Assessing bias in abundance estimates from aerial surveys to improve conservation of threatened franciscana dolphins: preliminary results from a survey conducted in southern Brazil

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ABSTRACT

Aerial surveys are considered the most effective way of estimating abundance of franciscanas (*Pontoporia blainvillei*). However, estimates obtained with data collected from aircrafts are often underestimated because of visibility bias or bias in estimating group sizes from a fast-moving platform. Independent boat and aerial surveys were concurrently carried out in Babitonga Bay, southern Brazil, to assess potential bias in aerial surveys for franciscana dolphins. Estimates of density and group sizes from the boats were assumed to be accurate (i.e. not affected by visibility or perception bias) and a preliminary correction factor (CF=4.74, CV=0.05) was computed as the ration of the density estimated by boats (D=3.32 ind/km^2, CV=0.22) and by the airplane (D=0.70 ind/km^2, CV=0.26). Group sizes estimates from the boats were significantly different (30% larger) than those from the aircraft and accounts for some of the bias in the aerial survey estimates. Visibility bias was substantial and accounted for 70% of the total bias. The correction factor reported above can be used to refine range-wide abundance estimates of franciscanas given certain assumptions are met. Additional work is underway to further refine the analysis presented in this document and results will be made available in the future.

INTRODUCTION

Distance sampling is one of the most widely methods used to estimate abundance of marine mammals. In order to compute unbiased estimates, this method assumes that all individuals or clusters of individuals are seen on the survey trackline (g[0] = 1) and that group sizes are accurately estimated (Buckland et al, 2001; 2004). In the case of aerial surveys neither of these assumptions often hold (e.g. Laake *et al.* 1997; Laake and Borchers, 2004) and therefore estimates of abundance are often negatively biased. Animals are missed because they are underwater (availability bias) or because they are available to be seen, but are missed by observers (perception bias) (e.g. Marsh and Sinclair, 1989). Another source of bias comes for undercounting the number of individuals in groups because some species have small body sizes and color patterns that makes than difficult to see from a fast survey platform such as an airplane.

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The franciscana (*Pontoporia blainvillei*) is an endemic small dolphin inhabiting coastal waters off eastern coast of South America between Brazil (18°25'S) and Argentina (41°10'S). The species is regarded as the most threatened cetaceans in South America due to high, possibly unsustainable, bycatch levels as well as increasing habitat degradation throughout its range (Ott *et al.*, 2002; Secchi *et al.*, 2003a) and is listed as Vulnerable by the IUCN Red List of Threatened Species (IUCN, 2010). The franciscana range was recently divided into four management stocks (known as Franciscana Management Areas or FMAs): Two in southeastern Brazil (FMA I and II), one in southern Brazil and Uruguay (FMA III) and one in Argentina (FMA IV) (Secchi et al. 2003b).

Aerial surveys have been considered the most appropriate survey method to estimate abundance of franciscanas (e.g. Secchi *et al.*, 2001; Crespo *et al.*, 2002). However, developing abundance estimates from aerial surveys for this species can be challenging because this species is difficult to see from the air. In fact, proper assessments of the conservation status of the various franciscana stocks have not been carried out because either population estimates do not exist (e.g. for FMA I, in southeastern Brazil) or because some existing estimates (Secchi *et al.,* 2001; Danilewicz *et al*., 2009; Crespo *et al*., 2010) have been considered unreliable due to inappropriate survey design or lack of proper estimates of visibility bias (IWC, 2007; Danilewicz *et al.*, 2009). In addition, previous studies have suggested that franciscana groups seen from airplanes are 2-4 times smaller than those seen from still or slow moving platforms (Bordino *et al.*, 1999; Secchi *et al*. 2001; Cremer and Simoes-Lopes, 2008; Crespo *et al*., 2010; Zerbini *et al*., 2010), indicating that biases in estimates of abundance from underestimation of group size can be substantial.

