Underwater noise impacts: myths and marine mammals

Stephen A S Jones
Marine Platforms and Equipment, QinetiQ Winfrith

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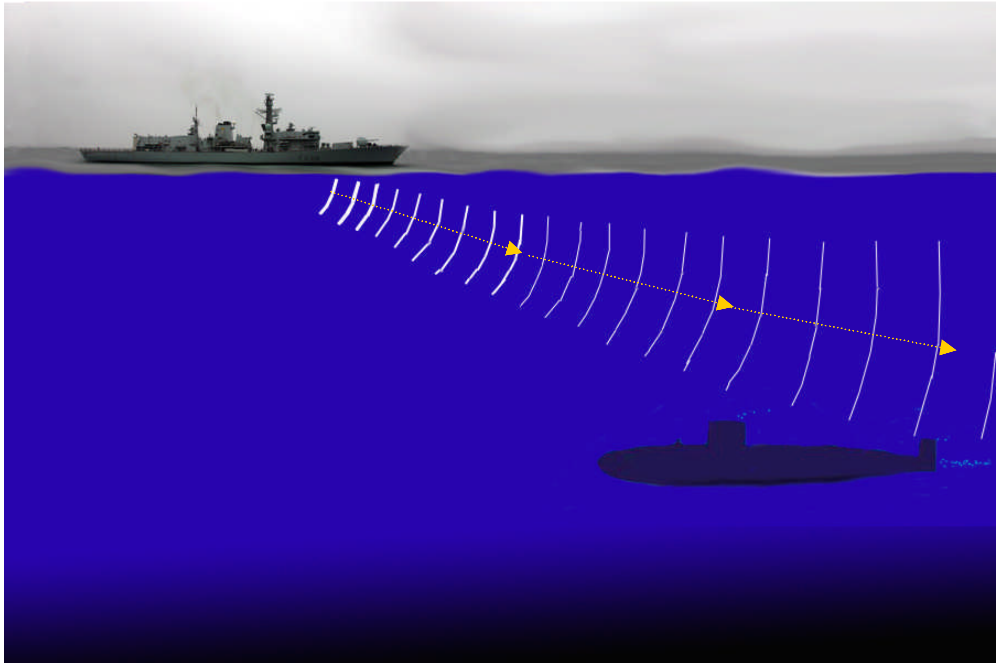
Contents

