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Exploring coda repertoires in two recently separated sperm whale (*Physeter macrocephalus*) social units off Mauritius

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Introduction

Coda

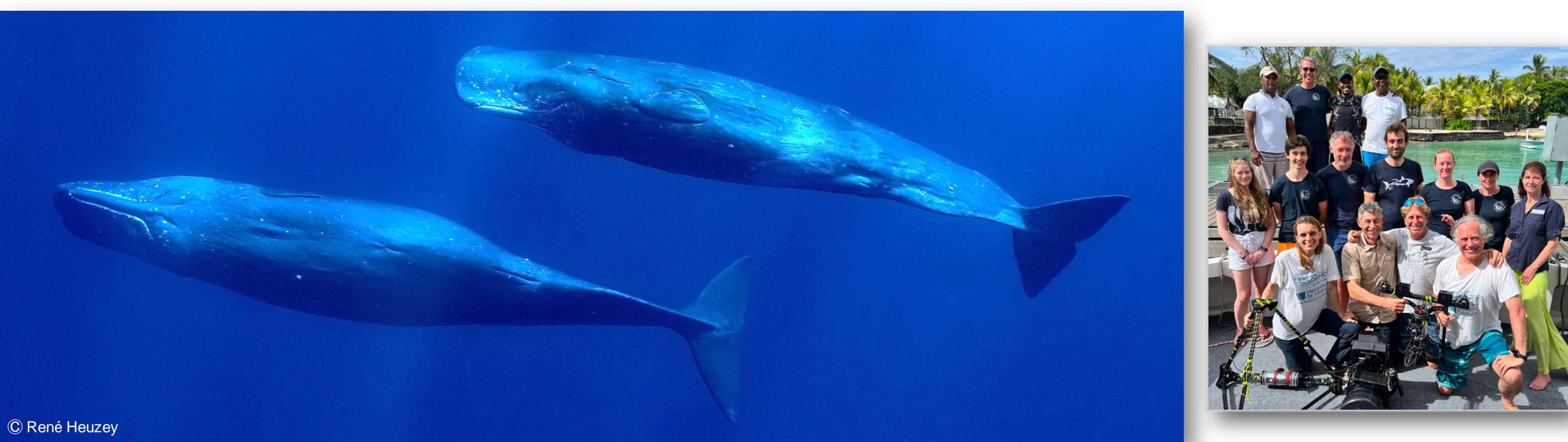
Series of clicks produced by sperm whales with stereotyped timings specific to a vocal clan, related to communication and social bonds^[1].

Context

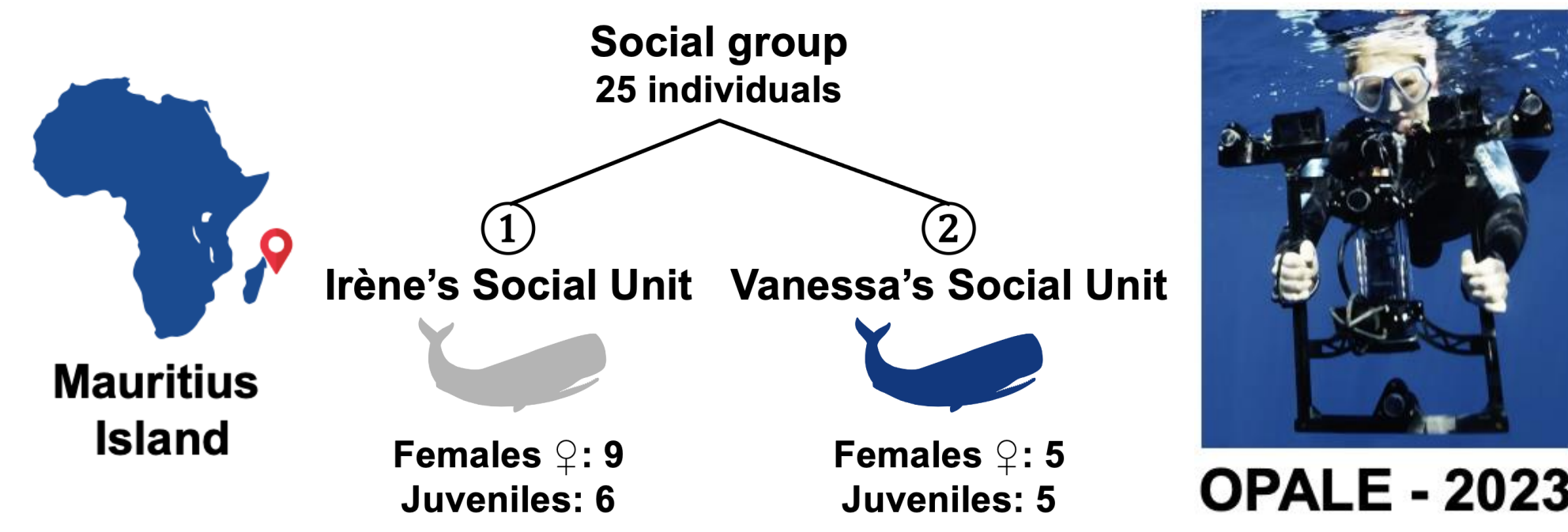
- Since 2008, 8-click codas are most recorded off Mauritius^[2].
- The Irène Gueule Tordue (IGT) sperm whale social group, studied from 2013, most frequently emits codas of the “2+1+1+1+1+1+1” type^[3, 4, 5, 6].
- As of 2017, the IGT group splits into 2 subgroups: Irène's and Vanessa's social units.

