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Patterns of social association in the franciscana, *Pontoporia blainvillei*

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Little is known from living animals about the social patterns of the franciscana, *Pontoporia blainvillei*, a small dolphin inhabiting a narrow strip of coastal waters off Argentina, Uruguay, and Brazil. These dolphins tend to be found in small groups, typically composed of two or three individuals (Bordino *et al.* 1999). Throughout much of the species' range, franciscanas encounter artisanal gill nets (Praderi 1989, Corcuera *et al.* 1994, Bertozzi and Zerbini 2002, Bordino *et al.* 2002, Secchi *et al.* 2003). Entanglement in these nets results in the deaths of thousands of individuals each year, at levels that are likely unsustainable (Bordino and Albareda 2004, Cappozzo *et al.* 2007).

Recent findings by Mendez *et al.* (2010) suggest that there are both quantitative and qualitative concerns with this bycatch. Genetic data from bycatch and from dolphins sampled during capture-release for tagging indicate that the nets may be killing not just individuals, but functional social units. Genetic data confirm the association of mothers and their calves killed in the same fishing nets (Valsecchi and Zanelatto 2003, Mendez *et al.* 2010, Costa-Urrutia *et al.* 2012). These authors have also suggested that captures of unrelated adult females and adult males in the same nets indicate the occurrence of breeding pairs. The associations of unrelated adult males and females in nets have led to the suggestion of the possibility of a single male or serial monogamy breeding system for this species. This hypothesis receives further support from the extremely small weight of franciscana testes relative to body weight (not conducive to sperm competition), the fact that adult females are larger than males (reverse sexual dimorphism), and the lack of obvious weapons and scarring on males related to conspecific aggression (Brownell 1989, Valsecchi and Zanelatto 2003, Danilewicz *et al.* 2004, Costa-Urrutia *et al.* 2012, Panebianco *et al.* 2012).

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However, mere capture of unrelated adult males and females in the same nets at a single point in their lives cannot provide unequivocal support for the existence of a social relationship.

Data on spatial and social patterns covering longer periods of time would help to define social relationships. Because of the small size of their dorsal fins, franciscanas do not lend themselves to the kinds of photographic identification studies or focal animal behavioral follows that have been effective for studies of social patterns in other species such as bottlenose dolphins (*e.g.*, Owen *et al.* 2002, McHugh *et al.* 2011). However, such information can also be derived from comparisons of concurrent locations for individuals, through radio telemetry, which provide opportunities for repeated measures of spatial proximity between individuals. In March 2008, we investigated social association patterns through the deployment of satellite-linked radio-tags on franciscanas in Bahia San Blas, Argentina (Bordino *et al.* 2008).

A team consisting of more than 40 researchers, volunteers, and government officials captured, tagged, and released members of two small groups of franciscanas on shallow sandbanks in Bahia San Blas (Table 1). Each group was captured using a standard technique of encirclement with a 500 m long, 4 m deep light-weight seine net (Loughlin *et al.* 2010). Group 1 was captured on March 4, and consisted of an adult male (Male #1), an adult female (Female #1), and a calf. Genetic analyses determined that the female and calf were related, while the male was unrelated to either (Mendez *et al.* 2010). Both adults were tagged with SPLASH time-depth recording satellite-linked transmitters (Wildlife Computers, Redmond, WA) and the calf received a small livestock ear tag. Group 2 was captured on March 7, and consisted of an adult male (Male #2) and an adult female (Female #2), determined through genetic analyses to be unrelated (Mendez *et al.* 2010). The male was tagged with a SPLASH tag, and the female received a SPOT5 location-only transmitter (Wildlife Computers, Redmond, WA). All of the tags were programmed to transmit during the same eight hour period each day. Data from the tags were collected for 82–176 d (Table 1).

