ASSESSING THE IMPACT OF MAN-MADE UNDERWATER NOISE FROM MARINE RENEWABLES IN THE OUTER HEBRIDES

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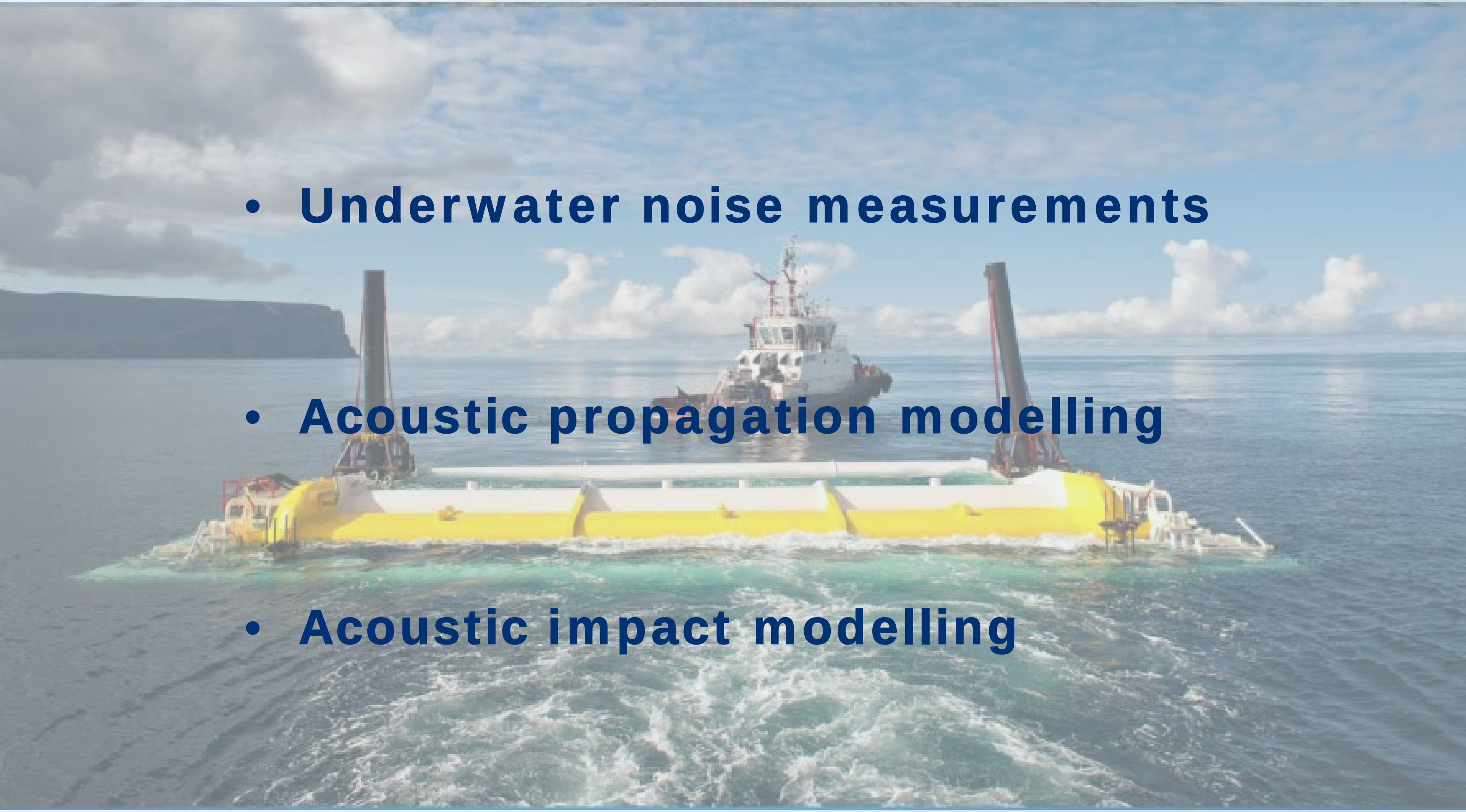
Presentation to EIMR 2014

