Received: 29 April 2021 | Accepted: 1 September 2021

DOI: 10.1111/mms.12879

ARTICLE

Marine Mammal Science

Tagging, ranging patterns, and behavior of franciscana dolphins (*Pontoporia blainvillei*) off Argentina and Brazil: Considerations for conservation

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Funding information
Chicago Board of Trade; Chicago Zoological Society; Disney Worldwide Conservation Fund; Dolphin Quest, Inc.; Fundacion Vida Silvestre Argentina; National Geographic Society; Petrobras Environmental Program; Scott Neotropical Fund of the Cleveland Metroparks Zoo; Wildlife Trust

Abstract

The franciscana dolphin, *Pontoporia blainvillei*, is one of the most threatened cetaceans in the Southwestern Atlantic. Within their limited coastal range off Argentina, Uruguay, and Brazil, franciscanas face human activities, including artisanal gillnet fishing and coastal development. A lack of information on ranging patterns, population structure, and behavior for informing management led to efforts to develop and apply approaches to tag franciscanas in Argentina (Bahía Samborombón [BS], Bahía San Blas [BSB]) and Brazil (Baía Babitonga [BB]) during 2005–2013. Findings

†Deceased. The coauthors dedicate this manuscript to the memory of Pablo Bordino for his incredible and pioneering dedication to franciscana conservation, and his role in involving the rest of us in franciscana conservation research.

from VHF tags deployed in BS in 2005 during feasibility tests for catching and handling franciscanas for tagging suggested residency over periods of weeks. Subsequently, satellite-linked tags confirmed patterns of residency at each site. Home range size varied, with ranges of 5–7 km^2 for BB, 51–312 km^2 for BS, and 49–1,014 km^2 for BSB. Diving patterns varied across sites, with the animals using the entire water column, exposing them to fishing nets regardless of the depth at which the nets were set. Tracking durations and follow-up observations indicated that this research approach is useful for studies of franciscanas. Small, definable ranges facilitate relating specific geographically based threats to appropriate population units, increasing the potential for effective conservation.

KEYWORDS
artisanal fisheries, core area, dive depths, dolphin conservation, franciscana, harbor development, home range, *Pontoporia blainvillei*, satellite-linked telemetry, site fidelity

1 | INTRODUCTION

Small cetaceans around the world are subject to a variety of threats, many of them from human activities. Effective conservation requires that information be available about both the nature and geographical extent of threats, and how the biology and behavior of the animals expose them to these threats, combined with an appropriate legal framework, political will, and enforceable actions from management agencies. Defining the exposure of populations to threats is crucial for determining the scale of conservation efforts. The degree to which these data are available varies across species and situations. Some threats to coastal small cetaceans, such as artisanal fisheries, other commercial fisheries, and harbor development, have a strong geographical basis that clearly defines an area of exposure. Determining the extent of exposure requires knowledge of the ranging patterns and population structure of the species of concern. In some cases where information on ranging patterns is lacking for population units of at-risk small cetaceans, telemetry research can help to fill data gaps. Here we describe how we adapted a catch-and-release approach and tagging techniques developed for common bottlenose dolphins, *Tursiops truncatus* (hereafter referred to as bottlenose dolphins), to be able to obtain the first data of their kind on the movements and behavior of franciscana dolphins, *Pontoporia blainvillei*, in three bays in Argentina and Brazil, where they face anthropogenic threats. We present our initial biological findings, as well as assessments of the evolving field approaches.

