The Serenity of the Surf

Not refereed

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Abstract

Quiet bach at the beach? Gentle soothing waves breaking on the shore? Does the reality match the dream?

What of the long straight ocean beach, with kilometres of endless waves; the ultimate "line source" perhaps?

This paper endeavours to establish the Sound Power Level of New Brighton Beach in Christchurch. A relationship to distance is determined, and the effective screening from houses is examined. Most of all, an answer is sought to the question "Is living near the beach as quiet and peaceful as our dreams lead us to believe?".

Introduction

Brighton beach, on the eastern edge of Christchurch, stretches from the southern spit of Southshore, north over 20km to the mouth of the Waimakariri river with barely more than a slight curve.

Beyond the river, the beach continues northwards, gradually arcing eastward over many kilometres.

Being an ocean beach, Brighton's shore is best known for its surf.

Because of its length, it is rare to be able to hear a single wave crashing. Instead, the sound of the beach is more akin to a pink noise source—continuous and almost unchanging.

Most nights, even at locations 1/2 km from the beach, passing traffic on a street 50m away is barely audible due to the constant sound of the sea.

Typical Sound Levels

As a convenient reference point, a number of measurements have been undertaken at a residential property in South Brighton—coincidentally owned by the author. This is just over 500m from the high tide mark.

The terrain between the beach and this property is completely flat, with the exception of a sand dune along the foreshore, maintained as part of current Council policy to a height of 8m above mean high water mark.

At this location, measurements taken over a period of several months show that the background noise level (L_{95}) typically varies from 40 dBA to 55 dBA, rarely dropping much below this range, irrespective of the time of day.

Whilst a stormy day may well exceed 55 dBA, weather conditions during such times prevent reliable noise measurements from being made.

The spectrum is typically as shown in figure 1. A typical spectrum at the

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Brighton Beach and foreshore sand dunes—an ideal line source?

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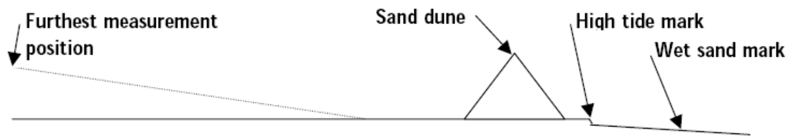
top of dune position is also shown.

Attenuation with Distance

Brighton beach is an excellent example of a line source. According to acoustic theory, sound levels at distances up to about 1/3 of the source length (length/π) drop off at the rate of 3dB per doubling of distance.

To measure the actual relationship, 3 separate locations have been chosen. The first of these is a residential street, perpendicular to the beach.

