Photo-identification of franciscanas (*Pontoporia blainvillei*) in Babitonga Bay, Santa Catarina State, Brazil

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ABSTRACT

The franciscana (*Pontoporia blainvillei*) is a small cetacean endemic to the South Atlantic distributed in coastal waters from Espírito Santo State in Brazil to Chubut Province in Argentina. Babitonga Bay, on the northern coast of Santa Catarina State, Brazil, is home to the only known franciscana population that resides throughout the year in an estuary. Photo-identification is a technique that serves to identify individuals in their natural environment through photographs of natural or artificial body marks. The objective of this paper was to assess the feasibility of identifying individuals from this population from marks present on the dorsal fin and the body. From February 2011 to August 2013, 172 boat surveys were carried out in Babitonga Bay. Groups of franciscanas were recorded on 576 occasions and on 542 of these (94.09%) were photographed. A total of 6,953 (11.89%) from a total of 58,471 photographs were considered of high enough quality to distinguish the features used to identify individuals. Throughout the sampling period, 23 franciscanas were identified. Most of the animals exhibited nicks on the trailing edge of the dorsal fin (82.6%), a mark of long-term duration. Scratches were recorded on only one animal on a single occasion. The rate of resightings ranged from 5.26% to 78.95%, with 39.13% of the individuals showing a rate higher than 50%. A total of 41.8% of the Babitonga Bay population was identified by the presence of marks on the dorsal fin. The study indicates that photo-identification can be applied to franciscanas, which may allow the realisation of various future studies. Because of this species threatened status, the use of this technique may become particularly important for monitoring franciscanas in Babitonga Bay and perhaps in other regions.

KEYWORDS: PHOTO-ID; BRAZIL; SURVEY–VESSEL; ATLANTIC OCEAN

INTRODUCTION

The franciscana[1] (*Pontoporia blainvillei*, Gervais and d'Orbigny, 1844, *Cetartiodactyla-Pontoporiidae*) is a small cetacean endemic to the Southwest Atlantic. This species inhabits coastal waters from Espírito Santo State in Brazil (Siciliano, 1994) to the Chubut Province in Argentina (Crespo *et al.,* 1998). It is one of the smallest and most endangered dolphins in the South Atlantic (Pinedo *et al.,* 1989; Reeves *et al.,* 2008), with incidental capture in fishing nets being the main threat to its long-term survival (Siciliano, 1994; Bertozzi and Zerbini, 2002; Kinas, 2002; Secchi *et al.,* 2003). Studies of franciscanas in their natural habitat are uncommon due to the great difficulty in observing these animals in the wild (Bordino *et al.,* 1999; Cremer and Simões-Lopes, 2005). Their small size, discrete surface behavior and the brownish grey coloration limit field observations (Cremer and Simões-Lopes, 2005).

In southern Brazil, data systematically collected over the last ten years indicate that the franciscana population that inhabits Babitonga Bay is resident throughout the year. Genetic analysis comparing samples from animals inside and outside the Bay indicated that the population of Babitonga has lower genetic diversity, reinforcing the residence hypothesis of the animals (Dias *et al.,* 2013). A study with satellite-linked telemetry and visual monitoring of tagged franciscanas was conducted in the area, and the results indicated that the animals remained in the same region where they were instrumented, in the inner Bay (Cremer *et al*., 2012b). Data indicates that the abundance of this population remains stable over a period of ten years (Cremer and Simões-Lopes, 2008; Zerbini *et al.,* 2011). Moreover, dolphins in Babitonga Bay are typically concentrated in an area where weather conditions are relatively good compared to the open coast, making them easier to observe and study (Cremer and Simões-Lopes, 2005).