Overview of presentation



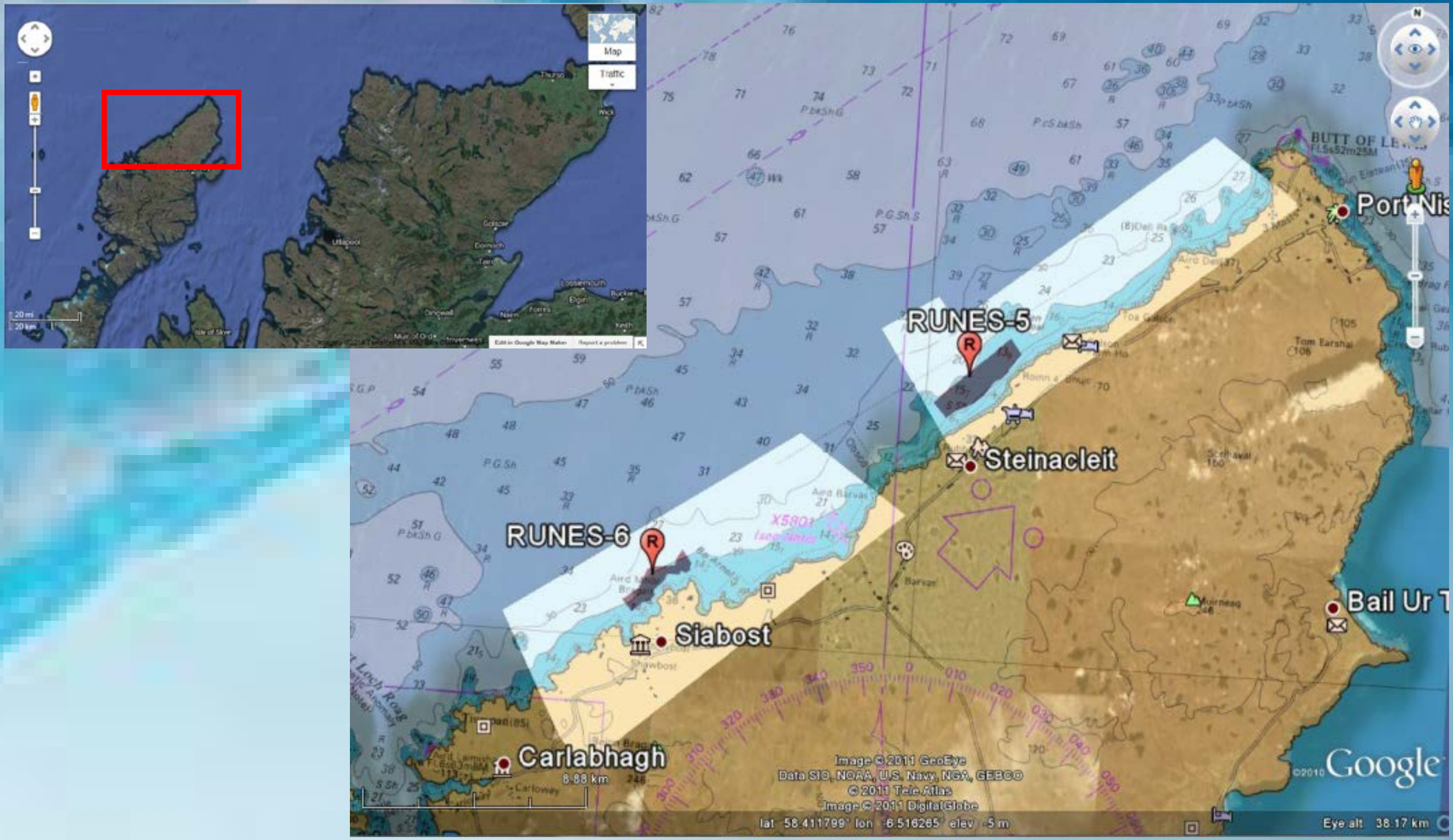
- Underwater noise measurements
- Acoustic propagation modelling
- Acoustic impact modelling

Underwater noise measurement

Kongsberg seabed recorder (RUNES) – autonomous underwater noise recorder.

