“The broadband acoustic output of marine seismic airgun sources"

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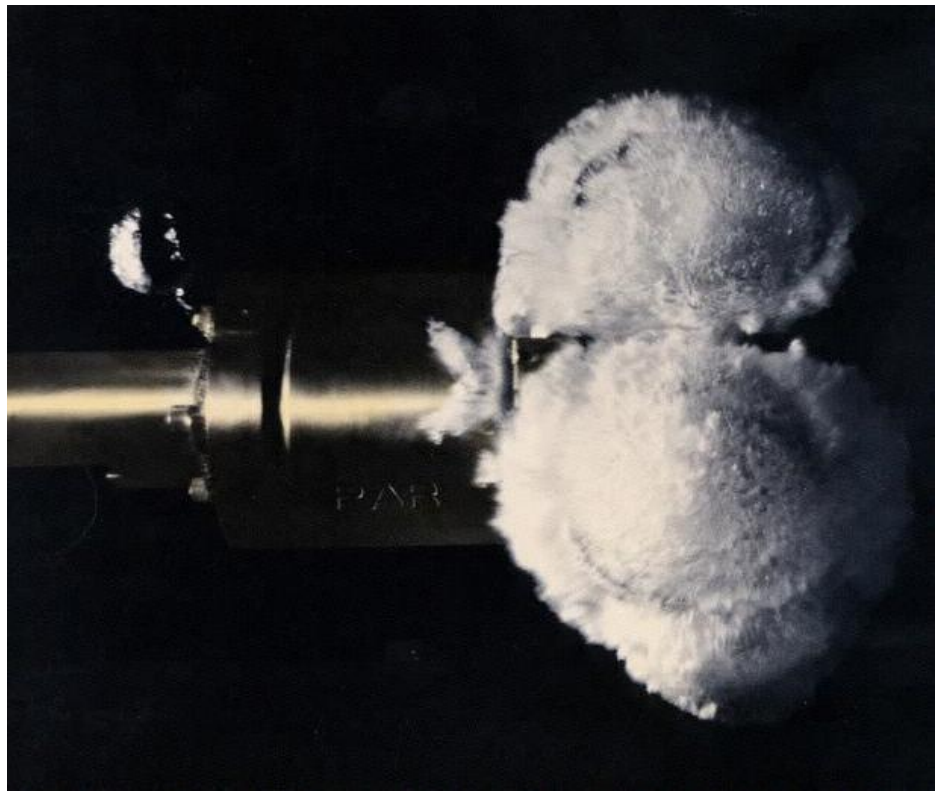
Overview

- Seismic sources – marine airguns
  - Introduction
  - Modelling
- Marine Life Impact
- Where next

Types of source – A Bolt 1500C airgun firing

Firing pressure
2000psi (138 bars)

Volume 100 cuin
(1.64 litres)



Little ones and big ones

Airgun movies

- **High-speed underwater movie of airgun firing**
- **Normal speed surface movie of airgun firing**

