Article title should be less than 15 words, no acronyms

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Put your abstract here. Abstracts are limited to 100 words and should be in a single paragraph. Please avoid the use of personal pronouns or the words “new” and/or “novel” in the abstract.

1. Introduction and first-level headings

Understanding and reporting ambient noise levels is a crucial part of all passive acoustic studies. Ambient noise levels can influence local marine life, sometimes adversely, and introduce bias into density, abundance, or occupancy estimates (Oedekoven et al. 2022, Palmer et al. 2022). Within the context of BOEMs wind energy areas (WEA), there is a concerted effort to understand whether and how ambient noise levels change between the baseline, construction, and operational phases of offshore wind farms and how this may affect different. These baseline data are critical to monitor changes in sound levels from anthropogenic sources in space and time as activities related to offshore wind development commence (Gabriel et al. 2018).

In creating sound level metrics, it is important to consider that levels vary as a function of three-dimensional location as well as time (Choelwiak et. al 2018). As the goal of many bioacoustics studies is to measure soundscape changes as they relate to species of interest, it is important to measure sound levels within the habitat they utilize or estimate it based on local measurements. For example, in deepwater environment measurements obtained from bottom mounted hydrophones my be representative of the foraging habitat of deep living, or diving, species but may not be representative of surface dwelling. Similarly, measurements from coastal locations are unlikely representative of offshore locations. While considerable efforts have been made to create spatial noise maps, they are often based on simulated sound sources (cite some of JASCO’s work and or that coming out of Arhus). While these approaches are hugely valuable, there is also a need to estimate or validate the spatial extent of noise by asking to what extent noise metrics in one location are representative levels in non-measured locations when sound source levels and positions are unknown.

In this preliminary work we lay out one approach for addressing these questions using a selection of data from the ADRIFT project. The ADRIFT project uses clusters of drifting buoys to produce snapshots of ambient noise levels and animal presence in wind energy areas. These short-term deployments are intended complement existing longitudinal studies from nearby seafloor hydrophones (cite sanct sound something from scripts). In this work we use correlation and Kriging and methods to document spatial variability in soundscapes and lay the groundwork for better understanding how well single sensors represent sound within the greater region.

1. Methods
   1. Data Collection

The ADRIFT project seeks to characterize soundscapes and habitat use around an wind lease area approximately 40km from Morro Bay, California, USA. Audio data were collected using custom drifting buoy (henceforth drifter) with attached SoundTrap ST640s and HTI microphones. Each drifter consisted of a surface suppression including a pole buoy with attached GPS unit which transmitted GPS coordinates ever 20 min, and a 0.5m surface float.

Soundtrap ST640 attached to

* 1. Audio Processing

Audio data were downloaded and decompressed after recovery. End-to-end calibration value was estimated as the sum of the soundtrap calibration value and the HTI hydrophone calibration values, both provided by the manufacturer(???).

Soundscape metrics were calculated using Triton Software (cite xxx), audio data were first decimated to 48 kHz and then long-term spectral averages (LTSAs) were calculated with 1 sec and 1 Hz resolution. From these LTSAs, several metrics including broadband and third octave band calculations were made. For the purpose of this analysis, median third octave levels per two-minute bin were used. Only levels from the lowest and highest third octave bands (cetner frequencies, XXX and YYY) were included to show contrast between the two frequency bands.

Polynomial interpolation was used to estimate the GPS receiver position for each 2-minute periods between subsequent pings. In doing so each noise level record was associated with a location

* 1. Spatial and Temporal Cohesion

As a preliminary analysis, spatial cohesion of ambient noise levels were investigated across the 7 drifter array. Here we used correlograms to measure similarity in trend in ambient noise levels. A correlograms show the relationship between each pair of numeric variables of a dataset. Highly correlated noise levels are expected with closely spaced receivers (e.g. recording noise levels in similar areas) and with low frequencies, where the transmission loss is low and soundscape is dominated by distant shipping and or storms.

* 1. Spatial and Temporal Autocorrelation

Noise levels recorded by the drifters are naturally correlated in space and time so care must be taken in the analysis in order to conflate these effects. This can be achieved in a variety of ways including using variograms to fit spatial/temporal models (CITE Fields) and or with spatial-temporal covariance structures (CITE gstat), each with their cost and benefits. However, teasing apart the spatial and temporal constrains in such a model typically involves multiple measurements at a fixed location which is not present in these data.

