

The dB_{ht} (*Species*); a metric for estimating the behavioural effects of noise on marine species.

Or, on the hearing of a herring and the deafness of a dab



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The underwater environment

- Most underwater animals use sound to navigate, communicate and explore their environment (fish, marine mammals, crustaceans,)
- Man made noise therefore has great capacity to effect their environment
- How do we judge the significance of noise?

(Research still in progress)

Underwater Source Levels

dB re 1 uPa @ 1 metre

Noise source	Source Level	Hear it!
Background noise	110-140	
Vessel	170-190	
Airgun array	190-240	
Piling	170-270	
Borehole blasting	220-260	

Effects of major noise sources

Type	Death and lethal injury	Non lethal and auditory injury	Behavioural effects
Typically characterised by....	Dead floating fish	Deafness and increased predation	Driven from area inc. feeding & breeding grounds
over...	Few 10s of metres, ~ .001 km ²	Few 100s of metres, ~ 0.5 km ²	Over 20 kilometres, ~ 1000 km ²
Effecting....	Odd unlucky marine mammal, a few fish	A few marine mammals, shoals of fish	Fish stocks, entire marine mammal populations

Behavioural effects of noise

Level at a point depends on

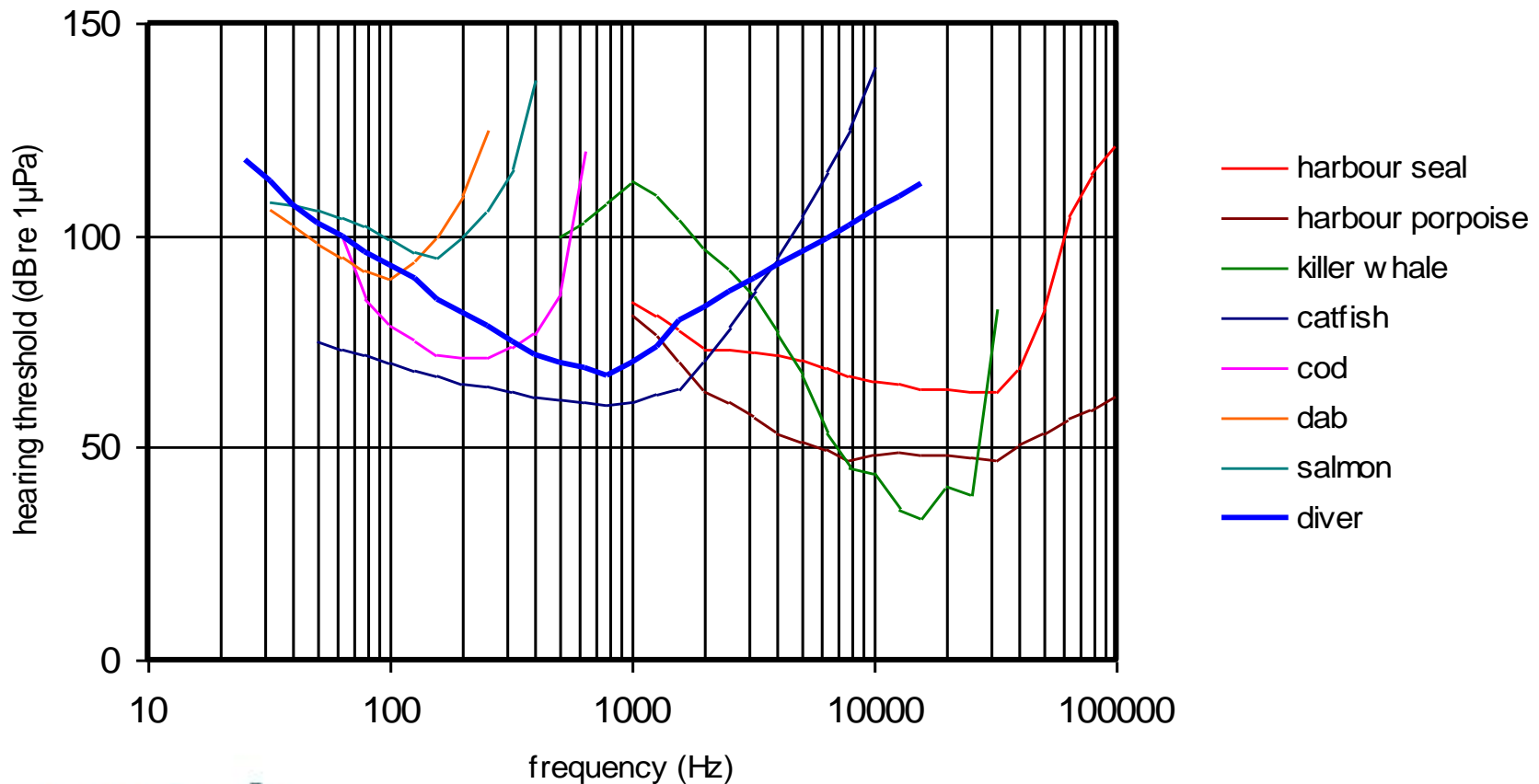
- Source Level
- Transmission Loss

But simple measurement or estimate completely useless without means to make biological interpretation

