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THE CASE FOR SPECTRAL BASELINE NOISE MONITORING FOR ENVIRONMENTAL NOISE ASSESSMENT

Michael Caley[1] and John Savery[2]

[1]Senior Consultant, Savery & Associates Pty Ltd, Brisbane Queensland
[2]Director, Savery & Associates Pty Ltd, Brisbane Queensland
mcaley@savery.com.au

Abstract

Norms of baseline environmental noise monitoring practice have historically been influenced by available instrumentation, often to the detriment of the technical needs of a monitoring situation.

Within Australia instrumentation that has been designed for broad-band traffic noise measurement at relatively high ambient noise levels is often used to measure low ambient noise environments where the results are critical to the impact assessment of major infrastructure projects. Often these noise environments contain significant seasonal and episodic biological noise.

A particular difficulty with traditional broad-band noise loggers deployed in relatively low noise environments is the inability to identify the contributions of seasonal and episodic noise sources such as insect and frog noise, resulting in an elevated assessment of baseline noise levels. Consequences of this limitation include:- difficulty achieving repeatability of 'long-term' baseline noise monitoring results by different acoustic practitioners; aggregate measures of diurnal noise patterns can appear counter-intuitively skewed, with night 'background' noise levels matching or even exceeding daytime 'background' noise levels; and environmental license conditions can be unintentionally overly permissive if based on the results of broad-band noise measurements that include seasonal biological noise.

A related issue that is briefly discussed is the need for baseline noise monitoring to provide a baseline noise spectrum shape to assist in determining the audibility of an introduced noise source.

Spectral baseline noise measurements enables evaluation of the content of baseline noise records, and in particular, the contribution of biological noise sources that may be present seasonally, or episodically. Examples are presented that contrast the conclusions that can be drawn from spectral baseline noise monitoring compared with traditional broad-band noise logging.

1. INTRODUCTION

1.1 Why does a baseline survey matter?

A baseline noise survey is fundamental to the impact assessment of introduced noise.

In many jurisdictions noise emissions limits for new industrial facilities and transportation infrastructure are based on the results of a baseline noise survey. The results of the baseline survey are then critical to the public account of potential noise impacts, environmental noise licensing and subsequent determinations of noise compliance.

1.2 The Problem

It may then come as a surprise to some that at times acoustic practitioners ‘guestimate’ baseline noise conditions for sizeable industrial facilities such as power stations, refineries, and port facilities, or unwittingly rely on heavily biased baseline noise samples.

The first common reason given for baseline ‘guestimates’ is that the instrumentation possessed an insufficiently low noise floor to capture the full dynamic range of baseline noise levels. The unstated reason would be that the project budget and timing would simply not accommodate re-measuring baseline noise levels with suitable instrumentation.

The second reason that is less commonly given for ‘guestimates’ which is of interest to this discussion, is that baseline monitoring was conducted with broad-band noise loggers that did not enable the discrimination of significant seasonal insect/frog/bird noise known to the ears of the acoustic practitioner. In this circumstance a lower ‘guestimate’ of baseline levels may be made.

Perhaps the worst situation is where the practitioner uncritically accepts the raw broad-band baseline noise data, without any evidence of what the noise environment is comprised of, and for some, as the saying goes, ignorance is bliss – at least in the short term. If one doesn’t know that the night-time baseline noise is ‘teaming’ with frog and cricket noise, and that the daytime record is ‘redlining’ with cicada noise, it might be found in the fullness of time that noise criteria have been set too high, resulting in unexpected noise complaints.

So what should be done?

1.3 Ideal (Nearly Never) Baseline Monitoring Time Frame

Ideally, acoustic practitioners would have the luxury of a baseline noise survey extending over a whole year, capturing the quiet times and the noisy times, inclusive of all meteorological and seasonal biological acoustic conditions. Statistically significant baseline parameters could be determined from the results of broad-band noise logging for the complete year.

1.4 Actual Baseline Monitoring Time Frame

In practice time is nearly always in short supply, and the idea of waiting six months until winter to complete baseline sampling for an environmental application due next week is not an option. Generally the period available for baseline monitoring is limited to no more than one or two weeks, similar to the minimum 'long-term' monitoring period defined by regulatory guidelines. For smaller investigations monitoring periods will often be much shorter at 1 to 2 days duration.

