Long-term observations of a potential great whale call from the central Indian Ocean during 2002-2019

Nikita R Pinto & Tarun K. Chandrayadula
Department of Ocean Engineering, Indian Institute of Technology Madras

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Figure: Hydrophones in the central Indian Ocean maintained by the Comprehensive Nuclear Test-Ban Treaty Organization

Figure: Average spectrogram of the unidentified Diego Garcia call
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Figure: Average daily spectra at the north and south stations show the long-term frequency changes of the Diego Garcia call.
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**Selected calls**

**Average spectrogram**

**Call subspace**

**Figure:** The methodology used to build subspace detectors for the Diego Garcia call and the Omura whale call
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**Figure:** Average spectrogram of the unidentified Diego Garcia call

**Matrix model for whale signal**

\[ x = H\theta + \text{noise} \]

\[ H = \begin{bmatrix} \theta_1 \\ \theta_2 \\ \vdots \\ \theta_p \end{bmatrix} \]
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Figure: Average spectrogram of the unidentified Diego Garcia call
The general seasonality of the Diego Garcia call:

- **North (gray):**
  November to February, sometimes March to June.

- **South (black):**
  June to November
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Figure: Tracking the call-frequencies using centroids in 1 Hz bands of the average call-periodograms
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Figure: Estimated call-frequencies of the Diego Garcia call at the North and South hydrophones

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**Figure:** Linear regression applied to the observed frequency changes
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**Table:** The rates of the Diego Garcia call-frequencies over the years

<table>
<thead>
<tr>
<th>Initial Frequency (Hz)</th>
<th>Rate of change (Hz/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>0.5580</td>
</tr>
<tr>
<td>41</td>
<td>0.7596</td>
</tr>
<tr>
<td>38</td>
<td>0.5566</td>
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<td>35</td>
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<tr>
<td>31</td>
<td>0.4691</td>
</tr>
<tr>
<td>30</td>
<td>0.5577</td>
</tr>
<tr>
<td>35</td>
<td>-0.3351</td>
</tr>
</tbody>
</table>

**Figure:** Call-frequency changes observed in other Indian and Southern Ocean whale species (Leroy et al., 2018)
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**Figure:** Daily averaged ambient noise levels over 15-60 Hz to investigate the relationship between ambient noise and the call-frequency changes over 2002-2019

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**Figure:** Annual one-minute spectral averages between 15 Hz and 60 Hz for each year between 2002 to 2019 for the north station (black), and the south station (gray).
Concluding remarks ... what is driving the call-frequency changes?

➢ Suggested hypotheses:
   1) frequency increase and decrease due to different pressures
   2) sound production mechanisms for the different frequencies are coupled together

➢ Investigating the relationship between frequency changes and migratory paths

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