In the past years, the IWC Scientific Committee has made a number of recommendations for improving abundance estimates for franciscanas, particularly in regards to refining survey design and to compute correction factors for the various sources of bias in aerial surveys (IWC, 2005; 2011). At its 2010 meeting, the IWC approved a proposal to assess bias in aerial surveys for franciscanas to be funded by the IWC/Australian Fund for Small Cetaceans Conservation Research. After the approval by the IWC, the government of Brazil, via the Instituto Chico Mendes for Biodiversity Conservation, decided to supplemented this research by providing additional aircraft time for aerial surveys.

In February 2011, an experiment was developed in Babitonga Bay (26°16'S, 048°42'W), southern Brazil to investigate potential sources of visibility bias and group size bias in aerial survey of franciscanas and to investigate whether correction factors to improve/correct for estimates of abundance of the species could be developed. This study consisted in survey a small area with high density of franciscanas using boats and an airplane. The two platforms operated independently and the rationale was that estimates of abundance and group sizes were considered true for the boat and were used to correct for the aircraft estimate. Preliminary results of this research are presented below and a summary of future work to be conducted within the next several months is presented at the end of the manuscript.

METHODS

Study Area and Survey Design

Aerial and boat-based surveys were conducted in Babitonga Bay (26°16'S, 048°42'W, Fig. 1), State of Santa Catarina, southern Brazil from 13 to 24 February 2011. Babitonga Bay presents a number of advantages for the type of study intended here: (1) this is a region where franciscanas predictably occur in relatively large densities throughout the year and show limited or no avoidance to small boats (Cremer and Simões-Lopes, 2008), (2) group sizes seen in the bay (range = 1 to 22 individuals; Cremer and Simões-Lopes, 2005) are believed to be representative of those seen through most of the franciscana range and (3) the bay is relatively protected and therefore provides good weather conditions (e.g. relatively calm waters) for sighting surveys.

A sampling area (Area A, 160km^2, Fig. 1) was selected based on locations where franciscanas were known to occur in relatively high densities (e.g. Cremer and Simões-Lopes, 2008). Aerial and boat surveys followed design-based line transect methods (Buckland *et al.*, 2001). A sampling grid of 16-17 equally spaced (at 600m from each other) tracklines was proposed. To ensure sampling was random and independent for each platform, the starting point of the grid was randomly selected for each realization of the design for both survey platform types. The total trackline length (74 km) of the design was specified in a way that the sampling area could be fully surveyed by two boats in a period of four hours. This period was chosen to maximize sampling during calm weather, usually observed in this region between dawn and noon. During these four hours, the airplane could complete 3-4 realizations of the survey design.