Courtesy IO limited

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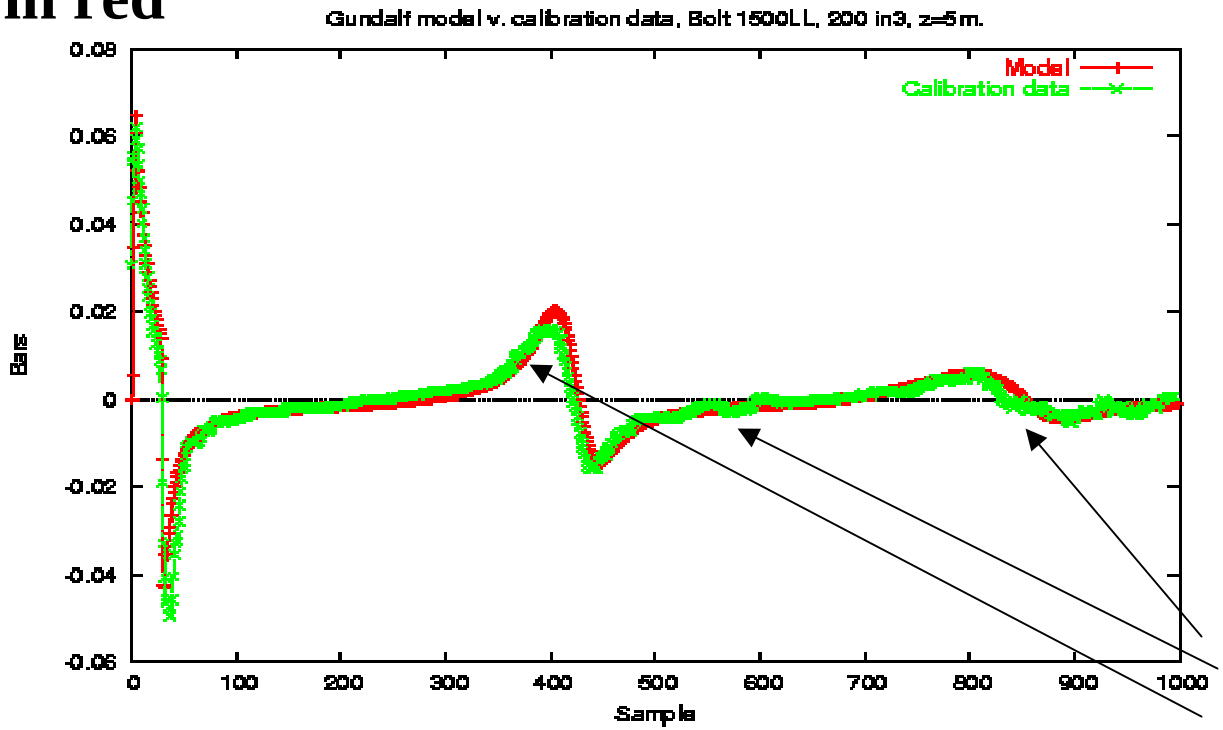
Airgun emission modelling

- Fundamental work done by Ziolkowski (1970)
- Extended both theoretically and experimentally 1980-present notably by Dragoset, Hatton, Haugland, Parkes, Landro, Laws, Vaage, Ziolkowski
- Treatment of very close clustering and high-frequency output by Hatton (2004-).

State of the art in modelling: (seismic band frequencies 0–400Hz)

- **200 cu.in 1500LL, Lake Seneca data (green), Gundalf model in red**



Side and bottom reflections

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Some notes on hearing in marine life

- Mammals hear the pressure field
- At least some fish appear to hear the particle velocity field
- Mammals appear to integrate the pressure field over somewhere between 1/3 and a full octave
- Potential impact includes pain, temporary loss of hearing (TTS), permanent loss of hearing, interference with echo-location and interference with communication
- Very little is known quantitatively

Marine species considered at risk by environmentalists

- Mammals
  - Pinnipeds
  - Mystoceti and Odontoceti
  - Carnivores
- Salt-water fish

A pub quiz guide to how we measure sound impact

- Pressure
  - Db. relative to 1 microPascal/Hz at 1m.
  - Db. relative to 1 microPascal at 1m.
  - (1 Pascal = 1 Newton/m^2, 1 Newton = 1kg.m/s^2, 1 bar = 10^5 Pascals)
- Particle Velocity
  - Db. relative to 1nm/s
- Energy
  - 1 Joule = 1 Newton m. (Power is measured in Watts, 1 Watt = 1 Joule /s)

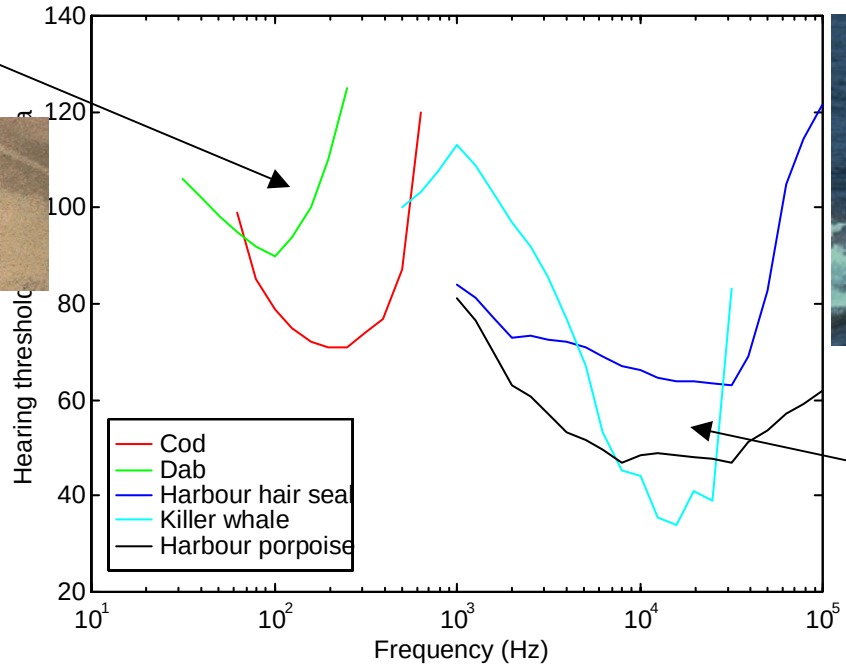
Environmental concerns: Effects on marine life