- Seabed located.
- Frequency range 20 Hz to 250 kHz.
- Sampling schedules – variable.
  In this case, it sampled for 2 minutes every 30 seconds every hour over a total period of around 6 weeks.

Underwater noise measurement

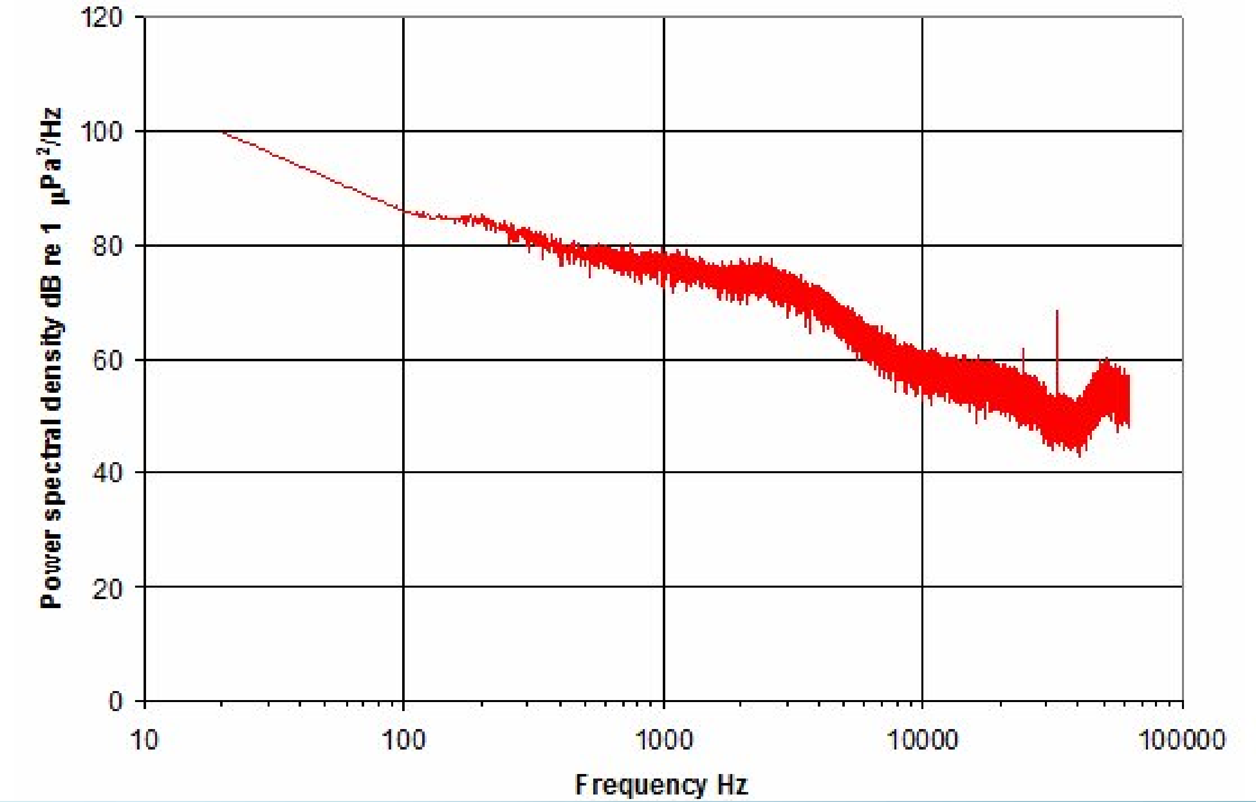


Aug 2011 - 2 x RUNES units were deployed in the Project Areas.

Deployment depths were around 25 - 30 m.

They were on-site for a total of 2 weeks. On recovery, there was around 500 GBytes of acoustic data available for processing.