The franciscana is the most endangered cetacean in the southwestern Atlantic (Secchi et al., 2021). It faces a risk of extinction, being listed as "Vulnerable" on a global scale (Zerbini et al., 2017). Mortality due to bycatch in gill nets is the main threat for the species throughout its range and has been impacting franciscana dolphins for about 50 years (e.g., Di Beneditto & Ramos, 2001; Negri et al., 2012; Ott et al., 2002; Prado et al., 2016; Secchi et al., 1997, 2003, 2021); trawl fishing has also recently been identified as responsible for the incidental capture of the species in Uruguay (Franco-Trecu et al., 2019). Despite this, little is known about movements, residency patterns, home range size, and behavior of this species, all of which is key information that should be considered for management and conservation measures. Several features of franciscana dolphins, such as small size, coloration that often matches that of the waters it inhabits, and cryptic behavior, make it difficult to obtain data on these parameters (Bordino et al., 1999; Cremer & Simões-Lopes, 2005).

The species inhabits coastal waters off Brazil, Uruguay, and Argentina, between the latitudes of 18°25′S and 41°10′S (Crespo et al., 1998; Siciliano et al., 2002). Typically, franciscana dolphins are found in waters up to 30 m deep (Gomez & Cassini, 2015), extending up to 50 m in some areas (Amaral et al., 2018; Danilewicz et al., 2009). This limited range overlaps the main areas used for fishing activities, and is also the zone where many human activities related to coastal development, and that potentially affect the species, occur (Cremer et al., 2018; Secchi, 2010). This range creates threats to the species from sources such as environmental contaminants (Arias et al., 2015; de la Torre et al., 2012; Dorneles et al., 2013; Gago-Ferrero et al., 2013; Gerpe et al., 2002; Panebianco et al., 2013; Polizzi et al., 2013), zoonoses (Sanchez-Sarmiento et al., 2019), plastic ingestion (Bastida et al., 2000; Denuncio et al., 2011) and, reduced prey availability (Bassoi & Secchi, 2000; Rodríguez et al. 2002).

Four management stocks of franciscana dolphins (FMA - Franciscana Management Areas) were proposed to guide research and conservation efforts for this species based on a combination of morphological and genetic information: two inhabiting southeastern and southern Brazil, one shared between Brazil and Uruguay, and one in Argentina (Secchi et al., 2003). Cunha et al. (2014) expanded the genetic analyses and proposed a subdivision of the FMAs; the analyses have been improved through consideration of microscale genetic differentiation across the species range, leading to finer scale descriptions of population structure (Costa-Urrutia et al., 2012; Gariboldi et al., 2015, 2016; Mendez et al., 2008, 2010). Stock definition to date has been based largely on samples collected from dead specimens from fishing nets or found stranded on the beach. Information on the behavioral ecology of the species can contribute immensely to the understanding of this population structure, but to date little work has been done in this regard (Bordino, 2002; Bordino et al., 1999; Cremer & Simões-Lopes 2005; Sartori et al., 2017; Wells et al., 2013).

Data from genetic analyses suggest that franciscana females exhibit site fidelity (Dias et al., 2013; Mendez et al., 2010), which could explain population differences between nearby localities (Costa-Urrutia et al., 2012; Mendez et al., 2008, 2010). In Baía Babitonga, in southern Brazil, 23 franciscanas were photographically identified and 78.9% were resighted over 15 months (Sartori et al., 2017); this population is considered resident (Cremer et al., 2018). The species also occurs year-round in other estuarine areas, such as Bahía San Blas, Bahía Anegada and the Rio Negro Estuary, Argentina (Bordino, 2002; Bordino et al., 1999; Failla et al., 2012), but the information from these areas has not been sufficient to conclude that these are resident populations.

In Bahía San Blas, in southern Argentina, franciscana dolphin sightings were made from shore-based sites and movements in and out of the bay were strongly related to tidal cycle (Bordino, 2002). The influence of the tide on the movements of the species was also recorded in Baía Babitonga, Brazil, where the franciscanas remained closer to the bay mouth at the end of ebb tide, and shifted with the current in favor of inner areas of the bay at the end of the flood tide (Paitach et al., 2017).

