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Biological parameters of franciscana dolphins, Pontoporia blainvillei, bycaught in artisanal fisheries off southern Buenos Aires, Argentina.

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Running head: Biological parameters of franciscanas of Argentina.

Biological parameters of franciscana dolphins, *Pontoporia blainvillei*, bycaught in artisanal fisheries off southern Buenos Aires, Argentina.

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Abstract

*The franciscana dolphin (*Pontoporia blainvillei*) is a small coastal dolphin endemic to the Southwestern Atlantic Ocean. Incidental captures in fishing gillnets is possibly the greatest conservation concern for this species and occurs within most of its geographical distribution. The aim of this paper was to determine the biological parameters of franciscana dolphin bycaught from artisanal coastal fisheries of the southern Buenos Aires province, Argentina. Between 2003 and 2009, carcasses of 54 incidentally captured franciscanas were collected. The age, sexual and physical maturity, and body condition of each specimen was determined. The sex ratio of the bycaught dolphins did not differ from parity and, consistent with other areas, juveniles younger than 4 years old were captured in higher proportion (69%). In addition, 74% of the entangled animals were sexually immature and the 85% physically immature. Sexually immature dolphins were predominant in the spring, a period that coincides with the breeding season. An assessment of the body condition of captured franciscanas suggested that entanglements were not associated with a disease or physiological disorder. The results presented here are important to assess the impact of artisanal fisheries on the population of franciscana dolphins in the southernmost area of its distribution.*

Keywords: Franciscana dolphin, *Pontoporia blainvillei*, biological parameters, sexual maturity, age, body condition, bycatch.

INTRODUCTION

The franciscana dolphin, *Pontoporia blainvillei* (Gervais and d'Orbigny, 1844), is a small coastal dolphin endemic to the Southwestern Atlantic Ocean. The species occurs from Itaúnas (18º25'S, 30º42'W), in central Brazil, to Golfo Nuevo (42º35'S, 64º48'W), near Península Valdés, Argentina (Siciliano, 1994; Crespo *et al*., 1998, 2010).

Incidental captures in fishing gillnets and other fishing gear occur all along its geographical distribution (Corcuera, 1994; Pinedo, 1994a; Di Beneditto *et al*., 1998; Rosas *et al*., 2002; Cappozzo *et al*., 2007; Franco Trecu *et al*., 2009; Prado *et al*., 2013). Nowadays, it is estimated that more than 400 dolphins/year are incidentally caught in fishing gillnets in the Buenos Aires province (Bordino & Albareda, 2004; Cappozzo *et al*., 2007; Negri *et al*., 2012). Because of high bycatch levels, the species has been classified as "vulnerable" by the International Union for the Conservation of Nature (IUCN) (Secchi, 2006; Reeves *et al*., 2012).

In Argentina, the main published study on biological parameters of franciscana dolphins bycaught in artisanal fisheries (Corcuera *et al*., 1994) is nearly 20 years old. That study reported the sex ratio, age and length distribution of bycaught franciscanas from Necochea and Claromecó (southern Buenos Aires province). It also made a preliminary comparison of reproductive parameters and physical maturity from a small Argentinian sample with those from Uruguay given by Kasuya and Brownell (1979) but emphasized that further data was required before firm conclusions could be reached. At the moment, some reproductive aspects of the franciscana from southern Buenos Aires province were revised by Panebianco *et* al. (2012a). However, because these parameters were used to establish franciscana management areas (FMAs) within a phylogeographic framework

(Secchi *et al*., 2003a), updated parameter estimates may help improve conservation of the species. In addition, collection of biological data from bycaught dolphins can be useful to assess the effects of bycatch and to estimate vital rates (Secchi *et al.*, 2003b). New estimates of population parameters are also relevant because some species under high levels of bycatch may show changes in growth rates (Caswell *et al*., 1998), age distribution, proportion of mature individuals in the population, and body fat conditions (Lockyer, 1990; Pinedo, 1994b; Murphy *et al*., 2009).

The main goal of this paper was to estimate several biological parameters (age, body condition, sexual and physical maturity) of the franciscana dolphins bycaught in artisanal coastal fishery off southern Buenos Aires province in the first decade of the 21st Century.

MATERIALS AND METHODS

Study area and sampled data

Between 2003 and 2009 we collected 54 carcasses of franciscana dolphins incidentally entangled in the artisanal fishing nets of the southern coast of Buenos Aires province, Argentina, between the localities of Necochea (38º 44' S, 58º 44' W) and Bahía Blanca (38º 44' S, 62º 16' W) (Figure 1). Dolphins were accidentally caught in gillnets and shrimper gears all year round at 0.1-30.0 km offshore and 11-50 m depth. The sample survey took place during an incidental mortality estimation project carried out by the authors (Negri *et al*., 2012). A description of the fishing area, gear and effort might be found at Negri *et al*. (2012).

We worked in collaboration with the artisanal fishermen who were asked not to discard the incidentally captured dolphins. Retrieved carcasses were kept in freezer (-20ºC) until necropsy was performed at the laboratory. During necropsies, standard information

on sex, weight and body external measurements (following Norris, 1961) were recorded systematically by the authors. The protocol of the necropsies was carried out following Winchell (1982).

Age

The age of 51 individuals was estimated by counting of growth layer groups (GLGs) in histological sections of teeth following the protocol of Pinedo & Hohn (2000) with *ad hoc* modifications (Negri, 2010). The teeth were decalcified in the commercial acid mix RDO® and sectioned in a cryostat at -21ºC. The 25 µm sections were stained with Mayer's Haematoxylin and mounted in slides with glycerine.

Sex ratio

The significance of differences in male and female sex ratios was tested by a chi-square test, both within the whole sample and within categories of sexual and physical maturity.

Sexual maturity

Sexual maturity was estimated through histological procedures for 25 males and 21 females following Harrison *et al*. (1981) and Danilewicz (2003) for females and Hohn *et al*. (1985) and Danilewicz *et al*. (2004) for males. During necropsy, the gonads were weighed to the nearest 0.1 g, measured to the nearest 0.01 cm and fixed in 10% formalin. The histological preparations followed standard protocols including inclusion of a 2–3 mm gonad block in Histoplast®, sectioning in 4–7 µm-thick slides by microtome, staining with haematoxylin and eosin, and inspection by a compound microscope at magnifications from 40 to 1000x. Because histological preparations were not feasible for three males, sexual maturity was inferred for them from morphometric parameters (Danilewicz *et al*., 2004) as follows:

Combined testes weight: CTW = rTW + lTW (g)

Testicular maturity index: IM = CTW / CTL (g/mm)

Where: r/lTW = right/left testis weight (g); CTL = combined testis length = rTL + lTL (mm); r/lTL = right/left testis length (mm).