In years when rain is plentiful, acoustic practitioners may have difficulty completing baseline noise monitoring during non-rain periods, or shortly after the cessation of rain. In these non-rain periods there will often be elevated levels of biological noise. Amphibian noise chorus can dramatically increase ambient noise as these creatures 'cluck', 'blop' 'chuckle' 'tock' and 'squaaark' away the night. Crickets can turn on pure tones, and a sort of cricket Morse Code. Cicada noise can reach a tearing roar in warm conditions.

Baseline noise monitoring is usually, in relative terms, just a 'snapshot' of the noise environment rather than a balanced sample of the full range of acoustic conditions that may exist at a site. As a 'snapshot', the results of baseline noise monitoring cannot be accepted uncritically. To minimise the potential for bias of baseline results through inadvertent inclusion of significant biological noise, it should be the responsibility of the acoustic practitioner to know as far as practicable what this sample of the noise environment is comprised of.

2. SPECTRAL BASELINE NOISE MONITORING

Acoustic instrumentation has now developed sufficiently that spectral analysis of the "snapshot" baseline noise record is possible, available and cost-competitive. The possibilities range from simple octave-band statistical noise logging, continuous third-octave band logging at short (0.1 to 1 second) intervals through, to complete digital audio recording to permit replay or FFT analysis to assist in the identification of noise sources.

2.1 Case Study – Short Term Baseline Noise Monitoring

The 24 hour time history presented in Figure 1 represents the ambient noise environment in a suburban environment in a central Queensland city, as would typically be presented from the results of a Type 1 broad-band noise logger.

The noise survey was conducted in January 2007, with no possibility of monitoring during winter months. In this instance the project budget did not justify one week of noise logging.

It appears that the day-time and night-time background noise levels are very similar, with night-time baseline levels unexpectedly higher than daytime levels, and some known freight handling operations that has increased ambient noise levels between 1900 hours and 2000 hours.

While it may be suspected that insect noise has contributed significantly to overnight noise there is not enough information from broad-band noise record to make a correction.