Instead, we evaluate the data from two perspectives, first we look at the temporal correlation in order to better understand how similar noise levels are between the units. Highly correlated noise levels indicate large-scale phenomena acting across the extent of the array whereas small temporal variations are indicative of local phenomena such as biological activity or small vessels.

Noise levels across the array were de-trended by calculating the 60 minute rolling median noise levels for each band across all instruments. The spatial model response was defined as the difference between the observed noise level and the rolling median noise level at that time.

We then use Kriging modelling of the normalized data to investigate areas with larger variation in ambient noise levels.

By separating the spatial and temporal components we are able to investigate the spatial extent of noise levels originating from large scale phenomena, such as storms, as well identify regions of higher noise activity caused by short-term activity sounds within the WEA.

* 1. Spatializing Fields

Following normalization, the fields package in r (cite xxxx) was used to investigate spatial variation in noise levels during the snapshot period. The fields package uses maximum likelihood to estimate covariance parameters for a user-defined covariance model (i.e. Kriging) and

. Different covariance structures were investigated with a subset of the total dataset through the use of variograms. Through this process the Matern covariance structure was selected. This was then fit to the full, 2 minute dataset using the micro-Krig process which is optimized for large datasets which uses Monte Carlo simulations to estimate the compute the trace of the smoothing matrix in the case of large datasets.

The model summary is reported as well as the predictive power of the method through k-fold cross validation in which one drifter is held out, the model is recreated with the remaining drifts and the predications are compared to the observations at the held-out model.

1. Results
   1. Data Collections

All seven drifters were deployed on March 11th, 2023 in the Morro Bay WLA and recovered by the 16th of March. All drifters transited south with the prevailing currents and six of the seven drifters stayed roughly clumped together. The drifter nearest shore, ADRIFT\_53, travelled further and faster than the remaining units. Median speed across all drifters was 0.15 m/s with a standard deviation of ±0.08 m/s. The distance travelled from deployment to recovery, ranged from 40.6 km to 66.8 km. The total distance travelled by each instrument throughout the deployment ranged from 61.9 km to 77.3 km for ADRIFT\_53.

* 1. Spatial Cohesion

Figure 1shows the 2-minute median noise level in two third octave bins during an 8-day drift near the Morro Bay WEA. Increase in noise levels from two storms are march 14th and 15th that raised baseline noise levels approximately 10 and 20dB re 1µ Pa for the lower and upper third octave band respectively.