Male dolphins were considered sexually mature for CTW $\geq$ 5.0 g and IM $\geq$ 0.08 (Danilewicz *et al*., 2004).

Because the symmetry in the external morphology of franciscana testes has been confirmed previously (Danilewicz *et al.*, 2004), if one gonad was missing we assumed it had the same characteristics as the remaining one.

Physical maturity

Physical maturity was established according to the degree of fusion of epiphyses to the vertebral *centra*. After removal of flesh, carcasses were boiled to be skeletonized. Once clean, the vertebral column was set in order and we determined the degree of fusion of each epiphysis to its vertebral centrum as: degree 1 = epiphyses completely unfused; degree 2 = epiphyses partially fused to the vertebral centrum; degree 3 = epiphyses fused to the vertebral centrum with visible line of fusion; degree 4 = epiphyses fused to the vertebral centrum without visible line of fusion. Dolphins were considered to be physically mature with 90% of the epiphyses fused to the vertebral centrum (degree 3 and/or 4) (Negri, 2010).

Body condition

In order to establish the body condition of each specimen, three relative indexes were used: Kn, fat index and liver index.

The relative index Kn measure the individual variations from the expected weight for length of an individual as indications of general 'well-being' and have been frequently studied under the general name of “condition” (Le Cren, 1951). In this sense, body condition was calculated for each individual as follows: $Kn = W_o / W_e$. Where W_o is the

measured total wet weight of the animal (kg) and the W_e is the total weight estimated (kg) from a standard length-weight potential regression. The regression was calculated from 63 bycaught franciscana dolphins sampled by the authors in the same studied area (Negri, 2010). Where the condition index is $Kn \geq 1$, the individual is deemed healthy while individuals with a condition index less than 1 is deemed underweight or unhealthy (Nilssen *et al.,* 1997; Caon, 1998; de Araujo, 2005; Reyes–Küppers, 2007, Panebianco *et al.*, 2012b).

The fat index was determined from the contribution in percentage of the total weight of the fat in the blubber W_f (g), to the total body mass W_o (g): Fat index = $W_f / W_o * 100$.

To analyse the fat index (Hanks, 1981), the left blubber layer was removed from the carcasses from the area around the ears to the caudal peduncle, excluding the dorsal and pectoral fins, and weighed. Thus, the total blubber weight was the double of this measure as it was considered that the blubber of the right and left sides of the dolphins was equal. For those specimens for which total blubber weight was not available (because of logistic issues or incomplete animals), it was estimated with the linear regression: $\text{Log}_{\text{BlubberWeight}} = (\text{Log}_{\text{AxillaryGirth}} - 0.741) / 0.284$ ($R^2 = 0.874$; $p < 0.001$). This regression was performed for both sexes combined as there were not significant gender differences (slope comparison t test, $p = 0.882$). The variable "axillary girth" is the girth with the greatest correlation with the total blubber weight of franciscana dolphins from the studied area (Negri, 2010).

The liver index was calculated from the contribution in percentage of the weight of the liver W_l (g) to the total body mass W_o (g): Liver index = $W_l / W_o * 100$. This index has been reported as a suitable body condition index for porpoises (Das *et al*., 2004) and franciscanas (Foglia, 2008) as it is not linked to the age or length of the dolphins.

Each relative body condition index was compared between sexes and sexual maturity with the non parametric test Mann Whitney U test as the samples groups did not follow a normal distribution. Moreover, our results were compared with the available results (mean ± SD) presented for neighbour areas (Rodríguez *et al*., 2002; Kamiya & Yamasaki, 1974) by t test.

RESULTS

Age and Length

The standard length for female franciscanas ranged from 78.70 to 160.50 cm (mean = 121.75, SD = 21.20, n = 22), and for males from 81.50 to 141.50 cm (mean = 117.33 cm, SD = 14.45, n = 32).

The oldest individual in our sample was a 13 years old male with a standard length of 141.5 cm and 23.1 kg of weight. The oldest females were two 8 years old dolphins; one with 160.5 cm of length and 38.2 kg of weight and the other, a pregnant individual with 149.0 cm of length and 52.0 kg of weight.

Sixty nine percent of the dolphins were juveniles less than 4 years old, 41% of which were males (Figure 2). The age frequency distribution was unimodal with a peak in ages 1 to 3 years for males and age 1 for females (Figure 2).

Sex Ratio

The sex ratio, 32 males: 22 females, did not differ from parity in the whole sample (χ^2, p = 0.174).

Sexual Maturity

A total of 74% of the dolphins examined in this study were immature. Males and females contributed equally to that fraction (χ^2, p = 0.739). Throughout the surveyed period, three pregnant females were registered. They were captured between November

and February and had 142.0–150.0 cm of standard length, 26.85–52.00 kg of weight, and 4–8 years of age. An 8 year old lactating female was also recorded with large amounts of milk in its mammary glands. This individual was 160.5 cm long and weighted 38.2 kg.

The seasonal frequency of mature and immature individuals showed that the proportion of dolphins of different sexual maturity stages was equal (67% of immature) within summer, autumn and winter but a higher frequency of immature animals (86%) were registered during the spring (September-November, Figure 3). However, the low sample size of mature animals precluded testing significant differences.

The age, standard length and weight of sexually mature and immature dolphins are presented in Table 1.

Physical Maturity

A total of 85% of the entangled franciscana dolphins were physically immature according to the analyses of the vertebral epiphyses. The proportion of physically immature males and females was not statistically different (50% males, 35% females, χ^2, $p = 0.238$).

The age, standard length and weight of physically mature and immature dolphins are presented in Table 2.

Body Condition

No statistical differences between sexes for the allometric coefficient *b* of the weight (W) - length (TL) curve were found (slope comparison t test, $p = 0.381$). Therefore, sexes were pooled in computing the following weight-length relationship: W_e (kg) = $0.0009 * TL\ (cm)^{2.1184}$; $R^2 = 0.827$ (Figure 4).

The relative body condition index Kn of the sampled dolphins oscillated between 0.78 and 1.44. The fat index ranged from 7.37% to 49.01%, the lowest value was registered

by a sexually mature male and the highest by an immature female. The relative liver index fluctuated between 0.97%–4.64%. A comparison of the three indexes by sex and sexual maturity (Table 3) did not reveal significant differences: Mann Whitney U tests, Kn $p_{F-M} = 0.071$, $p_{I-M} = 0.564$; Fat index $p_{F-M} = 0.115$, $p_{I-M} = 0.090$; Liver index $p_{F-M} = 0.424$, $p_{I-M} = 0.271$ (F-M: females-males; I-M: immature-mature).

