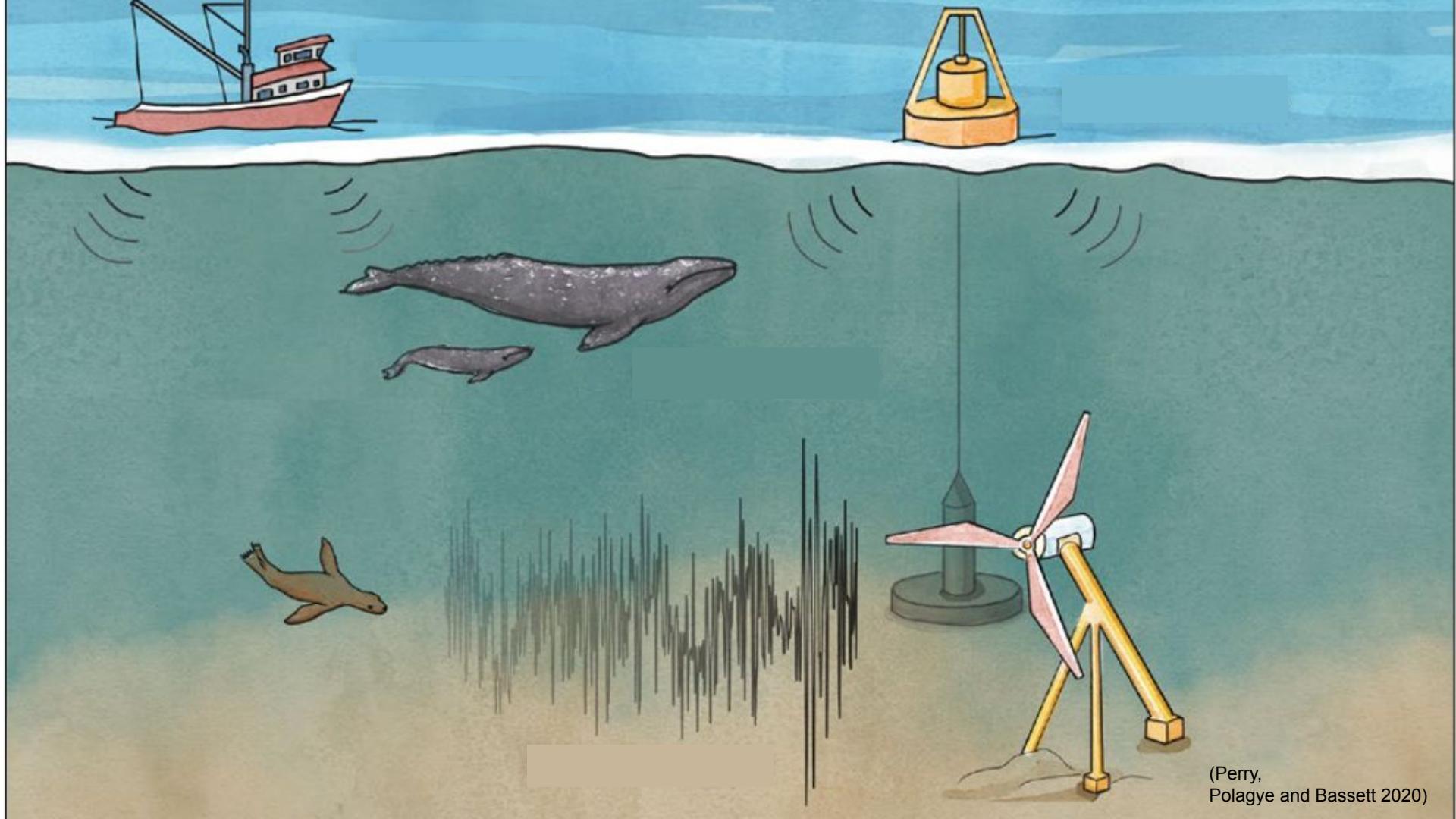


# Influence of powertrain components on noise from a pair of cross-flow turbines

**Lindsey Jones, Corey Crisp, Gemma  
Calandra, Kathryn Sellers Reynolds,  
Chris Bassett, and Brian Polagye**

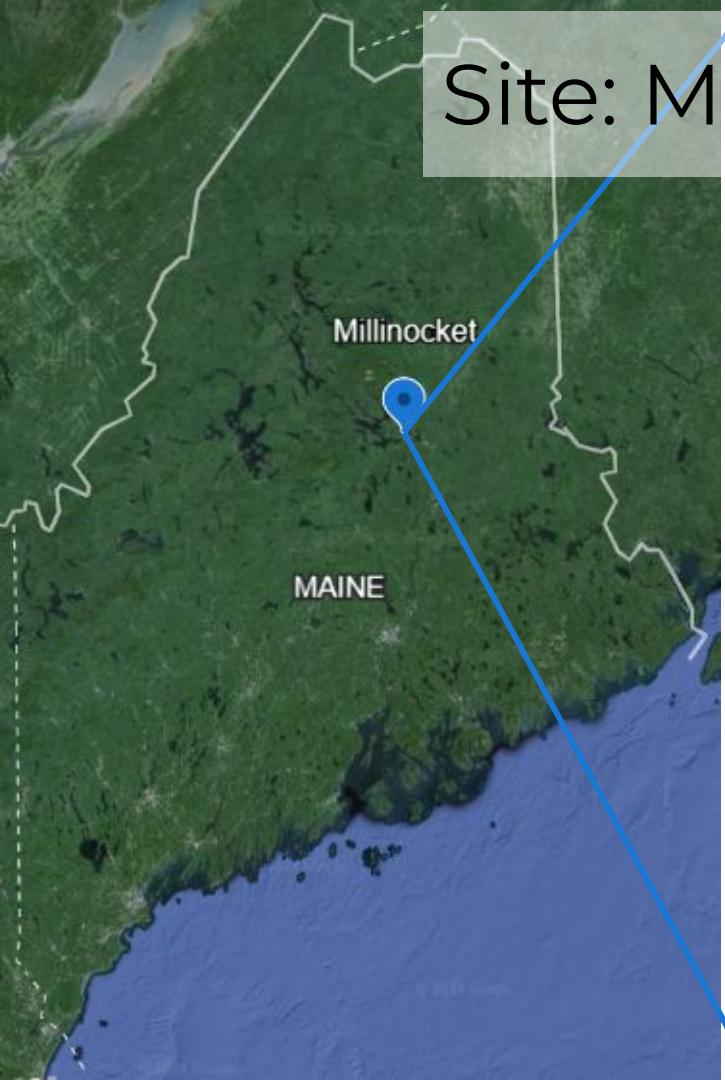




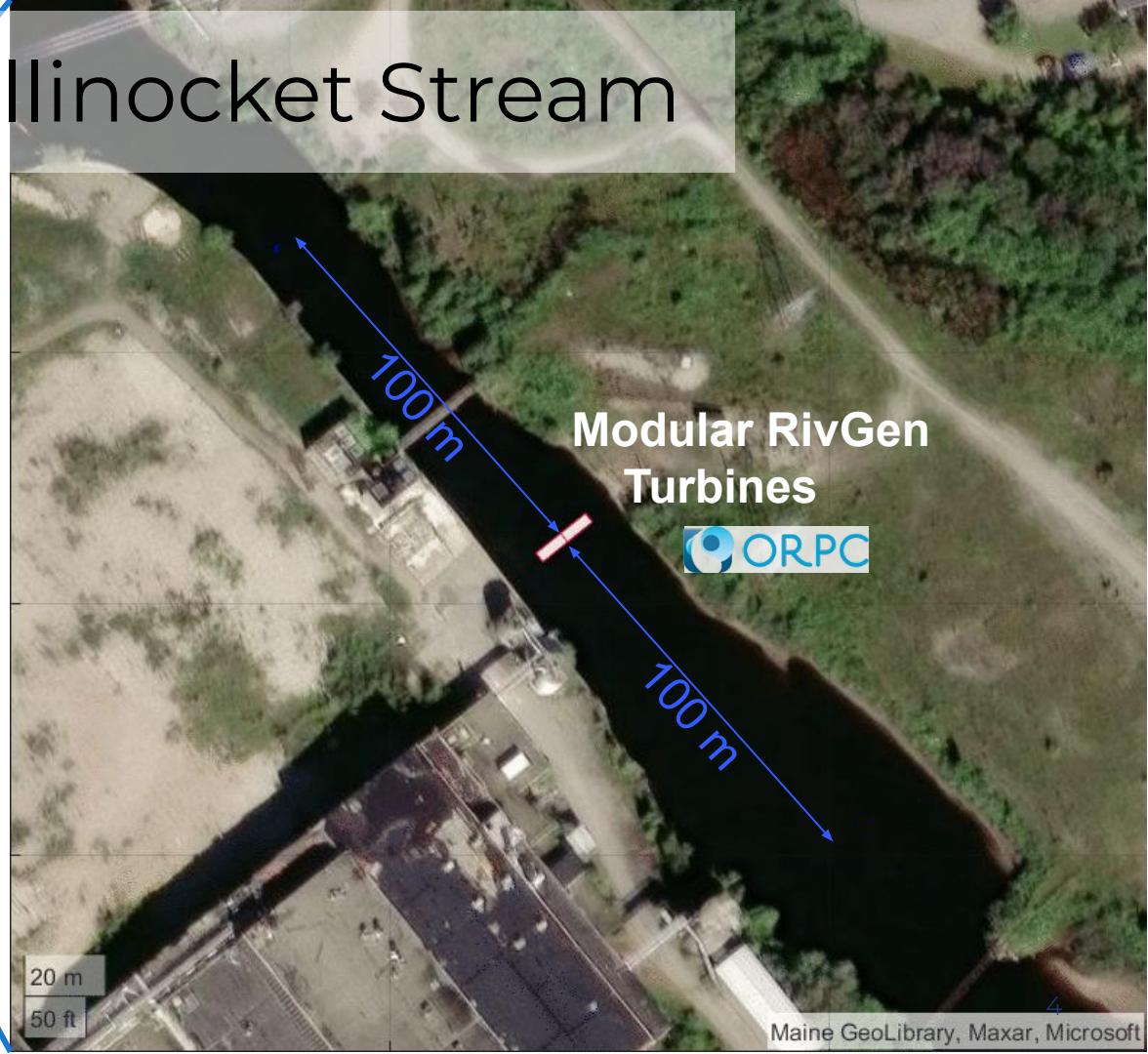
(Perry,  
Polagye and Bassett 2020)

