

Parameterizing animal sounds and motion with animal-attached tags to study acoustic communication

Behavioral Ecology and Sociobiology

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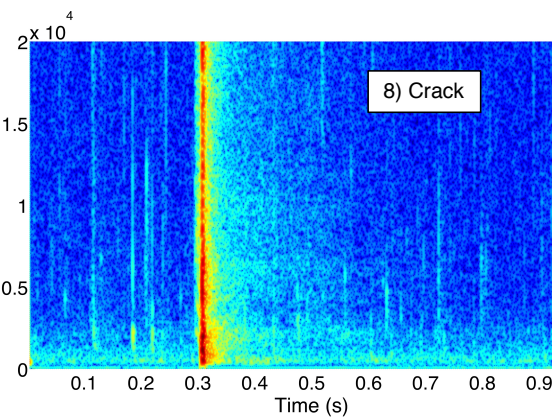
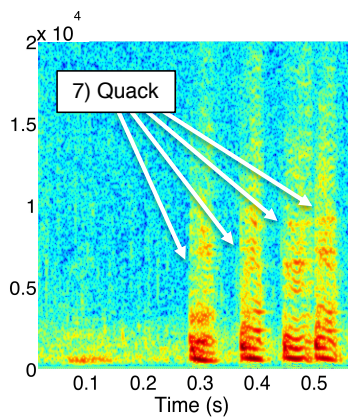
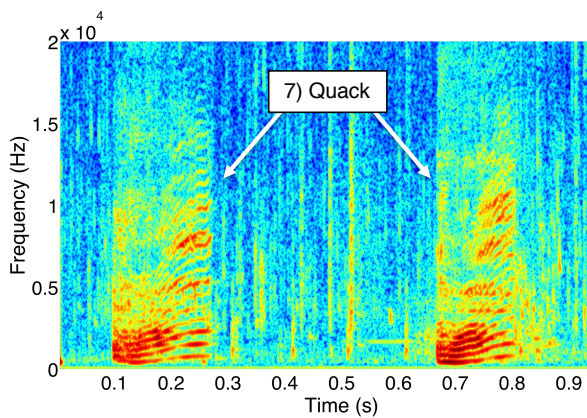
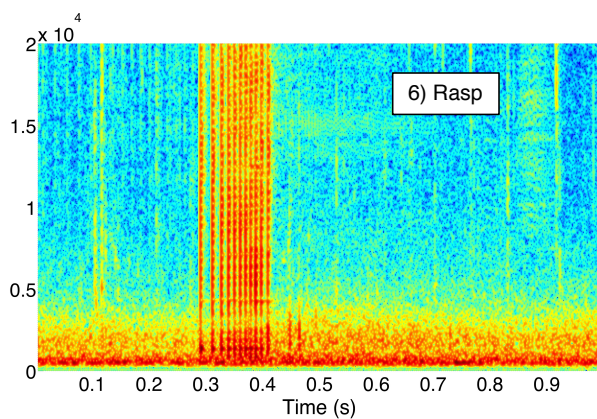
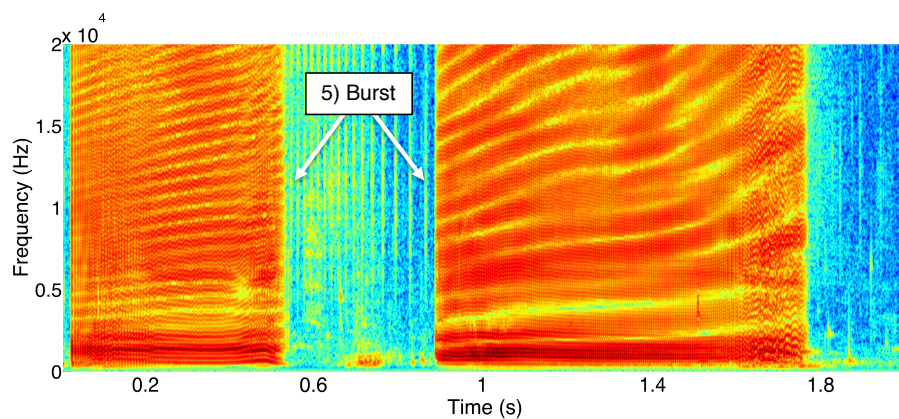
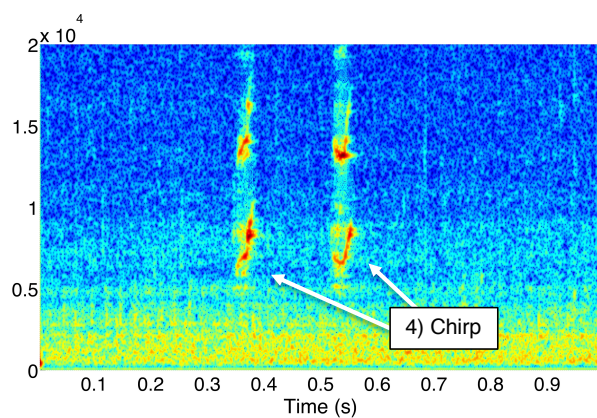
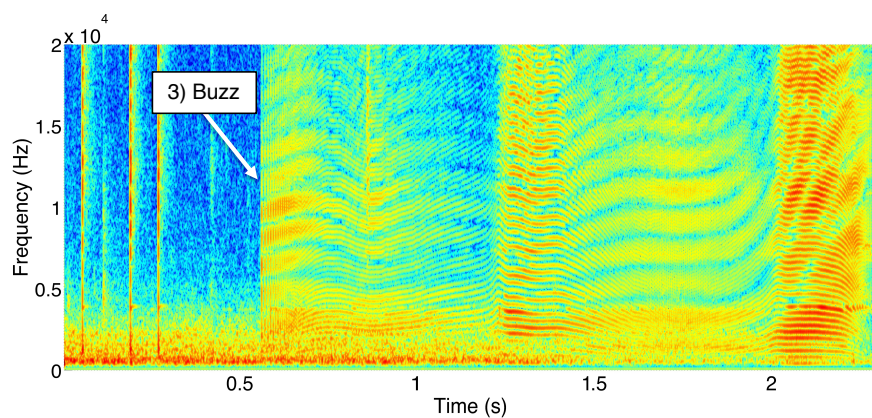
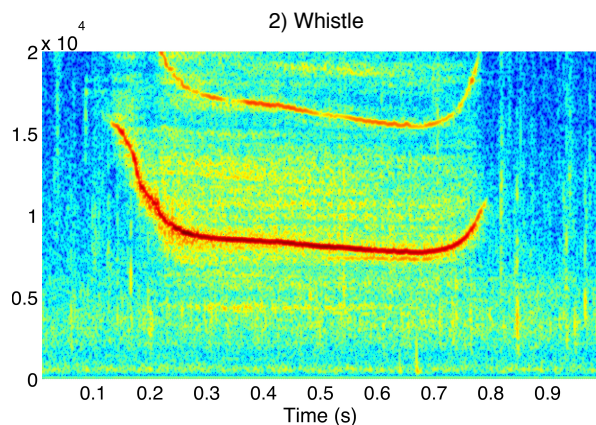
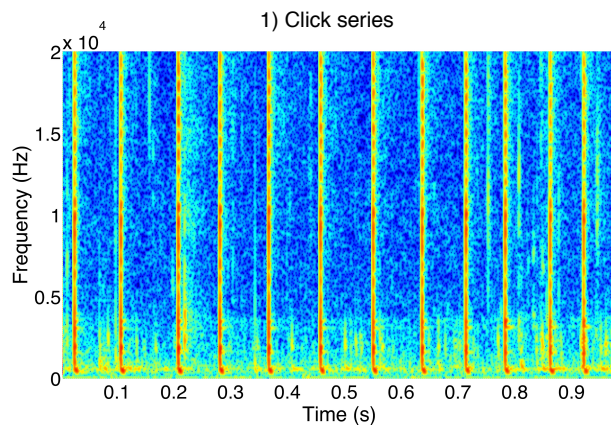
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Supplementary Methods