Contrasting with neighbour areas, the values of Kn presented here were not significantly different (t test, p = 0.084) from those obtained by Rodríguez *et al*. (2002) for the franciscanas entangled of northern Buenos Aires province (1.028 ± 0.120; n = 41). A significant difference was found in the fat index mean value of the franciscanas off the northern coast of Buenos Aires (Rodríguez *et al*., 2002), where values were higher (mean = 37.1, SD = 5.87, n = 10) than those reported here in this study (t test, p = 0.001). Finally, the mean liver index reported here did not differ from the mean value of the northern coast of the province (t test, p = 0.787). Moreover, comparisons made by sex with a small sample size of Uruguayan franciscanas also did not show differences among the studies in the liver index (females: 2.54 ± 0.30, t test p = 0.665; males: 2.67 ± 0.30, t test p = 0.558, Kamiya & Yamasaki, 1974).

DISCUSSION

Understanding the age distribution of incidentally killed animals is key to the evaluation of impacts of artisanal fisheries on incidental mortality of franciscana dolphins *Pontoporia blainvillei* (Crespo *et al*., 1997; Secchi & Fletcher, 2004). This information, if subject to careful treatment to reduce bias, may also be useful in the estimation of approximate survival rates (Secchi & Fletcher, 2004) and valuable for species risk assessments.

An assessment of the age distribution of the bycatch can also be relevant to understanding which age classes are more vulnerable. Previous studies have shown that juveniles appear to be most susceptible to fishing nets along the whole range of the species. For example, 62% of the franciscana dolphins captured in Uruguay and in southern Brazil (Pinedo & Hohn, 2000) were estimated to be less than 4 years old. This is consistent with findings for the Buenos Aires province, where 64% of the entangled franciscanas along the southern coast (Corcuera *et al*., 1994) and 67.5% of those measured along the northern coast (Denuncio, 2012) were younger than 4 years of age. Similarly, in the sample studied in this paper, over 60% of the entangled individuals were under age 4.

Some authors (e.g. Perrin *et al*., 1994; Danilewicz *et al*, 2004) have postulated that the higher proportion of young animals entangled in bycatch may be a consequence of behavior as compared to older (mature) individuals. The lack of familiarity of young dolphins with fishing nets could lead to behaviours tied to curiosity that could make these individuals more prone to entanglement. However, it is not empirically known whether this applies to franciscana. Furthermore, because population age distributions remain unknown, it is not possible to assess the reasons for juvenile-biased incidental catches.

More than 70% of the individuals captured in the study area from 1988–1992 (Corcuera, 1996) and 2003–2009 (this study) were sexually immature. In contrast, only 13% of the specimens entangled were sexually mature females. Even though immature animals were present in all seasons, small sample sizes in winter and autumn preclude robust conclusions in regards to seasonal variation in the proportion of mature and immature animals in the bycatch. The higher proportion of sexually immature individuals during spring coincide with the breeding season of the species in

Argentinean waters and are in line with observations of other authors (Bordino *et al*., 1999; Faillá *et al*., 2012; Denuncio *et al.*, 2013). The fact that more immature dolphins were captured during spring could be influenced by seasonal differences in artisanal fishing effort, since the number of fishing days and vessels usually increases during the spring and summer (Cappozzo *et al*., 2007, Negri *et al*., 2012), possibly leading to higher bycatch. On the other hand, it has been shown that there is age and sex segregation in some bays along the Argentinean coast, with juveniles found in shallower waters. It has also been shown that a seasonal distribution pattern may occur, with inshore movements during spring and summer (Bordino *et al*., 1999; Bordino & Albareda, 2004). Unfortunately, it is not yet known if the same patterns occur in open-ocean habitats like the one studied here, but a combination of these hypotheses (differences in fishing effort and use of habitat) might explain higher frequencies of immature individuals entangled during the spring.

A greater proportion of sexually immature franciscanas found in the bycatch at the southern end of their range suggests that the impact of the fisheries is not important as it would be if more mature animals were present (Caughley, 1977; Caswell, 2001). A risk assessment conducted with a species of relatively similar life history (Hector's dolphins, *Cephalorhynchus hectori* - Slooten *et al*., 2000) concluded that high levels of mortality of sexually mature animals increase extinction risk. Gearin *et al*. (1994), in assessing interactions between the harbour porpoise, *Phocoena phocoena*, and the salmon fisheries of Washington, USA, noted that 63% of the bycatch involved immature individuals. The authors also suggested that, in the short-term, this may result in a lower impact on populations than bycatch of mature individuals. However, they highlighted the potential future detrimental impacts on recruitment, specially in species with low

reproductive rates and relatively short life spans that limit reproductive flexibility, particularly with respect to a denso-dependent response to high levels of mortality.

The maximum age for *Pontoporia blainvillei* was recorded for the area of Uruguay, a female of 21 years (Pinedo & Hohn, 2000). The oldest reported male was 17 years old in Rio Grande de Sul, Brazil (Botta *et al.*, 2010). In the sample of southern Buenos Aires studied in this work, the oldest individual was a male of 13 years. Considering the age of sexual maturity and the reproductive rate of the species, the average franciscana may have between 5 and 10 offspring (Danilewicz, 2003) during a lifetime. Therefore, the species reproductive flexibility might be limited under population impacts caused by incidental mortality in gillnets.

The ages determined for mature males and females of the studied sample in southern Buenos Aires, would seem to coincide with the age estimates of attainment of sexual maturity (ASM) estimated by the species in the region. Most sexually mature dolphins had higher or equal ages than these estimates ($ASM_{females}$ = 4.3–4.5 years, Corcuera, 1996; ASM_{males} = 2.92–3.54, Panebianco *et al*., 2012a).

As physical maturity of these dolphins occurs a few years after sexual maturity (Corcuera, 1996; Botta, 2005), a higher percentage of physically immature individuals was expected to be accidentally captured. 83% of the entanglements observed in this study corresponded to specimens that had not reached 90% of vertebral epiphyses fusion to the vertebral centra, that is, were physically immature.

Even though incidental mortality appears to be biased towards young individuals, there does not seem to be a deviation within regards to sex ratio as the proportion of females and males sampled in this study is not statistically different from parity. This is consistent with studies of other cetacean species that also suffer from incidental catch in gillnets (e.g. bottlenose dolphins *Tursiops truncatus* [Cockcroft, 1992], and Chilean

dolphin *Cephalorhynchus eutropia* [Dawson, 1991]) and indicates that both sexes are equally vulnerable to bycatch. Differences found in the sex ratio of franciscana dolphins captured in fishing nets appear to be explained by other factors. For example, between 1988 and 1990 Corcuera *et al*. (1994) observed a male-bias in franciscana catches in southern Buenos Aires province. However, these authors speculated that this was likely linked to the difficulty of handling the larger-sized females which may, therefore, have been discarded by fishermen. So, comparisons of sex ratios might take into account this potential bias in behavior as well as potential changes of species habitat use, as discussed above.

