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

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Presentation O1.3-513

ORAL PRESENTATION

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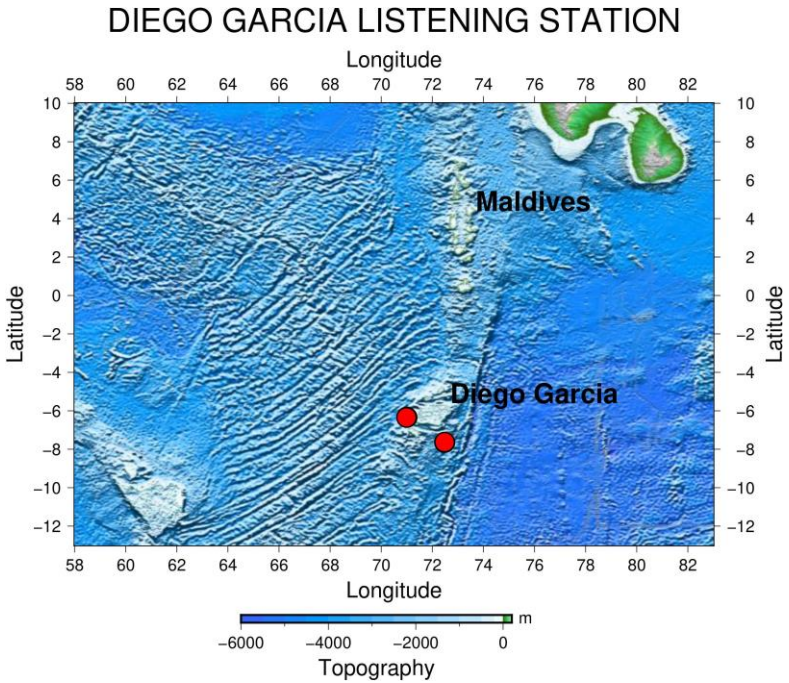

Figure: Hydrophones in the central Indian Ocean maintained by the Comprehensive Nuclear Test-Ban Treaty Organization