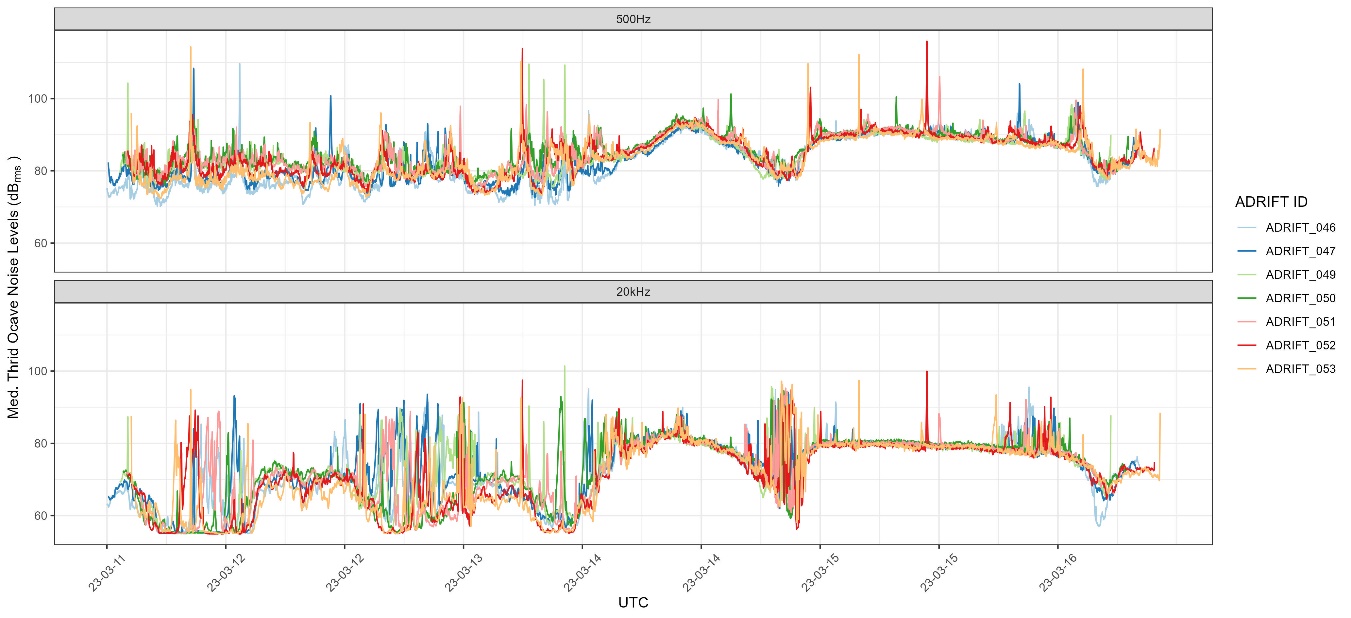


Figure 1 500 Hz and 20 kHz 1/3rd octave band timeseries of noise levels measured by ADRIFT.

Correlations in raw noise levels between instruments were also high ranging from 0.64 to 0.83 in the 20 kHz band and 0.70 to 0.91 in the 500 Hz band (Figure). After normalization, these values were decreased to -0.16 to 0.46 in the 20 kHz band and -0.24-0.52 in the 500 Hz band.

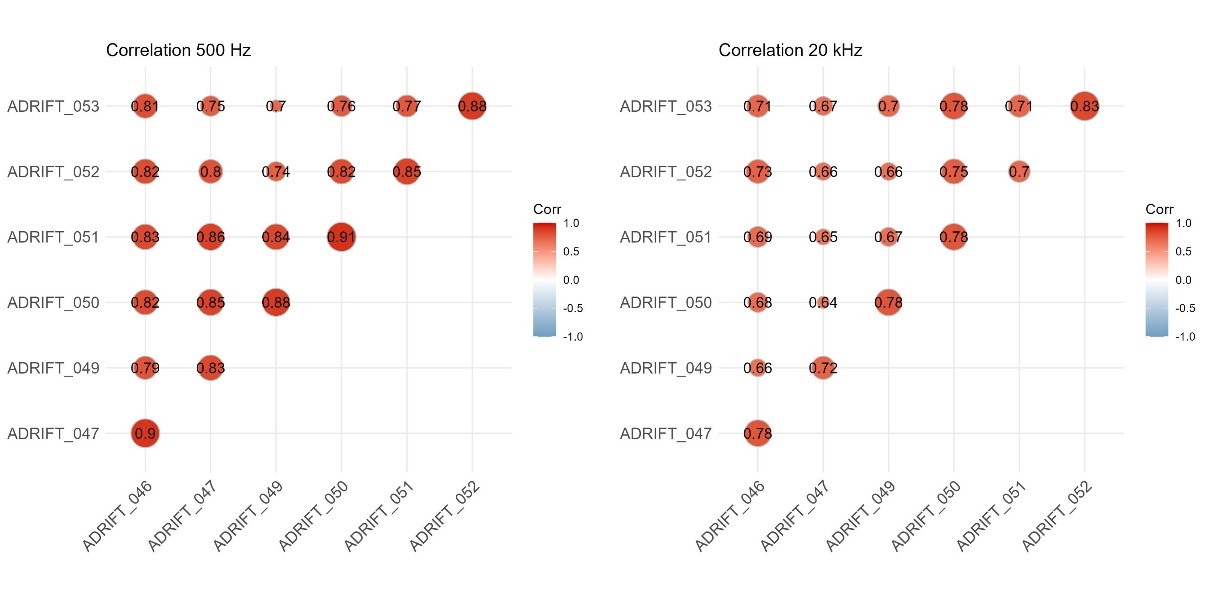


Figure 2 Raw collation scores between drifter data in the 500 hz (left) and 20 kHz (right) third-octave bins.

* 1. Spatial Cohesion

Model fitting resulted

4 Discussion

* Shown an approach for spatializing noise
* When used alone, can provide insights into
  + Propagation conditons
  + Spatial soundscape
* Can be combined with other analyses
  + Validate propagation models
  + Combine with windspeed to discriminate between environmental and anthropogenic inputs to the soundscape
  + Include spatialized noise levels in a predictor for habitat use for acoustically sentitive species

1. Conclusion

And in conclusion…

Supplementary Material

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Author Declarations

Conflict of Interest

A conflict-of-interest statement is required. If there are no conflicts to report, the authors must state that they have no conflicts to disclose.

Ethics Approval

Data Availability

A data availability statement is required. For the *Journal'*s data policy and suggested templates, please see the Information for Contributors: <https://pubs.aip.org/asa/jel/pages/manuscript>.

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