# Final Evaluation Report

| Your Details | |
|---|---|
| **Full Name** | Isha Bopardikar |
| **Project Title** | Acoustic communication in a noisy coastal habitat |
| **Application ID** | ab48f9-1 |
| **Grant Amount** | £5,000 |
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| **Date of this Report** | 22nd April 2019 |

**1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.**

| Objective | Not achieved | Partially achieved | Fully achieved | Comments |
|---|---|---|---|---|
| Characterise the vocal repertoire of *Sousa plumbea* (Indian Ocean humpback dolphin) | | | | We were able to record multiple humpback dolphin pods across spatial and temporal scales within the study area. A sampling rate of 192kHz on the recording equipment made it feasible to characterise the higher-frequency sounds (burst-pulses and clicks) produced by these animals. |
| Understand the behavioural context of different vocalisation types | | | | We obtained an overview of the behavioural context of different vocalisation types. However, these data reflect information only at the group level. Fine-scale data collection (individual focused) was not feasible given the large group sizes of humpback dolphins (>20-25) and the omnidirectional nature of the recording equipment. |
| Monitor possible changes in vocal behaviour with respect to disturbance by vessel traffic | | | | A preliminary understanding of possible changes in vocalisations in the presence of tourism vessels was achieved.<br>We believe long-term monitoring and more sample sizes are required to establish a robust relation between changes in acoustic behaviour and vessel presence. |
| Characterise the coastal soundscape | | | | While we were able to obtain recordings of sounds from different vessel types, we could not deploy static recording devices to monitor soundscapes continuously due to financial constraints of procuring the device. |

**2. Please explain any unforeseen difficulties that arose during the project and how these were tackled.**

The fieldwork for this study began in January 2018 due to a delay in logistics planning, and procuring the necessary recording equipment. This led to an extension in the study duration.

As mentioned in the proposed study design, we sampled for a total of 6 months excluding the monsoon period (February 2018-February 2019). Vessel surveys could not be carried out in October due to extended monsoons.

Unpredictable weather, irregular sea states, and high winds also led to a decrease in the number of days spent conducting vessel surveys each month.

**3. Briefly describe the three most important outcomes of your project.**

a. Characterised the vocal repertoire of *Sousa plumbea* (Indian Ocean humpback dolphin) inhabiting the waters off Sindhudurg, India.
   We characterised the high-frequency sounds (echolocation clicks and burst pulses) produced by humpback dolphins. We recorded vocalisations with nonlinear features (deterministic chaos, sidebands, and frequency jumps), which have not yet been described in this species. Some non-linear call types appeared to contain mixed components of whistles and pulses. These call types were primarily recorded during socialising, and possibly play a role in conveying individual identity or specific information during particular behaviours. During a few encounters when the predominant behaviour state was socialising, we also recorded low frequency click trains.

b. Baseline data for behavioural context of vocalisations of Indian Ocean humpback dolphins.
   We were able to establish a preliminary understanding of the acoustic behaviour of humpback dolphins. Acoustic recordings across group compositions, group sizes and behavioural states (travelling, socialising, foraging, and milling) showed varied patterns in the rate of call production, and types of vocalisations. Data gathered for this objective remains broadscale and focuses only on group level information for behaviour, as we could not identify individual callers within a group of vocalising animals.

c. Preliminary data for possible changes in vocal behaviour around increased vessel traffic.
   We recorded humpback dolphins in the presence of tourism (dolphin watching) vessels on multiple occasions. Vocalisations, particularly those used in social contexts (whistles), appeared to reduce in the presence of vessel traffic. We require a larger sample size and further monitoring of acoustic activity in the presence of vessel traffic before we can establish a direct link between changes in vocalisation due to increased ambient noise.

**4. Briefly describe the involvement of local communities and how they have benefitted from the project.**

While we did not directly engage with the local fisher community for this study, the vessel-based surveys we conducted heavily relied on local fishermen to operate the research vessel.

The local community of coastal Sindhudurg has played an integral role in cetacean research.

A community based cetacean monitoring network was established here in 2013 (Jog *et al*. 2017; funded by The Rufford Foundation, Sule *et al.* 2016). The network collects data on strandings and mortality events and reports baleen whale sightings in the area. Community engagement related to stranding events was kept active during this study (three mortalities were reported from the study area during 2018-19).

Our upcoming project to determine population densities of coastal cetaceans using passive acoustic monitoring will rely on data from this network to establish a relationship between population trends and observed mortality events.