Photo-identification is a non-invasive method that consists of identifying animals individually by visible marks, either natural or artificial (e.g. Hammond *et al.*, 1990). In cases where a substantial portion of a population can be individually identified, photo-identification data can be used to investigate various aspects of their ecology, including social structure, life history, presence of skin disease, among others (Wells *et al.,* 1987; Hammond *et al.,* 1990; Wursig and Jefferson, 1990). For many cetaceans, the marks used for individual recognition consist of scars, scratches, nicks and mutilations present on the dorsal fin and dorsal surface of the animals (Wursig and Jefferson, 1990). The origin of these marks may vary according to the behaviour of each species. Nicks and scratches are caused mainly by bites from conspecifics or abrasions from the ground (Wursig and Jefferson, 1990; Dufault and Whitehead, 1998). Marks can also be caused by collisions with vessels and non-fatal fishery interactions. In general, only a proportion of the individuals in a population have marks that allow photo-identification (Gowans and Whitehead, 2001).

Photo-identification studies of franciscanas have been conducted in two locations other than Babitonga Bay. In Paranaguá Bay (Brazil) five individuals presenting distinguishable natural marks on the dorsal fin have been observed, but only one individual was resighted, seen twice in 2008 in the Summer and Winter (Santos *et al*., 2009). In Anegada Bay (Argentina), a total of 27 resightings of a single marked individual was documented. In this latter location, three different dorsal fin shapes were distinguished (Thompson, 2000).

[1]Since 2008 listed as Vulnerable, IUCN Red List of Threatened Species (*http://iucnredlist.org*).

The aim of this paper was to evaluate the feasibility of using photo-identification techniques to study the ecology of franciscanas. In particular, photo-identification was employed to characterise natural marks in franciscanas from Babitonga Bay, to estimate the percentage of dolphins with recognisable marks, and to investigate the resighting rates of marked individuals.

METHODS

Study area

Babitonga Bay (26°16'S, 48°42'W) is an estuary located on the northern coast of Santa Catarina State in Southern Brazil (Fig. 1). It has an area of approximately 160km², an average depth of 6m, but depths of up to 28m are found in the main canal. In addition, the bay presents shallow areas that may become exposed during low tide. Babitonga Bay receives freshwater inputs from rivers flowing through surrounding cities, mainly those located in the northern portion of the Bay. The area is also affected by anthropogenic activity, e.g. boat traffic and net fishing (Vieira *et al.,* 2008).

Data collection

Franciscana dolphins were searched for with the aid of 7×50 binoculars. Photographs were collected from two vessels, an aluminium boat (5.5m in length, 60hp outboard motor) and a rigid-hull inflatable boat (6.2m in length, 200hp outboard motor), with two digital cameras (Canon EOS 7D), one with a 100–300mm zoom lens and the other with 100–400mm zoom lens.

Sampling strategies varied over the years. The search for franciscanas focused on areas where the species is known to occur (Cremer and Simões-Lopes, 2008). The photographs were collected occasionally between February and May 2011, and fortnightly between September 2011 and August 2013. Between May 2012 and August 2013 data collection was carried out through scans, covering pre-established routes at regular intervals of at maximum fifteen days. Two routes (Fig. 1) were simultaneously covered, and the boats started the routes in opposite directions. During the scans, the boats maintained a constant speed of about 20km/h. The photographs were taken only in calm sea conditions (Beaufort 0 and 1), and without rain.

When a group of franciscanas was sighted, the boat approached at low speed. The time spent with the dolphins, the number of individuals, and the presence of calves were recorded for each group. Care was exercised to ensure that all individuals in the group were photographed without favouring any animal, and to minimise disturbance and a consequent change in the behaviour of the dolphins in the group (Wursig and Jefferson, 1990). Whenever possible, the photographer was positioned at an approximate 90° angle relative to the animals and in favourable light conditions to ensure good contrast and quality of the photographs. Each group was followed until all individuals were photographed, or for a