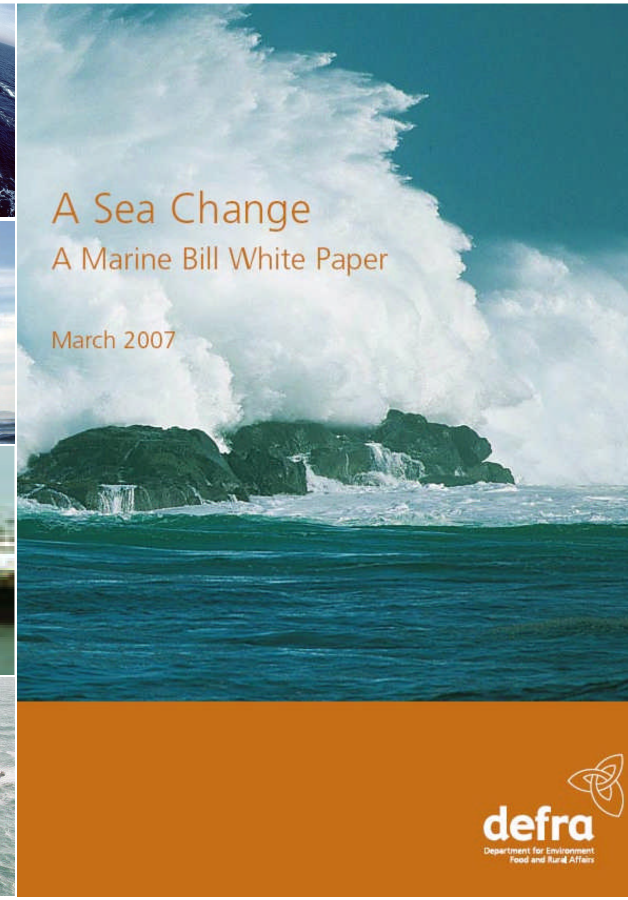
Uses of underwater sound

- Exploits good sound propagation underwater
- Military sonar for submarine detection and mine hunting
- Other sonar systems
  - Navigation
  - Scientific research
  - Fish finding
  - Seabed survey
- Seismic airgun arrays
- Regulated activities



The problem - noise and marine life

- Natural and human sources
  - Trends in ambient noise level
  - Changing nature and scale of human activities
- Radiated noise level and exposure duration
- Knowledge of underwater acoustic environment
- Understanding potential impacts on sensitive species
- Defining acceptable damage risk criteria
- Practicable mitigation measures



02
Myths

Statements on sonar acoustic levels – Myths?

"*has a maximum output of 230 decibels, compared with 100 decibels for a jumbo jet*"

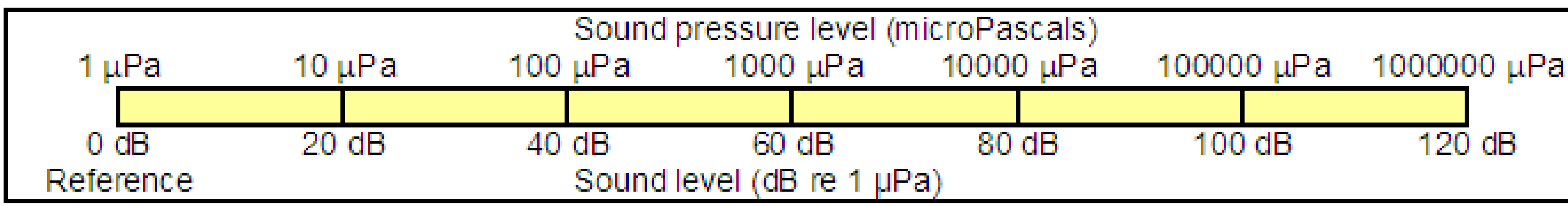
"*Some mid-frequency systems produce 235 decibels, as loud as a Saturn V rocket at launch*"

- No reference distances – are these source or received levels?
- No dB reference levels
- Comparison of noise levels – underwater and in air
- What is meant by loud?
- Bad science

