Modeling of zones of influence and ambient noise metrics to inform decision making

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Abstract

Measurements of underwater noise from pile driving were collected during a marine construction project in San Diego Bay. These measurements were used to identify the best placement of marine mammal observers, and to adhere to the requirements of an Incidental Harassment Authorization (IHA)**.** This work presents the **modeling of Zones of Influence** (ZOIs) for pile driving noise as well as results from ambient noise monitoring. Results from **real-time monitoring** showed good agreement with the modeling isopleths associated with the 190 dB and 180 dB isopleths (RMS level, dB re 1 µPa) that define Level A injury thresholds for pinnipeds and cetaceans, respectively. **Ambient** noise measurements were also collected in the bay; we evaluate the L_{10}, L_{50} and L_{90} exceedance levels (where L_x means these values were exceeded x% of the time) from a regulatory standpoint.

Modeling

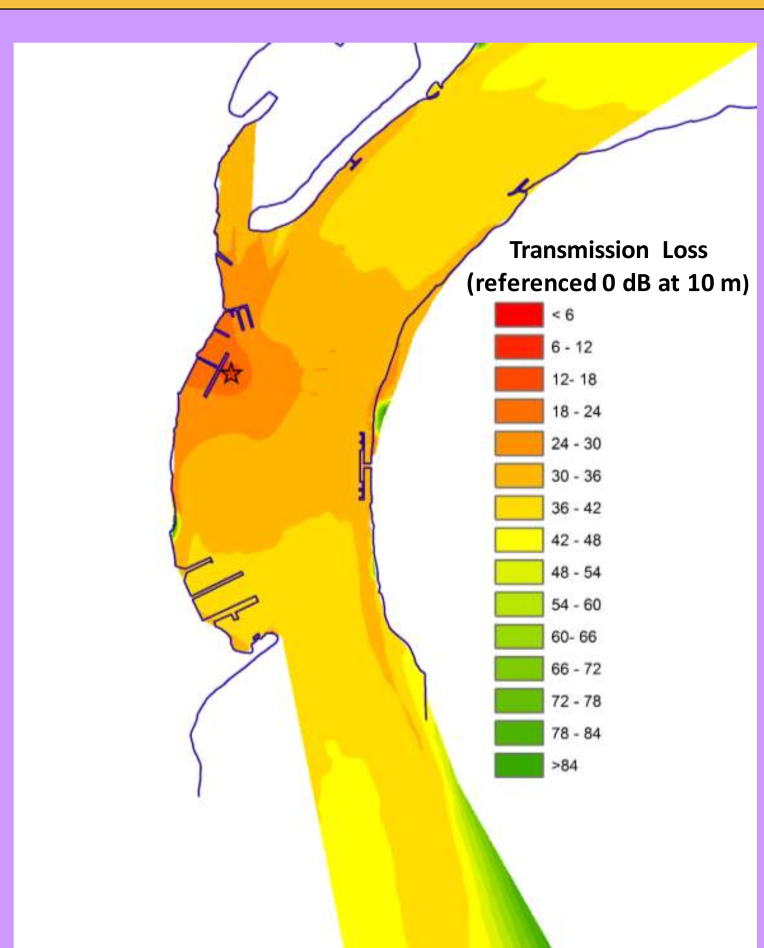

Figure 1. Predicted transmission loss

- Model (Figure 1) simulated depth-averaged transmission loss (TL), incorporated depth-dependence and bottom attenuation effects. Output can be applied to Peak Pressure, SEL and RMS measures.
- Isopleths associated with impact pile driving (for a source producing a level of 200 dB RMS at 10 m) are shown in Figure 2.

