



National Physical Laboratory

Underwater Noise Measurement Seminar

October 13th, 2005

Introduction

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National Physical Laboratory

- UK National Metrology Institute
- based in Teddington (west London)
- approx. 650 staff
- holds and maintains UK national standards for most physical measurements:
 - mass, length, electrical, time, frequency, ionising radiation
 - and **acoustics**



Work of NPL

- pivotal role in national measurement system
 - infrastructure providing traceable measurements
- measurement standards and specification standards
 - ISO, IEC, BSI, etc
- increase industrial competitiveness
- “Quality of Life” issues
 - including environmental issues
- knowledge transfer

Underwater noise seminar

Aims

- gather together experts in underwater noise assessment
- provide a forum transfer of knowledge to wider community
- exchange views and opinions on approaches to the challenges ahead

Impact of underwater noise

Effect on marine life

- in particular mammals
- major issue in news
- main headlines:
 - low frequency military sonar (LFAS)
 - petrochemical seismic surveying and drilling/piling

Effect on humans (divers)

- in particular, noise from underwater tools and machinery

Effect on other acoustic systems

- platform self-noise interferes with acoustic systems
- eg: degrades performance of acoustic positioning systems

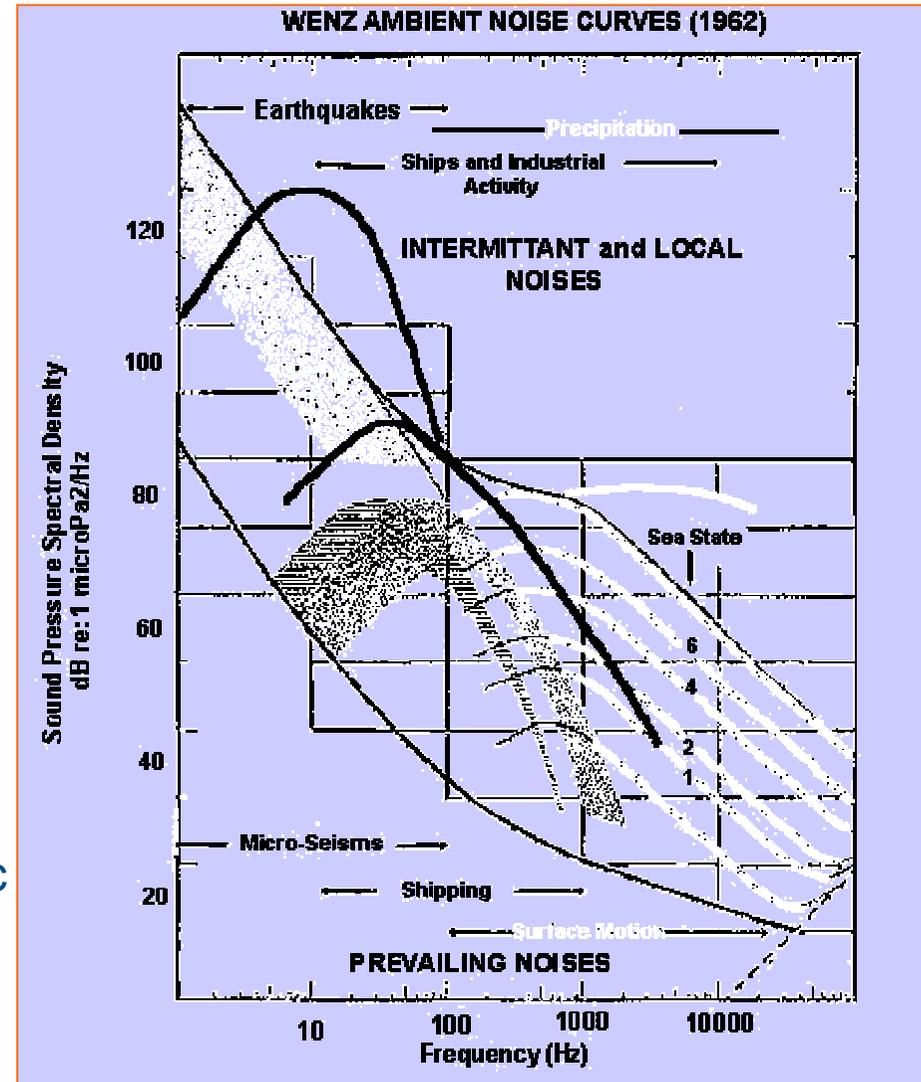
Impact on marine life: highlighted by events