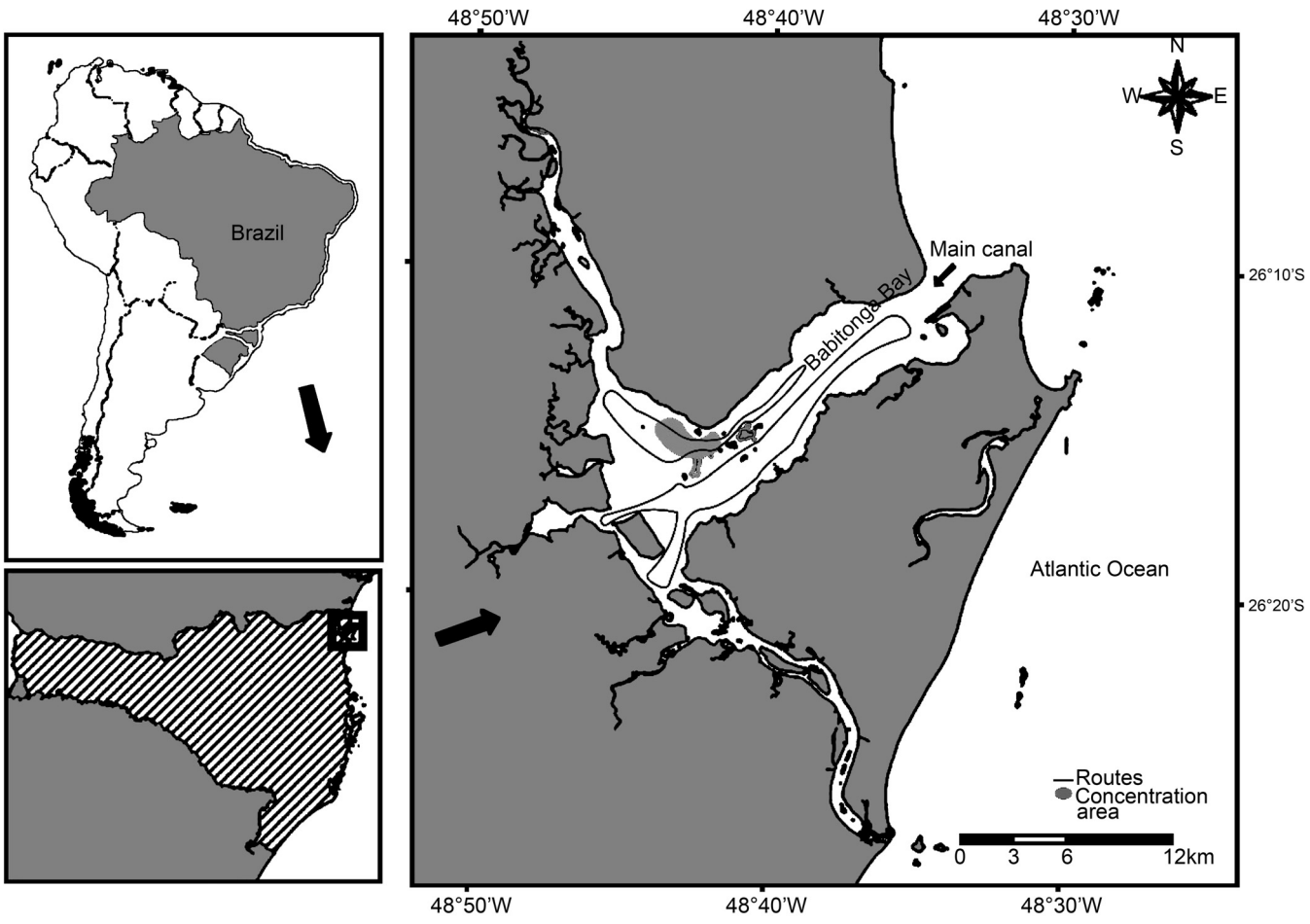

Fig. 1. Babitonga Bay, located on the northern coast of Santa Catarina State, where photo-identification studies for franciscanas have been conducted. The solid tracks and the grey polygons on the panel on the right correspond, respectively, to predetermined routes taken to perform scans and to the area where animals are typically concentrated (Cremer and Simões-Lopes, 2008).

maximum of 20 minutes, whichever occurred first. That time was stipulated in search of a balance between the need to photograph all the animals and the concern not to stress them. This decision was based on prior knowledge about this population, knowing that for large groups this time could not be sufficient to photograph all individuals in the group.