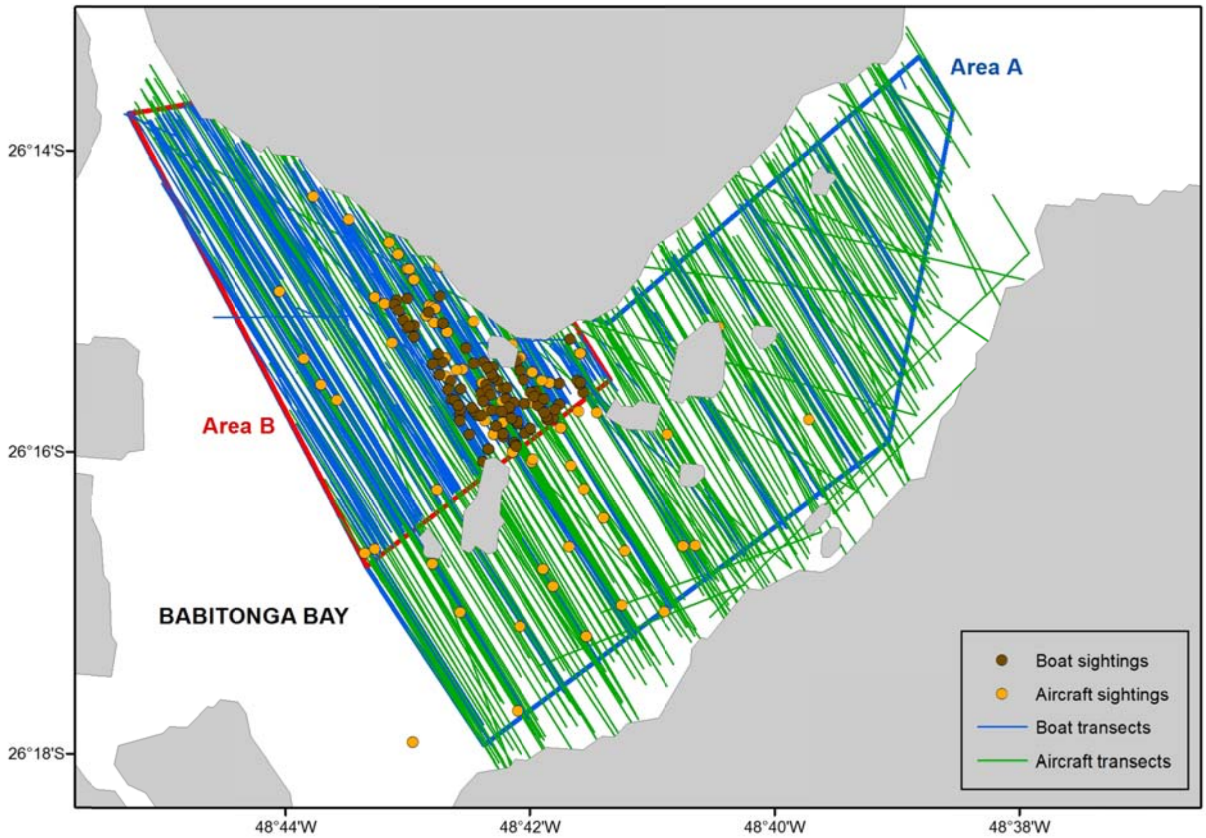


Fig 1 – Map of Babitonga Bay, southern Brazil, showing survey areas, realized trackline effort and franciscana sightings for both aircraft and boats.

After the first two survey days, it became clear that franciscanas were concentrated in a smaller region and therefore the sampling area was reduced to a smaller region (Area B, 17km^2 in Fig. 1) for the boat surveys to maximize collection of sighting data. The trackline design, however, maintained the same line spacing as the original design. The sampling strategy was not modified for the airplane because it could cover the entire survey area (Area

A) much faster and because sample sizes collected on the first two days indicated that sufficient sightings (60-80 records, Buckland *et al.*, 2011) would be recorded for estimation of detection probability for this platform. For the purpose of the analysis intended here, only data collected in Area B is considered for density estimation.

Field Methods

Sampling occurred under good weather conditions and calm seas (Beaufort Sea State <=2). Water transparency was measured with a Secchi disc at the beginning, middle and end of every boat transect and cloud cover was registered once changes were observed. Surveys were conducted in "passing mode" for both survey platforms.

Aerial surveys

Visual surveys were made from a high-wing, twin-engine Aero Commander aircraft at an approximately constant altitude of 150m (500ft) and a speed of 170-200km/h (~90-110 knots). The aircraft had four observation positions (two on each side of the plane), with bubble and flat windows available for front and rear observers, respectively. Different window configuration resulted in a partial overlap in the front and rear observer's field of view (beyond 80m from the trackline). Observers collected environmental data (e.g. sea conditions, water transparency, direction and intensity of glare) at the beginning and end of each transect or when conditions changed. The beginning and the end of each transects were informed to the observers by the pilot. No communication existed among the observers during the flights. Data were recorded on audio digital recorders and every record was time-referenced based on digital watches synchronized to a GPS. When a sighting was detected, the species and the size of the group were recorded. The declination angle between the horizontal and the sighting was obtained using an inclinometer when the group passed a beam of the plane. Additional information such as sea state, presence of calves in the groups, and water visibility were also recorded along with each sighting.

Sighting data collection was standardized while surveying the proposed transects as well as while transiting between transects. Therefore, if needed, all sightings recorded at transect and transit lines could be used for the estimation of the detection function. Sightings detected when the plane was flying from or into the airport or outside of the survey area (i.e., not on transect or transit lines) were considered "off-effort". Only sightings detected while flying the originally proposed survey design (Fig. 1) were used to compute the estimates of density and abundance.