Photo credit: NASA

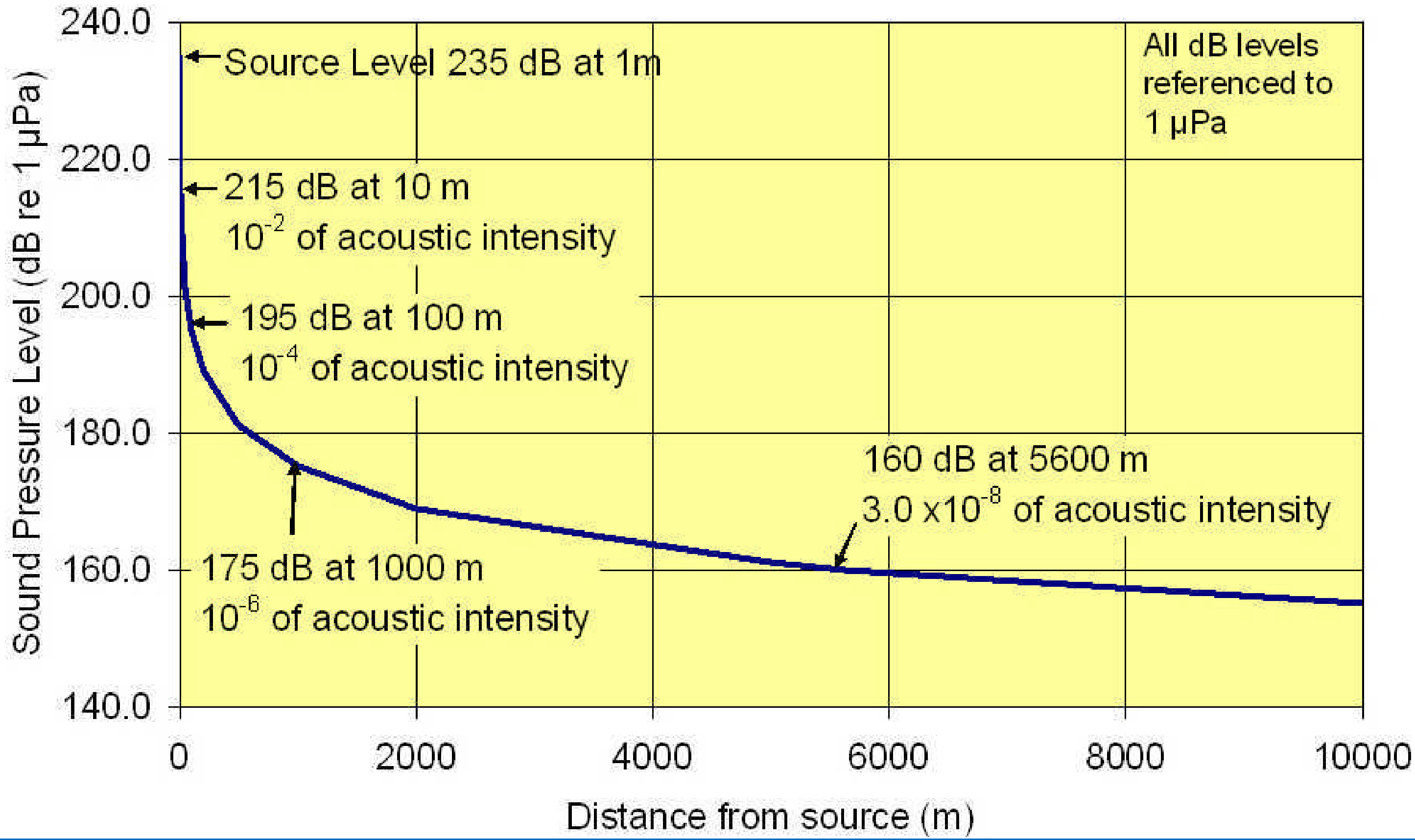
Decibel reference levels?

- The decibel is a numerical scale used to compare like quantities
- Used in acoustics to quantify sound levels relative to a reference (0 dB) level
- Can express a large range of sound levels
- Reference levels
  - 20 microPascals (μPa) for sound in air (human hearing threshold)
  - 1 μPa for underwater sound
- Pressure v Intensity



Propagation loss

- Reference distance for transmitted *source* level (usually 1 metre)
- No reference distance required for *received* levels

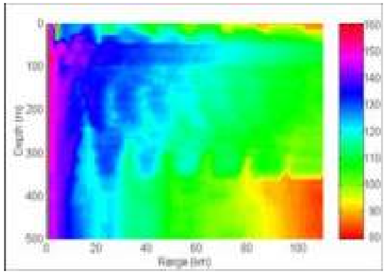


Comparing sonar with Saturn V – Exploding the myth?

- Compare underwater and in-air acoustic pressure levels
- Source level of sonar underwater at 1 m 235 dB re 1 μPa ≡ 53 dB re 1 Wm^{-2}
- In air intensity at 1 m of 53 dB re 1 Wm^{-2} is equivalent to 173 dB re 20 μPa
- Saturn V is 192 dB re 20 μPa at 1 m
- Need to consider source frequency, duration, propagation pathway and receptor response