# Presentation Structure

- How we conducted our study
- What sounds we observed and how we attributed them
- Which choices affect sound levels and their spatial distributions



# Site: Millinocket Stream

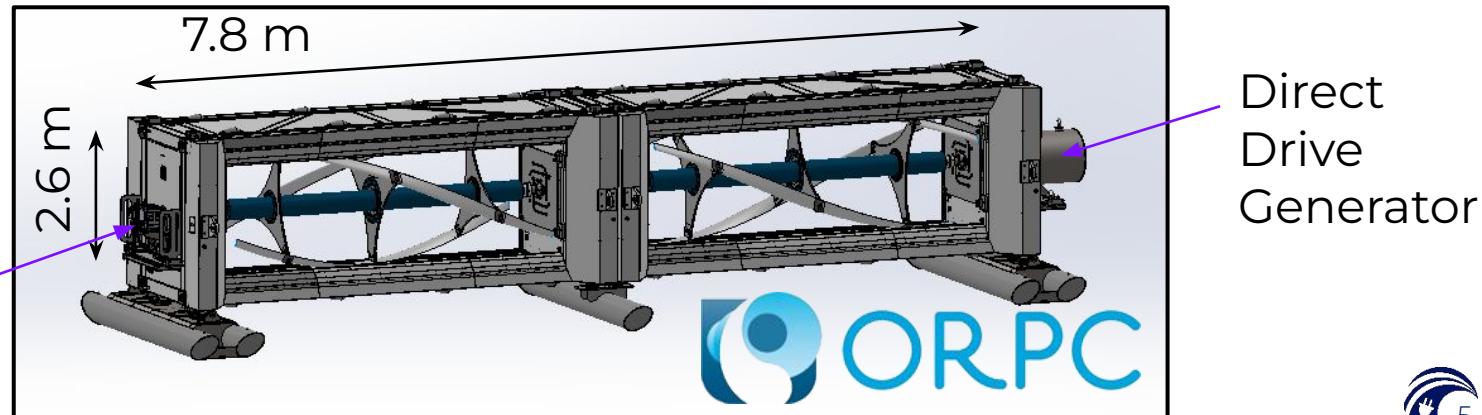


# Turbine Overview

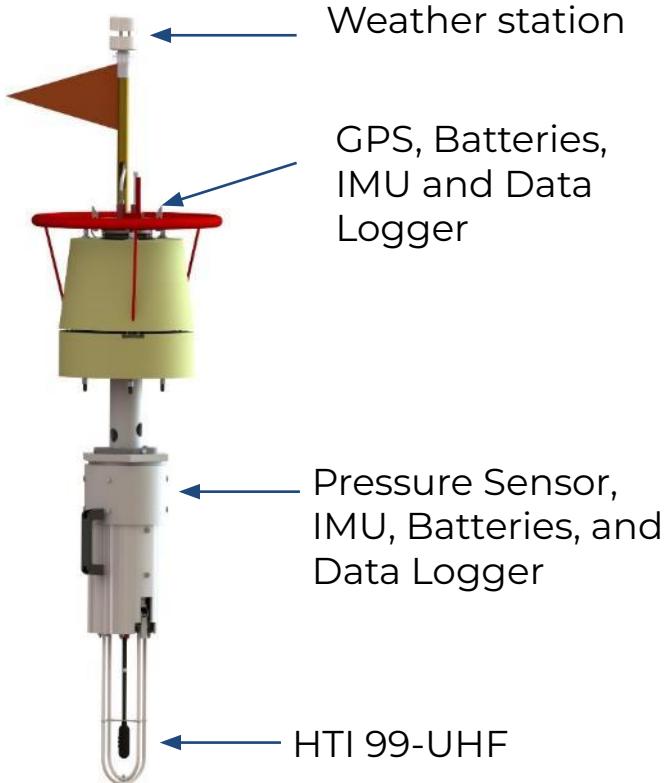


Credit: ORPC

- Ocean Renewable Power Company prototype turbines (“Modular RivGen”)
- Cross-flow (“vertical-axis”) turbine with three foils
- Variable Frequency Drive (VFD) on shore controls torque



