Drifting acoustic measurements of tidal turbine radiated noise in an urban waterway

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PMEC
Pacific Marine Energy Center

UAF
UNIVERSITY OF ALASKA FAIRBANKS

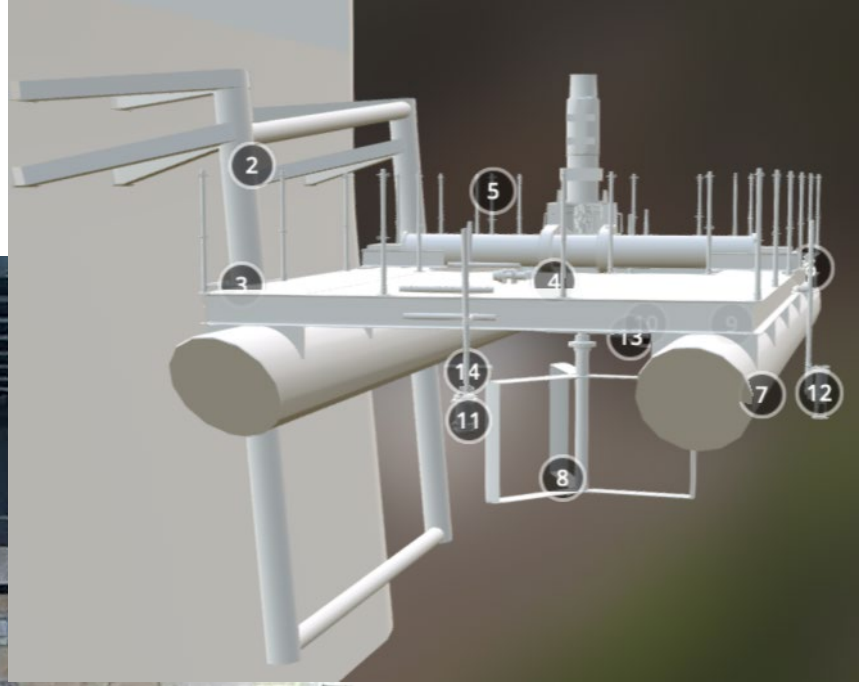
Oregon State University

UNIVERSITY of WASHINGTON

Portsmouth,
NH
95
Kittery
Memorial Bridge
Portsmouth
New Castle
NEW HAMPSHIRE
95

Living Bridge
Memorial Bridge
Piscataqua River
Kittery
Piscataqua River
Portsmouth