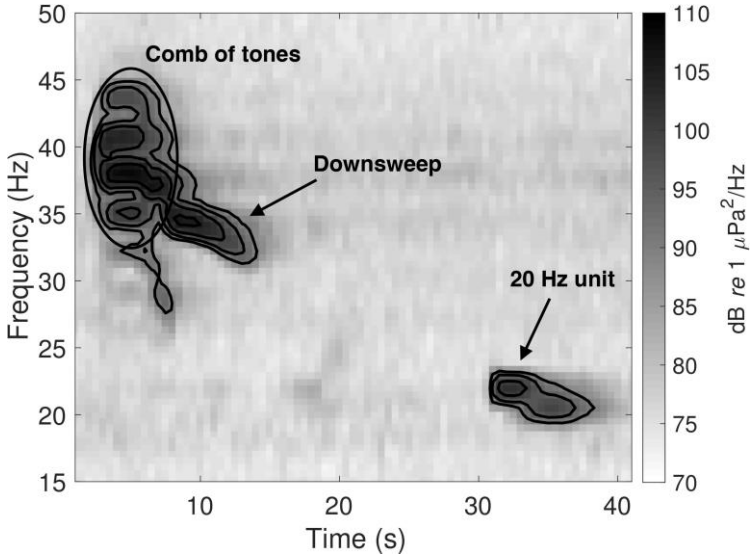

Figure: Average spectrogram of the unidentified Diego Garcia call

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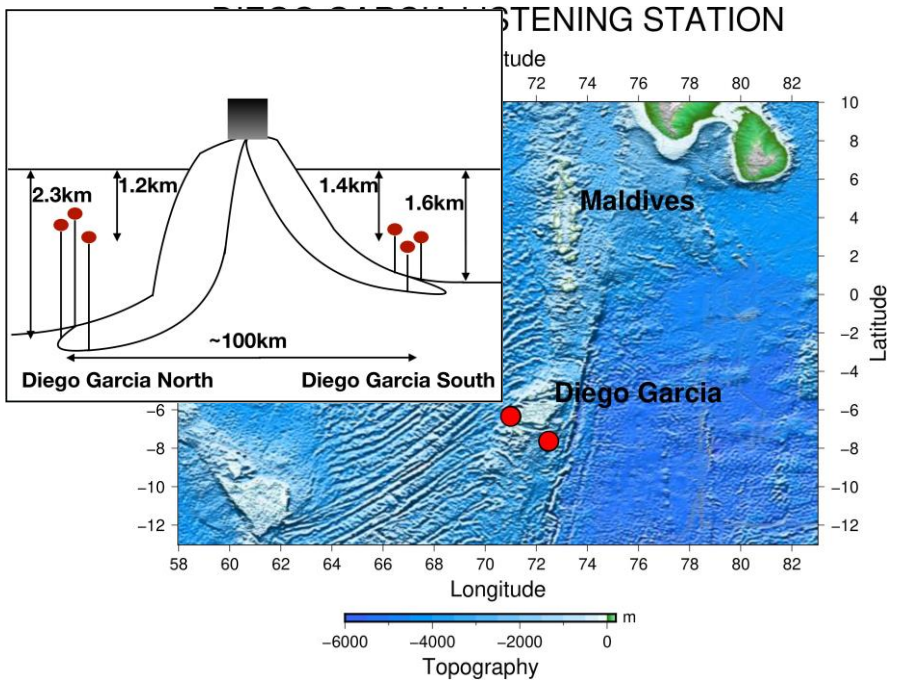

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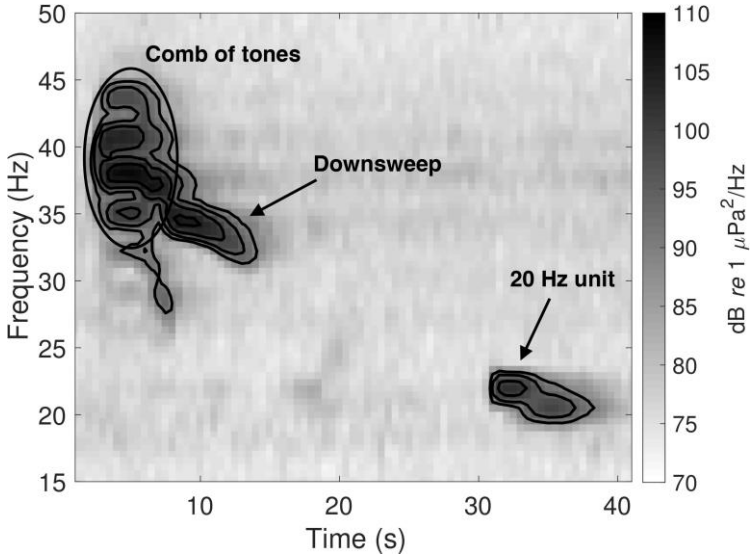

