Seismic Surveys in Complex Environments

Analysing the Variability of Exclusion Zones with Field Measurements and Models

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- **Anthropogenic sound levels in the sea are increasing**
- **Scientific evidence of negative effects of sound in marine species results in the definition of mitigation strategies**
- **Seismic surveys can be specially damaging**
- **A mitigation zone is monitored in real time to ensure no marine mammal is exposed to harmful sound levels**

A detailed characterisation of the sound field and a good understanding of the mechanisms of perception of sound in marine species are key to obtain accurate mitigation zones. There are multiple sound propagation and physiological factors that can affect the shape and coverage of a mitigation zone. In this poster, sound field simulations are used to analyse some of these factors in the context of a hypothetical seismic survey.

MODEL SETTINGS

A parabolic equation model for fluid seabeds (RAMGeo) has been used to simulate the received level in different sound propagation scenarios (Duncan, AcTUP2.2L,CMST).

The bathymetry, geology and auditory response used in these scenarios are shown by the figures on the right. The models assume arctic region conditions (cold water).

The acoustic source is a 1760 in^3 airgun array, placed at 2 m depth.

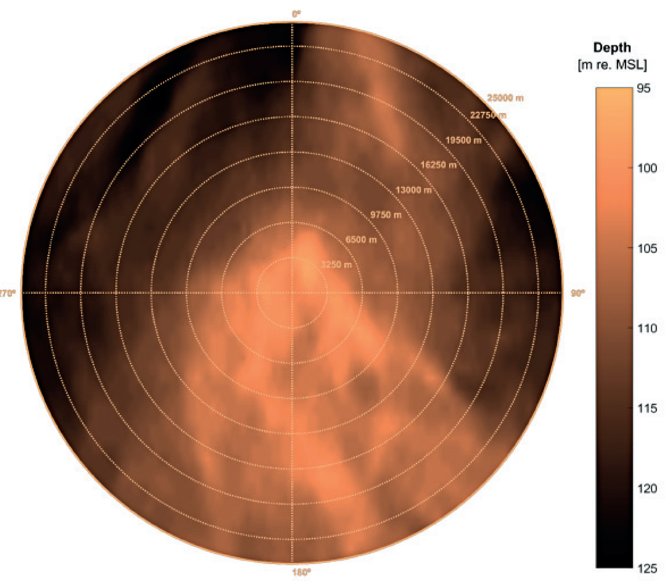

Figure 1 Bathymetry of continental shelf region. Depths ranging from 95 to 125 m, 25 km coverage. Data from 30 arcsec bathymetry grid (GEBCO, 2014).

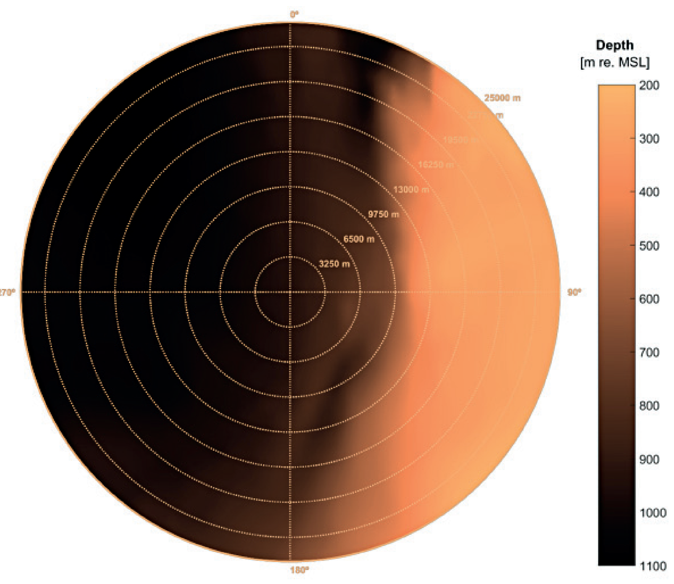

Figure 2 Bathymetry of continental slope region. Depths ranging from 200 to 1100 m, 25 km coverage. Data from 30 arcsec bathymetry grid (GEBCO, 2014).

