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Summary

Between October 11 and 16, 2019, and March 12 and 14, 2022, 9 flights were made on the coast of the province of Buenos Aires in meteorological conditions that allowed the sighting of several species of cetaceans. The two series of surveys (2019-2022) had to be carried out separately because of travel restrictions associated with the covid-19 pandemic. This document reports on results, including estimates of abundance, for franciscana dolphins (*Pontoporia blainvillei*). The number of sightings (and indviduals) in 2019 and 2022 were 41 (68 individuals) and 55 (80). Abundance for FMA IVb was estimated to be 8351,01, while FMA IVc was 2336,28. The total abundance of Franciscana for both areas would preliminary give a figure of 10687 dolphins if we consider the estimation obtained in 2022 plus 5896 dolphins estimated in 2004 for the southern areas, roughly 16600 individuals without considering those in deeper waters beyond the 30 meter isobath. In addition to franciscanas, several groups of common and dusky dolphins were observed during the aerial surveys, some very numerous.

Introduction

The first study in Argentine waters on the abundance of the threatened franciscana dolphin, *Pontoporia blainvillei* was carried out in Buenos Aires Province and the northern coast of Golfo San Matías, Rio Negro Province during 2003–2004. We carried out 17 aerial surveys using line transect sampling methodology. We observed 101 franciscanas in 71 sightings. A correction factor for submerged dolphins was applied to density and then extrapolated to the strip between the coastline and the 30-m isobath. In northern areas density was estimated at 0.377 individual/km2. Density was lower in southern areas (south of Bahia Blanca) (0.197/km2). Abundance in the northern area was estimated at 8,279 (4,904–13,960) individuals, while in the southern BA Province and Golfo

San Matías it was estimated at 5,896 (1,928–17,999) individuals (Crespo et al., 2010).

Considering a potential annual mortality of about 500–800 individuals, about 3.5%–5.6% of the stock may be removed each year by the fishery and over the 2% recommended by the International Whaling Commission (IWC) and may not be sustainable by the population. Higher densities in coastal areas make franciscanas more vulnerable to coastal fishing camps, which increased mortality in the years prior to the estimation (Corcuera, 1994).

Given all these facts there was a need of repeating the aerial surveys in order to assess if the abundance of franciscana has sustained or has declined during the last 15 years. The opportunity came with financial support by FAO and IWC to carry out a new series of surveys in the same area with the same designs used in the 2003-2004 surveys, scheduled to be carried out between the months of February and March 2019, mainly for two reasons: a) so that they were comparable to the surveys performed in the period 2003 - 2004, b) so that they were carried out in the best meteorological conditions possible.

However, the delay in signing the Letter of Agreement between FAO and CONICET, the late arrival of funds precluded the flights to be carried out in the proposed time window. Therefore, said surveys were carried out in October 2019. The COVID-19pandemic did not allow to complete the surveys so the following set of surveys was planned for March 2022. The difference in the season of surveys 2019 and 2022, would not allow to compare strictly the results achieved in this work with those obtained in the period 2003 - 2004. However, we tested separately and jointly both seasons in order to explore potential differences.

In addition, based on the paper by Cunha et al. (2022) who subdivided FMA IV in several new stocks), density and abundance estimates related to this new stock delineation were produced to assist the IWC with the ongoing review of the status of the franciscana. Stock-specific estimates were produced for those covered by aerial surveys, therefore some stocks did not have estimates.

On the base of the former arguments the following objectives of this paper include: a) estimate density and abundance for Buenos Aires Province and Argentine waters in general, b) estimate abundance for stocks under the Cunha et al. (2022) paradigm, and c) discuss mortality rates published and evaluate potential effects given the abundance estimates.

Material and Methods

The data were obtained using population sampling through linear transects applied to animals that are observed in groups. The method assumes that all animals will be observed in the transect line (under the plane the probability of detection g (0) = 1) and less far from it. To estimate the density of animals in the area, it is first necessary to adjust the distance data to mathematical functions that represent the way in which the probability of detecting animals declines as the observations are further away from the line (Fig. 2). These are called detection functions. The method is flexible enough to allow modifications of these functions and incorporate covariates that allow for better adjustment and reduce the coefficient of variation of the estimates (Buckland et al. 2001).