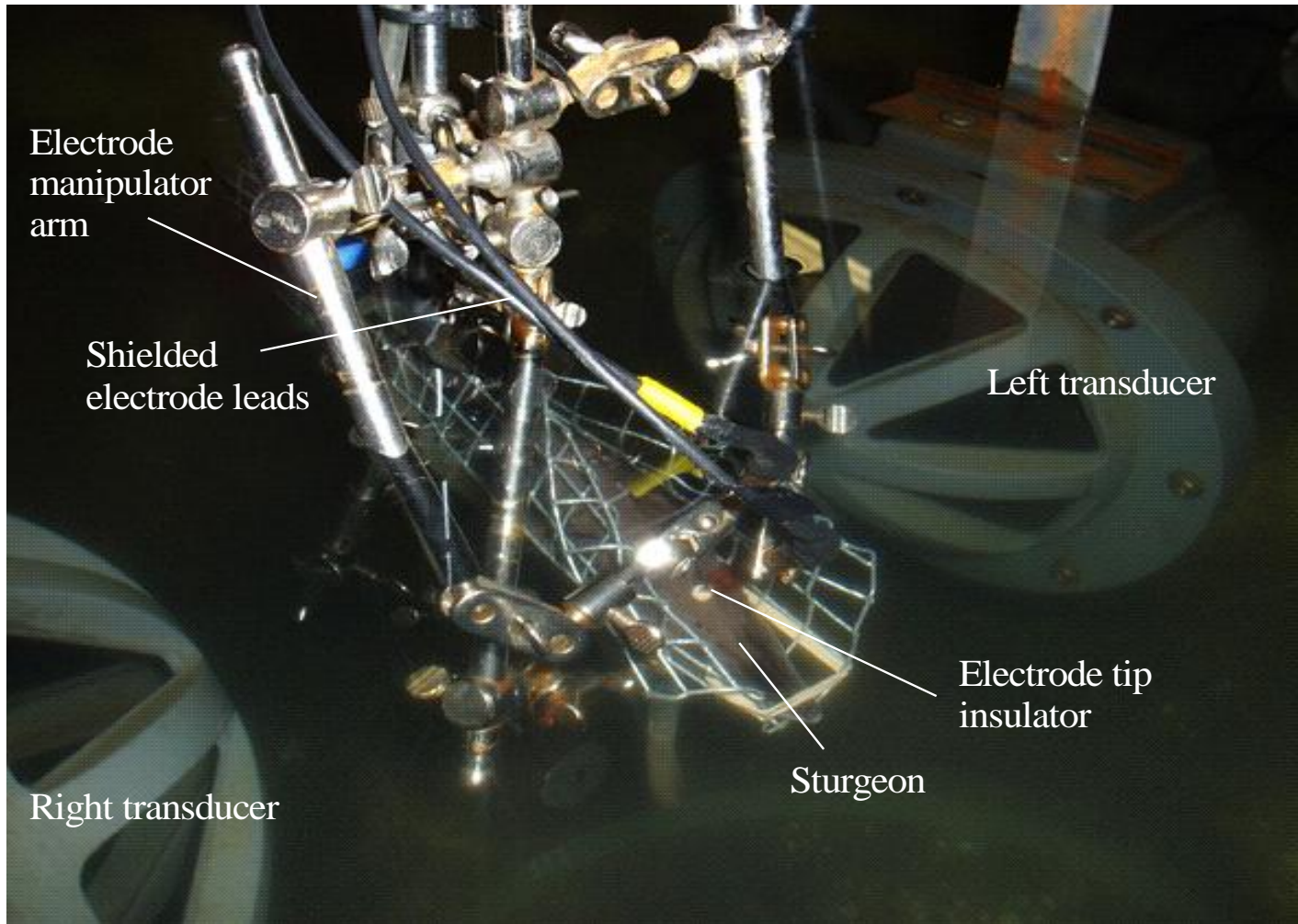
- **Sensitivity of animal to sound frequency content (spectrum) of sound**
- **Hearing range and ability of animal**