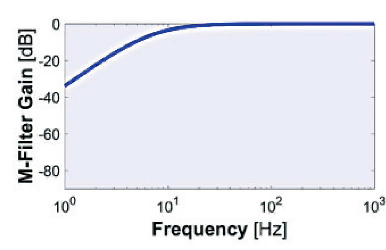

Figure 3 Auditory response of low-frequency LF cetaceans, e.g. right whale (Southall et al 2007, Aq. Mam. 33:4)[1].

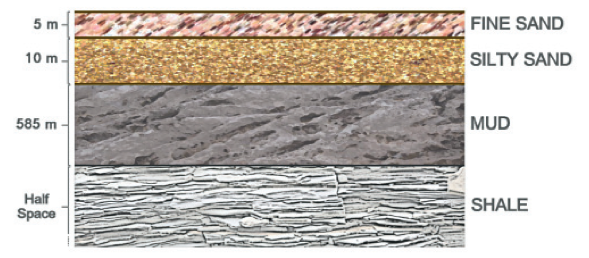

Figure 5 Modelled geology, case of a sandy surface sediment.

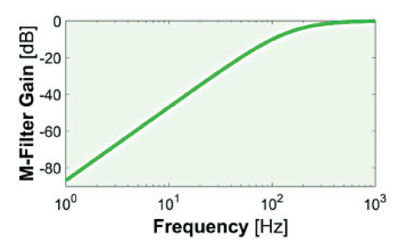

Figure 4 Auditory response[1] of mid-frequency MF cetaceans, e.g. common dolphin.

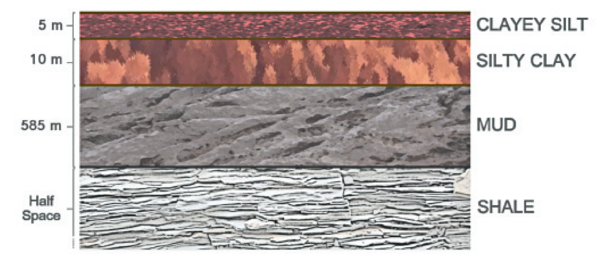

Figure 6 Modelled geology, case of a clayey surface sediment.

MITIGATION MODELS

Reference Scenario

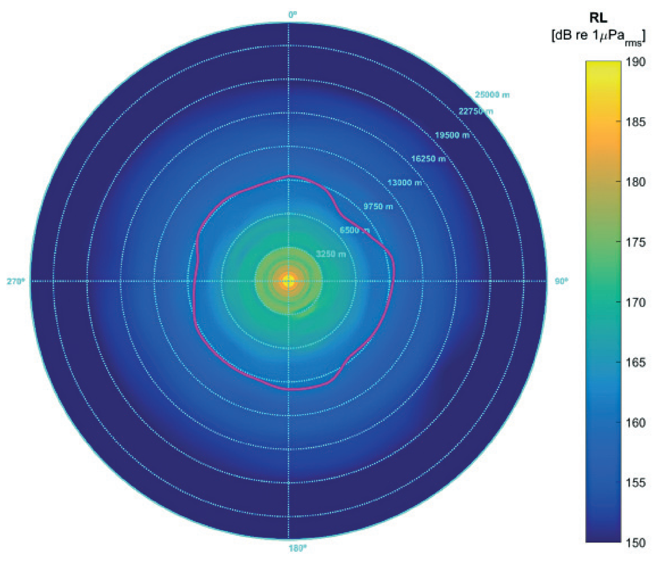

Figure 7 Broadband received level rms (95th percentile) and 160 dB$_{rms}$ mitigation zone in the reference scenario. Based on 62.5, 125, 250 and 500 Hz oct bands.

This modelled scenario is used as reference to study the effect of biological and environmental factors on the mitigation zone.

Model settings: continental shelf (fig. 1), sandy surface sediment (fig. 5), 2 m receiver depth (±0.5 m) and LF response (fig. 3).

Mitigation radius $\overline{mr}$ = 9974 m.