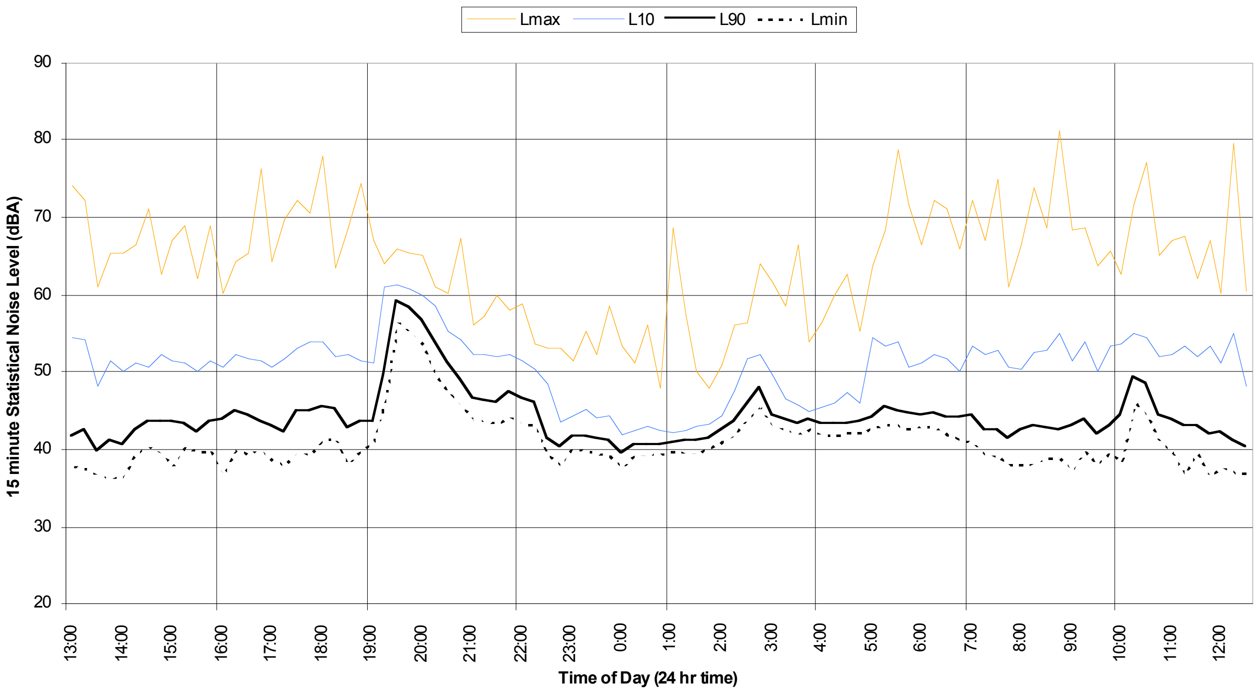

Figure 1. Broad-Band Statistical Baseline Noise Record

From the spectral noise data the presence of the insect noise that dominated the night-time noise spectrum can be confirmed as is illustrated for the example 3am 15 minute time slot. One-third octave noise data is illustrated as a sonogram on Figure 2, waterfall plot on Figure 3 and $L_{A90,15minute}$ spectrum on Figure 4.

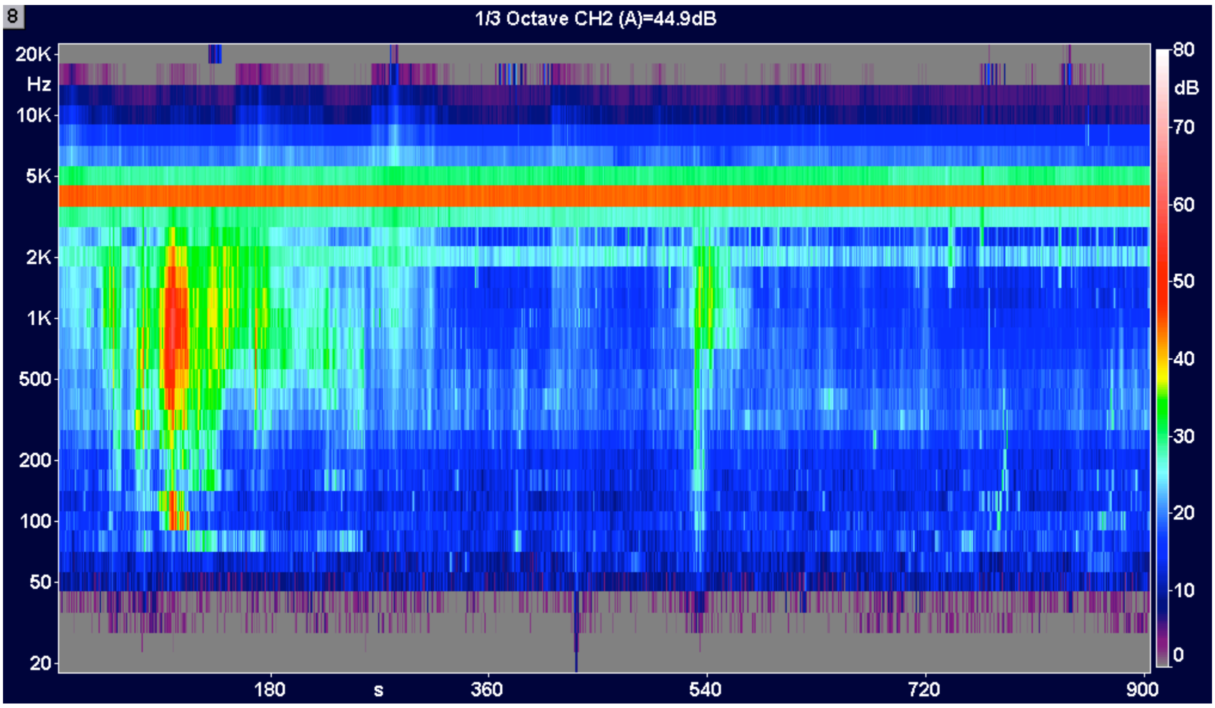

Figure 2. 15 minute One-third Octave Sonogram Representation of Ambient Noise at 3am

