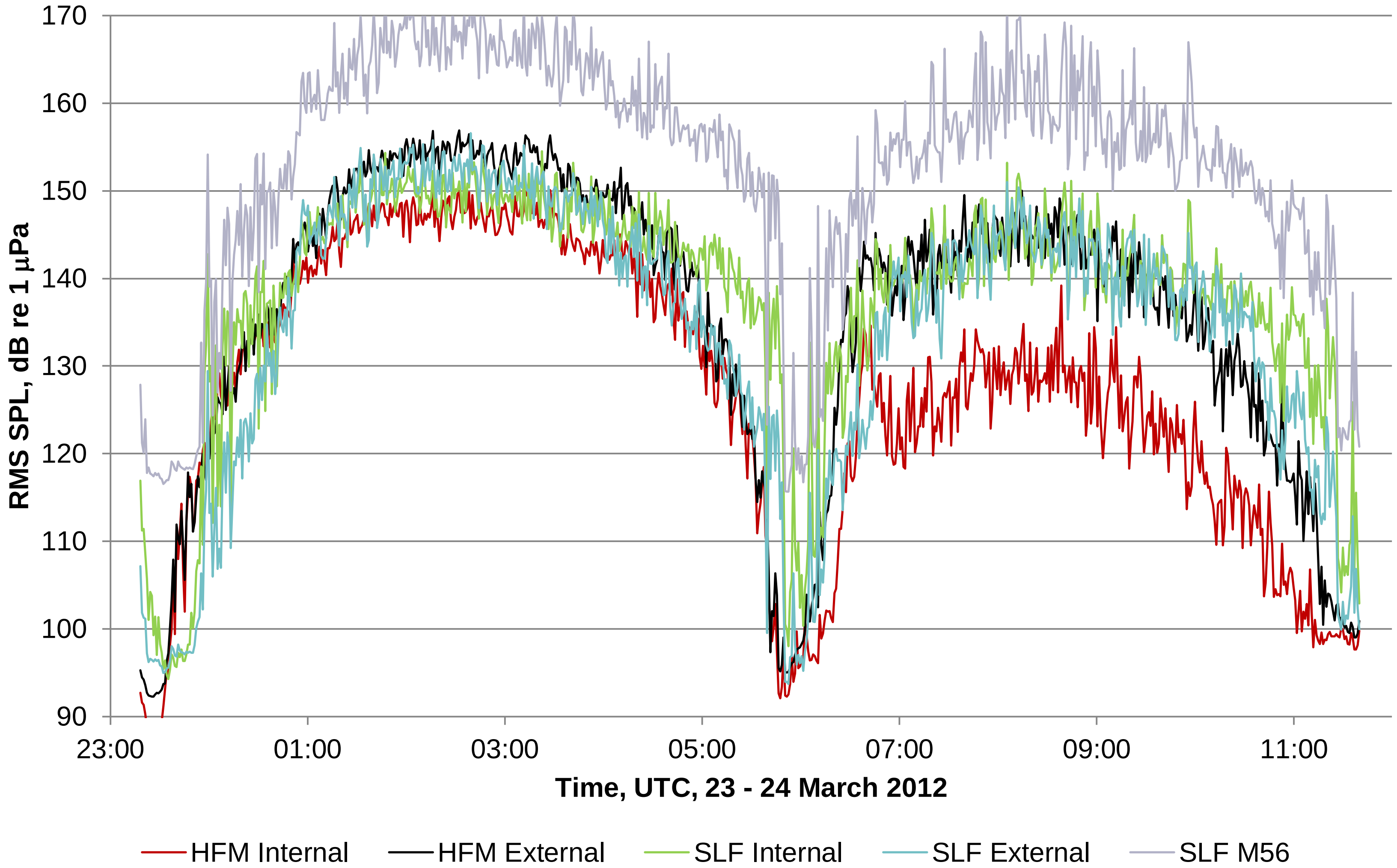
## SLF



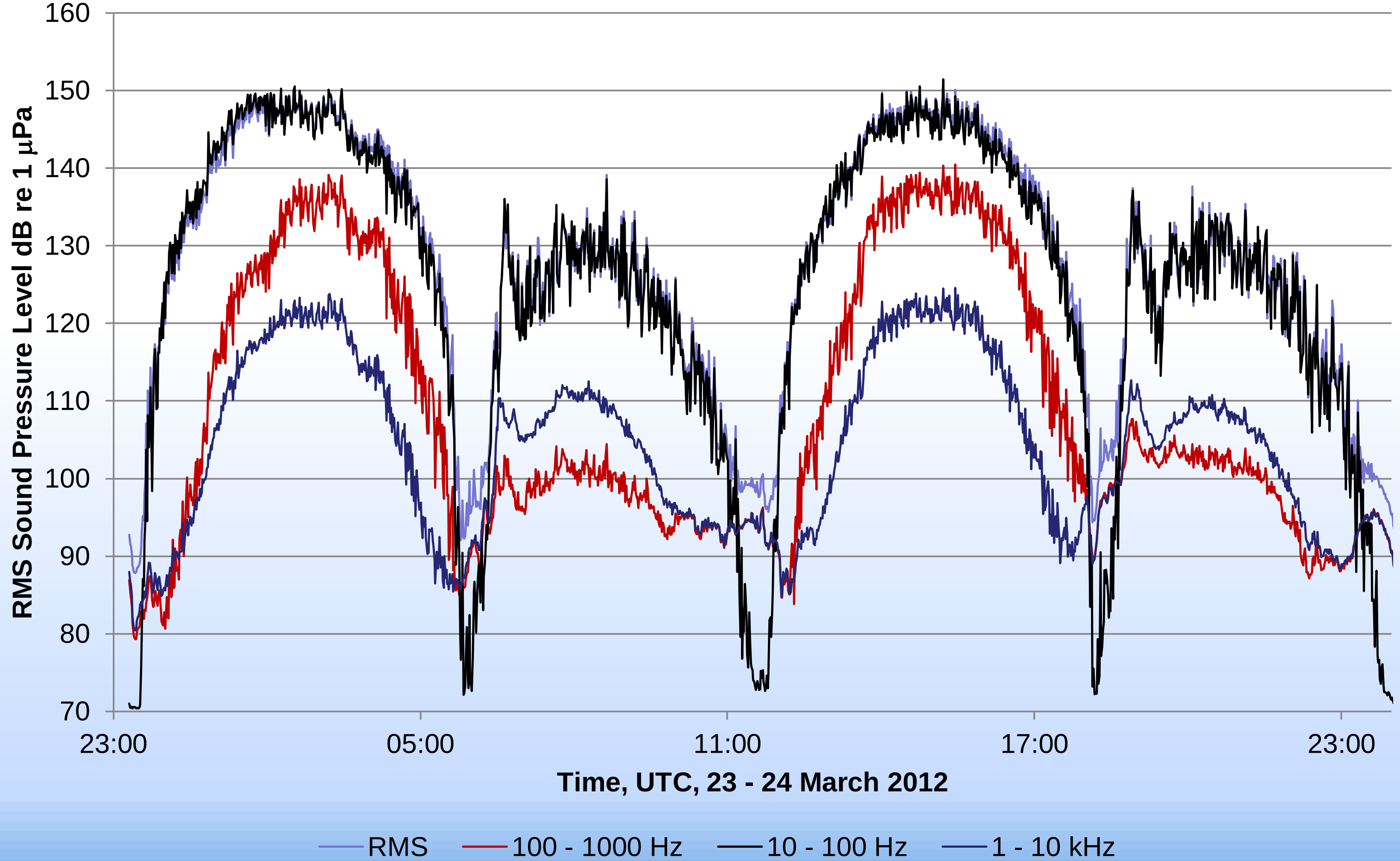

## HFM



# Comparison of Broadband