AMBIENT NOISE AND MARINE MAMMALS: LESSONS FROM PILOT STUDIES OF SHIP NOISE MONITORING IN THE DANISH WATERS.

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1 INTRODUCTION

The last decade has seen a rapid increase in the interest in ambient underwater noise and the possible negative effects on marine life by the increased anthropogenic contribution to the noise[1]. Most recently this has resulted in incorporation of an underwater noise indicator for good environmental status, as part of the EU marine strategy framework directive (MSFD)[2]. The MSFD operates with pressure indicators, i.e. indicators which should reflect the amount of acoustic energy emitted into the environment. One set of indicators is intended to reflect the contribution from large ships and is identified as the one-third octave band levels at 63 Hz and 125 Hz, respectively. In contrast to these pressure indicators are impact indicators, which are intended to reflect the impact on target species rather than just measure the contribution. Whereas pressure indicators really only are required to correlate well with the source (i.e. large ships) are impact indicators required to include assumptions on how the noise is perceived by target species and how these react to the noise. Some of the difficulties with both types of indicators were investigated, based on recordings of ship noise in the Inner Danish Waters (Great Belt and Kadet Trench).

2 METHODS

Automatic recorders (Loggerhead Instruments, Florida) were deployed on several occasions within the framework of a baseline study for an offshore wind farm (Rødsand 2) and the EU Interreg study BaltSeaPlan. Recorders were moored approx. 2 above the seabed. Each datalogger contains an HTI-96 hydrophone connected to a 16 bit A/D converter, capable of recording up to 80 ksamples/s. Data is stored on 16 Gb SD-memory cards. An onboard clock and a microprocessor allows for duty cycling of the recordings to increase deployment time. Thus short periods of noise (0.5-6 seconds) were recorded at regular intervals (every 2nd to 6th minute) for total deployment periods of 3-5 weeks.

3 RESULTS AND DISCUSSION

All recorders contained both very loud recordings from ships passing close by and quiet periods with little ship noise. One station was placed very close to the ferry route Gedser-Rostock and each passage of the ferry was clearly visible in the recordings as greatly increased sound levels (Figure 1). This figure illustrates the usefulness of the 63 Hz band as a pressure indicator (i.e. reliable indicator of the presence of the ship), as this band not only contains the highest level during passage, but also displays the highest increase in level from quiet to loud.
However, the data from all four dataloggers placed along a line parallel with the Kadet Trench reveals a problematic issue with this indicator, when used in shallow waters as in this example (Figure 2). In all four recordings are signatures of individual ships clearly visible, but instead of a peak at 63 Hz the main energy is around 500 Hz. This difference to the close passage of the ferry in Figure 1 is most likely due to a high pass filtering effect of the shallow waters bordering the shipping lane. Thus, in shallow waters it seems prudent to use a different pressure indicator, such as the 500 Hz band.

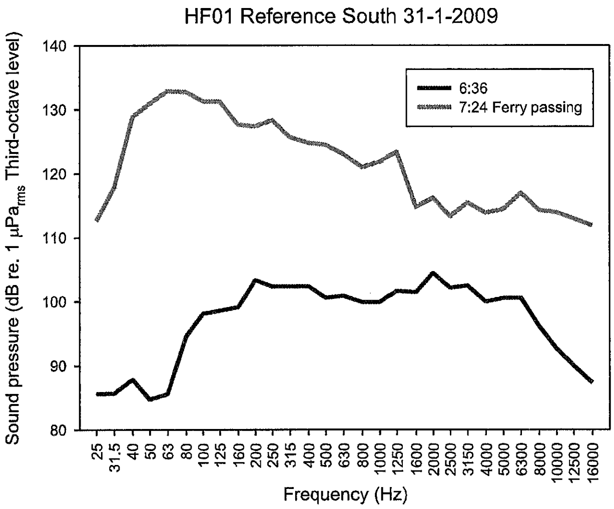

Figure 1. Third-octave spectrum of the noise from the Gedser-Rostock ferry passing within few hundred meters of the recording station, as well as ambient noise recorded between passage of two ferries. Note the large increase in noise in the 63 Hz band. Spectra averaged over 30 seconds.