Information on three-dimensional use of habitat, in the form of diving behavior, is even more scarce. Bordino et al. (1999) observed franciscana dolphin dives from shore and recorded a mean dive time of 21.7 s. Surface-dive cycles were recorded visually from a helicopter for an experiment designed to estimate availability bias, for use as a correction factor for franciscana aerial surveys (Sucunza et al., 2018). A dive interval was defined as the period of time in which all individuals of the group were not visible to the observers, including the animals that were near the surface, and it varied from 0.46 to 114.89 s. Data from accidental catches in fixed bottom-set gill nets have the potential to inform about dive depths, with the caveat that some dolphins could be caught during setting or hauling, when the bottom of the net is not on the seafloor. Danilewicz et al. (2009) reported that there was no difference between the mean depth where males and females were caught in nets in southern Brazil, ranging from 6 to 35 m for males and from 10 to 35 m for females, and all sizes and ages utilize nearly the entire water column.

Data about three-dimensional movement patterns, including dive behavior, are very helpful for evaluating impacts from human activities and are critical for establishing effective protection measures, mainly related to the management of fishing activities involved with bycatch and with coastal development. In order to better understand the behavior of franciscanas relative to exposure to specific anthropogenic threats, research was conducted in the waters of Argentina (Bahía Samborombón and Bahía San Blas) and Brazil (Baía Babitonga) during 2005–2013 with the objectives of: (1) determining the feasibility of capture-release for tagging; (2) exploring the feasibility of tagging and tracking franciscanas; (3) describing franciscana movement, home range patterns, and home range size; and (4) investigating franciscana use of the water column through examination of dive behavior.

2 | METHODS AND MATERIALS

In response to different anthropogenic threats, franciscana dolphins were tagged and tracked at two sites in Argentina experiencing different levels of artisanal gill net fishing (2005, 2006, 2007, 2008, and 2010) and one site in Brazil (2011 and 2013) facing habitat alteration for harbor development and experiencing artisanal gill net fishing.

2.1 | Study areas

2.1.1 | Argentina

The field sites are located in northern and southern coastal Buenos Aires Province (Figure 1). The northern study area was in the southern portion of Bahía Samborombón, a large bay along the western coast of the Rio de la Plata estuary, which encompasses more than 3,000 km^2 with an average depth of 5 m. The area contains a variety of

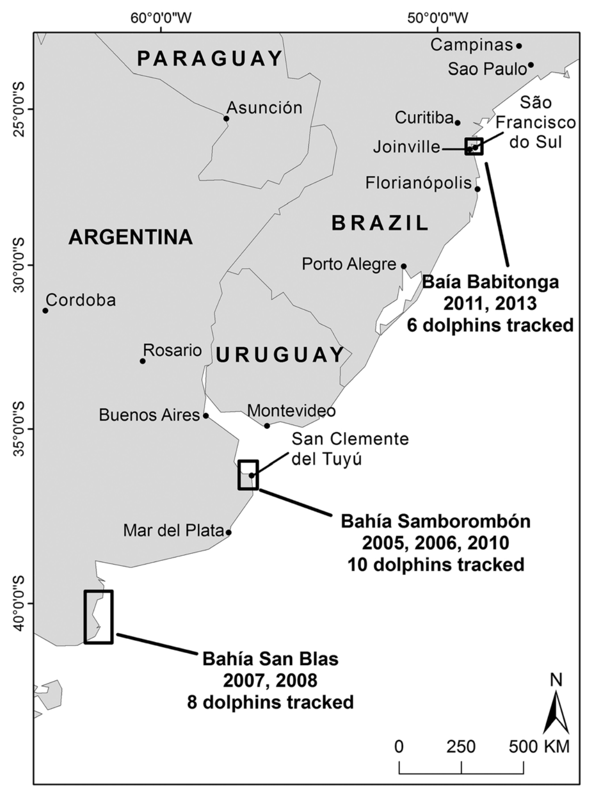

FIGURE 1 Franciscana tagging and tracking sites in Argentina and Brazil, 2005–2013.

