Habitat use patterns of franciscana dolphins (*Pontoporia blainvillei*) off southern Brazil in relation to water depth

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The patterns of habitat use by the franciscana dolphins (*Pontoporia blainvillei*) along its distribution are poorly known. This study investigates the patterns of habitat use with respect to depth for 181 individuals of different age, size, gender and reproductive condition off Rio Grande do Sul, southern Brazil. The results reveal that franciscanas are very homogeneously distributed according to depth. Individuals from all lengths utilize nearly the entire range of depths of the surveyed area. Larger or older animals do not use deeper waters than younger animals, indicating that body size and age are not limiting factors for franciscanas that occupy deeper or offshore waters. Gestation seems to not cause a change in the distribution of females. Although the sex-ratio of the overall data did not vary from 1:1 in different depth intervals, a small-scale comparison between the northern and southern coast demonstrated the existence of some kind of sexual segregation. Franciscana by-catch in Rio Grande do Sul is not sustainable and it is agreed that management procedures are needed. Nevertheless, the available data on species distribution do not allow the designing of a protected area in order to minimize the by-catches of a particular sex/reproductive class.

Keywords: habitat use, *Pontoporia blainvillei*, southern Brazil, water depth, incidental catches, sex-ratio

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INTRODUCTION

The franciscana, *Pontoporia blainvillei*, is a small dolphin endemic to shallow, coastal waters of tropical and temperate regions along the coasts of Brazil, Uruguay and Argentina (Crespo et al., 1998; Siciliano et al., 2002). Although it has been considered to be a member of the so-called river dolphins, franciscanas are found mainly in coastal marine waters with occasional occurrences in estuaries, being relatively common on the La Plata River estuary (Praderi, 1986; Rodriguez et al., 2002).

The preference for coastal waters makes the species vulnerable to the human activities. Incidental catches in fishing gears, especially gillnets and trammel nets, have been reported throughout its range, and the franciscana has been regarded as the most endangered small cetacean of the south-western Atlantic Ocean (Secchi et al., 2003a). On the coast of Rio Grande do Sul, southern Brazil, this species has been experiencing an intense by-catch in gillnets for at least three decades (Praderi et al., 1989; Moreno et al., 1997; Secchi et al., 1997a; Ott et al., 2002). The annual mortality of franciscanas in this region was estimated to be ranging from several hundreds up to around one thousand individuals (Secchi et al., 1997a, 2004; Ott, 1998; Ott et al., 2002). The estimated mortality rates outnumber the potential rate of population increase, suggesting that a population decline is likely due to persisting levels of human-induced mortality (Secchi, 2006).

For this reason, the population inhabiting the coast of Rio Grande do Sul and Uruguay (Franciscana Management Area III, see Secchi et al., 2003b) has been recently classified as Vulnerable by the IUCN Red List of Threatened Species (IUCN, 2008).

Due to the species avoidance of engine-powered boats, its small size, its inconspicuous colour pattern, and small group size, sightings of franciscanas in the wild are very rare. The only locations where franciscanas have been sighted regularly are some bays in Argentina and southern Brazil (Bordino, 2002; Cremer & Simões-Lopes, 2005). Presenting a very distinct situation of these localities, the Rio Grande do Sul coast is composed of almost continuous sandy beaches along 620 km, with no bay or inlet with protected waters. Although more than 150 surveys were made by experienced marine mammal researchers, onboard engine-powered fishing boats in this area to verify marine mammal–fishery interactions, no free-swimming franciscana were sighted. Surprisingly, levels of by-catch are high in the area (e.g. Ott et al., 2002).

