

Detecting Killer whales in the Salish Sea

WHEN AND WHY DO WHALES VOCALIZE?



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Introduction

- **Salish Sea:** intense boat traffic
- **2 killer whale ecotypes:**
 - Southern Resident killer whales* (SRKW): endangered population 74 individuals
 - Bigg's killer whales* (BKW): marine mammal's eater > 571 individuals
- **Intense boat traffic** → auditory masking, changes in foraging behavior, swimming and breathing
- Shipping routes run through **SKRW critical habitat**
- **Sound perception:** many behaviors!



→ When and why killer whales do vocalize or not?

Results

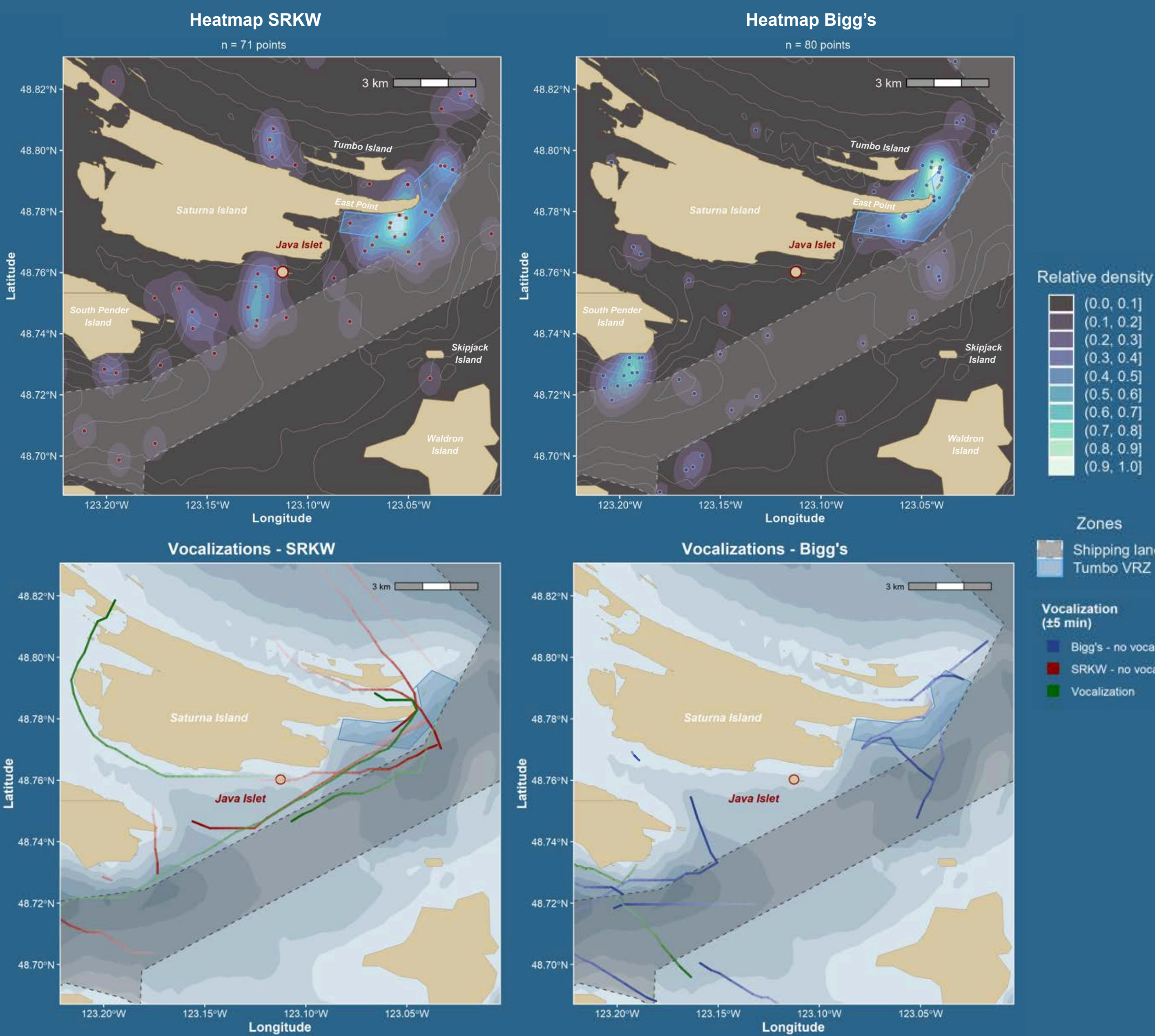
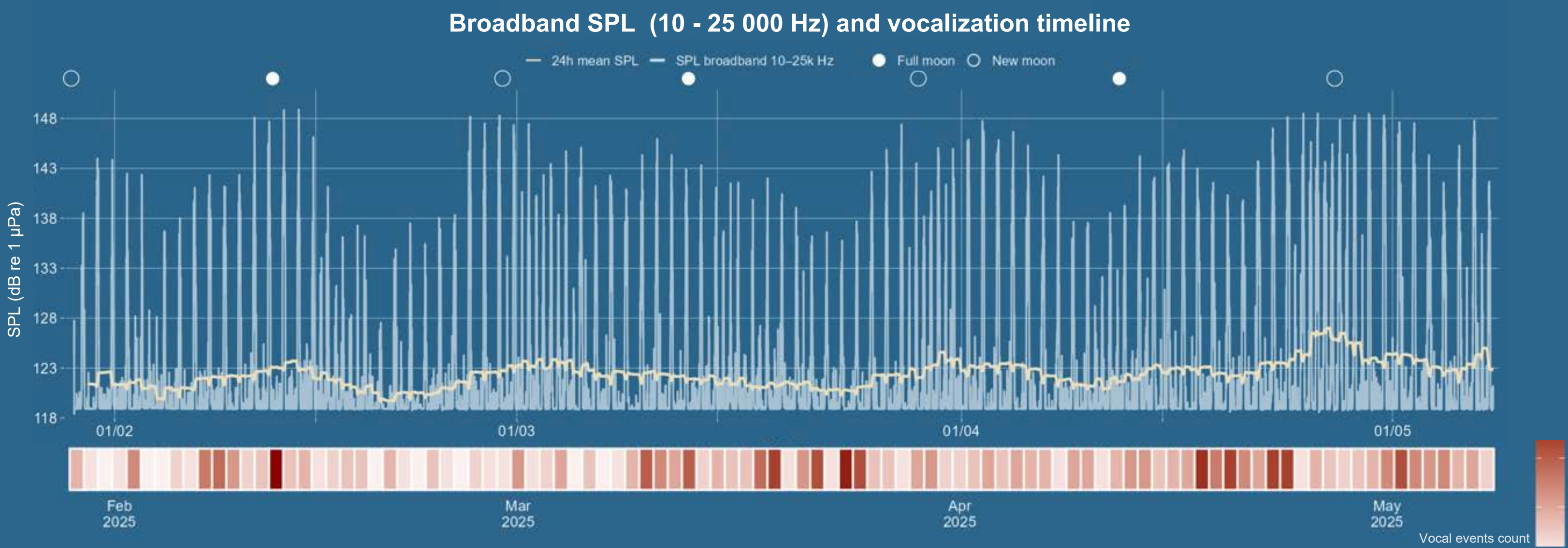