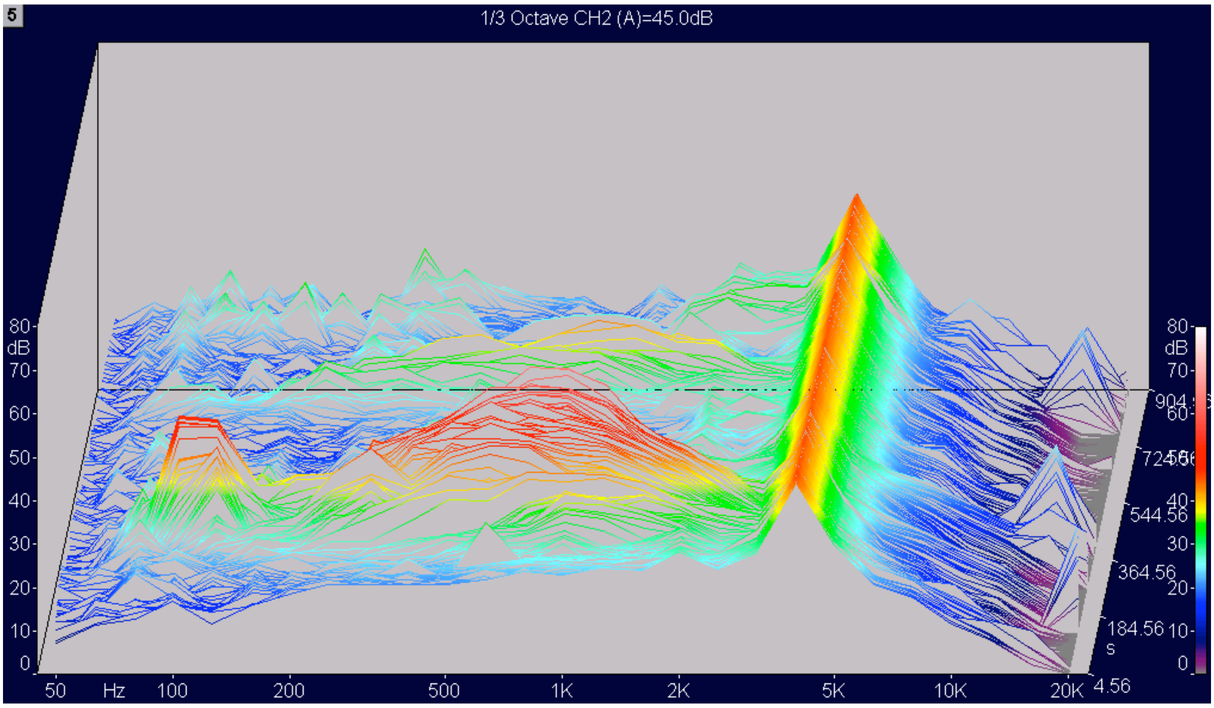

Figure 3. 15 minute One-third Octave Waterfall Representation of Ambient Noise at 3am