Hearing

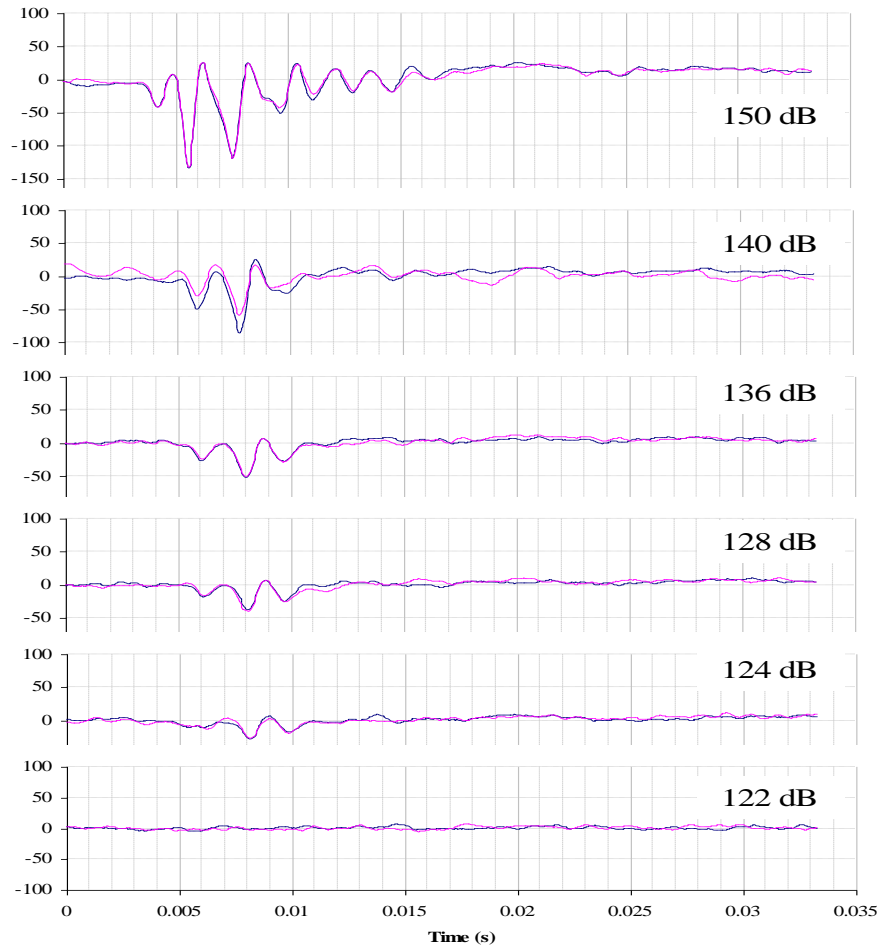
Defined by audiogram, lowest level of sound that can be perceived by species as function of frequency