Background noise results



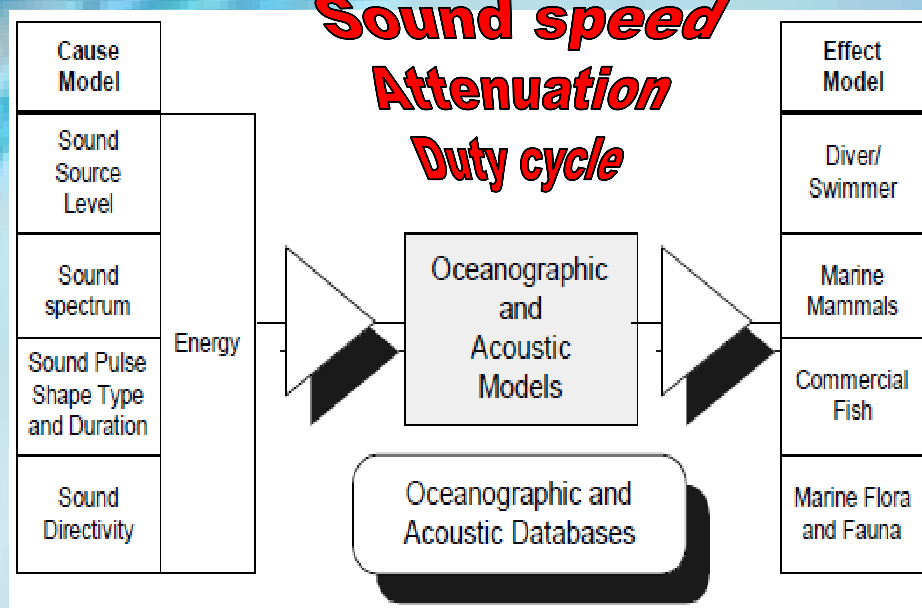
Frequency spectrum of the background noise.

Total noise level R5 - 119 ± 6 dB re. 1 μPa (Peak)

R6 - 117 ± 4 dB re. 1 μPa (Peak)

Acoustic propagation modelling

Time of year
Location
Water depth
Sound speed
Attenuation
Duty cycle



Cause and Effect modelling

Underwater acoustic propagation model

Need to model the propagation of underwater sound from the point of origin to a given receptor location

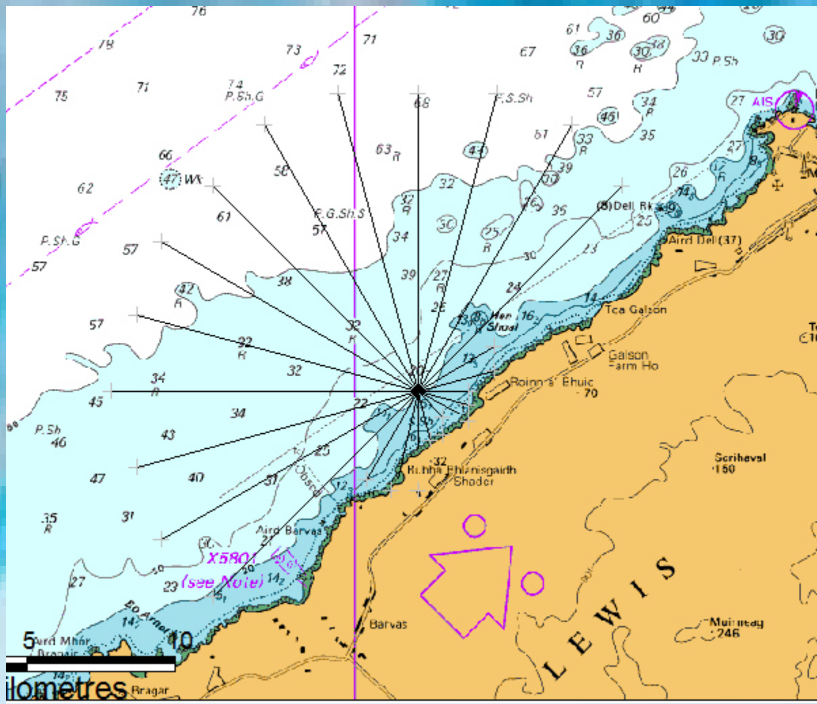
$$\nabla^2 g(x,y,z,t) - \{c(x,y,z)\}^{-2}\frac{\partial^2 g(x,y,z,t)}{\partial t^2} = -s(t)\delta(x-x')\delta(y-y')\delta(z-z'),$$