Objectives

- Compare the repertoire of codas recorded in 2023 within the two social units.
- Compare coda duration and inter-click intervals in the “2+1+1+1+1+1+1” coda.



Materials and Methods



- Period: March to June 2023 (20 days).
- 45 audio recordings totalling 1h14min38s.
- 438 codas registered; **351 codas analysed**.
- 19.9% excluded due to detection errors and overlapping codas.

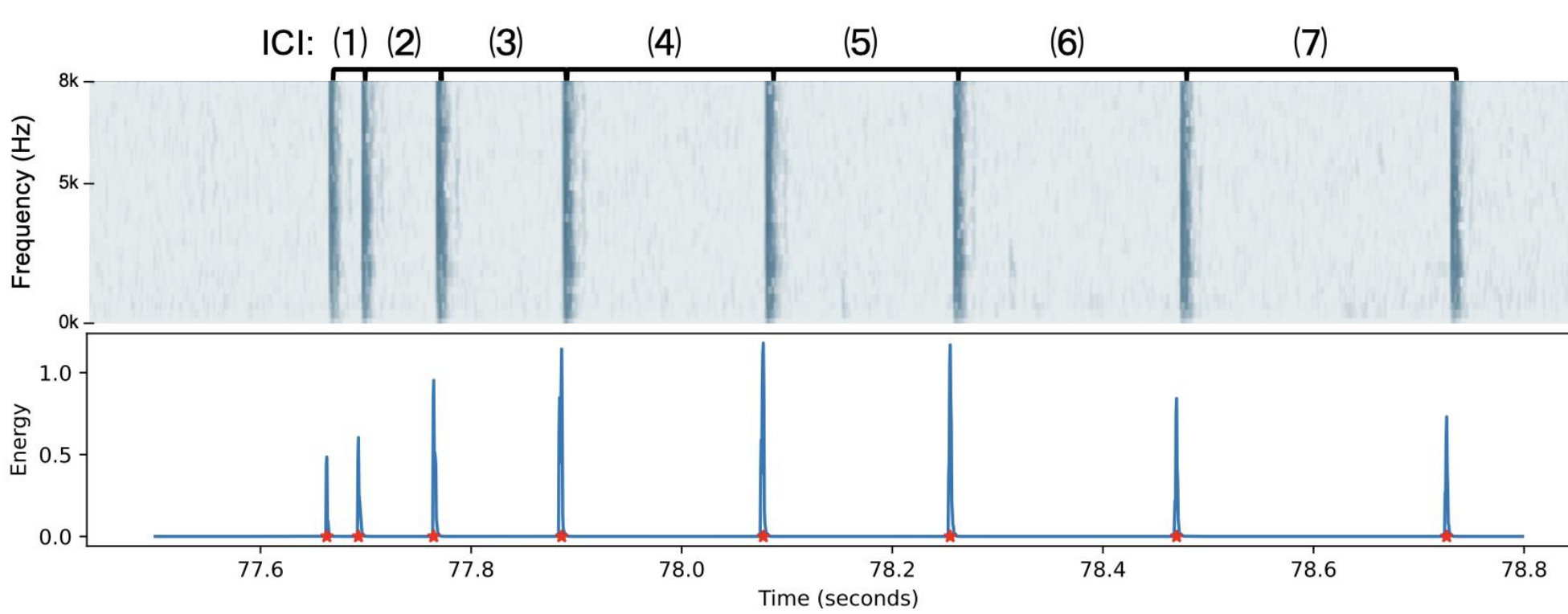


Fig. 1: Example of a coda “2+1+1+1+1+1+1”: frequency and energy with click detection (red stars: clicks detected).