The patterns of habitat use by the franciscana are poorly known. Past studies of incidental catches along the southern...
portion of its range (Uruguay and southern Brazil) have indicated that the species is distributed mainly to a maximum depth of 30 m, which usually corresponds to a distance of about 25–30 nautical miles from the coast (Pinedo et al., 1989; Moreno et al., 1997; Secchi et al., 1997a). Two previous studies that analysed the franciscana by-catch locations have proposed the existence of some degree of spatial segregation by water depth for the species (Secchi et al., 1997b; Rosas et al., 2002). However, little is still known how animals of different sexes, age, size or reproductive status are distributed within the species-range, or whether there is or not any sort of segregation among them. Such information is certainly essential to design a management plan for this vulnerable population.

This study was outlined to meet some of these shortcomings on the habitat use patterns of franciscanas. The hypothesis of a differential distribution in water depth is tested. Latitudinal variation to the northern and southern coast of Rio Grande do Sul, on the sex-ratio was also tested for incidence of a differential distribution in water depth is tested. The hypothesis of a differential distribution in water depth is tested. The habitat use analysis of the testes according to Hohn et al. (1985) as follows: (i) immature—seminiferous tubules containing mainly spermatogonias. Abundant interstitial tissue between the seminiferous tubules and lumen totally closed; (ii) pubertal—seminiferous tubules containing spermatogonias and spermatocytes. Less interstitial tissue present between the seminiferous tubules than in immature animals. The lumen is partially opened; and (iii) mature—seminiferous tubules containing spermatogonias, spermatocytes, spermatids and, in many times, spermatooza. Interstitial tissue is almost non-existent between the seminiferous tubules. The lumen is totally opened.

The determination of female reproductive status followed the criteria recommended by the International Whaling Commission (Perrin & Donovan, 1984) after the macroscopic and histological analysis of the ovaries, uterus and mammary glands. Females with no corpora lutea (CL) or albicania (CA) in the ovaries were classified as sexually immature. Females with at least one CL or CA in one ovary, denoting a past ovulation, were classified as sexually mature. Females were considered lactating if milk was detected in the mammary glands. The presence of a foetus in the uterus was used as criterion of pregnancy.

In order to increase the sample size of animals with known reproductive status for the habitat use analysis, dolphins for which the gonads could not be collected had their reproductive status determined indirectly based on the average age and length at sexual maturity and their upper and lower limits for females (Danilewicz, 2003) and males (Danilewicz et al., 2004). For the females, individuals smaller than 130.0 cm in length or aging 2 years or less were considered sexually immature, whereas any animal larger than 150.0 cm in length or aging 5 years or more was considered sexually mature. Likewise for the males, any individual smaller than 155.0 cm in length or aging up to 1 year was considered immature, whereas animals larger than 155.0 cm in length or aging 5 years or more were considered sexually mature. For both sexes, animals for which the gonads could not be collected and which were within these upper and lower limits were not included in the analysis.

**Reproductive status**

Male sexual maturity status was determined after histological analysis of the testes according to Hohn et al. (1985) as follows: (i) immature—seminiferous tubules containing mainly spermatogonias. Abundant interstitial tissue between the seminiferous tubules and lumen totally closed; (ii) pubertal—seminiferous tubules containing spermatogonias and spermatocytes. Less interstitial tissue present between the seminiferous tubules than in immature animals. The lumen is partially opened; and (iii) mature—seminiferous tubules containing spermatogonias, spermatocytes, spermatids and, in many times, spermatooza. Interstitial tissue is almost non-existent between the seminiferous tubules. The lumen is totally opened.

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**Habitat use analysis**

The water depth of each incidentally caught franciscana was determined with an echobathymeter, otherwise estimated with the assistance of a nautical chart in cases where franciscanas were caught by boats not having an echobathymeter.

Although floating gillnets are utilized in the study area, the great majority of the franciscana incidental catches occurred in fixed bottom-set gillnets. In this manner, the water depths reported in this paper reflect accurately the depths used by the dolphins.

On some occasions, the water depth of incidental catches was not accurately recorded rather it was allocated to bin intervals of 5 m. In such cases, the depth was arbitrarily considered as the mid-point of that interval. For example, when the recorded depth was within the 20–25 m interval, the depth of 22.5 m was considered in the analysis.

