What is “Dynamic Range”

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Retired audio curmudgeon

Dynamic Range

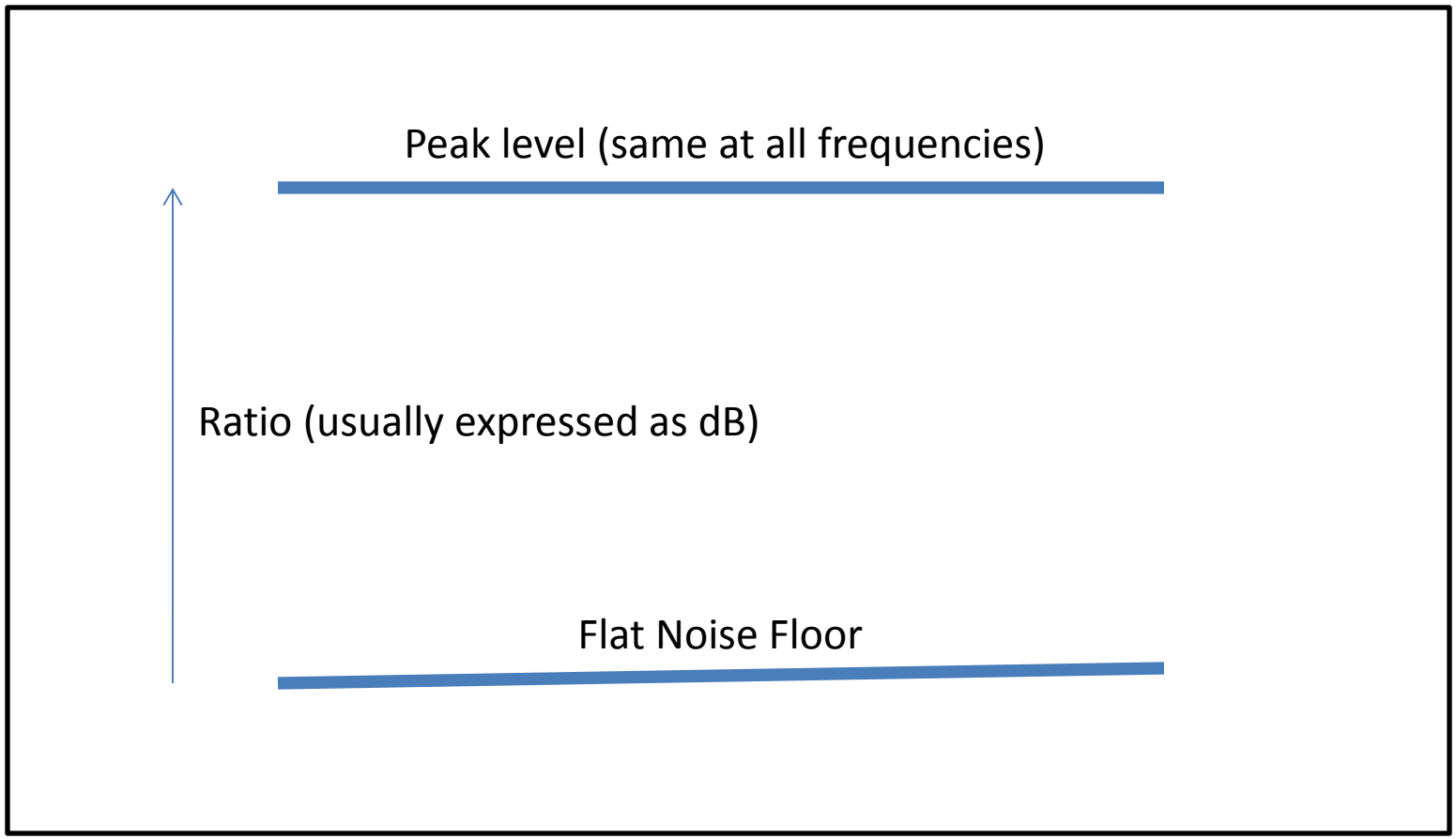
- Is it a perceptual thing? What kind of experience do listeners have:
  - Does that mean over the short term?
  - Does that mean from Loudest to Quietest?
- Is it an analytic thing?
  - Does it mean peak signal to lowest level
  - Peak to noise floor
  - RMS to noise floor
  - But what about peak/RMS ratio?

NOW, THAT'S A
REALLY
REALLY
GOOD QUESTION

There are some standards:

- I’m not going there.
- They are standards that are analytic measurements.
- They are what they are.

A Simple way to define it:



Otherwise it hasn't been defined very well.

- Some issues that might be involved
  - Is it loudness (i.e. perception)
    - Does that vary in the short term? Does that matter?
    - Does it vary in the long term? Does that matter?
    - Is it the Loudest to Softest part of the recording
      - But what about room noise, then?
    - Is it the distribution of loudnesses?

Who remembers what Loudness is?

- Loudness is sensation level
- Energy measurements are analytic levels

Loudness and Intensity

- Loudness is not SPL
- SPL is not loudness
- Don’t forget that.

Some analytic possibilities:

- It’s RMS level vs. noise floor
- It’s Peak Level vs. noise floor
- It’s bit depth
  - Room noise?