Boat surveys

Visual surveys were conducted with two small (5-6m) open boats equipped with 40 and 60hp outboard engines and a crew of four people: two observers, a data recorder and a pilot. The observers were located at the bow of the boat and searched for cetaceans with naked eyes. Observers on the left and right of the bow searched for a 0-50^{o} to the port and starboard, respectively. Once a group was detected, information on the (visually) estimated radial distance to the sighting, the radial angle (measured with an angle board) and the group size were relayed to the recorder and registered in a standard data sheet. The recorder was not involved in searching, but assisted the observers in identifying species, tracking detected groups and estimating group size and group composition.

There is evidence that group size estimation during passing mode can be biased low because observers do not spend sufficient time to obtain an accurate count of the individuals in a group. To assess whether this occurred in this study, the boats returned to areas of high density after the end of certain transect lines and randomly approached franciscana groups. A count of individuals in the group during these 'off-effort' approaches was then compared to group size estimation on the transect lines.

DISTANCE CALIBRATION EXPERIMENTS

Because radial distances were visually estimated by the boat observers, three calibration experiments were conducted before, during and after the surveys. The goal of the experiments was to assess measurement error in distance estimation and to correct for such error for each individual. Systematic measurement error can cause bias in abundance estimates (Marques and Buckland, 2004) and therefore correction is desirable especially when observers distance is estimated without the assistance of range measuring devices (e.g. a range finder or a reticuled binocular).

During these experiments, observers stood in a fixed platform and independently estimated their distance from a moored object placed at various known distances from the platform. The experiment was conducted in a location with similar visibility conditions to those found in the survey area and the distances at which the moored object was placed from the observers were within the range franciscanas were seen in boat surveys previously conducted in Babitonga Bay (Cremer and Simões-Lopes, 2008). For each of the three experiments, 12 distance estimates were obtained for each observer. True (measured) and estimated distances were used to correct for bias in radial distance estimation in a regression framework (e.g. Williams *et al.*, 2007).

Group Size Estimation and Comparison Across Platforms

Because one of the goals of this study was to assess possible differences in estimation group sizes from the aerial and surface platforms, it was important to ensure that observers on the boats and the aircraft use the same group size definition. This is relevant here because the perspective of what consists a group may be different between the platforms. A group was defined as an aggregation of animals in close proximity to each other (within ~10 body lengths) and in apparent association and engaged in the same type of behavior (e.g. Shane, 1990; Cremer and Simões-Lopes, 2008).

A general linear model (GLM) with a Poisson error structure was used to assess differences in group sizes estimated from the boats and the airplane. This model takes the following form:

$$Log(\mu) = \beta_0 + \beta_1 x_1 + \beta_k x_k + \varepsilon$$

Where: μ is the response variable (group size-1), β_0 is the intercept, $\beta_1 \ldots \beta_k$ are the coefficients for the $x_1 \ldots x_k$ explanatory variables and ε is an error term.

In this study, four models were proposed: a null model plus models with platform, distance or platform and distance as explanatory variables. Model selection was performed using the Akaike Information Criterion (AIC).

Analytical Methods

Estimation of Detection Probability

Detection probability was estimated using Conventional (CDS) and the Multiple Covariate Distance Sampling (MCDS) methods (Buckland et al., 2001; Marques and Buckland, 2003). MCDS differs from CDS as it allows for the inclusion of environmental covariates in the estimation of detection probability. Half normal and hazard rate models without covariates and with group size and sea state covariates were proposed to model perpendicular distance data. Exploratory analyses indicated that adequate fits were obtained by modeling ungrouped (boat) and grouped perpendicular distance data (plane, grouping intervals: 0-30m, 30-60m, 60-90m, 90-120m, 120-150m, 150-180m, 180-240m e 240m-300m) and by right truncating data at 180m (boat) and 300m (plane). Only data collected by the front observers in the airplane (bubble windows) are considered in the analysis presented below because of inconsistencies on how sightings detected by both front and rear observers were matched. This is currently under review and analysis of these data will be presented in the future (see discussion section below). The most supported model was selected according to the Akaike Information Criterion (AIC).