Noise Levels – one full cycle



# HFM Internal Hydrophone – Preferred Direction …



# 1/3 Octave band percentiles

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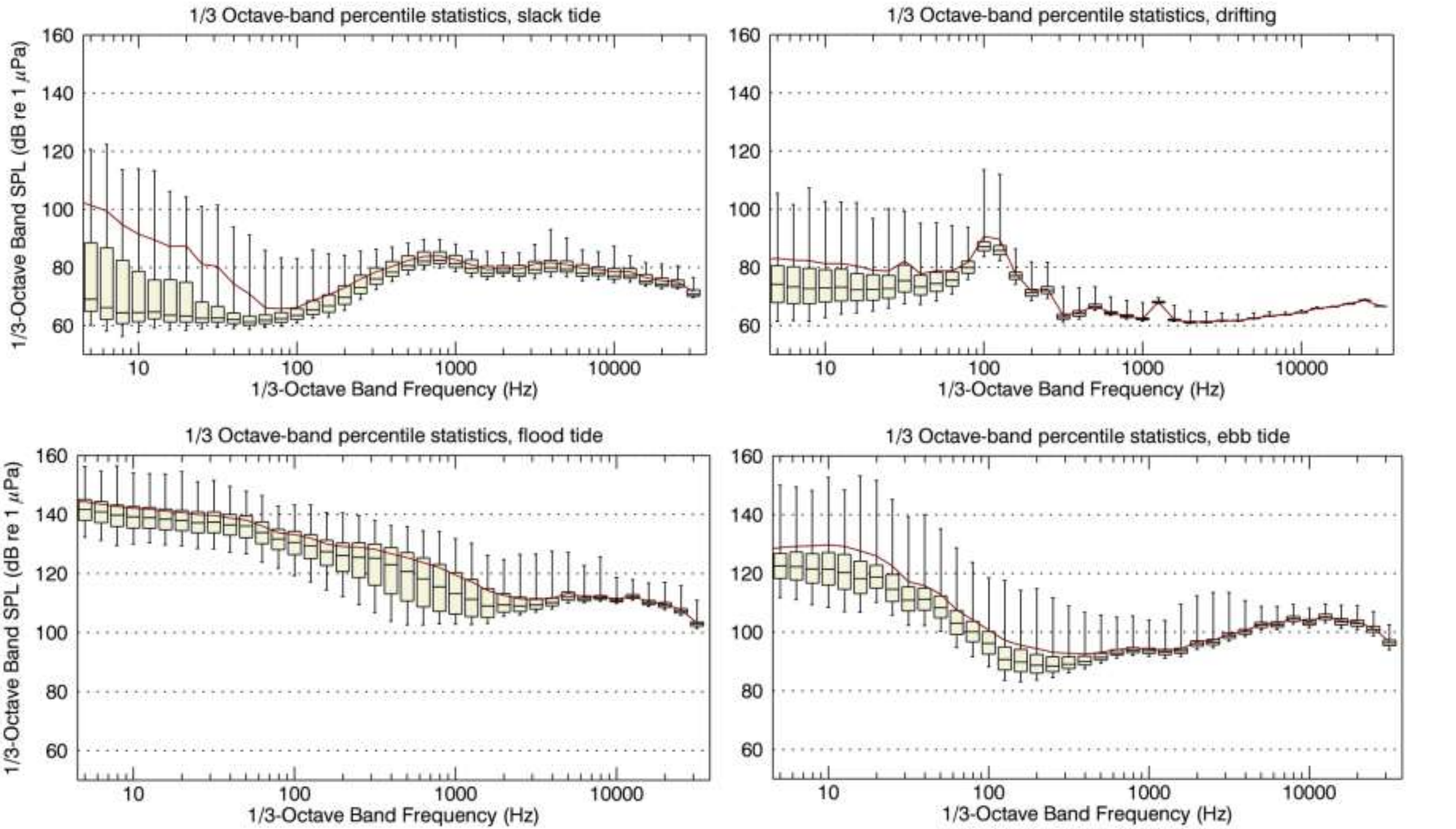
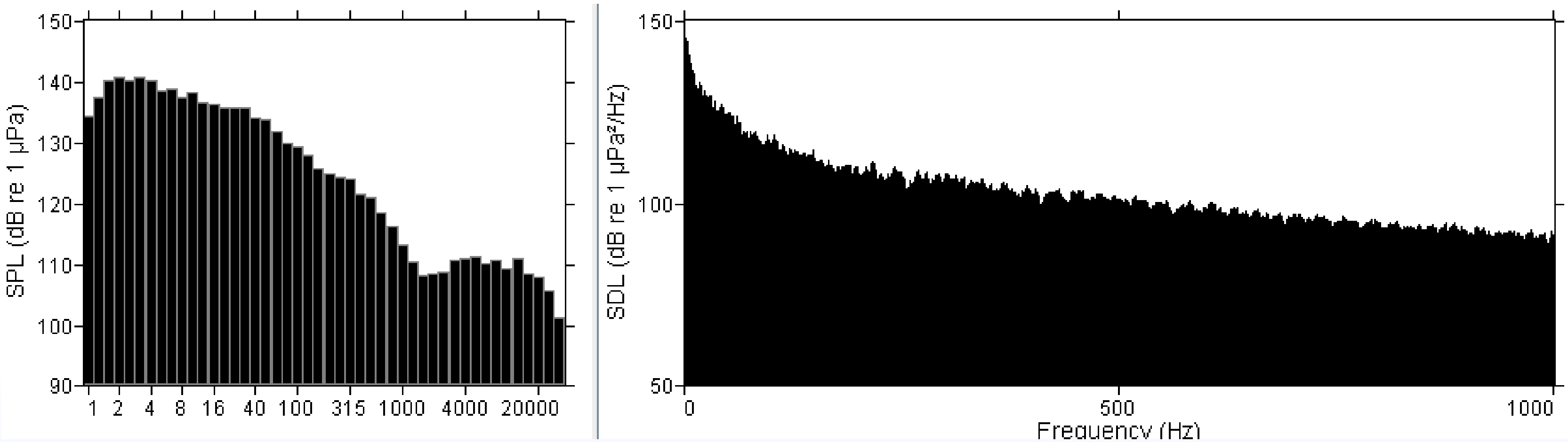