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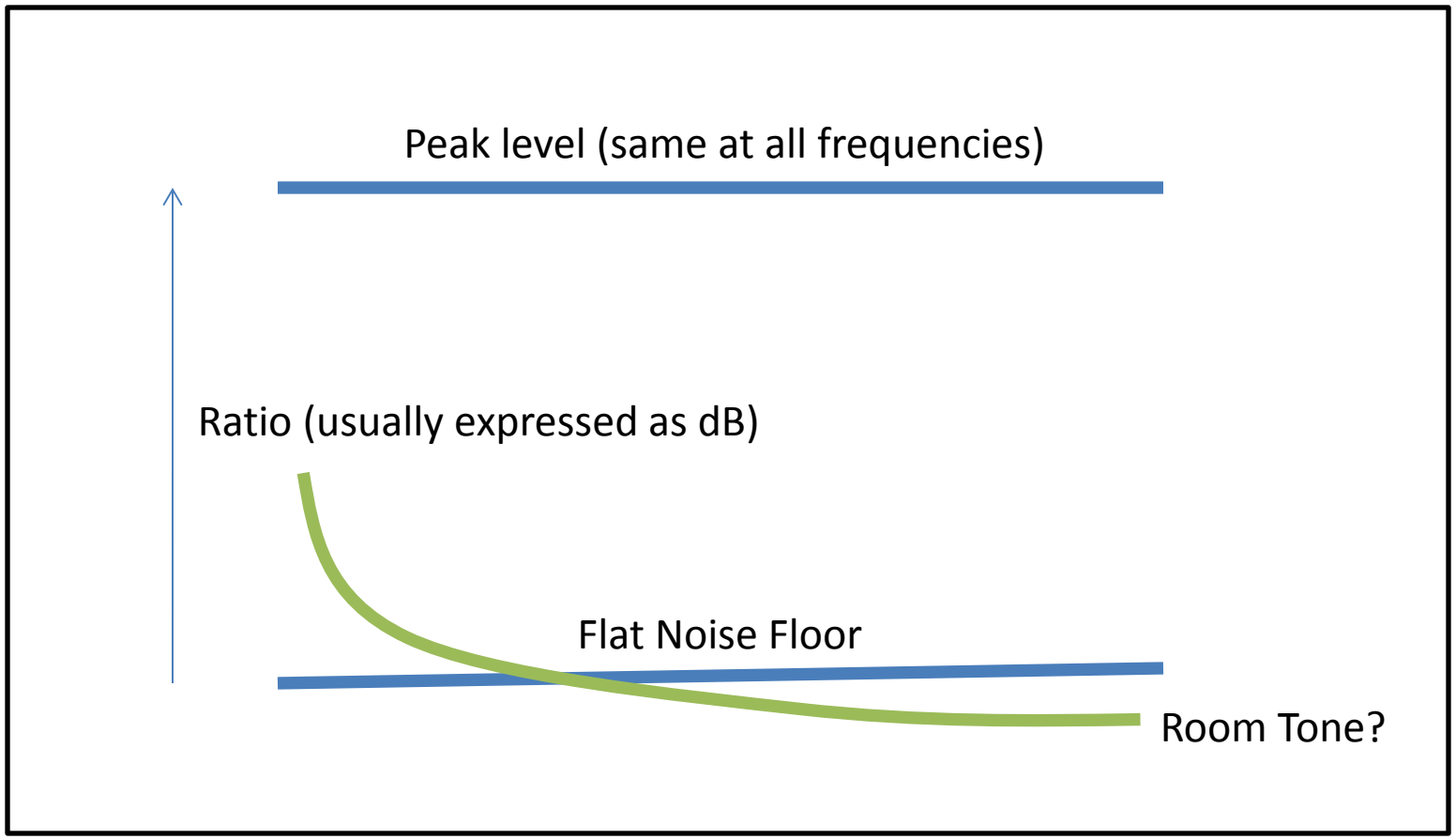
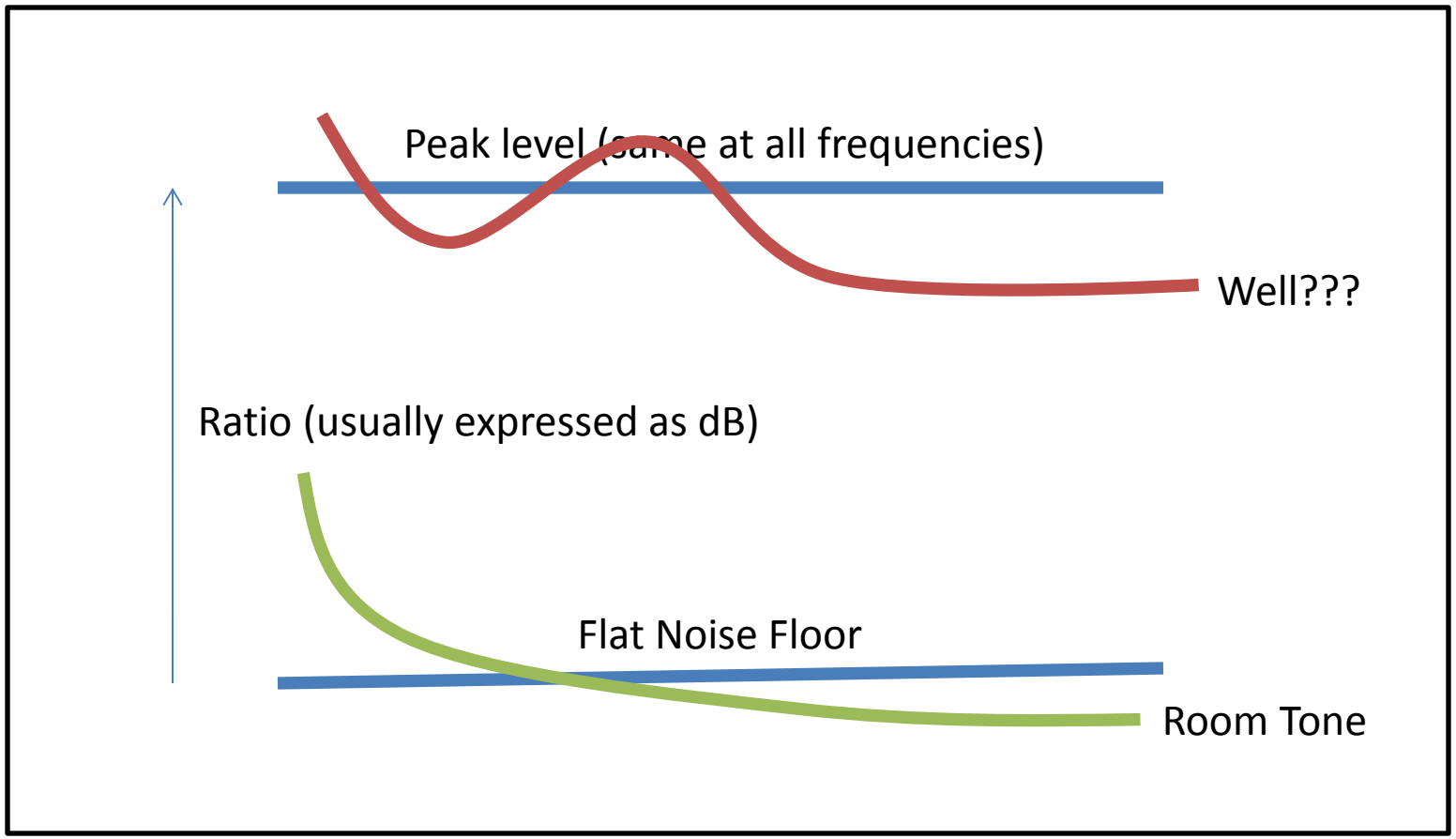


What peak?

- Highest level at some given frequency?
- Maximum RMS with white/pink noise?

- Peak level is frequency dependent in some systems.
  - Including some systems fed by PCM data, in fact.

A Simple way to define it:



Some Good News

- PCM and most (but not all) low-level electronics have a pretty flat noise floor and peak level.

- Amplifiers, speakers, vinyl, tape, FM, AM, well, not so much.
  - But that's bad news. Sorry.

Analytic Measurements

- They are very useful in some cases.
  - They help determine noise floor
  - They help determine overload issues

- THEY ARE ESSENTIAL TO UNDERSTANDING YOUR OVERALL GAIN STRUCTURE.

- So, when you are setting up a system, pay attention.

About “Dynamic Range” in amplifiers, etc?

- That is an analytic measurement, expressed in dB:
  - Maximum output is measured or calculated
  - Noise floor (perhaps in the presence of signal for digital equipment, to avoid zero-stuffing) is measured
  - The ratio is expressed in dB, providing us with a dynamic range measure.

The dynamic range of a listening room:

- Consider a reasonably quiet listening room, with the usual stereo equipment:
  - Low level (dB C) circa 40dB C
  - Low level (dB A) circa 20dB A
  - Peak level from a stereo 105dB C
  - Dynamic range is then 65dB – Doesn't seem like much, does it?
    - But wait, why the difference in C vs. A weight?

- True, but <u>useless</u>
  - You need to consider the frequency shape of the noise floor here.
    - And it wouldn't hurt to consider the spectrum of the signal you're listening too, either.

Noise Spectrum

- Even in the absence of peak level that changes with frequency, we need to look at the noise floor:
  - This affects PCM with a flat noise floor and peak level when the signal goes through any other equipment.
  - So, maybe a meaningful measurement would be “dynamic range as a function of frequency”
    - But there must still be assumptions made, except when you’re working on your gain structure.

Analytic measures

- Essential for setting up systems, gain structure, etc.
- Not very revealing for the average listening room
- Vary across frequency
  - Nobody measures that
  - Nobody provides that in their specs!

What's more useful (perhaps)?

- Perceptual systems.
  - Short-term variations in loudness do seem to correlate to "dynamic" signals
  - Long-term variations in loudness seem to give people a sense of dynamic range

- So, are "dynamics" short term or long term?


YES!

What do we measure Dynamic Range in units of, then?

- Well, that's a good question, presently one will see dB everywhere.
  - Sones or Phons would make sense for the perceptual issues. (remember, loudness is a perceptual quantity, not an analytic quantity)
  - How would we compare this to dB?
    - You can't.
    - Really.
    - Different problem, different units.
    - Don't do that, PLEASE?

Perception???

- Measuring loudness is possible, at least for instantaneous loudness.
  - I've talked about that already. Probably shouldn't go into that again. (Loudness tutorial, Apr 2006)
  - What, then, is the "loud" part, and what is the "quiet" part?
    - Do we look at the max and minimum over the entire system, or track, or signal, or music?
    - Do we, rather, look at local variations in loudness?

Well, guess what?

- Some people do one, some the other
  - People can't even agree on the long-term "loudness" of something (in a perceptual sense)
    - Some regard peak as the "loudness" for a track
    - Some seem to take some sort of average.
    - These can disagree by 10dB in equivalent gain change or more
- Dynamics is even worse
  - Some people want deep, dark quiet
  - Some people are more happy with a "comfort noise" background.

So, what now?