Photo credit: NASA

03
Marine mammals – noise mitigation



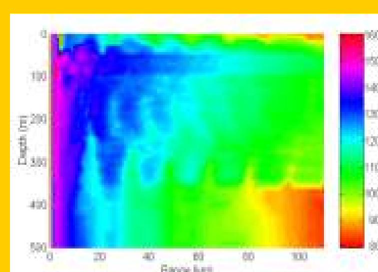
Source – Pathway – Receptor model

Source

Frequency, source level, pulse type & duration

Pathway

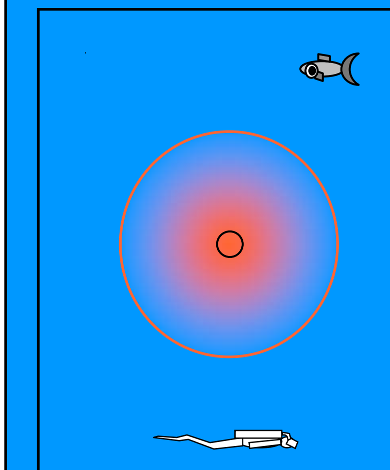
Properties of ocean, and seabed (models and databases)



Receptor

Sensitivity of environmental receptors & response

Footprint



Define Stand Off Range

In-air noise exposure

Human in-air noise exposure

Concept of sound dosage (duration of exposure)

Daily noise exposure depends on cumulative intensity and duration

$$L_{\mathrm{EP,d}} = 10\log_{10}\left[\frac{1}{T_0}\int_0^{T_\mathrm{e}}\left(\frac{p_\mathrm{A}(t)}{p_0}\right)^2 \mathrm{d}t\right]$$

Action limits to reduce risk of hearing damage

Assess the impact of underwater noise on marine fauna?

Marine receptor noise exposure

Application of human dosage principles to marine fauna

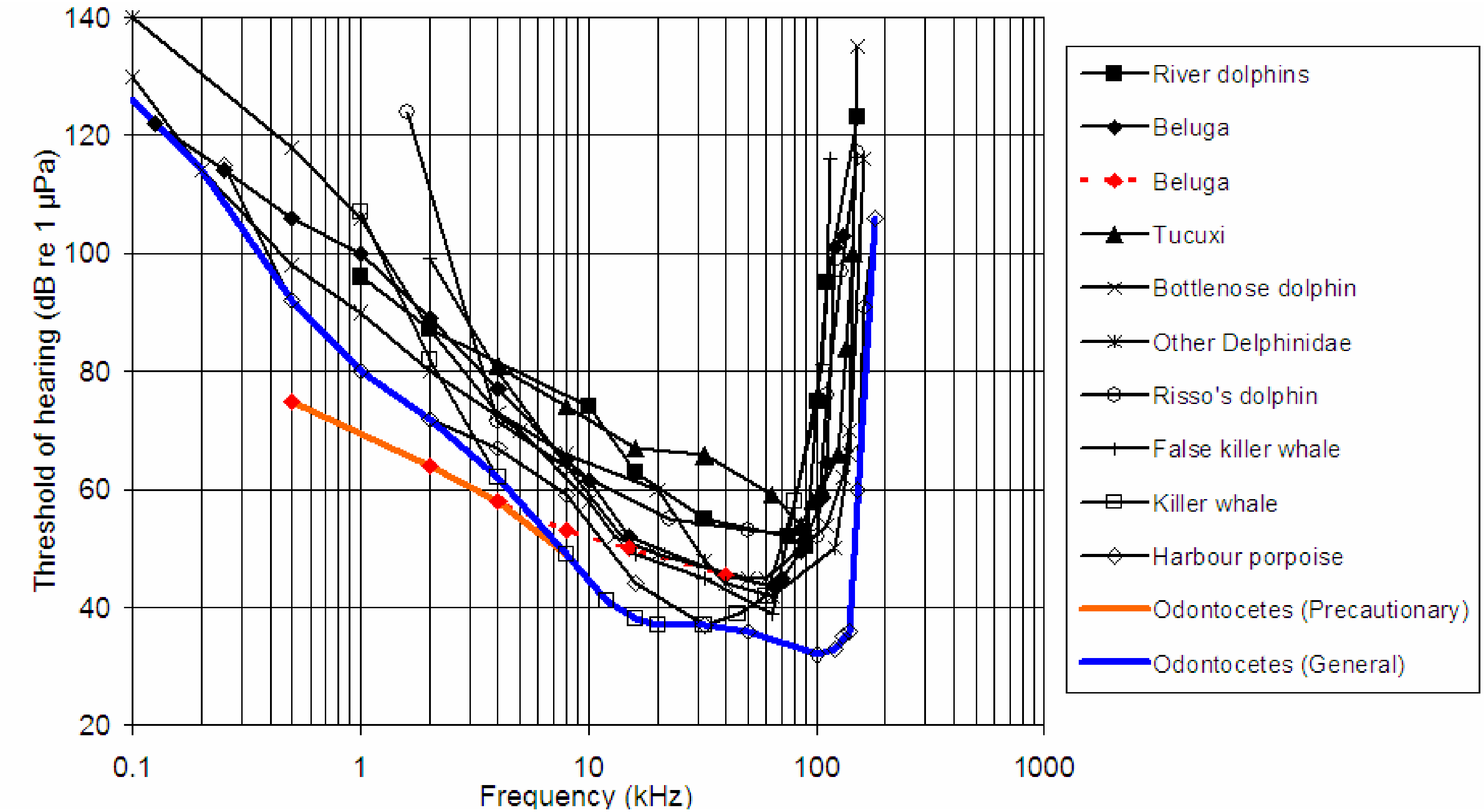
In-water noise exposure depends on:

