Laurie Fincham of KEF fame tried to tackle the issue of low frequency audibility in "The Subjective Importance of Uniform Group Delay at Low Frequencies", JAES, June '85:

He studied the effect of the typical analog record chain on low frequency phase performance and its perceptual results:

"Listening tests in carefully controlled conditions indicate that a reduction in group delay distortion at low frequencies in the replay chain is probably worthwile only when the recorded material is itself also free from such distortions. These effects are however quite subtle."

He did find that the insertion of two cascaded all-pass filters with a Q of root(2) each (Butterworth), and maximum phase shift at 40-50 Hz did in fact "cause distinct audible differences to be observed by most of the audience in a typical lecture theatre".

However, he used non-minimum phase filters, and the results are probably not applicable to a sub-woofer, which is minimum phase. The non-min phase filters would show a longer ringing time than an actual sub it was modeling.

From "Phase Distortin and Phase EQ in Audio Signal Processing- a Tutorial Review" By Doug Preis, Tufts Univ. and delivered at the 70th convention of the AES, Oct. 1981, below 100Hz, with headphones (not speakers in room), the limit of audibility was 2.5ms. With speakers, its much higher as articulated here: http://www.audioholics.com/education...ibility-part-2

Here is a quote from Peter W. Mitchell appearing in _Car Audio & Electronics_ in a sidebar titled "group delay: a measure of quality"

"Group delay is a measure of how sharply the phase of a signal changes from one frequency to the next. If the group delay remains low at all frequencies, the bass will be taut and well controlled. But if the group delay at some frequencies is much higher than 20 ms, the woofer is likely to exhibit poor transient response, thickening sounds at those frequences while robbing the woofer of clarity and impact."

Delay audibility mechanisms (this says nothing about the thresholds, just the mechanisms):
Delay skews perception of second harmonic distortion, but amazingly, in such a way that the skew is level dependent. This is an artifact of gross delay distortion that can easily be shown from a steep filter. It may explain the harshness many people talked about with old steep anti-aliasing filters.

Another point is that the non linearities in the ear itself can lead to changes in the transfer from outer to inner ear that are phase, not power, dependent. Some monaural phase effects can be explained by the concept of the inner spectrum, the spectrum available to the inner ear. This is different than the spectrum at the outer ear due to non linearities in the middle ear and inner ear. Identical external power spectra can lead to substantially different inner spectra for different phase angles.

A third aspect is that reversals of phase for some harmonics can create "beats" that change masking thresholds quite dramatically, often up to 30 dB. There are some major implications here for keeping tweeters and woofers in phase, keeping xover phase on a symmetrical basis and NOT just judging success on a power basis. Finally, I found a reference describing the threshold for localization movement based upon group delay. I have applied it as a group delay criteria for maintaining sharp images in multi way speaker systems.

There's also a good paper that looked at the impact of group delay across the spectrum, starting with 30 Hz fundamentals. The group delay across the board impacted the ability to pick out mid-range detail.

Other references that are worth reading if you have the time:
http://www.silcom.com/~aludwig/Phase_audibility.htm
http://www.music.miami.edu/programs/...title_page.htm
http://www.zainea.com/firing.htm