- There is a lot of room for meaningful experimentation
  - Yes, there is BS1770/BS1771.
    - It works great for stuff that's already been radio processed.
    - Be careful beyond that.
- That still doesn't cover "dynamic range"
- Ditto what a "dynamic" musical clip is

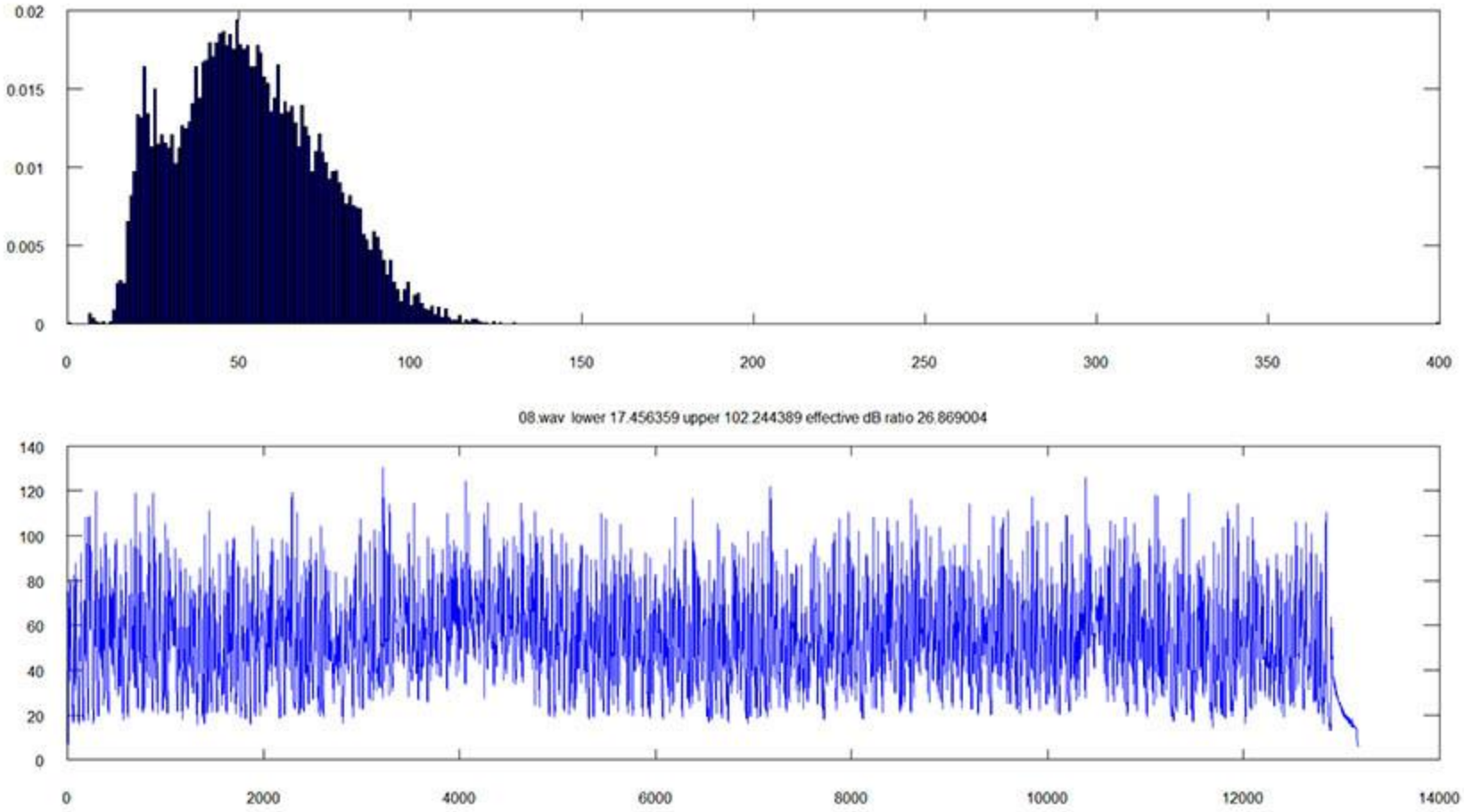
Some examples of measured loudness

- This is not a perfect measure, there's no such thing
- It doesn't consider absolute threshold
- It does not have proper time domain response for high frequencies.
- You can have the script any time you want
- You can improve it if you want
- It still works reasonably well

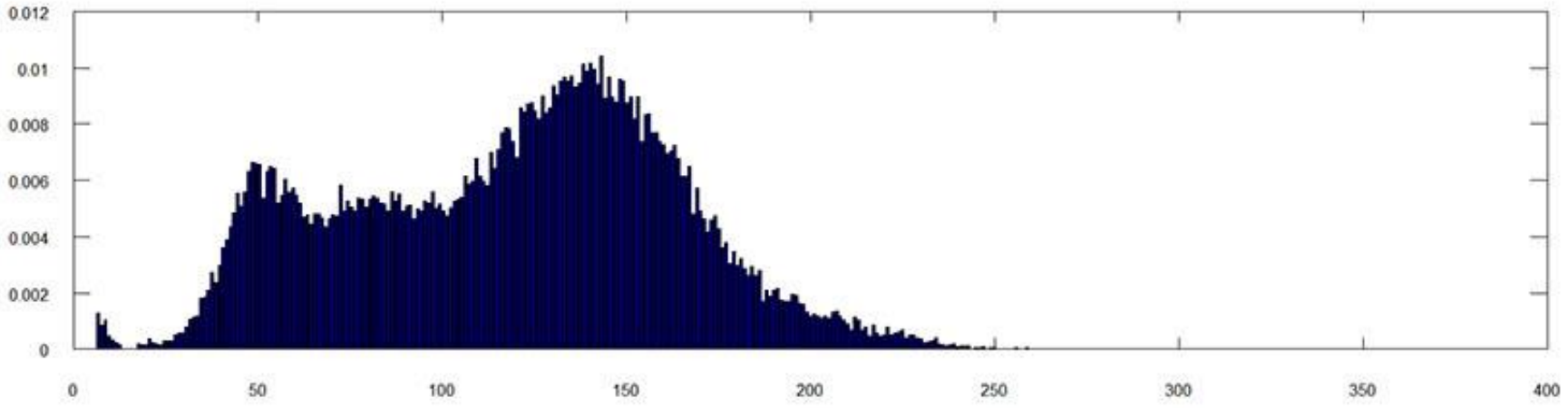
What's in the Plots?

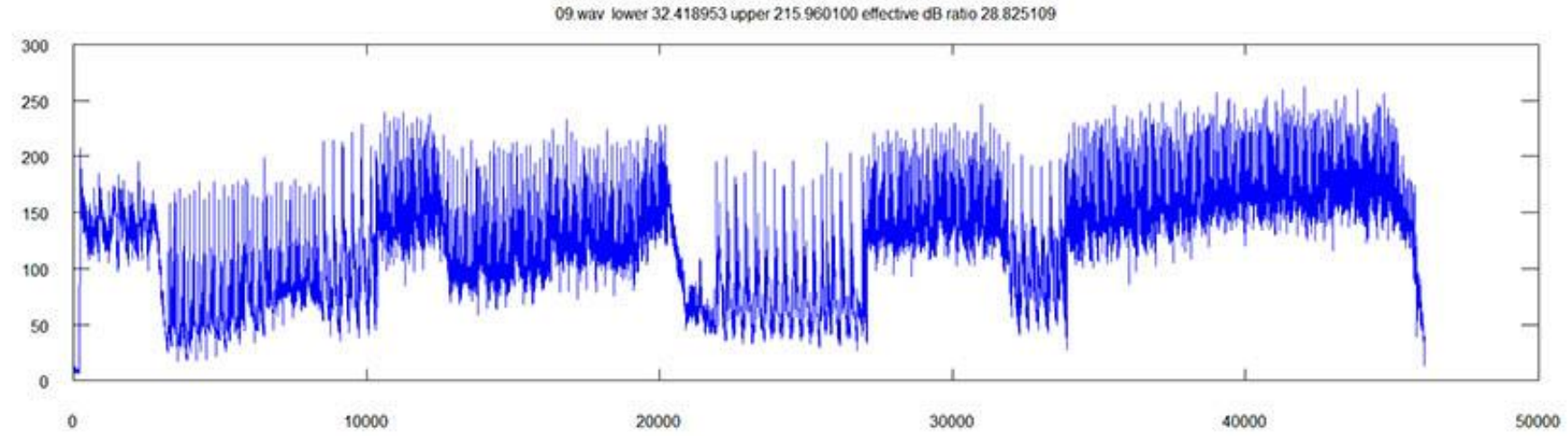
- The top plot:
  - Horizontal axis is loudness, in arbitrary units
  - Vertical axis is normalized probability of that loudness
- The bottom plot
  - Horizontal axis is time, without plotting silent blocks
  - Vertical axis is loudness, same arbitrary units