Regarding the franciscana body condition, Palomares *et al*. (2008) found that values of *b* (allometric coefficient of W vs. TL) ranged between 2.31 and 3.97 for 53 species of marine mammals. The estimated *b* of franciscana dolphins in this study ($b = 2.118 \pm 0.124$) is closed to that range and is comparable to those reported for northern Buenos Aires ($b = 2.22$; Rodríguez *et al*., 2002) and for Rio Grande do Sul, Brazil ($b = 2.07$; Botta *et al*., 2006). Results presented showed that the mean relative index Kn is nearly 1. Therefore, it is likely that the body condition of the entangled franciscana does not suggest any type of nutritional disorder. In addition, consistent with the findings for the southern coast (this study), Rodríguez *et al.* (2002) did not observe differences in Kn between sexes and between immature and sexual mature bycaught individuals.

In cetaceans, the blubber layer constitutes the main source of energy reserves (Aguilar and Borrell, 1990). As postulated by Hanks (1981), the fat index can be considered a variation of energy reserves in the form of fat and an index of physiological condition of the animal and its relationship with the environment. Sexually mature individuals tend to have lower values of total body fat relative to body weight because they consume some of their energy reserves during breeding (Caon *et al*., 2007). On the other hand,

immature dolphins, expend much of their energy reserves to grow and maintain their body temperature because of their low surface area/volume ratios (Lockyer, 1995; Denuncio, 2012). Unlike the finding of Caon *et al*. (2007) for franciscana dolphins from southern Brazil, there were not significant differences between the fat index between sexes and sexual maturity stages from this study. These might be a consequence of the small number of sexually mature dolphins analysed. Also, the disparity found with northern Buenos Aires might be a consequence of many factors: the low number of bycaught dolphins analysed in the northern area, differences in the biological characteristics (age and length) of franciscanas, the diet of dolphins or environmental conditions of each area (southern vs. northern coast) or a combination of these factors.

Finally, as it was stated before, the liver index might also be considered a nutritional indicator. In mammals and birds, fasting results in a significant reduction of body and liver mass (Krämer *et al*., 1993, Debacker *et al*., 2000, 2001). Taking into account the absence of differences in this index among areas and its stability in the ontogeny of the species, the values reported here might reflect not only a similar nutritional status but also the actual liver to total body mass ratio of healthy fresh franciscanas.

Despite that histopathological analysis were not performed to the franciscana sampled, the body condition indexes studied indicate that gillnetting is not related to any sickness or deficiency in the physical condition of the dolphins in terms of physiology and nutrition. This is important because, captured dolphins may be considered a representative sample of a healthy population. Therefore, a study of the biology and ecology of franciscana based on entangled dolphins would not lead to biased results.

In contrast, as postulated by Lockyer (1995) stranded animals may include a high proportion of sick and those in poor body condition, whilst bycatch animals may be healthier. In this sense, Das *et al*. (2004) reported that the body condition of stranded

harbour porpoises was poor compared to that of by-catch individuals, as reflected by blubber thickness and hepatic to total body-mass ratio. Moreover, despite a small sample size, Negri (2010) found statistically lower Kn and fat index values for stranded franciscanas compared to bycaught ones. Our results might be used as baseline data to better establish the post-mortem and the health conditions of stranded animals.

In conclusion, results reported here are important in the assessment of the impacts of artisanal fisheries on the population of franciscana dolphins in the southernmost area of its distribution. This is particularly relevant because of the relative scarcity of information on biological parameters of franciscana in the coast of Argentina. Moreover, the data presented may provide a basis to assess potential temporal changes in population parameters, thus improving management of the franciscana in this area.

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REFERENCES

Aguilar A. and Borrell A. (1990) Patterns of lipid content and stratification in the blubber of fin whales (*Balaenoptera physalus*). *Journal of Mammalogy* 71, 544–554.

Bordino P. and Albareda D. (2004) Incidental mortality of Franciscana dolphin *Pontoporia blainvillei* in coastal gillnet fisheries in northern Buenos Aires, Argentina. Paper SC/56/SM11 presented at the *International Whaling Commission Meeting*, Sorrento, Italy.

Bordino P., Thompson G. and Iñiguez, M. (1999) Ecology and behaviour of the franciscana (*Pontoporia blainvillei*) in Bahía Anegada, Argentina. *Journal of Cetacean Research and Management* 1, 213–222.

Botta S. (2005) *Reprodução e crescimento dos machos de toninha (*Pontoporia blainvillei*) do Rio Grande do Sul, Brasil.* MSc. Thesis. Universidade Federal do Rio Grande, Rio Grande, Brazil.

Botta S., Muelbert M.M.C. and Secchi E.R. (2006) Morphometric relationships of franciscana dolphin, *Pontoporia blainvillei* (Cetacea), off Rio Grande do Sul coast, southern Brazil. *The Latin American Journal of Aquatic Mammals* 5, 117–123.

Botta S., Muelbert M.C., Secchi E.R., Danilewicz D., Negri M.F., Cappozzo H.L. and Hohn A. (2010) Age and growth of Franciscana Dolphin, *Pontoporia blainvillei*, (Cetacea) incidentally caught off southern Brazil and northern Argentina. *Journal of the Marine Biological Association of the United Kingdom* 90, 1493–1500.

Caon G. (1998) *Análise da condição corporal da franciscana,* Pontoporia blainvillei *(Gervais & D'Orbigny, 1844) (Mammalia,Cetacea), no litoral norte do Rio Grande do Sul*. Bch Thesis. Universidade Federal do Rio Grande do Sul. Porto Alegre.

Caon G., Fialho C.B. and Danilewicz D. (2007) Body fat condition in franciscanas (*Pontoporia blainvillei*) in Rio Grande do Sul, southern Brazil. *Journal of Mammalogy* 88, 1335–1341.

Cappozzo H.L., Negri M.F., Pérez F.H., Albareda D., Monzón F. and Corcuera J.F. (2007) Incidental mortality of Franciscana Dolphin, (*Pontoporia blainvillei*), in Argentina. *The Latin American Journal of Aquatic Mammals* 6, 127– 37.

Caswell H. (2001) Matrix population models: construction, analysis, and interpretation. Sinauer Associates, Inc., Sunderland, USA. 722 pp.

Caswell H., Brault S., Read A.J. and Smith T.D. (1998) Harbor porpoise and fisheries: an uncertainty analysis of incidental mortality. *Ecological Applications* 8, 1226–1238.

Caughley G. (1977) Analysis of vertebrate populations. Wiley-Interscience Publication, John Wiley & Sons, London, 234 pp.

Cockcroft V.G. (1992) Incidental capture of bottlenose dolphins (*Tursiops truncatus*) in shark nets: an assessment of some possible causes. *Journal of Zoology* 226, 123–134.

