Submission code: B7XNPX5Q7Z

See this and other abstracts on our website: https://home.sbgf.org.br/Pages/resumos.php

Benefits of Real Time Passive Acoustic Monitoring for Mitigation

Jason Wood (SMRU Consulting), Sam Tabbutt (SMRU Consulting), Chloe Malinka (SMRU Consulting), Nara Pavan Lopes (TOVERI)

Benefits of Real Time Passive Acoustic Monitoring for Mitigation

Abstract Summary

Industrial activities pose threats to marine mammals due to noise, ship strikes, and entanglement. Passive acoustic monitoring (PAM) has been successfully used to monitor for marine mammals over long periods of time. PAM paired with real time processing and communication is an even more powerful tool to mitigate industrial impacts. Real time PAM can monitor exclusion zones for marine mammals and measure noise levels to ensure regulatory compliance and flag when mitigation equipment is not working within norms. This presentation will provide examples of 1) real time PAM use as a mitigation tool to monitor pile driving noise, 2) clear exclusion zones for offshore wind pile driving, and 3) for dredging associated with a port expansion (for offshore wind) to illustrate the benefits of real time PAM. These projects were conducted using Coastal Acoustic Buoys (CAB) which are autonomous buoys that conduct edge computing using industry standard PAMGuard software and relay results via radio or cell communications.

Introduction

Passive acoustic monitoring has been extensively used to measure ambient noise levels (e.g. Duarte et al. 2021) and monitor for the presence of vocalizing marine species (e.g. Parks et al. 2014). This is often done in an archival mode, where recorders are deployed for months to years and then data downloaded and processed after recovery. Real time PAM systems have additional value for mitigation to ensure compliance with regulatory requirements or industry best practices. The value of real time PAM extends not just to identifying periods when animals of concern are present, but also in providing noise measurements which can inform industrial operations.

In our pile driving scenario (1), CABs were used to demonstrate that the extent of the modelled exclusion zone was too large. Providing the field measurements in real time allowed for a fast application to shrink the exclusion zone to expedite construction. During the pile driving a bubble curtain was used to mitigate noise levels. CAB units provided real time feedback to the bubble curtain operators to optimize the mitigation efficacy of their system. In our offshore wind example (2), CABs were used in conjunction with > 3,500 playbacks of North Atlantic right whale like upcalls to characterize the detection function of the CAB system for clearing offshore wind exclusion zones and demonstrate that calculating bearings to calling animals reduces delays in construction, compared to non-bearing PAM systems between a factor of 6 and 12. In our dredging scenario (3), CABs successfully detected dolphins and porpoise during dredging and disposal to meet regulatory requirements for a port expansion.

Methods

1) Pile driving of 36” diameter piles was monitored for a pier expansion in Hood Canal, WA, USA on 30 September 2020 using two CAB units with either a Reson TC4033 or Reson TC4014 calibrated hydrophone. The ‘near’ CAB was located 131 m from the pile driving and the ‘far’ CAB was 494 m from the pile. Data were digitized at 62.5 kHz sample rate, 16-bit depth. The PAMGuard click detector was used to detect each pile strike and results were transmitted to our base station on site via radio to calculate single strike Sound Exposure Level (SEL_{ss}), zero to peak Sound Pressure Level (SPL_{pk}) and other relevant noise metrics. The first pile monitored was used to provide direct feedback to the bubble curtain operators on the efficacy of this noise mitigation strategy. The last three piles (with the bubble curtain optimized) were then

used to estimate transmission loss and cumulative SEL to estimate the range to the phocid frequency weighted permanent threshold shift at 185 dB re 1μPa^{2}s (zone of influence).

2) To demonstrate mitigation of offshore wind pile driving, five CAB units with three hydrophones spaced 2 m apart and 1 m off the seafloor were deployed offshore MD, USA in October 2021. These were deployed in an arc as if they were 10 km from a pile installation. The acoustic data from the HTI 96min hydrophones was digitized at 4 kHz and run through the PAMGuard right whale edge detector. Detections, time difference of arrival, and 2 second audio clips were sent via radio to our base station which ran a neural network classifier to further remove false positives. A PAM operator then determined which detections were true positives and if the detections were inside or outside the 10 km mitigation zone. Over 3,500 right whale like upcalls were played in a variety of locations to measure the detection function of the CAB system and the accuracy of the bearing estimates. This was then compared to a PAM system with no bearing capabilities to estimate the reduction in delays resulting from the additional bearing information. See Palmer et al. 2022 for further details.