Location data from the satellite-linked tags were processed by ARGOS (CLS America, Lanham, MD). Dolphin locations shown in Figure 1 include plausible locations as identified through application of the Douglas Argos Filter Algorithm (Klatsky *et al.* 2007, Wells *et al.* 2009, Douglas *et al.* 2012), with locations on land excluded. The filter removed implausible locations based on the tendency that most implausible ARGOS locations show the animal to have incorrectly moved a substantial distance and then return, and often with implausible movement rates. Based on previous tracking experience with franciscanas, key filtering criteria were to retain all locations of standard ARGOS location quality (LC 1, LC 2, and LC 3; estimated 1-sigma error radius <1.5 km), retain consecutive locations within 15 km of one another, and to exclude locations that resulted in rates of travel to exceed 20 km/h. To estimate separation distances between individual dolphins, proximity analyses were performed using only location pairs that were temporally coincident (<10 min apart), and both of standard ARGOS location quality. Mean separation was calculated using all pairwise locations during daily intervals. In general, we considered estimated separations ≤ 1.5 km within a 10 min window to be indicative of “close proximity.” This is within the radius of accuracy of the ARGOS location data selected for our analyses, and could place the animals side-by-side or up to 3 km apart.

The four tagged dolphins exhibited limited ranges during the tracking period, frequenting much of Bahia San Blas and associated coastal waters within about 20 km of shore (Fig. 1). Along the coast, ranges extended to about 70 km south of Bahia

Table 1. Franciscana tagging and tracking data, March 2008.

Dolphin ID	Deploy date	Release time (local)	Tag type	Sex	Length (cm)	# days tracked	# filtered locations	Deploy latitude	Deploy longitude
Male #1/CPb0108	4 March	1206	SPLASH	M	128	118	1,228	-40.5318	-62.2759
Female #1/CPb0208	4 March	1227	SPLASH	F	147	82	833	-40.5318	-62.2759
Calf of Female #1	4 March	1227	Roto	F	105	na	na	-40.5318	-62.2759
Male #2/CPb0308	7 March	1417	SPLASH	M	132	84	853	-40.5180	-62.3030
Female #2/CPb0408	7 March	1417	SPOT5	F	147	176	1,212	-40.5180	-62.3030

San Blas, and about 90 km north. The four dolphins shared core areas within Bahía San Blas and immediately offshore, but differed in the extent of their coastal ranges. Along the coast, Female #2 ranged farther than the others to the south, and Male #1 and Female #1 ranged farther to the north.

In each case, dolphins were captured as a mixed-sex pair of adults. The extent to which these pairs remained intact or reoccurred through the tracking period was remarkable. The (Female #1-Male #1) pair remained particularly close together, with a mean daily separation of about 1 km, measured from 563 paired locations over 82 d that both animals were transmitting (Table 2, Fig. 2a). For perspective, two transmitters deployed on any one animal would likely show a mean separation similar to what was found for Male #1 and Female #1, purely due to the (in)accuracy of the technique. Female #1 and Male #1 were not released together; releases were separated by 21 min (Table 1). After an initial spatial separation of up to about 9 km on the first day, Female #1 and Male #1 closed the distance by the third day, and remained