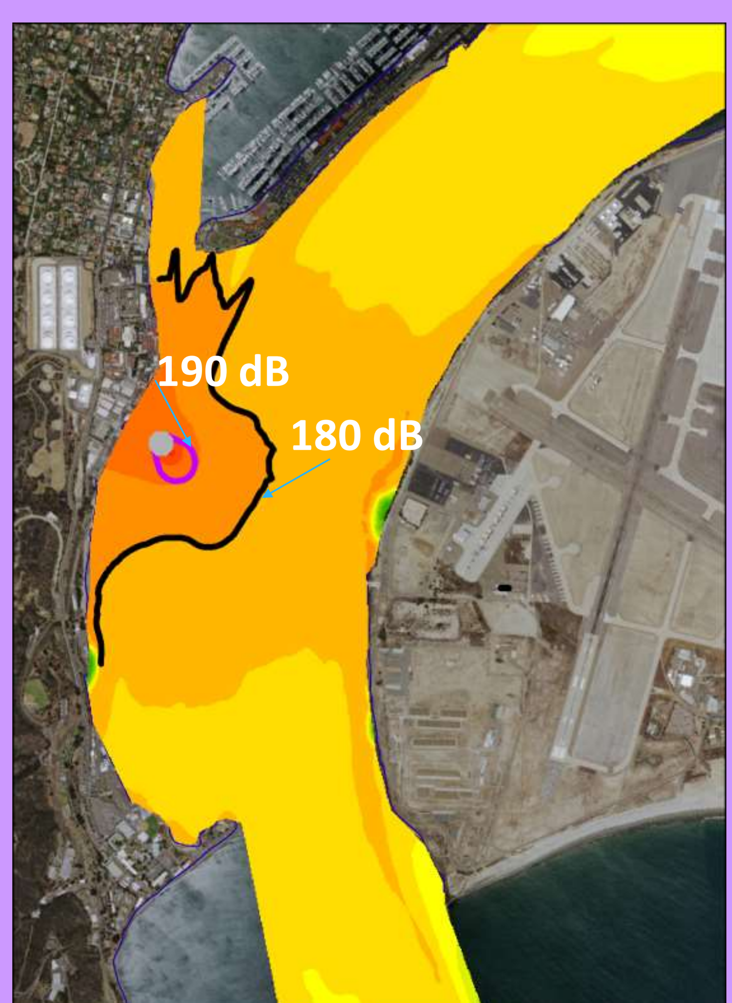

Figure 2. Predicted received levels

- The 180 and 190 dB isopleths correspond to Level A Harassment ZOIs for cetaceans and pinnipeds.
- Model shown here satisfactorily captured location of 180 and 190 dB isopleths and defined an upper bound on transmission loss levels further out into the bay