# “Shallow” DAISY



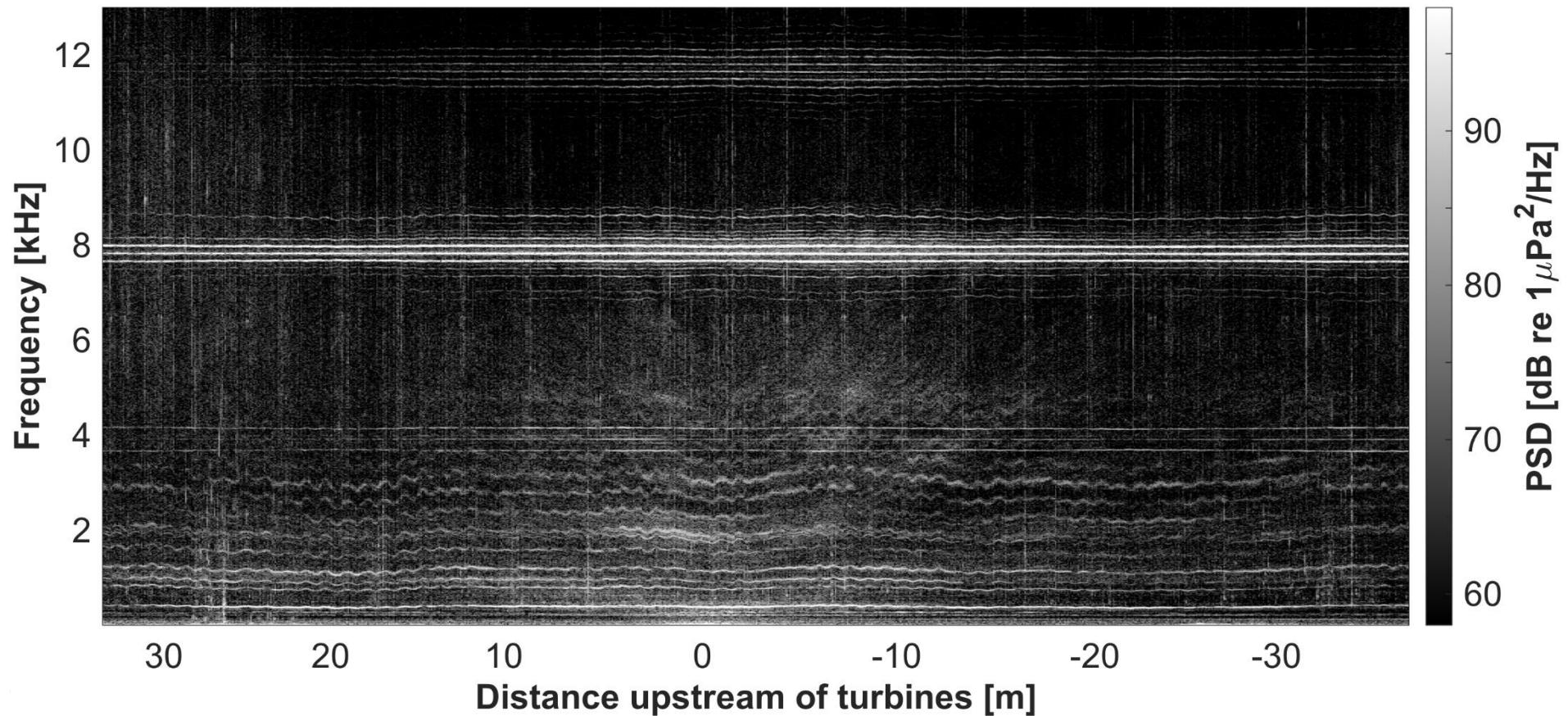
*Credit: Corey Crisp*



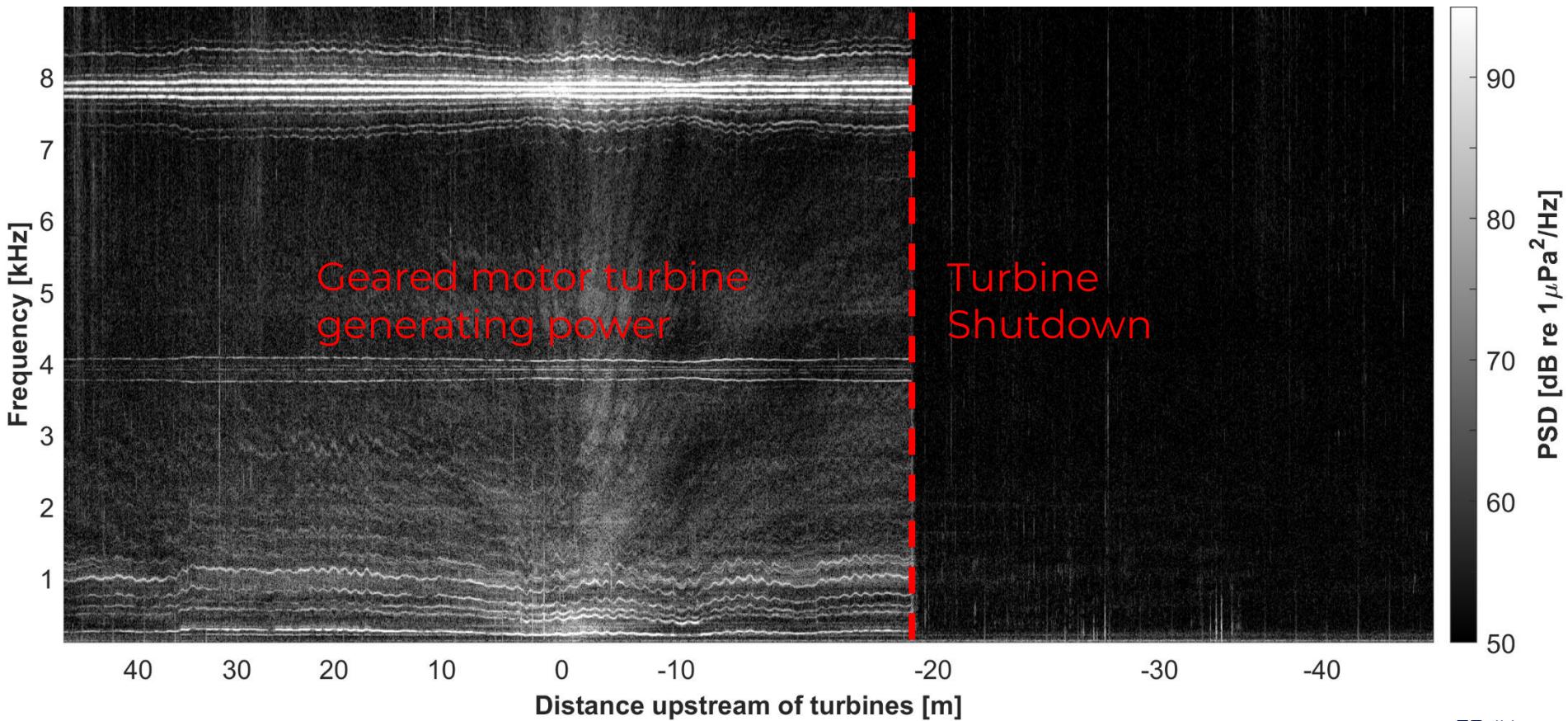
# DAISY Deployments



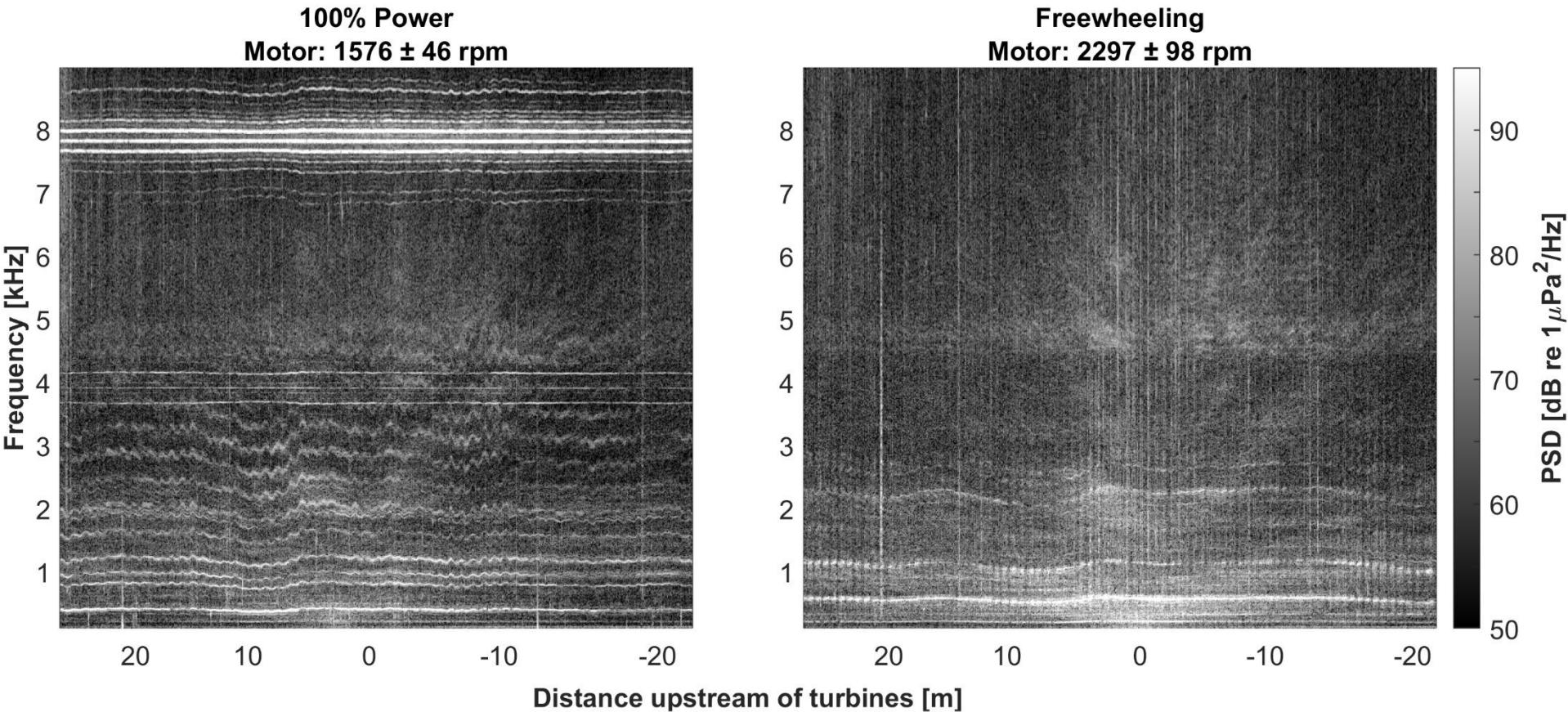
# Radiated Noise Drivers



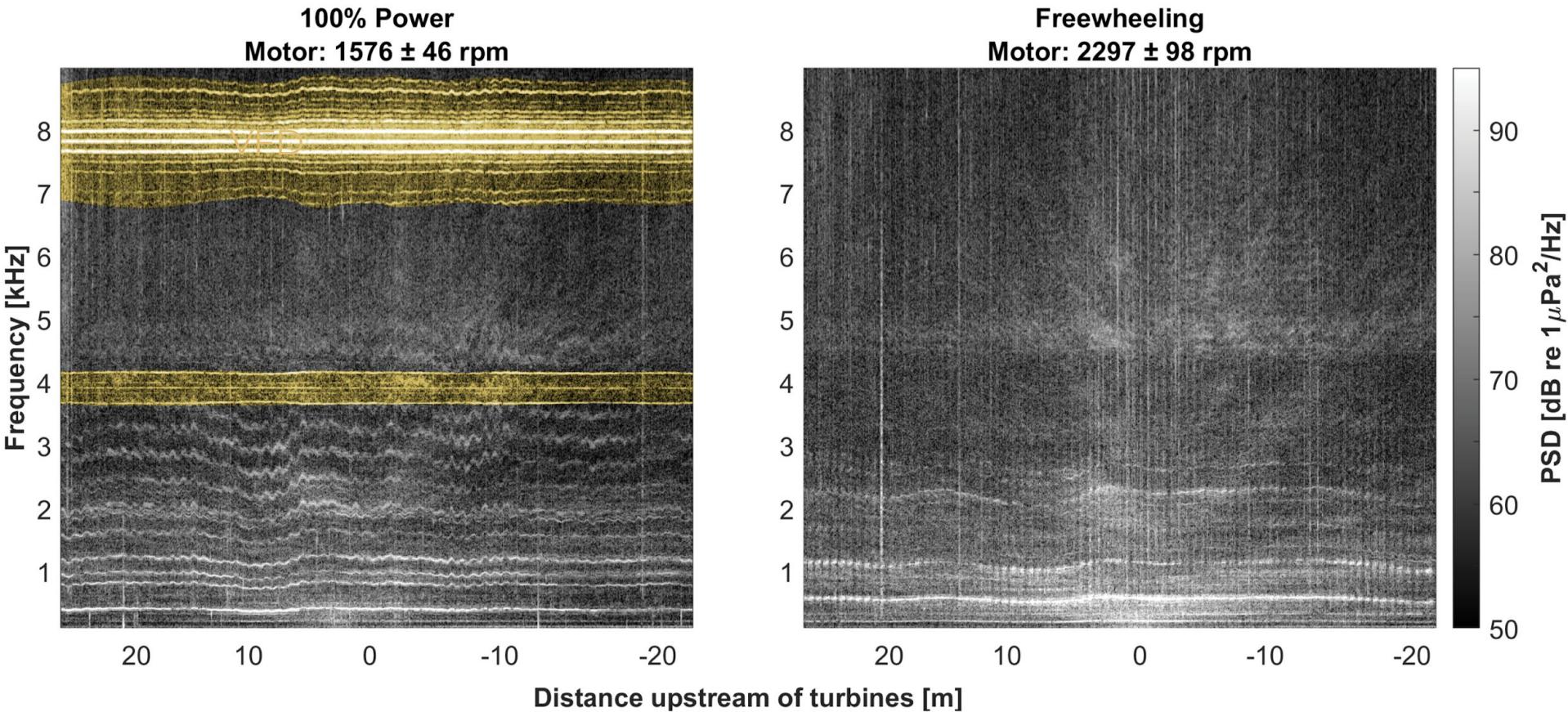