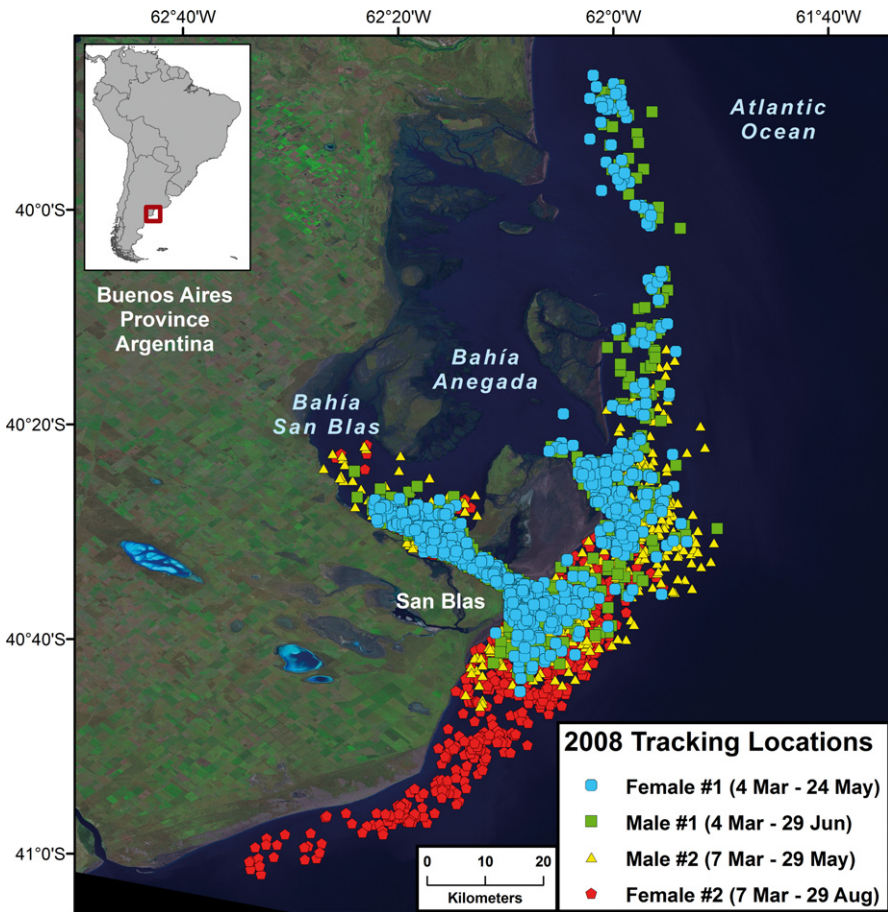


Figure 1. Filtered locations of tagged franciscanas in and near Bahía San Blas, Argentina, March–June 2008.

in close proximity for the next 80 d, until transmissions from Female #1 ceased. The median separation for this pair over the 82 d was 0.79 km.

The second pair, Female #2 and Male #2, released together, showed a pattern of prolonged, but discontinuous, repeated close proximities (Fig. 2b). Their mean daily separation over 315 paired locations over 84 d was about 11 km (Table 2), with a median of 3.54 km. This mean was less than all other pairwise combinations except Female #1 and Male #1. During the 84 d tracking period, close proximities (≤ 1.5 km) were recorded for seven periods of 1–12 d duration: 7–15, 18–29 March, 1–3, 5–7, 20–21, 24, April and 28 April–4 May. The periods of close proximity were interspersed with periods of separation >1.5 km of 1–25 d duration, when the dolphins separated by up to 41 km. At the time of Male #2's final transmission, the dolphins were 34 km apart.

In contrast, all other pairwise comparisons of dolphins yielded mean daily separations larger than those for the two pairs captured together, with mean separations of members of the pair of about 18–22 km (Table 2). Figure 2c traces the separations of the two dolphin groups over time. No pattern of association between the two groups was evident.

While Argos Doppler-based telemetry data cannot confirm the occurrence of two dolphins swimming together within a group, continuous close proximity over periods of days or weeks strongly suggests the coordinated movements typical of dolphins swimming within the same group. Remote tracking data do not provide information on the possible co-occurrence of other untagged adults in the group during the tracking period, but data from bycatch and capture-release for tagging suggest that such occurrences would be rare (Bordino *et al.* 2008, Mendez *et al.* 2010).

Within our small sample, we had one adult male-adult female pair that remained together continuously for an extended period, and another that repeatedly spent extended periods together, interspersed with periods of separation. Female-male pairing among adult dolphins is typically attributed to reproduction. The fact that adult animals in these groups have different mitochondrial haplotypes and are not significantly related according to microsatellite data (Mendez *et al.* 2010) rules out the possibility of adult males swimming with relatives. In the absence of any evidence suggesting that the adult pairs in our sample are part of the same family group, our presumption of reproductive pairs seems the most plausible cause for these pairings.

Our repeated close proximities between adult males and females during March–May appear to have occurred during, and extended beyond, the breeding season. Bordino *et al.* (1999) reported a November to March calving season for Bahia San Blas, which overlaps with calving seasons elsewhere in the species' range (November–December in Uruguay, Brownell 1989; October–March in Brazil, Danilewicz 2003;

Table 2. Mean daily separations between individual dolphins, with numbers of measurements, standard deviation, and standard error.

