BIRTH PREDICTION USING ACOUSTICS IN CAPTIVE BELUGA WHALES

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ABSTRACT
Since 2003, L’Oceanogràfic is studying the acoustic behaviour of 2 beluga whales (Delphinapterus leucas) as a long-term project. In November 2006 the female gave birth and the acoustic activity was monitored. Following the study protocol established during the first years of study, we measured the vocalization rate (number of vocalizations per hour) for the week before and after the birth. Significant statistical differences (one-way ANOVA, p< 0.05) were observed between both weeks. Vocalization rate decreased drastically during the birth process and remain very low for the following week (post hoc analysis HSD-Tukey, p< 0.05). These expected results are in concordance with previous analysis in which the vocalization rate of beluga whales decreased during stress contexts. The birth process as well as the presence of a new individual in the group (calf) are both stressors. These results suggest that monitoring the acoustic activity of beluga whales might be a potential method to predict birth as well as to detect other stressful contexts.

INTRODUCTION
Since 2003, L’Oceanogràfic is studying the acoustic behaviour of 2 beluga whales (Delphinapterus leucas) as a long-term project. As part of this project, acoustic activity was monitored in order to evaluate its possible application as a method to evaluate welfare. During the last days of pregnancy and birth process of the female beluga, acoustic behaviour was recorded and the birth process and calf presence were analyzed looking for changes in the vocalization rate.

MATERIALS AND METHODS
The study was made at L’Oceanogràfic in Valencia, Spain, at the beluga whale exhibit. Total water volume is 2,900,000 l. Facilities keep two beluga whales, one male and one female. Sampling was designed in recording sessions, three times per day, of 50 min starting 6 days before the birth and continuing 6 days after (including the day of birth). Following the protocol established in Castellote & Fossa 2006, audio files were displayed as spectrograms (Hanning window, fast Fourier transforms size: 512 samples, overlap 50%) using Adobe Audition, Version 1.5, audio editing software and were visually and aurally inspected for detection of vocalizations. All the vocalizations observed were used in the analysis. When pulsed vocalizations occurred in train series (i.e., echolocation clicks), the number of trains was used for the total count of vocalizations. Acoustic activity was measured as the total number of vocalizations observed in each 50-min session (NVs). The number of vocalizations per hour (60 min) (NVh) was calculated to obtain a standardized vocalization rate:

\[
NVh = \frac{NVs \times 60}{50}
\]
Weekly vocalization rate (WVR) for the weeks before and after birth was calculated as the mean value per hour of all recording sessions within the week as a measure of the acoustic activity of both beluga whales:

\[ WVR = \frac{\sum_{i=1}^{n} NVhi}{n} \]

\( n \) = total number of recording sessions within a week. There were eighteen sessions per week.

Behaviour analysis consisted in measuring time spent out from stereotypic state (aberrant behaviour) per observation session. During 45 minutes, events and states of the female beluga were monitored. The number of sessions per day varied from 1 to 12 depending on availability of the observers. Percentage of time spent out from stereotypic state was then calculated during each day.

STATISTICAL ANALYSIS AND RESULTS

This dataset consisted of WVR from 1 week before and 1 week after birth. Kolmogorov-Smirnov was used to determine if the samples follow a normal distribution. One-way analysis of variance (ANOVA, \( p < 0.05 \)) was used to determine if there was any difference in the WVR before and after birth. Results showed highly significant differences between vocalization rates (Figures 1 and 2).

![Figure 1: Box and whisker plot (mean ± SE and 95% CI) of the weekly vocalization rate (WVR) of belugas the week before and after the birth](image)
Figure 2: ANOVA, $p < 0.05$ to determine if there was any difference in the WVR before and after birth.

Tukey HSD post-hoc analysis was used to measure the level of significance of these differences, the information of the -6th and 0th day was eliminated for presenting an enormous variance, and results are presented in Figures 3, 4 and 5.

Figure 3: ANOVA, $p < 0.05$ to determine if there was any difference in the daily vocalization rate of belugas the days before and after the birth.
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<th>(J) Day</th>
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**Figure 5:** Tukey HSD post-hoc to measure the level of significance of these differences

As for behavioural results, percentage of time spent out form stereotypic state decreased during the last month and is presented in Figure 6.

**DISCUSSION**

In this study, the vocalization rate during last minutes before birth drastically increased, and during the birth process the acoustic activity was drastically reduced. After the birth, the
vocalization rate dropped dramatically, remained very low during the next 2 days, and did not reach the same level as before the birth until the 5th day. Our results suggest that acoustic recordings could be a valuable method to predict the birth and detect the delivery, since the beluga strongly reflected a change in the acoustic behaviour.

This acoustic response has been observed in both captive and free-ranging beluga whales (Morgan, 1979; Lésage et al., 1999; Karlsen, 2002; Van Parijs et al., 2003) and free-ranging narwhals (*Monodon monoceros*) (Finley et al., 1990) and has been associated with threat, startle, fright, alarm, or stress contexts and interpreted as a survival strategy to avoid detection by predators (Schevill, 1964; Fish & Vania, 1971; Morgan, 1979; Finley et al., 1990; Lésage et al., 1999). In the context of our study, predator avoidance during birth and the presence of a newborn is of strong survival significance.

Behaviour analysis was centred in the stereotypic state of the female beluga. Mammals normally display aberrant behaviours in captive context, which no obvious functionality. In our case, the female beluga has adopted a swimming cycle following a repeated path in the facilities. This was defined as stereotypic behaviour. The time spent out of this behaviour during observation sessions was monitored. Results show a gradual decrease of stereotypic behaviour during the last month of pregnancy. This change is interpreted as an increase of stress due to the final phase of the pregnancy. These observations, together with the acoustic results, show that monitoring both the vocalization rate and stereotypic behaviour might be a potential method to predict birth time with high accuracy.

The technique presented in this report refers to the total acoustic activity independently of the behaviour and communicative significance, in which the useful information for evaluation is the overall production of vocalizations as a measure of birth prediction, rather than detecting specific vocalizations associated to stressful contexts. Therefore, detailed acoustic and behavioural analysis is not needed for our purpose, making the analysis simple and time affordable for welfare evaluation. If the measurement of the acoustic activity and stereotypic behaviour in captive beluga whales proves to be an effective method for evaluating birth prediction, it is bound to be a useful tool in captive management.

Our proposed hypothesis is based on observations of one beluga whale birth, and our results must thus be interpreted as suggestive, rather than conclusive. More research is clearly needed before obtaining final conclusions. Monitoring more beluga whale births in facilities could help to validate this proposed hypothesis.

Hopefully, our efforts will be a source for future studies on captive animal welfare. We recommend that zoos and oceanaria consider incorporating acoustic activity monitoring into their standards for animal welfare and psychological well-being. This can be implemented without expensive acoustic equipment and little investment in training, data collection, and analysis.

ACKNOWLEDGMENTS

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