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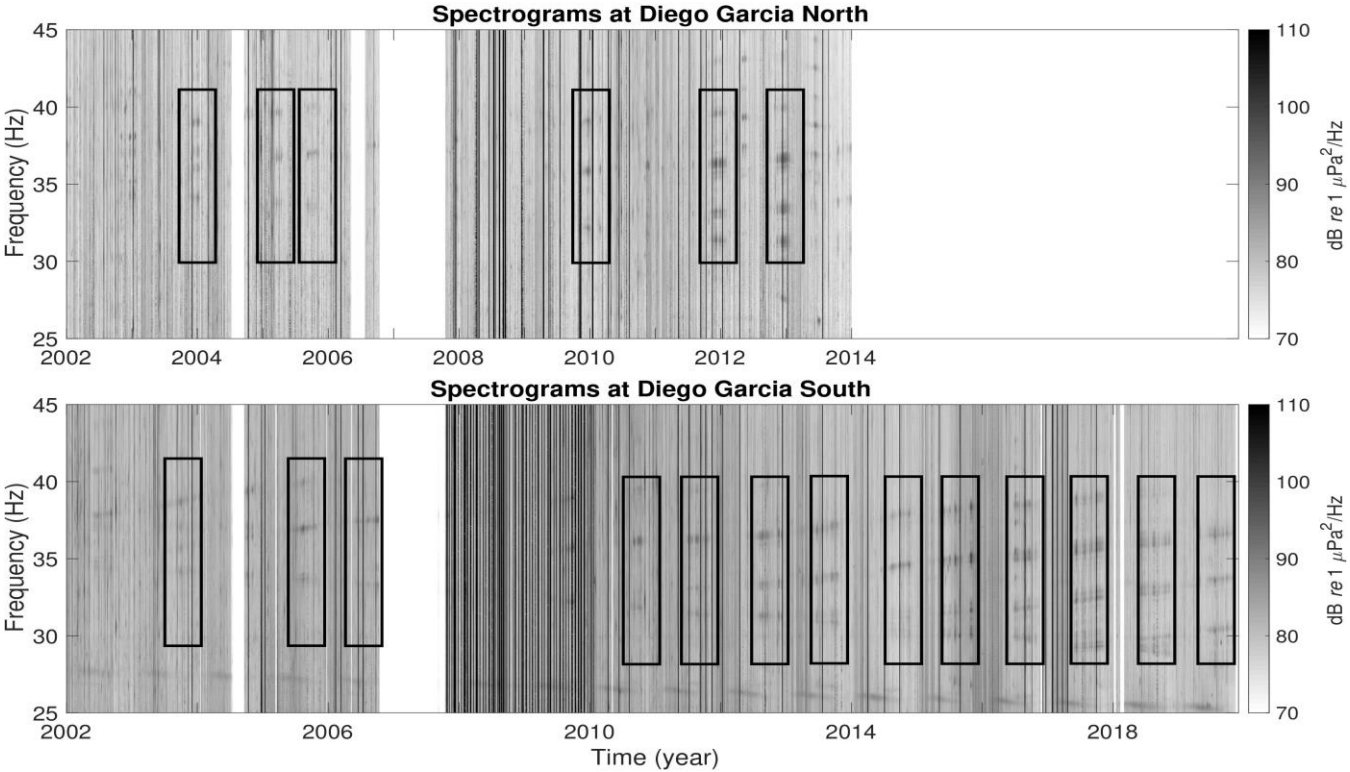

Figure: Average daily spectra at the north and south stations show the long-term frequency changes of the Diego Garcia call

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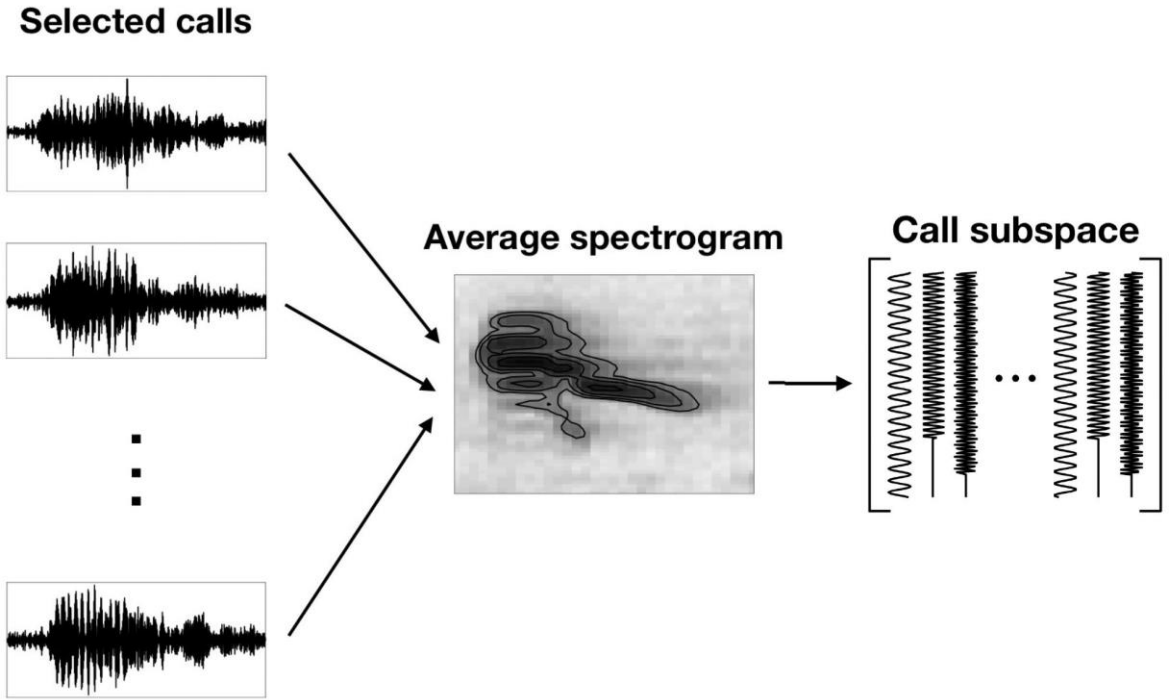