New Energy
Cross-flow turbine

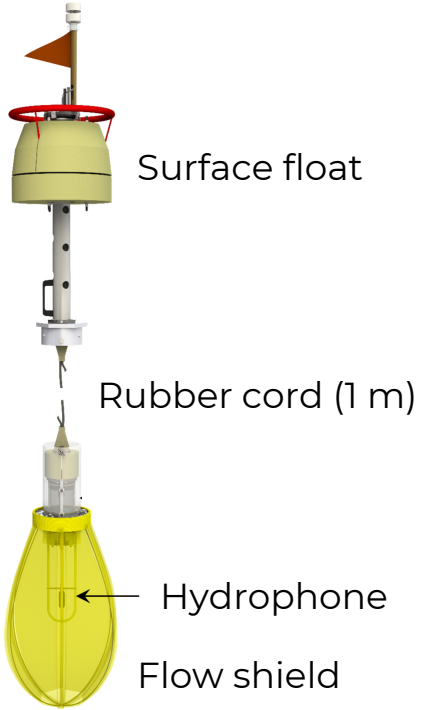


Images courtesy of
https://livingbridge.unh.edu/

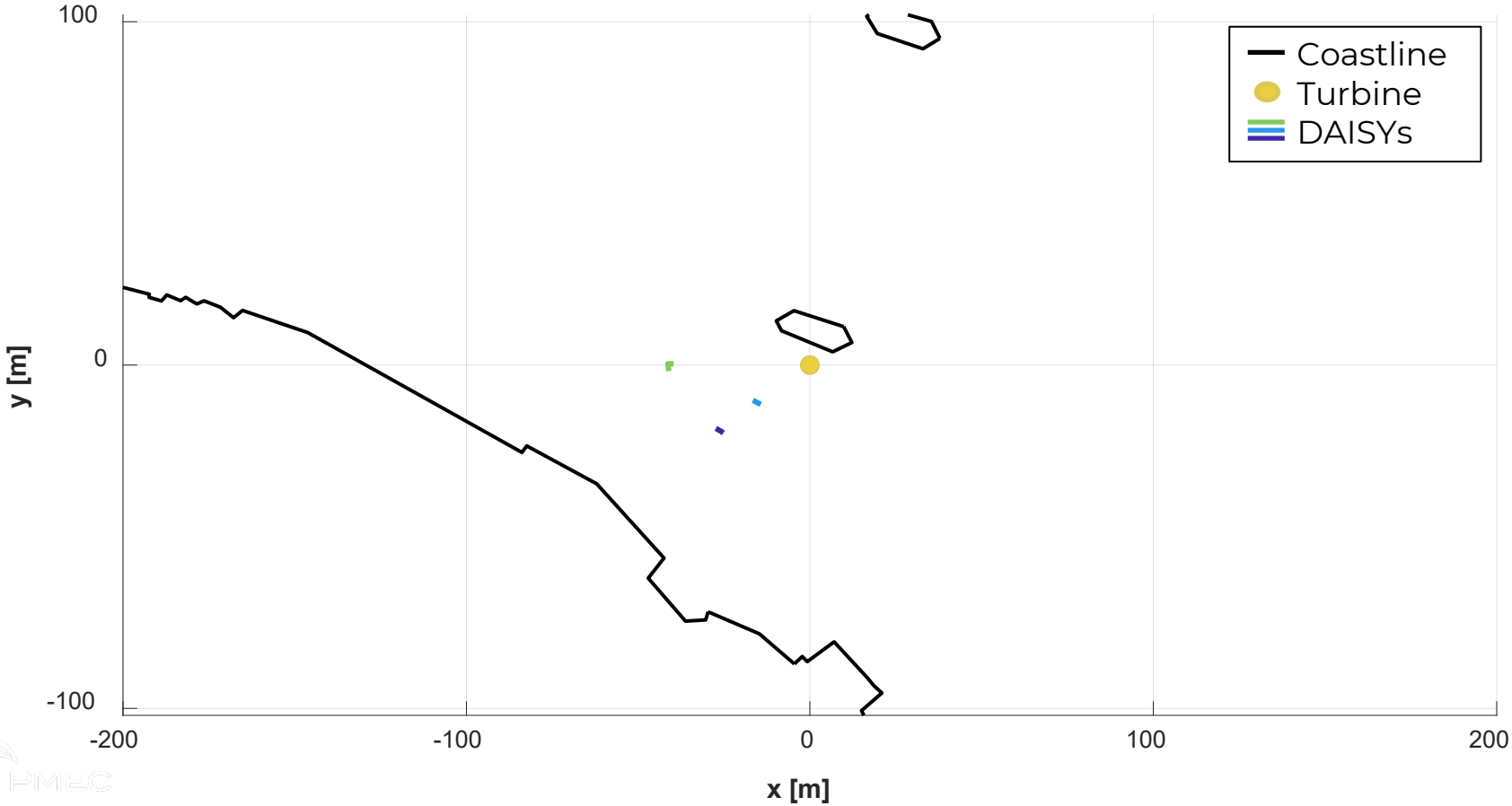
Goals

1. Measure noise from turbine
2. Evaluate potential for localization
3. Refine methodology (IEC TS 62600-40:2019)

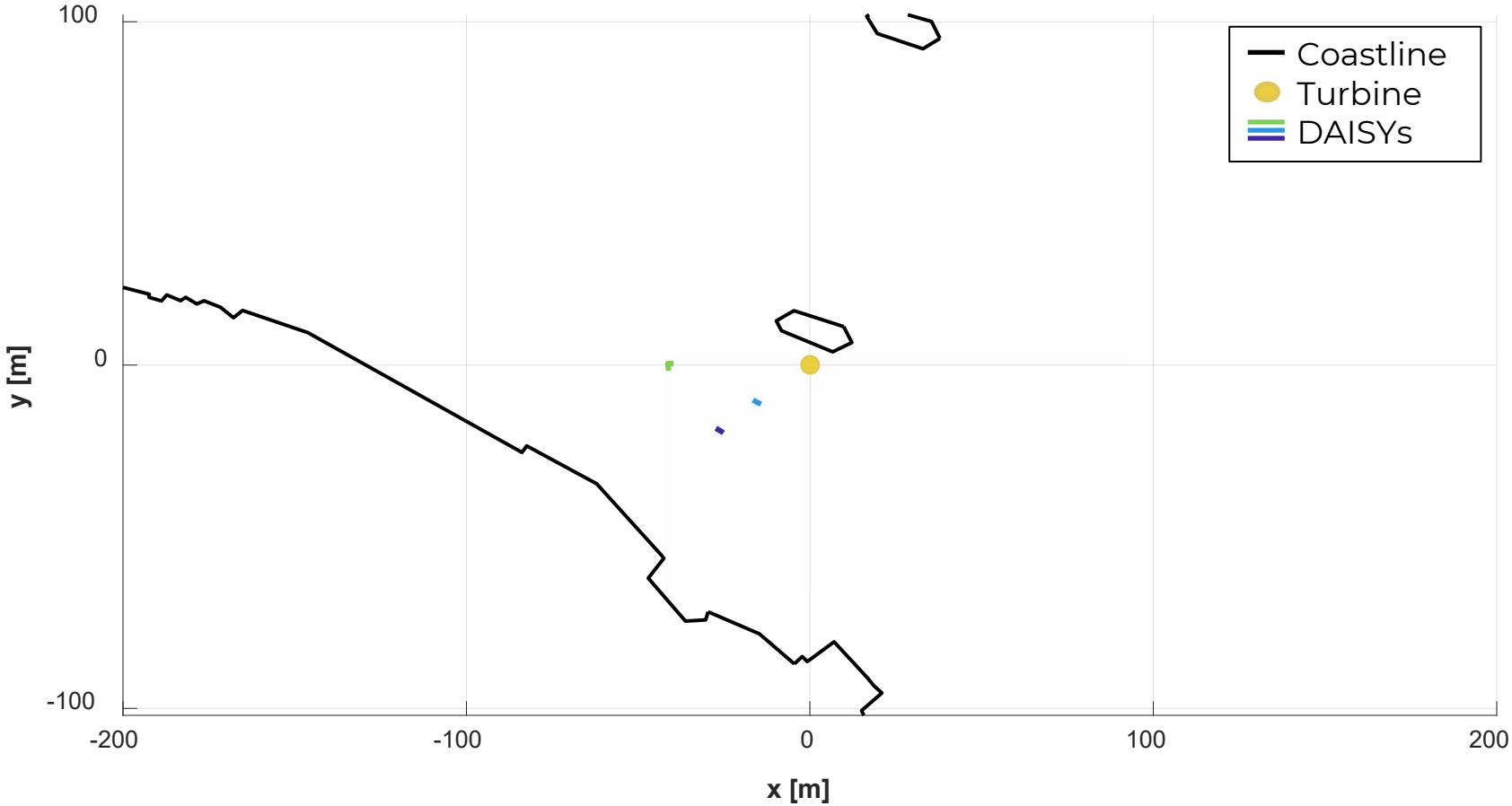
Drifting **A**coustic **I**nstrumentation **SY**stem



