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Duration of scratches in Guiana dolphin, *Sotalia guianensis* (Cetartiodactyla: Delphinidae): Supplementary marks to improve abundance estimates

Maieski, K.A.N.[†,*], **Schulze, B.**[‡] **and Cremer, M.J.**[†,‡,§]

[†]Programa de Pós-Graduação em Saúde e Meio Ambiente, Universidade da Região de Joinville – UNIVILLE. PO Box 246, 89219-710 Joinville, Santa Catarina, Brazil
[‡]Programa de Pós-Graduação em Ecologia, Departamento de Ecologia e Zoologia, Universidade Federal de Santa Catarina – UFSC. PO Box 476, 88040-900 Florianópolis, Santa Catarina, Brazil
[§]Programa de Pós-Graduação em Saúde e Meio Ambiente, Universidade da Região de Joinville – UNIVILLE. Joinville, Santa Catarina, Brazil
*Corresponding author: kamila_nt@hotmail.com

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Natural marks on the body of cetaceans have been used as part of the photo-identification technique for many years, being frequently used in life history studies (Würsig and Jefferson, 1990). Photo-identification is a non-invasive technique for recognizing individuals with minimal impact on the subjects. This technique allows the application of the mark-recapture method in several studies related to cetacean populations (Würsig and Jefferson, 1990).

Dolphins can present different types of marks, such as nicks, scratches, mutilations, and areas with distinct pigmentation. The origin of the marks may vary according to the behavior of each species, the anthropogenic impacts to which they are exposed, and characteristics of their habitat (Würsig and Jefferson, 1990). Nicks are produced when a small piece of tissue is lost and are commonly produced in the dorsal fin, where their visualization is easier during dolphins' emergence. In general, nicks are considered permanent marks, although some studies have already recorded the disappearance of nicks on pilot whales (*Globicephala melas*) (Auger-Methé and Whitehead, 2007). Nevertheless, nicks are the signature marks most frequently used in photo-identification studies since they are the most common marks in the dorsal fin (Würsig and Jefferson, 1990; Evans and Hammond, 2004; Rossi-Santos *et al.*, 2007; Simão *et al.*, 2012; Hupman *et al.*, 2017).

Scratches are marks characterized by the presence of one or multiple parallel straight lines (Lockyer and Morris, 1990). The scratches are produced mainly by intra or interspecific social contact, or also agonistic behavior. Single lines, however, can also be produced by the animal's contact with the seafloor (McCann, 1974; Lockyer and Morris, 1985; Scott *et al.*, 2004). The skin of cetaceans is more susceptible to cuts and abrasions than that of other mammals (McCann, 1974; Heyning, 1984). Scratches are the most common natural marks recorded in small odontocete species, even though they are not considered permanent (Lockyer and Morris, 1985).

Studies related to population parameters and residence patterns of the Guiana dolphin (*Sotalia guianensis*) conducted with the use of the photo-identification technique considered only permanent marks in the dorsal fin for the identification of individuals (Flores, 1999; Hardt *et al.,* 2010; Cantor *et al.*, 2012; Azevedo *et al.,* 2017). However, Flores (1999) stated that tiny nick-type marks, or their total absence, are common in Guiana dolphins, especially in juveniles and calves. Approximately 40% of the Guiana dolphins from the Babitonga Bay population in the south of Brazil do not have nicks or other type of marks (Hardt *et al.*, 2010). The high percentage of unmarked individuals in the population hampers the application of capture-recapture analytic methods for population parameters estimation. According to Gowans and Whitehead (2001), only 66% of the population of northern bottlenose whales (*Hyperoodon ampullatus*) have reliable marks for identification. Kügler and Orbach (2014) observed that 52% of the population of dusky dolphins (*Lagenorhynchus obscurus*) presented reliable marks for identification, with 6.5% being scratches. Marks can be unequally distributed within a population, allowing the identification of only some of the individuals (Gowans and Whitehead, 2001).

Even though nicks are long-lasting marks, the acquisition of new nicks over time, or changes to the existing ones, can also change marks used previously for identification. New

nicks are a drawback of the method and can lead to problems in identifying individuals, increasing the biases in abundance estimates (Gunnlaugsson and Sigurjónsson, 1990). A type-1 error, or "false positive" bias, occurs when a previously identified individual undergoes changes to its natural marks and is later misidentified as a new individual, resulting in the overestimation of the number of individuals in the population. A type-2 error, or "false negative", occurs when two individuals with similar marks are identified as the same, leading to the underestimation of the population size.