# Turbine Remote Control/Variation



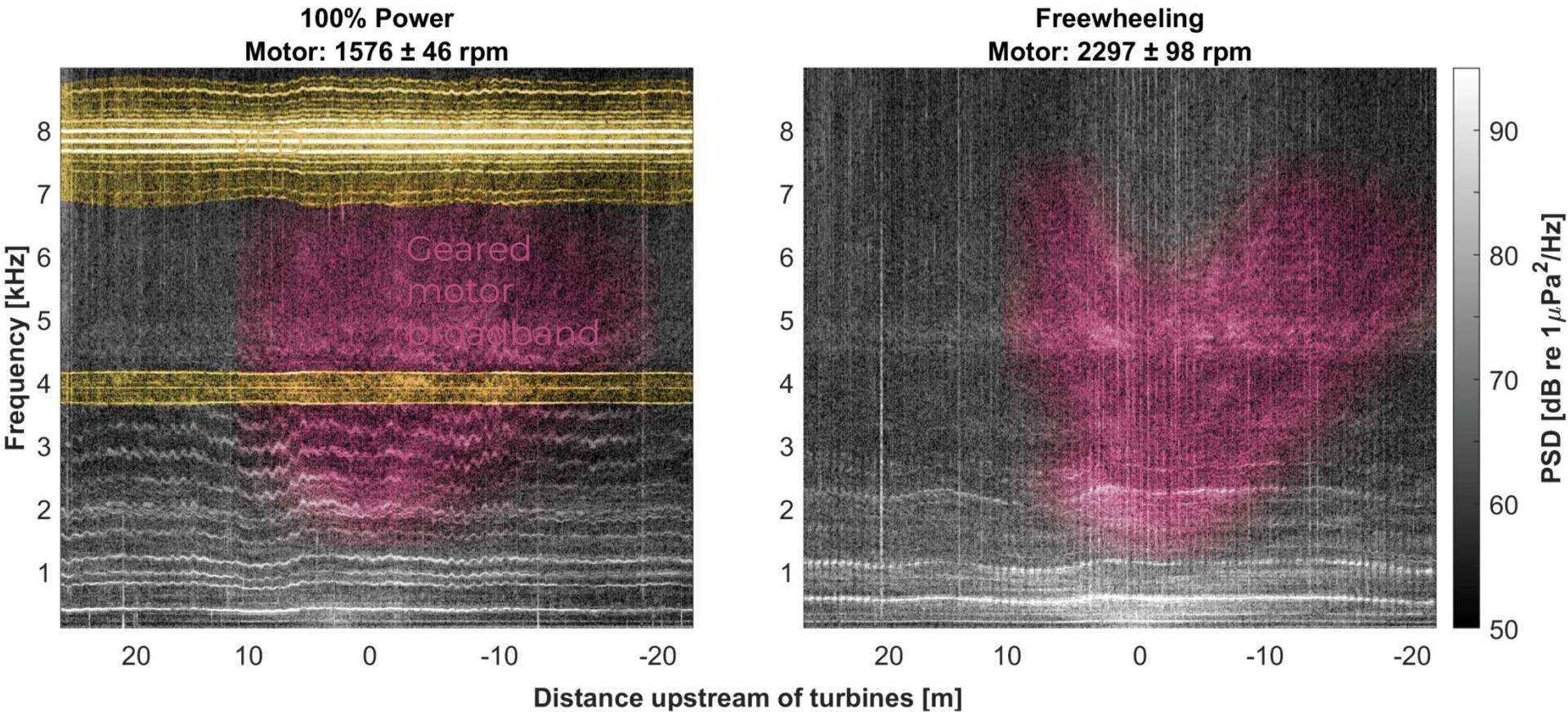
# Geared Motor Comparison



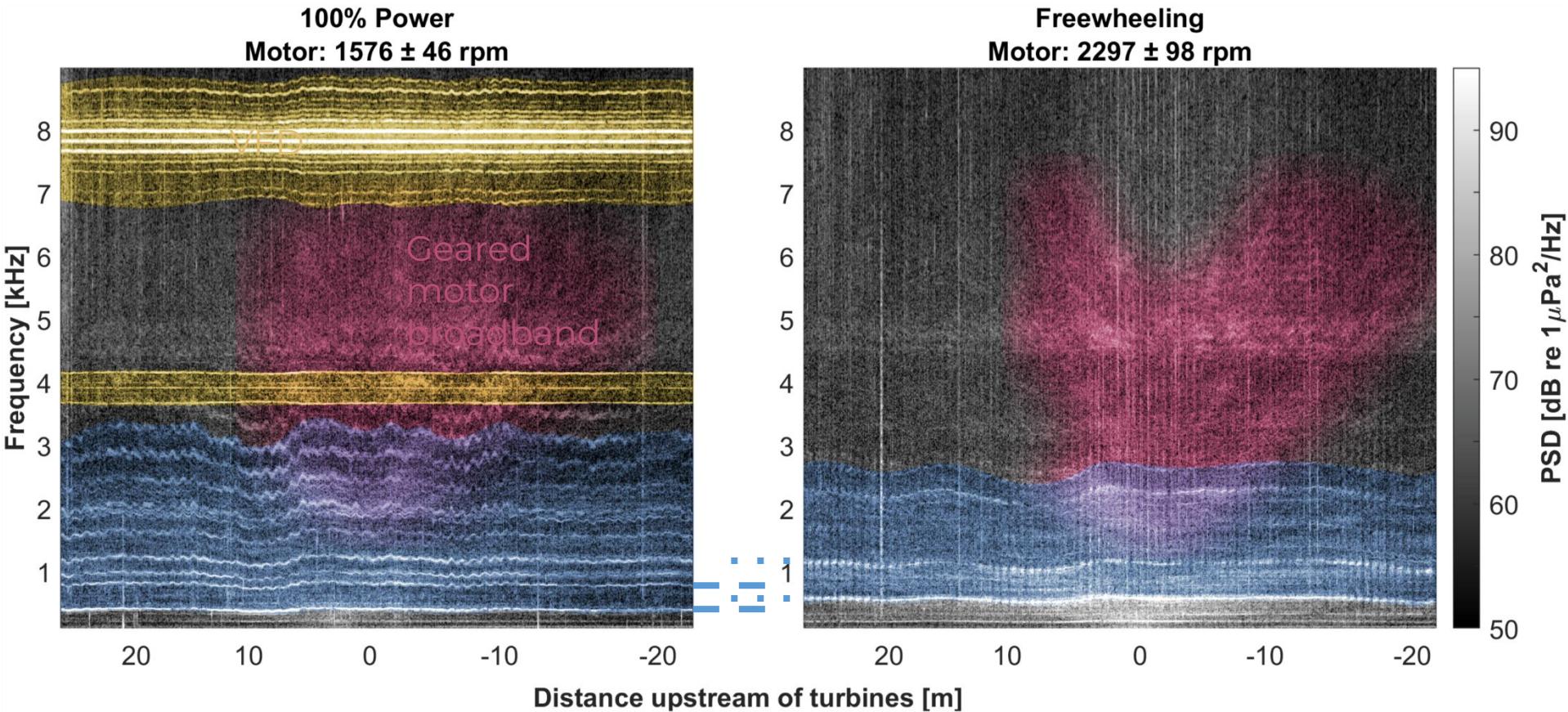
# Geared Motor Comparison



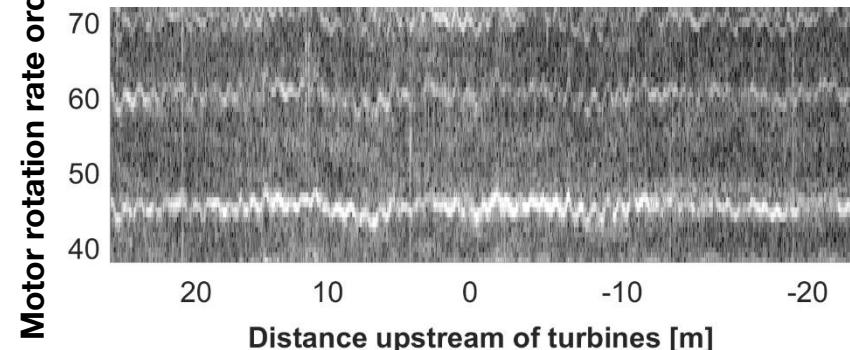
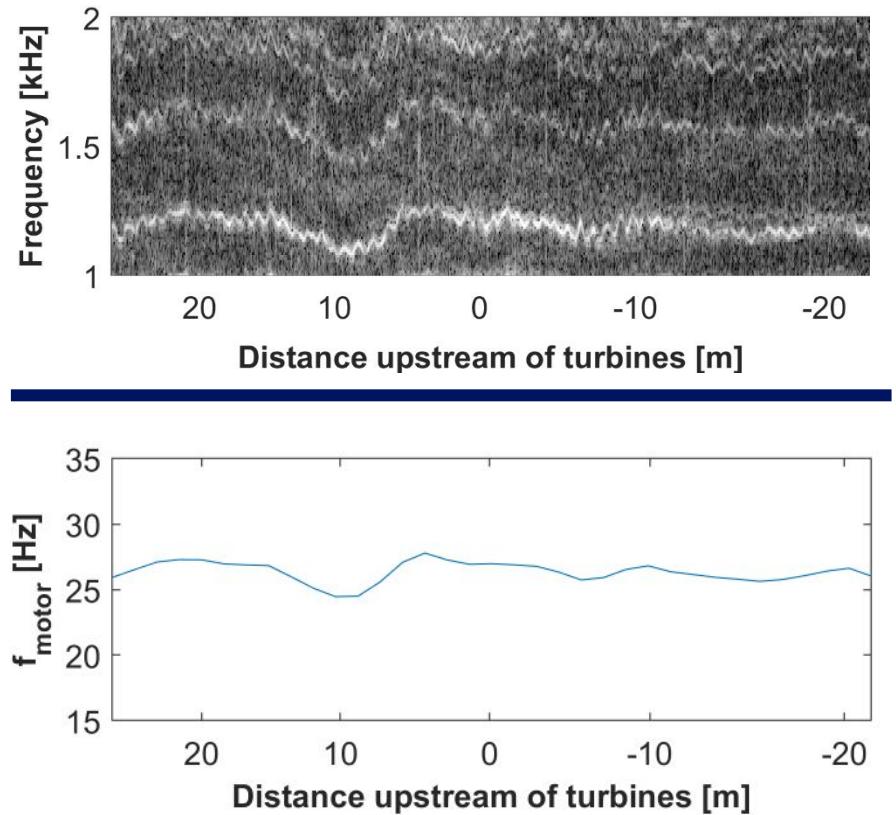
# Geared Motor Comparison