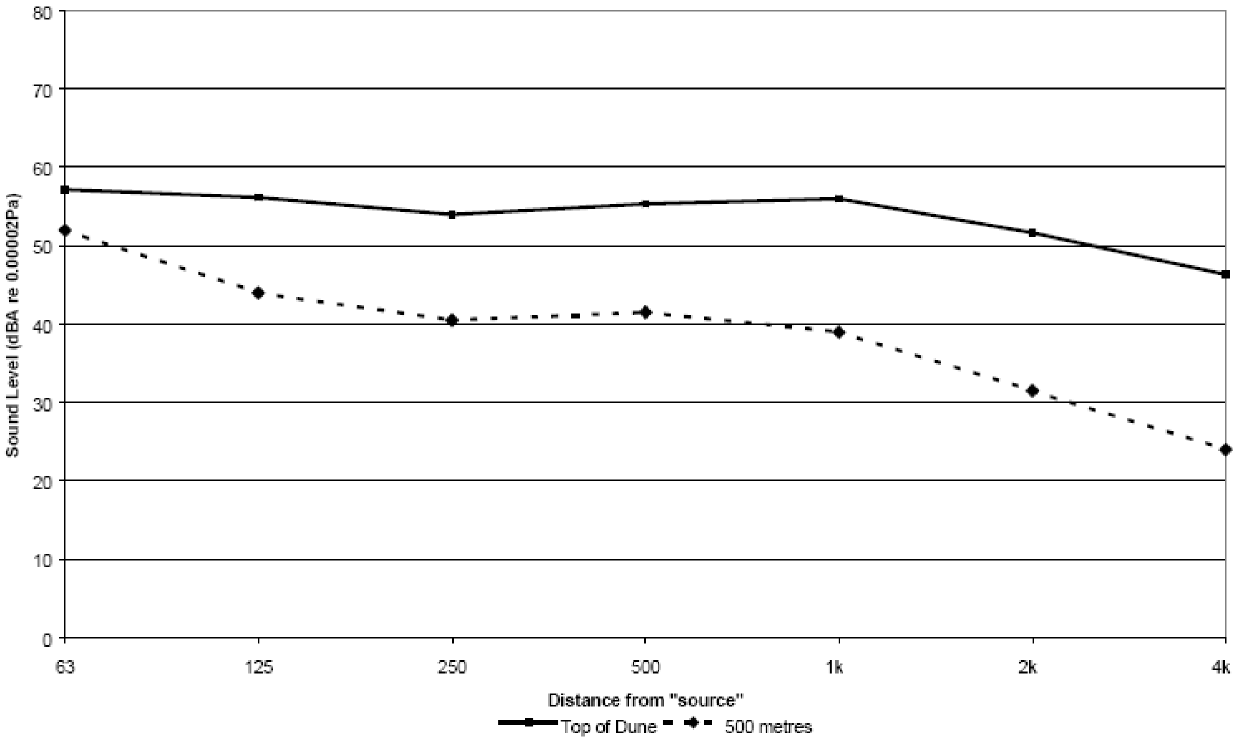
The second is a public park and golf course, with slight undulations in ground level, and several rows of mature pine/macrocarpa trees parallel with the beach.



Intervening land features	Approx. width of sand dunes	Approx. distance from high tide to centre of dune	Ground height at furthest measured position
Residential	30m	60m	1m above high tide
Park/some trees	30m	65m	5m above high tide
Rough Farmland	80m	150m	1m above high tide