- Opportunistic passive underwater observations conducted by Longitude 181^[4].
- Collection of high-definition acoustic data sets using OPALE acoustic array^[7].
- Manual coda annotation and automatic energy-based click detection (fig. 1).
- Statistical tests to compare the two social units: Shapiro-Wilk (normality), Mann-Whitney-Wilcoxon and Welch's t-test. **Significant if p-value < 0.05.**

Preliminary Results

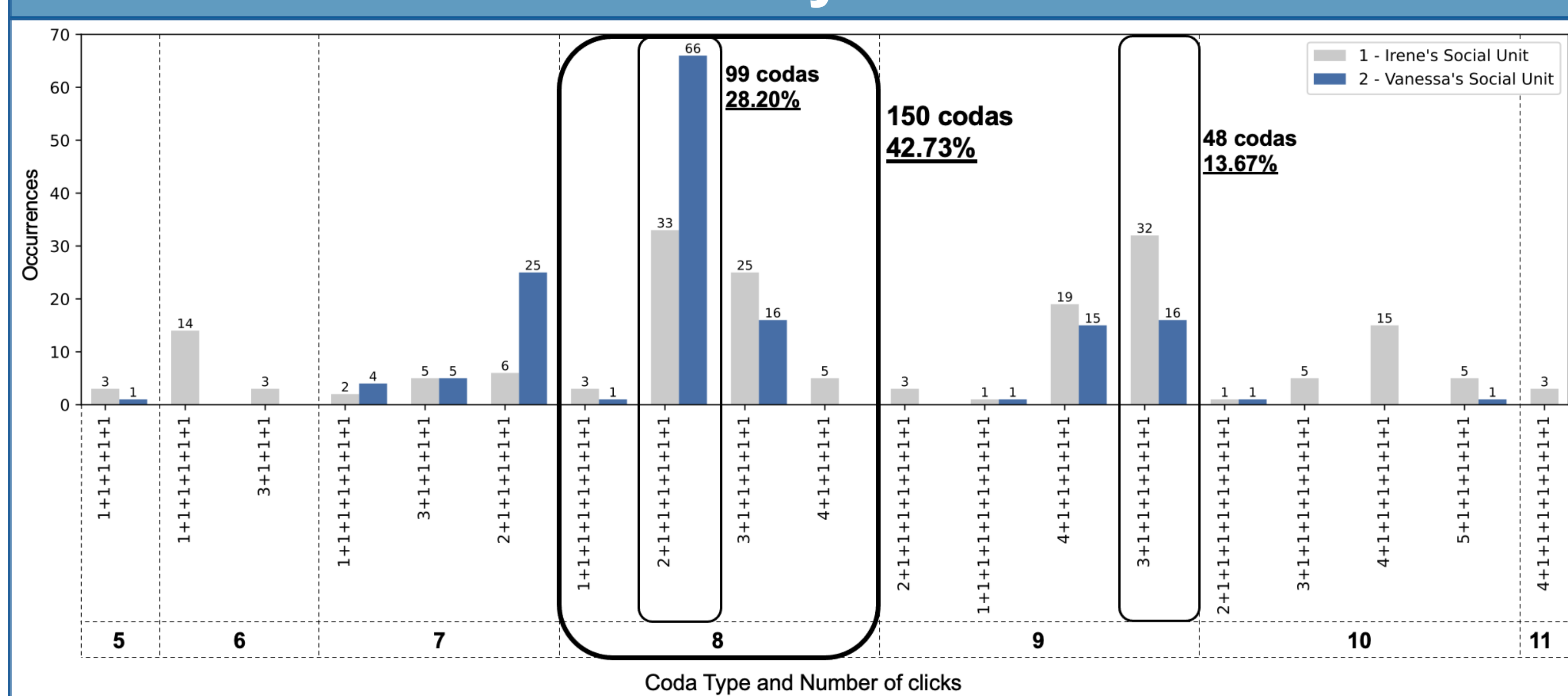


Fig. 2: Histogram representing similarities and differences in the coda repertoire of Irène's (n = 196 codas) and Vanessa's (n = 155 codas) social units by coda type, number of clicks and occurrences. Codas with occurrence < 2 in the dataset were excluded (n = 16).