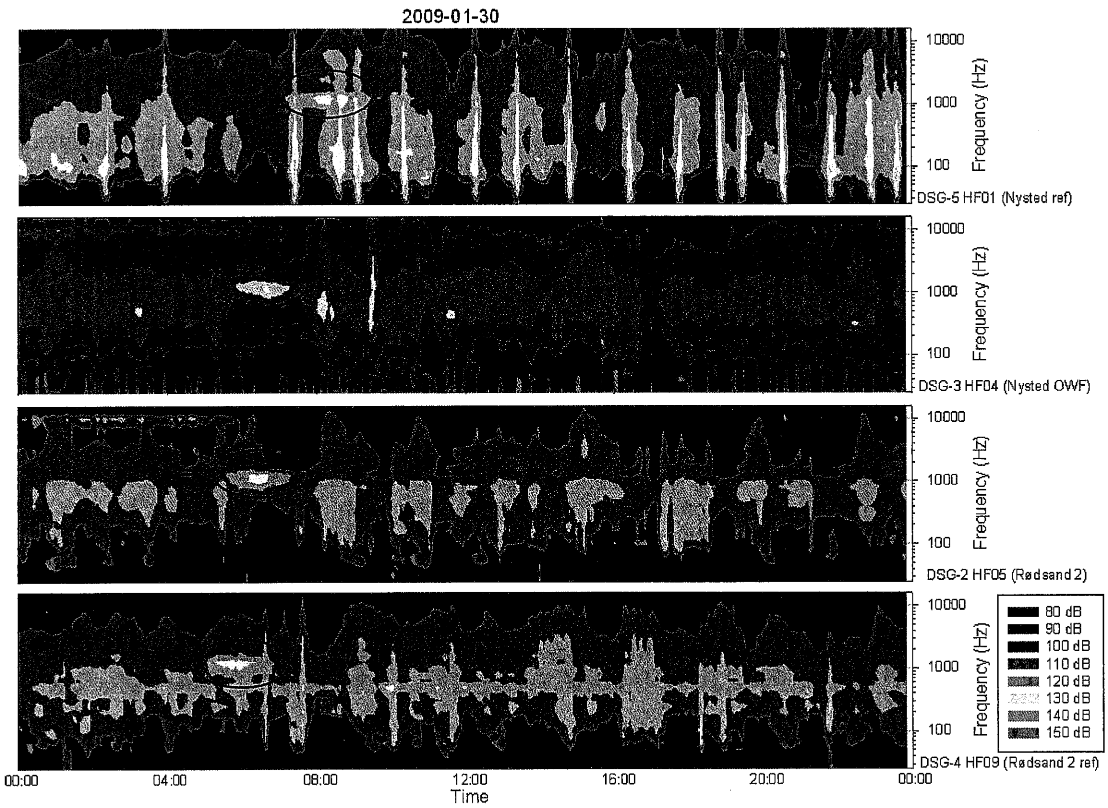

Figure 2. One-third octave spectra recorded every 6 minutes over 24 hours, shown as coloured contours. Noise at all stations dominated by ship noise centred at 500 Hz. Numerous passages of the Gedser-Rostock ferry is visible in the topmost recording. Red oval in all recordings indicate a single ship with deviating noise signature and passing parallel to the recorder chain. Colour scale in dB re. 1 µPa rms per 1/3 octave band.

Developing biologically meaningful impact indicators is a great challenge. In order for such an indicator to have any value it must be species specific and must be based on the auditory physiology and acoustic behaviour of the species in question. An example illustrative of the challenges is shown in Figure 3. Here are third-octave levels of two recordings of the same ship, taken 4 minutes apart and thus at different aspects of the ship. The two recordings sound very different and also the spectra are clearly different. However, several of the summary statistics, which could be used to categorise the recordings are identical (sound pressure level, peak frequency and centroid frequency). There is a small difference in kurtosis and only rms-bandwidth is markedly different between the two. A last measure is introduced, the audiogram-weighted sound pressure level (in this case for a harbour porpoise). When correction for audibility is made, a large difference (17 dB) emerges between the two recordings. Further studies where these (and possibly other) derived parameters are correlated with behaviour of harbour porpoises are required in order to determine which are useful as impact indicators and which are not.

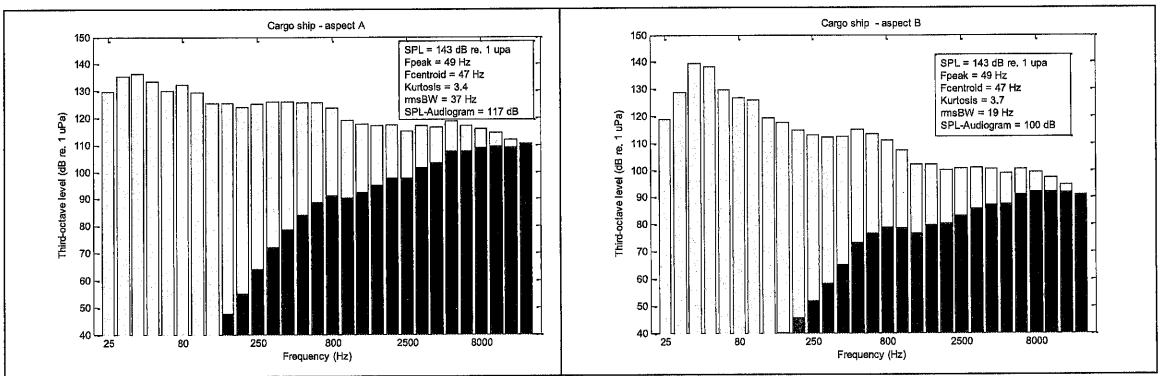

Figure 3. Two third-octave spectra of noise from the same unknown cargo ship recorded 4 minutes apart and thus at different aspects. Grey bars unweighted levels, red bars weighted by harbour porpoise audiogram[3].

4 ACKNOWLEDGEMENTS

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5 REFERENCES

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