Group Size, Density, Abundance Estimation
Density of groups (D_g) and individuals (D_i) was estimated using the Horvitz-Thompson estimator as follows (Marques and Buckland 2003):

$$\widehat{D_g} = \sum_{i=1}^{n} \frac{1}{\hat{p}(z_i)}$$

$$\widehat{D_\iota} = \sum_{i=1}^{n} \frac{s_i}{\hat{p}(z_i)}$$

Where:
n – number of observations (sightings); s_i – cluster size for observation i; $\hat{p}(z_i)$ – detection probability for vector of sighting-specific covariates z for each observation i.

Expected group size was estimated by dividing D_i/D_g (Innes *et al.*, 2002). Variance was estimating using the analytical estimator of Innes *et al.* (2002) and Log-normal 95% confidence intervals were computed as suggested by Buckland *et al.* (2001).

Computing a Correction Factor for Aerial Surveys
A factor to correct for visibility and group size bias in aerial survey-based estimates of density was computed by the following ratio:

$$CF = \frac{\widehat{D}_{boat}}{\widehat{D}_{plane}}$$

and variance for this CF was approximated by the delta method.

This CF assumes that no visibility bias occurred in the density estimated by the boat survey (i.e. $g[0]_{boat} = 1$) and that group sizes were accurately estimated (i.e. underestimation of group size by the boat observers would result in an underestimation of the CF and vice versa).

RESULTS

Survey effort in areas A and B by boat and aircraft are summarized in Table 1. In nearly 1900km of trackline, a total of 343 franciscana sightings were recorded in Babitonga Bay.

Table 1. Survey effort conducted by boats and airplane to estimate density of franciscanas in Babitonga Bay, southern Brazil, in February 2011.

	Boats	Airplane
Total survey effort (km) in Areas A and B	550.8	1422.1
Survey effort (km) in Area B	447.5	501.9

Group Size

Group size statistics for the franciscana aerial and boat surveys in Babitonga Bay are summarized in Table 2. Group sizes varied between 1 and 7 individuals during the survey for both platforms.

Table 2 – Summary of average (SE in parenthesis) group sizes of franciscanas in Babitonga Bay, southern Brazil in February 2011.

	Boat		Plane					
	All		Front		Rear		All	
	Mean (SE)	n	Mean (SE)	n	Mean (SE)	n	Mean (SE)	n
On effort groups	2.90 (1.24)	114	2.26 (1.12)	102	2.03 (1.28)	36	2.17 (1.16)	138
Off effort groups	2.88 (1.08)	50	2.35 (1.47)	31	2.4 (1.26)	10	2.36 (1.40)	41
Total		164		133		46		179

The GLM with distance and platform was the best model selected by AIC (Table 3) and parameter estimates for this model showed that group sizes estimates from the aircraft were significantly smaller that those from the boat (Table 4). Predicted group sizes for each platform can be computed from the model parameter estimates (boat average = $\exp(0.49217)+1 = 2.63$ and plane average = $\exp(0.49217-0.45256)+1 = 2.04$) and that indicate boat group size estimates are 30% greater than those from the airplane.

Table 3 – Models proposed to assess differences in group size estimation between boat and aircraft. Best model shown in italics.

Model	Explanatory variables	AIC
1	Null	619.24
2	Distance	616.81
3	Platform (2 levels, boat and aircraft)	607.43
4	*Distance and platform*	*603.88*

Table 4 – Model parameter estimates for the best model (#4) in Table 3, above.

Parameter	Mean	SE	P-value
Intercept	0.49217	0.09325	<0.00001
Distance	1.69843	0.68986	0.013
Platform (plane)	-0.45256	0.11986	0.00016

There was no significant difference in group sizes estimated by observer on the boat while surveying the transect lines (mean=2.90, SE=2.88) and when groups were approached off effort (mean=2.88, SE=1.08) for a more accurate estimation of the number of individuals in the group (p-value = 0.0012).