- Ship Shock Tests 1994
- ATOC 1995
- NATO Greek Strandings 1996
- Bahamas Strandings 2000
- Seismic Research 2002
- US Navy LF sonar 2003



Natural sound sources: ocean ambient noise

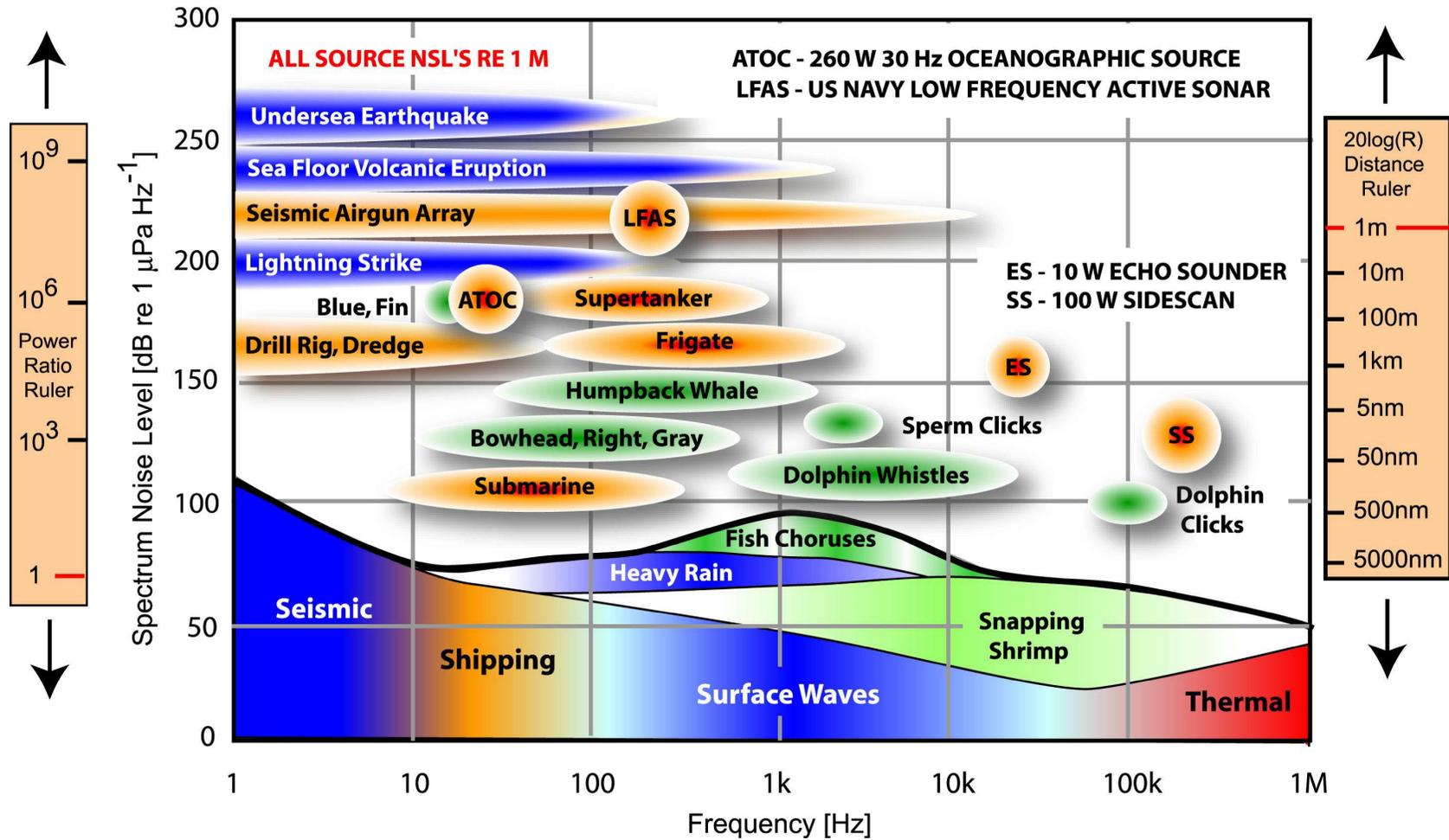
- Wenz (1962)
- seismic (LF)
- “distant” shipping
- rain
- waves
 - depends on sea state and wind speed
- biological
 - snapping shrimp, mammals, etc