Table 1: Indicative cross-section of measurement paths

Figure 1: Typical Spectra



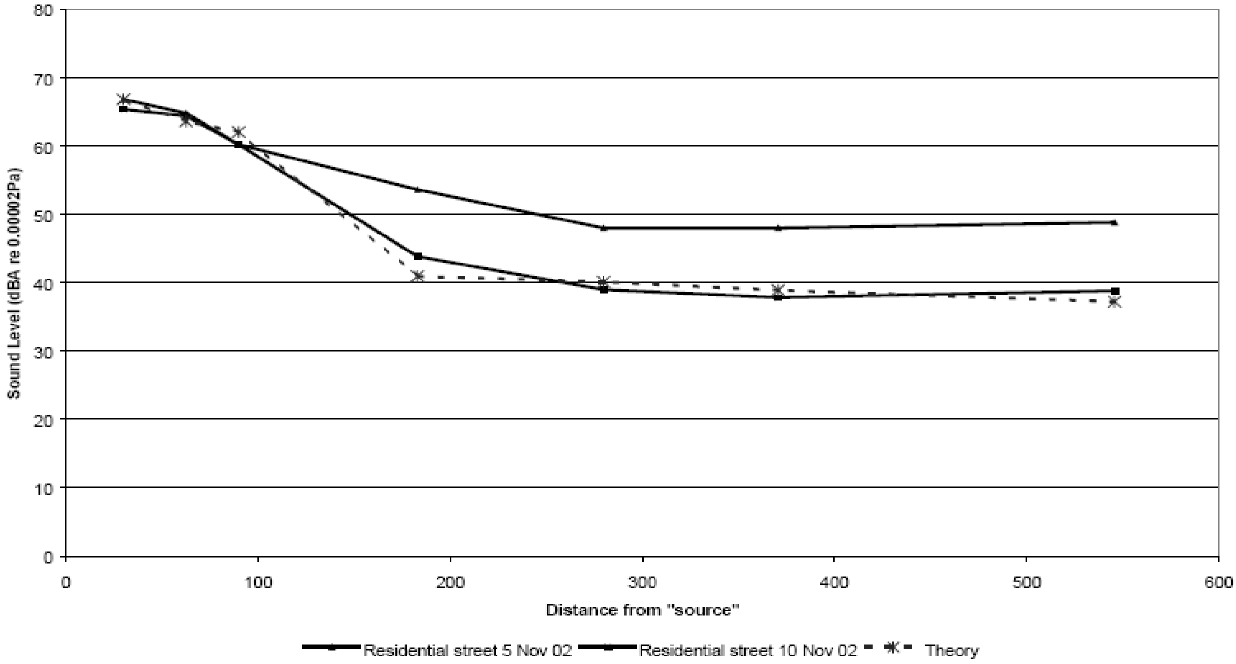


Figure 2: Residential Street

The third location includes a large lagoon and rough open paddocks.

These three locations are separated from north to south by a total distance of approximately 11km.

Interestingly, on two occasions recently, the wind direction on the beach at the northern location was completely different to that at the southernmost location—raising the possibility of additional down-wind effects at some locations.

The arrangement of the sand dunes and land varies slightly from location to location. Table 1 indicates the approximate arrangement.

In all cases, the source position has been assumed to be 30 m from the wet sand mark.

Figures 2 – 4 show the results of measurements at each of these three locations. Also shown on these figures is the theoretical behaviour, normalised to the measured level at the "wet sand mark", being the position of the tide at the time of measurement. On 5th November, the tide was outgoing, and the wet sand mark was approximately 30 m below the high tide mark. On 10th November, the tide was incoming, and the wet sand was only about 15 m below high tide. By Brighton