Correction for submerged animals

Detection Probability (g0): considering the chance of missing submerged dolphins under the plane, the probability of detecting a Franciscana was estimated based on the equation used by Barlow et al. (1988) in abundance estimation of harbour porpoises (*Phocoena phocoena*). This equation was previously used for the abundance estimation of franciscanas at Rio Grande do Sul (Secchi et al. 2001b):

$$g_0 = \Pr(\text{dolphin is visible} \mid \text{dolphin is on transect line}) = \frac{s+t}{s+d}$$

where *s* is the average time of a franciscana being at the surface, *d* is the average time of a franciscana being submerged, and *t* is the time window during which the franciscana is within the visual range of an observer. Values of *s* and *d* were obtained in Babitonga and Ubatuba (Brazil) during controlled experiments from aircrafts (Sucunza et al., 2022), while *t* was measured directly on board the aircraft from seabirds, carcasses, or any other floating objects.

For completeness we define g0 = 1 if $t > d$. The variance of g0 was estimated by the delta method (Seber 1982) given by the following equation:

$$Var(g_0) = [Var(d)] \left[\frac{-s-t}{(s+d)^2}\right]^2 + [Var(t)] \left[\frac{1}{(s+d)}\right]^2 + [Var(s)] \left[\frac{d-t}{(s+d)^2}\right]^2$$

Even though the values of *s* and *d* are correlated, the information for each was taken independently in different events. Given that there was no chance of estimating the covariance, it was assumed to be 0 for the calculation of Var (g0) as in other previous articles (Secchi et al. 2001b).

Density estimation

The density of the Franciscan dolphin (D = Du = uncorrected density) was estimated using the standard methods of distance sampling applied to groups of animals (Buckland et al. 1993, 2001). The data was analysed using the DISTANCE 7.1 version 2 program (Thomas et al. 2004). Essentially, the program adjusts a detection function to the distribution of perpendicular distances and this function is used to estimate the effective strip width (ESW). Then, the density is estimated using the following equation:

$$D = \frac{n * Es}{2l * ESW}$$

where *n* is the number of sightings, *l* is the total search effort and *Es* is the average group size. The quantity n / l is known as the encounter rate, which is the number of sightings per km travelled. This estimate does not include animals that are not observed in a blind strip on each side under the plane because the plane windows of the aircraft do not allow the detection of animals at angles closer to the transect line. Data were left truncated at 88m including the blind strip on each side below the plane. This is consequence of the flat windows in the aircraft that did not permit the detection of animals at angles closer to the transect line.

The aircraft used was a twin-wing Tecnam P2006T Twin MkII twin-engine (Fig. 1). The P2006T Twin MkII works with fuel savings and noise emissions much lower than other previously used aircraft, such as the Cessna 337 Super-Skymaster. On flights made the dolphins, and in particular the franciscana, did not react to engine noise, which happened with the Cessna 337 (Crespo et al., 2010).

Figure 1: Aircraft used for aerial surveys

The length of the transects was defined in 15 nautical miles, in accordance with the security restrictions of the owner of the private company of the rented aircraft. The basic plan was to follow the zigzag transects (Fig. 2) according to the same survey designs performed in 2003-2004. The same layout of the transects was flown both in 2019 and 2022. The surveys were carried out with a calm sea state on the Beaufort scale of 3 or less, which means that there are no waves that break that would lead to an underestimation of individuals. The two sets of track lines were surveyed in both 2019 and 2022 surveys as they were flown in 2003-2004.