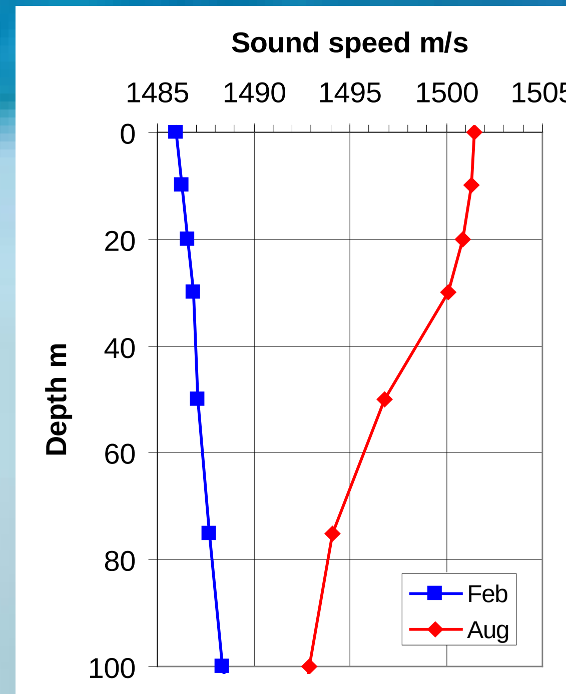
$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial G(r,\ z)}{\partial r}\right) + \frac{\partial^2 G(r,\ z)}{\partial z^2} + \frac{\omega^2}{c^2(z)}G(r,\ z) = -\frac{1}{\pi r}\delta(r)\delta(z-z'),$$

Models based on

1. Ray theory
2. Parabolic equation
3. Normal modes
4. Full field or Wavenumber integration
5. Empirical - eg. Energy-flux theory