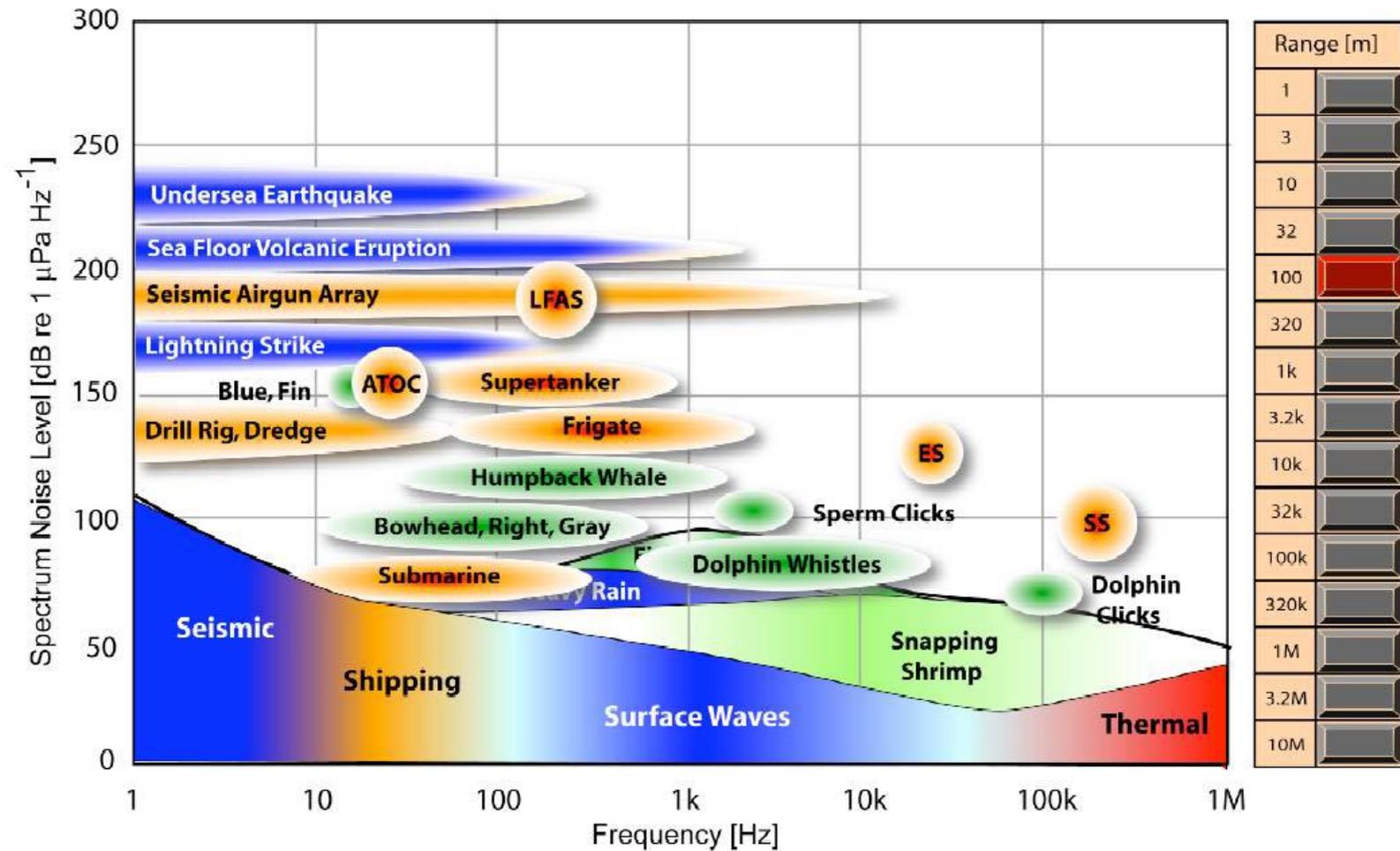
Anthropogenic sound sources

- Shipping
- Geophysical surveying
- Drilling, piling, dredging
- Explosions
- Underwater vehicles
- SONAR
- Acoustic communication and positioning transducers
- Echo sounders