# Geared Motor Comparison

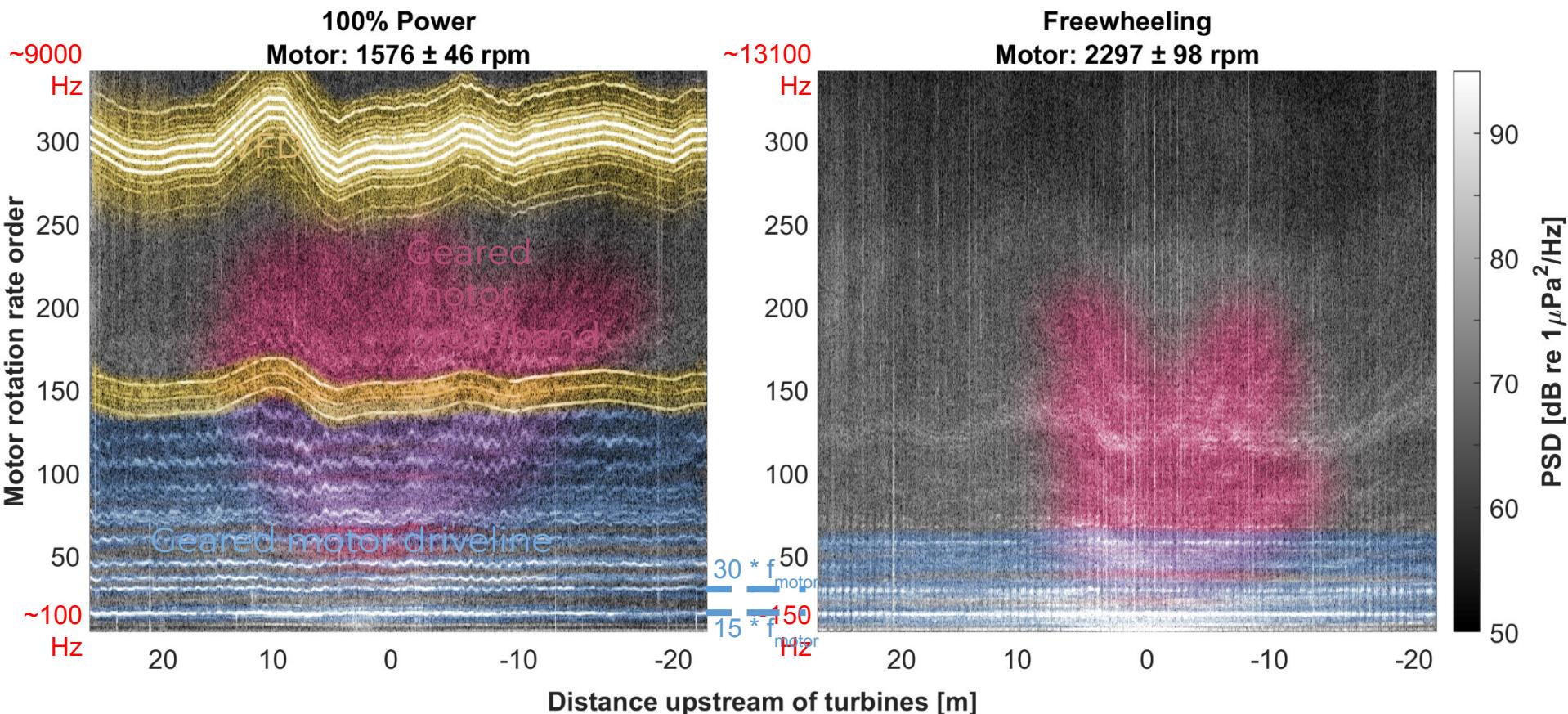


# Order Analysis

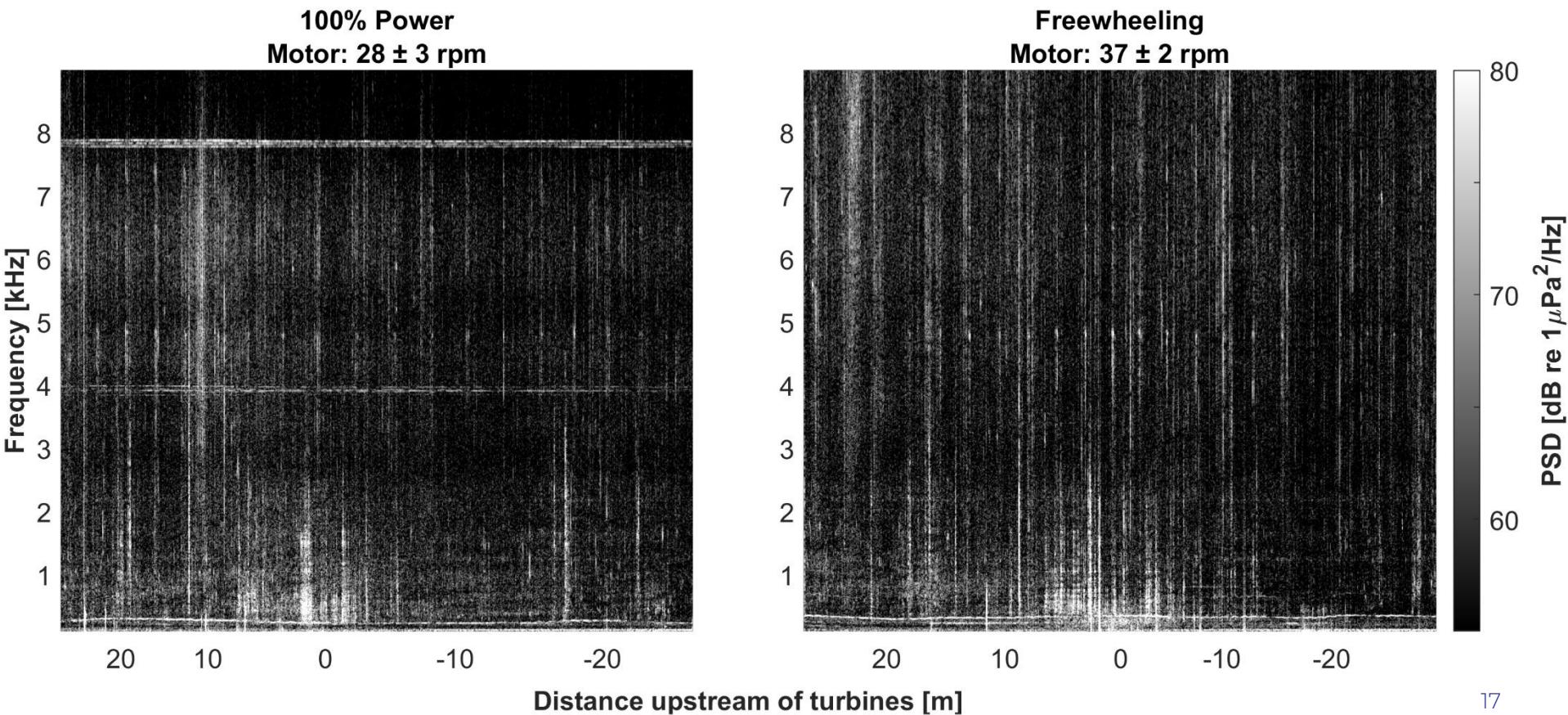


# Geared Motor Order Analysis

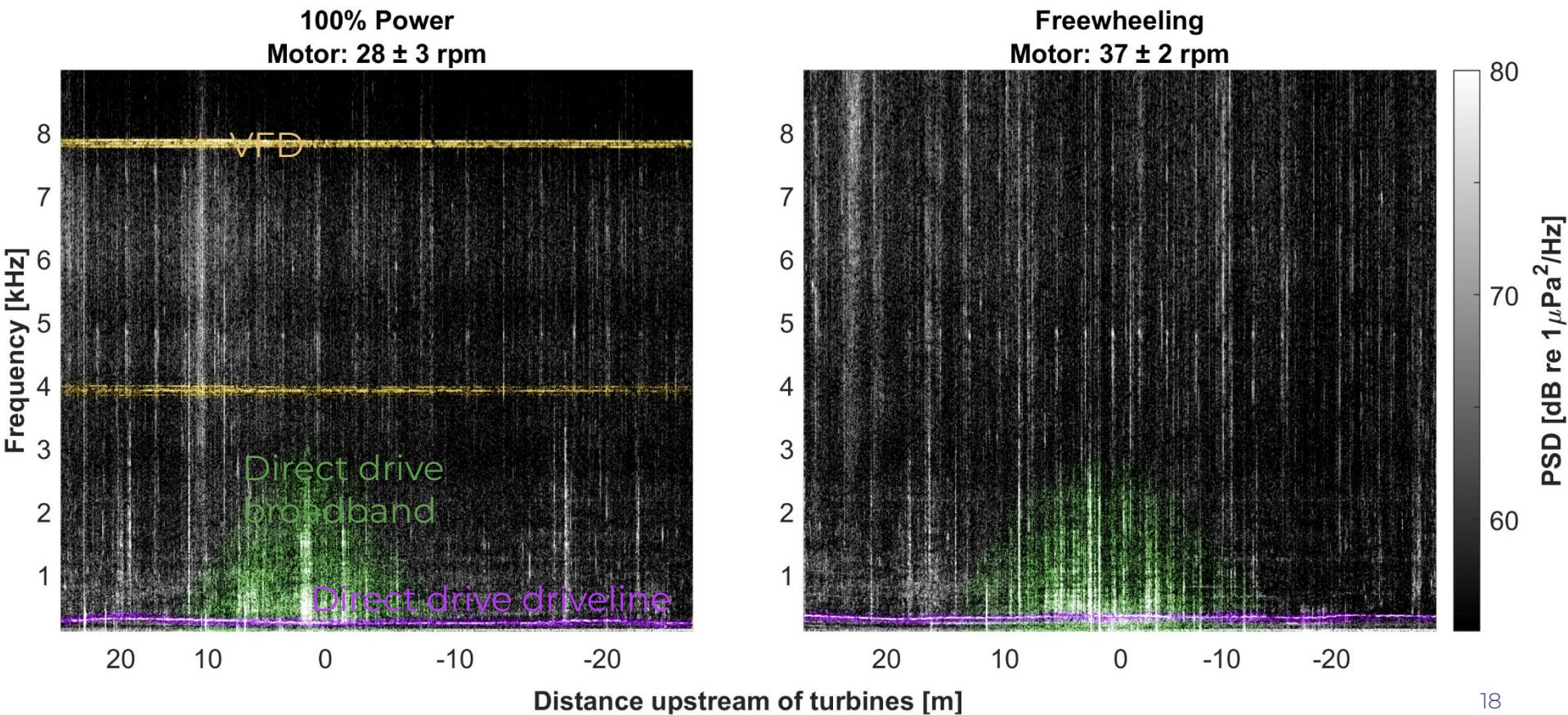
$$order = \frac{f}{f_{motor}}$$



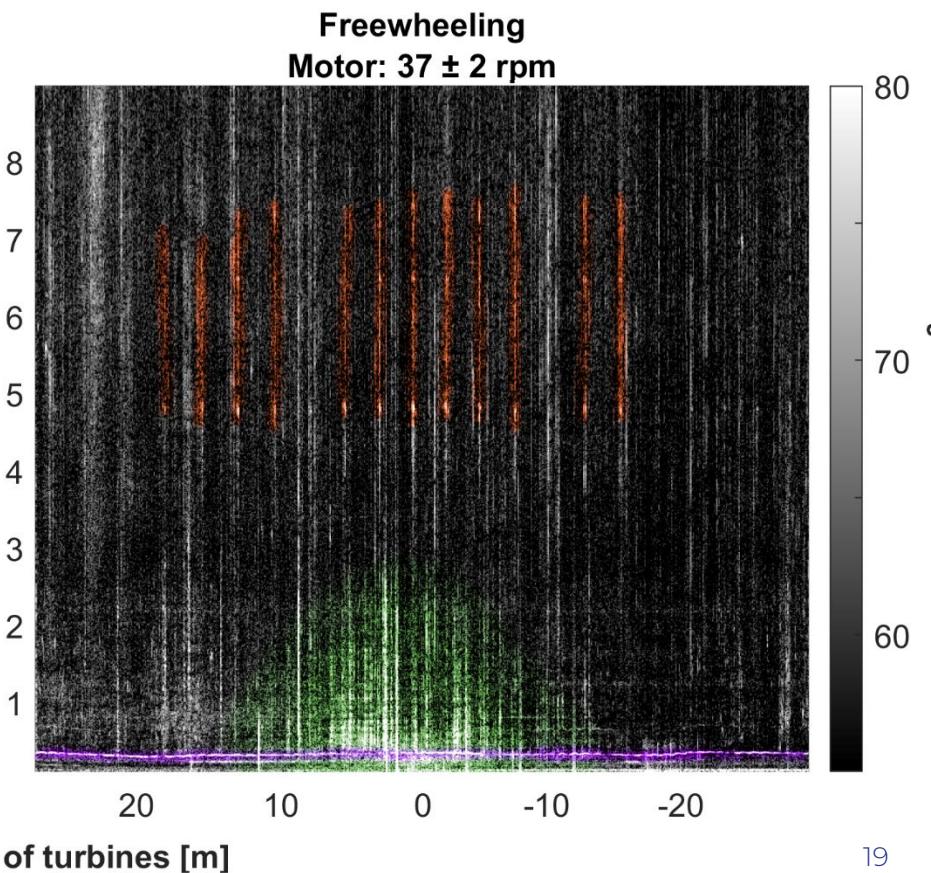