Figure 2. Heatmap of WRAS sightings per ecotype (January 29 to May 8, 2025). SRKW (left) and BKW (right), in Java Islet's hydrophone detection area of 8 km. Bathymetric contours every 50 m. Each dot is a killer whale detection. The color scale is a relative density scale, 1 being the area with the highest concentration of observations, and 0 the area with the lowest.

Figure 3. Map of reconstructed trajectories overlapped with vocalizations. SRKW trajectories (left), and BKW trajectories (right), from January 29 to May 8, 2025, in the 8 km detection area. The dark part of the color gradient is the most recent point of the trajectory.



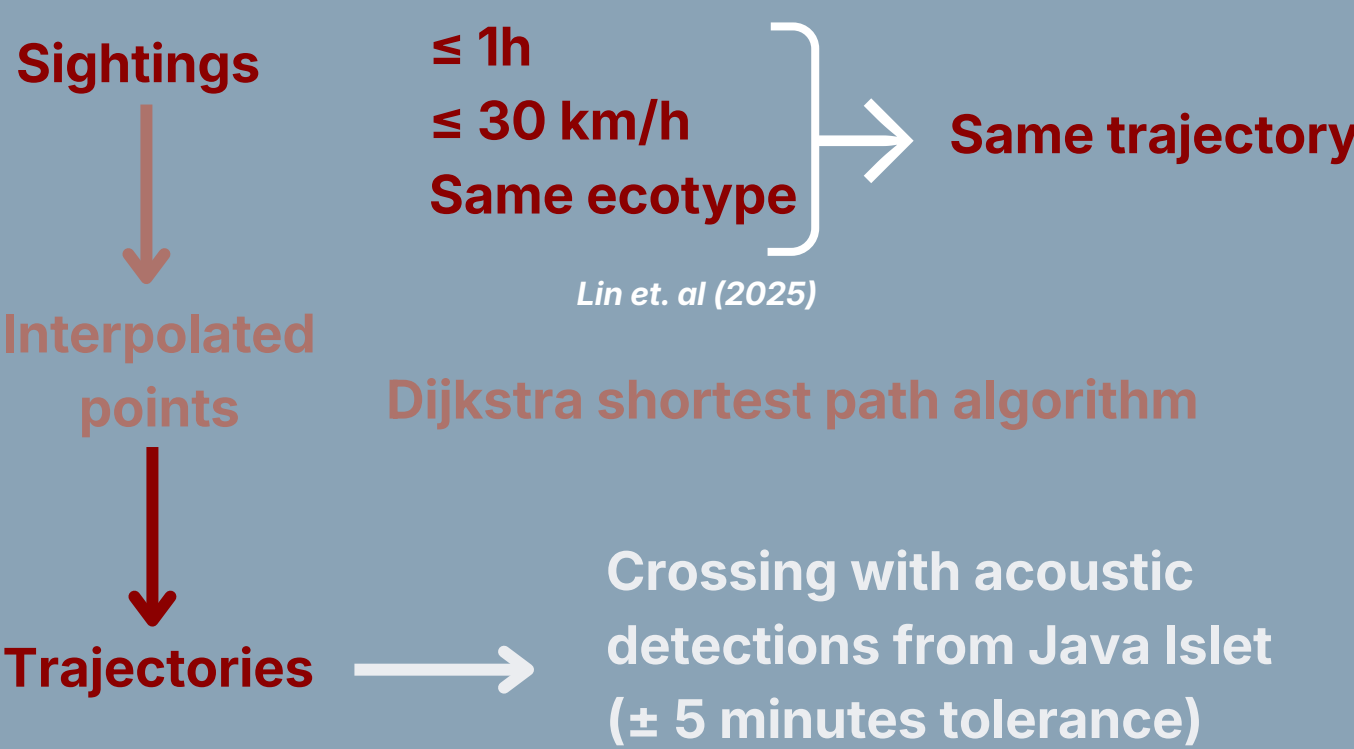
Methods

Trajectories

Figure 1. Trajectory interpolation method.



- **Presence data:** 2025 WRAS dataset
- **Acoustic records:** Java Islet - Jan 29 → May 8, 2025



Acoustic analyses

- **Soundscape analysis**
 - **Whistle and Moan Detector**
 - **MIRFEE Live Classifier**
- Certainty score ≥ 0.9
≤ 5 minutes apart = 1 vocal event

	Band (Hz)	Description
Soundscape	10 – 25000	Broadband acoustic soundscape
Vessel	100 – 1000	Vessel presence marker
Vessel (big)	57 – 71	63 1/3 octave band
Vessel (small)	113 – 141	125 1/3 octave band
Abiotic	10 – 100	Low-frequency wind, wave and water turbulence
Abiotic	7500 – 8500	Wind
Abiotic	18500 – 20500	Rain noise

Table 1. Spectral bands used for soundscape analyses and their associated source (Vagle et. al, 2021).