Modelling input parameters – Site-specific data

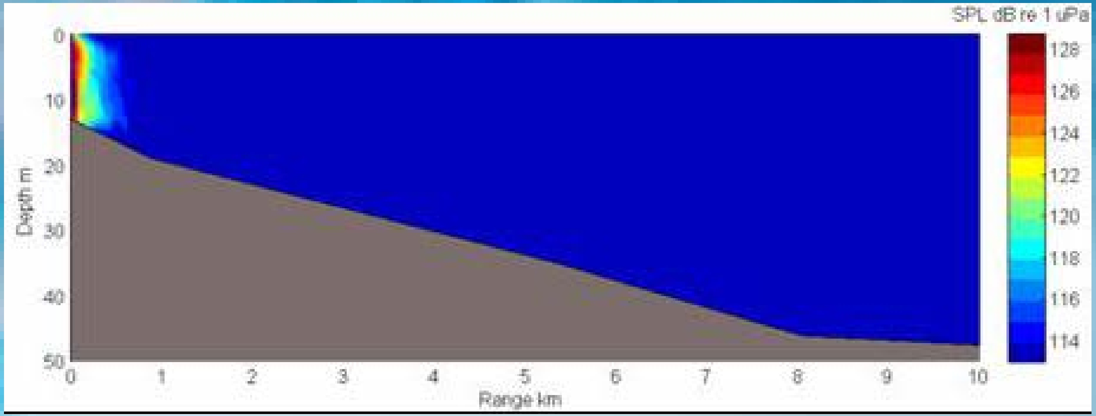


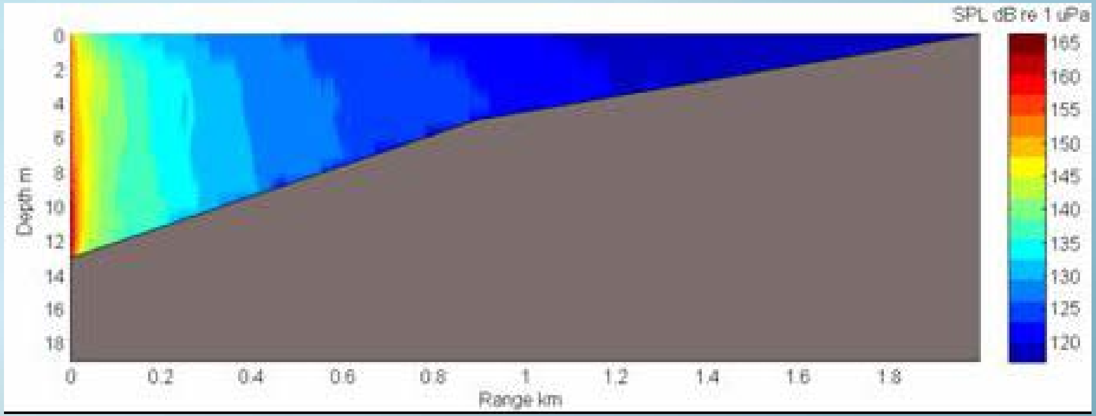


Key data inputs

1. Bathymetry – ETOPO1 – Global database, 1 minute resolution
2. Oceanography – WOA09 - Global database, 1 degree resolution
3. Seabed geoacoustics – BGS charts and geophysical/geological surveys

Acoustic propagation modelling
Results





Drilling noise downslope and upslope during the month of February

Acoustic impact thresholds

Exposure limit	Effect	Study
240 dB re 1 µPa (Peak)	Lethality	Yelverton and Richmond (1981)
230 dB re 1 µPa (Peak)	PTS Auditory injury onset in cetaceans	Southall *et al.* (2007)
218 dB re 1 µPa (Peak)	PTS Auditory injury onset in pinnipeds	Southall *et al.* (2007)
215 dB re.1µPa^{2}s SEL M-Weighted	PTS Auditory injury onset in cetaceans	Southall *et al.* (2007)
203 dB re.1µPa^{2}s SEL M-Weighted	PTS Auditory injury onset in pinnipeds	Southall *et al.* (2007)
224 dB re 1 µPa (Peak)	TTS onset in cetaceans	Southall *et al.* (2007)
212 dB re 1 µPa (Peak)	TTS onset in pinnipeds	Southall *et al.* (2007)
193.7 dB re 1 µPa (Peak)	TTS onset in harbour porpoise	Lucke *et al*. (2009)
195 dB re.1µPa^{2}s SEL M-Weighted	TTS onset in cetaceans	Southall *et al.* (2007)
183 dB re.1µPa^{2}s SEL M-Weighted	TTS onset in pinnipeds	Southall *et al.* (2007)
164.3 dB re 1 µPa^{2}s SEL	TTS onset in harbour porpoise	Lucke *et al*. (2009)
190 dB re 1 µPa (RMS)	Auditory injury criteria – pinnipeds	NMFS, (1995)
180 dB re 1 µPa (RMS)	Auditory injury criteria – cetaceans	NMFS, (1995)
174 dB re 1 µPa (Peak)	Aversive behavioural reaction in harbour porpoise	Lucke *et al*. (2009)
145 dB re 1 µPa^{2}s SEL	Aversive behavioural reaction in harbour porpoise	Lucke *et al*. (2009)
120 dB re 1 µPa (RMS)	Level B - Harassment in cetaceans and pinnipeds exposed to continuous sounds	NMFS, (1995)

Acoustic impact thresholds are taken from the peer-reviewed international literature. They are subject to change from time to time as our knowledge of the effects of sound on marine life improves.

Acoustic propagation modelling
Results

	Lethality	PTS	TTS	Level B –Harassment
Drilling	None	None	None	0 – 97 m *
Operational noise	None	None	None	0 – 65 m *

* dependent on background noise levels

Conclusions

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Summary

1. No significant impacts – fatalities, permanent or temporary deafness
2. Behavioural impacts possible – but dependent on background noise
   Deemed minimal and manageable
3. Consent awarded to Oyster project May 2013!!!

What I left out

1. Characterisation of sound sources
   - Construction noise
     Drilling noise
     Vessel noise
   - Operational noise
2. Temporal / spatial variability of acoustic propagation
3. Cumulative impacts …