Corcuera J. (1994) Incidental mortality of Franciscanas in Argentine Waters: The threat of small fishing camps. *Reports of the International Whaling Commission* 15, 291–294.

Corcuera J. (1996) Edad de madurez sexual del delfín Franciscana en el Sur de la Provincia de Buenos Aires Argentina. *Abstracts of the VII Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur, Viña del Mar, Chile, 1996*, p. 39.

Corcuera J., Monzón F., Crespo E.A., Aguilar A. and Raga, J.A. (1994) Interactions between marine mammals and the coastal fisheries of Necochea and Claromecó (Buenos Aires Province, Argentina). *Reports of the International Whaling Commission* 15, 283–290.

Crespo E.A., Pedraza S., Dans S., Koen Alonso M., Reyes L.M., García N.A., Coscarella M. and Schiavini A.C.M. (1997) Direct and indirect effects of the highseas fisheries on the

marine mammals populatios in the northern and central Patagonian Coast. *Journal of Northwest Atlantic Fishery Science* 22, 189–207.

Crespo E.A., Harris G. and González R. (1998) Group size and distributional range of the Franciscana *Pontoporia blainvillei. Marine Mammals Science* 14, 845–849.

Crespo E.A., Pedraza S.N., Grandi M.F., Dans S.L. and Garaffo G.V. (2010) Abundance and distribution of endangered Franciscana dolphins in Argentine waters and conservation implications. *Marine Mammal Science* 26, 17-35.

Danilewicz D. (2003) Reproduction of female Franciscana (*Pontoporia blainvillei*) in Rio Grande do Sul, Southern Brazil. *The Latin American Journal of Aquatic Mammals* 2, 67–78.

Danilewicz D., Claver J.A., Pérez Carrera A.L., Secchi E.R. and Fontoura N. (2004) Reproductive biology of male franciscanas (*Pontoporia blainvillei*) (Mammalia: Cetacea) from Rio Grande do Sul, southern Brazil. *Fishery Bulletin* 102, 581–592.

Das K., Siebert U., Fontaine M., Jauniaux T., Holsbeek L. and Bouquegneau J.M. (2004) Ecological and pathological factors related to trace metal concentrations in harbour porpoises *Phocoena phocoena* from the North Sea and adjacent areas. *Marine Ecology Progress Series* 281, 283–295.

Dawson S. (1991) Incidental catch of Hector's dolphins in inshore gillnets. *Marine Mammals Science* 7, 283–295.

de Araujo, D.M. (2005) A *camada de gordura das toninhas,* Pontoporia blainvillei *(Mammalia, Cetacea) no litoral sul do RS: variação na espessura e na composição de ácidos graxos em resposta a fatores ambientais e fisiológicos*. MSc. Thesis. Universidade Federal do Rio Grande, Rio Grande, Brazil.

Debacker V., Jauniaux T., Coignoul F. and Bouquegneau J.M. (2000) Heavy metal contamination and body condition of wintering guillemots (*Uria aalge*) at the Belgian coast from 1993 to 1998. *Environmental Research* 84, 310–317.

Debacker V., Rutten A., Jauniaux T., Daemers C. and Bouquegneau J.M. (2001) Combined effects of experimental heavy-metal contamination (Cu, Zn, and CH3-Hg) and starvation on

quail's body condition. Parallelism with a wild common guillemot population found stranded at the Belgian coasts. *Biological Trace Element Research*, 87:82–107.

Denuncio, P. (2012) *Biología y conservación del delfín del Plata (Pontoporia blainvillei) en el sector costero bonaerense.* PhD Thesis. Universidad Nacional de Mar del Plata, Buenos Aires, Argentina.

Denuncio P., Bastida R., Danilewicz D., Moron S., Rodriguez Heredia S. and Rodríguez D. (2013) Calf chronology of the franciscana dolphin: birth, lactation and onset on feeding ecology in coastal waters of Argentina. *Aquatic Mammals* 39: 73-80.

Di Beneditto A.P.M., Ramos R.M.A. and Lima N.R.W. (1998) Fishing activity in northern Rio de Janeiro State (Brazil) and its relation with small cetaceans. *Brazilian Archive of Biology and Technology* 41, 296–302.

Failla M., Seijas V.A., Espósito R. and Iñíguez M.I. (2012) Franciscana dolphins, *Pontoporia blainvillei*, of the Río Negro Estuary, Patagonia, Argentina. *Marine Biodiversity Records* 5, e102 doi:10.1017/S1755267212000875.

Foglia M. (2008) *Niveles de mercurio y cadmio en franciscana Pontoporia blainvillei, a lo largo de la costa Uruguaya*. Graduate Thesis. Universidad de la República, Montevideo, Uruguay.

Franco-Trecu V., Costa P., Abud C., Dimitriadis C., Laporta P., Passadore C. and Szephegy M. (2009) By-catch of franciscana *Pontoporia blainvillei* in uruguayan artisanal gillnet fisheries: an evaluation after a twelve-year gap in data collection. *The Latin American Journal of Aquatic Mammals* 7, 11–22.

Gearin P.J., Melin S.R., De Long R.L., Kajimura H. and Johnson M.A. (1994) Harbor porpoise interactions with a chinook salmon fishery in Washington State. *Reports of the International Whaling Commission* 15, 427–438.

Hanks J. (1981) Characterization of population condition. In Fowler C.W., Smith T.D. (eds.) *Dynamics of Large Mammal Populations.* New York, United States of America: John Wiley & Sons, pp. 47–73.

Harrison R.J., Bryden M.M., McBrearty D.A. and Brownnell Jr. R.L. (1981) The ovaries and reproduction in *Pontoporia blainvillei* (Cetacea: Platanistidae). *Journal of Zoology* 193, 563–580.

Hohn A.A., Chiver S.J. and Barlow J. (1985) Reproductive maturity and seasonality of male spotted dolphins, *Stenella attenuata*, in the eastern tropical pacific. *Marine Mammals Science* 1, 273–293.

Kamiya T. and Yamasaki F. (1974) Organ weights of *Pontoporia blainvillei* and *Platanista gangetica* (Platanistidae). Scientic Reports of theWhales Research Institute, 26, 265-270.

Kasuya T. and Brownell Jr. R.L. (1979) Age determination, reproduction and growth of the franciscana dolphin, *Pontoporia blainvillei. Scientific Reports of the Whales Research Institute* 31, 43–67.

Krämer K, Markwitan A, Menne A and Pallauf J (1993) Zinc metabolism in fasted rats. *Journal of trace elements and electrolytes in health and disease* 7, 141–146.

Le Cren E.D. (1951) The length-weigth relationship and seasonal cycles in gonad weigth and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology* 20, 201–219.