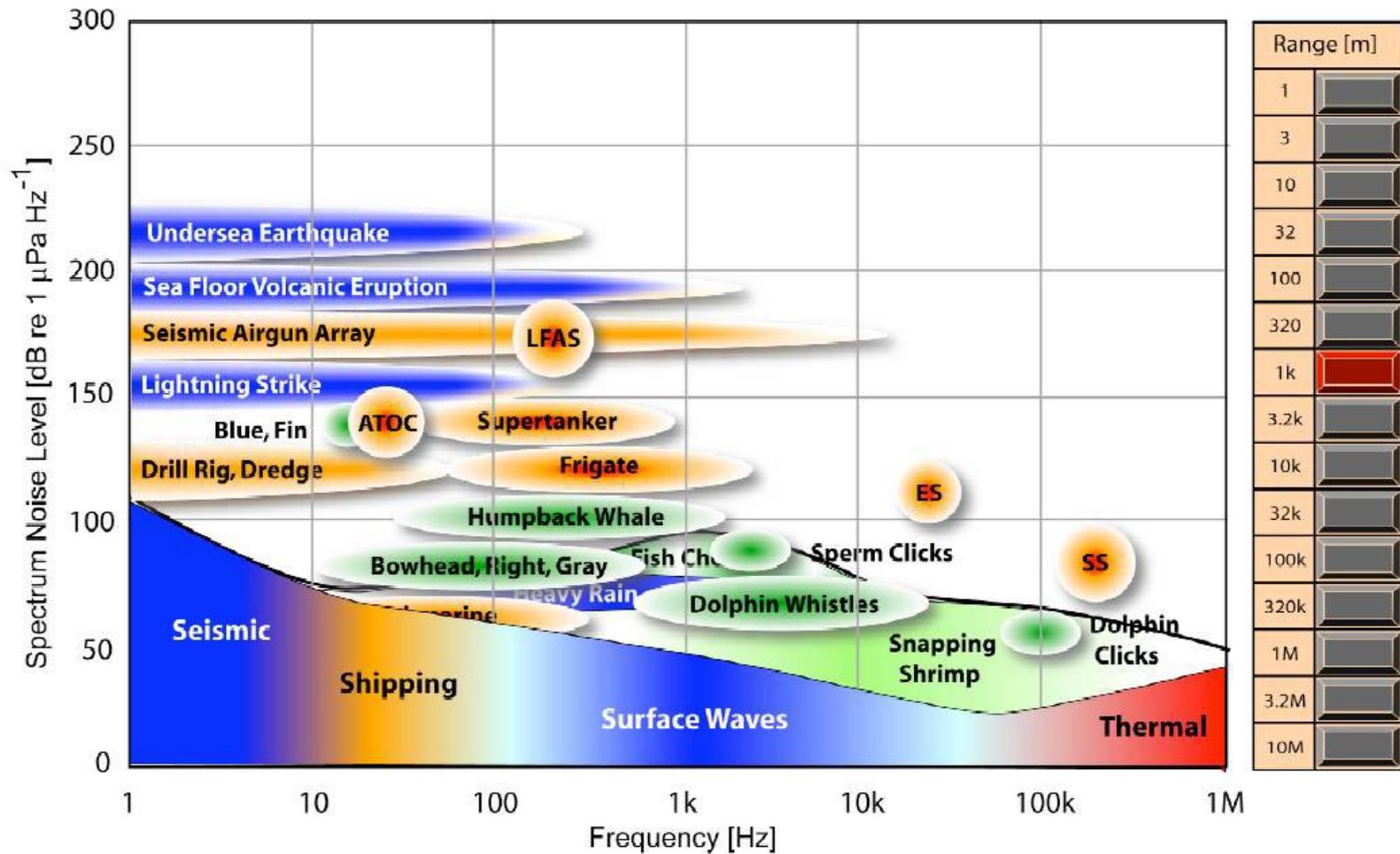
Examples of undersea noise



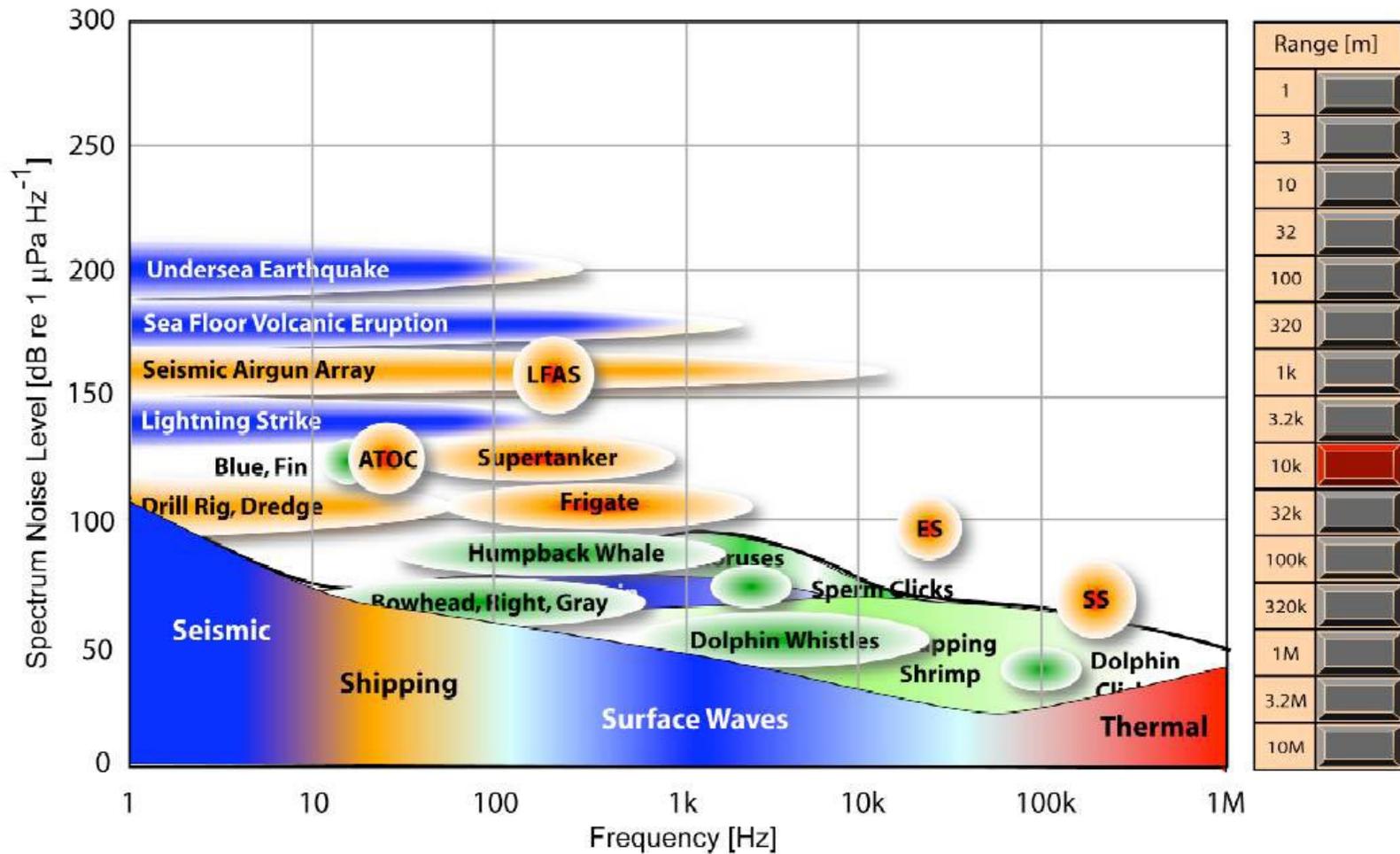
Examples of undersea noise



Examples of undersea noise



Examples of undersea noise



Easily made mistakes

- misunderstanding of decibel notation
- incorrect reference levels used
- source level versus sound pressure level
- confusion between air and underwater acoustics
 - eg use of dBA notation

Noise assessment – basic methodology

Divide the assessment of noise into stages:

- noise emission from sources
 - requires source to be characterised
 - ideally in terms of sound power or source level
- sound transmission
 - propagation can be highly complex
 - depends on boundary conditions and environmental conditions
- background noise
 - the ambient noise level in the ocean
- sound reception
