Visualizing Hydrophone Data

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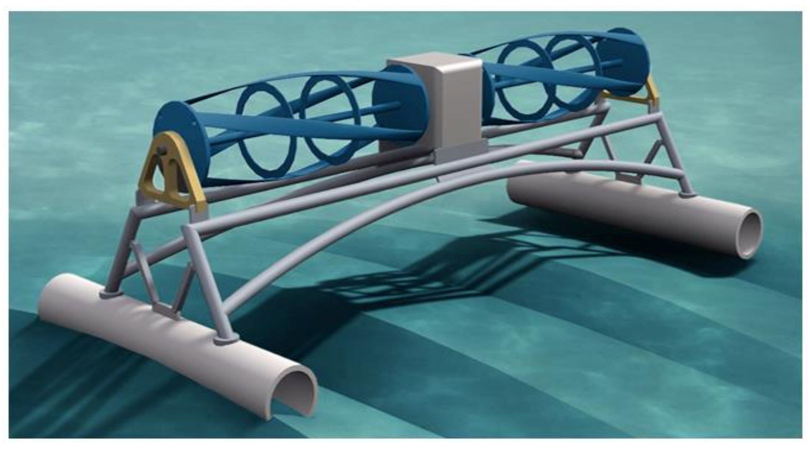
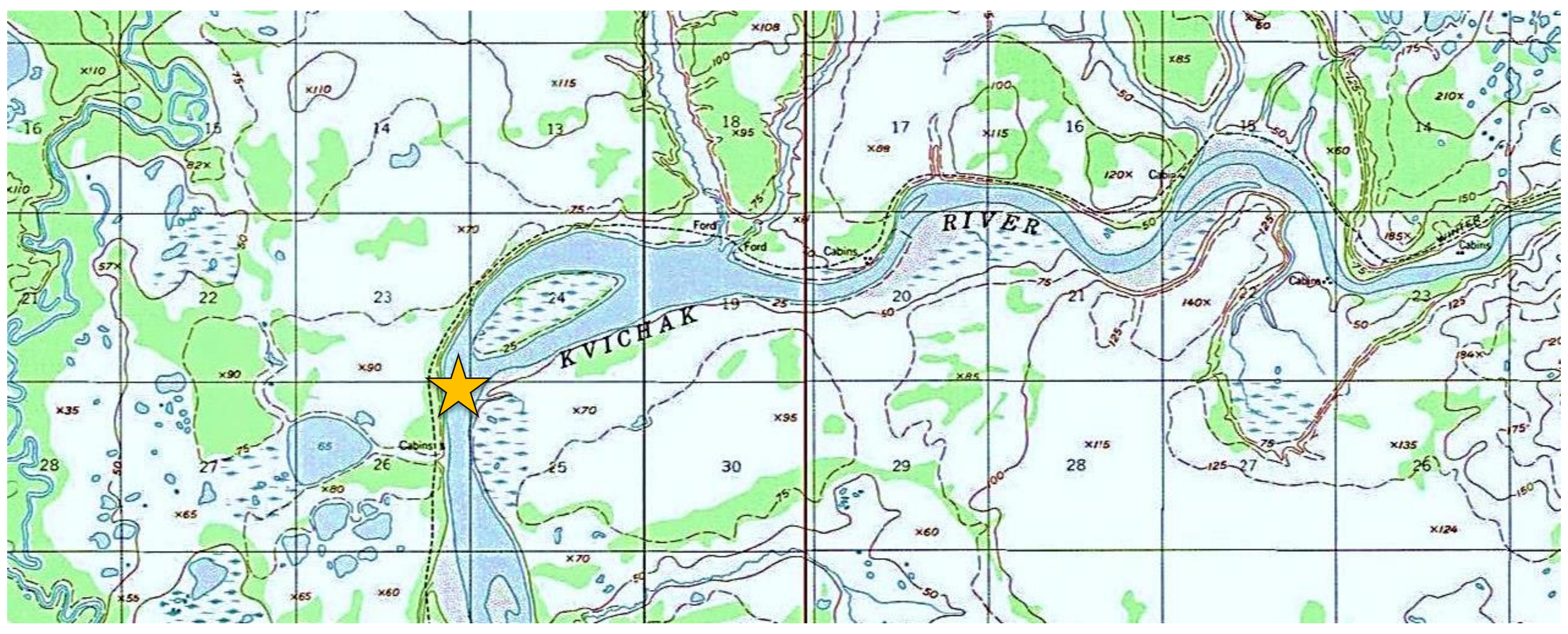
Problem

Underwater noise generated by river, ocean or tidal turbines has the potential to affect fish and marine life. The noise may lead to injury, avoidance, attraction or behavioral modifications. It is essential to understand the relationship between turbine placement and noise generated to inform design and siting decisions.