habitats, including intertidal mudflats and creeks, tidal salt marshes, and permanent and seasonally flooded freshwater lagoons, creating a complex hydrological system with a diversity of wetland types. The estuarine turbidity front, an area of plankton concentration, creates a highly productive area and acts as one of the most important nursery areas for some commercial fish. The bay supports a traditional artisanal fishery, as well as industrial fishing efforts. Approximately 35 coastal artisanal fishermen operated with gillnets throughout the year in this area during the period of our research (2005–2010), targeting mainly white croaker (*Micropogonias furnieri*) and striped weakfish (*Cynoscion guatucupa*). Industrial bottom trawlers occasionally fish in the bay, and trawlers based out of Uruguay have been documented to catch franciscanas (Franco-Trecu et al., 2019).

The southern area is located in Bahía San Blas/Bahía Anegada, extending over 1,800 km^2 (Figure 1). It is a coastal marsh zone, which includes a group of five islands and sand embankments. However, the coast drops off steeply in some places even inside the bay, with depths of up to 5 m at distances of only 10 m from shore. This area includes the town of Bahía San Blas, the only developed zone in the region, where at least 20 vessels operate in a shark sport fishery. Also, about four artisanal fishery vessels operated in the area from September to November during the period of our research (2007–2008), targeting mainly Patagonian smoothhound *(Mustelus schmitti)*. Both were rod and reel fisheries.

The semidiurnal tide regime in Bahía Samborombón and Bahía San Blas had mean tide amplitudes of about 0.75 m and 2.50 m, respectively. These areas are important habitats for anadromous and marine fish, as well as an important concentration area for shorebirds. These two Argentine bays are provincial protected areas (managed by authorities at a level intermediate to federal or municipal) separated by about 700 km. Franciscana dolphins frequent the relatively sheltered waters in these areas (Bordino, 2002; Bordino et al., 1999, 2004).

2.1.2 | Brazil

Tagging studies in Brazil occurred in Baía Babitonga, a small, enclosed embayment located in the north coast of Santa Catarina state, South Brazil (Figure 1). Most of the estuarine area is fringed by mangrove forests, but there are also some rocky shores and sand beaches. The total area is 160 km^2. The bay connects to the ocean through a deep channel, up to 28 m deep. Most of the bay has an average depth of 6 m. The tidal amplitude in this area reaches up to 2.1 m. In the innermost areas of the bay there are large tidal flats, used extensively by franciscanas (Cremer et al., 2018). Artisanal fishing is a very important activity in this area, with more than 12 communities involved (Serafini et al., 2012). Baía Babitonga is an area with high productivity, acting as an important nursery area for shrimps, fishes, sea turtles, birds, and cetaceans (Cremer et al., 2018; Fink & Cremer, 2015; Gerhardinger et al., 2020). There are six cities around the bay, totaling more than 620,000 inhabitants, which creates strong anthropogenic pressure. Despite its importance for reproduction of many marine species, the area is threatened by many activities related to the cities around it, including harbor activity and development, industrial discharges, and mangrove landfill. The bay has two harbors for large, ocean-going vessels, located in the main channel, and the innermost area of the bay has been proposed for harbor expansion (Herbst et al., 2020). A resident population of franciscanas has been monitored in this area since 2000 (Cremer et al., 2018; Sartori et al., 2017).

2.2 | Capture, tagging, release

Capture sites were sand banks <3 m deep: (1) in the southeastern portion of Bahía Samborombón near the mouth of the bay at Punta Rasa, near San Clemente del Tuyú; (2) inside Bahía San Blas; and (3) deep inside Baía Babitonga, southwest of São Francisco do Sul. Franciscanas were captured by encirclement in shallow water with a 500 × 4.5 m seine net made of #18 twine with 15 cm stretch mesh, modeled after similar operations with bottlenose dolphins conducted over decades in Sarasota, Florida (Loughlin et al., 2010; Wells et al., 2004). The operations required the coordination of about 40 people on six to eight small outboard boats looking for dolphins during calm sea conditions (Beaufort <3). When dolphins were sighted, the group size and presence of calves within the group were recorded. The water depth was measured to ensure safe capture conditions. Once the depth was determined to be <3 m, the net was deployed from a fast-moving boat by an Argentine fisherman who, along with many of the handlers, received prior training with bottlenose dolphins in Sarasota Bay. Handlers were in boats distributed around the net circle to assist dolphins.