Source: Nedwell, Needham, Turnpenny and Hampson (2004)

Audiogram data

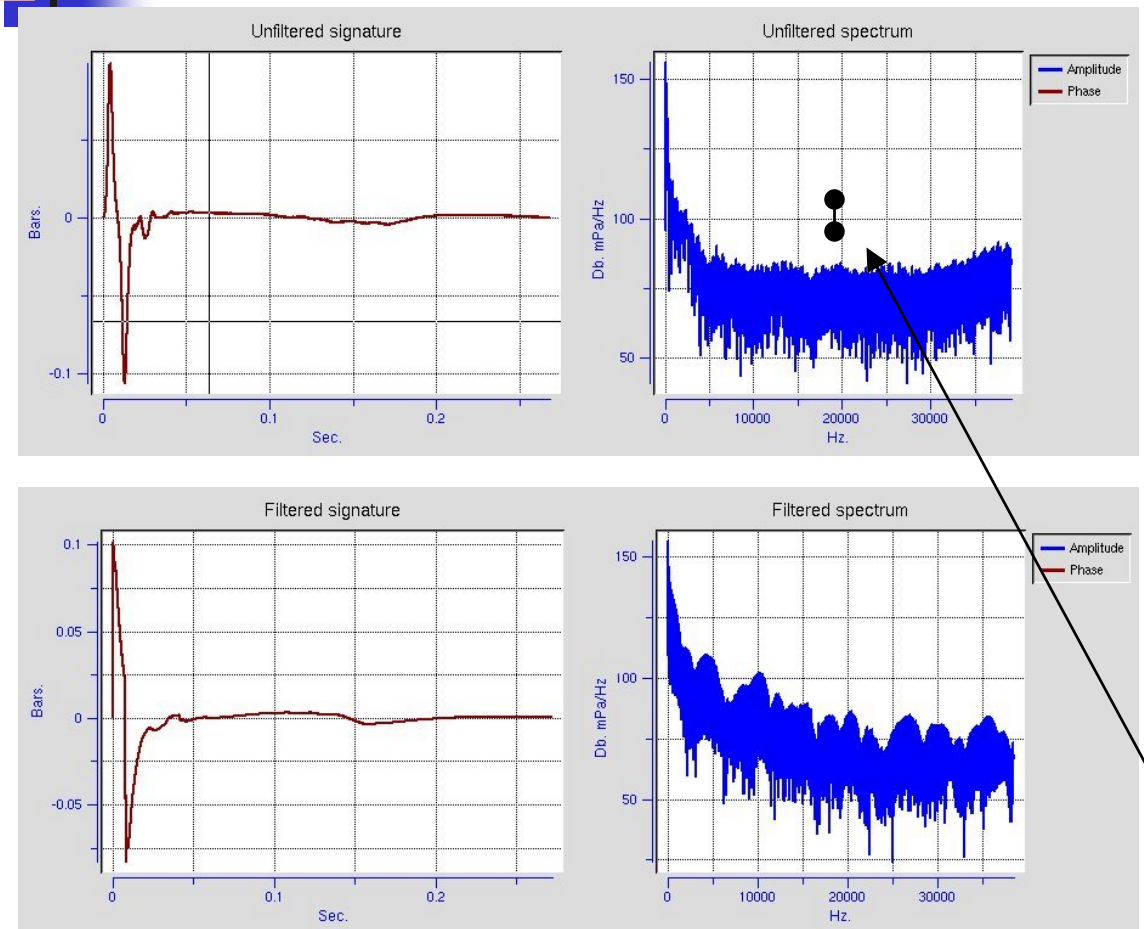
- What we hear depends on our aural sensitivity

Fish



Mammals

State of the art in modelling: (high frequencies)