Audiograms

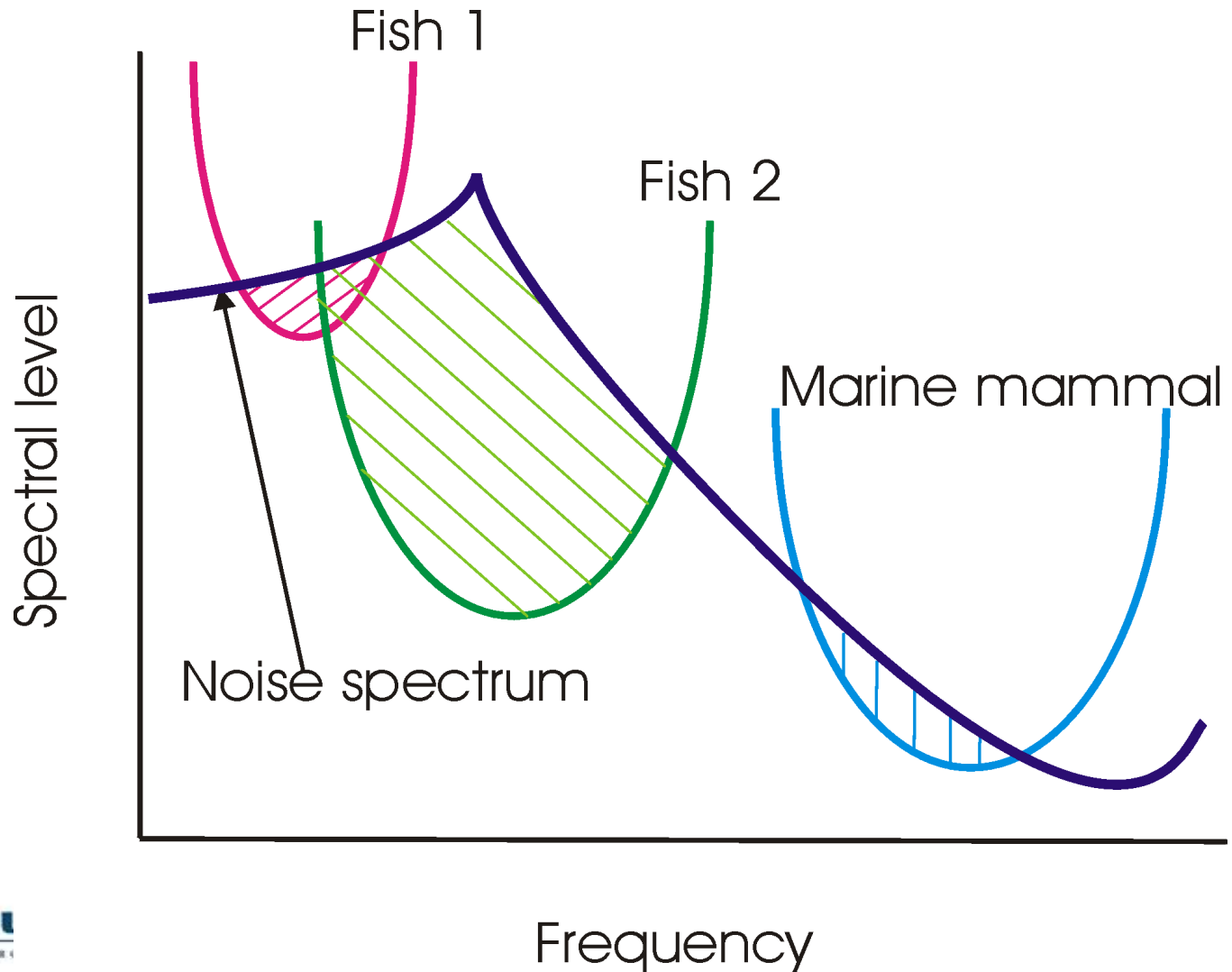


Auditory Brainstem Response



- Threshold of hearing is estimated by finding the level of sound at which the brainstem auditory response just appears above noise.

“Loudness” of sound



Effects of noise

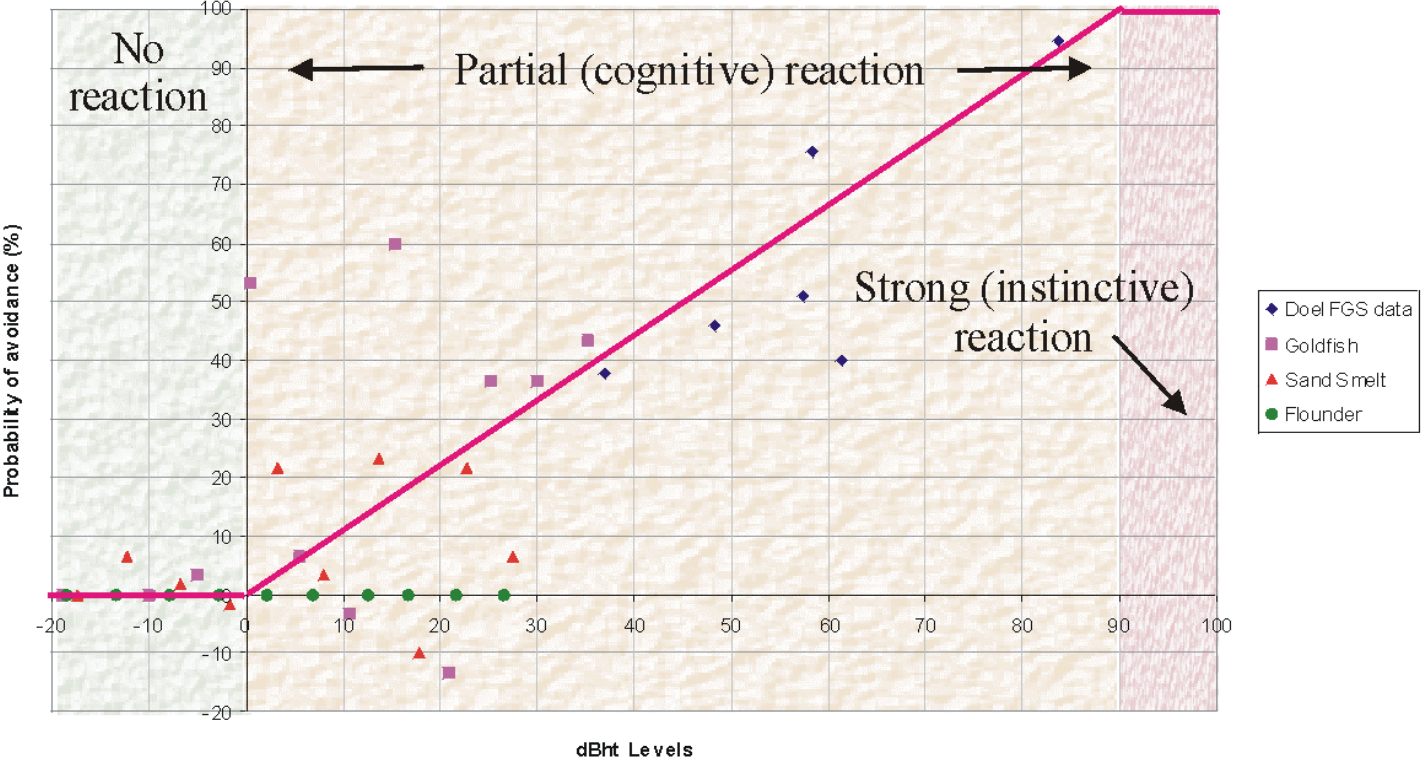
Level	Comment	Effects	Human equivalent
$< 0 \text{ dB}_{\text{ht}}$	Animal can't hear it	No reaction	Soundproof room
0-90 dB_{ht}	Increasingly loud	Reactions primarily cognitive	e.g. office 50, workshop 70 dB_{ht}
90-130 dB_{ht}	Unbearably loud	Instinctive reaction (avoidance)	Roadhammer $>100\text{dB}_{\text{ht}}$
$> 130 \text{ dB}_{\text{ht}}$	Deafening	Traumatic hearing damage	Gunfire near ear