Dolphins	Mean daily separation (km)	<i>n</i>	SD	SE
Female #2-Female #1	17.94	364	18.67	0.97
Female #2-Male #2	11.19	315	12.66	0.71
Female #2-Male #1	18.86	599	16.77	0.68
Female #1-Male #2	21.33	421	19.03	0.92
Female #1-Male #1	1.01	563	1.26	0.05
Male #2-Male #1	21.56	507	19.01	0.84

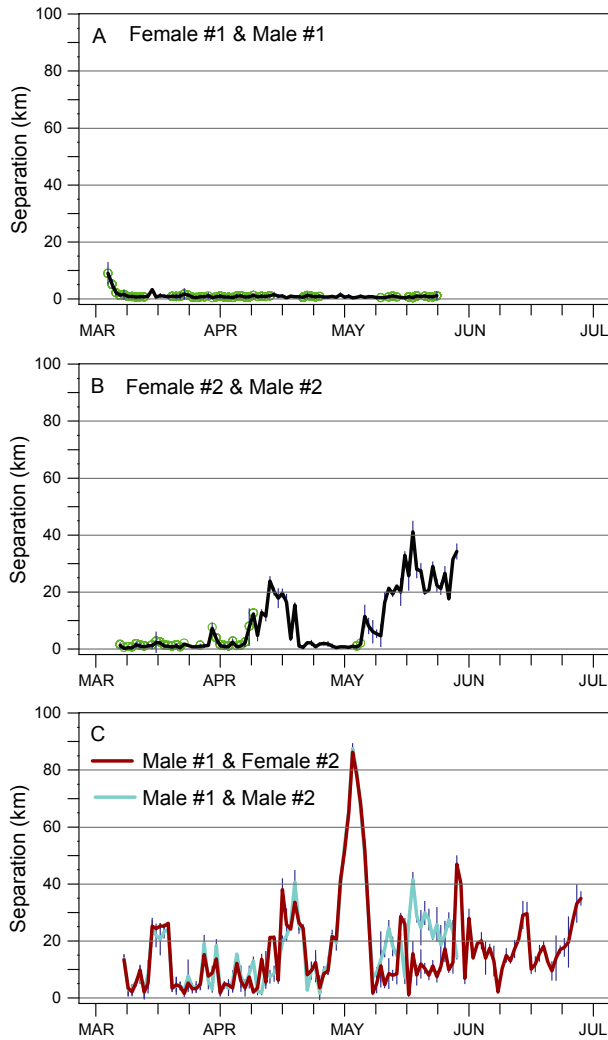


Figure 2. Separations within and between groups of dolphins: (a) Female #1 and Male #1, within group, circles indicate days when at least one member of the pair was within Bahia San Blas; (b) Female #2 and Male #2, within group, circles indicate days when at least one member of the pair was within Bahia San Blas; (c) separation of the groups composed of Female #1/Male #1 and Female #2/Male #2.

October–December in Brazil, Rosas and Monteiro-Filho 2001). Given an approximately 10.5–11 mo gestation period (Harrison *et al.* 1981, Brownell 1989, Rosas and Monteiro-Filho 2001), most successful breeding likely occurs during mid-December through mid-April in Bahia San Blas. However, males and females have both also been found to be reproductively active outside of the main spring/summer breeding season (Danilewicz 2003, Danilewicz *et al.* 2004), providing additional incentive for males to remain in association with females.

Our observations of prolonged or repeated close proximities of unrelated adult males and females support the hypothesis of a single male mating system. The associations at capture are likely not instantaneous and coincidental, but instead may be indicative of longer-term associations. Single male breeding systems are rare in cetaceans (Brownell 1989, Wells *et al.* 1999, Connor *et al.* 2000), but evidence is mounting in support of this hypothesis for franciscanas. Tracking data indicate that some adult males appear to remain in a social unit with adult females during and beyond the breeding season, as suggested previously (Valsecchi and Zanelatto 2003, Costa-Urrutia *et al.* 2012). The lack of relatedness between the adult male and the calf in Group 1 (Mendez *et al.* 2010) indicates that this was not a permanent family unit traveling as a kin group, as suggested by Valsecchi and Zanelatto (2003) to be a common feature of franciscana society. Whether a male continues to associate with a female following the birth of a calf resulting from its mating, and provide paternal care as hypothesized by Valsecchi and Zanelatto (2003) and Costa-Urrutia *et al.* (2012), remains to be seen. The calf of Female #1 was not sired by Male #1, but it is not known if the father was attendant with Female #1 and her calf prior to our observations. Regardless of whether the unusually prolonged associations between unrelated males and females involve mate guarding or are extended to include paternal care, behavioral data reinforce the hypothesis of a single male mating system for franciscanas, a rare occurrence among mammals.

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