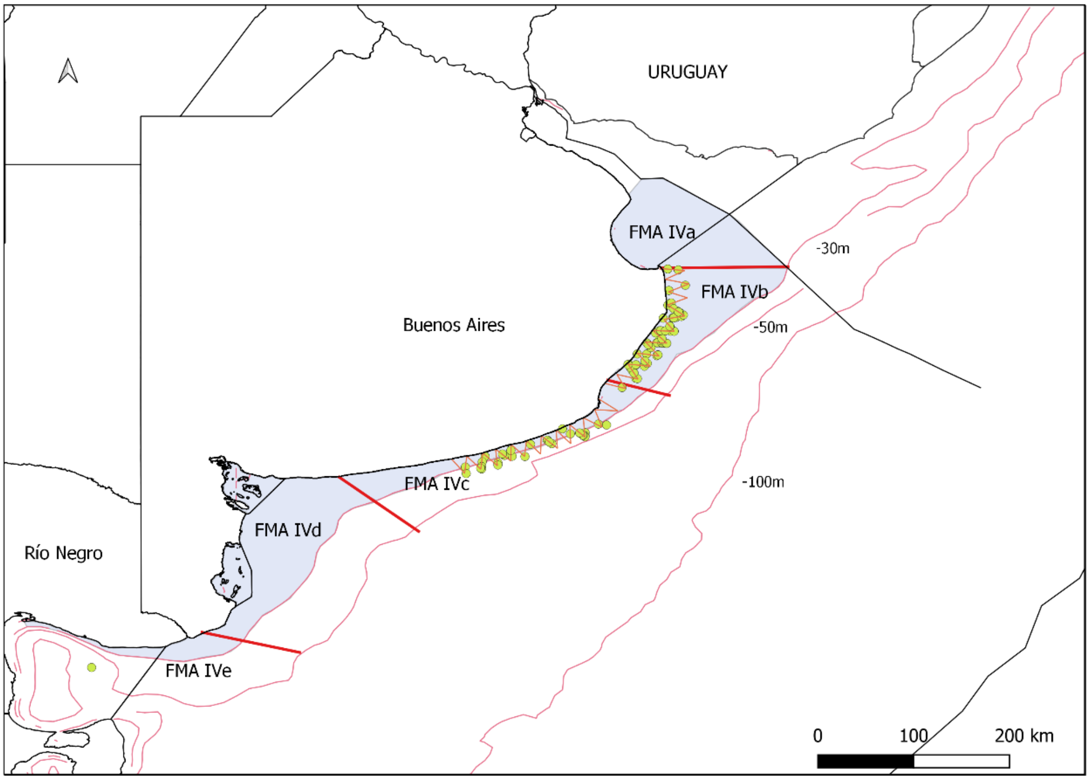

Figure 2: Map showing the sub-areas within FMA VI. The sampling transects surveyed both in 2019 and 2022, the limits of the proposed FMA IV, and the isobaths of 30, 50 and 100m are shown. The circles denote the observed cluster of franciscana dolphins during both surveys.

Results

Between October 11 and 16, 2019 and March 12 and 14, 2022, 9 flights were made along the coast of the province of Buenos Aires in weather conditions that allowed the sighting of several species of cetaceans. In particular, for 2019, 41 sightings of franciscana dolphins (*Pontoporia blainvillei*) were made, totalling 68 individuals (Table 1). For the 2022 census, 55 sightings of 80 franciscanas were made.

In addition, several pods of common dolphins (*Delphinus delphis*) were observed in 2019, some very large. Individual sightings of dusky dolphins (*Lagenorhynchus obscurus*), bottlenose dolphins (*Tursiops truncatus*), killer whales (*Orcinus orca*), unidentified fin whales (Balaenoptera spp.), South American fur seals (*Otaria flavescens*) and seabirds such as gulls and shearwaters were also made. In 2022, in addition to common and bottlenose dolphins and South American sea lions, leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*) and/or loggerhead (*Caretta caretta*) turtles and hammerhead sharks (*Sphyrna zigaena*) were observed. It was not possible to distinguish between green and loggerhead turtles.

Table 1. Sightings and number of Franciscana dolphins recorded in flights

Surveys	No. of flights	FMA	No. sighting	No. individuals
2019	3	IVb	27	44
	2	IVc	14	24
	total		41	68
2022	2	IVb	50	71
	2	IVc	5	9
	total		55	80

With respect to parameter estimation, the expected cluster encounter rate, size, and density were analysed by year and FAM IV subarea and for data combined considering both years (2019/2022). The best-fitted model was always a Halfnormal/Cosine series without expansion (Fig. 3). Total combined effort for 2019 was 1,482.58km and for 2022 was 1641.76km. The estimates obtained are shown in Table 2.

