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TOOLS FOR THE CLASSIFICATION OF NBHF SPECIES IN SOUTHERN CHILE

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INTRODUCTION

In the southern cone of America, four species of dolphins and porpoises emitting NBHF (Narrow Band High-Frequency) clicks are sympatric species. Their acoustic emissions are very similar (frequency content

around 125-130 kHz and narrow bandwidth, see below) and there is currently no way of acoustically classifying the different species.

"NBHF" SPECIES

Thirteen species of odontocetes, within four families (Phocoenidae, Pontoporiidae, Kogiidae, Delphinidae) are known to produce narrow band high-frequency short echolocation signals usually called NBHF click. With their bandwidth of usually less than 20kHz and their peak frequency of about 130kHz, the waveform of these clicks are polycyclic (fig. 3). In the southern cone of America, two species of *Cephalorhynchus*, *eutropia* (Chilean dolphin) and *commersonii* (Commerçon's dolphin), as well as the Peale's dolphin *Lagenorhynchus australis* and the Burmeister's porpoise *Phocoena spinipinnis* share very similar echolocation clicks as well as coastal habitats. In this study, only two of them (depicted in fig. 1, 2) were registered.

TWO CHILEAN SPECIES

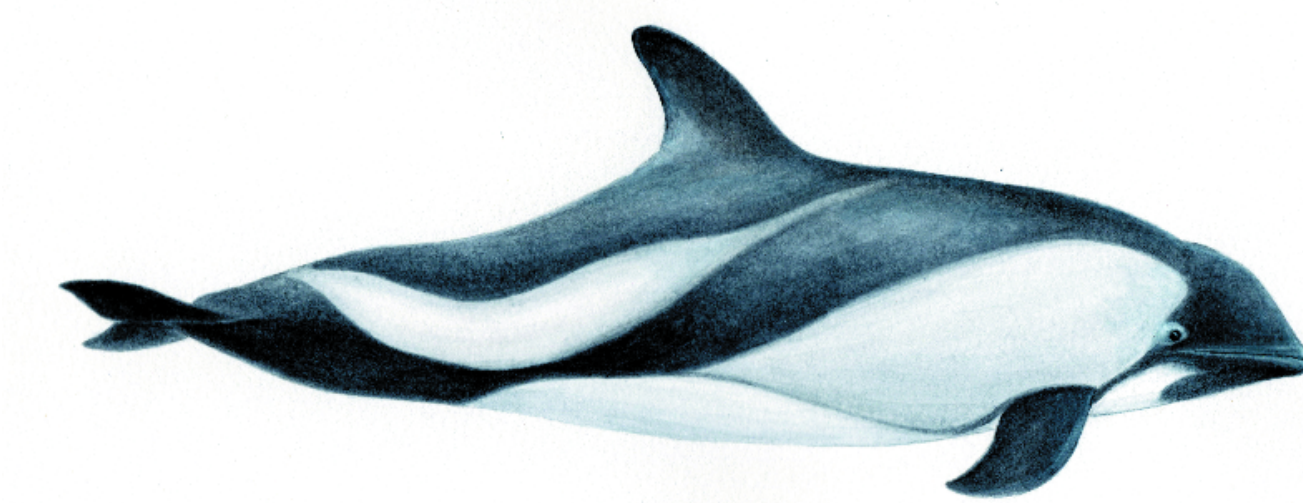


Figure 1: Peale's dolphin *Lagenorhynchus australis*.



Figure 2: Chilean dolphin *Cephalorhynchus eutropia*. Credit : Andres Calderón.

ACOUSTICAL PARAMETERS

signal	symbol	Gabor wavelet
Signal	$s(t)$	$Ae^{-\frac{(t-t_0)^2}{T^2}} \cos(2\pi f_0(t-t_0) + \phi)$
Dur. at -10dB	Δt_{-10dB}	$\sqrt{2\ln(10)} T \approx 2.15 T$
Dur. at -20dB	Δt_{-20dB}	$\sqrt{4\ln(10)} T \approx 3.03 T$
Dur. 'rms'	Δt	$\approx \frac{1}{2} T$
Peak f.	f_p	$\approx f_0$ ou $-f_0$
Centroid f.	f_c	0 (or f_0)
BW at -3dB	Δf_{-3dB}	$\approx \frac{\sqrt{2\ln(2)}}{\pi} \frac{1}{T} \approx 0.37 \frac{1}{T}$
BW at -10dB	Δf_{-10dB}	$\approx \frac{\sqrt{2\ln(10)}}{\pi} \frac{1}{T} \approx 0.68 \frac{1}{T}$
BW 'rms'	Δf	$\approx \frac{1}{2\pi} \frac{1}{T} \approx 0.16 \frac{1}{T}$
Q -3dB	Q_{-3dB}	$\approx \frac{\pi}{\sqrt{2\ln(2)}} f_0 T \approx 2.67 f_0 T$
Q 'rms'	Q_{rms}	$\approx 2\pi f_0 T \approx 6.28 f_0 T$
dur.-BW product	P_{uncert}	$\approx \frac{1}{4\pi}$