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Measurements

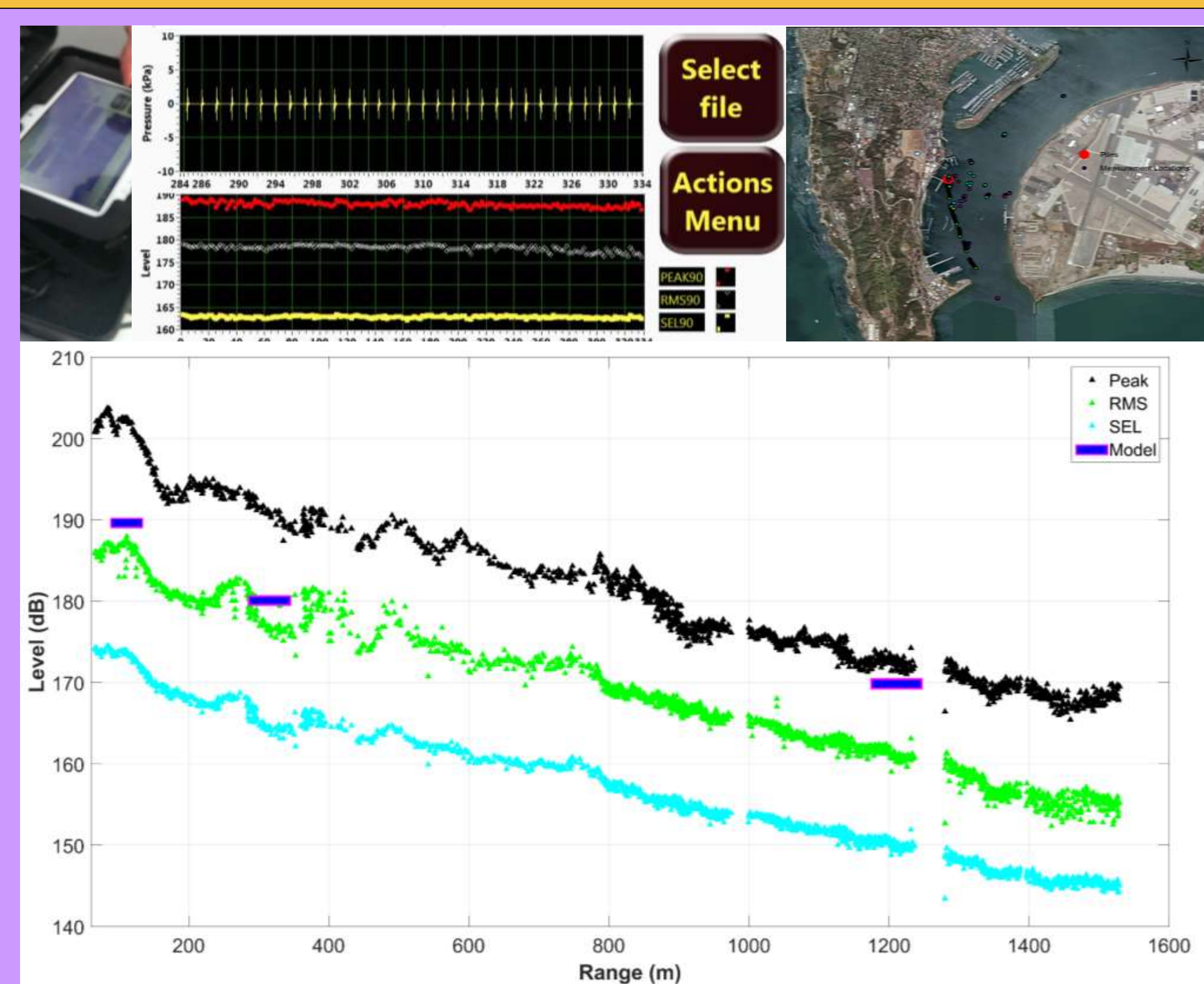

Figure 3. Measured received levels at ~300-400 m from source (top, center) and measured levels from various locations-including drifting away from the source (bottom). Model predicted ranges for select received levels are indicated by the outlined blue bars.

- Real-time monitoring of levels with a USLM[1] was used to inform placement of marine mammal observers[3], and ensure adherence to Incidental Harassment Authorization (IHA) requirements.
- The predicted ranges for the 180 and 190 dB zones of influence were in good agreement with field measurements (Figure 3).

Ambient noise

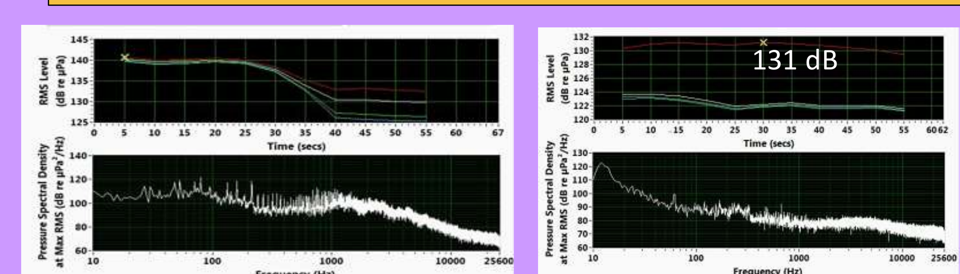

Figure 4. Analysis of frequency content in real-time monitoring to deduce background noise levels.