Biological Factors

Receiver Depth

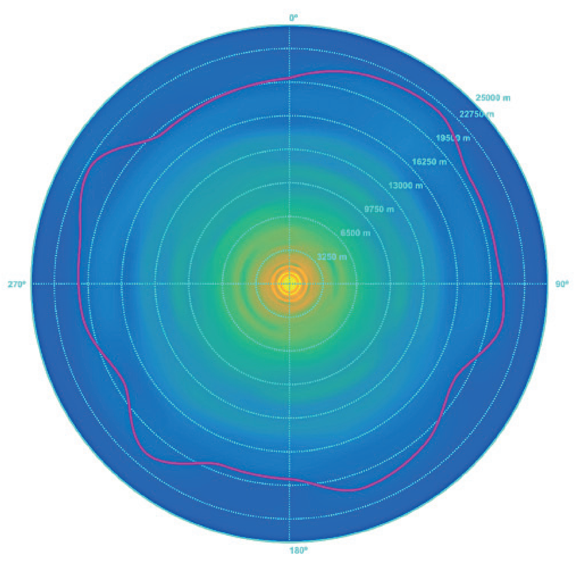

Figure 8 Broadband received level rms (95th percentile) and 160 dB$_{rms}$ mitigation zone at 40 m rec. depth.

Model settings: continental shelf (fig. 1), sandy surface sediment (fig. 5), 40 m receiver depth (±0.5 m) and LF response (fig. 3).

Mitigation radius $\overline{mr}$ = 2042 m.

Auditory Response

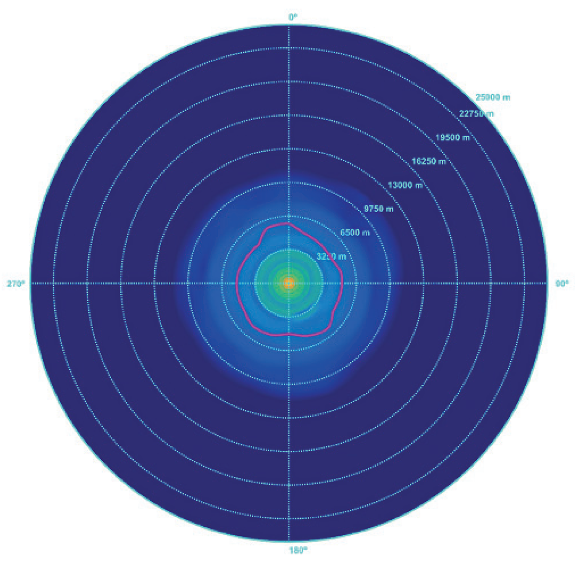

Figure 9 Broadband received level rms (95th percentile) and 160 dB$_{rms}$ mitigation zone for MF species.

Model settings: continental shelf (fig. 1), sandy surface sediment (fig. 5), 2 m receiver depth (±0.5 m) and MF response (fig. 4).

Mitigation radius $\overline{mr}$ = 5064 m.

Environmental Factors

Bathymetry

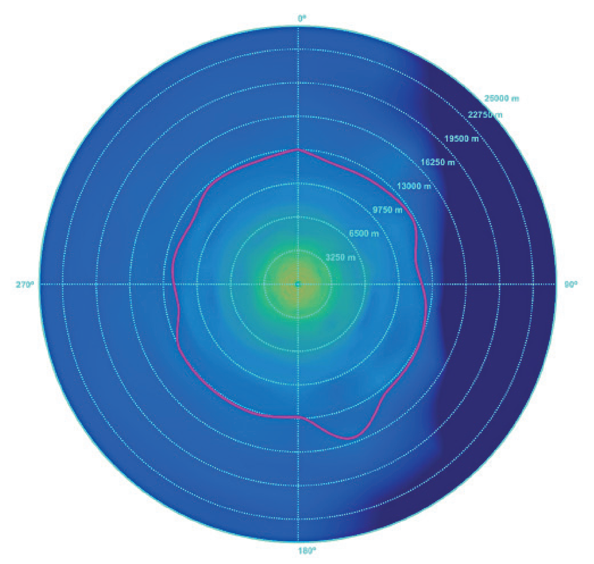

Figure 10 Broadband received level rms (95th percentile) and 160 dB$_{rms}$ mitigation zone in continental slope.