Ragtime Piano



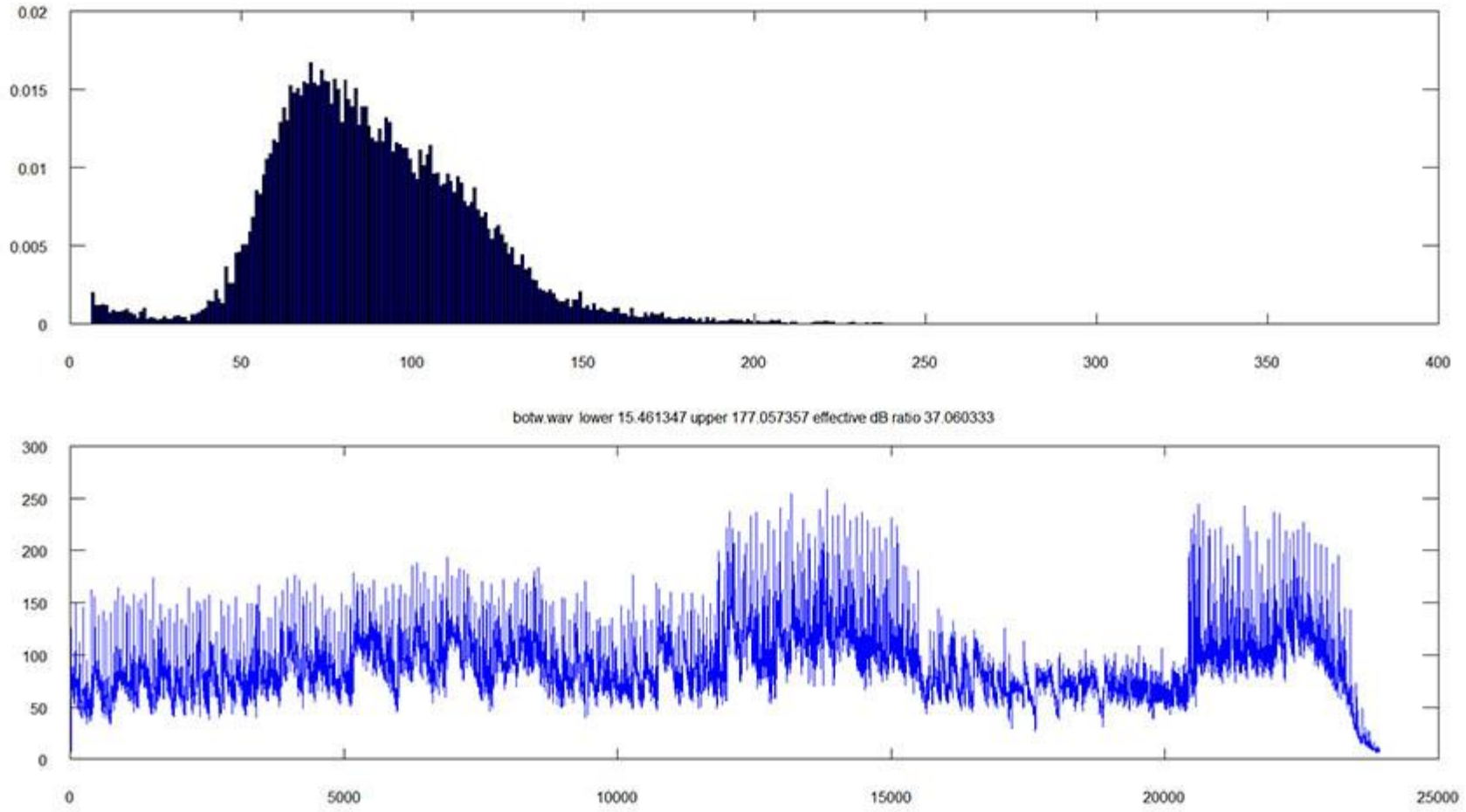
King Crimson - Epitaph





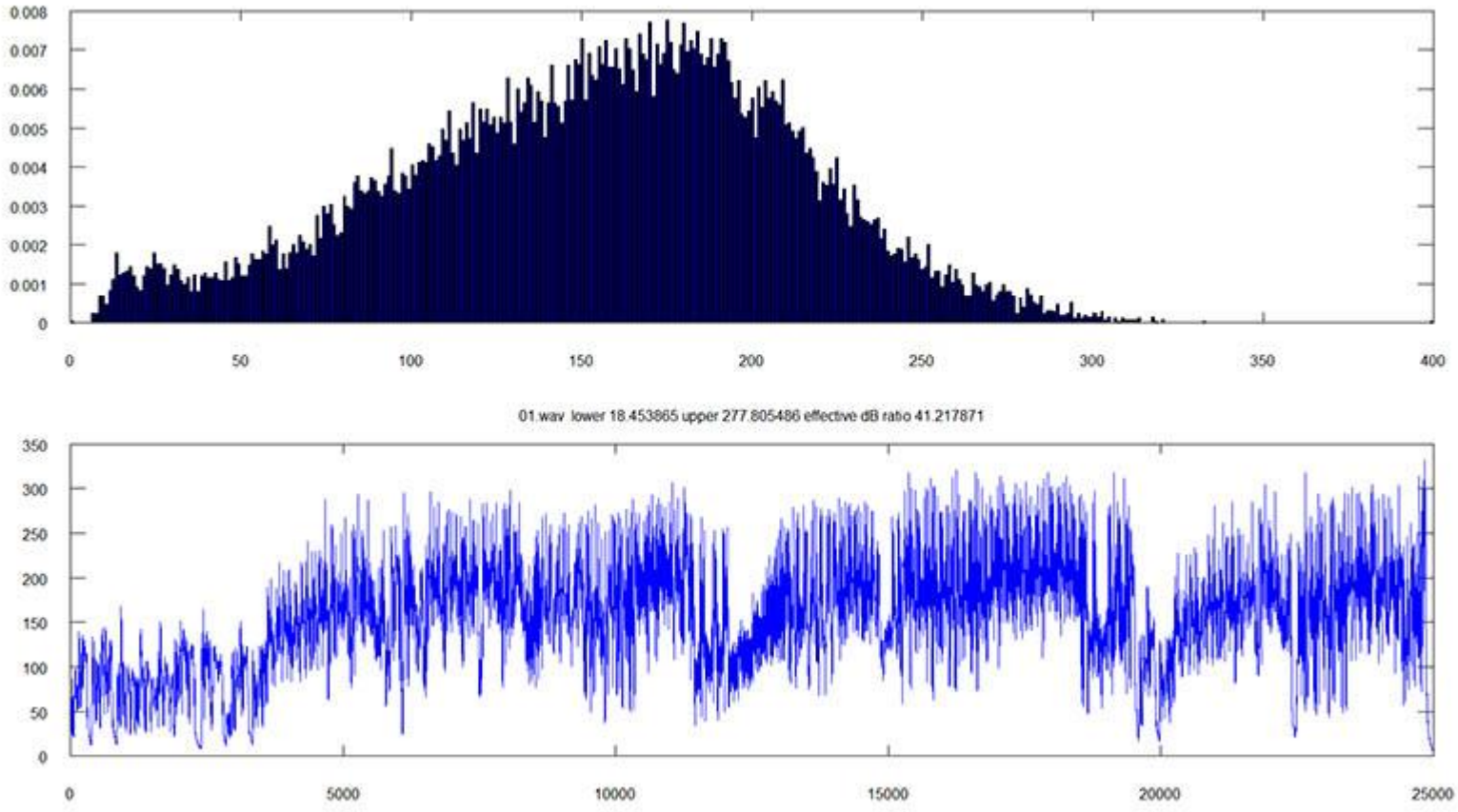
A natural recording in a small space, no processing for good or bad.