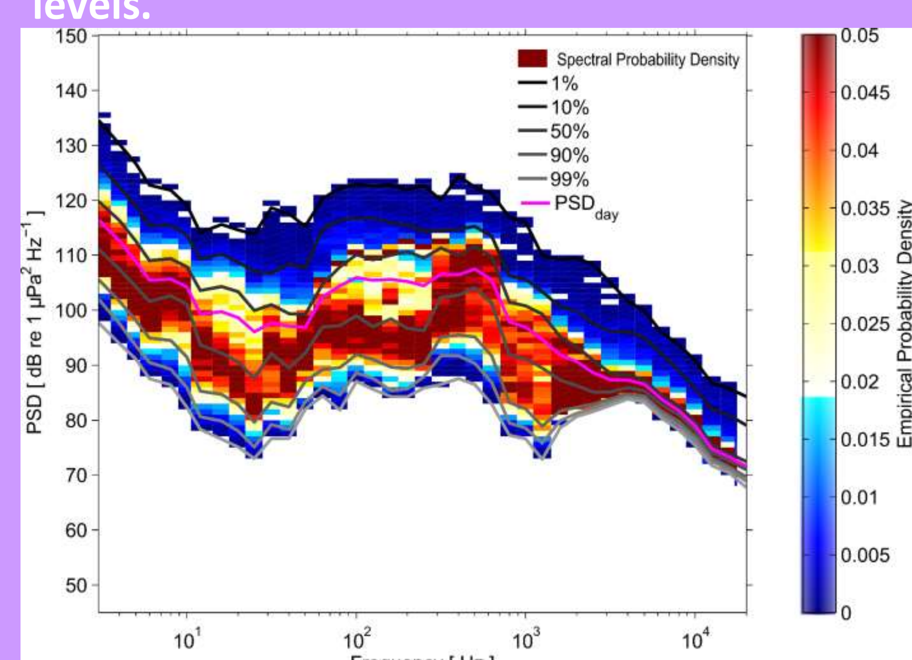

Figure 5. Spectral probability density plot of ambient noise from Monitoring location 1. Deep red shows highest density of levels. Analysis of Pressure Spectral Density (PSD) assists in choice of broadband metric.

- Modeling is extended to ambient, but what is ambient?
- Knowledge that the frequency content of pile driving noise is predominantly less than 2000 Hz can be used to inform real-time assessment of ambient noise levels (Figure 4).
- Analysis of the spectral density of ambient noise suggested that the L_{50} exceedance level was a good indicator of the trend in ambient noise levels. Figure 5 shows a typical trend of ambient noise levels in May 2015 from Monitoring Location 1 (Figure 6).

Ambient noise (continued)