Model settings: continental slope (fig. 2), sandy surface sediment (fig. 5), 2 m receiver depth (±0.5 m) and LF response (fig. 3).

Mitigation radius $\overline{mr}$ = 12716 m.

Geology

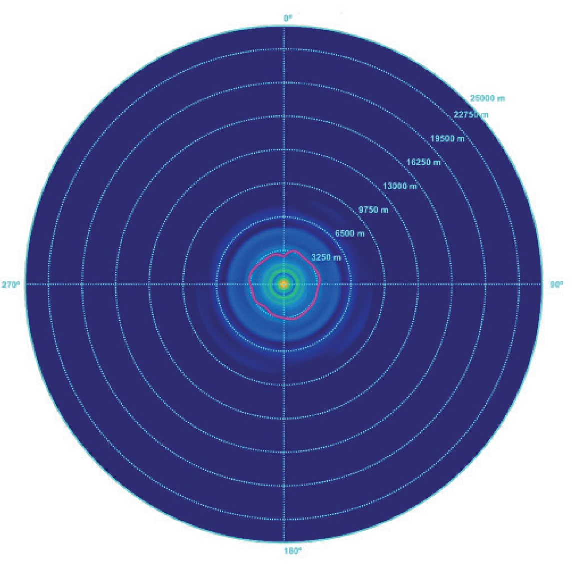

Figure 11 Broadband received level rms (95th percentile) and 160 dB$_{rms}$ mitigation zone for clayey sediment

Model settings: continental shelf (fig. 1), clayey surface sediment (fig. 6), 2 m receiver depth (±0.5 m) and LF response (fig. 3).

Mitigation radius $\overline{mr}$ = 3590 m.

CONCLUSIONS

- **Real mitigation zones are not circular,** but relative variations are small enough to make an average mitigation radius a reasonable approximation.
- The analysed biological and environmental **factors** have an **evident influence on the mitigation zone.**
- Among all factors that can affect the mitigation zone, only some of them have been addressed in this poster. Others: 1) **Operational** – source level, directivity, depth, signature; 2) **Environmental** – sound speed profile in water; 3) **Biological** – threshold level and sound level metric.

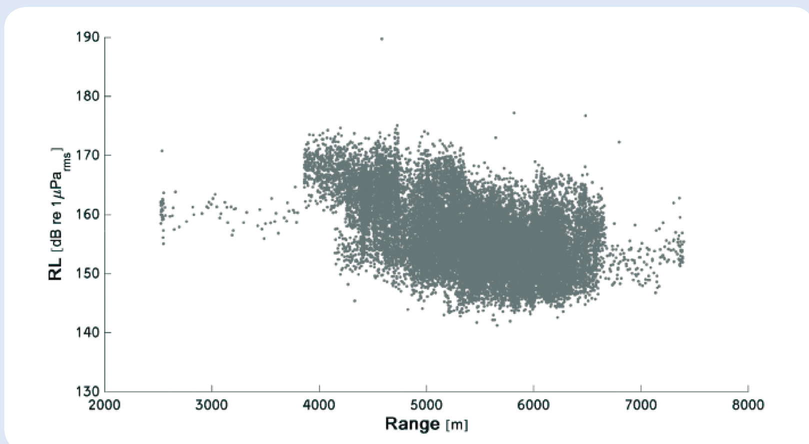

Figure 12 Measured sound level at range. Data gathered by Seiche Ltd. along a large area during a sound source verification survey in the North Atlantic. The large variation in sound levels at range results from changes in source position and environment.

DISCUSSION

- **A single, generally applicable mitigation range may not be sufficient.** The estimation of mitigation zones should be based on scientific data (e.g. sound source verification and population studies).
- **An additional mitigation zone should be defined** if there is a noticeable variation on any operational, environmental or biological factor (e.g. different source layout, source position or marine species).
- There is not a common methodology for the estimation of mitigation ranges among regulations from different countries, and tend to be simplistic. **Standard required.**