Data analyses

Franciscana photographs were separated into two categories: high quality and low quality. Images with focus, sharpness and at an approximate angle of 90° to the photographer were considered of high quality and, therefore, suitable for analysis (Wursig and Jefferson, 1990). High quality images were then divided into two sub-categories: animals with marks on the dorsal fin and animals without marks.

Visual analyses of individuals with marks were performed by two independent researchers. In addition to the presence of marks, the shape of the dorsal fin was also examined (Wursig and Jefferson, 1990; Gomez-Salazar *et al,*. 2011) by the two researchers who made a comparison of the fins analysed. In instances where there was no consensus on whether an individual could be identified, the image was included in a sub-category 'without marks', meaning in this case that the animal did not have prominent enough marks to ensure identification.

To estimate the percentage of the population with marks, we considered the abundance of franciscanas in Babitonga Bay (55 individuals in 2011) as estimated by Zerbini *et al.* (2011). The formula used was: number of individuals identified/55×100.

To evaluate sampling sufficiency, collector and rarefaction curves were produced (following Magurram, 1988, op. cit. Colwell and Coddington, 1994) which evaluated the necessity of additional sampling effort to identify individuals in the population with marks. The collector curve shows the accumulated value (the individuals, in this case) and the rarefaction curve shows a statistical proportion of this value.

To calculate the resighting rate we adapted the method based on the Jolly-Seber model proposed by Simões-Lopes and Fabian (1999) for residence patterns. In particular, the term 'resighting rate' used in this paper is based on the premise that the data do not reflect residence patterns but rather the susceptibility of each individual to being photographed. The resighting rate of the individuals was calculated as the total number of months in which the identified animal was sighted/the total number of sampled months×100, expressed as a percentage (%).

RESULTS

From February 2011 to August 2013, a total of 172 surveys were carried out in 19 sampling months. Of these, 162 were made at regular intervals (fortnightly), 114 in the area with the highest concentration of animals, and 48 along the predetermined scanning routes. Sampling effort totaled 458 hours and 22 minutes. A total of 576 groups of franciscana were recorded, 542 of which (94.09%) were photographed. A total of 58,471 images were taken, 6,953 of which were classified as high quality images (11.89% of photos used). Throughout the period, 23 franciscanas (Fig. 2) were identified by marks in the dorsal fin.

Twenty-two franciscanas were identified by the presence of nicks on the dorsal fin and another individual was identified based on the unusual shape of the dorsal fin (PbB-20 in Fig. 2). Thirteen franciscanas had only one nick (56.5%), 7 had 2 nicks (30.4%) and 2 had 3 nicks (8.6%). The disposition of the nicks in the dorsal fin, and the percentage of individuals identified are listed in Table 1. One individual (PbB-12) acquired a new mark throughout the study. It remained for 25 months with one nick and was then seen with two nicks on two separate occasions.

The resighting rate of the animals ranged from 5.2% (animals sighted in only one month) to 78.9% (animals sighted in 15 months) (Fig. 2). A total of 39.1% of the individuals showed a resighting rate higher than 50%. Individuals PbB-13 and PbB-15 showed the highest resighting rate (78.9%). Individual PbB-23 was not re-sighted possibly because it was registered only in the last month of sampling.

Four shapes of dorsal fin were observed: falcate (with more rounded upper part and the rear concave), rounded (with rounded upper end forming a larger angle, ~60°), triangular (with pointed upper end forming a sharp angle, 40°, and straight sides), and an anomalous shape (with the silhouette turn to the opposite side) (Thompson, 2000). For some individuals whose marks were similar (PbB-03 and PbB-13; PbB-10 and PbB-14), identity was confirmed by dorsal fin shape. The anomalous shape of the dorsal of individual PbB-20 was confirmed by inspecting sequences of images of the animal while surfacing, leaving no doubt of its identity (Fig. 3). This dolphin had no dorsal fin marks.

Scratches were rarely observed, being recorded near the top of the dorsal fin on one individual on one occasion.