Boat Observer Calibration
Results of the calibration experiment are summarized in Table 5. One out of five observers tended to underestimate distance by 7% on average. The other four observers overestimated distance by on average 9-31%.

Table 5 – Observer bias in estimating radial distance from calibration experiments

Observer	Bias	p-value
1	+20%	<0.001
2	+9%	<0.001
3	-7%	<0.001
4	+12%	<0.001
5	+31%	<0.001

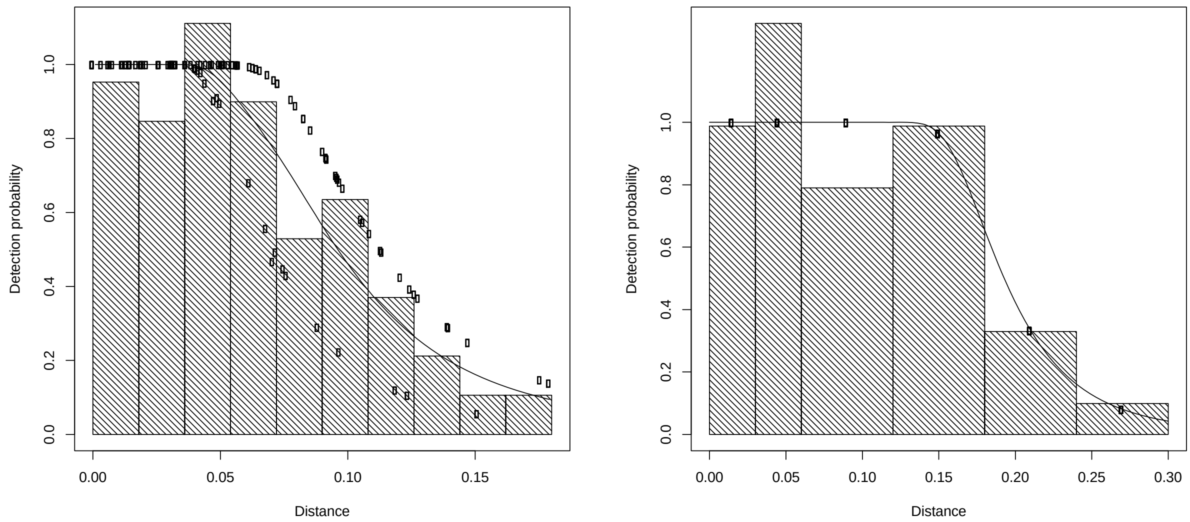
These results led to a correction of radial distance before the analysis of distance sampling data and resulted in an average 17% reduction in perpendicular distance data used in fitting detection probability models.

Density and Abundance Estimates and Correction Factor Computation
Quantities related to density and abundance estimation are summarized in Table 6. The hazard rate model with no covariate or with sea state (Beaufort) covariate provided the best fit for perpendicular distance data for airplane and boats, respectively (Fig. 2, Table 6). Boat (3.32 ind/km^2, 95% CI = 2.14-5.13) and plane (0.70 ind/km^2, 95% CI = 0.42-1.17) densities were significantly different and the ratio of the two resulted in a correction factor of 4.74 (CV=0.05). This clearly demonstrates that estimates from the airplane are biased low to a relatively large extent if no correction is applied for visibility or group size bias.

Table 6. Quantities related to estimation of density of franciscanas in Babitonga Bay, southern Brazil in February 2011 (CVs are shown in parenthesis when applicable).

	Boats	Airplane
Survey effort (km) in Area B	447.5	501.9
On effort sightings (km) in Area B	114	68
Encounter rate	0.69 (0.21)	0.28 (0.25)
Sightings used in fitting the detection function (after truncation)	109	102
Average detection probability (*p*)	0.58 (0.09)	0.67 (0.07)
Expected group size[1]	2.82 (0.05)	2.09 (0.06)
Density	3.32 (0.22)	0.70 (0.26)
Abundance	55 (0.22)	12 (0.26)

[1]Expected group size was computed after truncation and fitting a detection probability function.