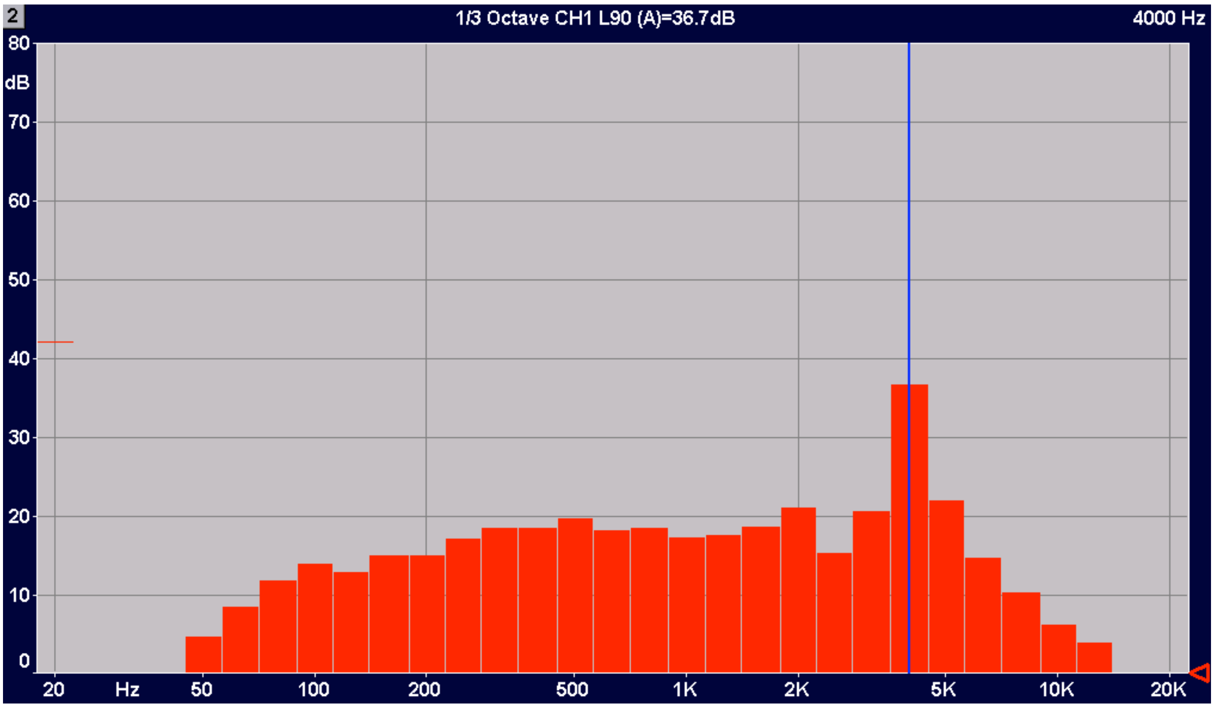

Figure 4. 15 minute One-third Octave L_{A90} Spectrum of Ambient Noise at 3am

When the one-third octave record is used to remove the insect noise within the 4 kHz band a substantial reduction in the Assessment Background Noise Level (ABL) results as illustrated in Table 1. Without spectral analysis a 10 dB over-estimate of night-time assessment background noise level (ABL) would have resulted.

Table 1. Assessment Background Noise Levels

Time Period	Assessment Background Noise Level (L_{A90})	
	With Seasonal insect/Frog Noise	Seasonal Noise Excluded
Day 7am – 6pm	41	41
Evening 6pm – 10pm	44	35
Night 10pm – 7am	41	32

2.2 Algorithm for removal of unwanted biological noise

Once the presence and frequency bands of significant biological noise has been identified by perusal of a sonogram or waterfall plot (or even better by listening to an attached audio sample) an algorithm is needed to mathematically extract or modify these band contributions to re-calculate the aggregate measure of baseline noise (e.g. ABL or RBL) that would have occurred if the biological noise had been absent.

Two algorithms have been used by the authors to extract unwanted biological noise from spectral background noise records. The first simpler method is to fully deduct the energy in the band of interest from the all-pass L_{A90} level. This method may lead to some under-estimation, particularly for octave-band data, as this assumes an energy level of 0 dB in that band.

The second and preferred method of extracting unwanted biological noise is to replace the band level(s) containing the biological noise with a level approximated by interpolation from 'normal' adjacent frequency bands.

2.3 Audibility Investigations – Industrial Facilities

There are many noise impact assessment situations where the assessment of audibility requires a frequency spectrum approach. The most common outdoors situation is the assessment of amplified music containing significant music bass.

There are many more situations where broad-band statistical dB(A) analyses are conducted that are arguably more suited to a frequency-dependent analysis. However the most pressing situation is believed to be the prediction and assessment of noise from large industrial facilities.

Predicting the audibility of tonal components of industrial facility noise in low ambient noise environments is an area of acoustic modelling that is not well developed in Australia. A significant difficulty encountered is the limited availability of spectral source emission data. This difficulty may be facilitated by the simplicity of broad-band noise planning and compliance criteria generally. For example, power station turbine manufacturers (or manufacturers of almost any large plant item) will often advise source noise emissions as 85 dB(A) at 1 m, which reflects their contractual obligations in relation to OH&S rather than any serious attempt to characterise the actual noise output.

However the fact that noise complaints relating to industrial facilities usually relate to tonal characteristics indicates that broad-band dB(A) analyses of impact and potential audibility will eventually be superseded by a spectrum-based approaches. A first step to carrying out this type of analysis will be the collection of spectral baseline noise records.

3. CONCLUSIONS

Baseline noise parameters determined from broad-band noise logging can readily be over-estimated by as much as 10 dB(A) by the unintentional inclusion of seasonal or episodic noise of biological origin.

To minimise the potential for bias of baseline results through inclusion of significant seasonal or episodic biological noise, or man-made noise, spectral baseline monitoring is recommended.

Spectral baseline noise monitoring allows the presence and frequency bands of significant biological noise to be identified by perusal of a sonogram or waterfall plot for the monitoring period. Algorithms can then be applied to mathematically extract or modify these band contributions enabling re-calculation of the aggregate measures of baseline noise (e.g. ABL or RBL) with significant biological noise removed.

In addition to improving the reliability of broad-band baseline noise parameter estimates, it is anticipated that the use of spectral baseline noise monitoring will increase as analyses of environmental noise, and industrial noise in particular, are refined to predict and assess the audibility of problematic tonal characteristics.