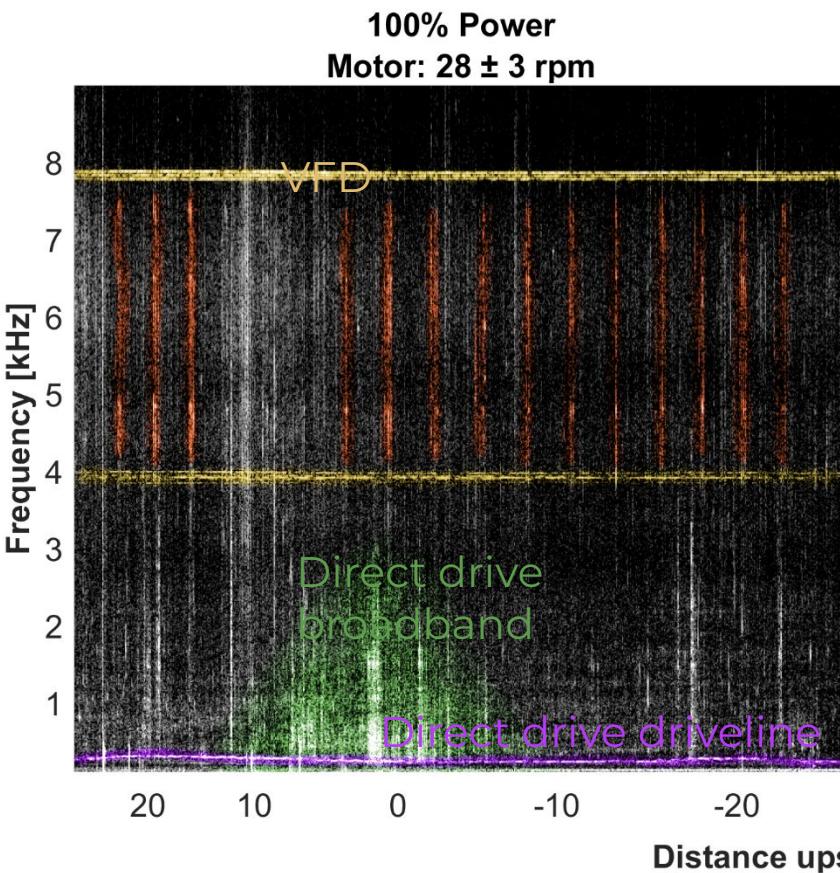
# Direct Drive Comparison



# Direct Drive Comparison

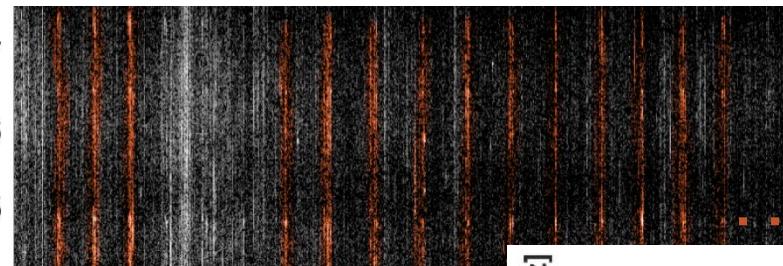


# Direct Drive Comparison

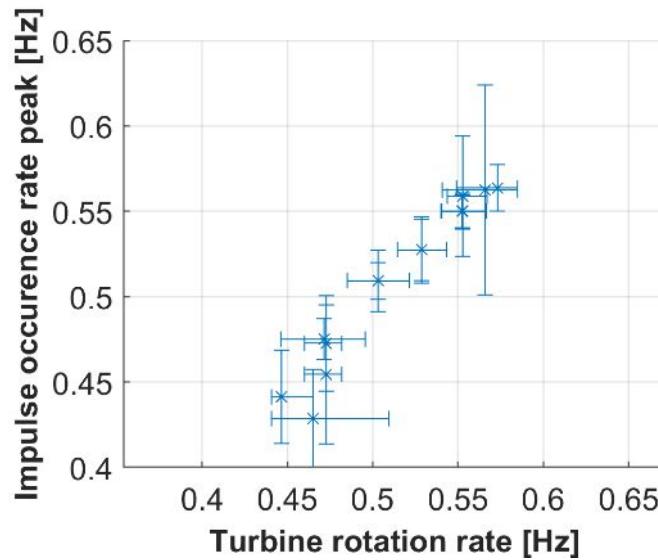
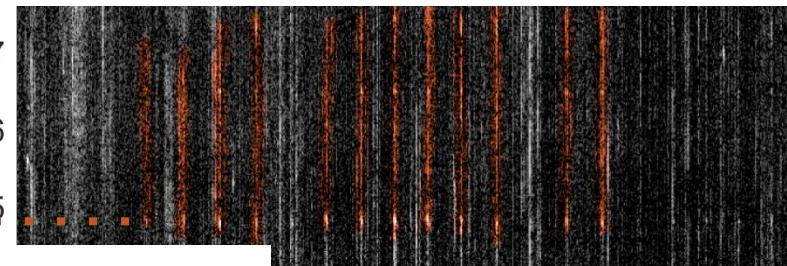