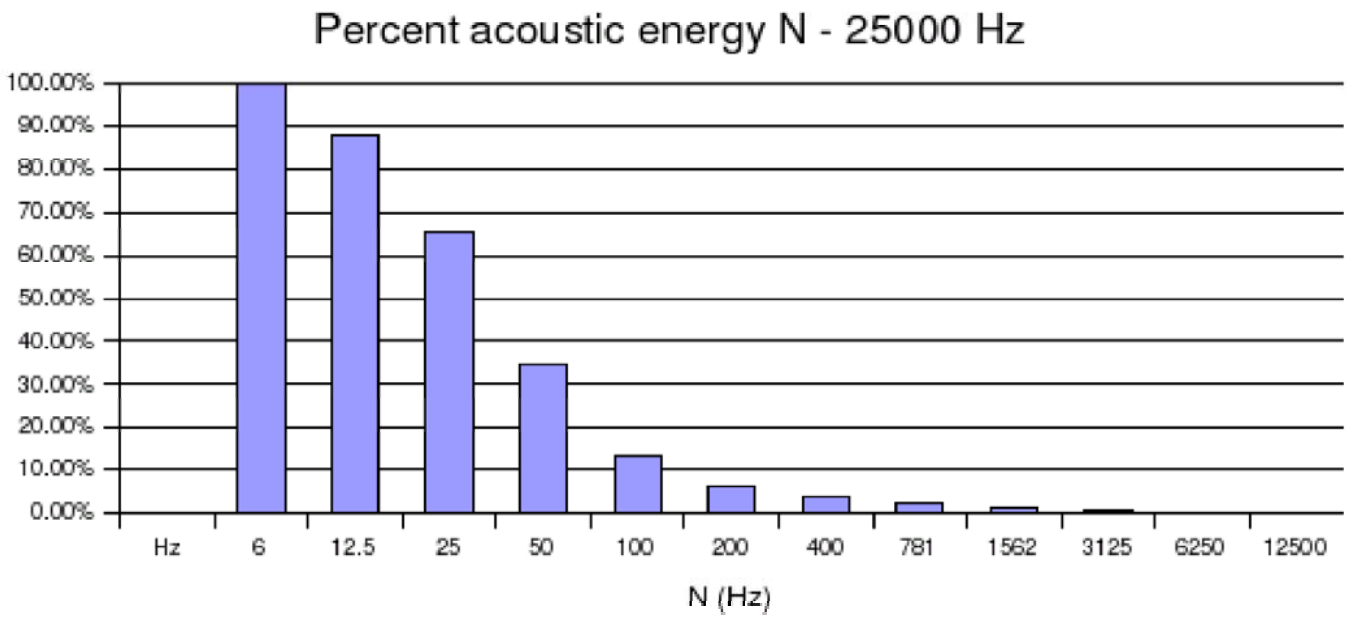


IFRC data 0-40kHz

Gundalf model

Depth transponder

High frequency energy



Impact on human diver

- Humans feel pain at around 9 Joules / m^2 …
  - For this array, this corresponds to around 75m from the array.
- Assuming 12db is sufficient for discriminating signals in interference, echo-locating at 20kHz would be disrupted at around 20m or closer.

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The current position

- **Conventional data (0-500Hz)**
  - **Most gun types measured under laboratory conditions for depths 3-30m**
- **Extended data (0-1500Hz)**
  - **Some gun types in restricted conditions**
- **IFRC (0-40kHz)**
  - **One data set with 3590 cu.in. array**
- **OGP (0-50kHz)**
  - **In progress in Norway since 2007 but currently blocked by Norwegian Fisheries. Will not resume before 2009.**

Where next

- Controlled tank experiments
- Controlled sea experiments

LabOceano,
University of Rio de Janeiro

Conclusions

- Modelling is satisfyingly accurate out to 50kHz.
- At 500m the average output per discharge is around 6.10^{-5} Joules / m^2 . (For a typical array of around 170,000 Joules / discharge).
- For a human diver, this would cause pain around 75m.
- The depth transponder is around 20db higher than a typical airgun array at the peak sensitivity echo-location frequency of 18kHz.
- Airguns are fundamentally low frequency sources so the maximal impact is likely to be at low frequencies.
- We understand airguns a great deal better than we understand mammal response

References

More information:-

http://www.leshatton.org/, http://www.gundalf.com/