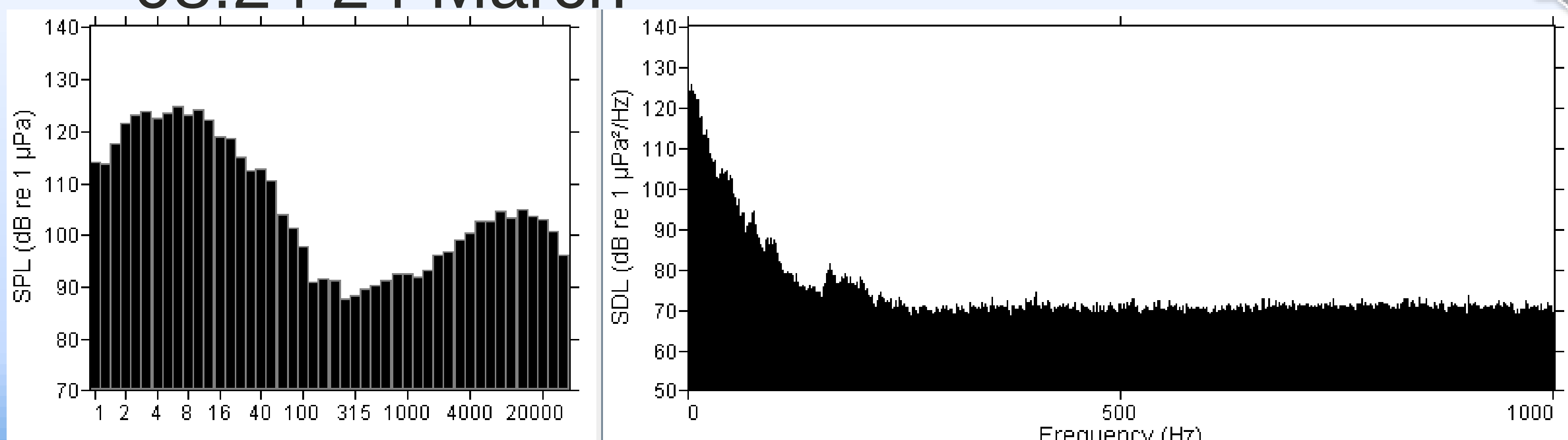

Calculated from 1 second long FFTs, 50% overlap, 30 min data.