 - the sensitivity of the receiver (or animal) at the location where the sound is detected

Sound propagation underwater

- sound speed varies with **temperature, depth, salinity**
- sound speed profile important – governs **refraction**
- also important: **reflection** from **surface** and **bottom**
- simple spreading assumptions:
 - spherical (deep water)
 - cylindrical (shallow channel)
- propagation models:
 - normal modes approach
 - ray tracing

Noise measurement methodology

Methods

- analogous to ISO3740 series but logistics are difficult
- hydrophones used
pressure → intensity → power
- intensity sensors would be useful

Issues

- Free-field conditions difficult – complex propagation
- Possible hemi-anechoic ?
- Reverberant versus free-field
- Far-field versus near-field
- Accuracy versus practicality
- *In situ* measurements difficult

Example approaches



- fixed noise ranges
- “portable” ranges
- *in-situ* measurements
- reverberant tanks

Type of source affects method used

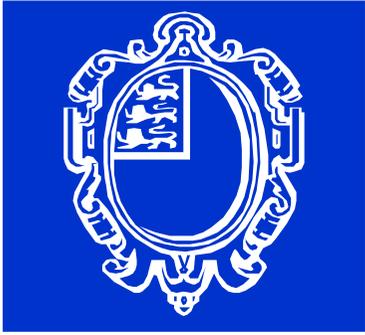
- **Vessels**
- **Vehicles and platforms**
 - **ROVs, AUVs**
- **Machinery**
- **Diver tools**
- **Drilling and piling sites**
- **Dredging sites**
- **Off-shore wind farms**
- **Wave power generators**

And introducing the rest of the day...

Topics covered

- Noise impact on marine life
- Mitigation measures
- DTI environmental policy regarding off-shore operations
- Noise measurement methodology and analogies to air acoustics
- Experiences of measuring and modelling noise from various sources
- Quantifying exposure of marine species
- Acoustic monitoring
- Exposure of humans (divers and swimmers)

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