Bird on a Wire



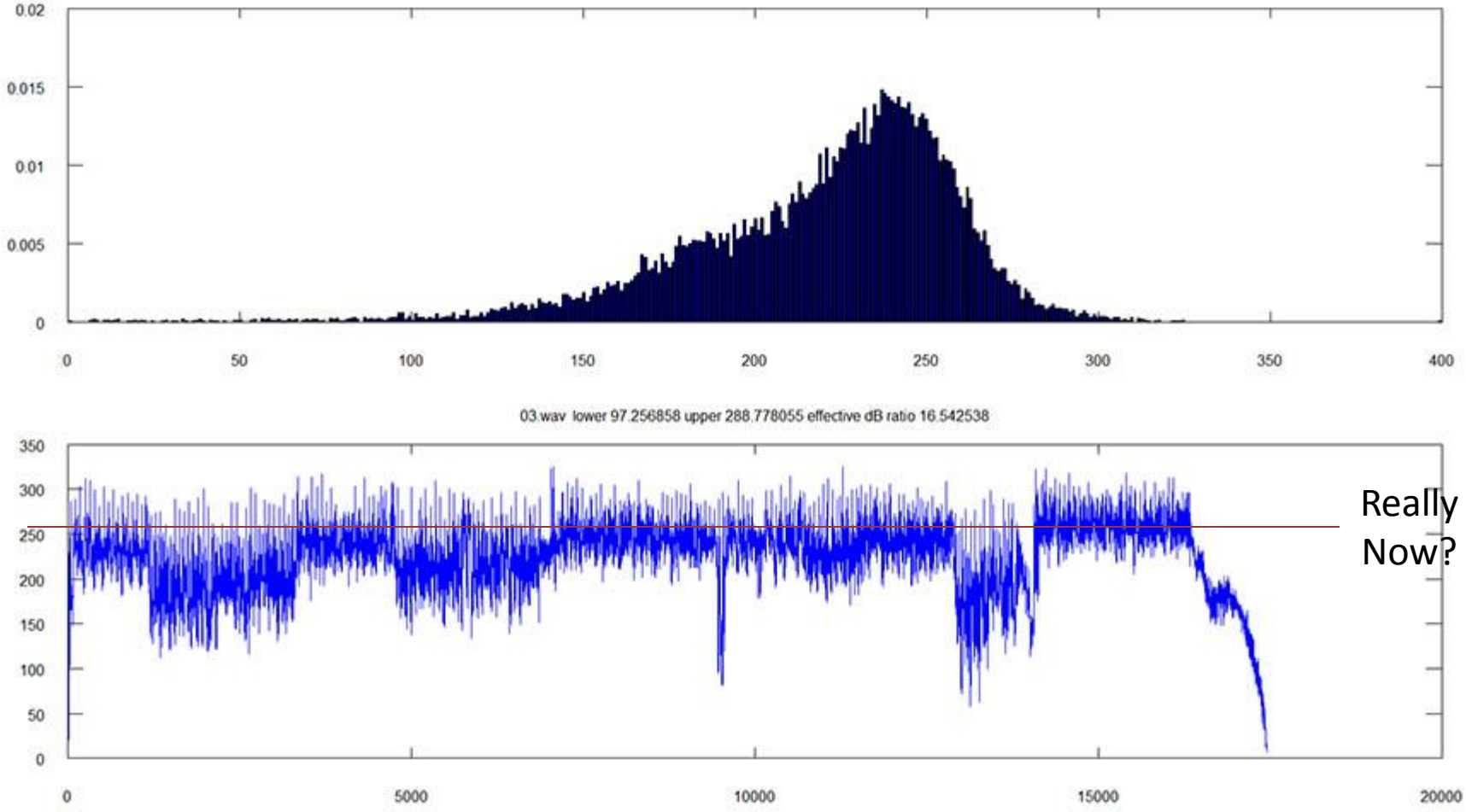
An acclaimed, older pop recording.

Songs from the Woods



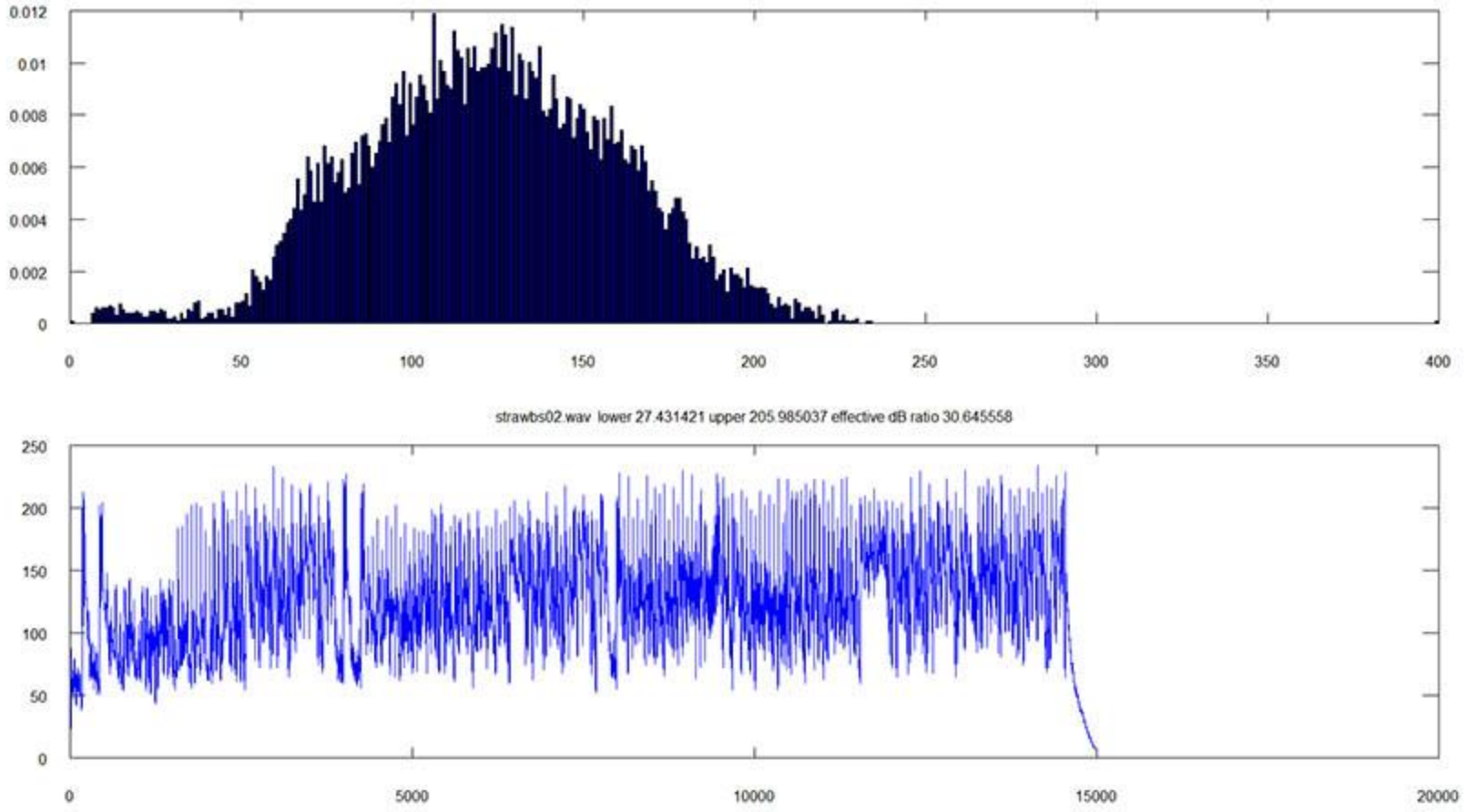
A newer rock/pop recording, mostly vocal.