Figure: The methodology used to build subspace detectors for the Diego Garcia call and the Omura whale call

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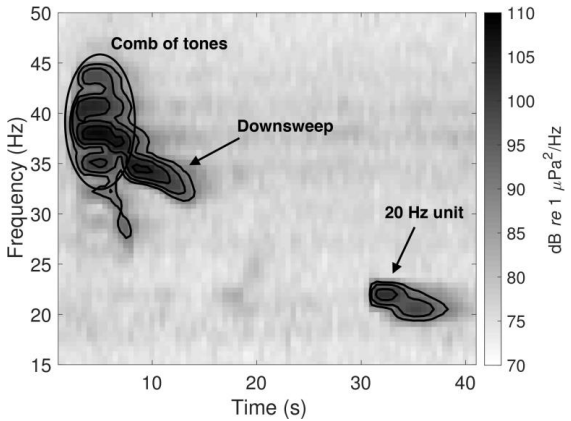

Figure: Average spectrogram of the unidentified Diego Garcia call

Matrix model for whale signal

$$x = H\theta + \text{noise}$$

$$H = \begin{bmatrix} \vdots & \vdots & & \vdots & \vdots \end{bmatrix} \qquad \theta = \begin{bmatrix} \theta_1 \\ \theta_2 \\ \vdots \\ \theta_p \end{bmatrix}$$

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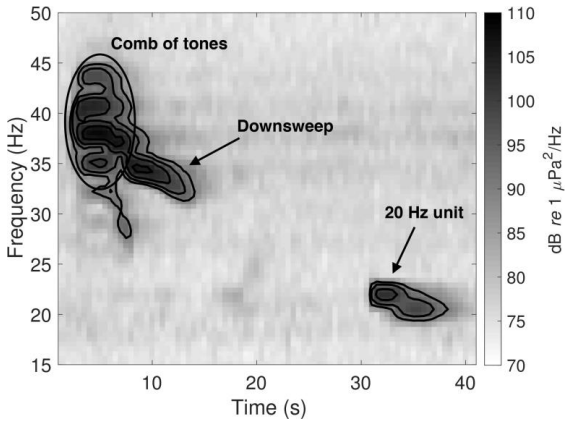

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Optimal subspace detector statistic

$$x \rightarrow \boxed{\frac{x^T P_H x}{x^T (I - P_H) x}} \rightarrow T(x)$$

$$P_H = H(H^T H)^{-1} H^T$$

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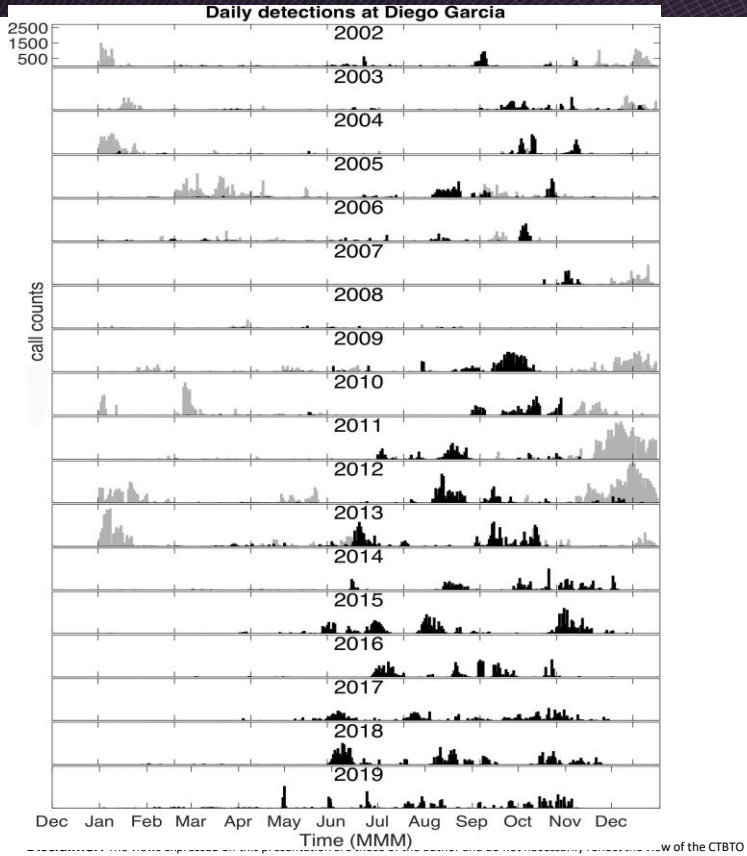

