How marine mammals respond to underwater ambient noise

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DOSITS Webinar
Underwater sounds

- Biophony
- Geophony
- Anthropophony

Cauchy et al. (2023) Gliders for passive acoustic monitoring of the oceanic environment. Front Mar Sci
Global noise studies

Africa specific bioacoustics research

Becker et al. (2021) Sounding out a continent: seven decades of bioacoustics research in Africa. Bioacoustics
Operation Phakisa: Sectors to develop

1) Marine transport and manufacturing
2) Offshore oil and gas exploration
3) Aquaculture
4) Marine protection services and ocean governance
5) Tourism
6) Small harbour and infrastructural development
Acoustic modelling (sound exposure levels):
- Noise risk assessment
- Environmental impact assessment

SLR Consulting Australia (2021) Report
PAM off the west coast of South Africa

- Duty cycling
- Onboard data archival
Detected whale calls
Whale call detection ranges off the west coast of SA


Shabangu & Andrew (2020) Sperm whale clicks. Endang Spec Res
Noise at different frequency bands

AAR2

AAR3

Prediction vs. Observation

- 10-500 Hz
- 500-1000 Hz
- 1000-2000 Hz
- 2000-3000 Hz
- 3000-4000 Hz
Noise statistics

- Autocorrelation between frequency bands
- No multi-collinearity between environmental variables
- Ocean current speed > 11 cm s\(^{-1}\) filtered out
- Data from AAR1 and AAR4 excluded from noise analysis due to high pseudo-noise

<table>
<thead>
<tr>
<th>Model</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise level RF model</td>
<td>(L_{eq} \sim \text{Month} + \text{Hour} + \text{wind speed} + \text{wind direction} + \text{total precipitation} + \text{Wave height} + \text{Wave period} + \text{Number of vessels} + \text{Current speed} )</td>
</tr>
<tr>
<td>Whale detection GLM model</td>
<td>Species detection \sim \text{Lowest frequency band} + \text{Highest frequency band}</td>
</tr>
</tbody>
</table>
Vessel traffic

Shabangu et al. (2022) Whales and underwater noise. Mar Pol Bul
Sources of underwater noise

Shabangu et al. (2022) Whales and underwater noise, Mar Pol Bul
Whale response to underwater noise

Possible use of the region:
- Migration
- Feeding
- Breeding/mating
- Year-round habitat

Shabangu et al. (2022) Whales and underwater noise. Mar Pol Bul
Girola et al. (2023) Singing humpback whales respond to wind noise, but not to vessel noise. Proc. R. Soc. B

Barlow et al. (2022) Shaken, not stirred- Blue whales show no acoustic response to earthquake events. R. Soc. Open Sci.

Dunlop et al. (2010) Your attention please- increasing ambient noise levels elicits a change in communication behaviour in humpback whales. Proc. R. Soc. B
Sub-Antarctic passive acoustic monitoring

- Water depth: 167 m
- Recorder depth: 162 m
- SR: 96 kHz
- DC: 14 minutes
- Durability: 375 days
- Mid-2021 to date
Sound propagation

- Peregrine, a 3-dimensional parabolic equation (PE) model developed by Applied Ocean Sciences (Heaney and Campbell, 2016)
- Bathymetry influence
- Bearing from the sensor
- Temperature and time of year
Whales around the PEIs
- Seasonal presence
- Year-round presence
- Feeding
- Overwintering
- Migratory route
Noise at different frequency bands
### Predictors of underwater noise: PEIs

<table>
<thead>
<tr>
<th>Current speed (cm/s)</th>
<th>Hour</th>
<th>Month</th>
<th>SSH (m)</th>
<th>Wave direction (°)</th>
<th>Wave height (m)</th>
<th>Wave period (s)</th>
<th>Wind speed (m/s)</th>
</tr>
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<tbody>
<tr>
<td><img src="chart1.png" alt="Graph" /></td>
<td><img src="chart2.png" alt="Graph" /></td>
<td><img src="chart3.png" alt="Graph" /></td>
<td><img src="chart4.png" alt="Graph" /></td>
<td><img src="chart5.png" alt="Graph" /></td>
<td><img src="chart6.png" alt="Graph" /></td>
<td><img src="chart7.png" alt="Graph" /></td>
<td><img src="chart8.png" alt="Graph" /></td>
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</tbody>
</table>

<table>
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<tr>
<th>Partial effect</th>
<th>Equivalent continuous sound pressure level (dB re 1 μPa)</th>
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<tbody>
<tr>
<td><img src="chart9.png" alt="Graph" /></td>
<td><img src="chart10.png" alt="Graph" /></td>
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</table>
Ranked relative variable importance

<table>
<thead>
<tr>
<th>Variables</th>
<th>20-120 Hz</th>
<th>121-800 Hz</th>
<th>801-25000 Hz</th>
<th>25001-48000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed</td>
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<td>Hour</td>
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</table>
Responses of whales to noise: PEIs

- Antarctic blue whale
- D-call
- Fin 20 Hz pulse
- Fin 40 Hz pulse
- Humpback whale
- Madagascan blue whale
- Minke whale
- Sei whale

**Balancing method:**
- ADASYN
- Downsampling
- SMOTE
- Unbalanced
- Upsampling

**Frequency band:**
- 20-120 Hz
- 25001-48000 Hz

**Equivalent continuous sound pressure level (dB re 1 μPa)**
Dolphin response to noise: PEIs killer whales
Dolphin response to noise: PEI's killer whales
Antarctica
Maud Rise, Antarctica

- Water depth: 1250 m
- Recorder depth: 250 m
- SR: 2 kHz
- DC: 30 minutes
- Durability: 9 months (Jan-Sep 2013)
Antarctic soundscape

Shabangu et al. (2020) Blue and fin whales under different sea ice condition. End Spec Res
Shabangu et al. (2020) Blue and fin whales under different sea ice condition. Endang Spec Res
Marine mammal response to noise in Antarctica


Shabangu and Charif (2021) Crabeater seal acoustic occurrence. Bioacoustics


Shabangu et al. (2017) Acoustic occurrence and behaviour of Antarctic blue whales. PlosONE

Polynyas around Maud Rise: ~40,000 km²
Summary

- Marine traffic significantly contributed to low frequency noise in SA
- Weather is the major contributor of underwater noise in the soundscape for PEIs and Antarctica
- Species- and region-specific responses to underwater noise
- Biological and physiological processes of whales might be negatively impacted by noise
- No seismic airgun signal were detected in SA and PEIs but were detected in Antarctica
- More (long-term) underwater noise research is needed in the Southern Hemisphere
Thank you!

International Whaling Commission

The Society for Marine Mammalogy

The Goldie and David Blanksteens Foundation

Southern Ocean Research Partnership

University of Pretoria

University of Cape Town

Cape Peninsula University of Technology

SANCOR

University of Rhode Island

ANTARCTIC SCIENCE INTERNATIONAL BURSARY

NRF National Research Foundation

SANAP

APPLIED OCEAN SCIENCES

The Cornell Lab of Ornithology

BCRE

Center for Conservation Bioacoustics