- Transmitted acoustic level (Source)
- Sound propagation (Pathway)
- Sensitivity of hearing (Receptor)
- Duration of exposure (Source)
  - duty cycle
  - cumulative effects

$$L_{\mathrm{EP,d}} = 10\log_{10}\left[\frac{1}{T_0}\sum_{t=0}^{t=24\,\mathrm{h}}\left(10^{\frac{SPL-GTH}{10}}\Delta t\right)\right]$$

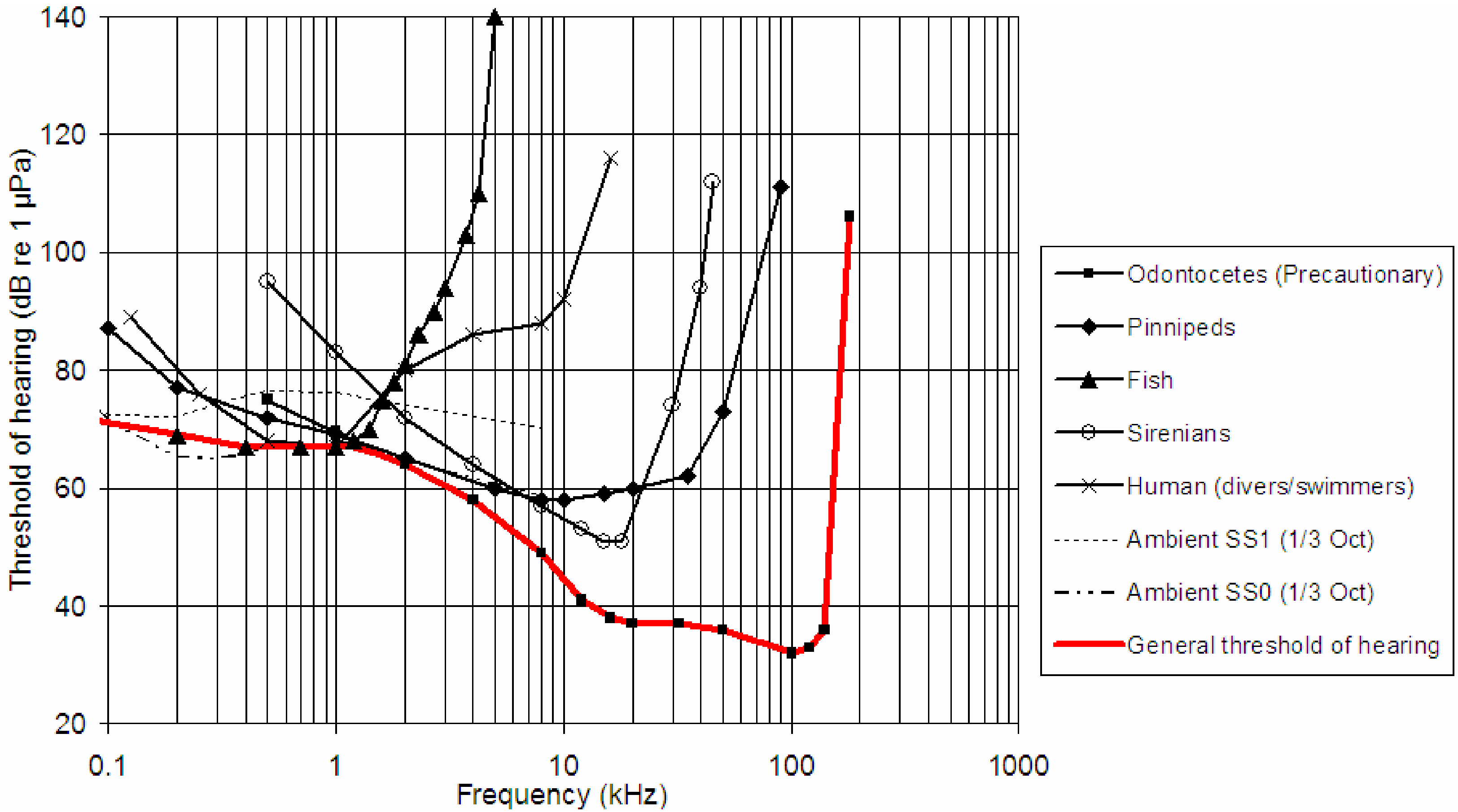
Receptor model - sensitivity of hearing

Published audiogram measurements for toothed whales