Some notes on dB_{ht}

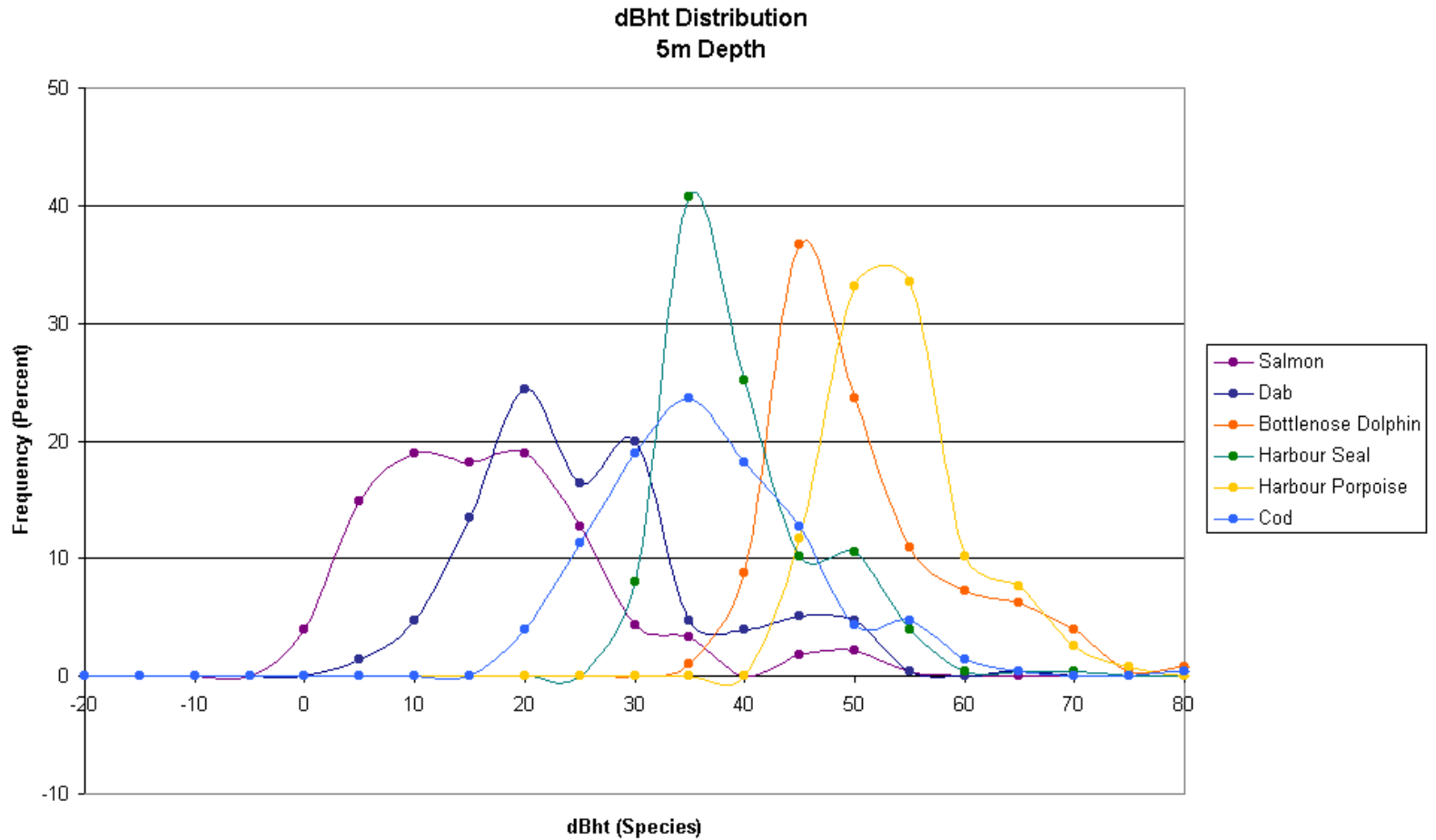
- Prospect: A “marine species” sound level meter
- dB_{ht} is an estimate of the *perceivable* level of sound, or its “loudness”
- In concept, similar to dB(A) used for humans
- Units of dB level re species hearing threshold (hence dB_{ht})
- Since different for different species, must have species name appended e.g. $88 \text{ dB}_{\text{ht}}(\textit{Gadhus Morhua})$ for cod, unless used generically (“levels of $90 \text{ dB}_{\text{ht}}$ and above will cause avoidance....”)
- Concept similar to dB(A) ; effect of sound determined by level *above threshold*.
- Not a perfect scale – but much better than absolute sound levels. (e.g. some effects may occur lower in “nervous” species (for instance, the grazers) than in “bold” (predatory) species.)