The stratification of Rio Grande do Sul in southern and northern coasts was based in the fishing grounds of vessels...
operating from Rio Grande and Tramandai/Imbé, respectively. The Rio Grande commercial fleet operates mainly from the lighthouse of Sarita (32°38’S) to the lighthouse of Mostardas (31°13’S) (Secchi et al., 1997a), whereas vessels from Tramandai operate mainly around Solidão lighthouse (30°41’S 50°30’W) and Capão da Canoa (29°44’S 50°00’W) (Moreno et al., 1997; Ott, 1998) (Figure 1).

The sex-ratio for each stratum was calculated as:

\[ r = \frac{m}{f} \]

where \( r \) is the ratio of males to females in the sample, \( m \) is the number of males and \( f \) is the number of females.

Since information concerning the fishery effort by depth in Rio Grande do Sul was not incorporated in the present analyses, conclusions about habitat preference within a group (e.g. sex and reproductive status) could not be carried out. However, comparisons between groups (e.g. males versus females; mature versus immature animals) in the same area were permitted.

Differences in the mean water depth between gender and reproductive status were tested using Student’s \( t \)-test or Mann–Whitney rank sum test. Age and size-related spatial segregation according to water depth was tested by fitting a linear regression and verifying whether the resulting slope was different or equal to 0. Differences between observed and expected sex-ratio were examined with Chi-squared goodness-of-fit tests. A level of significance \( \alpha = 0.05 \) was considered for all tests.

RESULTS

Information on the depth of franciscana by-catch location off Rio Grande do Sul state coast allowed us to analyse the depth-related distribution pattern according to dolphin’s age, length, gender and reproductive status.

Sex-ratio

The sex-ratio calculated for franciscanas incidentally caught on the northern and southern coast of Rio Grande do Sul is presented in Table 1. The observed sex-ratio of foetuses did not differ from the expected 1:1. On the northern coast, the sex-ratio was biased towards males in all length intervals (Figure 2).

On the southern coast, the proportions of sexually mature females and males were 37.5% and 42.1%, respectively. On the northern coast, the proportion was quite similar for mature females (36.6%) \((\chi^2 = 0.82, 0.25 < P < 0.50)\), but significantly smaller (11.9%) for mature males \((\chi^2 = 37.42, P < 0.001)\).

Operational sex-ratio\(^1\) of franciscanas bycaught in the southern area (1.16 mature male for each mature female) did not differ from unity \((\chi^2 = 0.46, P = 0.50, N = 78)\). In the northern area, operational sex-ratio was biased towards females (2.3 mature females to each mature male), although this ratio was not significantly different from unity due to the small sample size of mature animals \((\chi^2 = 1.60, 0.10 < P < 0.25, N = 10)\).

Water depth and gender

There was no significant difference between the mean depth where males (mean = 21.7 m) and females (mean = 21.1 m) \((t = 0.61, df = 134, P = 0.55)\) were caught. Depth of the by-catch locations ranged from 6 to 35 m for males and from 10 to 35 m for females. Similarly, when data were analysed by region, no differences were found in the mean depth of by-catch between males (mean = 23.0 m) and females (mean = 20.9 m) from the southern area \((t = 1.61, df = 78, P = 0.11)\), and between males (mean = 18.1 m) and females (mean = 21.7 m) from the northern area \((t = 1.9, df = 26, P = 0.07)\). Depth-related sex-ratio did not differ from 1 (Table 2).

Water depth and age

The slope of the linear regression to test correlation between age of males and water depth of by-catch is not significant \((b = 0.087, P = 0.85, IC 95\% = -0.85–1.02)\) (Figure 3). The slope was significantly negative for females \((b = -0.83, P = 0.044, IC 95\% = -1.63–0.023)\) (Figure 4). However, this trend was clearly produced due to the influence of the low depth of by-catch of the two oldest animals: 10 and 11 year old females bycaught in water depths of 14 and 12 m, respectively. After excluding these two animals, no significant trend was detected \((b = -0.56, P = 0.31, IC 95\% = -1.66–0.53)\).