The data indicated that 41.8% of the population showed features that allowed individual identification. However, the asymptotic curve was not reached (Fig. 4), suggesting that the number of individuals in the population having marks may be higher.

DISCUSSION

The results of this study indicate that franciscanas have long-term marks on the dorsal fin that are useful for photo-identification, making this technique a potentially useful tool for studying franciscana ecology. The relatively calm weather conditions found within the enclosed environment of Babitonga Bay contributed to the successful application of this method.

Nicks on the dorsal fin were practically the only type of mark observed in this species. Nicks are considered long-term and the most common mark used for individual identification of small cetaceans. This type of mark allows recognition independent of body side (Wursig and Jefferson, 1990). These marks likely originated from social interactions between individuals of the same species, for example during mating or feeding, as reported for boto (*Inia geoffrensis*) (Martin and da Silva, 2006) and Risso's dolphin (*Grampus griseus*) (Kruse *et al.,* 1999). Mutilations and skin spots were not recorded during this study. Mutilations are usually associated with interactions with human activities, such as collision with boats or accidental interaction with fishing activities, or as a consequence of predator attacks (Wood

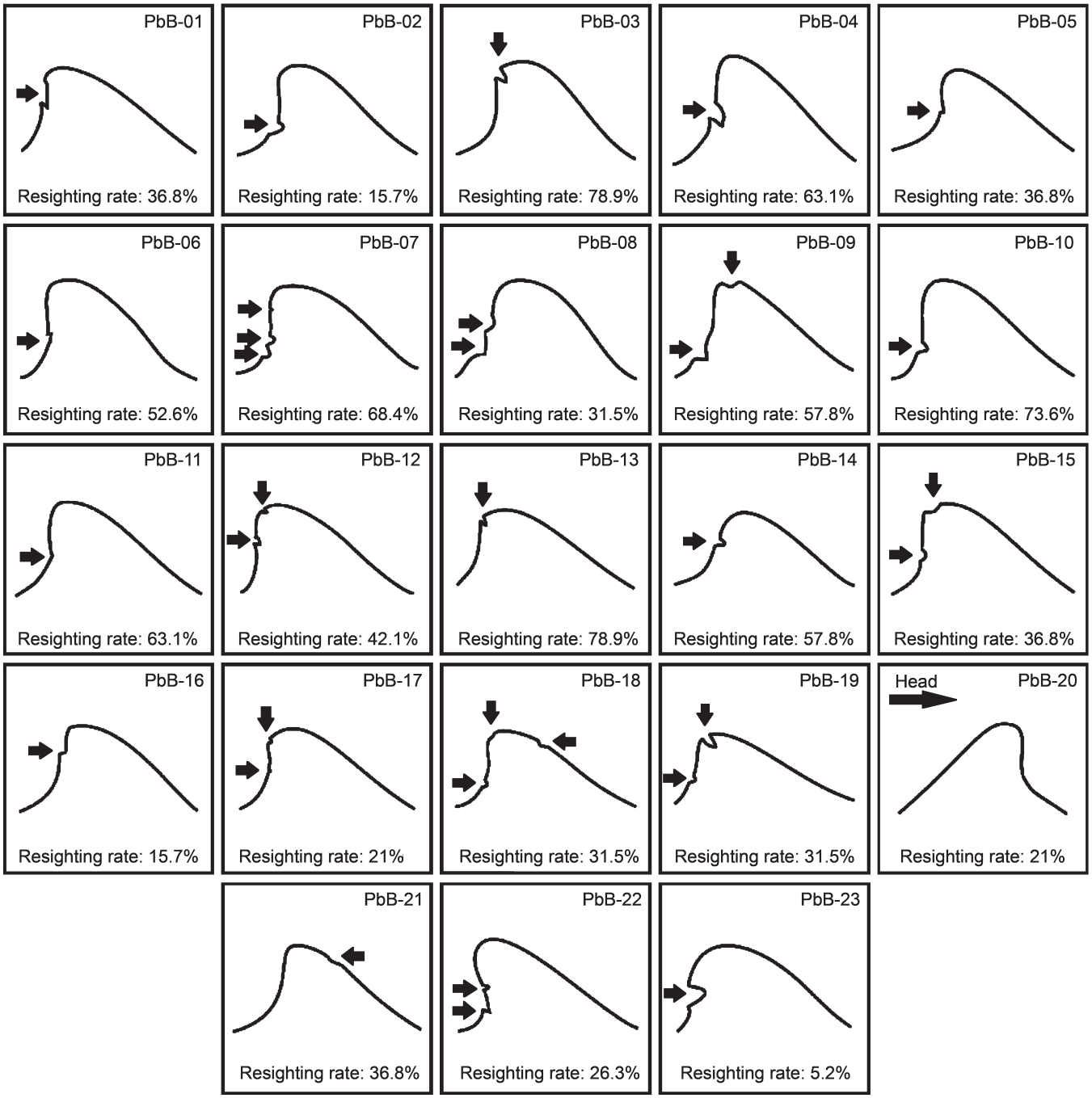

Fig. 2. Schematics of the dorsal fin shape, and disposition of marks of 23 franciscanas (*Pontoporia blainvillei*) individually identified in Babitonga Bay. The resighting rate of each individual (number of months each individual was sighted divided by the total number of sampling months).

Table 1

Position of the nicks on the dorsal fin of the franciscanas, the percentage of individuals with nicks on the indicated part of the dorsal fin, and the identity of individuals who have nicks on the indicated part of the dorsal fin.

Position of nicks on the dorsal fin	% of individuals that have nicks on the indicated part of the dorsal fin	Individuals who have nicks on the indicated part of the dorsal fin
Posterior edge	56.52%	PbB-01; PbB-02; PbB-04; PbB-05; PbB-06; PbB-07; PbB-08; PbB-10; PbB-11; PbB-14; PbB-16; PbB-22; PbB-23
Top	8,69%	PbB-03;PbB-13
Anterior edge	4.34%	PbB-21
Different parts of the dorsal fin	26.08%	PbB-09; PbB-12; PbB-15; PbB-17; PbB-18; PbB-19
No nick	4,34%	PbB-22

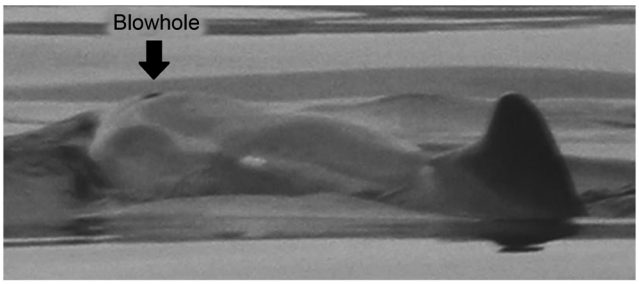

Fig. 3. Dorsum of individual PbB-20 showing the anomalous (inverted) shape of the dorsal fin. The blow whole is indicated for reference.

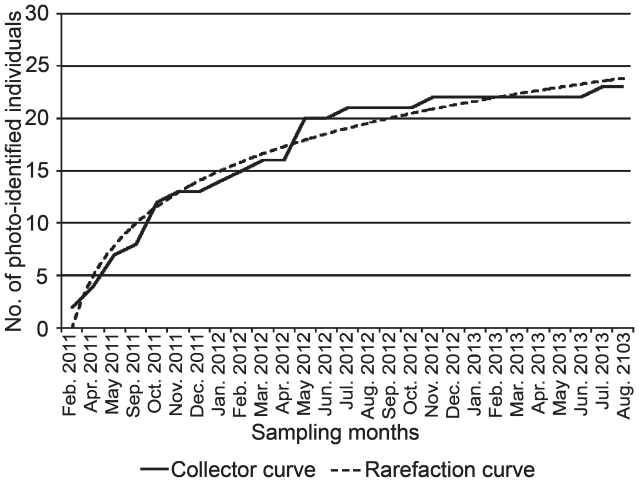

Fig. 4. Collector curve and rarefaction curve with the number and percentage of franciscanas (*Pontoporia blainvillei*) identified in each sampling month in Babitonga Bay, respectively.