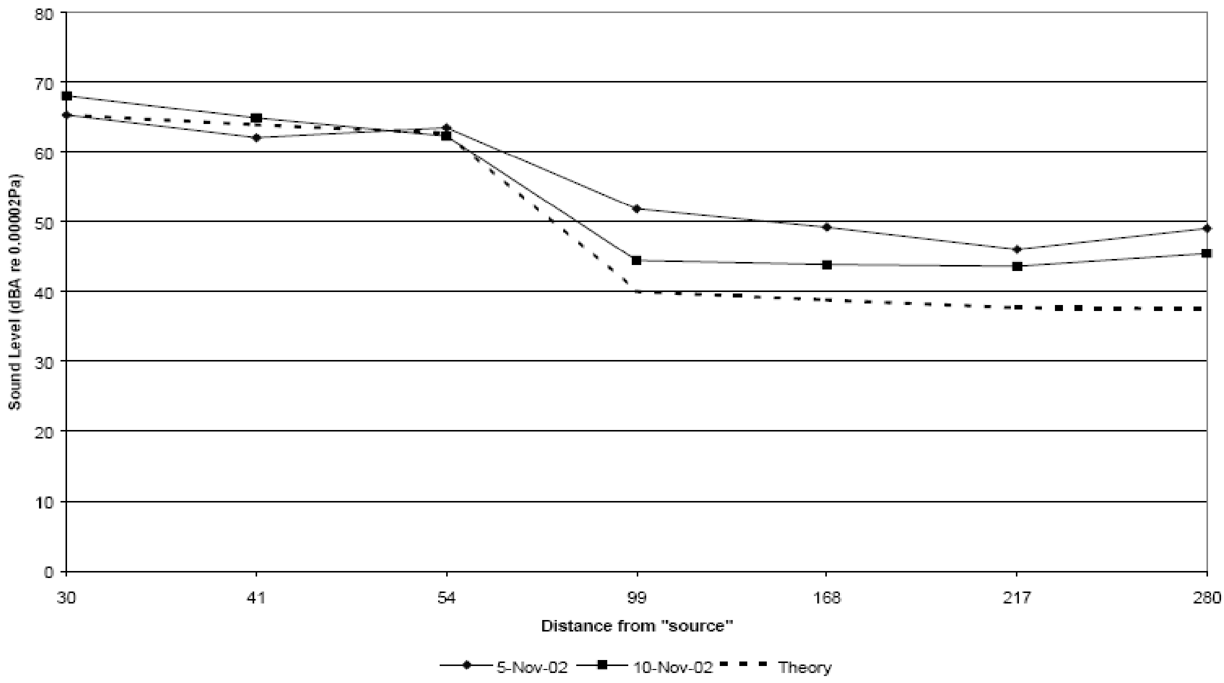


Figure 3: Park with Some Trees

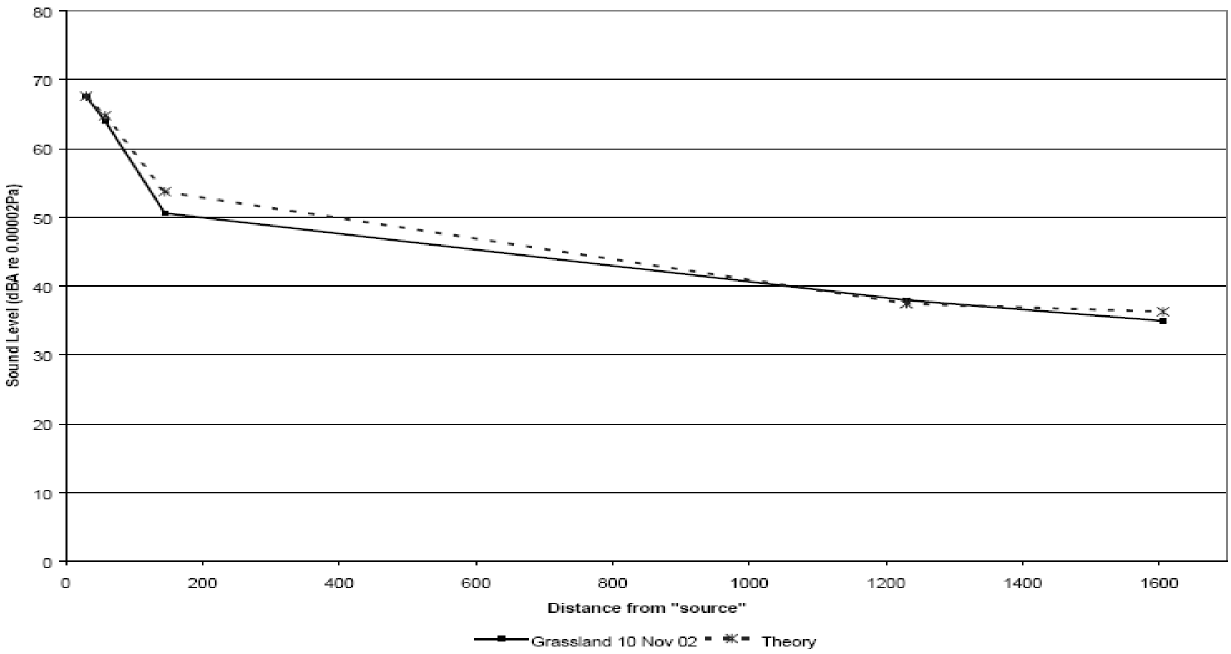


Figure 4: Rough Farmland

standards, both days were "flat calm", with waves only about 300 mm high—considerably smaller than perhaps the norm.

The sound measurements shown are the L_{95} values. Whilst this might arguably slightly under-represent the sea noise, it made the task of eliminating extraneous noises considerably simpler. All measurements were made using a Brüel & Kjær precision grade sound level meter type 2260.

To account for the barrier effect of the sand dunes, a simple screening calculation was undertaken using a typical spectrum measured at the top of the dune. A brief calculation showed that for this noise source, the A-weighted barrier insertion loss is numerically equivalent to the 1 kHz value.