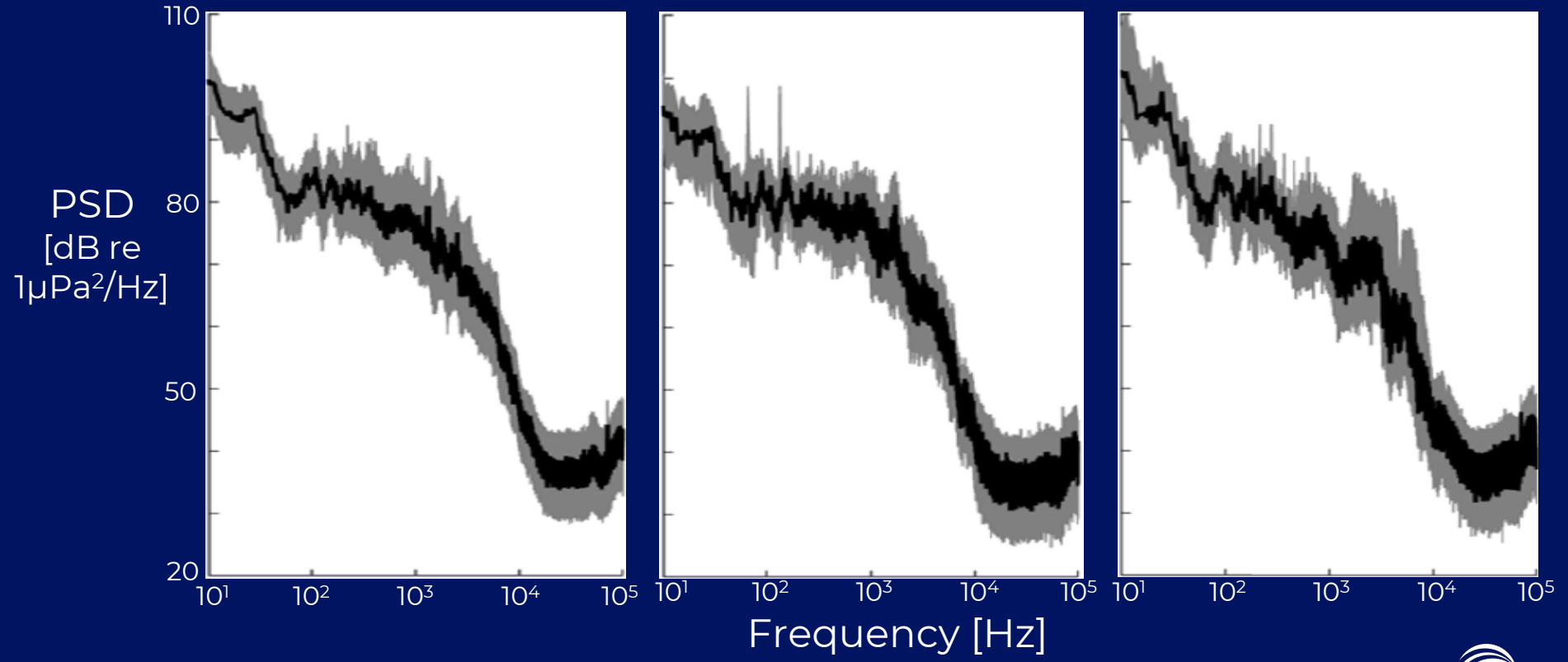
Deployment



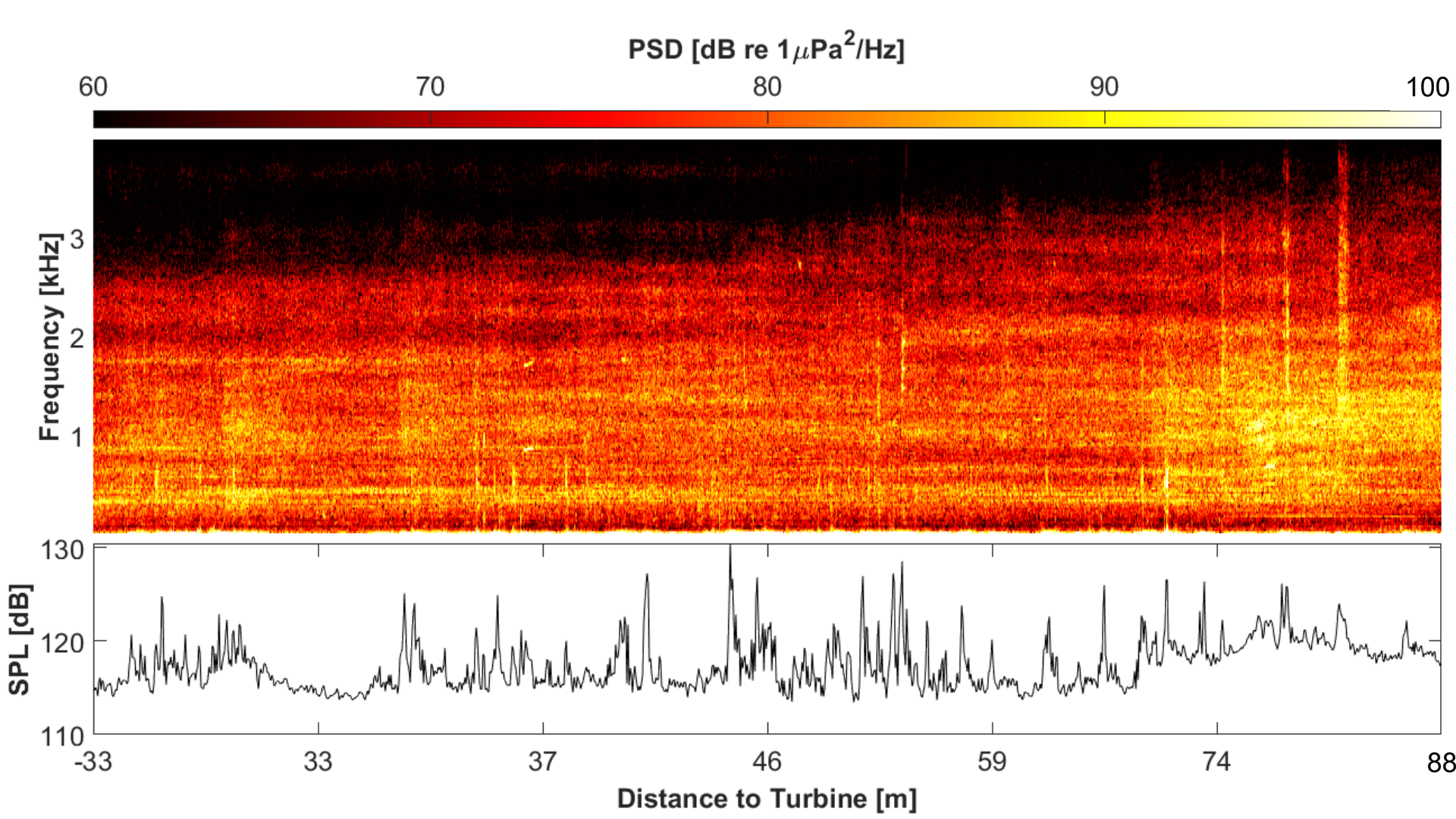
Deployment

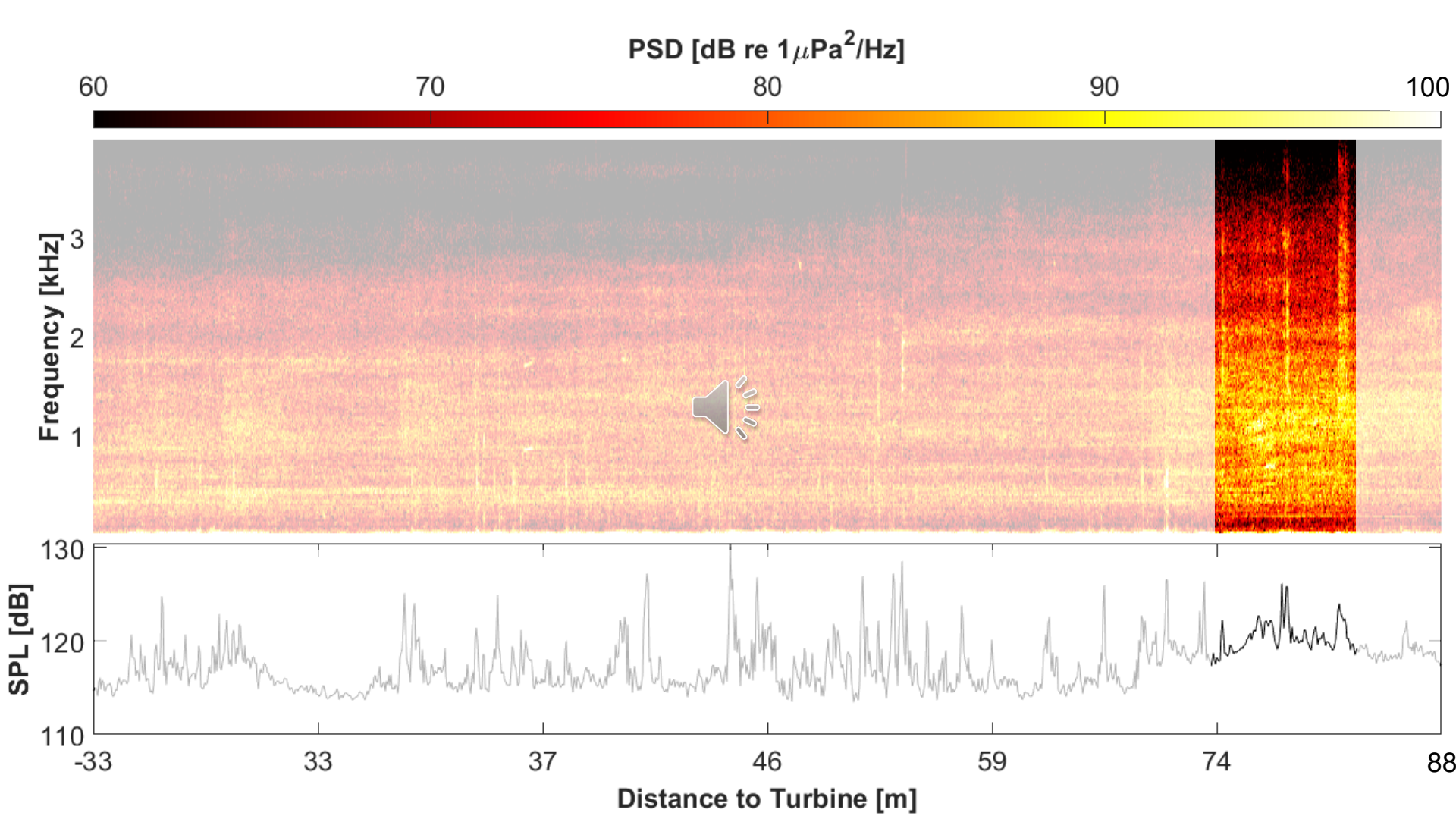


PNNL results



Haxel et al. (2022)


PSD [dB re 1μPa^2/Hz]
60
70
80
90
100
Frequency [kHz]
3
2
1
SPL [dB]
130
120
110
-33
33
37
46
59
74
88