et al., 1970; Corkeron *et al.,* 1987; Wells *et al.,* 1987; Heithaus, 2001). However, the small size of franciscanas likely reduces the probability of survival after boat collisions or predator attacks (Brownell, 1975; Praderi, 1985). Observations in the field indicated that individuals with marks in the top of dorsal fin are easier to recognise, which could influence in the resighting rate. However, because only photographs that showed the entire dorsal fin (bottom to top) were used in this study, it is believed that the likelihood of resighting franciscanas in this study to be similar across individuals.

Only one individual was observed with a visible scratch. This scratch, characterised by a sequence of parallel lines, was probably produced by the teeth of another franciscana. However, because this individual had no other identifiable mark which could allow for recognition during multiple resightings, it was not possible to determine the duration of this type of mark. Scratches are considered low-duration marks in other cetacean species (Auger-Méthé and Whitehead, 2007; Gomez-Salazar *et al.,* 2011) and possibly not a useful feature to individually identify franciscana dolphins. Scratches are usually caused by intra or interspecific contact, such as bites, but can also be caused by contact with abrasive materials (Wursig and Wursig, 1977; 1980; Wursig and Jefferson, 1990; Gonzalez, 1994; Dufault and Whitehead, 1998). Di Beneditto *et al.* (2001) reported scratches on 26.6% of franciscanas accidentally caught in fishing nets in southeastern Brazil, and proposed that they are probably caused during rescue attempts when an animal becomes entangled in a gillnet. Pilleri (1971) reported three individuals caught on fishing nets, and one of them was a female calf which had teeth marks on the tail and body. The distance between the scratches corresponded to the distance between the teeth of an adult female. Cremer *et al.* (2006) reported a dead franciscana calf with several scratches and net marks on the rostrum, suggesting the occurrence of epimeletic behaviour.

The low occurrence of body scratches on franciscanas reinforces the hypothesis that male disputes are rare or nonexistent for this species (Danilewicz *et al.,* 2004). Analysis of the gonads suggests that franciscanas have a monogamous mating system (Rosas and Monteiro-Filho, 2001), a feature also supported by genetic studies (Mendez *et al.,* 2008). This is different from the boto (*Inia geoffrensis*), which has a promiscuous mating system, and scars and scratches are common and intensify with the age; marks are particularly common in sexually active males, which compete for females (Martin and da Silva, 2006). Risso's dolphin (*Grampus griseus*) is a species that is often heavily scratched too. These marks can be produced by individuals of the same species, mainly by males competing for females or individuals feeding on squid, their main prey (Kruse *et al.,* 1999).

The four dorsal fin shape patterns identified in franciscanas were similar to the shapes described by Thompson (2000). The existence of different dorsal fin shapes suggests the possibility of a relationship between these shapes and some biological characteristics of the species, such as age, gender and sexual maturity (Jefferson *et al.,* 2008). In killer whales (*Orcinus orca*) the dorsal fin of females and juvenile males are falcate and measure maximally 0.9 meters in height, while adult male dorsal fins are triangular and can be as tall as 1.8 meters (Heyning and Dahlheim, 1988). For spinner dolphins (*Stenella longirostris*) the shape of the dorsal fin varies from triangular to falcate, being predominantly triangular in adult males (Perrin, 2002), like males of *Stenella longirostris orientali,* which have the dorsal fin forward-canted (Ralls and Mesnick, 2009). However, a comparative analysis between the dorsal fin shape and gender in Babitonga Bay franciscanas has not yet been performed. In every case but one, dorsal fin shape was not used for identification alone, but rather as an additional feature.