# Spectra …

- 02:36 24 March



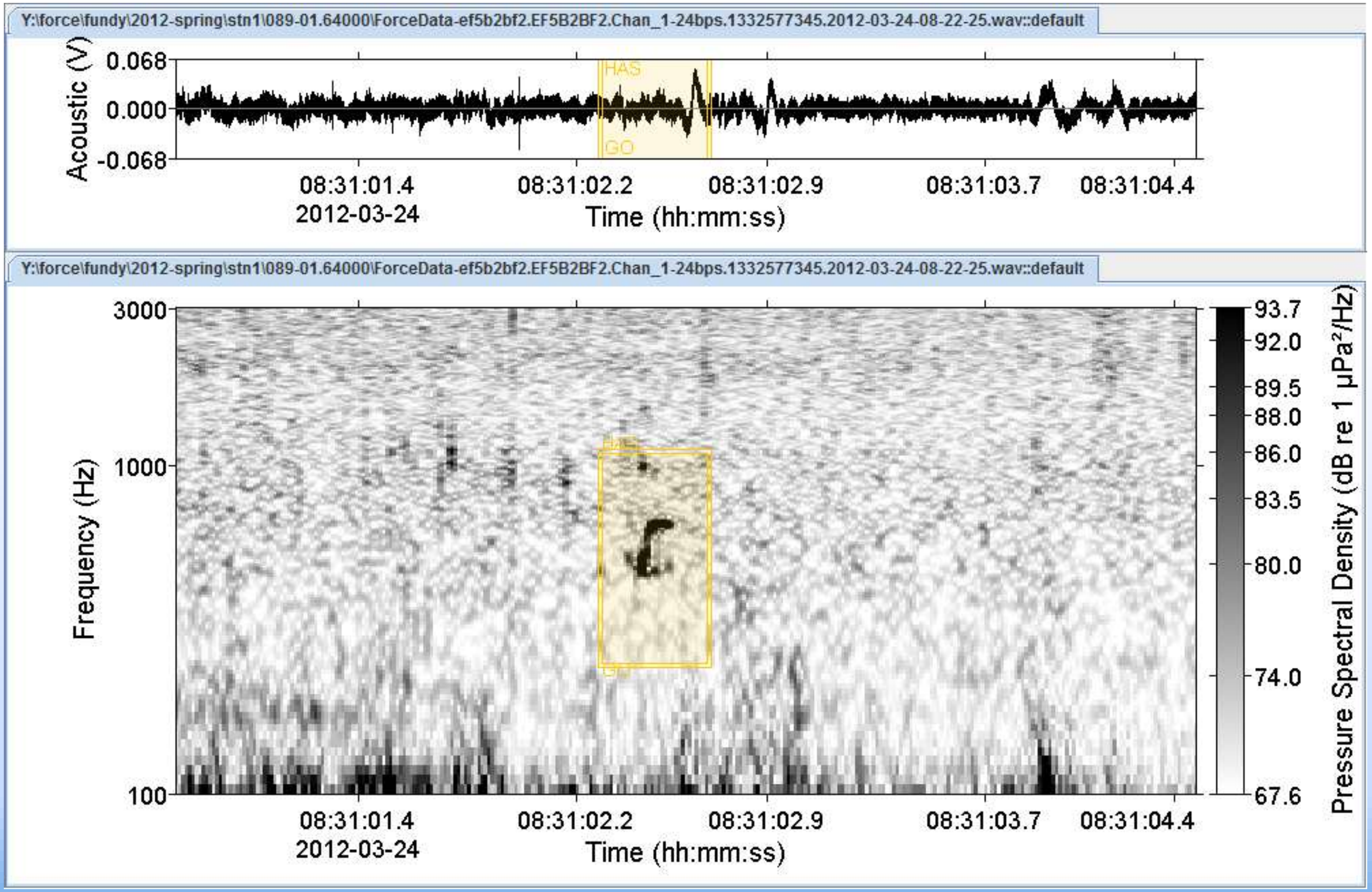

- 08:24 24 March




Calculated from 4 second long FFTs, 50% overlap, 16 averages.

# Possible Seal Vocalization

- Full Flow, 08:31 24 March UTC



# Summary

- Hydrophone noise levels in high flow environments depend on the mooring.
- Drifting hydrophones have the lowest noise, but only provide instantaneous measurements and are prone to fouling.
- The high-flow mooring proposed here minimizes flow noise and allows accurate long-term measurements of the soundscape.

# Questions