Sk8rboi



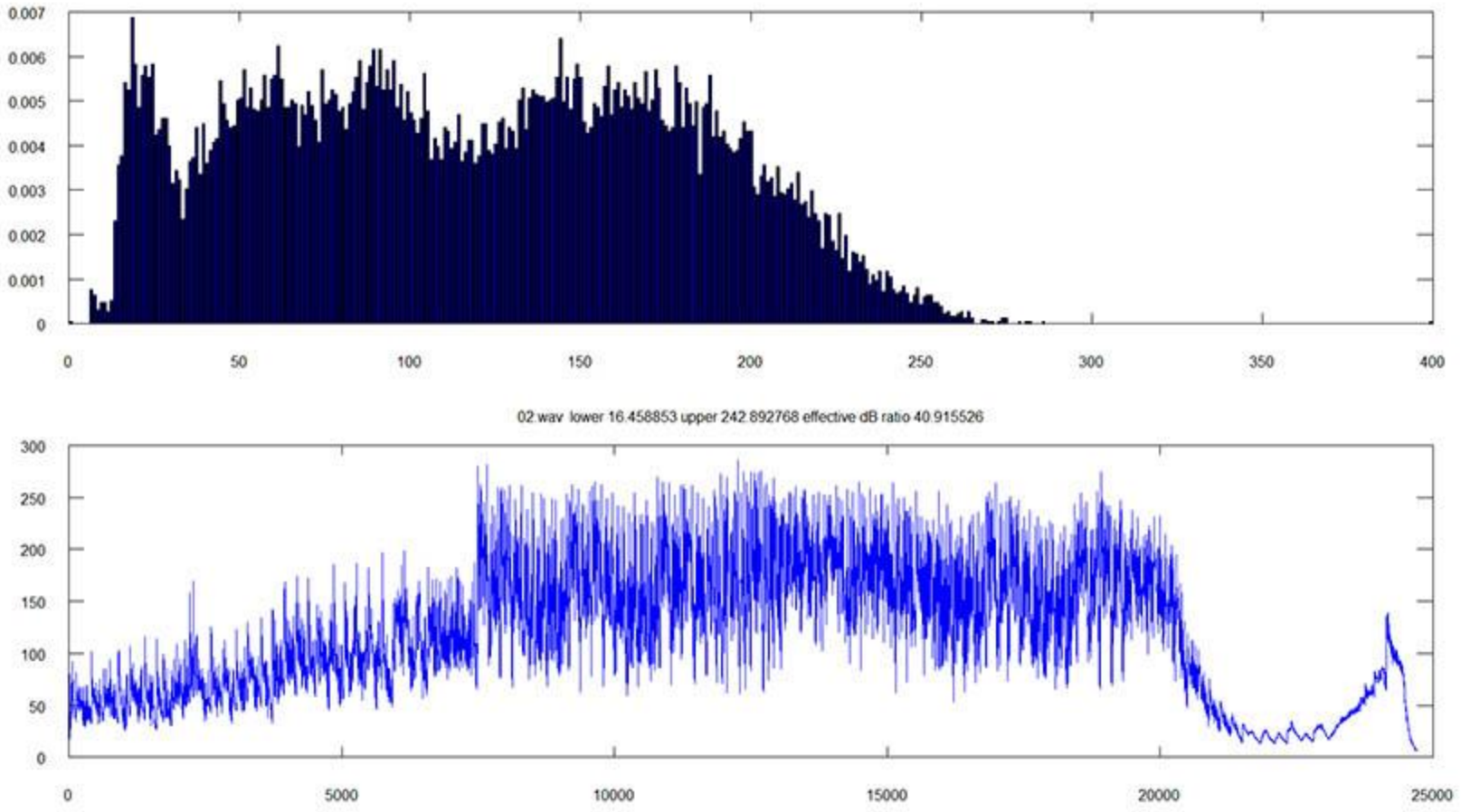
More recent pop recording.

Strawbs – Part of the Union



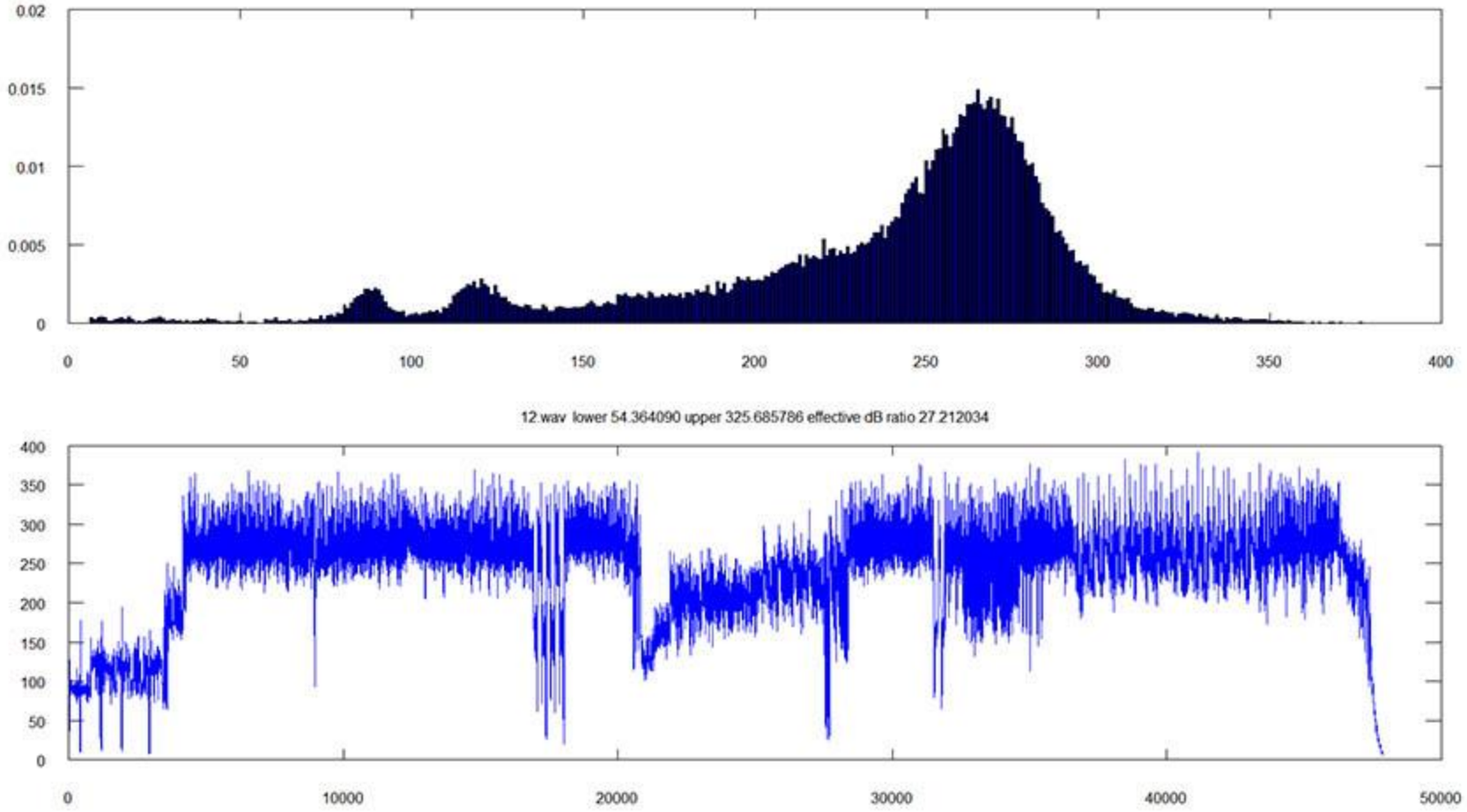
Older British Rock recording.