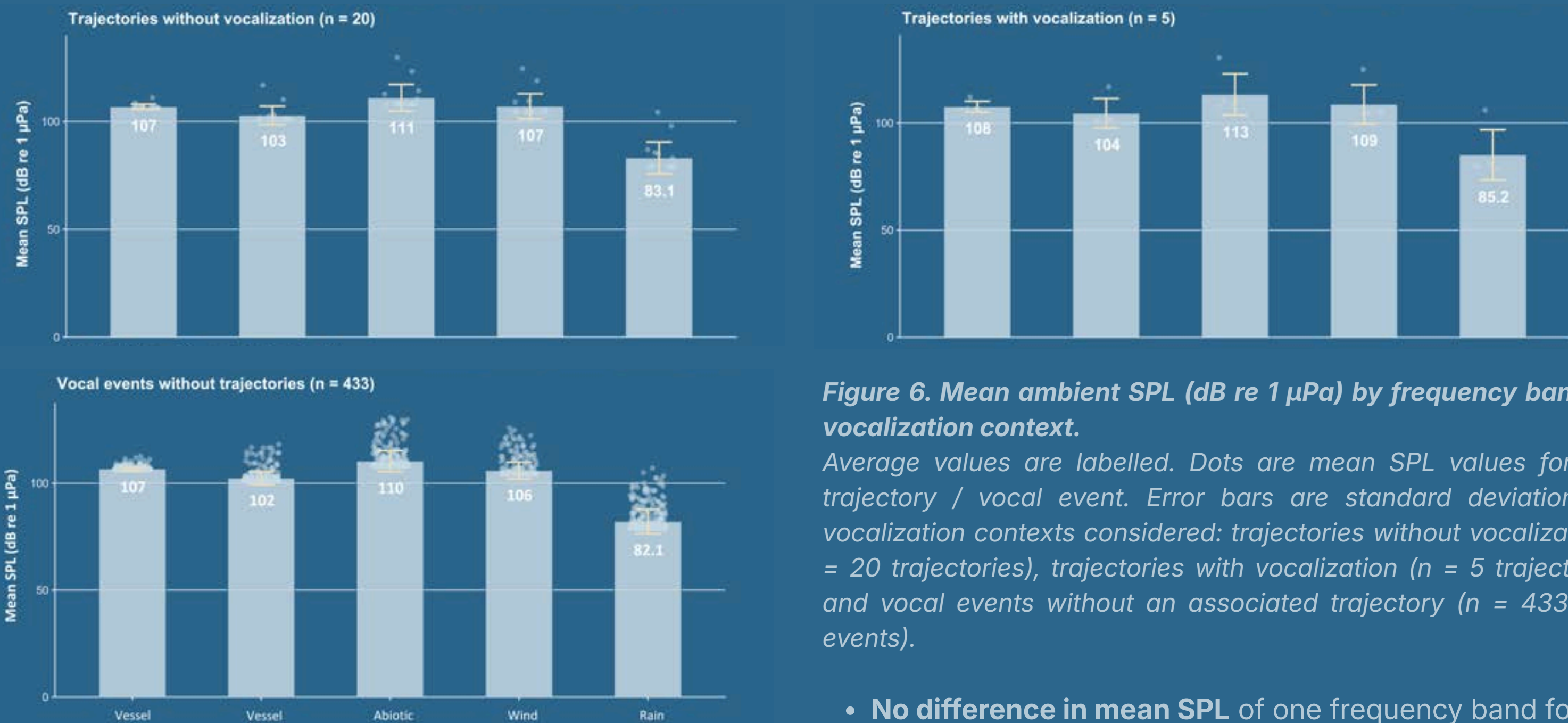


Figure 6. Mean ambient SPL (dB re 1 µPa) by frequency band and vocalization context. Average values are labelled. Dots are mean SPL values for each trajectory / vocal event. Error bars are standard deviations. 3 vocalization contexts considered: trajectories without vocalization (n = 20 trajectories), trajectories with vocalization (n = 5 trajectories), and vocal events without an associated trajectory (n = 433 vocal events).

- **No difference in mean SPL** of one frequency band for the three contexts (Kruskal-Wallis test, all $p > 0.05$)