Lockyer C.H. (1990) The importance of biological parameters in population assessments. *Northatlantic Studies* 2, 22-31

Lockyer C.H. (1995) Aspects of the morphology, body fat condition and biology of the harbour porpoise, *Phocoena phocoena*, in British waters. *Reports of the International Whaling Commission* 16, 199–209.

Murphy S., Winship A., Dabin W., Jepson P.D., Deaville R., Reid R.J., Spurrier C., Rogan E., López A., González A., Read F., Addink M., Silva M., Ridoux V., Learmonth J.A., Pierce G.J. and Northridge S.P. (2009) Importance of biological parameters in assessing the status of *Delphinus delphis*. *Marine Ecology Progress Series*, 388: 273-291.

Negri M.F. (2010) *Estudio de la biología y ecología del delfín franciscana,* Pontoporia blainvillei, *y su interacción con la pesquería costera en la provincia de Buenos Aires*. PhD Thesis. University of Buenos Aires, Buenos Aires, Argentina.

Negri M.F., Denuncio P., Panebianco M.V. and Cappozzo, H.L. (2012) Bycatch of franciscana dolphins *Pontoporia blainvillei* and the dynamic of artisanal fisheries in the species' southernmost area of distribution. *Brazilian Journal of Oceanography* 60, 151–160.

Nilssen K.T., Haug T., Grotnes P.E. and Potelov V. (1997) Seasonal variation in body condition of adult Barents Sea harp seals (Phoca groenlandica). *Journal of the Northwest Atlantic Fisheries Science* 22, 17–25.

Norris K.S. (1961) Standardized methods for measuring and recording data on the smaller cetacea. *Journal of Mammalogy* 42, 471–476.

Palomares M.L.D., Sorongon P.M.E., Hunter A. and Pauly D. (2008) Growth of marine mammals. In Palomares M.L.D. and Pauly D. (eds.) *Von Bertalanffy Growth Parameters of Non-Fish Marine Organisms.* Fisheries Centre Research Reports 16, Fisheries Centre: University of British Columbia, Canada, pp. 2–26.

Panebianco M.V., Negri M.F. and Cappozzo H.L. (2012a). Reproductive aspects of male franciscana dolphins (*Pontoporia blainvillei*) off Argentina. *Animal Reproduction Science* 131, 41-48.

Panebianco M.V., Botte S.E., Negri M.F., Marcovecchio J.E. and Cappozzo H.L. (2012b) Heavy Metals in Liver of the Franciscana Dolphin, *Pontoporia blainvillei*, from the Southern Coast of Buenos Aires Province, Argentina. *Journal of the Brazilian Society and Ecotoxicology* 7(1), 33-41.

Perrin W.F., Donovan G.P. and Barlow J. (1994) Report of the workshop on mortality of cetaceans in passive fishing nets and traps. *Reports of the International Whaling Commission* 15, 6–57.

Pinedo M.C. (1994a) Review of small cetacean fishery interactions in southern Brazil with special reference to the franciscana, *Pontoporia blainvillei*. *Reports of the International Whaling Commission* 15, 251–259.

Pinedo M.C. (1994b) Impact of incidental fishery mortality on the age structure of *Pontoporia blainvillei* in Southern Brazil and Uruguay. *Reports of the International Whaling Commission* 15, 261–264.

Pinedo M.C. and Hohn A.A. (2000) Growth layer patterns in teeth from the franciscana, *Pontoporia blainvillei*: developing a model for precision in age estimation. *Marine Mammals Science* 16, 1–27.

Prado J.H.F., Secchi E.R. and Kinas P.G. (2013) Mark-recapture of the endangered franciscana dolphin (*Pontoporia blainvillei*) killed in gillnet fisheries to estimate past bycatch from time series of stranded carcasses in southern Brazil. *Ecological Indicators* 32, 35–41.

Reeves R., Dalebout M., Jefferson T.A., Karkzmarski L., Laidre K., O'Corry-Crowe G., Rojas-Bracho L., Secchi E., Slooten E., Smith B.D., Wang J.Y., Zerbini A.N. and Zhou, K. (2012) *Pontoporia blainvillei*. In IUCN 2012. IUCN Red List of Threatened Species.

Reyes-Küppers K. (2007) *Ecology and behavior o the Southern river otter Lontra provocax Thomas 1908 in Chile.* PhD thesis. University of Osnabrück, Germany.

Rodríguez D., Rivero L. and Bastida R. (2002) Feeding Ecology of the Franciscana (*Pontoporia blainvillei*) In Marine and Estuarine Waters of Argentina. *The Latin American Journal of Aquatic Mammals* 1, 77–94.

Rosas F.C.W., Monteiro Filho E.L.A. and Oliveira M.R. de. (2002) Incidental catches of Franciscana (*Pontoporia blainvillei*) on the Southern Coast of São Paulo State and the coast of Paraná State, Brazil. *The Latin American Journal of Aquatic Mammals* 1, 161–167.

Secchi, E. R. (2006). *Modelling the population dynamics and viability analysis of franciscana (Pontoporia blainvillei) and Hector's dolphins (Cephalorhynchus hectori) under the effects of bycatch in fisheries, parameter uncertainty and stochasticity.* PhD Thesis. University of Otago.

Secchi E.R. and Fletcher D. (2004). Estimating survival rates of franciscana by fitting the Siler model to data on age-at death of beachcast and bycatch and by a modeling approach using life tables of similar species: a comparison. *International Whaling Commission*, Scientific Committee Paper SC/56/SM16.

Secchi E.R., Danilewicz D. and Ott P.H. (2003a) Applying the phylogeographic concept to identify franciscana dolphin stocks: implications to meet management objectives. *Journal of Cetacean Research and Management* 5, 61-68.

Secchi E.R., Ott P.H. and Danilewicz D. (2003b) Effects of fishing by-catch and conservation status of the franciscana dolphin, *Pontoporia blainvillei*. In Gales N., Hindell M. and Kirkwood R. (eds) *Marine mammals: fisheries, tourism and management issues*. CSIRO Publishing, Collingwood, Australia, pp. 174-191.

Siciliano S. (1994) Review of small cetaceans and fishery interactions in coastal waters of Brazil. *Reports of the International Whaling Commission* 15, 241–250.

Slooten E., Fletcher D. and Taylor B.L. (2000) Accounting for uncertainty in risk assessment: case study of Hector's dolphin mortality due to gillnet entanglement. *Conservation Biology* 14, 1264–1270.

Winchell J.M. (1982) *Field manual for small cetacean dissection.* Bar Harbor, Maine: College of the Atlantic.

Fig. 1. Study area (shaded in grey) in southern Buenos Aires, Argentina.

Fig. 2. Age frequency distribution of the bycaught franciscana dolphins off southern Buenos Aires province in the period 2003–2009.