GABOR WAVELET MODEL

The classical acoustical parameters (peak frequency, centroid frequency, 10dB duration, 3db Bandwidth, etc, see [1]) used to characterize the NBHF clicks are probably not precise enough to separate different species. We propose a new method of measuring the frequency and duration of a click, by fitting a Gabor wavelet to the registered click (fig. 3). With this model, in the polycyclic approximation, all the usual measured parameters are reduced to two : the duration T and the Gabor frequency f .

ASPECT OF A NBHF CLICK

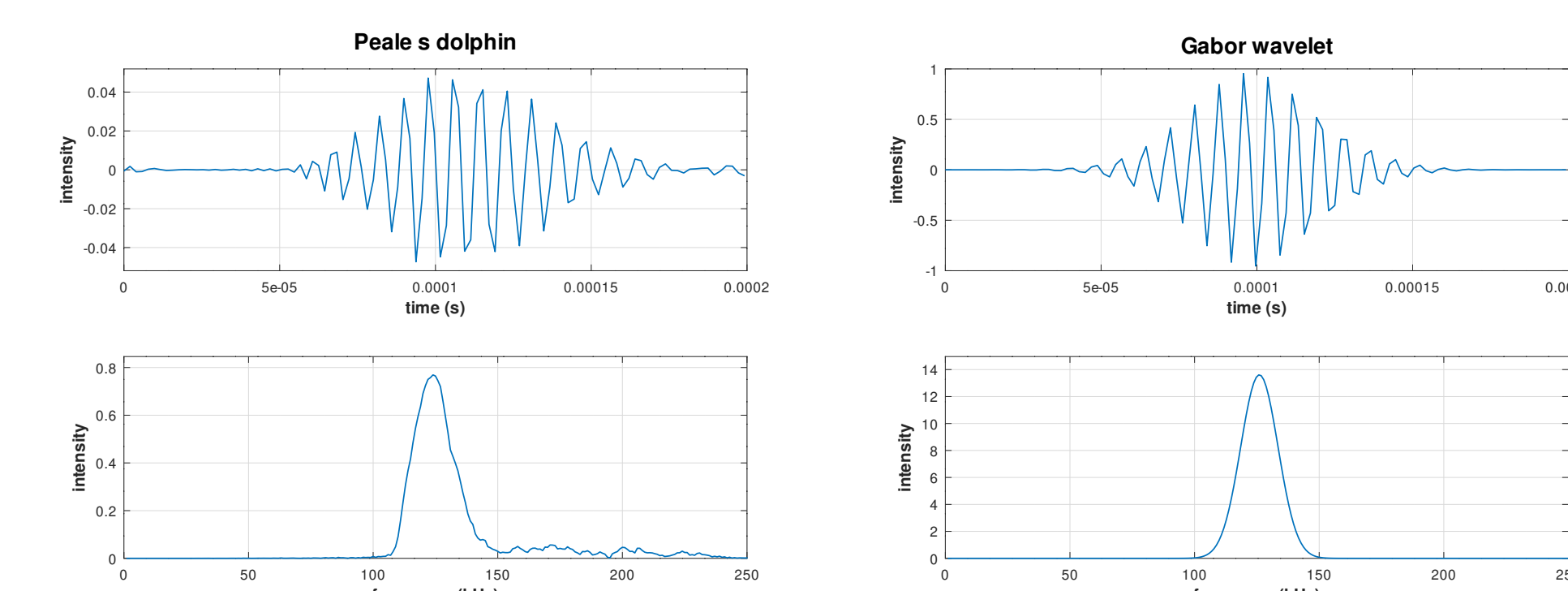
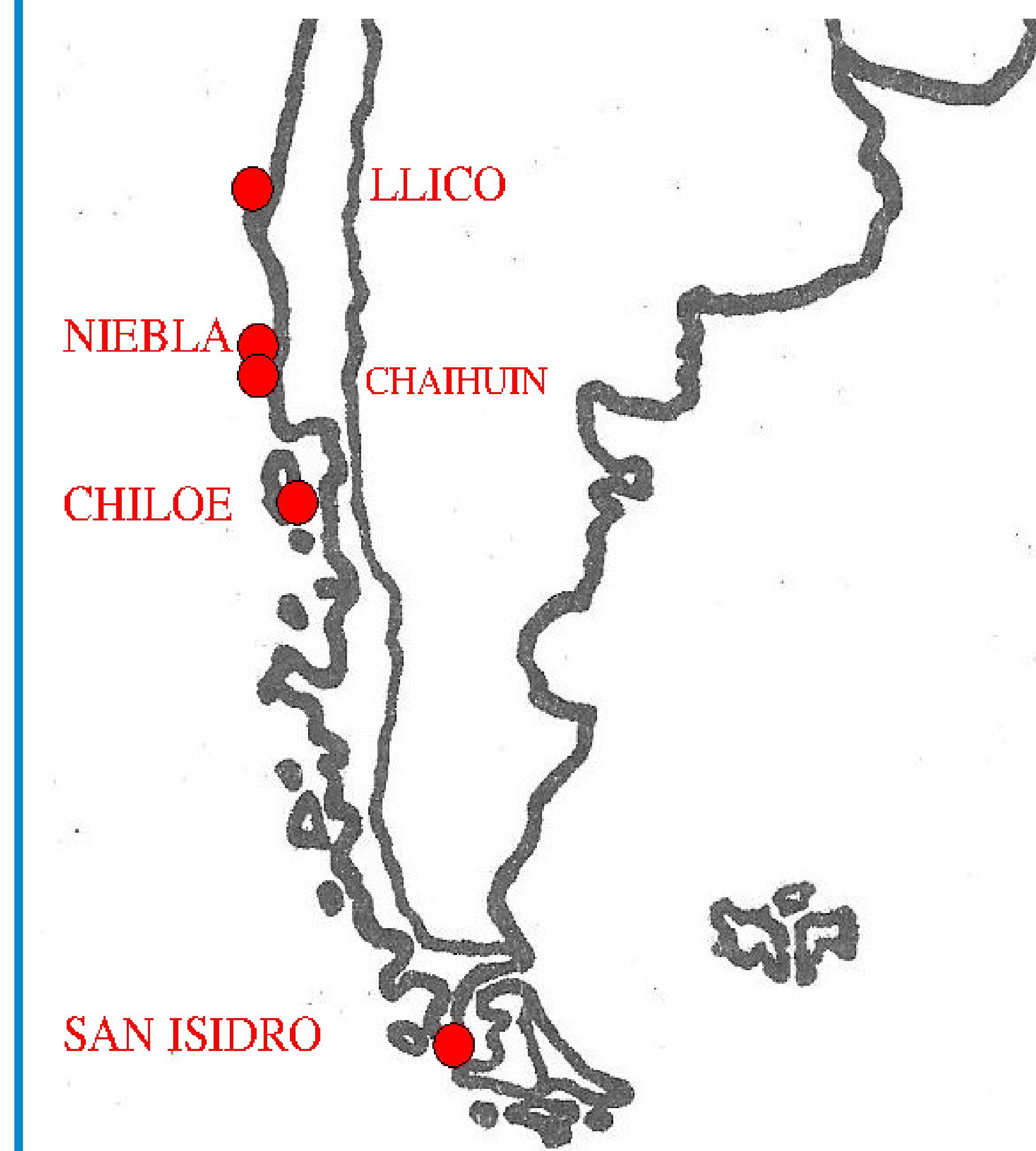