Data were analysed breaking down available observations. The distance of x = 0 from the transect line was considered to occur at a perpendicular distance of 88 m (clinometers angle of 60°), and all other distances rescaled accordingly. The rescaled perpendicular distances were left-truncated at a distance of 15m in order to correct for the peak of observations away from zero distance as a consequence of observation bias. The detection function was then extrapolated and fitted to these truncated data back to the track line. It is suspected that some dolphins could have been missed at 15 m beyond the 88-m blind spot under the plane because of improper observation by some of the observers as pointed out by Crespo et al. (2010). Data were also right-truncated at w = 250 m, therefore leaving a strip width of 235 m.

The areas used for extrapolating the estimates were derived from the limits presented for each sub-FMA IV, the coastline and the 30 isobath. The 30 m isobath was used in Crespo et al. (2010) and it is believed to be a natural limit for the franciscana distribution.

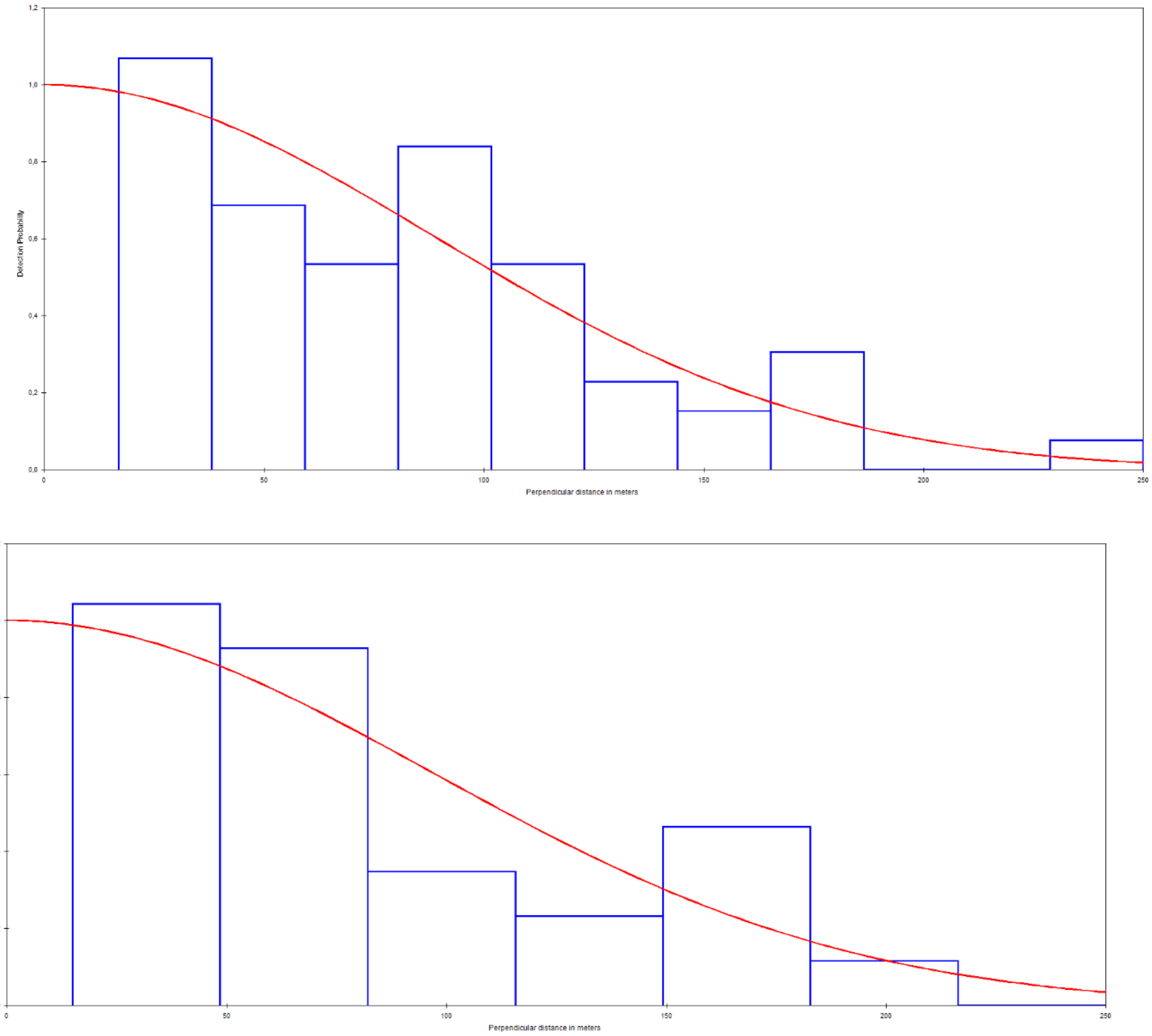

Figure 3: Detection probability function of franciscana sightings for the FMA IVb (upper graph) and FMA IVc (lower graph) surveys for 2019 and 2022 data combined

Abundance estimates of proposed sub-units within FMA IV

When we consider the genetic substocks proposed by Cunha et al. (2022) shown in Fig 2 and Table 2, FMA IVa (Bahia Samborombón) was not flown given the lack of fuel availability. FMA IVb coincides mainly with Mar del Plata – Lavalle and FMA IVc coincides mainly with Mar del Plata – Claromecó reported in Crespo et al. (2010).The areas now considered to be FMA IVd and FMA IVe were flown in 2003-2004 but not in 2019/2022.

The correction factor was derived considering the submerged time (s = 23.7 sec), the mean diving time (d = 53.33 sec) estimated by Sucunza et al. (2022). The correction factor was estimated in 0.398 and population estimates are shown in Table 2.

Table 2: Density and abundance estimations for FMA IVb and FMA IVc for 2019, 2022 and for both years combined.

FMA	Extrapol Area (km2)	Dens Unc	Dens Unc L limit	Dens Unc U limit	Corr Fect	Corr Dens	Dens Corr L Limit	Dens Corr U Limit	N	N L Limit	N U Limit
FMA IVb - 2019	10489.11	0.22	0.07	0.68	0.40	0.55	0.17	1.71	5722.29	1825.13	17940.98