**5. Are there any plans to continue this work?**

Yes, I have long-term plans to continue working along the Sindhudurg coast, and my doctoral research will be based in this area.

The next phase of my study will involve understanding the fine-scale acoustic behaviour of humpback dolphins using a multi-channel hydrophone array. I will also focus on using acoustic methods to estimate population densities of humpback dolphins and finless porpoises along the Sindhudurg coast. The multi-channel array will allow us to conduct target motion analysis on the recorded acoustic files. From these data, we can then localise the sound source to provide estimates on the number of animals present in the area. Focal group follows with concurrent acoustic and visual monitoring will help collect robust data on the vocalisation-production rates across group sizes. I will primarily use echolocation clicks to detect and locate animals, as these sounds are highly directional in nature. The click-production rates will be utilised to strengthen the method used to estimate group densities of humpback dolphins using acoustic monitoring. With this long-term study, I aim to understand the variations in spatiotemporal occurrence patterns of these species along the Sindhdurg coast. The study will help identify critical habitats and hotspots. The year-round surveys will also determine the degree of overlap between areas of high population densities and intensive anthropogenic activities (e.g., fishing, dolphin-watching tourism).

**6. How do you plan to share the results of your work with others?**

I presented an overview of this project, and initial findings at the Rufford India Conference, Goa (18-21st September 2018).

A popular article featuring our project was published in Mongabay. I also contributed to a podcast (Mongabay International) talking about my work with humpback dolphin sounds. I was invited for a Marine Meet-up hosted by the Marine Life of Mumbai (MLOM) where I spoke about underwater acoustics and our research using sounds to study coastal cetaceans in Sindhudurg (https://www.youtube.com/watch?v=KI3UBWZvj1E).

My future plans include developing outreach and science education material, primarily for a young age group (8-12 yrs), explaining the acoustic behaviour of dolphins and how they use sounds to communicate and navigate their surroundings. We will translate this material in the regional language (Marathi) of the study site and plan to distribute it in local schools.

I am now working towards publishing some of the results from this study in peer-reviewed journals.

**7. Timescale: Over what period was the grant used? How does this compare to the anticipated or actual length of the project?**

Our initial timeframe for fieldwork was from October 2017-April 2018, which faced a delay and we sampled between two seasons excluding the monsoon, i.e. from February 2018-April 2018 and November 2018-February 2019. However, our sampling duration of six months as initially mentioned in the study remained the same.

**8. Budget: Provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used. It is important that you retain the management accounts and all paid invoices relating to the project for at least 2 years, as these may be required for inspection at our discretion.** Exchange rate 1 GBP = 90.18 INR

| Item | Budgeted Amount | Actual Amount | Difference | Comments |
|---|---|---|---|---|
| Acoustic recording equipment + Shipping cost | 900 | 927 | +27 | MixPre6 and an extension battery pack (SoundDevices, USA), connector cables, SD card (1) and two sets of rechargeable batteries (bill of purchase available for all equipment) |
| Fuel for vessel survey + maintenance of research vessel | 1100 | 1063 | -37 | Unsuitable weather conditions slightly reduced the total number of days spent on vessel surveys each month. |
| Daily living expense for researchers | 800 | 781 | -19 | |

| | | | | |
|---|---|---|---|---|
| Stationery (data sheets, files, pens), Miscellaneous health expenses while on field | 100 | 97 | -3 | |
| Salary for boatmen | 800 | 846 | +46 | We had to hire two boatmen instead of one, this led to an increased budget for salaries. |
| Travel within field-site | 550 | 571 | +21 | Vehicle maintenance costs were slightly higher than expected. |
| Rent for field station | 750 | 610 | -140 | Cheaper accommodation was available between Feb-April 2018, reducing the rental costs |
| **Total** | **5000** | **4895** | **-105** | Funds left over from the study will be used to cover partial costs of developing outreach material. |

**9. Looking ahead, what do you feel are the important next steps?**

a. Continue concurrent behavioural and acoustic sampling using focal group follows of humpback dolphins to monitor fine-scale acoustic behaviour. Use these data to further strengthen applications of acoustic techniques to answer broad-scale questions (e.g. density estimation of humpback dolphins using passive acoustics).

b. Long-term monitoring of acoustic and communication behaviour in the presence of vessel traffic to monitor changes over time. Monitoring soundscapes and overall anthropogenic activity in humpback dolphin hotspots.