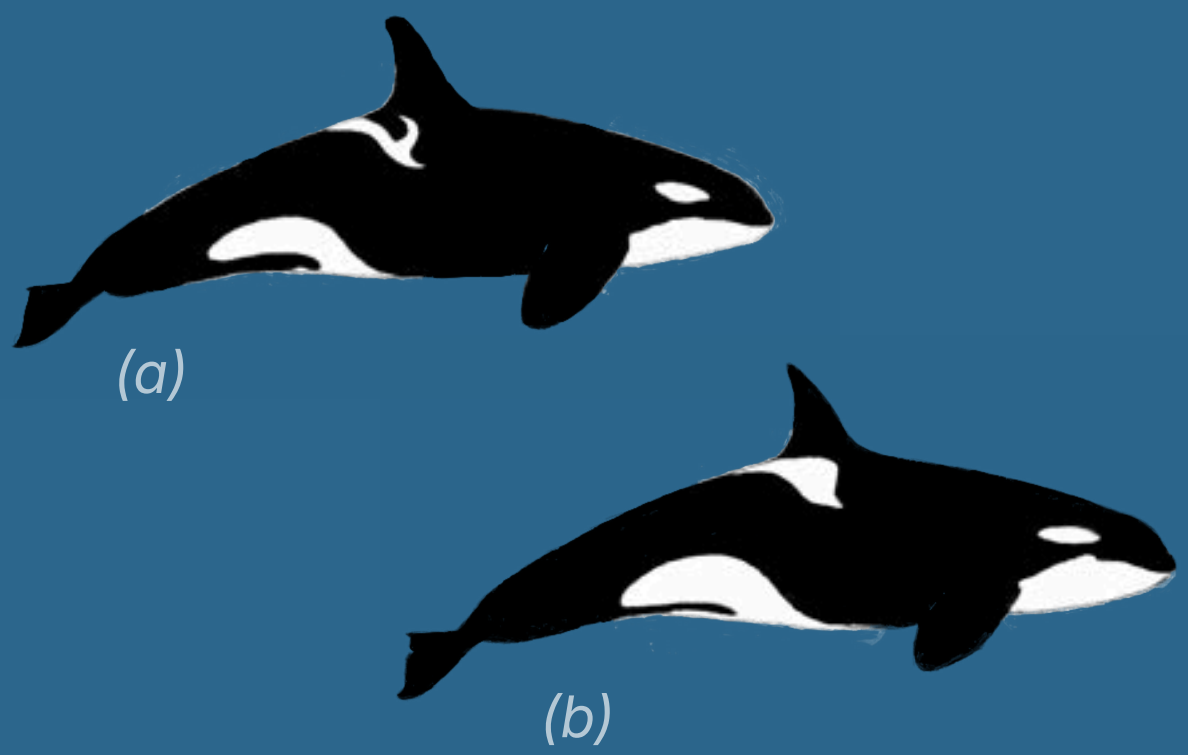


Figure 4. Illustrations of a SRKW (a) and a BKW (b).
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Figure 5. Broadband soundscape SPL (dB re 1 µPa) and vocal events count timeline (29 Jan - May 8, 2025). Broadband soundscape SPL (10-25 000 Hz) (grey line) and 24h mean SPL (white line) in dB re 1 µPa. Full moons ● and new moons ○ are located on the day they occur (top). Each bar is a day. Color scale: number of vocal events detected for this day. (bottom).

- Mean broadband SPL **122.4 dB**
- Broadband SPL **not related to lunar cycle** (GLS-AR(1), $p > 0.05$)
- Changes in SPL (all frequency bands) **does not explain changes in vocalization count** (Negative binomial GLM, all $p > 0.05$)