\(^1\)Operational sex-ratio \((\text{sensu Emlem & Oring, 1977})\) is the ratio of sexually mature males to the sexually mature females.

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Table 1. Sex-ratio of incidentally caught franciscanas, Pontoporia blainvillei, on the northern coast (RSN) and southern coast (RSS) of Rio Grande do Sul. Values significantly different from 1 are symbolized as * \((\alpha = 0.05)\).

| Sample                        | Females | Males | Sex-ratio | \(\chi^2\) |
|-------------------------------|---------|-------|-----------|------------|
| Foetuses                      | 6       | 8     | 1.32      | 0.29       |
| By-catches southern coast     | 89      | 106   | 1.19      | 1.48       |
| By-catches northern coast     | 19      | 37    | 1.92      | 5.79*      |
Water depth and standard length

The slope of the linear regression to test correlation between water depth and franciscana standard length was not significant either in males (\(b = 0.10, P = 0.70, 95\% \ CI = -0.42 - 0.63\)) (Figure 5) or in females (\(b = -0.056, P = 0.28, 95\% \ CI = -0.16 - 0.046\)) (Figure 6).

Water depth and reproductive status

In order to test whether or not pregnancy influenced distribution of females, we compared the depth at the location of by-catch of pregnant (mean = 19.2 m, \(N = 10\)) and non-pregnant mature females (mean = 21.5 m, \(N = 8\)). Difference in water depth of the by-catch between these two groups was non-significant (\(t = -0.84, df = 12, P = 0.41\)). In addition, to investigate the influence of the stage of the gestation in the habitat use, we studied the relationship between foetus length and depth and again no significant difference in the slope of the linear regression between these variables was found (\(b = 0.031, P = 0.73, CI \ 95\% = -0.17 - 0.23, r^2 = 0.015\)).

Distribution of franciscanas of different reproductive status does not change according to water depth. In the southern area, depth of occurrence of immature (mean = 25.1 m) and mature males (mean = 24.6 m) is not significantly different (\(t = 0.38, df = 52, P = 0.70\)). Similarly, no significant difference was found in the mean water depth of by-catch between immature (mean = 22.8 m) and mature females (mean = 20.7 m) (\(t = 0.85, df = 52, P = 0.40\)).

Water depth of the by-catch was recorded only for six lactating females. In order to increase sample size and allow for a comparison with non-lactating mature females, we assumed that by-catch location of six calves presumably still suckling, according to their small lengths (less than 95.0 cm; see Brownell, 1984), represents the distribution of their mothers. A significant difference was detected for the mean depth of by-catch between lactating (mean = 25.0 m) and non-lactating females (mean = 18.8 m) (\(t = 2.84, df = 22, P = 0.0095\)).

DISCUSSION

This study suggests that there is no reproductive status, gender, or age-related segregation of franciscanas according to water depth off Rio Grande do Sul. Individuals of all sizes and ages utilize nearly the entire depth-range of the surveyed area, indicating that franciscana occurrence in deeper waters is not limited by body size or age. In Uruguay, despite changes in the fishing grounds from the 1969–1975 period (concentrated in water depths ranging from 20 to 30 m) to the 1980–1982 period (concentrated in water depths of 6 to 15 m) no difference in the age–frequency of bycaught animals was also observed between the two periods (Praderi et al., 1989; Pinedo, 1994).

In a previous study in Rio Grande do Sul, based on a smaller sample, Secchi et al. (1997b) found differences in the mean depth of by-catch between males (31 m) and females (22 m). Rosas et al. (2002) also suggested that a certain degree of spatial segregation may exist for the franciscanas in Paraná/southern São Paulo, where the immature utilize shallower waters than adult individuals. However, conclusions from both studies are based on limited sample sizes.