The general seasonality of the Diego Garcia call:

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

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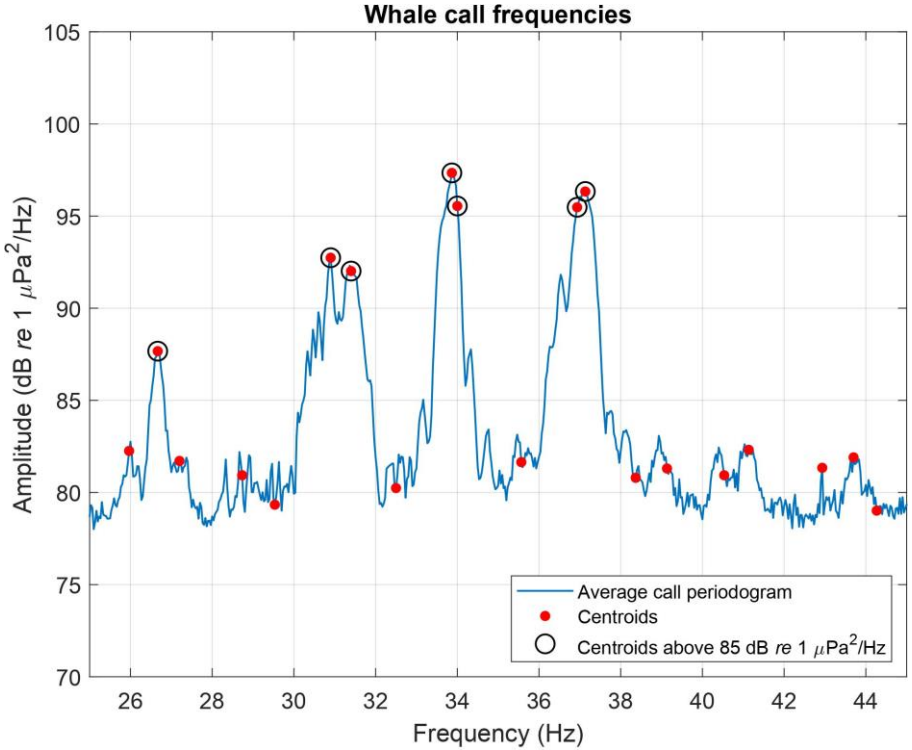

Figure: Tracking the call-frequencies using centroids in 1 Hz bands of the average call-periodograms