The unusual shape of the dorsal fin of the individual PbB-20 (which was identified by shape alone) is an uncommon pattern in cetaceans. This feature has been recorded for sexually active males of some species of Delphinidae, killer whale and spinner dolphin (Jefferson *et al.,* 2009). This anomaly could be a consequence of reproductive problems related to contamination (Couch *et al.,* 1972; Haskins and Robinson, 2007). Pollution has been shown to have various effects on the health of cetaceans, such as reduction in reproductive potential, immunosuppression, endocrine disruption and cancer (Borrel and Aguilar, 1994; Martineau *et al.,* 1999; Schecter *et al.,* 2006). The franciscanas of Babitonga Bay showed high liver concentration of difenilpolibromado ether (PBDE) and polybrominated biphenyl (PBB) (Alonso *et al.,* 2012). These

agents are highly persistent in the environment, are lipophilic and have a high potential for bioaccumulation (Ghiselli and Garden, 2007). Another hypothesis to explain the inverted dorsal fin is inbreeding depression, a result of mating between genetically close individuals which increase the chances of offspring being affected by deleterious recessive genes (Jiménez *et al.,* 1994). The pectoral fin malformations registered in six franciscanas from Cananéia, São Paulo State, were shown to be related to inbreeding (Rodrigues and Monteiro-Filho, 2012). The Babitonga Bay population is small, estimated at nearly 50 individuals (Cremer and Simões-Lopes, 2008; Zerbini *et al*., 2011), is resident of the Babitonga Bay estuary (Cremer *et al.,* 2012a) and has low genetic diversity (Dias *et al.,* 2013), reinforcing the hypothesis that inbreeding could be happening.

The data indicate that 41.8% of the Babitonga Bay franciscanas have features allowing identification, and the resighting rate was greater than 50% for 39.13% of the animals. In Argentina, Thompson (2000) estimated that less than 20% of the franciscanas in Anegada Bay were identifiable by natural marks on the dorsal fin. Differences in the number of individuals with marks between populations were registered for short-finned pilot whale (*Globicephala macrorhynchus*), but the causes were not identified (Shane and McSweeney, 1990). For the boto, 55% of the population in the Colombian Amazon and Orinoco rivers was individually identified (Gomez-Salazar *et al.,* 2011), while for narwhal (*Monodon monocerus*), 84% of the Koluktoo, Canada population included identified individuals (Auger-Methe *et al.,* 2010). For the sympatric Guiana dolphin (*Sotalia guianensis*) population in Babitonga Bay, 37% of the individuals were identified (Schulze, 2012).

The collector and rarefaction curves suggest that the number of individuals in the population having marks may be higher. Although this population is relatively small, we probably did not identify all the individuals. A high number of dolphins were identified when photo-identification efforts were first initiated. However, later in the study mainly previously identified individuals were being sighted with just a few newly identified dolphins being added to the catalogue at that stage. The main problem with photo-identification of franciscanas is the difficulty in observing the species and not the absence of defining marks on individuals. Even under favourable conditions such as in Babitonga Bay, cryptic colouration, small size and discrete surface behaviour in this species make good quality dorsal fin photographs difficult to obtain. These characteristics may also hinder use of the technique with other species, as in the case of the vaquita (*Phocoena sinus*) (Jefferson *et al.,* 2009), the Dall's porpoise (*Phocoenoides dalli*) (Jefferson, 1991) and the baiji (*Lipotes vexillifer*) (Yuanyu *et al.,* 1990). However, other locations along the distributional range of the franciscana could present conditions favourable enough for the application of this technique. For example, studies performed in Cananéia (Santos *et al.,* 2009) and Anegada Bay (Thompson, 2000) indicated individual identification of franciscanas was possible in these locations.

Photo-identification is a powerful tool to improve knowledge about the life history of small cetaceans. In the case of franciscanas, this technique can potentially provide important information about the home range, residence patterns, habitat use, life history and behaviour, which are still largely unknown for this species. At the local level, this information can contribute greatly to the conservation of fransciscanas in Babitonga Bay, especially considering the threats resulting from increasing anthropogenic activities in this area. Therefore, continued photo-identification and monitoring of this population are strongly recommended.

ACKNOWLEDGEMENTS

Projeto Toninhas/UNIVILLE is sponsored by Petrobras, which enabled this work. We thank the staff of Projeto Toninhas for executive management and assistance in the field.

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