Coda Types

- Identified codas: 35 types, 5 to 14 clicks.
- In common: 12 types.

Repertoires comparison

- Coda types: significant difference.
- Number of clicks per coda: no significant difference.

① Irène's Social Unit

- Total Coda Types: 32.
- Most frequent codas and types: **8-click** (n=66) and **9-click** codas (n=56) **2+1+1+1+1+1+1** and **3+1+1+1+1+1+1**.

② Vanessa's Social Unit

- Total Coda Types: 15.
- Most frequent codas and types: **8-click** (n=84) and **9-click** codas (n=32) **2+1+1+1+1+1+1** and **2+1+1+1+1+1**.

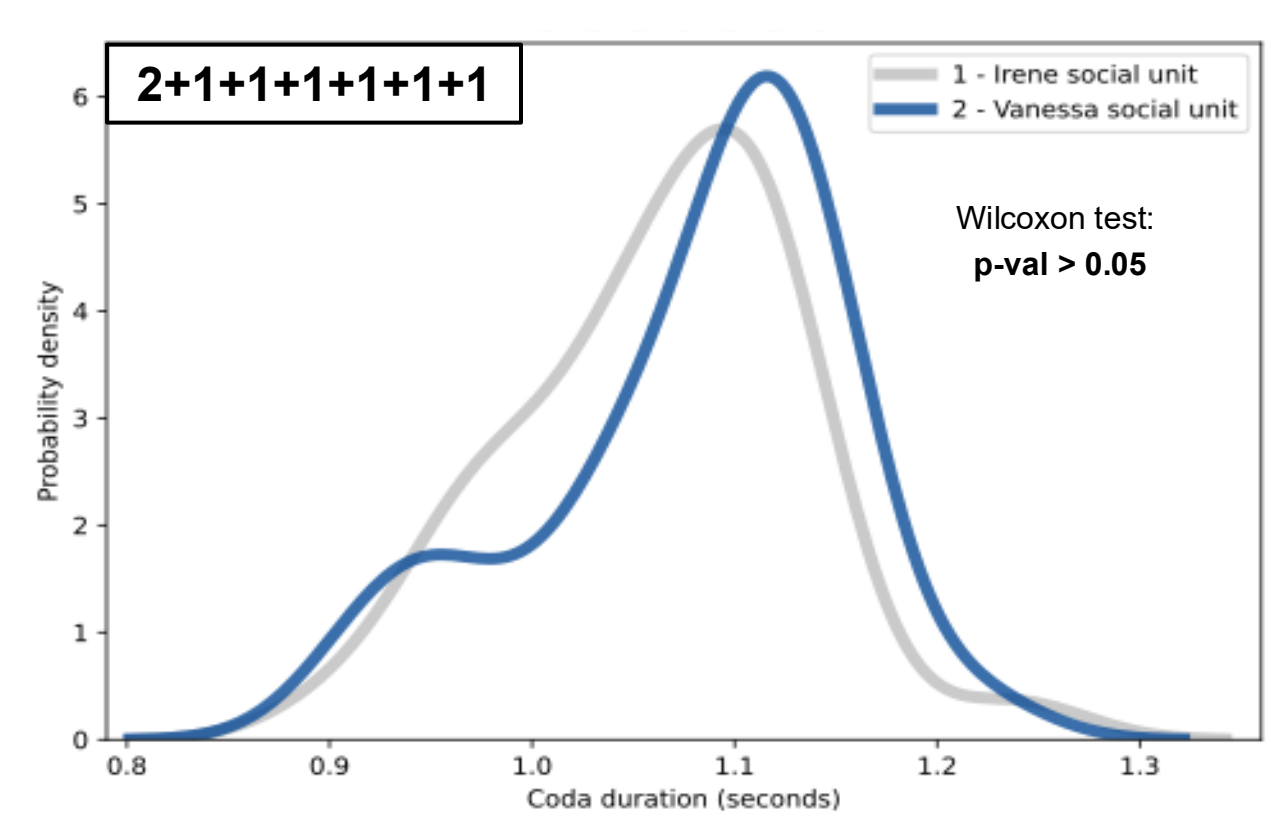


Fig. 3: Kernel Density Estimate plot to visualise the distribution of codas by their total duration.