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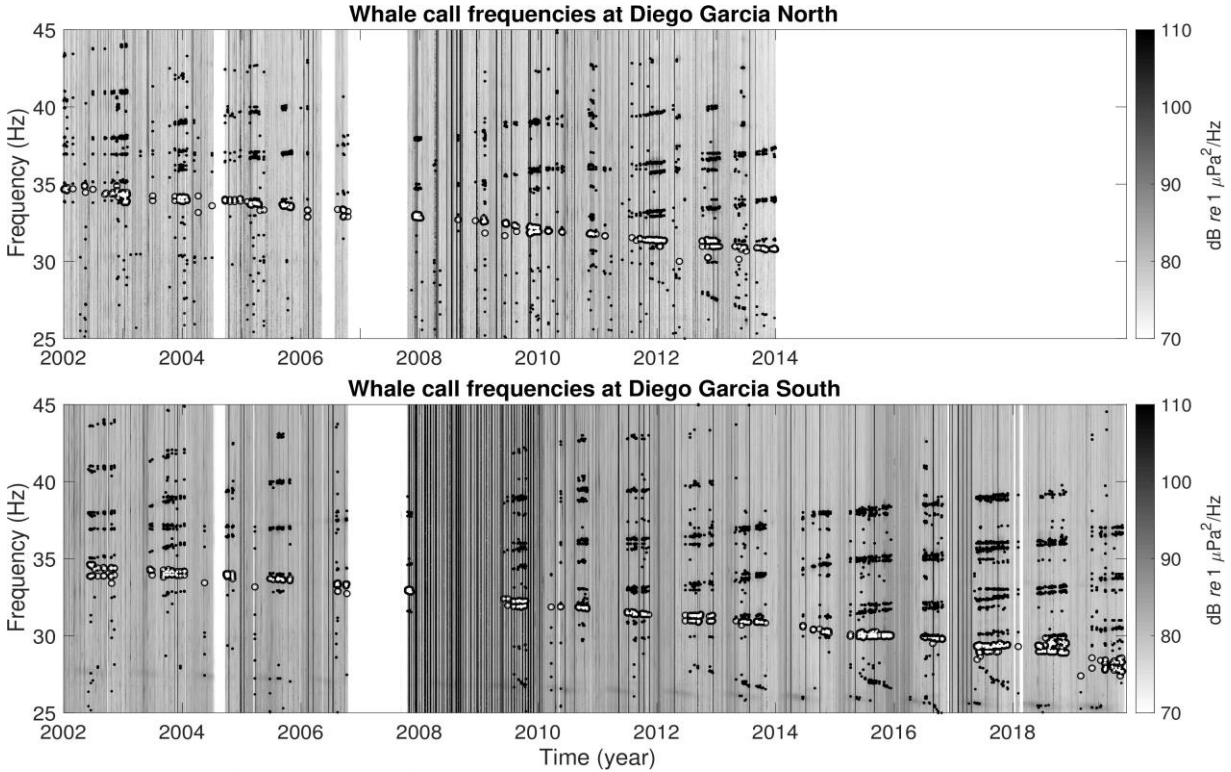

Figure: Estimated call-frequencies of the Diego Garcia call at the North and South hydrophones

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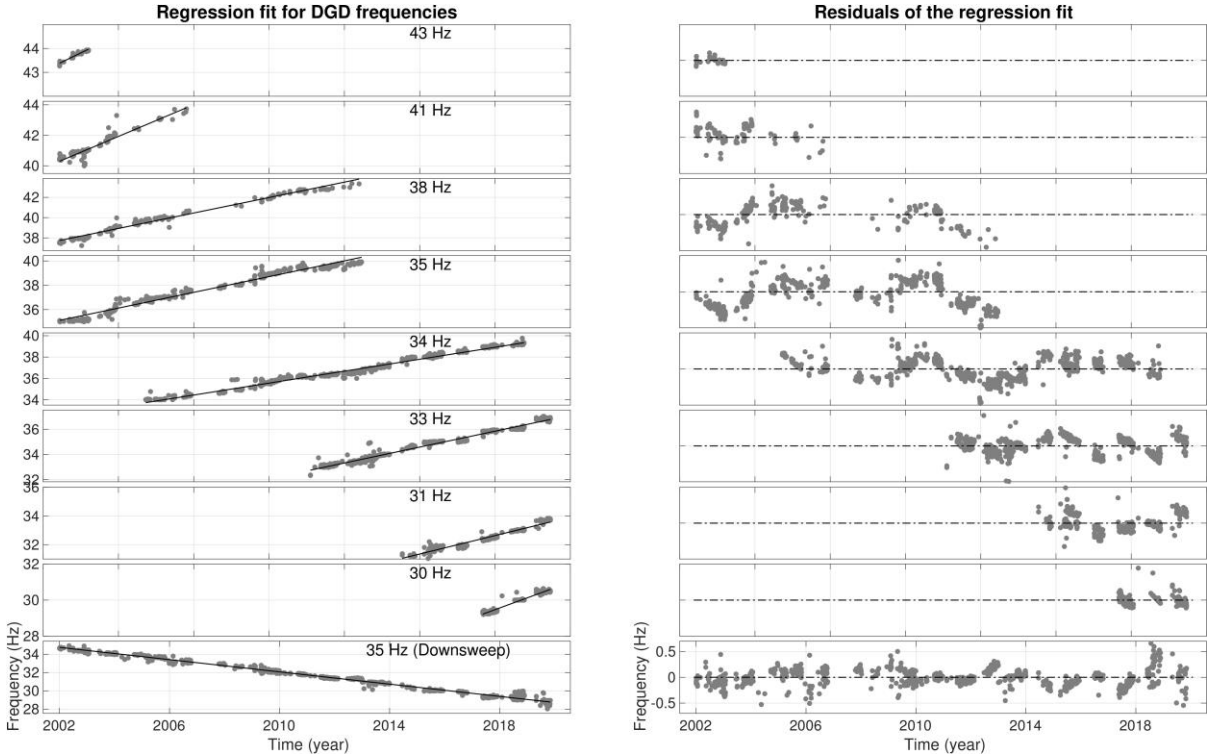