Library of call categories. Representative call spectrograms for the call categories used in the study.



Definitions of call categories

The call categories used in this study were: 1) whistle, a tonal narrow-band frequency-modulated signal with duration ≥ 0.1 seconds; 2) chirp, a tonal frequency-modulated signal shorter than 0.1 seconds (Caldwell and Caldwell 1970); 3) click series, a sequence of short broadband pulsed signals, each of them being a click, where inter-click intervals are long enough for individual clicks to be visually discernible; for the spectrogram settings used in the study, this corresponds to inter-click intervals of about 13 ms or longer; 4) buzz, a sequence of clicks where inter-click intervals are so short that individual clicks are no longer visually discernible (inter-click intervals < 13 ms); buzzes or series of buzzes are always preceded by a click series within about 1 second, and typically present a lower click amplitude relative to the preceding click series; this kind of sound has often been used for odontocetes as indicator of the final approach on a potential prey (Miller et al. 1995); 5) burst, a sequence of clicks where individual clicks are no longer discernible, without a preceding click series; 6) rasp, a short rapid sequence of clicks, with typical duration < 0.5 seconds and uniform sound energy up to 20 kHz or more (Sayigh et al. 2017); 7) crack, a high-energy pulsed sound with distinctive short rise time and reverberant component at the end (Caldwell et al. 1962; Sayigh et al. 2017); 8) quack, a short low-frequency sound with distinctive tonal component below 6 kHz (Sayigh et al. 2017); 9) indeterminate, a category used for unknown signal types.

SNR calculations for the extraction of acoustic parameters

The first step for the extraction of acoustic parameters as time series from tag data involved SNR calculations that made it possible to: 1) precisely locate onset and end of signals within labelled sounds; 2) eliminate from the analyses signals with low SNR; 3) discard noise periods before measuring frequency parameters. For SNR calculations, RMS comparisons were carried out among short time segments of 1024 points each (4.3 ms, 50% overlap between successive segments), generated for both the “Signal” (i.e. a labelled sound with a 60-ms buffer in front and at the end added to compensate for labelling imprecisions) and a 100-ms precedent “Noise” segment. The location of the Noise segment was manually picked by human operators for each call. This was necessary since with concentrated sequences of sounds no automated method appeared reliable for selecting ambient noise that did not contain other dolphin signals or transient loud noise (e.g., due to water flow or physical contacts with the tag hydrophones), and at the same time that was reasonably close in time to the Signal.

The SNR cut-off used to select 1024-point segments of the Signal comprising a dolphin sound was the following: the RMS of a segment had to be above the 90th percentile RMS of the 1024-point segments of the Noise, + 6 dB. In order to find onset and end of dolphin sounds, the Signal was cut from the first 1024-point segment with high SNR to the last 1024-point segment with high SNR. The isolated sound waveform was therefore divided into consecutive non-overlapping time windows of 0.1 seconds for which acoustic parameters were measured. If no 1024-point segment presented a high SNR, a labelled sound was excluded from the analyses.