Reaction to noise

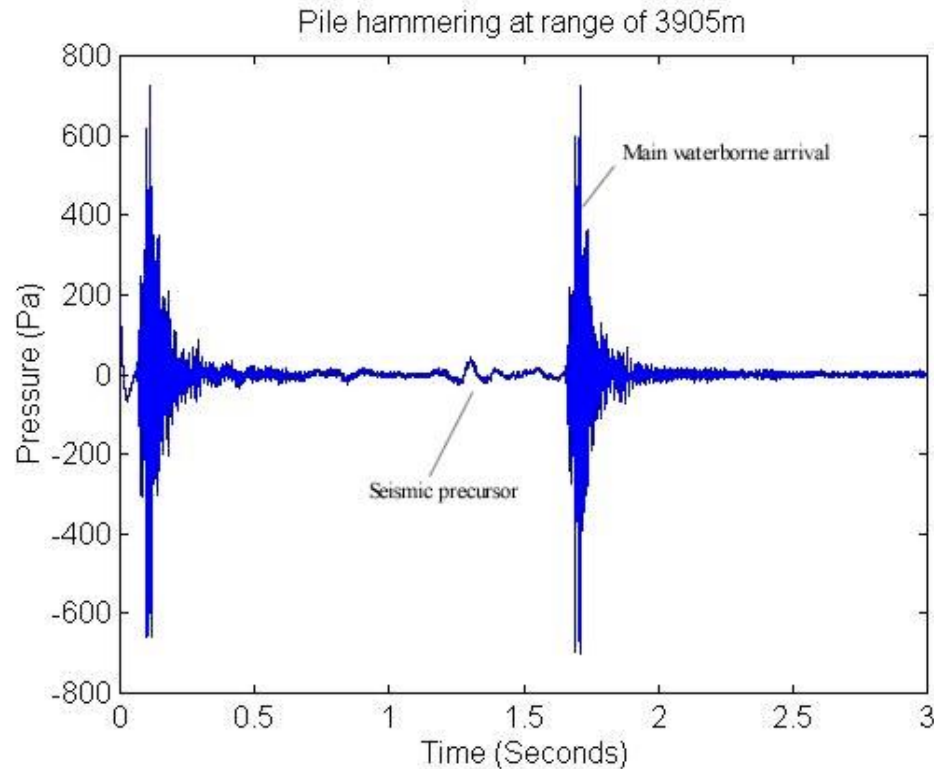
dBht Levels vs Deterrent Efficiency



Coastal background noise



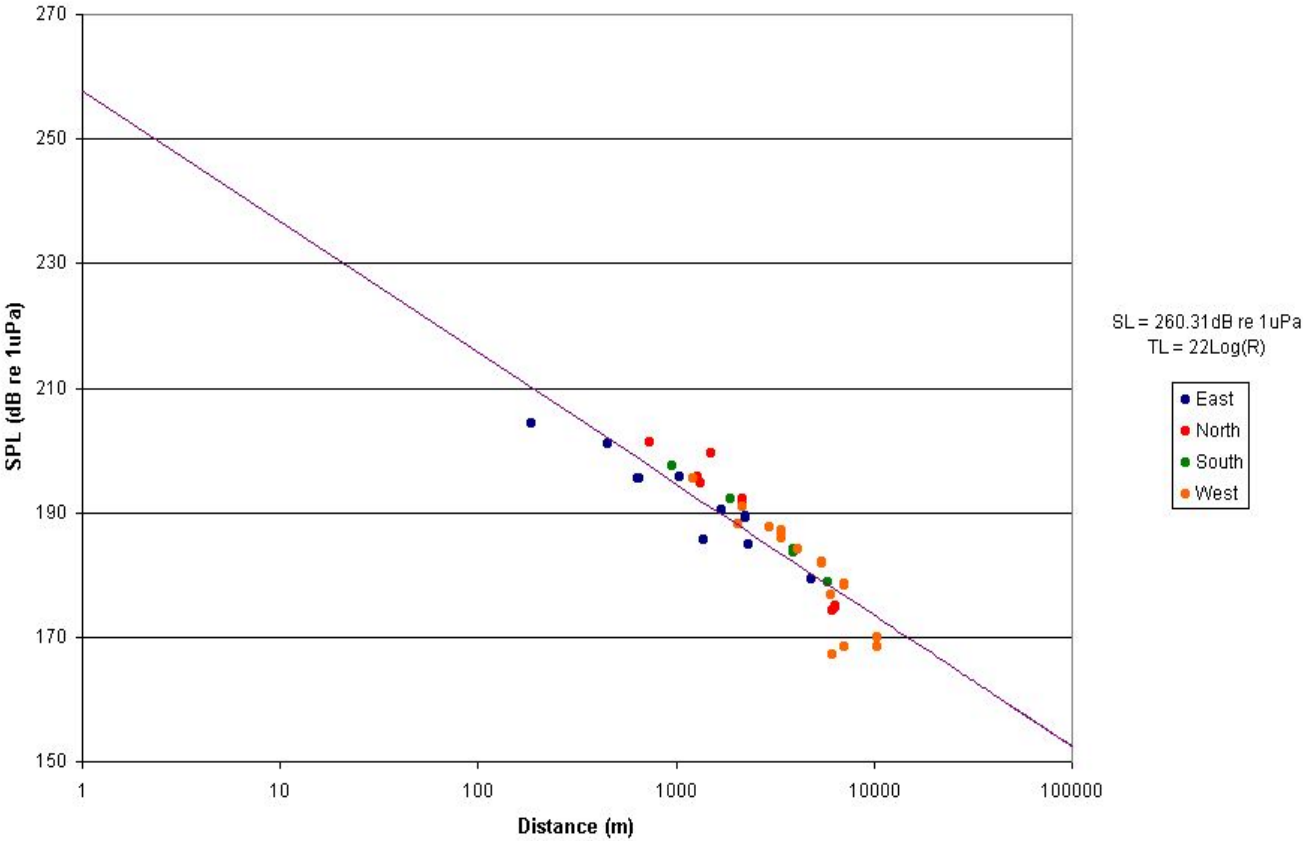
Piling noise



Hammering of 4.3 m diameter pile at 4 km

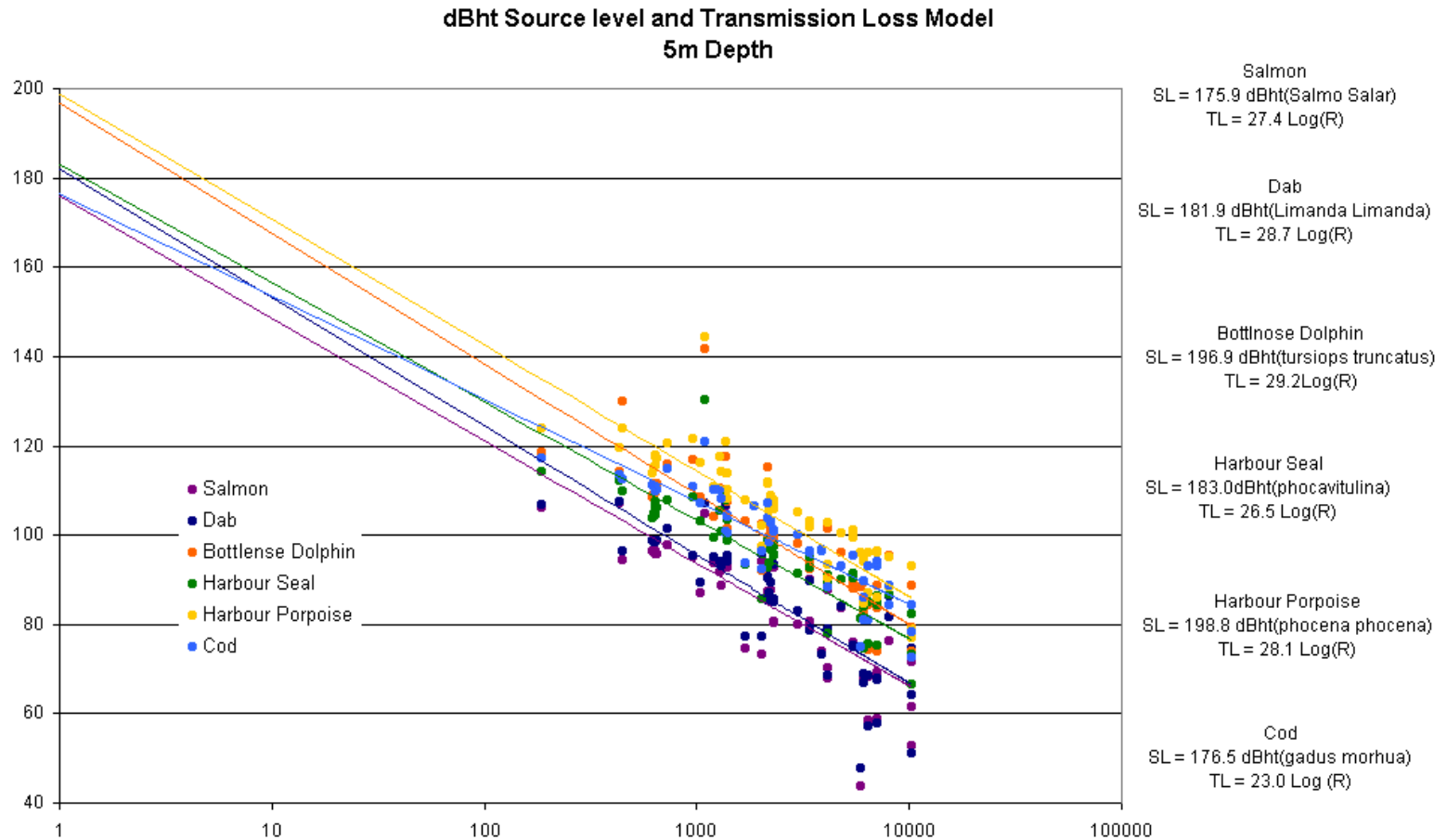
Piling noise

5m - All Transects



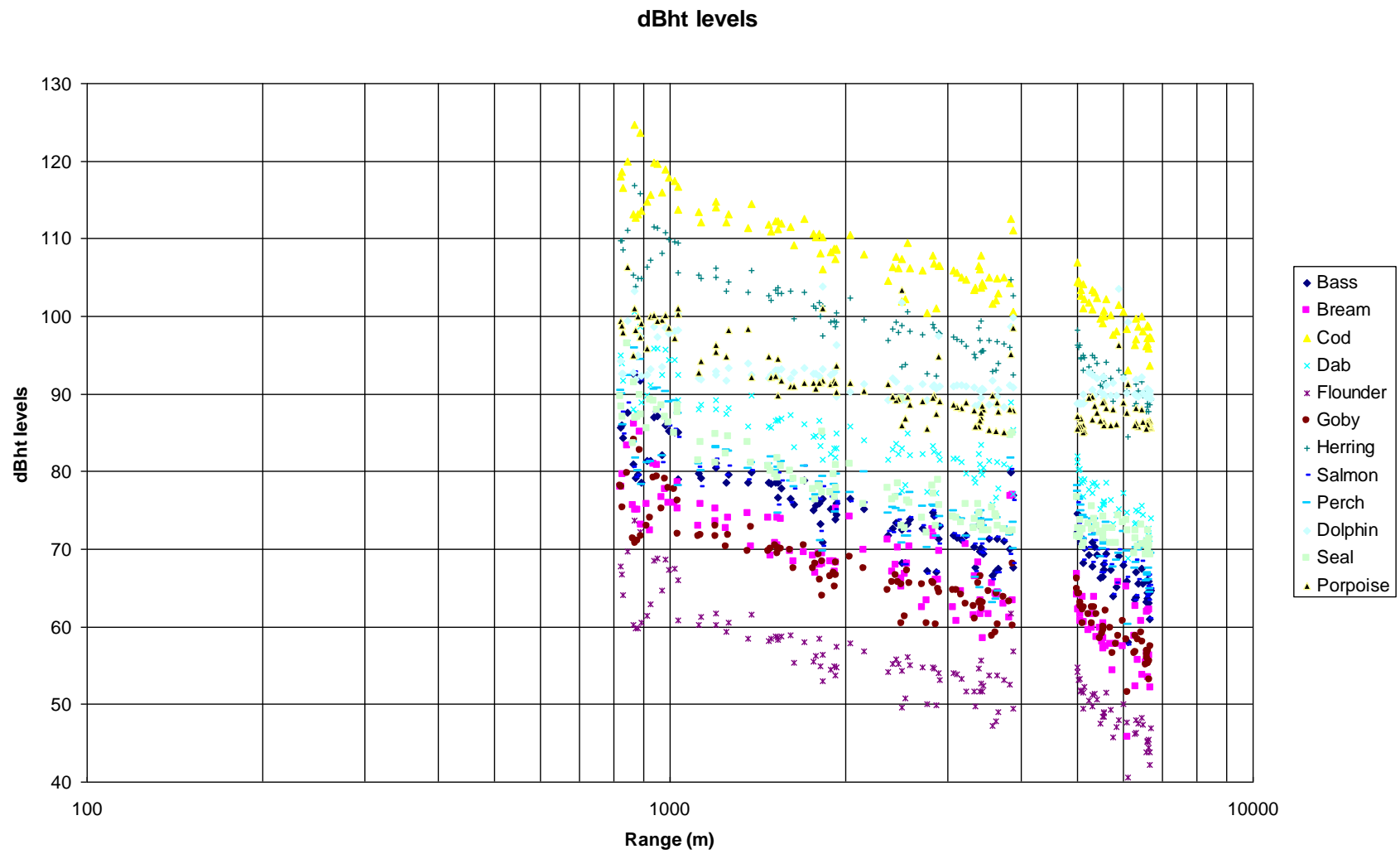
SL and TL Model for measurements of pile hammering noise

Behavioural effects of piling noise?



Pile hammering noise measurements at 5m depth

Behavioural effects of seismics?



Evidence?

- Piling: World's largest offshore wind farm was build on Horns Reef in the Danish North Sea in 2002; observations from ship surveys showed a significant change in behaviour of harbour porpoise on days with pile driving at distances up to 15 km from the wind farm