Distance to Turbine [m]


PSD [dB re 1μPa^2/Hz]
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Frequency [kHz]
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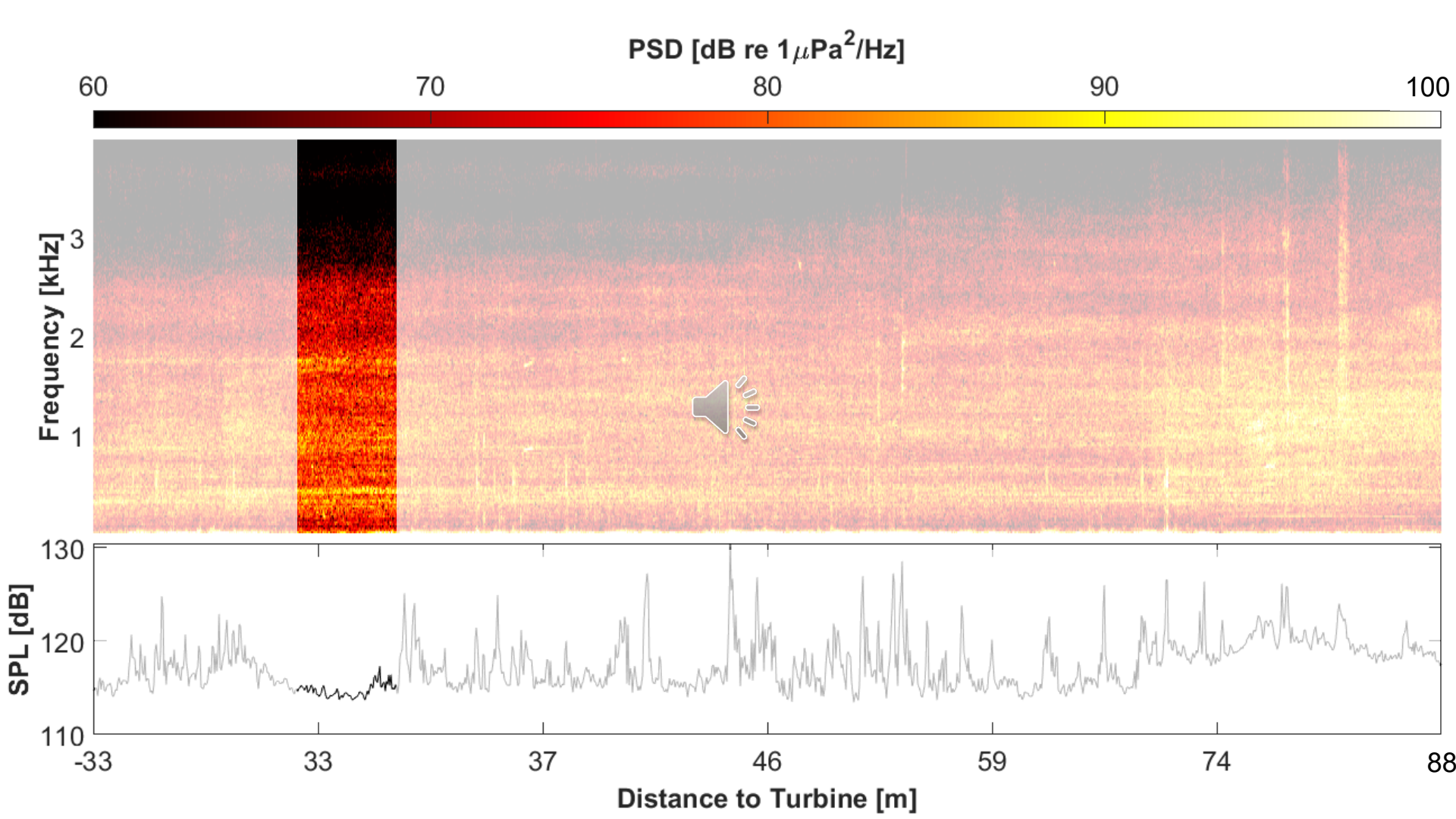
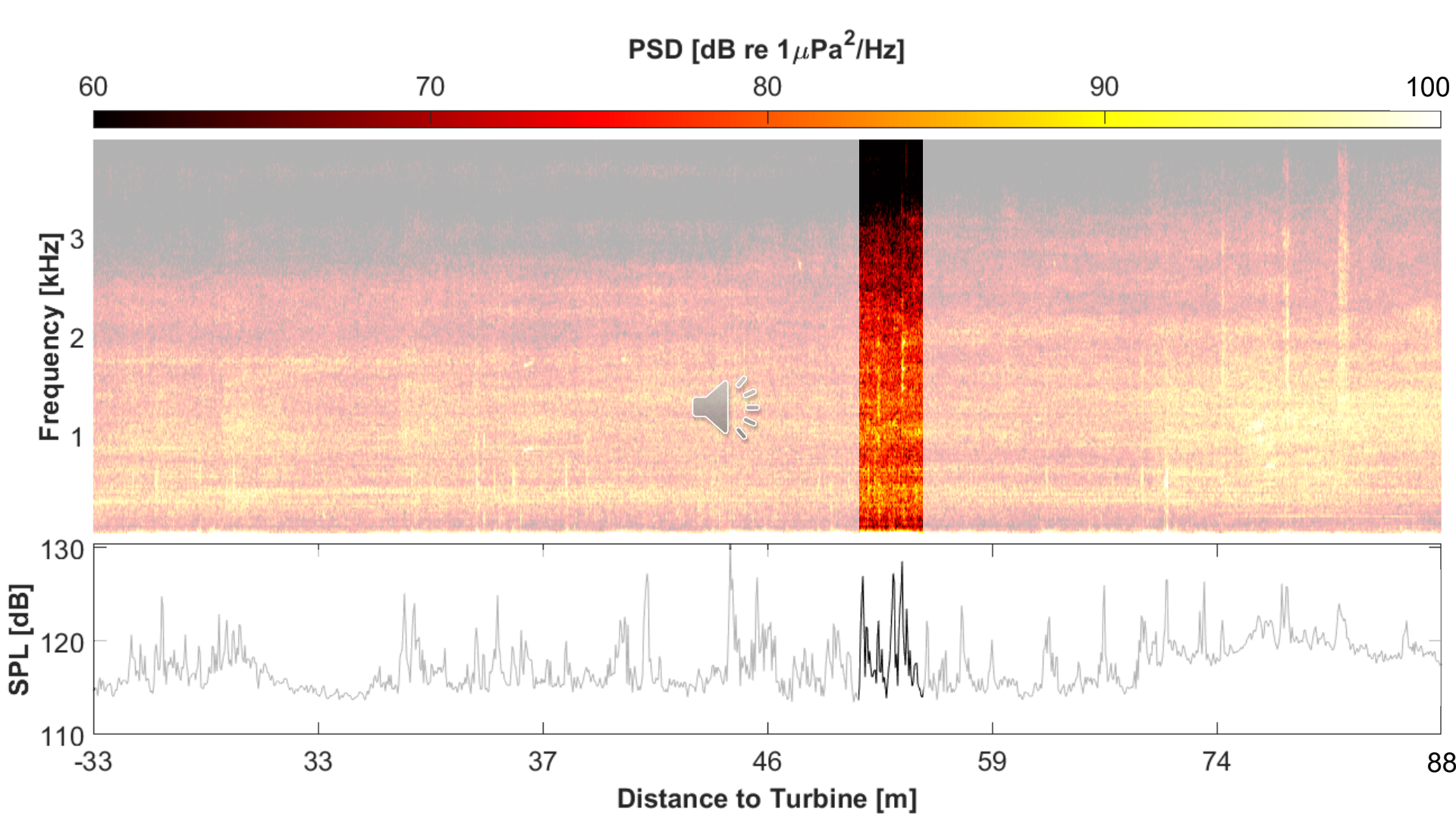
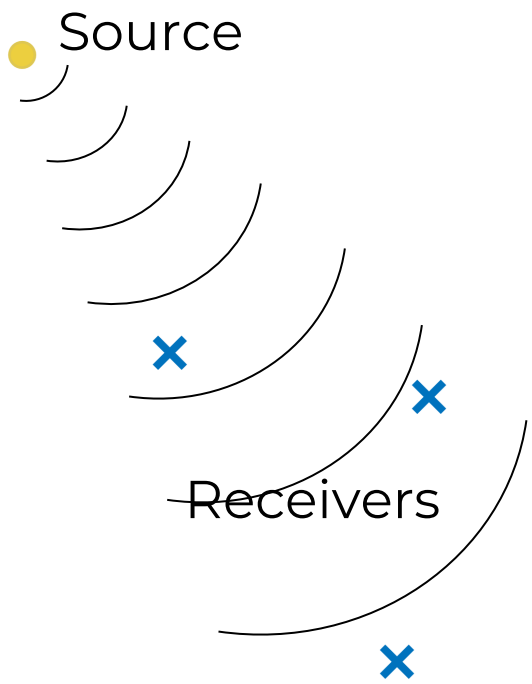
Distance to Turbine [m]