Receptor model - sensitivity of hearing

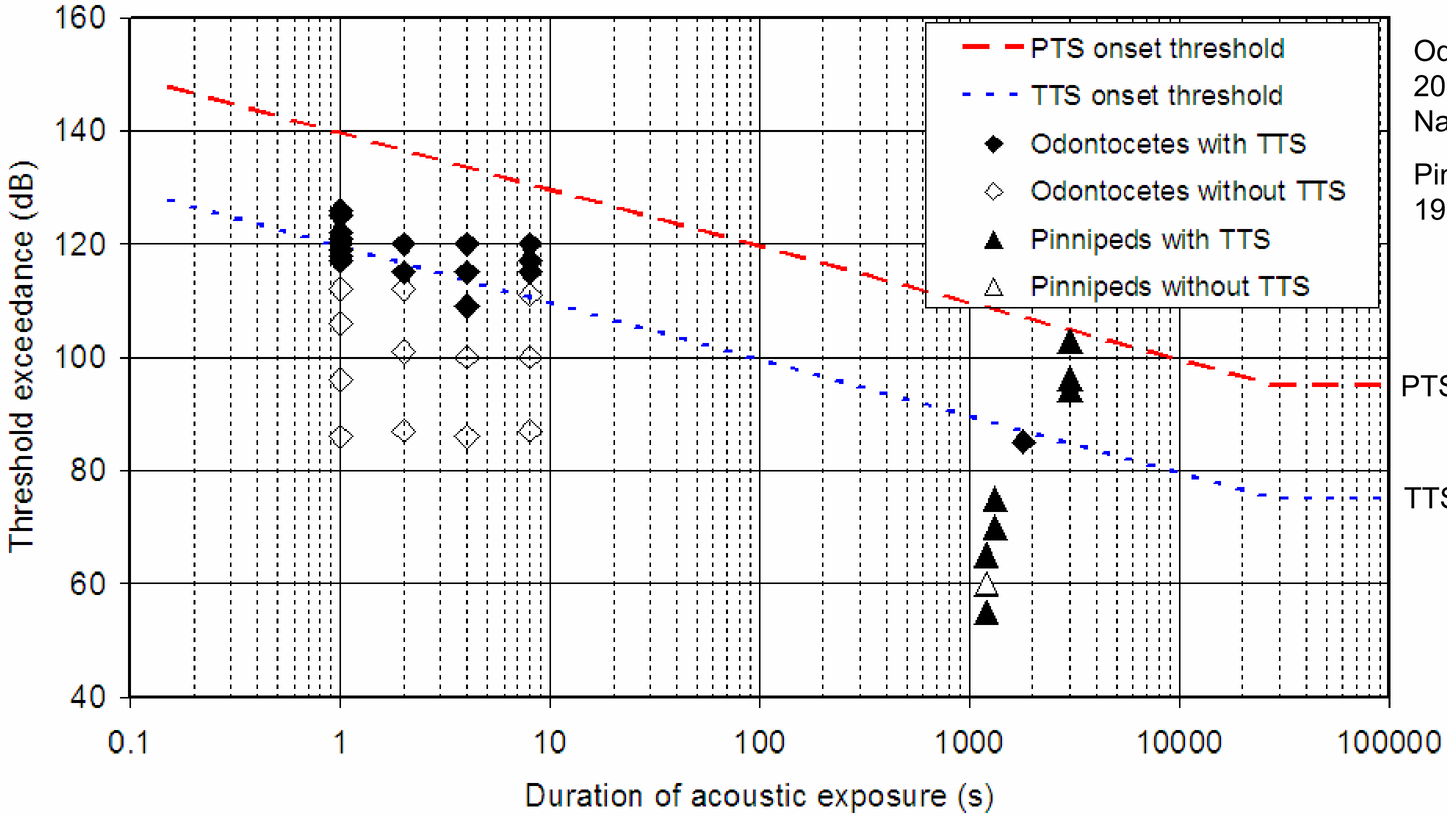
General threshold of hearing curve – marine fauna



Receptor model – onset of hearing loss

Compare predicted sound exposure level with damage risk criteria

- Threshold exceedance for temporary and permanent hearing loss
  - 75 dB for TTS onset, 95 dB for PTS onset



Odontocetes: Schlundt *et al*, 2000, Finneran *et al*, 2005, Nachtigall *et al*, 2004