**10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?**

Yes, I have used The Rufford Foundation logo on all images and sound files produced within the timeframe of the study. The logo was also used during my research talk at IISER, Tirupati, titled 'Contour classification of Indian Ocean humpback dolphin whistles using CART' as part of a sound analysis and recording workshop taught by the Bioacoustics Research Program (Cornell Lab of Ornithology, Cornell University).

The images and sound clips from this study are included in articles published online. Two of these popular articles (one podcast) featured our study on humpback dolphin acoustics. The Rufford Foundation as a funding agency is mentioned in these articles.

Links to all articles are attached below:

a. https://india.mongabay.com/2019/02/what-underwater-sounds-tells-us-about-marine-life/

b. https://news.mongabay.com/2019/03/audio-what-underwater-sounds-can-tell-us-about-indian-ocean-humpback-dolphins/

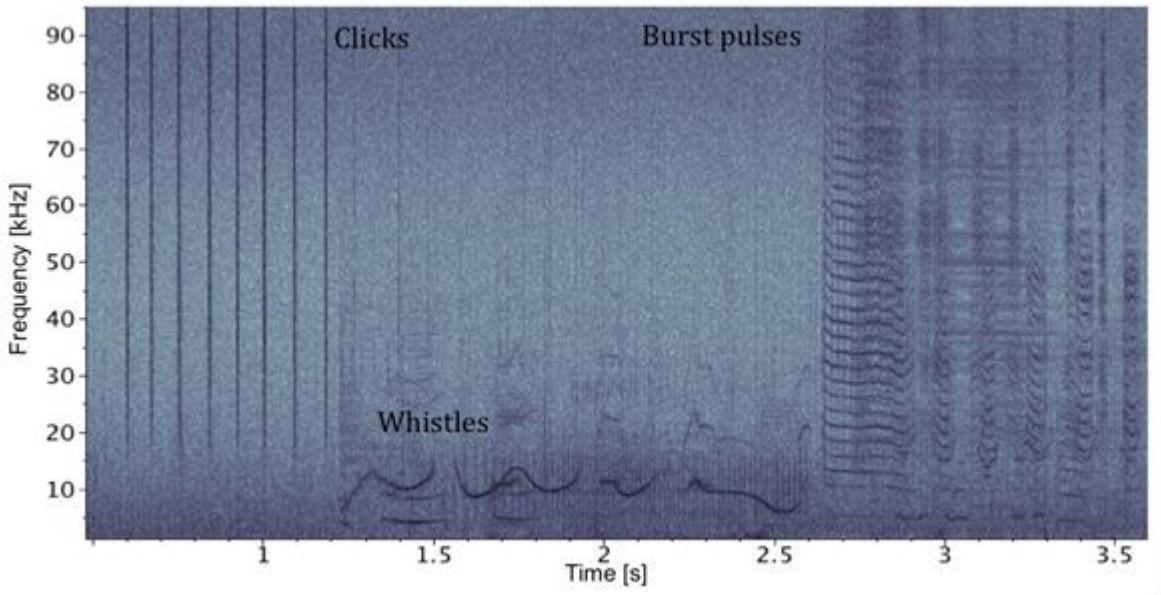
c. https://inlaksshivdasanifoundationblog.org/home/2018/6/20/intern-update-isha-bopardikar

**11. Please provide a full list of all the members of your team and briefly what was their role in the project.**

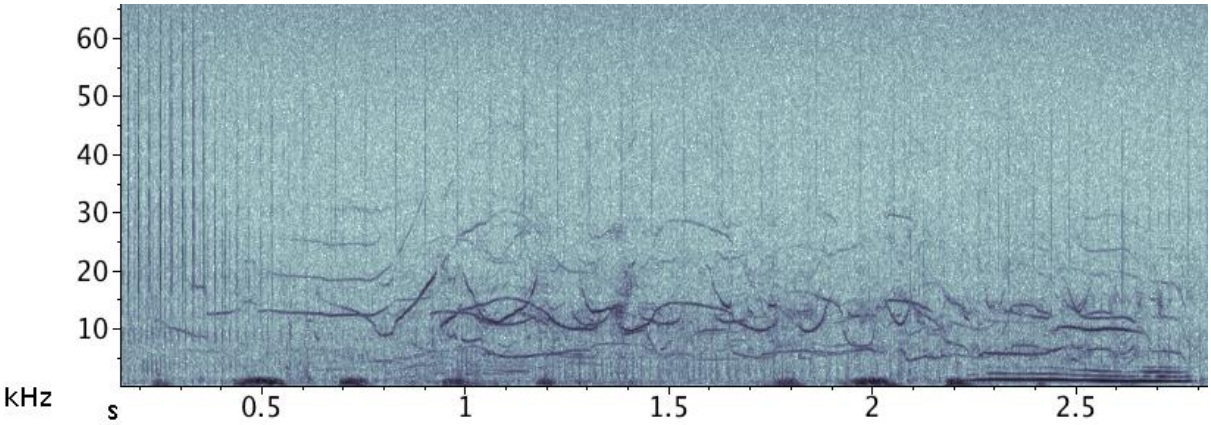
**Dr Dipani Sutaria** has been my research advisor since 2014. She supervised the methodology for behaviour sampling and study design. She was also on field to assist with the data collection and helped with analysis.