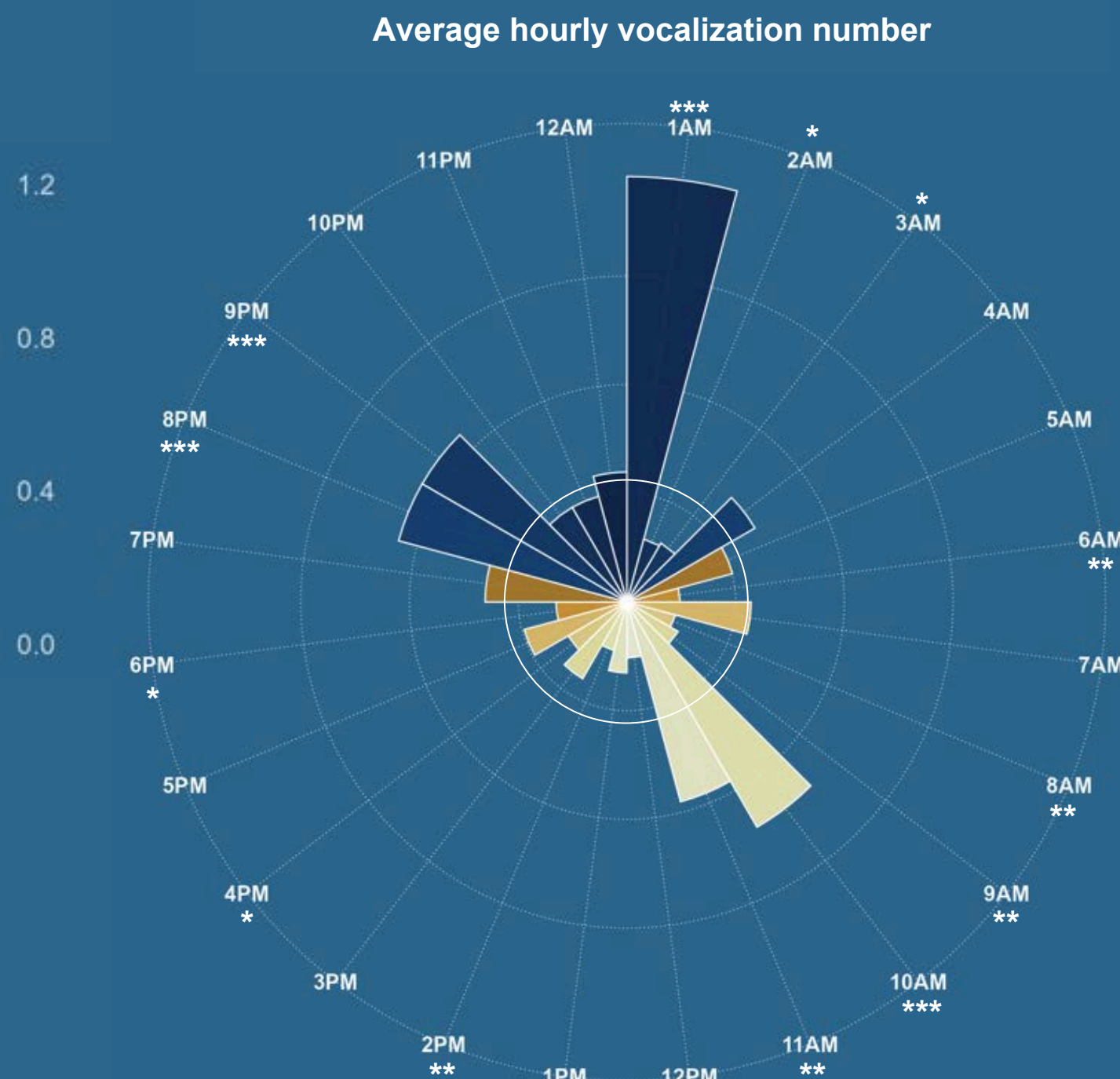


Figure 7. Hourly mean killer whale vocalization count on a 24h cycle. Plot center is 0, the first circle is 0.4, etc. The white circle is the average value for the whole day. Scale: average number of vocalizations detected during this time slot over the entire period. Poisson GLM p-values: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

- **Non-homogeneous distribution** (Rao test, $p < 0.001$)
- Poisson GLM → **1 AM, 10 AM, 8 PM, 9 PM** with most vocalizations