FMA IVc - 2019	8003.17	0.15	0.08	0.28	0.40	0.37	0.19	0.70	2961.27	1557.98	5628.33
FMA Ivb 2022	10489.11	0.37	0.23	0.58	0.40	0.92	0.58	1.45	9627.60	6080.79	15243.29
FMA IVc - 2022	8003.17	xxx									
FMA IVb	10489.11	0.32	0.22	0.46	0.40	0.80	0.54	1.17	8351.01	5698.33	12238.43
FMA IVc	8003.17	0.12	0.07	0.21	0.40	0.29	0.16	0.52	2336.28	1310.19	4166.07

Ref: Dens Unc: Uncorrected density; Corr Fact: Correction factor applied; Corr Dens: Corrected Density; Extrapol Area: Extrapolation Area; L Limit: Lower limit 95% CI; U Limit: Upper limit 95% CI.Density is expressed in individuals / km2; the extrapolation area is expressed in km2 and abundance is expressed in number of individuals.

xxx: No estimate available due to the low number of observations.

When analysing the 2019 surveys, FMA IVb shown a higher density and therefore a higher abundance than FMA IVc. When we consider the surface area to which density was extrapolated, we find a total of 8683 considering the correction factor. For 2022 surveys density was higher in FMA IVb than in 2019 but density in FMA IVc could not be estimated given the low number of sightings.

The estimate considering both surveys (2019/2022) for each area was done using the year as a covariate in order to lower the associated variance. The number of individuals for FMA IVb and FMAc reached 10687 using the correction factor. There is a significant difference in the density estimate between both areas, being FMA IVb higher. It should be remembered that for the 2003-2004 surveys the density between those areas gave no statistical differences (Crespo et al. 2010).

Discussion and some preliminary conclusions

The results achieved indicated the existence of a higher abundance of franciscana compared to what was previously available (0.377individuals / km2 for 2003-2004, (Crespo et al. 2010) to 0.80 individuals/km2 for FMA IVb, this study). However, since the data are not completely comparable, a greater abundance or a positive population trend from the period cited to the present cannot be considered as credited. The increase in numbers between the 2019/2022 surveys with respect to those performed 15 years ago should not be interpreted as an increase in the population. Those differences may be due to the better conditions and consequently the number of sightings in which the 2019/2022 surveys were performed.