Pinnipeds: Kastak *et al*, 1999, 2005

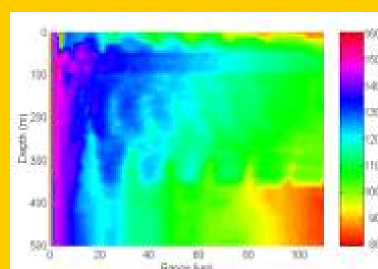
Source – Pathway – Receptor model

Source

Frequency, source level, pulse type & duration

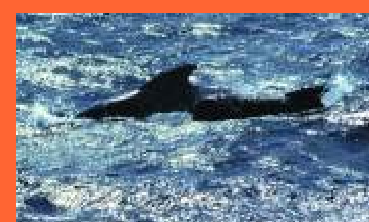
Pathway

Properties of ocean, and seabed (models and databases)



Receptor

Sensitivity of environmental receptors & response



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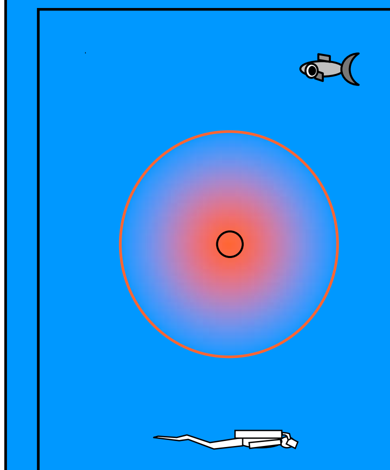