Table 2. Absolute frequency of male and female franciscanas, Pontoporia blainvillei, stratified by water depth intervals (in metres).

| Depth interval | Males | Females | Sex-ratio | \(\chi^2\) |
|---------------|-------|---------|-----------|-----------|
| 6–10          | 2     | 2       | 1         | 0.0       |
| 11–15         | 10    | 12      | 0.84      | 0.18      |
| 16–20         | 20    | 12      | 1.64      | 2.0       |
| 21–25         | 36    | 24      | 1.49      | 2.4       |
| 26–30         | 22    | 14      | 0.64      | 1.78      |
| 31–35         | 4     | 5       | 0.82      | 0.11      |
| Total         | 94    | 69      |           |           |

Fig. 2. Sex-ratio of franciscanas, Pontoporia blainvillei, incidentally caught in the northern coast of Rio Grande do Sul. The dark line represents the sex-ratio 1:1. Values higher than 1 denote a male-biased sex-ratio. Largest male in the sample is 135.5 cm.

Fig. 3. Relationship between age and bottom depth at the locality of the incidental catch for male franciscanas, Pontoporia blainvillei, in Rio Grande do Sul (\(N = 61\)).

Fig. 4. Relationship between age and bottom depth at the locality of the incidental catch for female franciscanas, Pontoporia blainvillei, in Rio Grande do Sul (\(N = 53\)). The thinner and the thicker line represent the slopes with and without the two oldest females, respectively.
The franciscana lives in small groups, usually 1–6 animals (Crespo et al., 1998; Bordino et al., 1999), and preys mainly upon coastal demersal fish and squids (Bassoi, 1997; Rodríguez et al., 2002). The species inhabits a moderately narrow strip of coast in the south-western Atlantic. This strip initiates in very coastal waters, just beyond the surf zone, as documented by some incidental catches and a recent aerial survey (Danilewicz, unpublished data). However, the offshore limit of the franciscana distribution strip is not well defined. The maximum bottom depth of by-catch of a franciscana in this study is 35 m. Nevertheless, this result is influenced by the fishery effort and must not be seen as the isobath limit for the species. At least in Rio Grande do Sul, some records in waters up to 55–60 m deep have been made (Danilewicz, personal observation), though the density in these areas is likely to be very low.

It has been documented that franciscanas move inshore in spring and summer for feeding, mating and calving in Anegada Bay, Argentina (Bordino et al., 1999). The authors related the use of the bay’s coastal waters by calves and adults during the reproductive period to the protection from predation in a food-rich habitat. In our study site—a distinct open ocean habitat without major tide influence—we were not able to corroborate the same findings. Also, pregnant females do not seem to change their habitat related to bottom depth as a response to the progress of gestation.

Shallow waters have been considered as a synonym of a protective environment for cetaceans. This proposition is usually based on the consideration that encounters with predators are less frequent in these areas. The use of coastal and shallow habitats by odontocetes as a strategy to avoid encounters with predatory sharks has been proposed for Hawaiian spinner dolphins, *Stenella longirostris* (Norris & Dohl, 1980) and bottlenose dolphins, *Tursiops truncatus* (Wells et al., 1987). Mann et al. (2000) have found higher calf survivorship in female bottlenose dolphins that raised their calves in shallow waters. Nevertheless, the relationship between water depth and shark predation risk is not completely understood and may be complex and highly variable geographically (Heithaus, 2001). In a comprehensive study on habitat use of bottlenose dolphins in Shark Bay, Australia, Heithaus & Dill (2002) demonstrated a trade-off between energy intake and predation risk. In that region, habitat characteristics and shark density turn shallow waters into a relatively more risky ambient in some periods of the year, with the dolphins selecting deeper waters to rest.