# Direct Drive Impulses

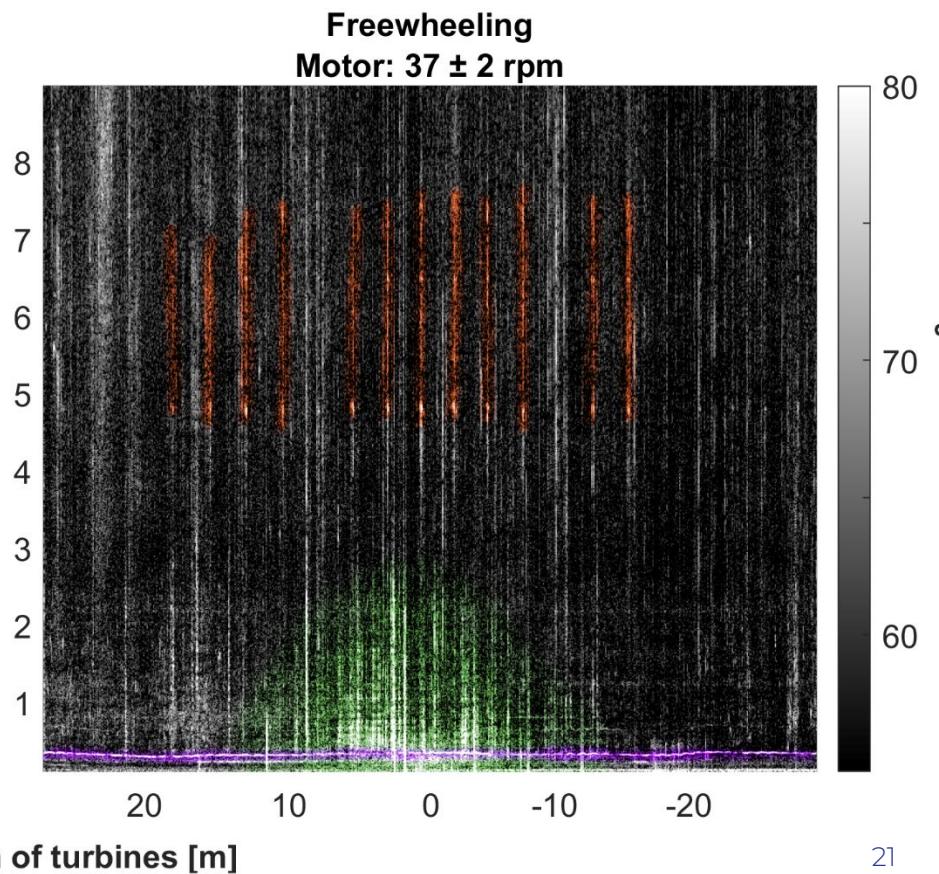
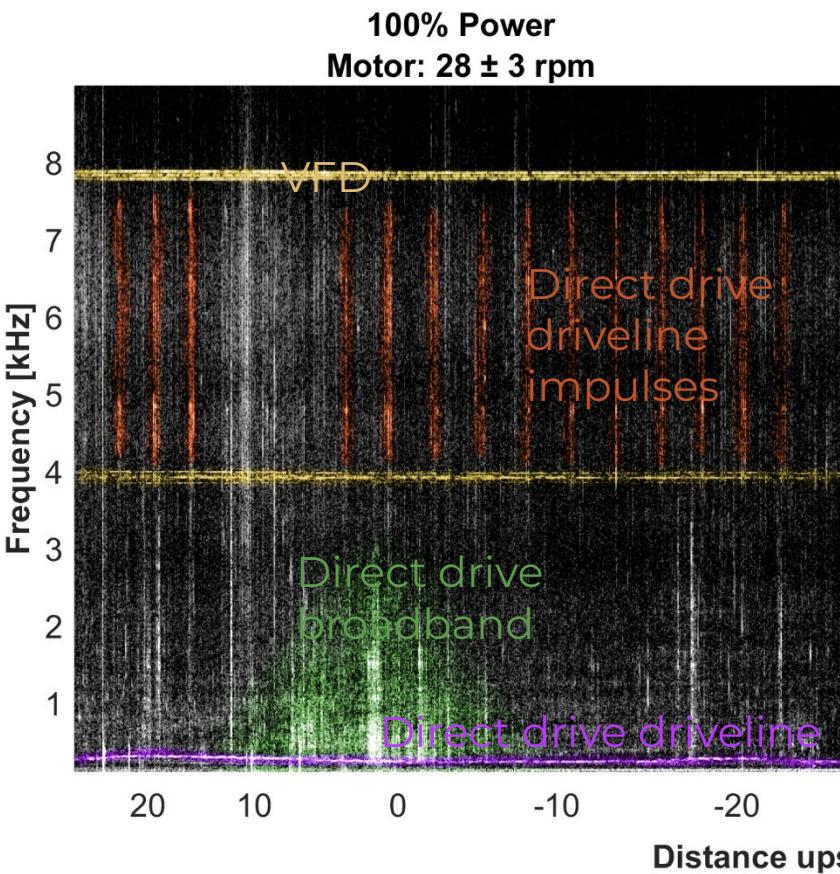
100% Power  
Motor:  $28 \pm 3$  rpm