The current estimated abundance could have been the product of the time of the year in which the surveys were made, since mid-spring is the time when it is possible (unsafe, without empirical evidence) that animals are grouped for reproduction. The censuses of the period 2003 - 2004 were carried out at the end of the summer - beginning of autumn, with which the reproductive biology could be indicating another hormonal state in the individuals, manifesting a greater dispersion and hence the observed differences. Since this is a hypothesis, it would be necessary to continue monitoring abundance in the future, as well as obtaining more accurate estimates of mortality.

When considering the sub-areas proposed by Cunha et al (2020), estimates are also in the very close to those obtained previously. Even though data was re-analysed there are no significant differences, albeit the areas to which the extrapolation was done differ. Regarding the limits of the proposed sub-areas within the FMA IV, the estimates were based on the lines proposed by the SD/DNA group. These lines may be provisional and may change when more data are obtained. More sampling effort is needed because the current genetic analysis are based on a relatively small sample size from stranded animals for some localities (Cunha et al. 2020). The estimates presented here may change in the future if new data results in changes in the stock boundaries.

Regarding mortality rates published along the last 3 or 4 decades all of them are beyond the 2% recommended by the IWC. During the 80´s Perez Macri & Crespo (1989) estimated 340-350 dolphins/year for whole BA Province (based on interviews with cooperative fishermen). Corcuera et al. (1994) estimated 303 dolphins/year for 1984-1990, 41% of the fleet was monitored (mainly based on interviews). Bordino & Albareda (2004) recorded in total, 312 dolphins caught on board of vessels during four consecutive fishing seasons (average: 78 dolphins/year) based on 22 % of the fleet. This figure was extrapolated to the whole area as 651 indiv/year only for northern BA prov. Cappozzo et al. (2007) estimated 354 dolphins/year for 1997-2000 and 307 dolphins/year for 2002-2003. A minimum of 400 dolphins / year was calculated based on interviews with cooperative fishermen. Negri et al. 2012 estimated 107 dolphins/year in southern BA Prov. and 360-539 for whole BA Province again based on interviews with cooperative fishermen. More recently Franco-Trecu et al. (2019) evaluated the impact of coastal bottom trawl fisheries on franciscana and other marine mammals, which has never been evaluated before in the Río de la Plata Estuary and the adjacent Atlantic Ocean. This area coincides with FMIVa, an area which was not surveyed for availability of fuel, not during the 2003-2004 surveys, not now. By-catch per unit effort (BcPUE) and incidental mortality rates of marine mamals caused by the industrial coastal bottom trawl fisheries fleet were conducted an onboard involving crew members of 10 vessels (30%) of the Uruguayan coastal bottom trawl fleet. Mortalities estimated for franciscana dolphin were the highest among the species affected, with values adding up to ~100 individuals for year. BcPUE showed significant temporal variation, with franciscana dolphin BcPUE varying seasonally.

The common features of all these estimations are that all of them extrapolated the sample of a small group of fishermen (interviewed or onboard) to the whole fleet. It is clear that not all fishermen of a given locality behaved in the same way. Therefore, these estimations could be severely biased upward.

Our problem is that these mortalities in case of being accurate, would have driven the franciscana near to local extinction in a short time if our abundance estimations are realistic. The estimates obtained both in 2004 and during this study have shown that the abundance did not decreased, in fact estimated a larger population. This poses a conflict: we may be underestimating abundance and/or overestimating mortality, but this conflict will not be solved until we have better estimations of trend in abundance and more reliable mortality estimations as well.

According to a paper published recently by Sucunza et al. (2022), abundance computed from aerial surveys underestimate the true abundance by about 4-5 times, with ~70% of the total bias resulting from visibility bias (~80% from availability bias and ~20% from perception bias) and ~30% from bias in estimates of group size. The use of multiple survey platforms in contrasting habitats provided the opportunity to compute correction factors that can be used to refine range wide abundance estimates of the threatened franciscana given certain assumptions are met. Visibility bias and group size bias were substantial and clearly indicate the importance for accounting for such correction factors to produce unequivocal population assessment based on aerial survey data.

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