Moreover, depending on the shark species predation behaviour, coastal turbid waters may represent a more dangerous habitat than translucent pelagic waters. Excessively shallow waters may impose limitations on the echolocation effectiveness and on the dolphin escaping. Franciscanas are predated both by sharks and killer whales (Praderi, 1985; Ott & Danilewicz, 1998; Santos & Netto, 2005). Regarding the two shark species known to predate on franciscanas (Praderi, 1985), the sevengill shark, *Notorhynchus cepedianus*, prefers turbid waters while the tiger shark, *Galeocerdo cuvieri*, camouflage efficiently against dark backgrounds. In this manner, the turbid coastal waters of Rio Grande do Sul and Uruguay may not be so advantageous for franciscana female–calf pairs in terms of predation avoidance in order to make them restrict their activities exclusively to this habitat.

On many occasions, segregation may be revealed not only by the differential use of space, but also by differences in the diet (Bowyer, 2004). The franciscana diet has been studied in many areas with no evidence for significant differences between sexes and age-classes, with the exception of shrimps that are important only in the diet of juvenile dolphins (Pinedo et al., 1989; Ott, 1994; Bassoi, 1997; Rodríguez et al., 2002).

It is fundamental to be aware that the detection of sexual segregation is dependent on scale (Bowyer, 2004). Although our results reveal that in a large scale, franciscanas of different ages, sizes, gender and reproductive classes (for females) are homogeneously distributed according to water depth, the sex-ratio comparison between areas suggests that sexual segregation may occur on a smaller scale. Franciscanas are born in a 1:1 sex-ratio (Brownell, 1984; Danilewicz, 2003). However, some study sites present remarkable exceptions. In the coast of Necochea and Claromecó, northern Argentina, Corcuera et al. (1994) recorded a sex-ratio deviated towards males (1.61 males for each female). In São Paulo, southeastern Brazil, a higher sex-ratio towards males (1.73) has been recorded (C. Bertozzi, personal communication).

The sex-ratio towards males for the franciscanas from the northern coast of Rio Grande do Sul may be effectively reflecting the real structure of the population in a small area or being caused artificially by methodological biases. Corcuera et al. (1994) commented that the sex-ratio biased to male franciscanas could be attributed to a greater difficulty of manipulation of the largest dolphins by the fishermen. The authors argued that on occasions when the researchers are not onboard, the
fishermen could discard the larger animals and collect preferentially the smaller ones. Since the franciscana presents reversed sexual size dimorphism (RSSD) (i.e. females larger than males), this could cause an artificial increase in the number of males collected. Nevertheless, this hypothesis is rejected since the sex-ratio in the northern coast fishery ground is directed towards males even for juveniles, when the RSSD is low or even non-existent. Consequently, the sex-ratio deviated towards males on the northern coast may in fact reflect differences in the distribution patterns of males and females in Rio Grande do Sul.

Franciscana by-catch in Rio Grande do Sul is not sustainable (Kinas, 2002; Secchi et al., 2003a). It is agreed that management procedures in the fishery certainly need to be taken in the next few years. The information on the distribution of a particular species and the location of interactions with fisheries are necessary in making management decisions leading to the implementation of regulations. One possible management action for the franciscana problem could be the restriction of certain fishery grounds through the creation of a marine protected area. The results of the present study indicate that the available data do not allow the designing of a protected area in order to minimize the by-catches of a particular sex/reproductive class of franciscana (e.g. mature or pregnant females).

This study is a first attempt to shed some light on the habitat use patterns of this elusive dolphin in southern Brazil, but important aspects on this subject still remain to be understood. Although a habitat preference by water depth could not be noticed, it is plausible that some segregation or habitat preference exists by latitude or season. The achievement of a larger sample and a more accurate set of data (e.g. coordinates of the by-catch locality) jointly with refined information on the fishery effort in future analyses will improve our knowledge on the habitat use of franciscana dolphins.

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REFERENCES

American Society of Mammalogy (1961) Standardized methods for measuring and recording data on the smaller cetaceans. Journal of Mammalogy 42, 471–476.