In studies using the photo-identification technique, the violation of the premises of the method of recapture of marks may be a consequence of the analysis of the photos collected, generating a great bias in the abundance estimates. Care must be taken to ensure that the estimates are accurate and that all possible biases are minimized (Urian *et al.*, 2014). Cullock (2004) shows that errors can occur when using a software, and these errors can overestimate the population.

The purpose of this paper is to provide information on the duration of the scratches on Guiana dolphins, contributing for the bias reduction. This work aims also to discuss the potential of the scratches as primary marks in short-term photo-identification studies (duration of days) and also the use of scratches as accessory marks in capture/recapture studies that use photo-identification.

The study was conducted in Babitonga Bay, located in southern Brazil (Fig. 1) (26°07'-26°27' S). The bay has an area of 160 km^2 and is surrounded by mangroves, beaches, and rocky shores (Ibama, 1998). A resident population of approximately 208 Guiana dolphins was estimated for this area (Cremer *et al.*, 2011).

Photographs of dorsal fins were taken from January 2010 to March 2015 to identify individual dolphins. Whenever possible, images were taken within two weeks interval, from either a 5.5-m long aluminum boat equipped with a 60-hp outboard engine, or a 6.2-m inflatable boat with a 200-hp outboard engine. Photographs were taken only under good sea conditions (Beaufort 0 to 2). Canon EOS 20D and EOS 7D digital cameras, equipped with 100-300 and 100-400 mm zoom lenses, were used to photograph the dolphins. Photographs of the dorsal region of the animals were taken at a perpendicular angle to the position of the photographer and with adequate brightness, considering the position of the sun (Baird *et al.*, 2001). The images were transferred to a computer where they were stored and screened for analysis. Only high-quality photos with good focus and contrast were analyzed. Only the animals that were individually identified through permanent marks (nicks) in the dorsal fin were considered for the analysis of scratch duration. The identification process was performed manually by at least two observers, and the scratch duration was analyzed by only one observer to standardize the definition of the scratch category for each record. The scratches were also classified into two categories considering the number of lines present: (1) multiple scratches, with two or more parallel lines; and (2) single scratches, consisting of only one line.

To estimate the minimum duration of the scratches, regardless of the degree of penetration, we analyzed only the ones that initially presented a dark color, an indication of being a recent scratch (B. Schulze, pers. obs.). Clearer scratches were considered older (Fig. 2). The minimum duration of an identifiable scratch was estimated as the time (number of days) between the first and the last record of a scratch, with the last record being the one in which the scratch became clearer or completely disappeared (Fig. 3).

A total of 869 photos, taken of twenty individual dolphins, were analyzed. Forty-one scratches were recorded on at least two different dates; 27 were multiple scratches and 14 were

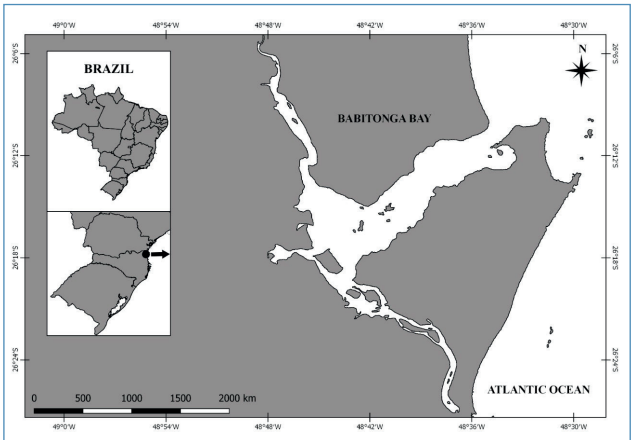

Figure 1. Location of Babitonga Bay, South Brazil

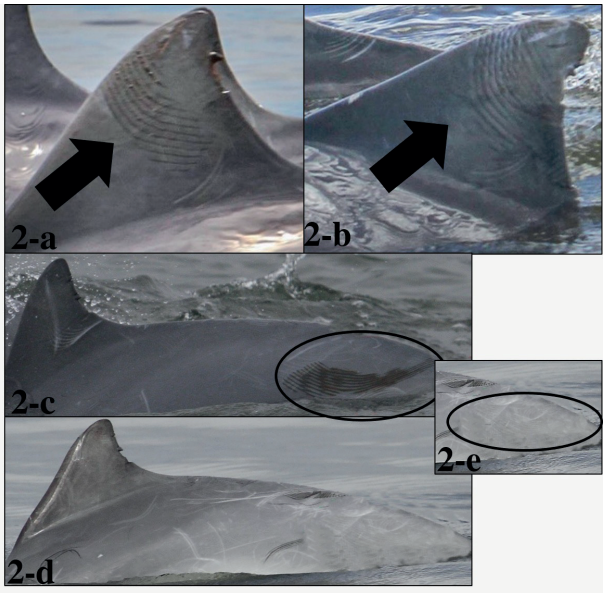

Figure 2. Date of first (2-a) and last sighting (2-b) of a category 1 multiple scratch as proposed by Lockyer and Morris (1990) (18 February 2013-01 March 2013). Date of the first (2-c) and last sighting (2-d; 2-e) of a multiple scratch of category 2 (11 August 2010-24 August 2012)