Figure: Linear regression applied to the observed frequency changes

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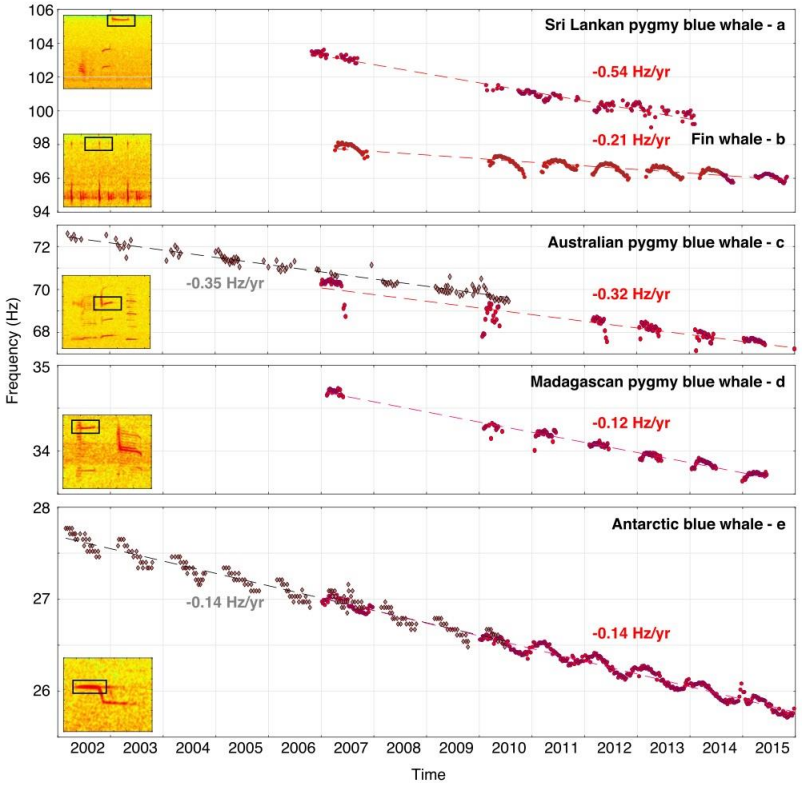

Table: The rates of the Diego Garcia call-frequencies over the years

Initial Frequency (Hz)	Rate of change (Hz/year)
43	0.5580
41	0.7596
38	0.5566
35	0.4721
34	0.4081
33	0.4602
31	0.4691
30	0.5577
35	-0.3351

Figure: Call-frequency changes observed in other Indian and Southern Ocean whale species (Leroy *et al.*, 2018)