Figure 3: Left : example of a Peale's dolphin echolocation signal. Right : a Gabor wavelet.

OUR DATASET

From 2021 to 2023, 6 acoustical datasets (3 with Chilean dolphins, 3 with Peale's dolphins) have been collected in different coastal areas of Chile. Each dataset is of about 3 days of continuous recording at a sample rate of $f_s = 512$ kHz with the autonomous High Blue recorder device [2], with visual follow-up for species identification. With a custom-made detector [3], we compiled the parameters of around 7500 clicks for the Chilean dolphin and 18700 for the Peale's dolphin. In one of the data sets no clicks have been detected (in Niebla, november 2022) and in Niebla (december 2022), we visually separated the two species.



CONCLUSION

The modelling of NBHF clicks could help reducing the number of measured parameters and help comparing the emissions of different species. However, we find in our dataset that the echolocation clicks are extremely similar. Our data suggest that the difference between species could be found, rather, in other types of sounds emitted by the cetaceans. Therefore, we advocate for a more thorough examination of each species' acoustic repertoire. This approach could enhance the ability to distinguish between species, leading to more efficient acoustic monitoring of these endangered animals.

RESULTS

Figure 5 present the density of clicks in the f_0, T plane for each data set. The great majority of the clicks from the two species and the five places are very similar and present a f_0 around 130 kHz and a T around $50\mu s$ as already noticed by former studies [4, 5]. No differences appear between the two species using these acoustic parameters. The species appear to exhibit greater variability between sites than interspecifically.

GRAPHICAL RESULTS

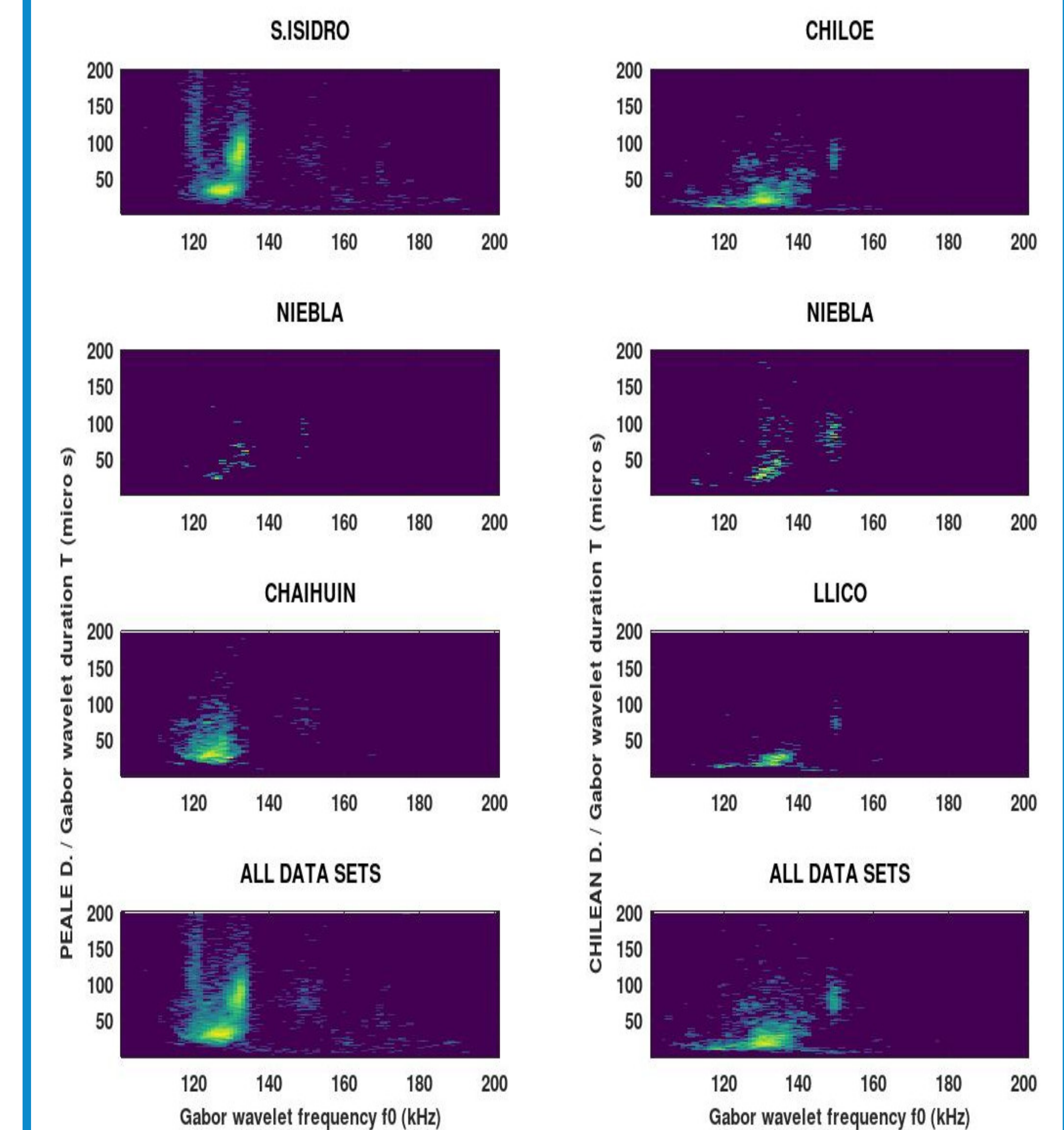


Figure 5: Heat map of the clicks analyzed (for each pixel of size 1kHz/1μs, the log of the number of clicks is computed). (Results for Peale's dolphins on the left and Chilean dolphins on the right)

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