Echolocation behavior of franciscana dolphins
(Pontoporia blainvillei) in the wild

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Abstract: Franciscana dolphins are small odontocetes hard to study in the field. In particular, little is known on their echolocation behavior in the wild. In this study we recorded 357 min and analyzed 1019 echolocation signals in the Rio Negro Estuary, Argentina. The clicks had a peak frequency at 139 kHz, and a bandwidth of 19 kHz, ranging from 130 to 149 kHz. This is the first study describing echolocation signals of franciscana dolphins in the wild, showing the presence of narrow-band high frequency signals in these dolphins. Whether they use other vocalizations to communicate or not remains uncertain.

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PACS numbers: 43.80.Ka [CM]
Date Received: March 1, 2012 Date Accepted: March 30, 2012

1. Introduction

Passive acoustic monitoring has gained considerable attention in the last years and it is considered a useful tool to detect marine mammals in the wild. Franciscana dolphins (Pontoporia blainvillei) are small odontocetes that live in coastal waters of the South western Atlantic from Itauna, (18°25′ S), Brazil to Golfo San Matias (42°10′ S), Argentina (Crespo et al., 1998; Siciliano et al., 2002). Their size along with their coloration and rare aerial displays makes them difficult to study in the wild. In fact, most of the knowledge on these animals to date has been collected from individuals caught in fishing nets, their main threat (e.g., Ott et al., 2002; Cappozzo et al., 2007).

In particular, very little is known on their echolocation signals. Von Fersen et al. (1997) recorded the echolocation behavior of a captive animal, noticing that the main frequency of the clicks was of 130 kHz with a bandwidth of about 20 kHz, and the mean duration of click train was of 90 s. However, there are no data on this species in the wild.

The aim of the present work was to fully describe the echolocation signals of franciscana dolphins in the wild to better understand their behavior and to be able to apply passive acoustic monitoring to this species.

2. Materials and methods

In December 2011, we conducted sound recordings from a semirigid boat in the Rio Negro Estuary, located in the Northeast Patagonia, Argentina (latitude: 41°1′ S – 41°2′ S, longitude: 62°47′ W). While the boat moved slowly transiting in the area, two trained observers were on board looking for franciscana dolphins. When one or more animals were sighted, we turned off the motor, deployed the hydrophone and conducted sound recordings. Once we stopped recording animals we waited for about 5 min and moved to the next place, as long as weather conditions were appropriate. All the recordings were done with a Beaufort scale < 2, swell < 1.2 m, wind < 20 km/h and high tide, to avoid loud noise due to wind and turbulence.

We used a hydrophone Reson TC 4033. The sound was digitized by Avisoft Ultrasound-Gate (connected with the Ultrasound-Gate charge amplifier), with a
sampling rate of 500 kHz and stored as 1 min wav-files in a laptop. Further analysis was performed with custom-made scripts in MATLAB 7 (Natick, MA, USA). The whole system was calibrated and, since the equipment did not have a flat response over the desired range, we applied the transfer function (or calibration curve) to correct our recorded levels.

First, all sound files were manually screened in search for the presence of echolocation signals. Only those with clear echolocation signals were selected for further analysis. A detector was created to automatically extract echolocation signals of franciscana dolphins and avoid bias in click detection. Files containing strong boat noise were discarded due to a higher detection of false echolocation signals. We only picked echolocation signals with a signal-to-noise ratio over 12 dB, which was also our criterion for click onset.

To test the performance of the automatic detector, we randomly selected about 20% of the recordings and manually counted the false positives. Less than 7% of the detections were false positives and were included in the analysis.

Spectra were calculated for every single echolocation signal detected, from 15 µs prior to the onset of the click, including the first 800 µs. This criterion was chosen to minimize the presence of echoes from the animals’ surroundings in the analysis of the echolocation signals. For this, we used a Hamming window with an FFT of 160 points and an overlap of 95%.

After calculating peak frequency, we determined the lowest and highest frequency when the intensity of the click was 6 dB below the maximum intensity. Duration was estimated from 20 calls, even though we could not tell which clicks were on-axis. We tried to pick calls with no reverberations proceeding from structures which were located approximately 20 cm from the sound source. Inter-click interval was manually calculated as the difference between the start time of an echolocation signal and the start time of the previous one. For this latter parameter we used 10 different click trains and calculated 12 inter-click intervals per click train. Then we computed the mean of each sample and reported the mean of the mean with its corresponding standard error.

Means of the individual spectra were calculated for all the clicks to calculate the mean spectrum (with a filter between 15 kHz to get rid of the low frequency noise, and 240 kHz).

3. Results

We were able to record franciscana dolphins on three days. Distances from the recorded individuals to the hydrophone varied between 1 and 50 m, approximately. From those working days, we obtained 357 min of sound recordings, out of which 61 were analyzed because of the presence of franciscana dolphins’ echolocation signals.

![Fig. 1. Spectrogram of a representative click train of a franciscana dolphin echolocating in the wild (displayed FFT = 1000, overlap = 0%). The mean inter-click interval was 33 ms.](http://dx.doi.org/10.1121/1.4710837)
and absence of noise proceeding from boat engines. A total of 1019 clicks met all of our criteria for analysis and were included in the results of the present work.