Over the hills (and far away)



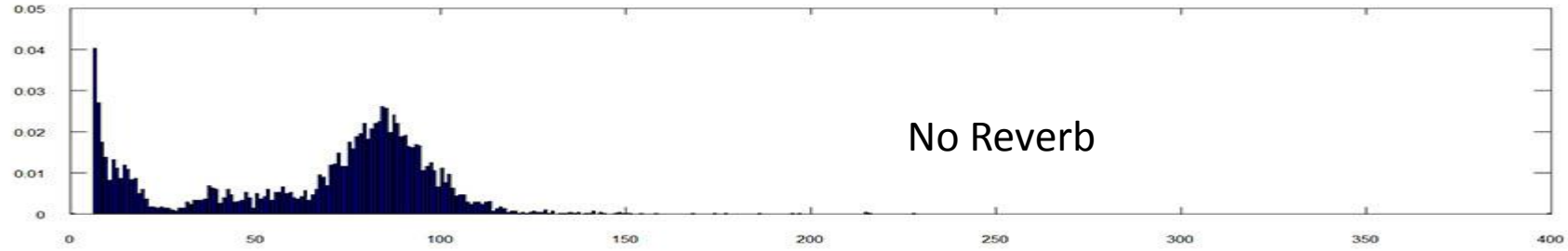
Classic 1970's Rock

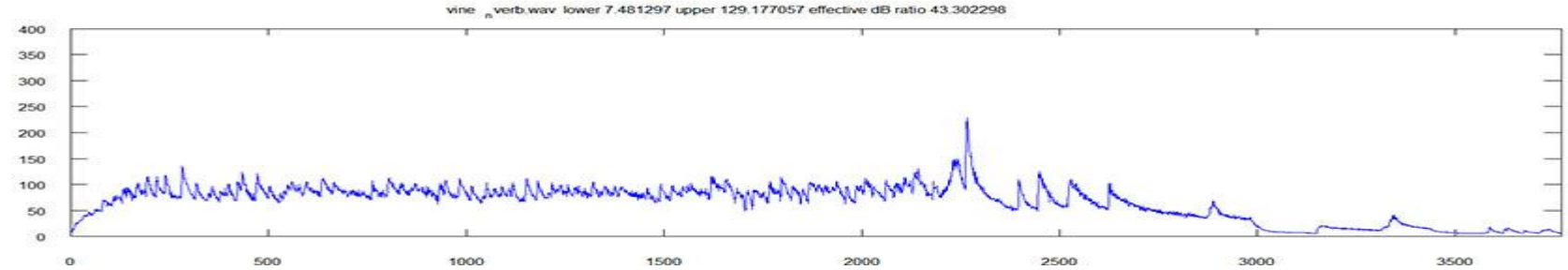
Green Day

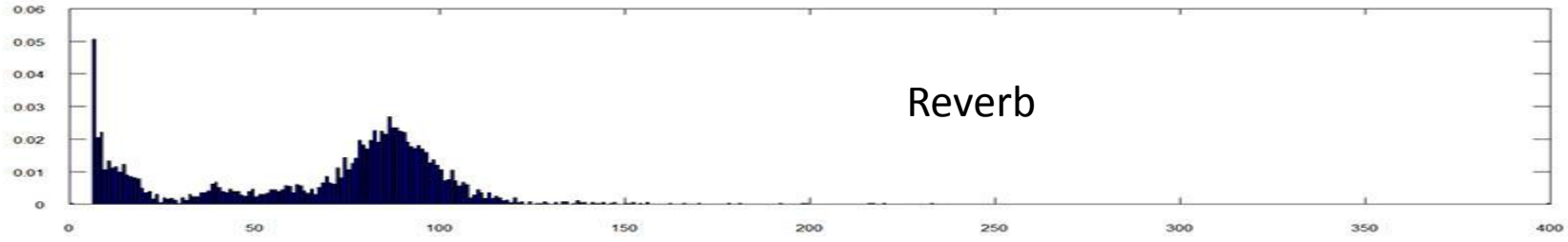


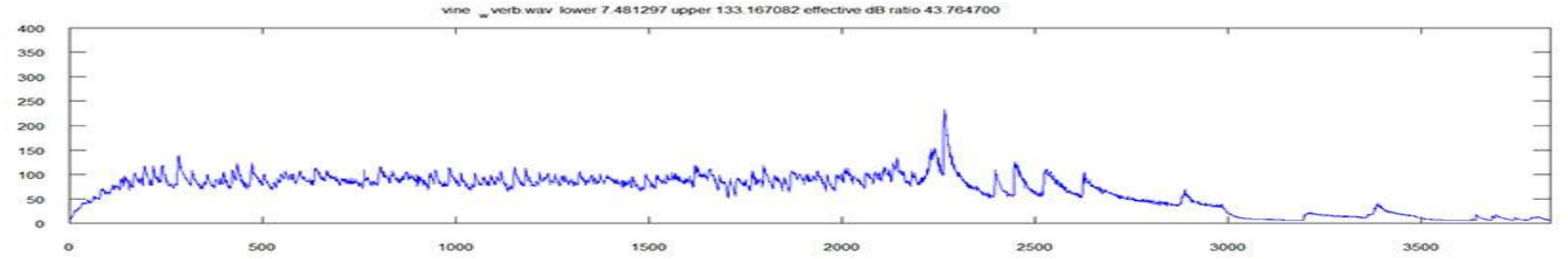
Modern Rock