Fig. 3. Absolute frequency of the bycaught franciscana dolphins per season, sex (F: females, M: males) and sexual maturity.

Fig. 4. Standard length (TL) - weight (W) relationship of franciscana dolphins off southern Buenos Aires.

Table 1. Age (n = 46), standard length (TL) (n = 49) and weight (n = 48) of the sexually mature (M) and immature (I) franciscana dolphins bycaught in artisanal fisheries off southern Buenos Aires province.

	Sexual Maturity	Age			TL (cm)			Weight (kg)		
		Mean (SD)	Range	n	Mean (SD)	Range	n	Mean (SD)	Range	n
Males	I	1.69 (1.14)	0–4	16	110.84 (12.70)	81.50–135.20	19	18.59 (4.08)	9.87–23.00	19
	M	5.56 (3.40)	2–13	9	129.58 (7.48)	120.00–141.50	9	24.90 (5.26)	19.37–35.20	8
	Total	3.08 (2.87)	0–13	25	116.86 (14.27)	81.50–141.50	28	20.46 (5.25)	9.87–35.20	27
Females	I	2.06 (1.52)	0–5	17	116.68 (17.21)	78.70–147.00	17	22.20 (6.61)	8.40–32.20	17
	M	6.25 (2.06)	4–8	4	150.38 (7.63)	142.00–160.50	4	38.42 (10.35)	26.85–52.00	4
	Total	2.86 (2.31)	0–8	21	123.10 (20.72)	78.70–160.50	21	25.29 (9.68)	8.40–52.00	21

n, sample size; SD, standard deviation.

Table 2. Age (n = 51) and standard length (TL, n = 54) of the physically mature (M) and immature (I) franciscana dolphins bycaught in artisanal fisheries off southern Buenos Aires province.

	Physical maturity	Age			TL (cm)		
		Mean (SD)	Range	n	Mean (SD)	Range	n
Males	I	2.04 (1.20)	0–4	24	115.06 (14.23)	81.50–139.00	27
	M	7.60 (3.29)	5–13	5	129.58 (8.88)	120.00–141,50	5
Females	I	2.11 (1.52)	0–5	19	116.78 (18.14)	78.70–147.00	19
	M	7.00 (1.73)	5–8	3	153.17 (6.37)	149.00–160.50	3

n, sample size; SD, standard deviation.

Table 3. Relative body condition indexes: Kn (n = 52), Fat Index (%) (n = 51) and Liver Index (%) (n = 50) of franciscana dolphins bycaught in artisanal fisheries off southern Buenos Aires province. Comparisons of the three indexes by sex and sexual maturity did not reveal significant differences (Mann Whitney U tests, $p > 0.05$).

		Kn	n	Fat Index	n	Liver Index	n
Females		1.02 (0.16)	22	30.24 (8.04)	21	2.65 (0.68)	21
Males		0.95 (0.12)	30	27.57 (6.92)	30	2.52 (0.60)	29
Immature		0.98 (0.13)	36	29.90 (6.52)	35	2.62 (0.63)	35
Mature		0.97 (0.18)	12	24.89 (9.74)	12	2.41 (0.31)	12
Females	Immature	1.01 (0.14)	17	30.39 (8.36)	16	2.66 (0.75)	17
	Mature	1.04 (0.27)	4	29.05 (8.85)	4	2.61 (0.24)	4
Males	Immature	0.96 (0.12)	19	29.50 (4.66)	19	2.58 (0.51)	18
	Mature	0.93 (0.12)	8	22.80 (10.04)	8	2.31 (0.31)	8
Total		0.98 (0.14)	52	28.67 (7.44)	51	2.57 (0.63)	50

n, sample size; mean (SD, standard deviation).

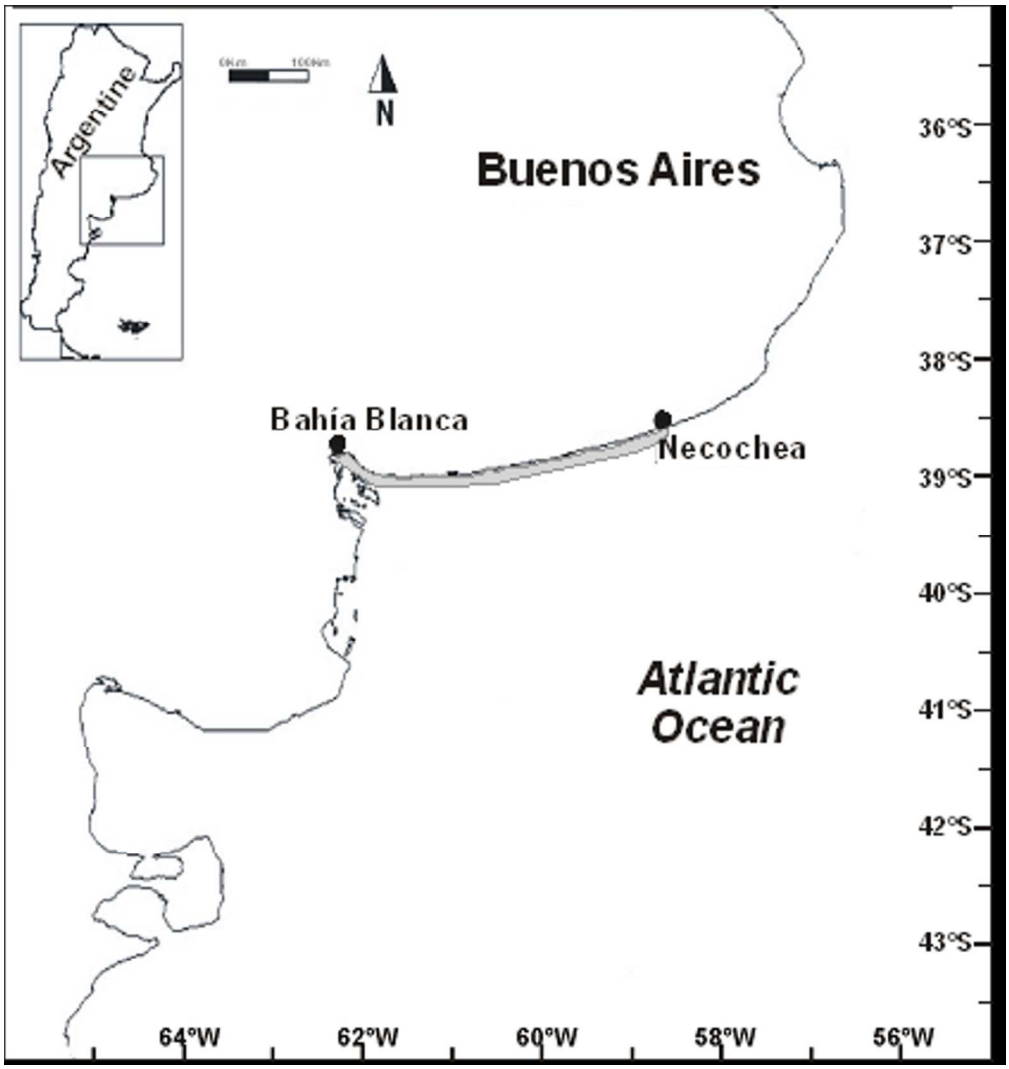


Fig. 1. Study area (shaded in grey) in southern Buenos Aires, Argentina.