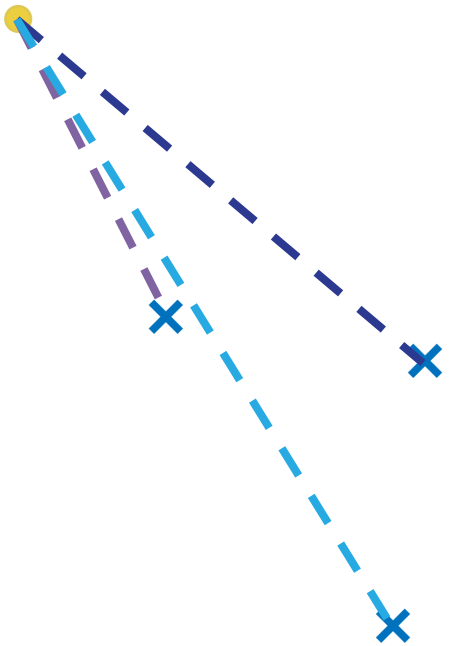

PSD [dB re 1μPa^2/Hz]
60
70
80
90
100
Frequency [kHz]
3
2
1
SPL [dB]
130
120
110
-33
33
37
46
59
74
88
Distance to Turbine [m]


PSD [dB re 1μPa^2/Hz]
60
70
80
90
100
Frequency [kHz]
3
2
1
SPL [dB]
130
120
110
-33
33
37
46
59
74
88
Distance to Turbine [m]