Basso M. (1997) Feeding of franciscana, Pontoporia blainvillei (Gervais & D’Orbigny, 1844), accidentally caught in coastal gillnetting in southern Brazil. Bs dissertation. Universidade do Rio Grande, Rio Grande, Brazil.

Bordino P. (2002) Movement patterns of franciscana dolphin (Pontoporia blainvillei) in Bahia Anegada, Buenos Aires, Argentina. Latin American Journal of Aquatic Mammals 1, 71–76.

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

Bowyer R.T. (2004) Sexual segregation in ruminants: definitions, hypotheses, and implications for conservation and management. Journal of Mammalogy 85, 1039–1052.

Brownell R.L. Jr (1984) Review of reproduction in platistans dolphins. Report of the International Whaling Commission 6, 149–158.

Cacqua E., Monzon 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). Report of the International Whaling Commission 15, 283–290.

Cremer M.J. and Simões-Lopes P.C. (2005) The occurrence of Pontoporia blainvillei (Gervais & d’Orbigny) (Cetacea, Pontoporiidae) in an estuarine area in southern Brazil. Revista Brasileira de Zoologia 22, 717–723.

Crespo E.A., Harris G. and Gonzalez R. (1998) Group size and distribution range of the franciscana, Pontoporia blainvillei. Marine Mammal Science 14, 845–849.

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

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

Emlet S.T. and Oring L.W. (1977) Ecology, sexual selection, and the evolution of mating systems. Science 197, 215–223.

Heithaus M.R. (2001) Predator–prey and competitive interactions between sharks (Order Selachii) and dolphins (Suborder Odontoceti): a review. Journal of Zoology 253, 53–68.

Heithaus M.R. and Dill L.M. (2002) Food availability and tiger shark predation risk influence bottlenose dolphin habitat use. Ecology 83, 480–491.

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

IUCN (2008) IUCN Red List of Threatened Species: A Global Species Assessment. Gland, Switzerland and Cambridge, UK: IUCN. Pontoporia blainvillei. Available from http://www.iucnredlist.org/search/details.php?41761/all (accessed September 2008).

Kinas P.G. (2002) The impact of incidental kills by gillnets on the franciscana dolphin (Pontoporia blainvillei) in southern Brazil. Journal of Marine Science 70, 409–421.
Mann J., Connor R.C., Barre L.M. and Heithaus M.R. (2000) Female reproductive success in bottlenose dolphins (Tursiops sp.): life history, habitat, provisioning, and group size effects. Behavioral Ecology 11, 210–219.

Moreno I.B., Ott P.H. and Danilewicz D. (1997) Análise preliminar do impacto da pesca artesanal costeira sobre Pontoporia blainvillei no litoral norte do Rio Grande do Sul, sul do Brasil. In Proceedings of the 2nd Workshop for the Coordination of Research and Conservation of Franciscana in the Southwestern Atlantic, Buenos Aires, Argentina, 1997, pp. 31–41.

Norris K.S. and Dohl T.P. (1986) Behavior of the Hawaiian spinner dolphin, Stenella longirostris. Fishery Bulletin 77, 821–849.

Ott P.H. (1994) Estudo da ecoologia alimentar de Pontoporia blainvillei (Gervais; D’Orbigny 1844) (Cetacea, Pontoporiidae) no litoral norte do Rio Grande do Sul, Sul do Brasil. BSc dissertation. Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil.

Ott P.H. (1998) Análise das capturas acidentais da toninha, Pontoporia blainvillei, no litoral norte do Rio Grande do Sul, sul do Brasil. MSc dissertation. Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, Brazil.

Ott P.H. and Danilewicz D. (1998) Presence of franciscana dolphins (Pontoporia blainvillei) in the stomach of a killer whale (Orcinus orca) stranded in southern Brazil. Mammalia 62, 605–609.