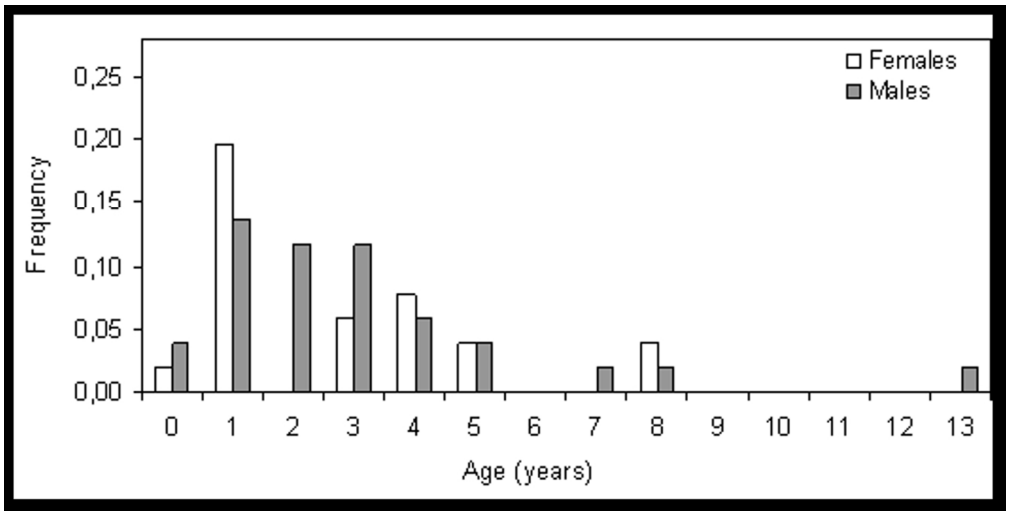
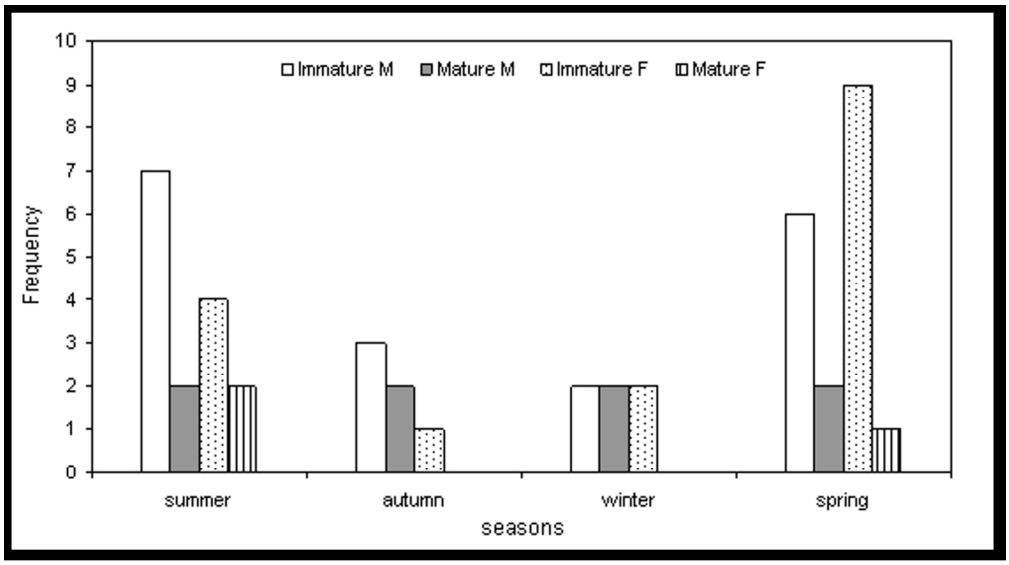


Fig. 2. Age frequency distribution of the bycaught franciscana dolphins off southern Buenos Aires province in the period 2003–2009.



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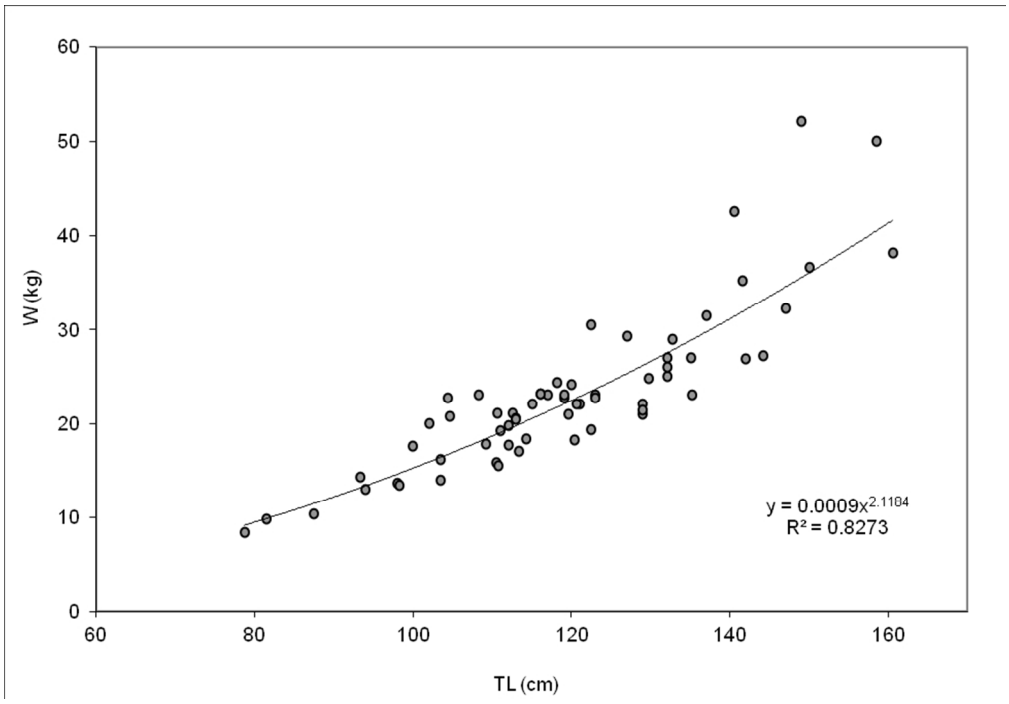

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