Localization: Time Delay of Arrival

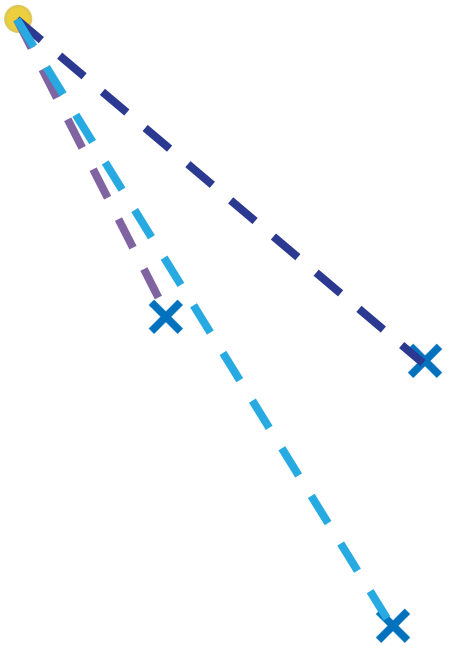


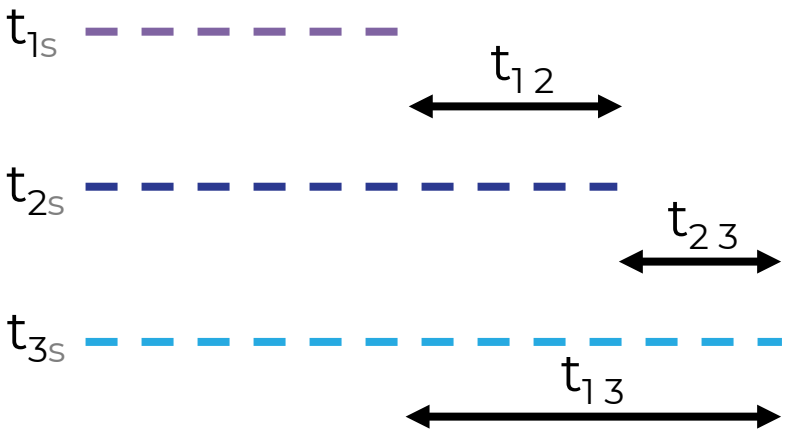
Localization: Time Delay of Arrival



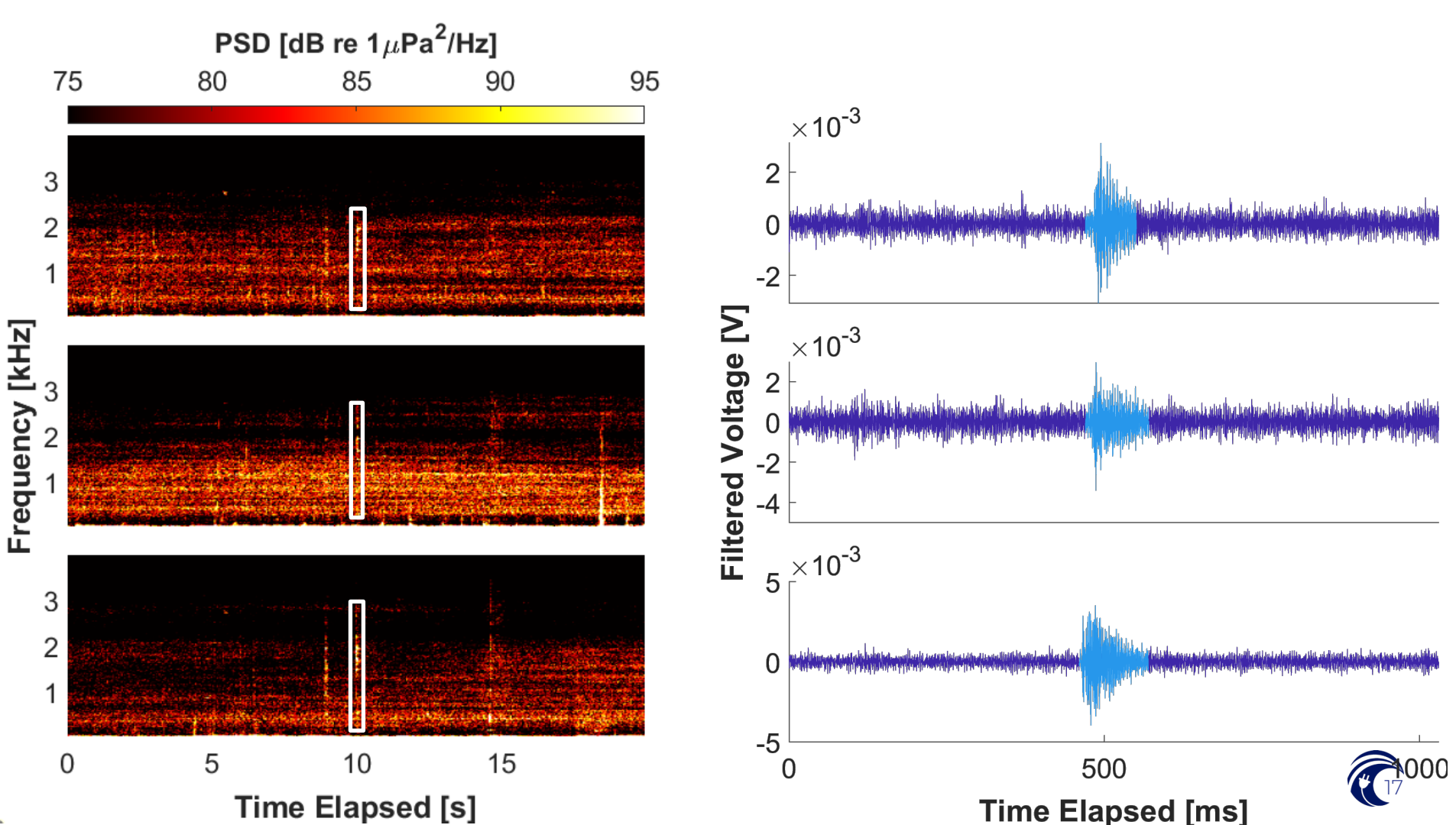
Based on Sayed et al. (2005)