Hence, the remaining calculations were done by simply applying the 1khz value based on the calculated path length difference for each measurement position. Interestingly, the calculated barrier insertion loss at distances up to about 500m was around 17 - 20 dBA—significantly greater than the typical 10 dBA which we assume for a fence/mound.

So the next time you are asked to guarantee 15 dBA from the fence you have proposed as mitigation, all you have to do is ensure that it is 8 m tall and as wide as a sand dune!

It is interesting to note that the house owners near the beach who periodically petition Council to remove the dunes would experience sound levels of about 60 dBA (L_{95}) even on a quiet day.

Add this to the cold blast of the typical easterly wind and one wonders at the merits of their proposal.

From figures 2 – 4, we can see that the measured levels on 10th November show extremely good agreement with theory. So good, in fact, that the cynical observer might well assume that the method has been massaged to give the required results.

These measurements were undertaken early in the morning, on a day when the wind developed into a strong north-westerly. Hence, any hint of wind during the measurements was of a west or north-west direction, and hence directly "offshore".

In contrast, the wind on the 5th November was a light on-shore wind (east to south-easterly). The measured noise levels are typically around 10 dBA higher than with the offshore wind, despite the levels close to the sea being almost identical.

However, the drop off with distance beyond the sand dune is very close to the 3 dBA per doubling observed in the later measurements, which suggests that the effect of the on-shore wind is to significantly reduce the barrier performance of the sand dunes.

This behaviour is predicted in the texts, and it is perhaps notable that it occurs with even a very light breeze. The results suggest that 10 of the typical 17 dBA insertion loss is lost with a light breeze towards the receiver. With slightly more wind, it is entirely possible that the remaining 7 dBA insertion loss is also lost, and this would account for the total measured variation of around 17 dBA in sound levels at the chosen residential property.

It is interesting to note that distance attenuation alone provides exceptionally good agreement with the measured data. Other effects such as soft ground attenuation do not seem to be significant, although a more detailed spectral analysis may prove otherwise. However, theory states that soft ground attenuation only occurs when the sound path is at a constant height over the intervening ground, and therefore it should not occur when there is a large barrier in place such as the sand dunes.

In the case of the measured residential street (figure 2), it is notable that there is no obvious additional noise reduction due to the screening from houses on either side of the street. Although each measurement position on the street has a clear line of sight to the sand dune, the houses mean that this is a very narrow angle of view, which would normally be expected to reduce sound levels somewhat.

Sound Power Calculation

Given the good agreement between measurement and theory, it is interesting to calculate the approximate sound power level of the beach at Brighton on a calm day.

Using the three measurement locations, and taking the "wet sand mark" measurement as a basis, the data shown in Table 2 is obtained.

The calculated sound power level is not numerically as high as one might imagine. However, it is important to remember that the calculated sound power level of a line source is actually the sound power per metre of its length. Every metre of the more than 20 km of its length, Brighton beach produces a sound power level of around 93 dBA. If it were possible to somehow squeeze all this energy into a single point source, the total sound power level of that source would be around 136 dBA. Now that is a serious noise source.

Table 2: Sound Power Level

Location	Calculated Sound Power Level
Residential	93 dBA
Park/some trees	91 dBA
Rough Farmland	93 dBA

Conclusions

The relationship between sound level and distance from the sea follows the expected 3dB per doubling relationship for a line source, irrespective of whether the intervening land is open parkland, rough farmland or a residential street perpendicular to the beach.

The Council maintained sand dunes at Brighton are providing acoustic screening in the order of 17-20 dBA.

If the 20km length of Brighton beach could be compressed into a single point source, the total sound power level would be around 136 dBA.

Living near the beach in Christchurch results in background noise levels of 40–55 dBA even at properties 500m from the beach. If the sand dunes were removed, residents close to the beach could expect background levels of around 60 dBA even on a calm day. Serenity indeed! ❑