Ott P.H., Secchi E.R., Moreno I.B., Danilewicz D., Crespo E.A., Bordino P., Ramos R., Di Benedetto A.P., Bertozzi C., Bastida R., Zanelatto R., Perez J. and Kinas P.G. (2002) Report of the working group of fishery interactions. Latin American Journal of Aquatic Mammals 1, 55–64.

Perrin W.F. and Donovan G.P. (1984) Report of the workshop. Report of the International Whaling Commission 6, 1–24.

Pinedo M.C. (1996) Impact of incidental fishery mortality on the age structure of Pontoporia blainvillei in southern Brazil and Uruguay. Report of the International Whaling Commission 15, 261–264.

Pinedo M.C. and Hohn A. (2001) Growth layer patterns in teeth from the franciscana dolphin (Pontoporia blainvillei) stranded in southern Brazil. In Proceedings of the 2nd Workshop for the Coordination of Research and Conservation of Franciscana in the Southwestern Atlantic, Buenos Aires, Argentina, 1997, pp. 31–41.

Perrin W.F., Brownell R.L. Jr., Kaya Z. and Jiankang L. (eds) (2002) effects of fishing by-catch and the conservation status of the franciscana dolphin, Pontoporia blainvillei. In Gales N., Hindell M. and Kirkwood R. (eds) Marine mammals: fisheries, tourism and management issues. Collingwood, Australia: CSIRO Publishing, pp. 174–191.

Perrin W.F., Danilewicz D. and Ott P.H. (2003b) Applying the phylogeographic concept to identify Franciscana dolphin stocks: implications to meet management objectives. Journal of Cetacean Research and Management 5, 61–68.

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

Rosas F.C.W., Monteiro-Filho E.L.A. and Oliveira M.R. (2002) Incidental catches of franciscana (Pontoporia blainvillei) on the southern coast of São Paulo state and the coast of Paraná state, Brazil. Latin American Journal of Aquatic Mammals 1, 161–167.

Santos M.C.O. and Netto D.F. (2005) Killer whale (Orcinus orca) predation on a franciscana dolphin (Pontoporia blainvillei) in Brazilian waters. Latin American Journal of Aquatic Mammals 4, 69–72.

Secchi E.R., Zerbini A.N., Bassoi M., Dalla Rosa L., Moller L.M. and Rocha-Campos C.C. (1997a) Mortality of franciscana, Pontoporia blainvillei, in coastal gillnetting in southern Brazil. Report of the International Whaling Commission 47, 653–658.

Secchi E.R., Dalla Rosa L., Bassoi M. and Barcellos L. (1997b) Uma alternativa para minimizar o impacto da pesca costeira de emalhe sobre a população de toninhas, Pontoporia blainvillei (Cetacea, Pontoporiidae), no sul do Brasil. In Proceedings of the 7th Congresso Latino-Americano sobre Ciências do Mar, Santos, SP, 1997, Associação Latino-Americana dos Profissionais de Ciências do Mar, pp. 428–429.

Secchi E.R., Kinas P.G. and Muelbert M. (2004) Incidental catches of franciscana in coastal gillnet fisheries in the Franciscana Management Area III: period 1999–2000. Latin American Journal of Aquatic Mammals 3, 61–68.

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. Doctoral thesis, University of Otago, Dunedin, New Zealand.

Siciliano S., Di Benedetto A.P. and Ramos R.M.A. (2002) A toninha, Pontoporia blainvillei (Gervais & d’Orbigny, 1844) (Mammalia, Cetacea, Pontoporiidae), nos estados do Rio de Janeiro e Espírito Santo, costa sudeste do Brasil: caracterizações dos habitats e fatores de isolamento das populações. Boletim do Museu Nacional. (Zoológia) 476, 1–15.

and

Wells R.S., Scott M.D. and Irvine A.B. (1987) The social structure of free-ranging bottlenose dolphins. In Enoways H.H. (ed.) Current mammalogy. Volume 1. New York: Plenum Press, pp. 247–305.

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