3) Two CAB units were deployed near Ardersier Port in Scotland on 22 March 2025 to monitor a dredging and disposal site as the port expands to support the offshore wind industry. The units are still in use. Both units use three HTI 99HF hydrophones spaced 2 m apart and 1 m from the seafloor. There are multiple acoustic processes running onboard the buoys. Two PAMGuard tonal detectors are used to detect bottlenose dolphins (whistles and brays) and estimate bearings to calling animals. A click detector is also used to detect harbor porpoise. Long term spectrogram averages are calculated to monitor data quality and broadband and octave band noise levels are calculated every minute. These data are transmitted via cell modem to cloud servers where PAM operators can monitor in real time for dolphins and porpoise using PAMGuard software.

Results

1) The ability to provide feedback in real time to the bubble curtain operator allowed for optimization of the bubble curtain, resulting in approximately 8 dB of noise reduction during pile driving (Fig. 1). During the optimization of the bubble curtain, the system malfunctioned due to excess airflow being applied. This was corrected for the subsequent piles from which a transmission loss curve was fit and an average SEL_{ss} measured. These in turn allowed for a reduction in the phocid zone of influence from a predicted 217 m to a measured 92 m.

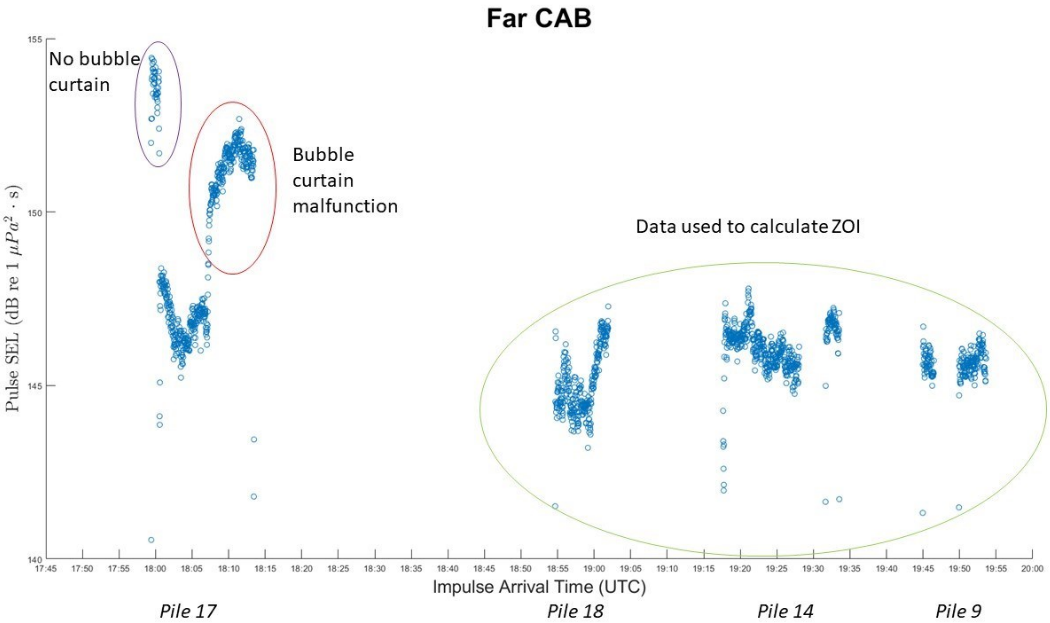

Figure 1: Single strike SEL measured 494 m from the piles. Pile 17 was used to provide feedback to the bubble curtain operators on how much airflow optimized the efficacy of that system in reducing underwater noise. Piles 18, 14 and 9 were used to estimate the phocid zone of influence.

2) The CAB detection and classification system was capable of detecting well over 95% of right whale like playbacks when the signal to noise ratio (SNR) was ≥ 6 dB. The median bearing error was < 1º (Palmer et al. 2022). A simulation of calling right whales and 5 buoys with detection and bearing capabilities reported in Palmer et al. 2022 results in an unrequired shutdown (or delay) probability of 6% when bearing information is available and an unrequired shutdown probability of 55% when bearing information is not available (Fig. 2).

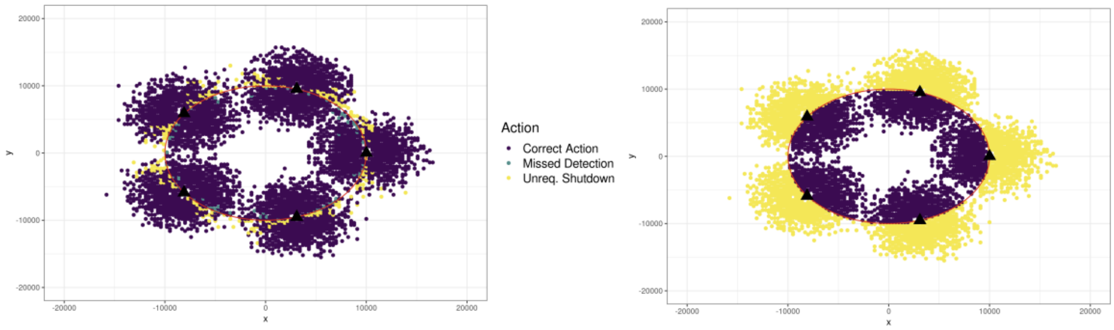

Figure 2: Simulation of 5 buoys with the detection function and bearing accuracy of Palmer et al. 2022. The left scenario has bearing information to determine if a detection is inside or outside the 10 km exclusion zone. The right scenario does not. Triangles are the buoy locations. A correct action is a delay in construction if the detection is inside the exclusion zone or no delay in construction if the detection is outside the exclusion zone. A missed detection is a false negative. An unrequired shutdown is a result of a detection that is outside the exclusion zone but is considered inside either due to bearing error or due to no bearing information.