Define Stand Off Range

Acoustic environmental impact assessment

Acoustic damage risk criteria for marine fauna

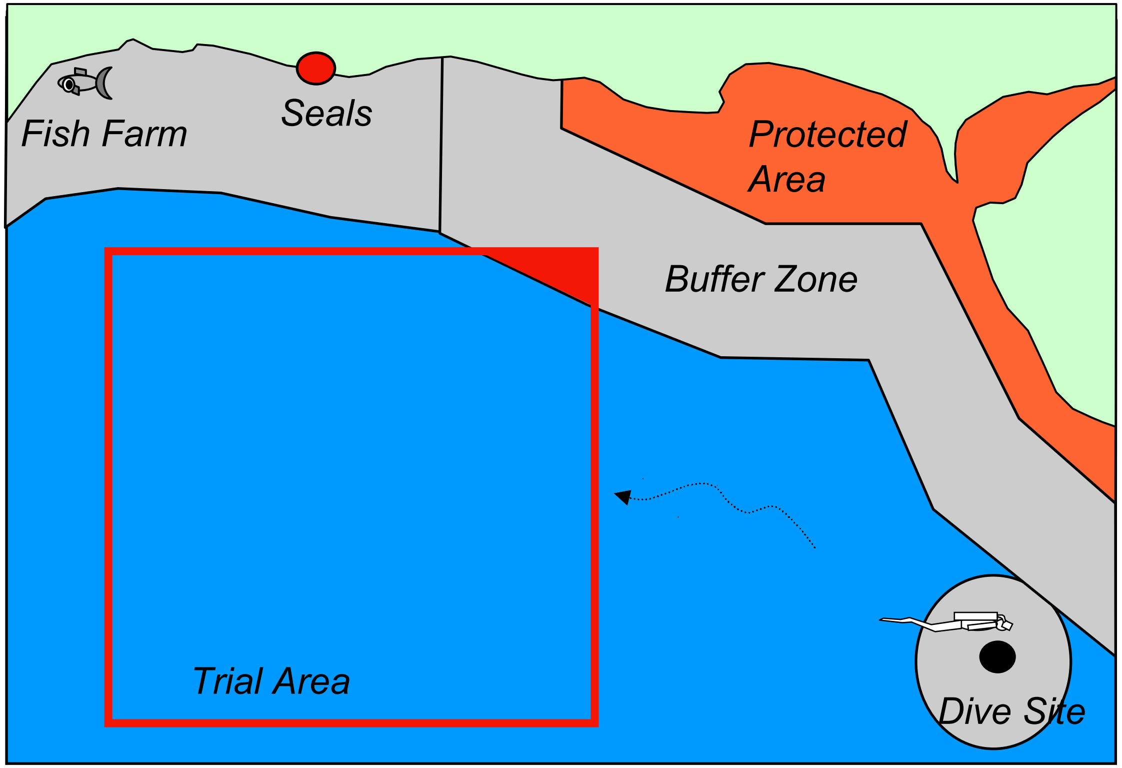
Physiological impacts and behavioural effects

Minimise cumulative noise exposure to avoid:

- Permanent Threshold Shift (PTS) in hearing
- Temporary Threshold Shift (TTS) in hearing
- Adverse behavioural reaction

Define safe operating distances for mitigation

Mitigation - Environmental Protection Planning



Biological

- Marine mammals, fish, turtles, humans etc

Socio-economic

- Fisheries, exploration, whale watching

Physical

- e.g. historic wrecks

Summary

Impact of radiated noise on marine life

In air and in water perspective

Explored some myths

Source – Pathway – Receptor model

- Source characteristics
- Acoustic propagation
- Receptor sensitivity and response – damage risk criteria
- Practicable and effective mitigation