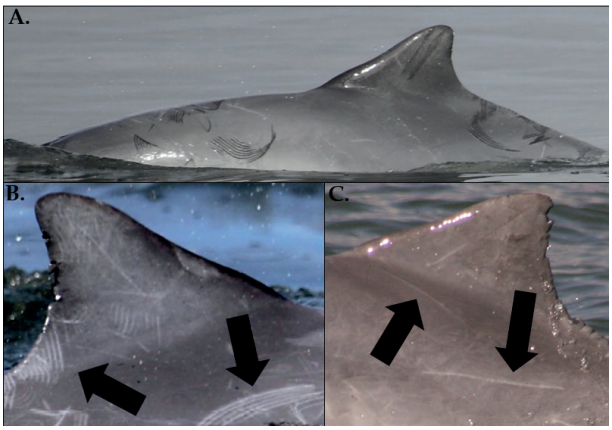

Figure 3. A. Guiana dolphin (*Sotalia guianensis*) with recent scratches in the dorsal region; B. Multiple old scratches; C. Single old scratches

single scratches. Multiple scratches had a mean duration of 188 days (SD = 160.02) whereas single scratches had a mean duration of 173 days (SD = 111.79).

The longest duration of a scratch was estimated for a multiple scratch, in 24 months (733 days). For a single scratch, the longest duration was estimated to be 12 months (369 days). Those scratches probably penetrated the adipose layer of the individuals' skin, and for that reason they were visible for a longer time, being considered as category (2) or deep scratches (Lockyer and Morris, 1990). The shortest scratch duration was 11 days for a multiple scratch and 51 days for a single scratch. Those scratches did not penetrate the dermis layer, being considered as category (1) or superficial scratches (Lockyer and Morris, 1990) (Table 1). The study results indicate that the scratches on Guiana dolphins show great variability in their duration, and may disappear between 11 to 733 days.

Our results indicate that scratches can be used as primary identification marks in specific short-term studies (maximum ~11 days for multiple scratches and ~51 for single scratches) to estimate abundance during limited periods, for instance. Therefore, the use of scratches to identify individuals increases the number of individuals that can be identified in the population, since young individuals and adults without permanent marks can also be included in the study (Flores, 1999; Wilson *et al.*, 1999). This could help reduce the variance and confidence interval, providing a more precise abundance estimate. However, it is important to mention that this approach does not allow the estimation of other parameters, such as immigration, emigration, and survival rates, among others.

This study encourages and reinforces that scratches can be consistently used as supplementary marks for the individual identification of Guiana dolphins to reduce biases from type 1 (false positive) and type 2 (false negative) errors in identification (Gunnlaugsson and Sigurjónsson, 1990). When identification of an individual is unclear (whether an individual gained or lost marks or if it is actually a new individual), scratches can be used as secondary marks to help reduce identification uncertainty. For example, if in doubt as to whether individual "x" has gained a new mark, scratches seen in previous photos may be used to aid identification as long as they are recent. If that individual still presents the same scratch, then individual "x" has gained a new identification mark. If the same scratches are not found in both photos, the chances of it being a different individual are higher (Gunnlaugsson and Sigurjónsson, 1990).

Therefore, scratches can only be used as a primary mark in short-term studies, since they usually become invisible in weeks. Also, they can be used as supplementary marks in the identification of Guiana dolphins, thus avoiding the under- or overestimation of population parameters through the biases described above.

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Table 1. Average and standard deviation (SD) of number of days, maximum and minimum duration (in days) of the multiple and single scratches of the *Sotalia guianensis* population from Babitonga Bay. Category (1) superficial scratches that do not penetrate the dermis and whose duration can vary from days to a few months; Category (2) deep scratches, that normally penetrate deeper in the skin, reaching the adipose layer, with a duration of about 5 to 20 months.

	Duration (days)		
	Multiple scratches	Single scratches	Scratch category (Lockyer and Morris, 1990)
Average	188 (SD=160.02)	173 (SD=111.79)	
Minimum	11	51	1
Maximum	733	369	2

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