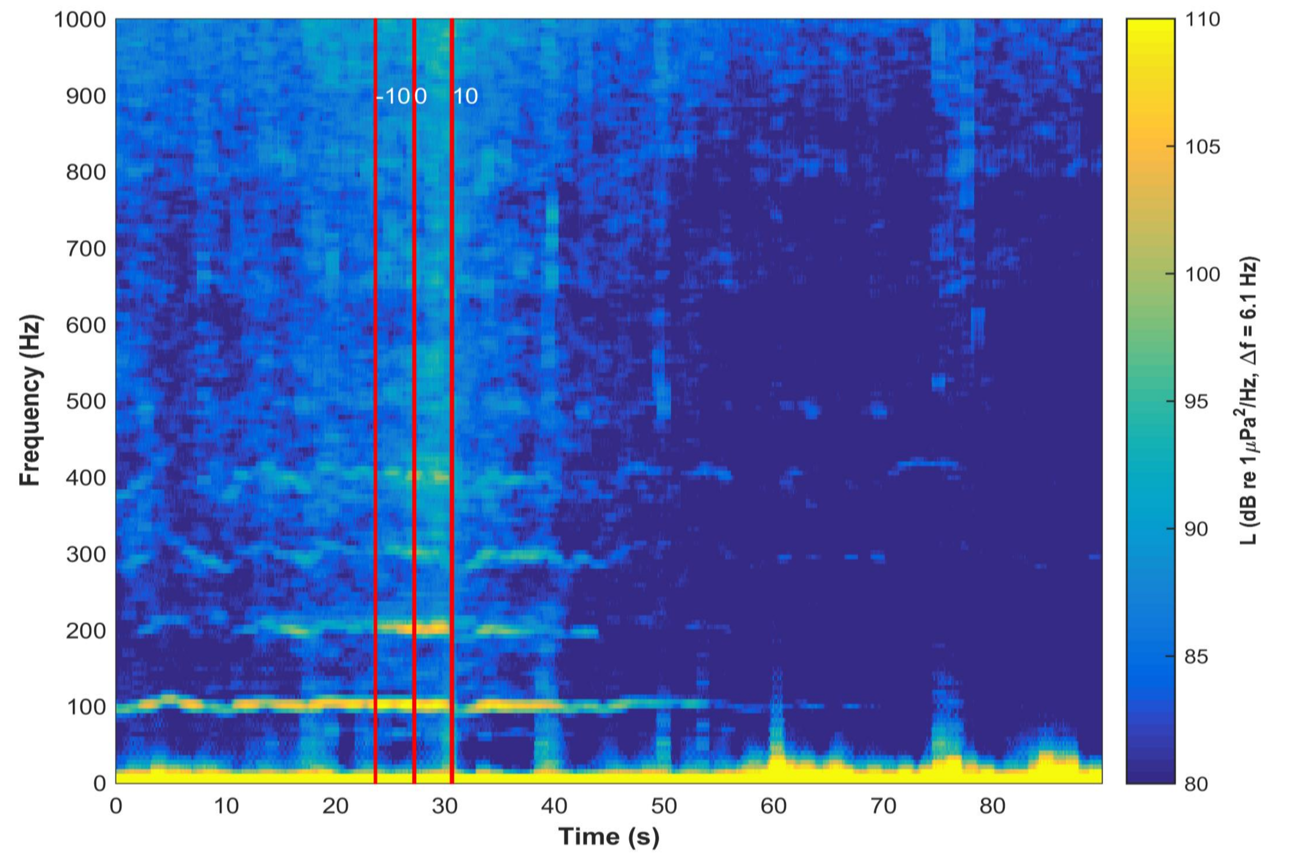


The sound produced by a helical cross-flow hydrokinetic turbine operating near Iguigig, AK (USA) was monitored to characterize its acoustic signature in the riverine environment using spar buoys equipped with hydrophones.



Motivation

Spectrograms are commonly used to represent signals such as sound. In these plots the amplitude of the signal at a specific time and frequency are encoded using color. The sound from this turbine consists of broadband emissions and tones, which vary in proportion to the turbine rotation rate. These sounds attenuate as you move away from the turbine.



The spectrogram representation makes it challenging to visualize and quantify the attenuation of the turbine noise in the spatial domain. Further analysis is required to interpret the acoustic propagation of the turbine noise in aquatic environments.

Approach

The visualization explores the way different frequency bands of the recorded signals attenuate in the spatial domain for different turbine operating conditions, and asks if this is affected by the shape and depth of the riverbed, the frequency of the signal, or other conditions. The visualization is created for experts in the field as a tool to inform design and siting decisions. Several separate, dynamically linked images convey both the frequency characteristics of the hydrophone signal and how the magnitude of the recorded pressures change with distance from the turbine.