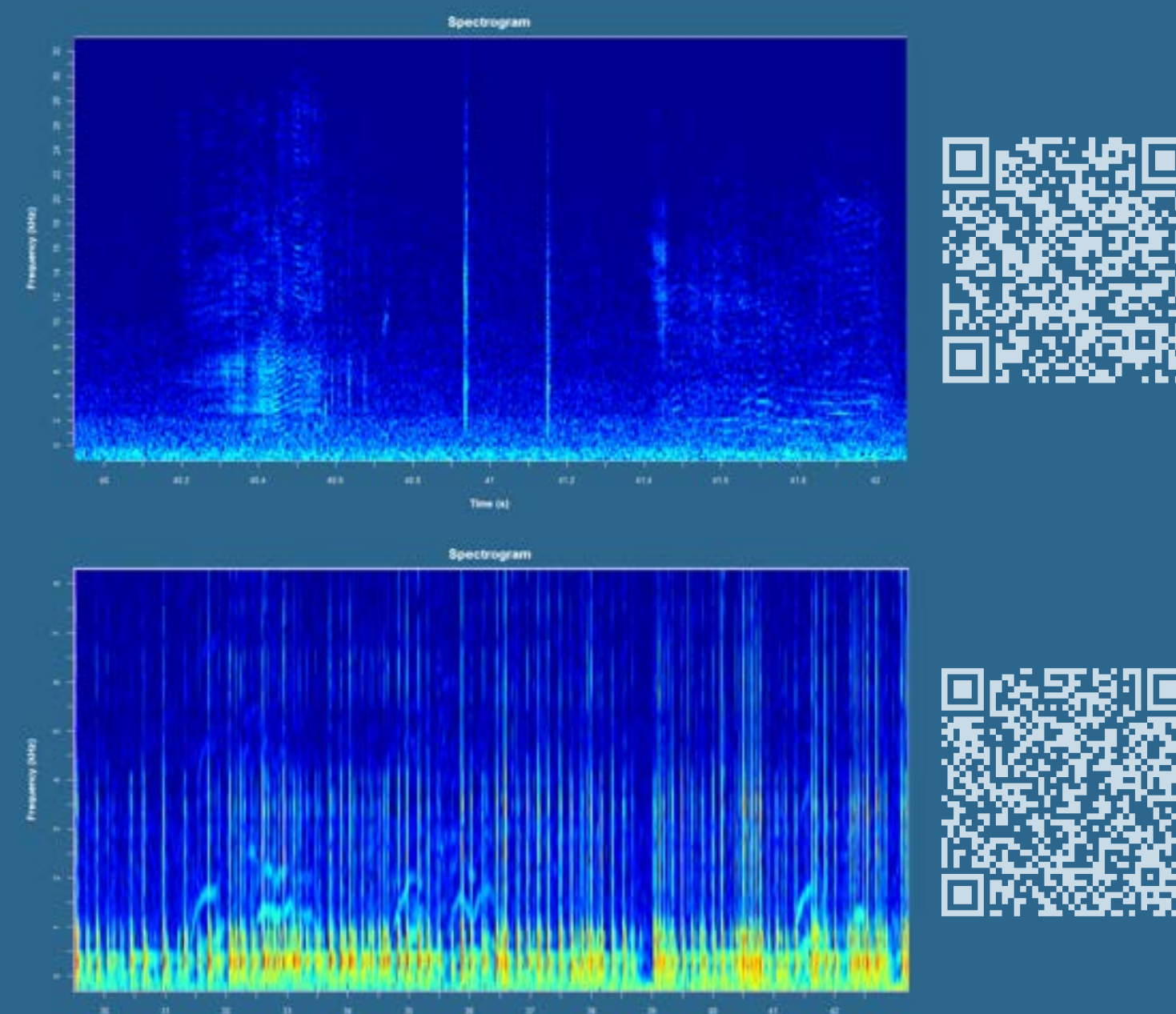


Figure 8. Spectrograms of a killer whale vocalization (top), and a vocalization hidden by a low-frequency noise (bottom). Scan the QR codes to listen to the audio files!

Discussion

- No distinctive pattern has been found for killer whale vocalization context
- Sightings and trajectories → killer whales tend to **stay away from boats**
- **Average SPL of 122.4 dB** and lunar cycles patterns : studied by previous research
- Nocturnal vocalizations: BKW hunting strategy
- **Low-frequency noise:** ↓ vocalization visibility in spectrograms: affects automated detection performance
- No observed relationships → **difficulties detecting vocalizations** in noisy environments, rather than indicating that vessel noise has no effect on killer whale vocal behavior

Bibliography

Lin, T.-W., Dowd, M., and Joy, R.: Forecasting trajectories of Southern Resident killer whales with stochastic movement models incorporating direction modification, *Ecological Modelling*, 509, 111254, <https://doi.org/10.1016/j.ecolmodel.2025.111254>, 2025.
Vagle, S., Burnham, R., Thupaki, P., Kohrad, C., Toews, S., and Thornton, S. J.: Vessel presence and acoustic environment within southern resident killer whale (*Orcinus orca*) critical habitat in the Salish Sea and Swiftsure Bank area, *Fisheries and Oceans Canada*, 2021.