Boats Airplane

Fig. 2 - Detection probability functions fit to perpendicular distance data collected in Babitonga Bay by the boats and the airplane in February 2011 (distance shown in km).

DISCUSSION

Group Size Bias

Existing data suggested that bias in group size estimation of franciscanas from airplanes could be substantial as groups seen from land or from slow-moving surface platforms (e.g. Bordino *et al.*, 1999; Cremer and Simões-Lopes, 2008; Flores, 2009) were on average 2-4 times greater than groups seen from aerial surveys (Secchi *et al.*, 2001; Danilewicz *et al.*, 2009; Crespo *et al.*, 2010; Zerbini *et al.*, 2010). Results of this study showed that there is a significant negative bias (~30%) in the estimated size of groups detected from the aircraft, however the magnitude of the bias is smaller than previously thought. This difference in magnitude may be explained by possible differences in the definition of what constituted a group across different surveys. For example, if groups seen during previous land/surface platform studies were determined after extensive periods of time were spent with the target animals, estimates may represent the total number of individuals seen while that "group" was observed and not necessarily the number counted after the group was initially detected. In other words, if individuals in the surroundings of the original sighting joined that group before observations ended, these incoming individuals would be added to the number seen originally resulting in a greater group size estimate.

In this study, the estimates of group size were considered accurate for comparison with estimates from the aircraft. However, trackline sampling by the boats were conducted using passing mode and therefore, group size estimates may be biased low. This is considered unlikely here because groups seen off effort (i.e. those approached so that sizes were determined after spending additional time with the group) were not statistically different from those seen during the trackline sampling). If groups size estimate from the boats are biased low, the 30% group size bias computed here for the airplane is also negatively biased.

Another way of assessing bias in group size estimates from the airplane would be to compare the expected group sizes computed with the abundance estimates (analysis in Distance). In the estimates presented above, groups estimated from the plane (2.09 ind/group) are 35% smaller than those seen from the boats (2.82 ind/group). This figure is comparable to that computed with the GLM analysis (30%) and likely occurs because the sample sizes used in the two approaches are different and because different factors are considered in their computations. While the GLM uses all on effort sightings detected by the boats and by the airplane (front/bubble windows only), the expected group sizes calculated when computing the abundance estimates only consider groups within the truncation distances of the two platforms. The GLM analysis is preferred here because it uses more data and takes into account perpendicular distance at which groups were estimated from the trackline. Because detection probability models with a group size covariate were not selected by AIC for the estimation of density/abundance, the expected group sizes computed by the analysis in distance correspond to a simple mean of the sizes of the groups seen by the two survey platforms.

Visibility Bias

Marsh and Sinclair (1989) coined the terms perception and availability bias to differentiate two forms of visibility bias. Perception bias occurs when groups of dolphins are available to be seen but are missed by the observers while availability bias corresponds to animals that are missed because they are submerged. If one assumes that 30% of the bias in estimates of franciscana abundance from aerial surveys comes from underestimation of group sizes, the fraction of the correction factor computed above that corresponds to visibility bias is 3.32 (=4.74*[1-0.3]), which is equivalent to an estimate of *g(0)* of 0.301. This figure is consistent with studies conducted elsewhere for other small cetacean species. For example, Laake *et al.* (1997) estimated *g(0)* values of 0.079 (SE=0.046) and 0.292 (SE=0.107) for, respectively, inexperienced and experienced observers during aerial surveys for harbor porpoise in coastal waters of Washington State (USA). In their study, Laake *et al.* (1997) were able to distinguish between availability and perception bias. They estimated that availability (proportion of time at surface) of harbor porpoise groups ranged from 0.262 (SE=0.032) to 0.338 (SE=0.061) and that experienced observers saw 86.5% of the groups available (perception bias = 0.865) while inexperienced observer saw only 23.4% of groups (perception bias = 0.234). In the present study distinction between availability and perception bias was not yet assessed, but should be possible once data from independent survey platforms is examined within a distance sampling/capture-recapture framework is used in the estimation of perception bias (e.g. Laake and Borchers, 2004; Borchers *et al.*, 2006). Availability bias can then be computed as perception bias/total visibility bias. Furthermore, the accuracy of this estimate can be tested when information on diving parameters of franciscanas in Babitonga bay become available (see item Future Work below).