Once the net was deployed, observers monitored the net corral for the presence of the encircled dolphins to ensure that they did not become entangled, and were ready to intervene if that happened. Franciscanas swam calmly inside the circle. As the circle was slowly contracted to a small diameter, the dolphins swam into the net, where they received immediate assistance from trained handlers. Each captured dolphin in the group was removed from the net immediately, and gently held in the water by handlers and monitored by a veterinarian until they were transferred, one at a time, to the foam-padded deck of an inflatable boat for processing. While on deck, the dolphin was kept wet with seawater sponged over its body. The dolphins were carefully and continuously monitored by veterinarians for overall behavior and responsiveness, respiration rates and quality, heart rate and rhythm, eye appearance, and any other physical, physiological, or behavioral characteristic that might warrant attention. If the animals showed any concerning change in condition while onboard the tagging vessel, they were immediately returned to the water and supported alongside the boat, where they quickly recovered. Tagging and measuring typically required about 5 min or less. Standard blood sampling from vessels in the dolphin's fluke was included for health assessment of five dolphins in Argentina; such sampling increased the time the animals were onboard the boat to about 10 min (Barratclough et al., 2019; Wells et al., 2004). These samples were analyzed using a portable blood gas analyzer (iSTAT1 Handheld Clinical Analyzer; Heska Corporation, Loveland, CO) with a CG4+ cartridge (iSTAT CG4+ cartridges; Heska Corporation), providing data on lactate, pH, and base excess as indications of response to capture and handling.

Three kinds of electronic tags were attached to dorsal fins over the course of the projects: (1) VHF (Model AI-2 radio transmitters, Holohil Systems, Ltd., Carp, Ontario, Canada); (2) satellite-linked location-only (SPOT5, SPOT100, or SPOT299-B); and (3) satellite-linked location and depth-transmitting (SPLASH or SPLASH10) (Table 1). Different configurations of satellite-linked tags, all produced by Wildlife Computers (Redmond, WA), were used in different years as designs evolved (Figure 2). In all cases, tags were attached to dorsal fins via one or three plastic pins 0.64 or 0.79 cm in diameter, depending on the tag design (Delrin; DuPont, Richmond, VA). The satellite-linked tags used in 2006 (Figure 2b), 2007 (Figure 2b), and 2008 (Figure 2b,c) were mounted on the left side of the fin with closed-cell foam backing material as padding, and were secured to padded washers on the right side of the fin. The VHF tags (Figure 2a) and the satellite-linked tags used in 2010 (Figure 2d), 2011 (Figure 2e,f), and 2013 (Figure 2g) trailed behind the dorsal fin and were attached by a single pin. Holes for the pins were formed with a sterilized custom-made coring tool. Skin from the cores was preserved for genetic analyses (Cunha et al., 2020; Mendez et al., 2010). Through 2010, the pins were threaded on each end and the tags were secured with corrodible lock nuts designed to jettison after the end of the tag's battery life. During 2011 and 2013, the 0.79 cm diameter plastic pins were cored to allow threading with 0.95 cm Tri-P 10–14 zinc-plated steel thread-forming screws for plastic, drawn up against stainless steel washers on the outside of each tag flange to encourage corrosion and tag shedding after the end of the battery life. In some years, tags were colored differently to facilitate visual identification during subsequent field efforts. In 2013, the tag received an antifouling coating (Propspeed, Fort Lauderdale, FL).