(Tougaard, J, Carstensen,J, Skov,H, Teilmann,J, and Henriksen, O D (2003). Effects from pile driving operations on harbour porpoises at Horns Reef offshore windfarm, monitored by T-PODs and behavioural observations. Report by National Environmental Reseach Institute, Frederiksborgvej 399, DK-4000 Roskilde,Denmark)

- Seismics: Significant study by Engås in 1992 confirmed that a 3-D seismic survey caused an immediate reduction in commercial catch rates in its vicinity of substantially more than 50%, while having lesser effects extending at least 20 km away and perhaps further

(ENGÅS, A., S. LØKKEBORG, E. ONA & A.V. SOLDAL (1993). Effects of seismic shooting on catch and catch-availability of cod and haddock. Fisken og Havet 1993(9): 117p.)

Summary

- Research and validation still in progress
- Data confirm the $\text{dB}_{\text{ht}}(\textit{Species})$ hypothesis, that the degree of behavioural effect induced by sound depends primarily on the $\text{dB}_{\text{ht}}(\textit{Species})$ level.
- Enables detailed investigation of species specific effects, sorting out real problems from red herrings, and simple generic statements about behavioural effects (e.g. “sound above $90 \text{ dB}_{\text{ht}}$ will cause strong avoidance reaction”)

Acknowledgements

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