Localization: Time Delay of Arrival

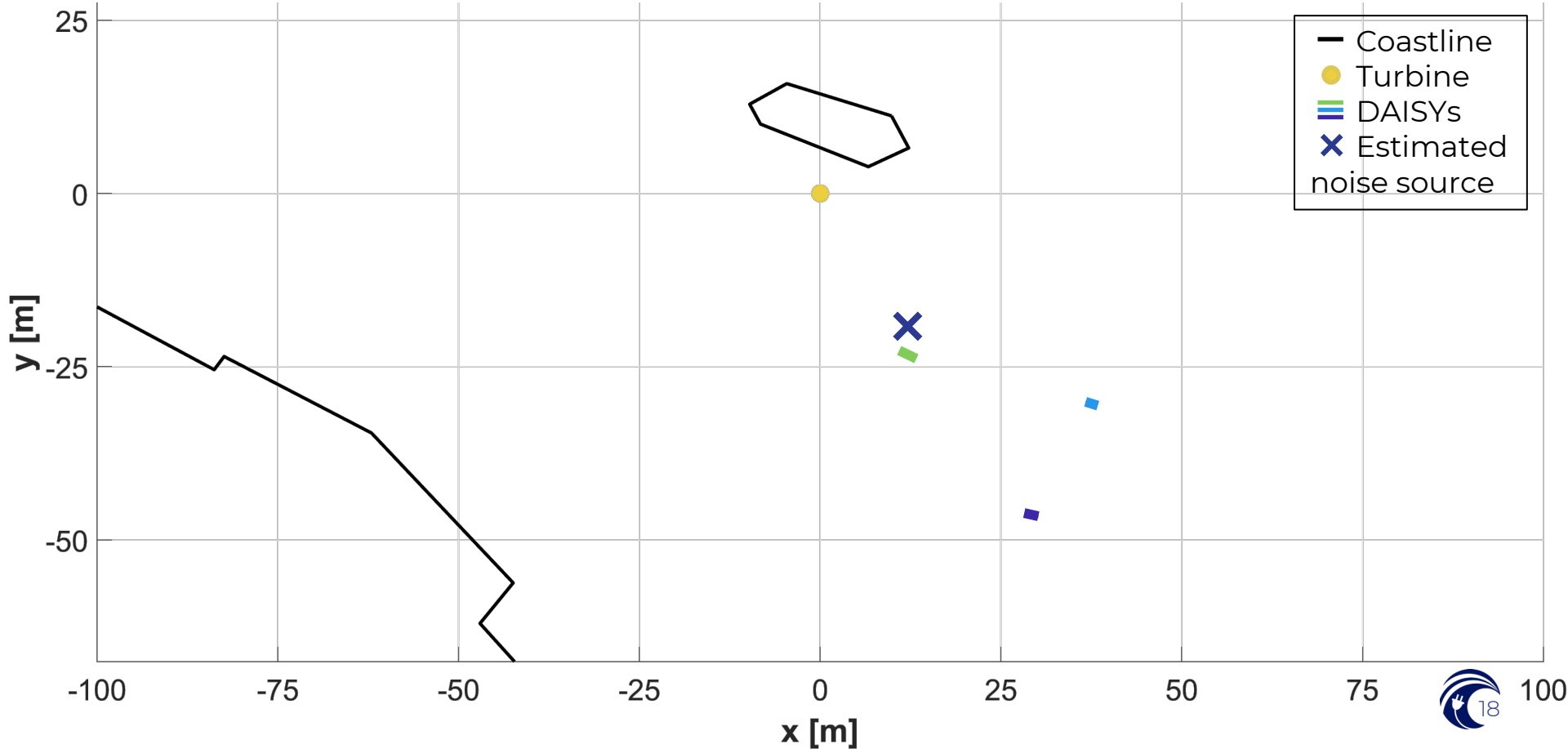




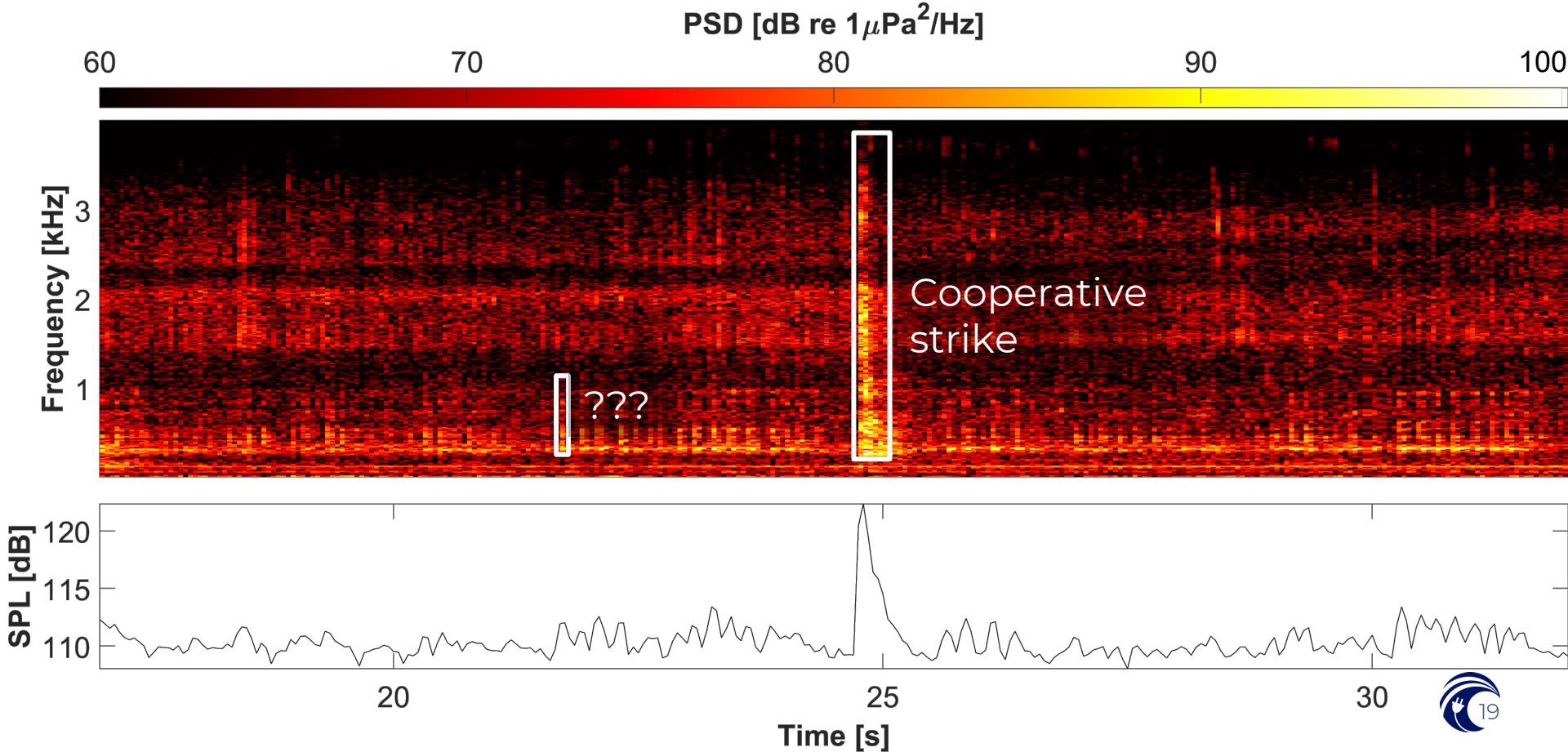
Based on Sayed et al. (2005)


PSD [dB re 1 μPa^2/Hz]
75
80
85
90
95
Frequency [kHz]
3
2
1
0
5
10
15
Time Elapsed [s]
Filtered Voltage [V]
$\times 10^{-3}$
2
0
-2
-4
-5
500
1000
Time Elapsed [ms]

