“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 Dragoșet, 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
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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/m², 1 Newton = 1 kg·m/s², 1 bar = 10⁵ Pascals)

- **Particle Velocity**
  - Db. relative to 1 nm/s

- **Energy**
  - 1 Joule = 1 Newton m. (Power is measured in Watts, 1 Watt = 1 Joule /s)
Environmental concerns: Effects on marine life

Audiogram data

- What we hear depends on our aural sensitivity

Source: Nedwell, Needham, Turnpenny and Hampson (2004)
State of the art in modelling: (high frequencies)

IFRC data 0-40kHz

Gundalf model

Depth transponder
High frequency energy

Percent acoustic energy N - 25000 Hz

- 100.00%
- 90.00%
- 80.00%
- 70.00%
- 60.00%
- 50.00%
- 40.00%
- 30.00%
- 20.00%
- 10.00%
- 0.00%

Hz  6  12.5  25  50  100  200  400  781  1562  3125  6250  12500

N (Hz)
Humans feel pain at around 9 Joules / m² …

- 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.
More information:-