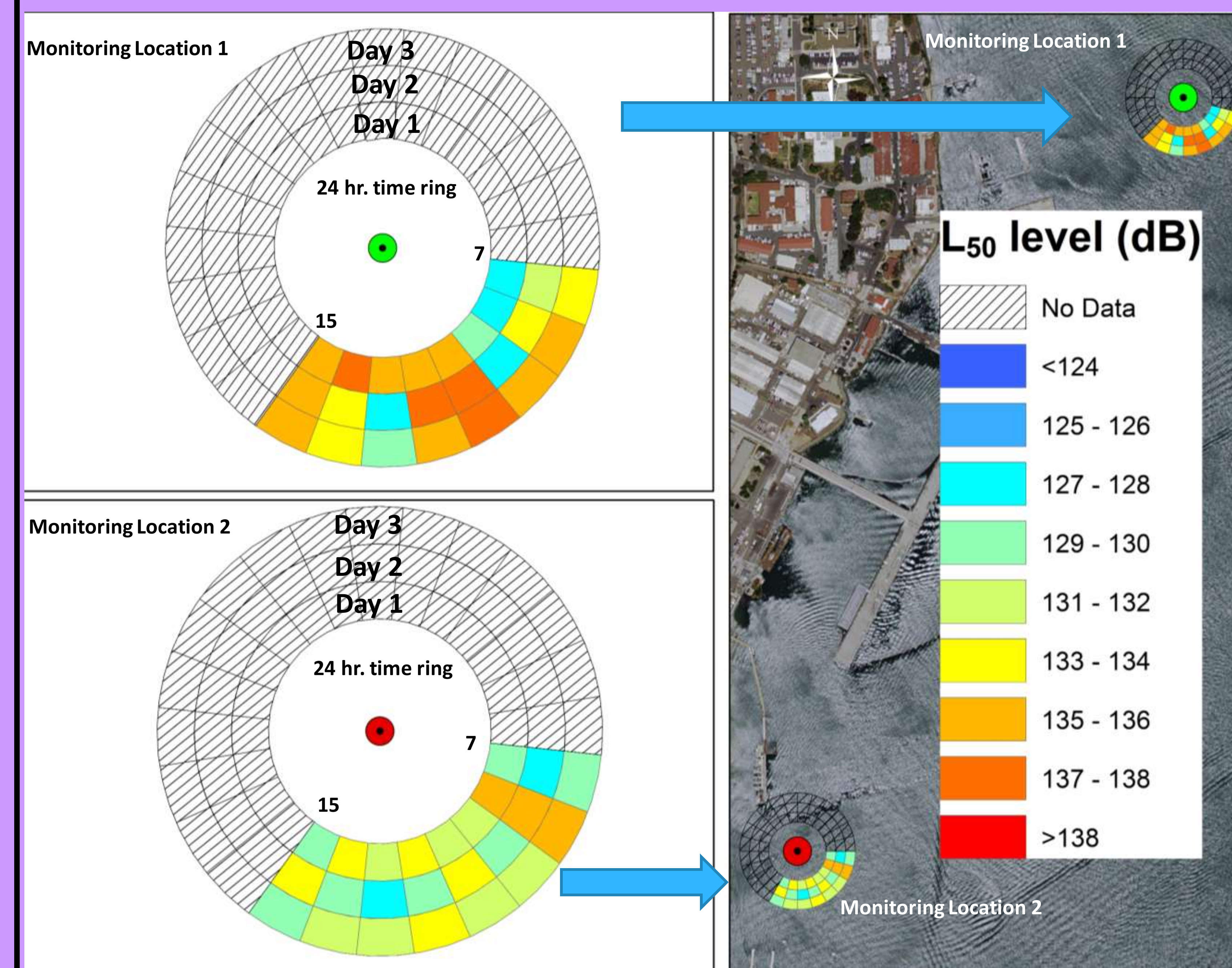

Figure 6. L_{50} levels for each hour of 8 hours of background noise monitoring at two locations within the bay in May 2015

- Simultaneous monitoring of ambient noise levels was undertaken during a time period during which construction activities might typically occur. Noise levels were consistently higher than 126 dB.

Conclusions

- Modeling of transmission loss within the bay was able to predict isopleths important for marine mammal monitoring.
- Choice of noise metric can skew designation of ambient and influence regulatory region of concern for modeling.
- L_{50} noise level may be the best choice for the data analyzed.

Future work

- Refinement of model to possibly include additional bathymetric effects and to improve long range prediction[2].
- Continued paired ambient noise monitoring in the bay at additional locations.

References

[1]Dahl, Peter H., D.R. Dall'Osto, M. Perdue, T. McConcnchie, D. Lerma, A. Fredell and D.M. Farrell. 2015. A hand–held tool for rapid assessment of underwater sound to inform decision-making. Society for Marine Mammalogy Biennial Conference. Poster Presentation.

[2]Dahl, Peter H., D. R. Dall'Osto, and D. M. Farrell. 2015. The underwater sound field from vibratory pile driving. The Journal of the Acoustical Society of America 137, no. 6 : 3544-3554.

[3]McConchie, T. , D. Lerma, M. Perdue, M. Dungan. 2015 Asessment of Marine Mammal Interaction with Pile Driving Events in San Diego Bay, California, USA. Society for Marine Mammalogy Biennial Conference. Poster Presentation.