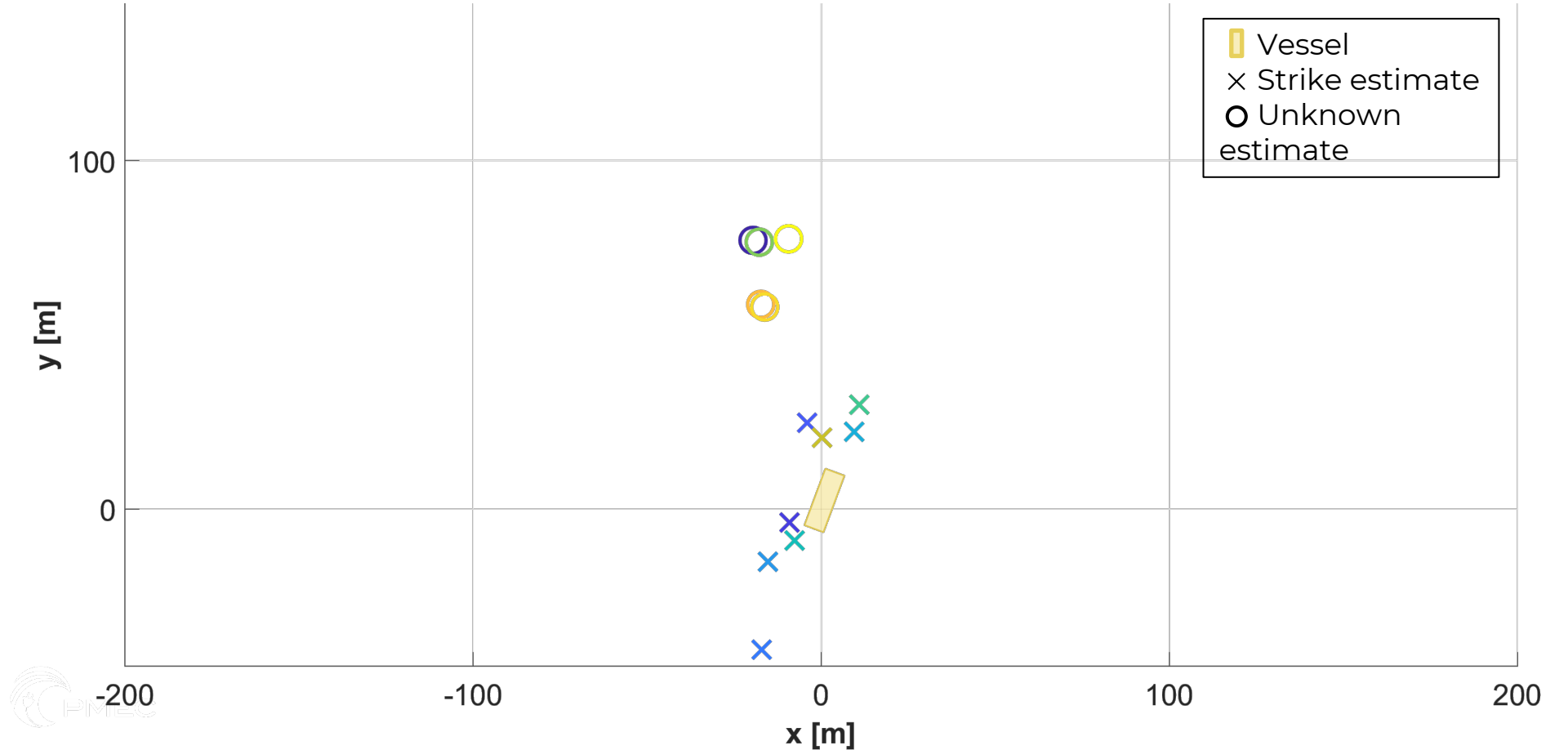
Localization Results Example



Agate Pass, WA. April 2022



Agate Pass, WA. April 2022



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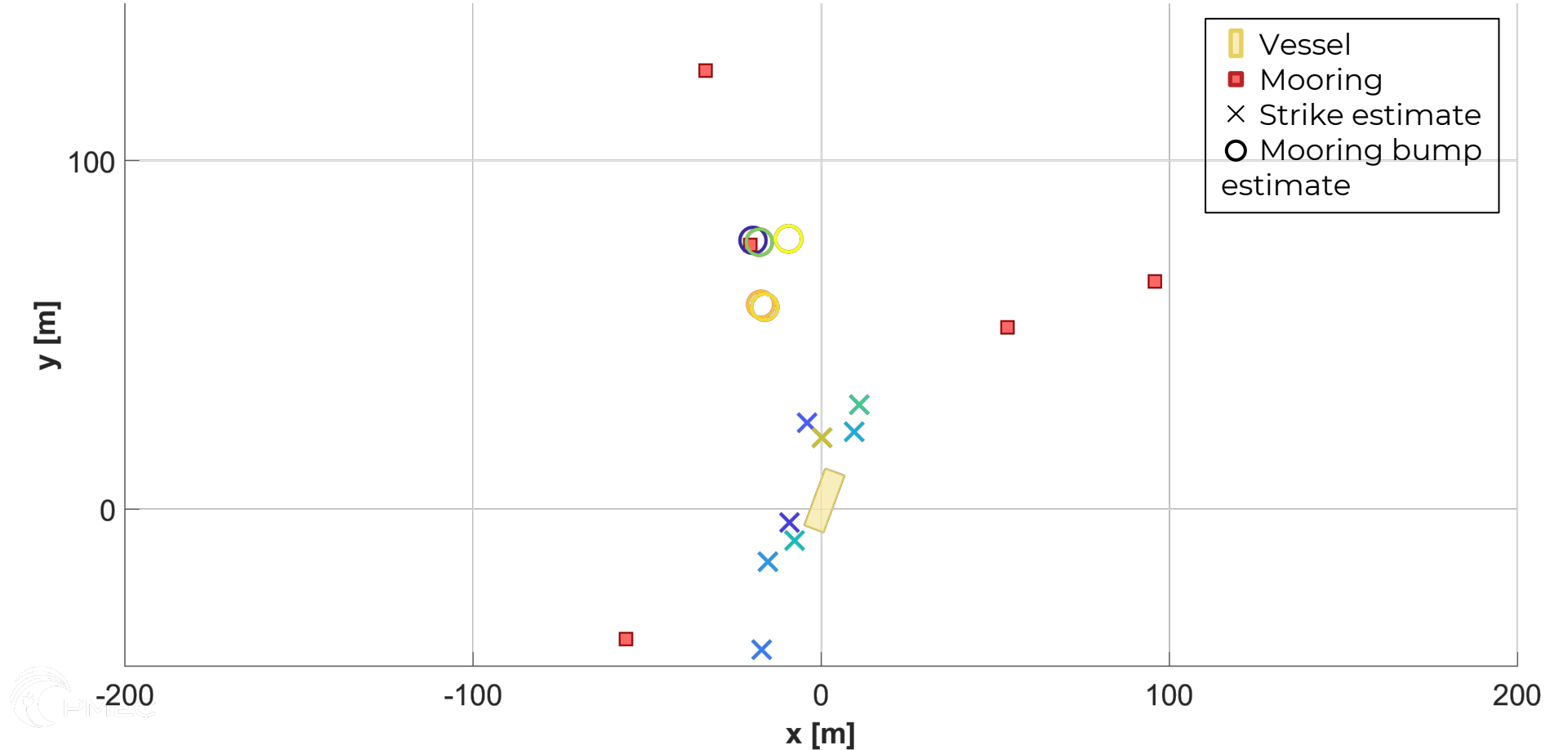

Acknowledgements

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Questions?

Citations

- University of New Hampshire. (n.d.). *Turbine Deployment Platform Interactive Model*. Portsmouth Memorial Bridge: The The Living Bridge. Retrieved July 10, 2022, from https://livingbridge.unh.edu/bridge-models/interactive-models/interactive-model-platform/
- Haxel, J., Zang, X., Martinez, J., Polagye, B., Staines, G., Deng, Z. D., Wosnik M., & O'Byrne, P. (2022). Underwater Noise Measurements around a Tidal Turbine in a Busy Port Setting. *Journal of Marine Science and Engineering*, *10*(5), 632.
- Sayed, A. H., Tarighat, A., & Khajehnouri, N. (2005). Network-based wireless location: challenges faced in developing techniques for accurate wireless location information. *IEEE signal processing magazine*, *22*(4), 24-40.

Localization equations

$$r_{ij} = (t_i - t_j)c$$

$$\begin{bmatrix} x_s \\ y_s \end{bmatrix} = r_{1s} \begin{bmatrix} x_2 & y_2 \\ x_3 & y_3 \end{bmatrix}^{-1} + \begin{bmatrix} -r_{21} \\ -r_{31} \end{bmatrix} + \begin{bmatrix} x_2 & y_2 \\ x_3 & y_3 \end{bmatrix}^{-1} + \frac{1}{2} \begin{bmatrix} {x_2}^2 + {y_2}^2 - r_{21}^2 \\ {x_3}^2 + {y_3}^2 - r_{31}^2 \end{bmatrix}$$

$$r_{ij} = r_{is} - r_{js} = \sqrt{(x_i - x_s)^2 + (y_i - y_s)^2} - \sqrt{(x_j - x_s)^2 + (y_j - y_s)^2}$$