Some “Modern Classical” examples

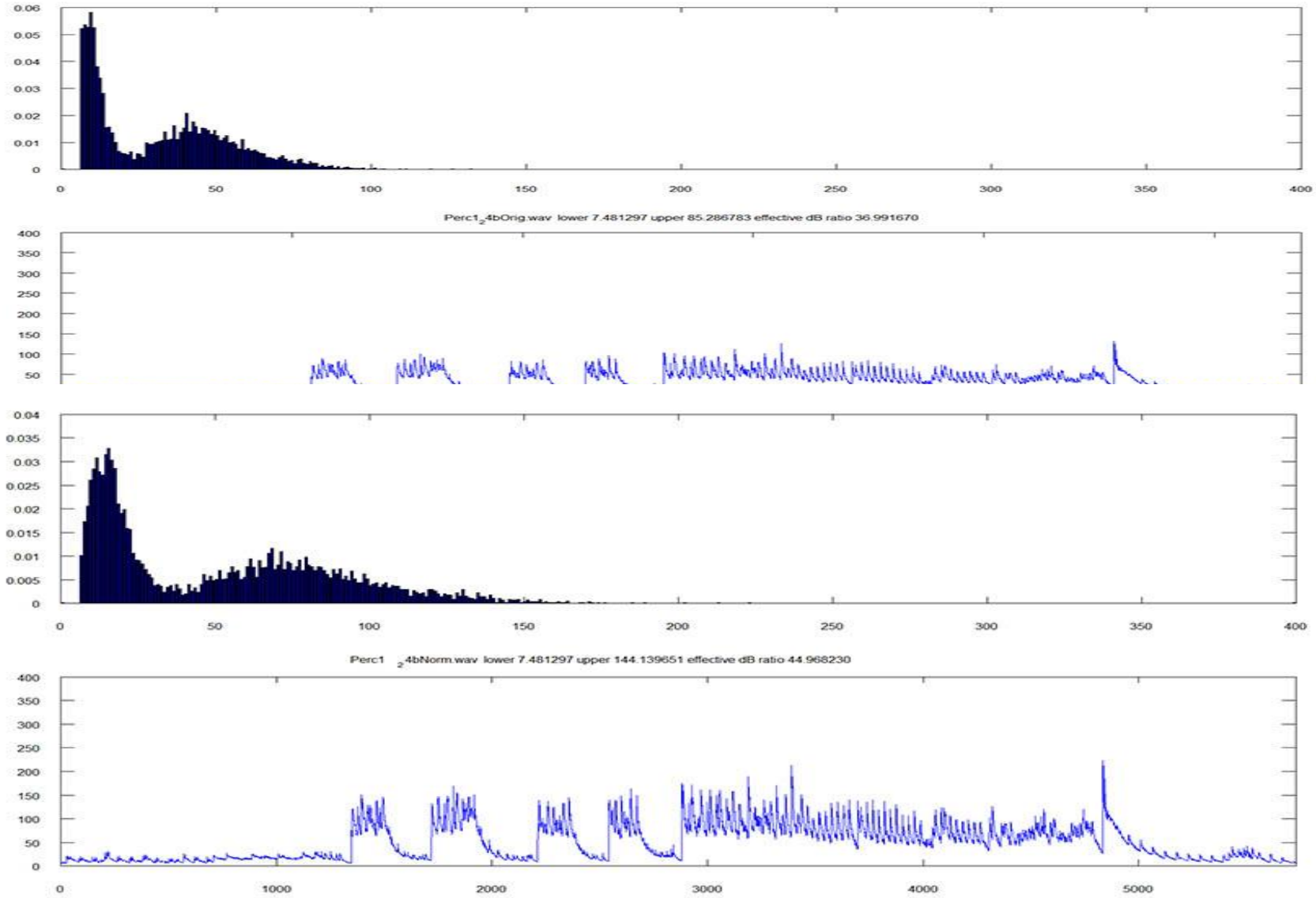




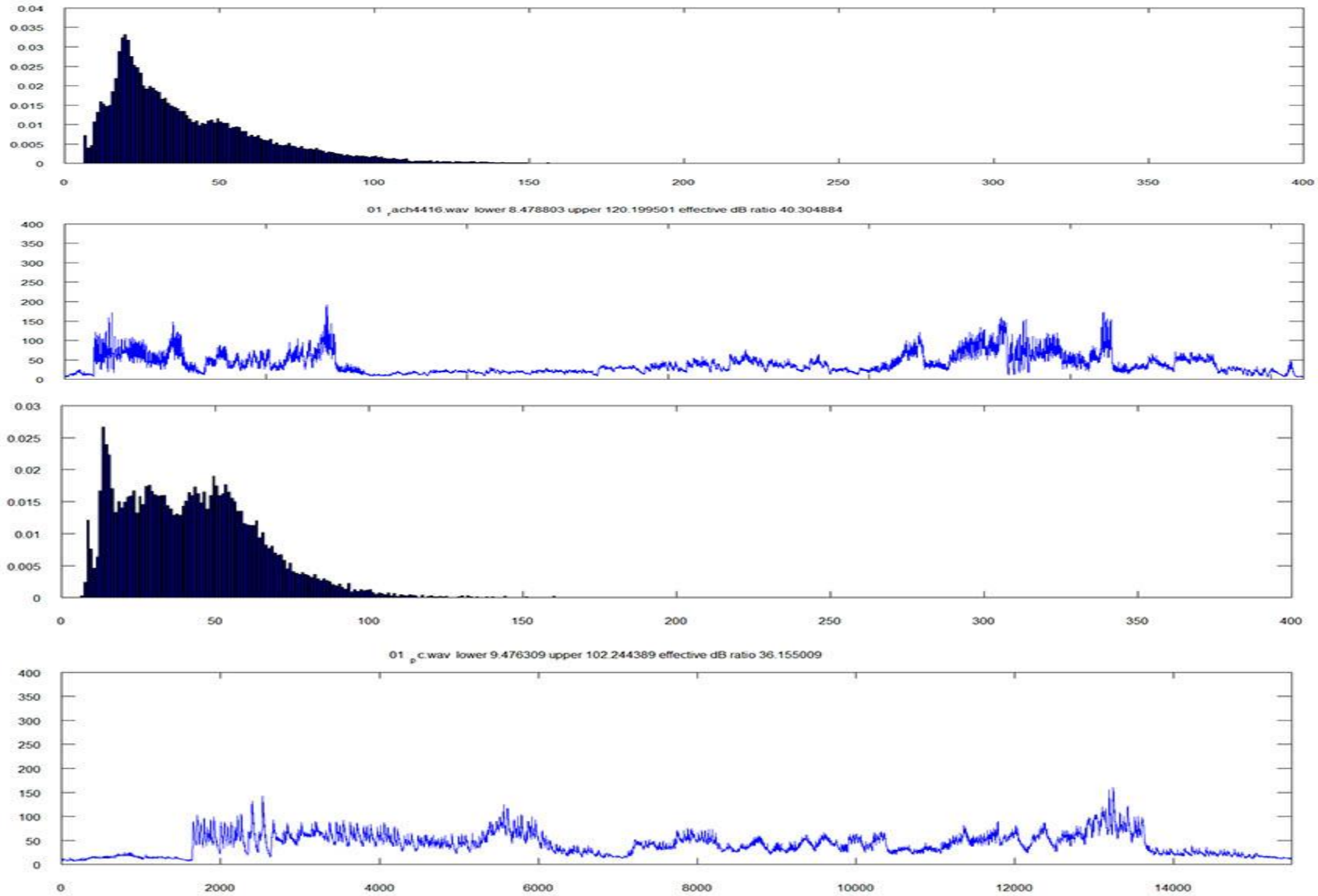




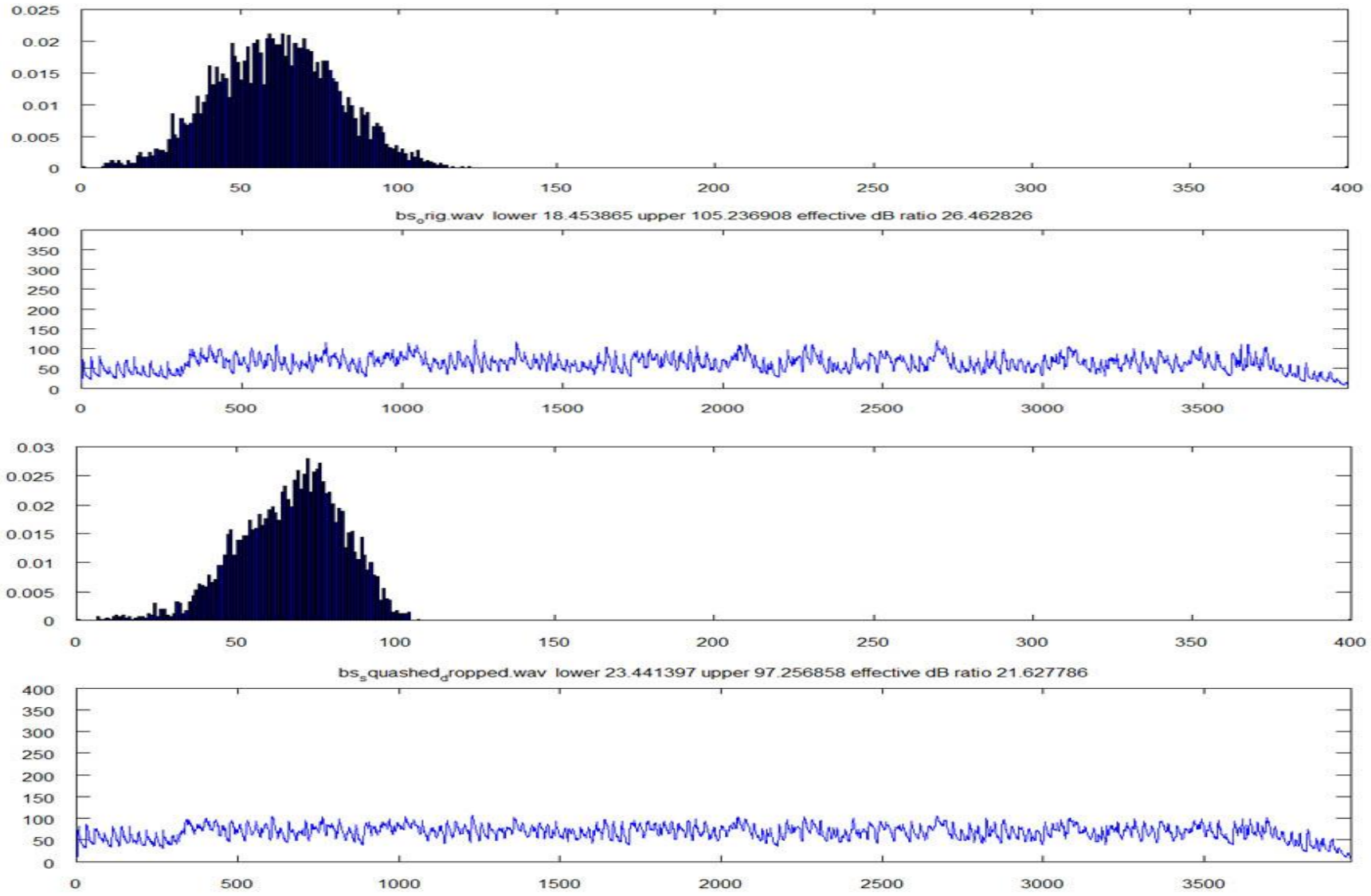
Effects of Normalization



Moderate Squishing



Toothpasting



And made L O U D