Application of the Correction Factor to Existing and Future Franciscana Abundance Estimates

While the correction factor computed here provides a quantitative measure of the magnitude of the bias in franciscana abundance estimates from aerial surveys, its use to correct for existing range-wide surveys requires careful consideration at present. If different aircrafts or observers were used (e.g. Secchi *et al.*, 2001), the correction factor presented above may not be applicable due to differences in the field of view and speed of the airplane and in franciscana detectability by the observers. For surveys using the same airplane and some of the same observers (Danilewicz *et al.*, 2009 and Zerbini *et al.*, 2010) the use of the correction factor will be assessed once additional analysis (see Future Work below) are completed. Finally, if future surveys are carried out with the same aircraft and observers, the application of this correction factors is valid and should be performed. In fact, provided funding becomes available, aerial surveys planned for the only franciscana management area for which estimates of abundance do not exist (FMA I) shall be conducted at the end of 2011 with the same platform and team of observers employed in the Babitonga Bay experiment.

Future Work

The following additional analysis are planned for data collected during the surveys conducted in Babitonga Bay in February:

(1) Sightings data from independent observers in the airplane will be used to compute availability and perception bias (as specified in the item Visibility Bias, above)

(2) Information on water transparency and cloud cover will be integrated into models used to estimate franciscana detection probability.

(3) Use of non-linear models (e.g. Williams *et al.*, 2007) and models with different error structures (e.g. Marques, 2004) to estimate measurement error in visual distance estimation by the boat observers.

In addition, (4) a new experiment will be carried out to assess diving parameters of the franciscana using a helicopter. This study will serve to test accuracy of availability bias computed using the Barlow *et al.* (1988) method and the approach proposed in item Visibility Bias, above. This approach is more appropriate for the kind of analysis intended here that boat-based assessment of the diving times of franciscanas originally proposed for this study.

By-Products

This study was funded by the IWC/Australian Fund for Small Cetaceans Conservation Research and we believe this support made an important contribution to the conservation of a threatened species in a country under scientific development. We believe the implications of this study are much broader than the development of a correction factor for abundance estimates computed from aerial surveys. We highlight the following points as evidence of the impact this contribution will have in the future:

(1) Funding of this research encouraged the Government of Brazil to provide additional support to Franciscana research by donating aircraft hours for aerial surveys. Some of these hours were used in the Babitonga experiment in February 2011, but there are still time left to be used in an experiment to assess availability bias for franciscanas seen from an aerial platform.

(2) In addition to franciscanas, a population of Guyana dolphins (*Sotalia guianensis*) inhabits Babitonga Bay. There is a growing body of evidence indicating that these species live in the region through the year and that there is limited (if any) interchange with populations in adjacent areas. The surveys conducted here provided sufficient information for the estimation of abundance of the two species in the area, which can be compared to previous estimates (Cremer and Simões-Lopes, 2008; Cremer *et al.*, 2011) to assess trends in abundance. This is extremely relevant in a conservation context since large size port terminals have been or will be built in the channel that

connects the Bay to the ocean and in areas that overlap with the known range of the two species. These abundance/trend estimates will therefore serve as baseline information for the assessment of the status of these populations as they become more exposed to activities related to the operation of the port (and other anthropogenic activities).

(3) This study was important also in the context of capacity building. In addition to the principal investigators, six students (Ph.D., MS and BS level) participated in field activities and received training in the survey design and data collection techniques employed during this project. Many of them had no previous experience with aerial or boat surveys and with line transect methods. In addition, a scientist from Argentina (PD), where additional franciscana aerial surveys are also urgently needed, took part on the study and received training on the aerial survey methods adopted during this research.

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