- Duration: 0.89 to 1.24 s.
- No significant difference, unimodal distribution.

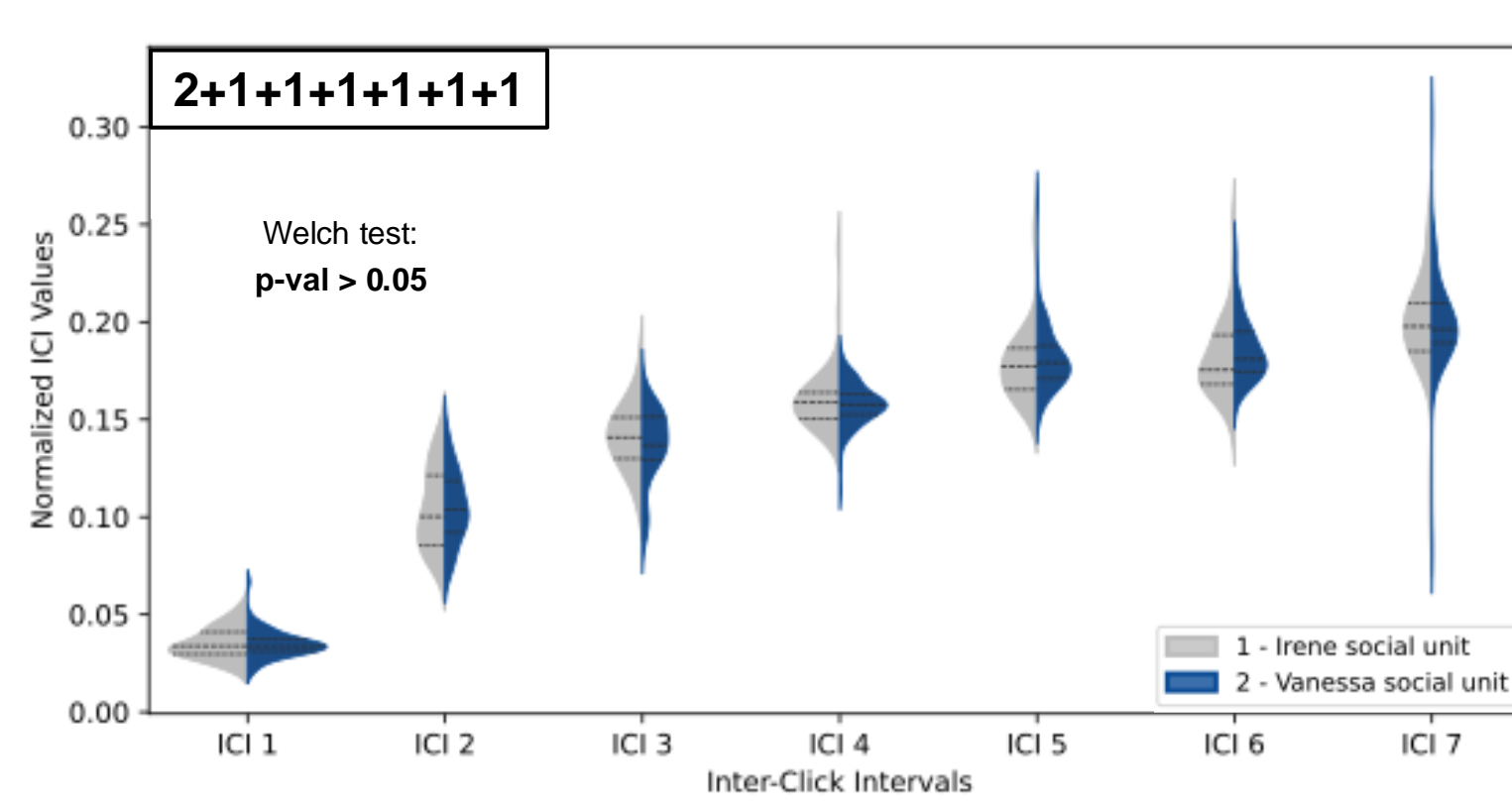


Fig. 4: Violin plot comparing the distribution of normalized intervals between clicks in social units.

- ICI coda normalized by total duration
- No significant difference.