Echolocation signals consisted of high-frequency clicks with a mean inter-click interval of 33 ± 4 ms (ranging between 14 and 43 ms). Figure 1 depicts a typical click train produced by a franciscana dolphin when only one adult was sighted. The time series and spectrum of a single click are represented in Figs. 2(a) and 2(b), respectively. The duration of the chosen click was of about 200 μs. Echoes from the surroundings are also present in the time series. The peak frequency of the click was at 142 kHz.

The mean spectrum of all clicks analyzed (Fig. 3) showed a peak frequency at 139 kHz. Using a criterion of −10 dB below the peak frequency, the lowest frequency of the echolocation signals detected was of 130 ± 3 kHz and the highest frequency 149 ± 3 kHz. Note that the mean click represents only the majority of the clicks registered. However, there were some rare cases when animals were close to the

Fig. 2. (a) Normalized time series of a single echolocation signal analyzed. The onset of the click is represented at 200 μs. Note the presence of echoes proceeding from the surroundings after the click. (b) Normalized spectrum of the same echolocation signal emitted by a franciscana dolphin (FFT = 160, overlap = 95%, sampling frequency = 500 kHz).
hydrophone and the recorded clicks probably reached frequencies over 250 kHz. The mean click duration with its standard deviation was 212 ± 56 µs.

Echolocation clicks within buzzes presented a similar spectral structure to regular echolocation clicks. They were produced with inter-click intervals of 4–7 ms.

4. Discussion

The present work represents the first published description of the echolocation signals used by franciscana dolphins in the wild when commuting from one place to another or while foraging. These behavioral contexts were supported by visual observations noted while conducting the sound recordings (data not published). The latter behavior was also supported by the registered buzzes.

Even though we reported the mean duration of a subset of echolocation signals, we are aware that no certainty can be assigned to the selection of on-axis clicks. However, the real duration of the clicks is probably shorter than 200 µs, since the shown click may present distortions if it was not recorded on-axis. We simply chose a rather high signal-to-noise ratio to include in the analysis only high quality echolocation signals. It was not rare to found reverberations after the echolocation signals proceeding from about 20 cm from the sound source. They may actually be echoes from the beak, since it is a known phenomenon that these animals often swim upside down (Von Fersen et al., 1997).

Regarding the duration of click trains, although we did not measure them thoroughly, we rarely recorded a click train exceeding 5 s. This duration consists of a contradiction with the work done by Von Fersen et al. (1997). These differences may be due to an abnormal behavior of the franciscana dolphin recorded in captivity, or a scanning behavior in the wild that does not allow us to record the whole click train but only portions of it.

The frequency spectrum described here for echolocation signals falls into the expected frequency range of vocalizations expected for dolphins of the size of franciscanas (Podos et al., 2002). The fact that we did not find two distinct peaks in frequency may reflect the rather similar size of both dorsal bursae, as predicted by Cranford et al. (1996). Strikingly, we found that this species produces narrow-band high frequency clicks, similar to porpoises and dolphins of the genus Cephalorhynchus (Kyhn et al., 2009, 2010), which are believed to have evolved under the selective pressure of killer whales (Morisaka and Connor, 2007). Assuming that killer whales...
are not capable of hearing above 100 kHz, all these odontocetes are able to echolocate
without being heard by their predators. Franciscana dolphins are known to be killer
whales’ prey as well (Ott and Danilewicz, 1998; Failla et al., 2004; Santos and Netto,
2005). Thus, it is not surprising that they also emit high frequency calls. However, it is
uncertain whether the narrow-band high frequency clicks are produced in the same
way as most delphinids' clicks, and/or if there is a physiological limitation for the
bandwidth when the signals are above 100 kHz.

We would like to emphasize on the difficulty to record the echolocation signals
of franciscana dolphins. First, because of the frequency range they utilize when echolo-
cating, which is higher than 120 kHz and often reaches frequencies over 250 kHz. Also,
due to the faster attenuation of high frequencies, the detection range of these animals
is more restricted than the one of other species (Urick, 1975). Whether franciscanas
use the whole spectrum of the echolocation clicks remains to be answered. Further-
more, high frequencies usually imply a narrower beam width, which leads again to a
lower probability to record these animals. Second, the combination of the small group
size of franciscana dolphins along with the fact that they do not seem to be vocally
very active, makes the echolocation signals harder to record. Finally, franciscana dol-
phins usually inhabit very noisy waters. Wind noise, waves, tide differences, currents
and boat noise tend to mask the echolocation clicks of these dolphins and their echoes
may be more sensitive to the noise. How they manage to echolocate in such environ-
ments remains a mystery.

Acknowledgments

We would like to thank the kind cooperation of V. A. Seijas, L. Russo Lacerna and Prefec-
tura Naval Argentina of Carmen de Patagones. We are also thankful to J. A. Hildebrand
for facilitating recording equipment and useful comments on the manuscript and people
from the Whale Acoustics laboratory at Scripps Institution of Oceanography, University
of California San Diego, for building the system and calibrating it. The present study was
financed by the Whale and Dolphin Conservation Society. This study was carried out with
permission of the Dirección de Fauna de la Provincia de Río Negro, Argentina (Exp. N°
132264-DF-2010).

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