- The user can choose the frequency range and the data record by brushing and selecting.
- The cross-flow amplitudes along the hydrophone's path can be selected by brushing.
- Linking between the panels helps the user stay oriented across the multiple windows.

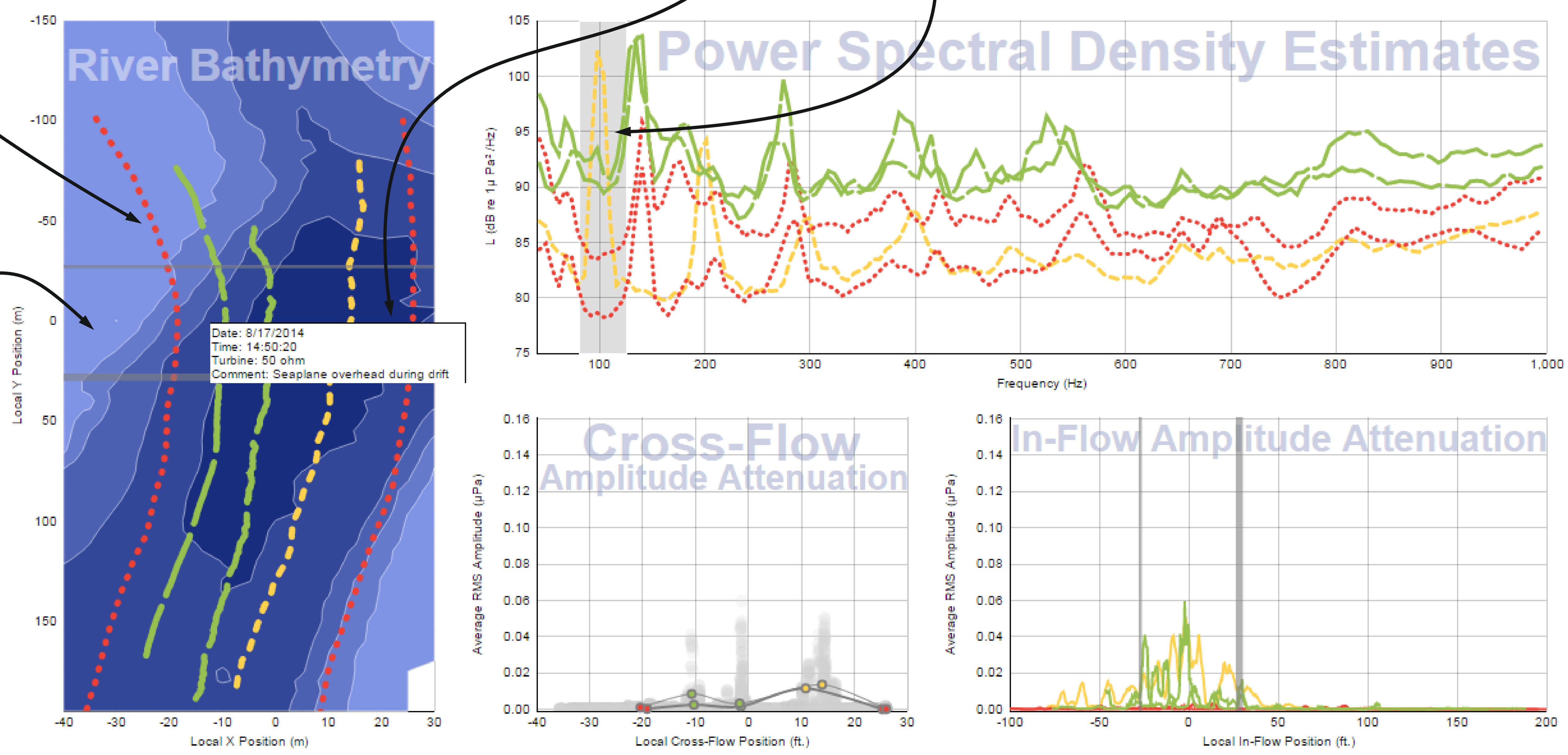
Results

Line type and color distinguish different turbine operating conditions.

Tooltips display metadata about each run.

Brushing filters amplitude plots to investigate specific tones attributed to turbine functioning

River depth is encoded with color value.



Brushing updates cross-flow and in-flow amplitude profiles, while line-width identifies the selected up- and down-stream positions

Future Work

- Adjust visual encodings for better scalability.
- Add selection based on turbine condition.
- Include river depth plot along the with-flow signal amplitude.
- Include upload capabilities for real time analysis.
- Build in frequency analysis tools to analyze and filter data.
- Build in regression models for amplitude attenuation.

Acknowledgments

Access to this dataset was provided by Dr. Brian Polagye and Paul Murphy, and their assistance is gratefully acknowledged.