3) The two CAB units at Ardersier Port have been detecting both bottlenose dolphins and harbor porpoise during this deployment thus helping the Port meet their regulatory requirements. The detections and noise processing have been reliably conducted on the buoys in the field with the results transmitted via cell modem to our cloud servers in < 1.3 sec (Fig. 3). This has allowed the

PAM operators to monitor for dolphins and porpoise in a timely manner using PAMGuard to visualize the data.

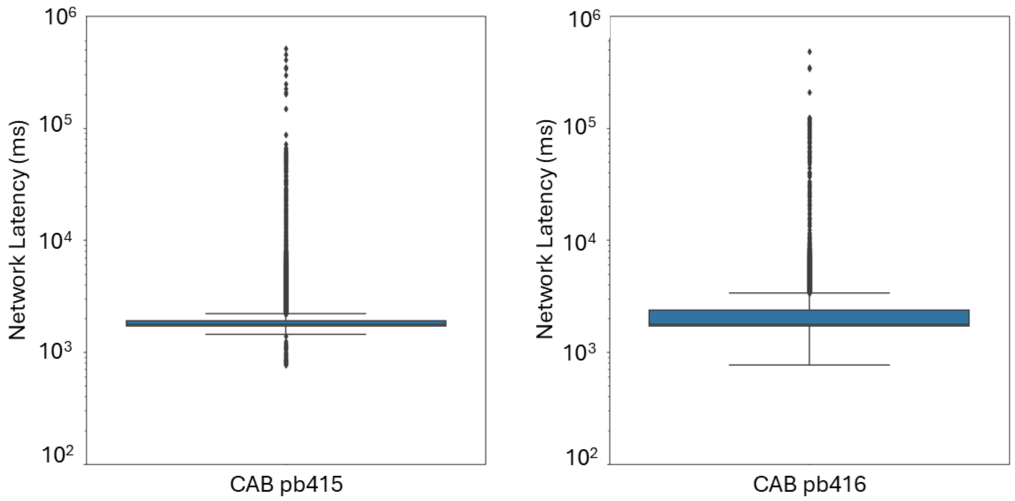

Figure 3: Data transmission latency (ms) as measured on both Ardersier Port buoys from 22 March to 5 June 2025 showing typical latency of < 1.3 sec. Latency in this example measures the time delay from when the data are sent from the buoy to when they are received on our cloud servers.

Conclusions

Passive acoustic monitoring has a long history of providing valuable information on ambient noise levels and species presence over long periods of time. Real time or near real time PAM has a much more recent history. Technological advances have made it much more feasible to use edge computing to measure noise and detect marine mammals in real time and transmit those data to mitigation teams and decision makers. This adds significant value to these data as it allows for meaningful mitigation of human activities to minimize impacts on marine life. By providing results in a timely manner, real time PAM also has the potential to reduce costs on developers by reducing activity down time and reducing regulatory reporting time.

References

Duarte C.M., L. Chapuis, S.P. Collin, D.P. Costa, R.P. Devassy, V.M Eguiluz, C. Erbe, T.A.C. Gordon, B.S Halpern, H.R. Harding, M.N. Havlik, M. Meekan, N.D. Merchant, J.L. Miksis-Olds, M. Parsons, M. Predragovic, A.N. Radford, C.A. Radford, S.D. Simpson, H. Slabbekoorn, E. Staaterman, I.C. Van Opzeeland, J. Winderen, X. Zhang, F. Juanes, 2021 The soundscape of the Anthropocene ocean: Science, 371(6529):eaba4658. doi: 10.1126/science.aba4658.

Palmer, K. J., S. Tabbutt, D. Gillespie, , J. Turner, P. King, D. Tollit, J. Thompson, and J. Wood, 2022, Evaluation of a coastal acoustic buoy for cetacean detections, bearing accuracy and exclusion zone monitoring: Methods in Ecology and Evolution, *00*, 1–12. doi: 10.1111/2041-210X.13973.

Parks, S., J. Miksis-Olds, S. Denes, 2014, Assessing Marine Ecosystem Acoustic Diversity Across Ocean Basins: Ecological Informatics, 21, 81-88. doi: 10.1016/j.ecoinf.2013.11.003