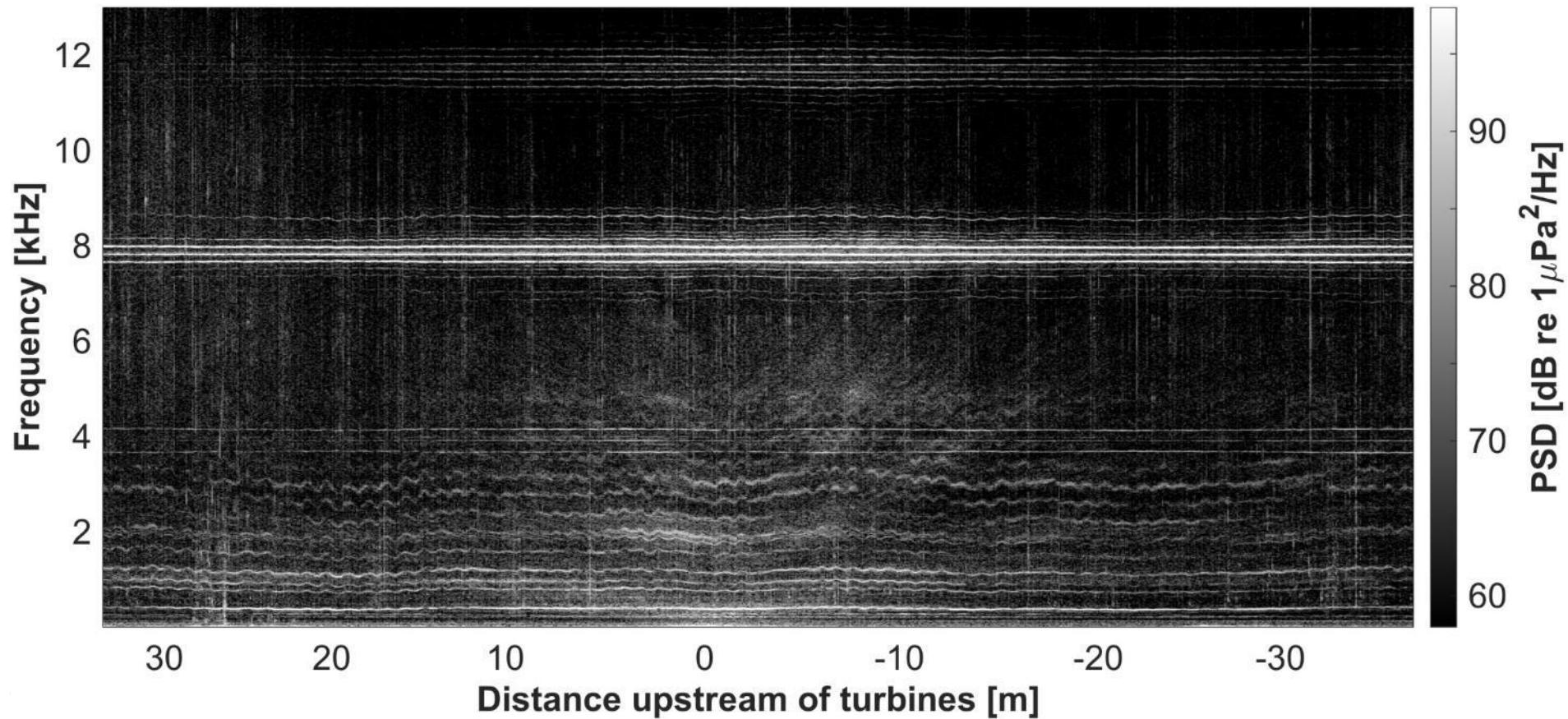
Freewheeling  
Motor:  $37 \pm 2$  rpm



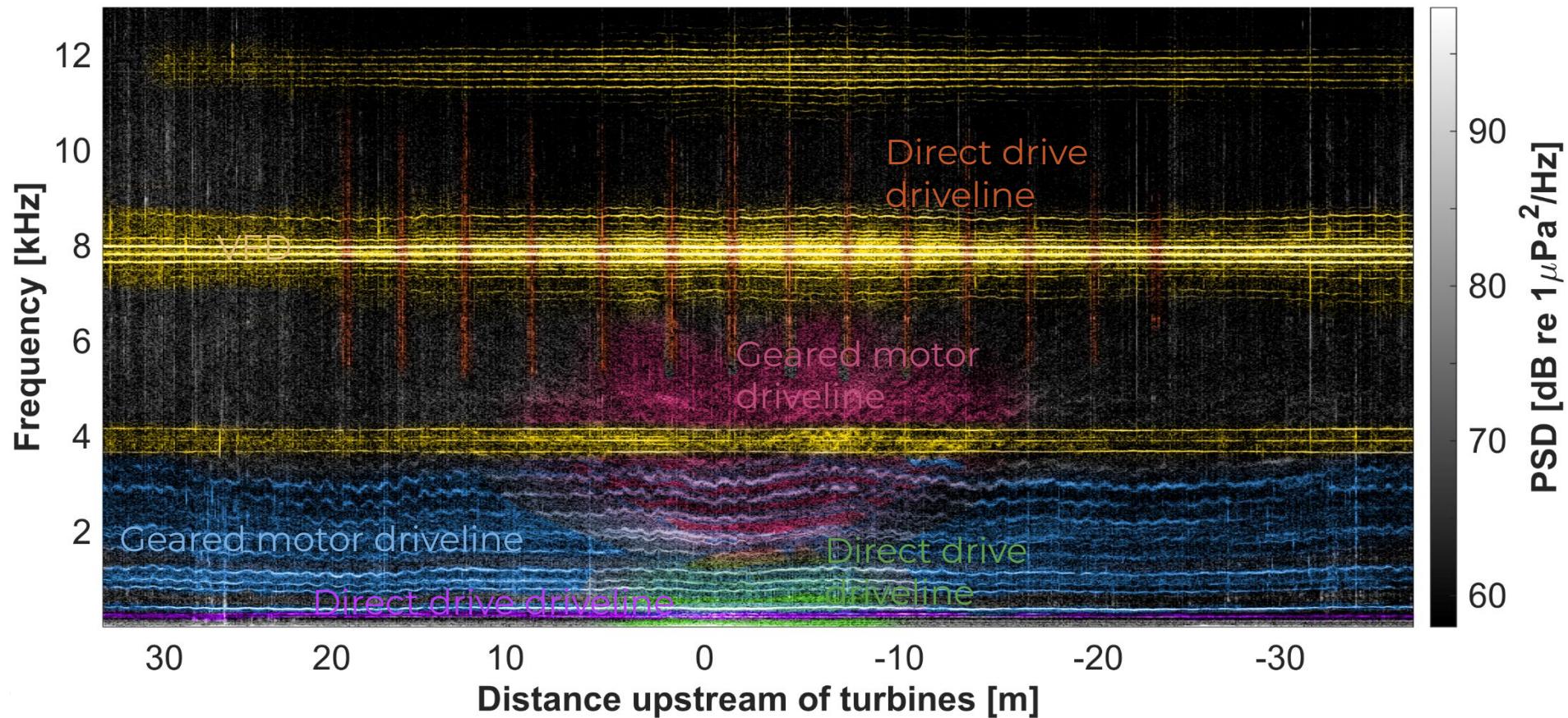
# Direct Drive Comparison



# Radiated Noise Drivers

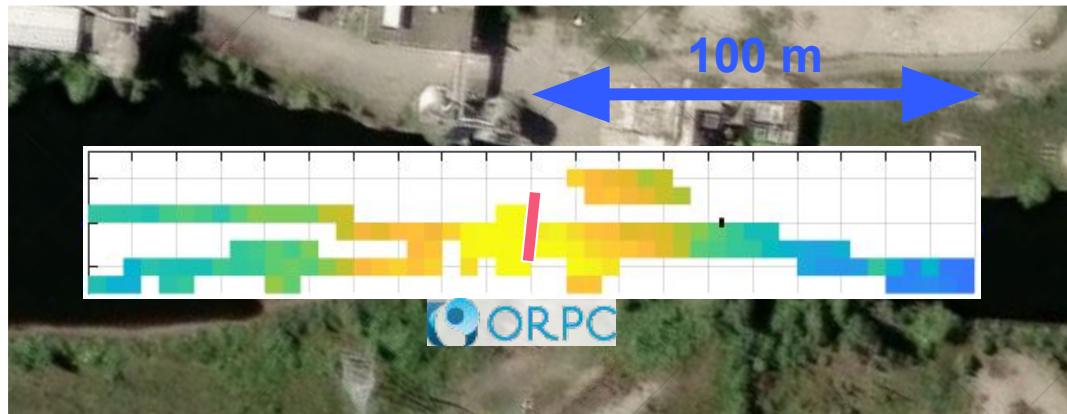


# Radiated Noise Drivers



# Acoustic spatial distributions

SW



Quieter

NE

Louder

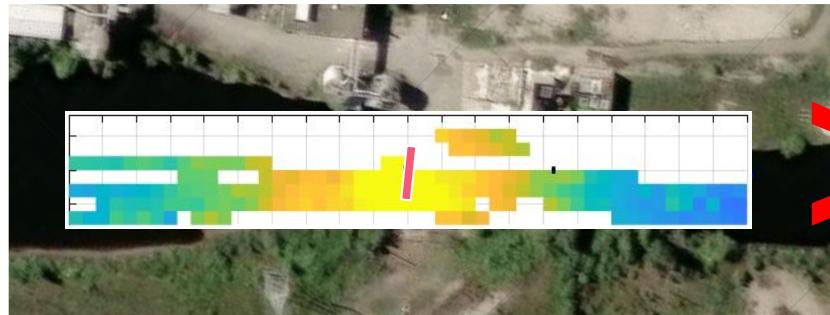
90 95 100 105 110 115 120 125 130

SPL [dB re 1  $\mu$ Pa]

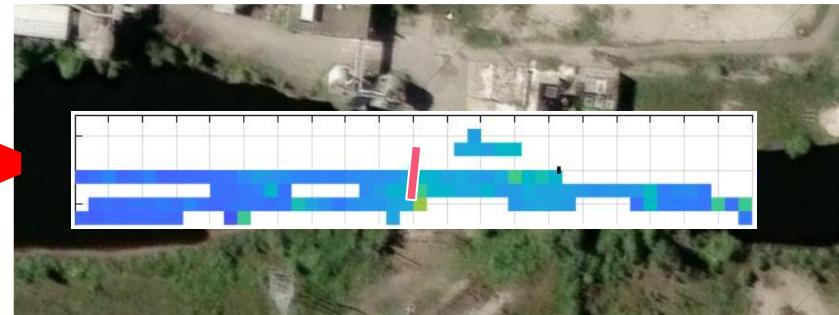
for 180-26000 Hz

# Does driveline affect noise levels?

Geared motor turbine

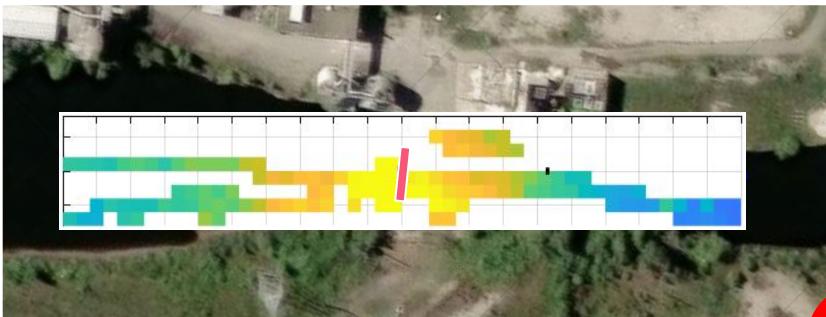


Direct drive turbine

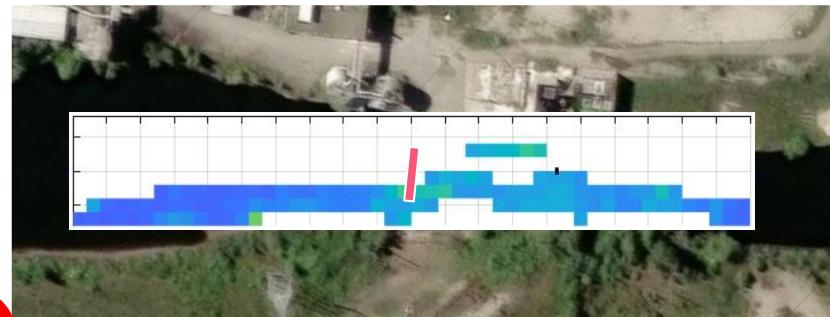


# Does rotation speed affect noise levels?

**Geared motor: 30-40 shaft RPM**



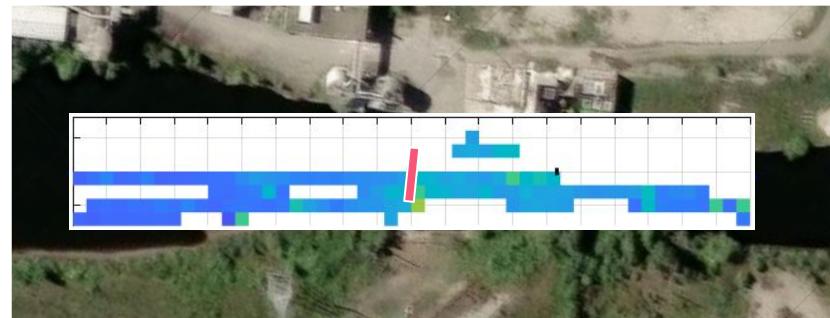
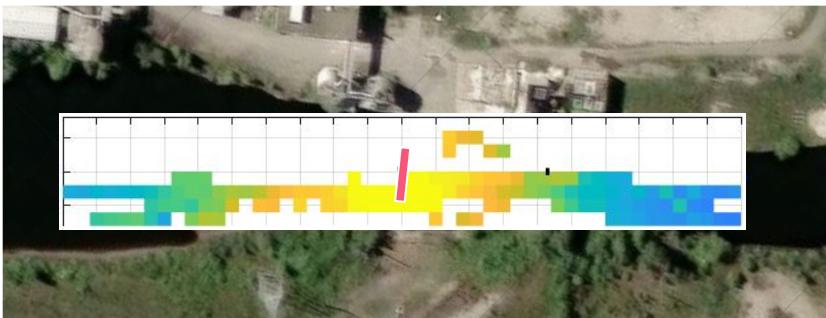
**Direct drive: 20-30 shaft RPM**



**Geared motor: 40-50 shaft RPM**



**Direct drive: 30-40 shaft RPM**



SPL [dB re 1  $\mu$ Pa] for 180-26000 Hz

# Conclusions

- **Unique opportunity for close-range measurements around prototype turbines**
  - Individual signals could be attributed to driveline vs VFD
- **Value of order analysis**
- **Powertrain choice strongly impacts radiated noise**
  - Opportunities to significantly alter radiated noise through powertrain design

# Acknowledgements

This study was funded by the U.S. Department of Energy through the Testing Expertise & Access for Marine Energy Research (TEAMER) program

Thank you to Nicholas Harris and Kaelin Chancey of ORPC for their field support.



Corey  
Crisp



Gemma  
Calandra



Kathryn Sellers  
Reynolds  
(ORPC)



Dr. Chris  
Bassett



Dr. Brian  
Polagye

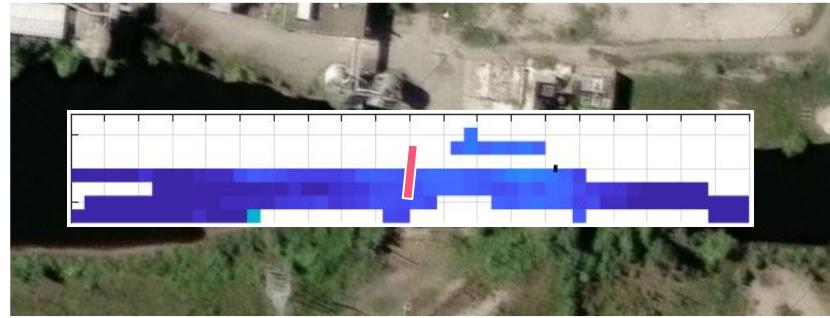
# Considering different frequency ranges

Geared motor turbine

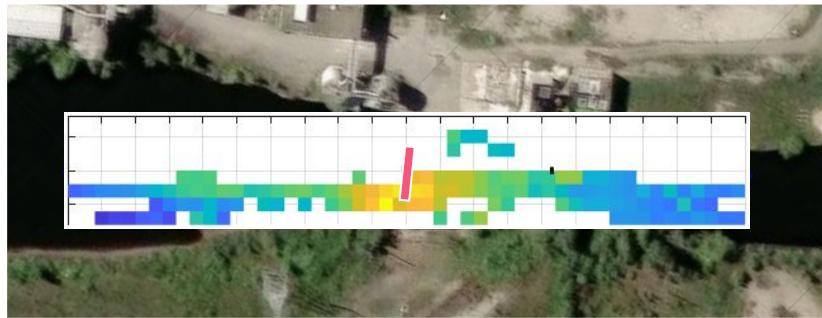
7000  
-9000  
Hz



Direct drive turbine



180  
-3500  
Hz



SPL [dB re 1  $\mu$ Pa]

# Direct Drive Order Analysis