Discussion

- Greater diversity of coda types in Irène's social unit: Richer communication? Composition of social unit? Irène social unit with more adult females and two newborns.
- Distinct coda types: communication divergences in social units?

Potential bias:

- More codas in Irène's social unit.
- Analysis period limited to 2023.
- Individual variability and behavioral context not yet explored.

Conclusion and Perspectives

Further research: confirm hypotheses and explore underlying causes of similarities and differences, to better understand the social dynamics and communication strategies of sperm whales.

- Compare coda repertoires before, during, after the split of IGT social group.
- Integrate behavioral data.
- Identify individual variability using age, sex, family link^[3,4,5], inter-pulse intervals and speaker identification with OPALE^[7].

Classify all codas, compare the underlying combinatorial structures^[8] (such as coda duration and normalized ICIs) and correlate them with behaviors to identify patterns and analyze vocal "conversations" (fig. 5).

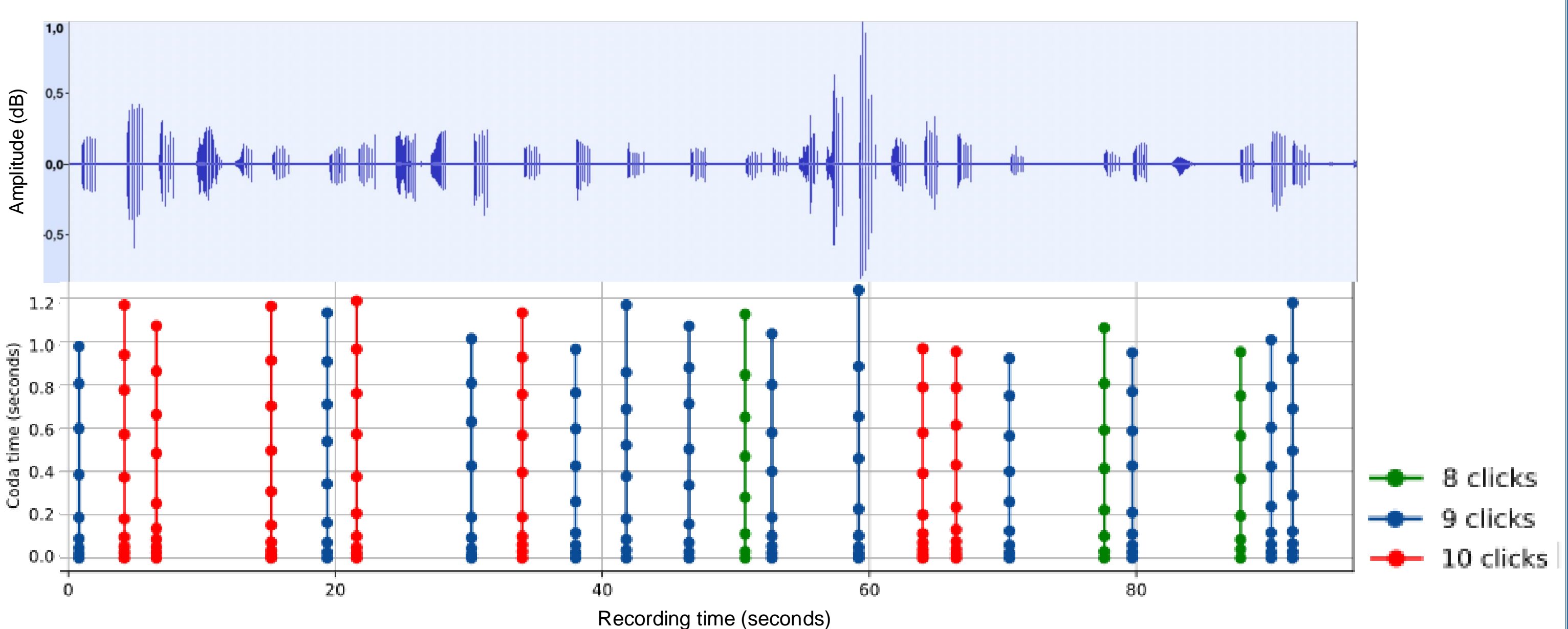


Fig. 5: Spectrogram and representation of codas in a “conversation” with multiple individuals in Irène's social unit. Duration: 1min 36s; Number of codas: 22; Vertical lines = one coda; Dots = clicks.

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