**Dr Holger Klinck** has been advising me since 2015. His research focuses on the development of hard- and software tools for passive acoustic monitoring of terrestrial, aquatic and marine ecosystems and biodiversity. Dr Klinck also provided some of the recording equipment (a Teledyne Reson TC4033 hydrophone and a Teledyne Reson EC6067 preamplifier).

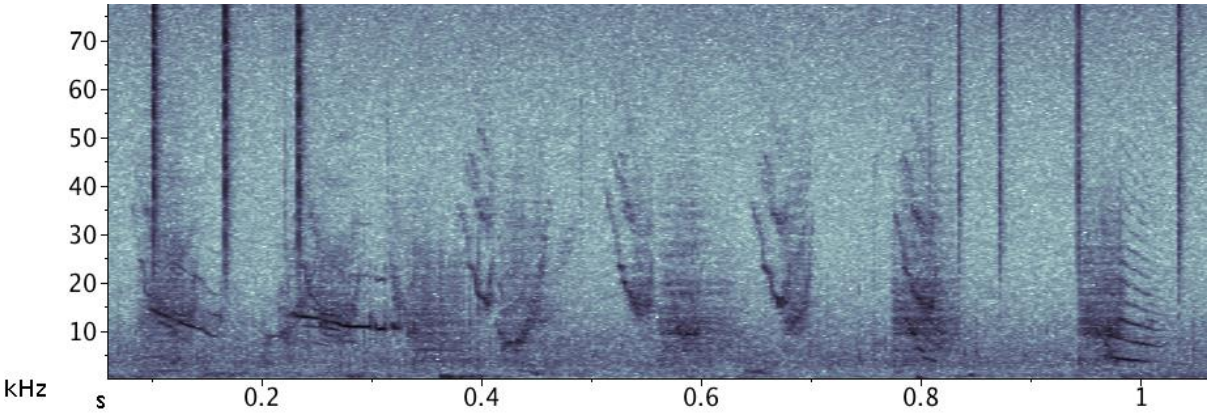
Team members: **Ketki Jog, Gaurav Patil** and **Mahi Mankeshwar** collected visual data for behavioural observations during vessel-based surveys. Ketki and Gaurav also collected opportunistic photo-identification data.