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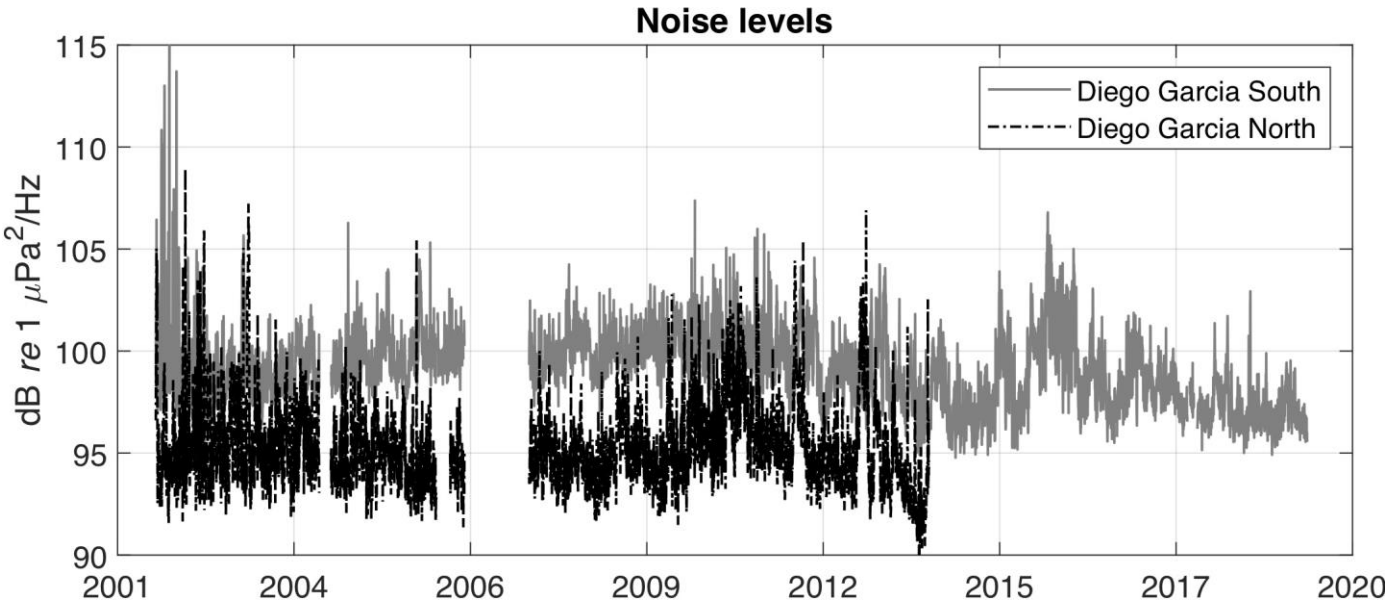

Figure: Daily averaged ambient noise levels over 15-60 Hz to investigate the relationship between ambient noise and the call-frequency changes over 2002-2019

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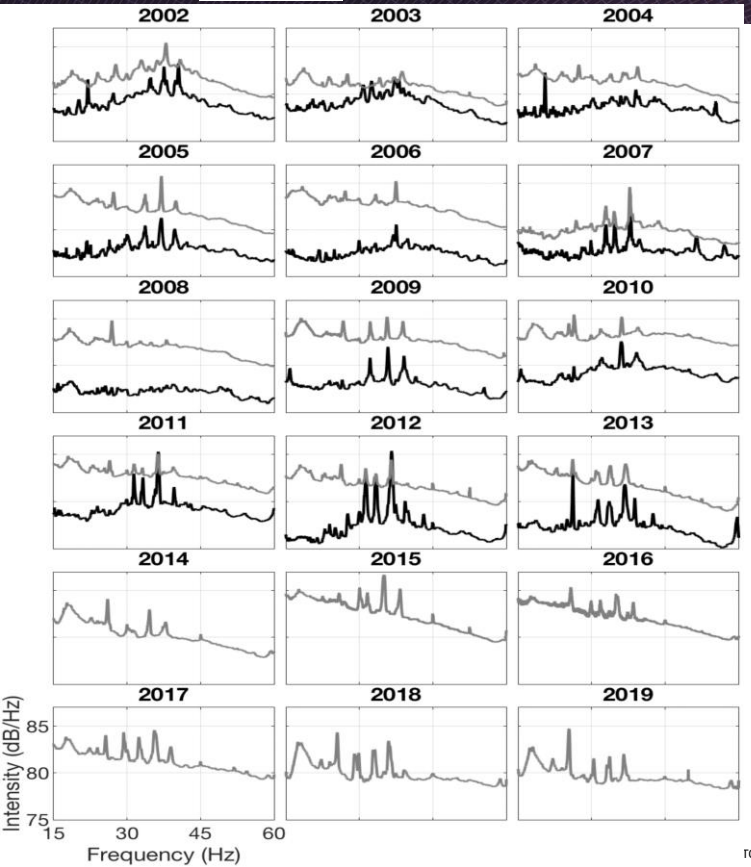

Figure: Annual one-minute spectral averages between 15 Hz and 60 Hz for each year between 2002 to 2019 for the north station (black), and the south station (gray).

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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

Gratefully acknowledge the data from the CTBTO,
and the financial support from the Naval Research Board (NRB) India