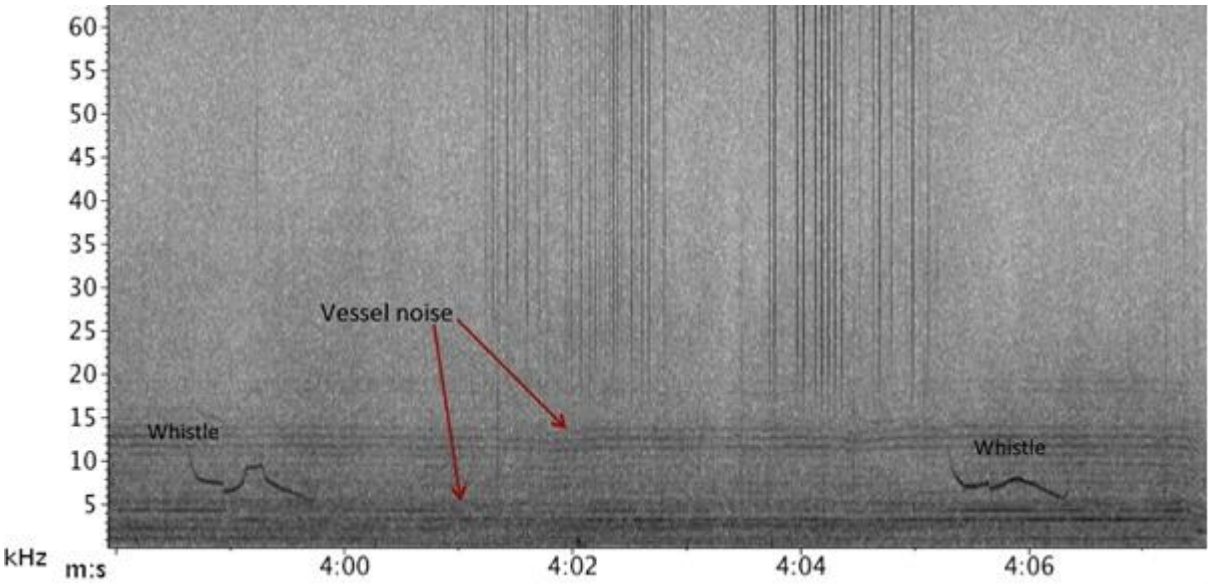

Spectrogram of three categories of vocalisations produced by humpback dolphins. X-axis represents frequency measured in kilohertz and Y-axis represents time in seconds. Echolocation clicks are primarily used for navigation and prey detection. Whistles and burst pulses are used for communication and in social contexts.



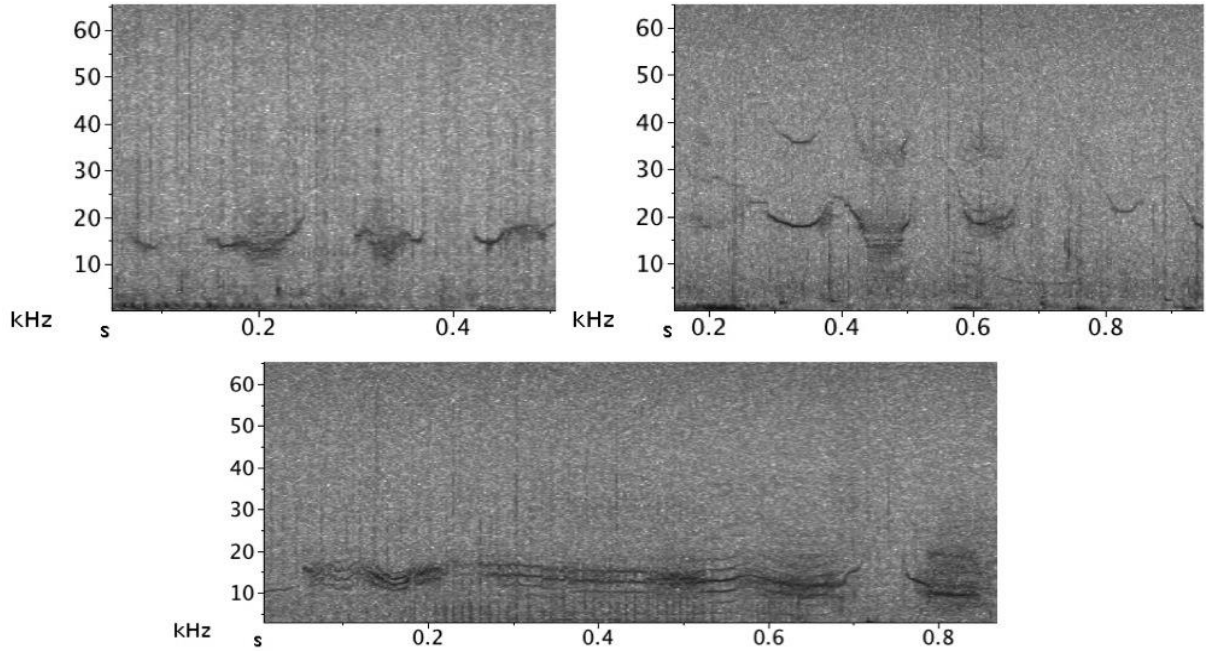

Vocalisations recorded during intense social activity




Calls with tonal and pulse components




Vessel noise overlapping in frequency with humpback dolphin whistles




Examples of calls with tonal and pulsed components


Left: Surveying for humpback dolphins on-board the research vessel ©Sarang Naik. Right: Noting down observations and recording acoustic data ©Shaunak Modi. Bottom: Pod of Indian Ocean humpback dolphins (Sousa plumbea) socialising.