VHF tags (Figure 2a) were deployed on three dolphins in Bahía Samborombón during 2005 as part of a feasibility study to determine whether franciscanas could be safely captured, handled, tagged, and tracked. The VHF tags were secured in custom-made orthopedic plastic housings and attached by a single plastic pin to the trailing edge of the dorsal fin (Figure 2a). The tags were specially designed and weighed only 15 g, including an 18 cm flexible antenna. The tags emitted a signal at 148 MHz range every 0.7 s. Tagged dolphins were tracked via VHF receivers (Telonics TR2 and TR4) with hand-held directional antennae from the beach, vessels, building roof-tops, and a lighthouse. Presence and nonpresence of tagged dolphins within the study area was recorded, along with bearing.

TABLE 1 Tagging and tracking summary, including individual animal and tag deployment information, tracking results, and home range and core area measures.

Deploy date	Site	Tag type	# of tag pins	Tag ID	Dolphin ID	Sex	TL (cm)	# of transmit days	# LC1	# LC2	# LC3	95% UD (km^2)	50% UD (km^2)
2005													
March 17	BS	VHF	1	148.521	Patricia	F	119	44	na	na	na	na	na
March 19	BS	VHF	1	148.379	Emily	F	na	39	na	na	na	na	na
March 19	BS	VHF	1	148.459	Beatrice	F	na	38	na	na	na	na	na
2006													
March 8	BS	SPOT5	3	65626	Pampa	F	147	7	20	4	0	5.4	3.9
March 8	BS	SPOT5	3	65625	Bruce	M	115	173	144	171	61	312.0	46.4
March 10	BS	SPOT5	3	65624	Chica	F	147	258	246	269	56	104.0	18.4
March 10	BS	SPOT5	3	65628	Tango	M	130	109	133	142	35	51.1	11.8
2007													
March 10	BSB	SPOT5	3	35961	Yaana	F	150	189	436	138	11	306.6	72.1
March 11	BSB	SPOT5	3	35962	Marta	F	135	12	19	16	4	44.0	13.6
March 13	BSB	SPOT5	3	35963	Roberto	M	140	55	139	53	8	102.8	27.4
March 13	BSB	SPOT5	3	35965	Lea	F	147	53	132	42	10	49.4	15.8
2008													
March 4	BSB	SPLASH	3	42483	Tunkën	M	128	118	412	387	96	700.9	72.0
March 4	BSB	SPLASH	3	42485	Kurë	F	147	82	366	155	25	1013.5	103.9
March 7	BSB	SPLASH	3	53625	Nahuel	M	132	84	367	68	11	448.9	112.3
March 7	BSB	SPOT5	3	35967	Kona	F	147	176	403	300	62	622.4	151.4
2010													
March 18	BS	SPLASH10	1	50758	Nélio	M	130	67	80	46	26	111.4	25.9
March 18	BS	SPLASH10	1	50760	Doc	M	125	47	26	25	8	39.3	11.2
March 20	BS	SPLASH10	1	50767	El Tío	M	127	36	47	35	10	86.2	14.4
2011													
October 2	BB	SPLASH10	1	111838	Bill	M	145	27	88	28	6	6.5	2.0

(Continues)

TABLE 1 (Continued)

Deploy date	Site	Tag type	# of tag pins	Tag ID	Dolphin ID	Sex	TL (cm)	# of transmit days	# LC1	# LC2	# LC3	95% UD (km²)	50% UD (km²)
October 3	BB	SPLASH10	1	111839	Samba	M	145	13	59	40	8	2.1	0.5
October 3	BB	SPOT100	1	111837	Babi	M	128	27	88	25	4	5.5	1.1
October 4	BB	SPOT100	1	111835	Pitanga	F	148	12	17	9	8	1.2	0.4
October 6	BB	SPOT100	1	111836	Carijó	M	108	61	179	65	9	7.0	1.6
2013													
April 10	BB	SPOT299-B	1	128253	Chico	M	125	191	132	246	159	6.7	1.8

Note: TL = total body length; LC1, LC2, LC3 = Argos location quality codes; 95% UD = overall home range; 50% UD = core area.

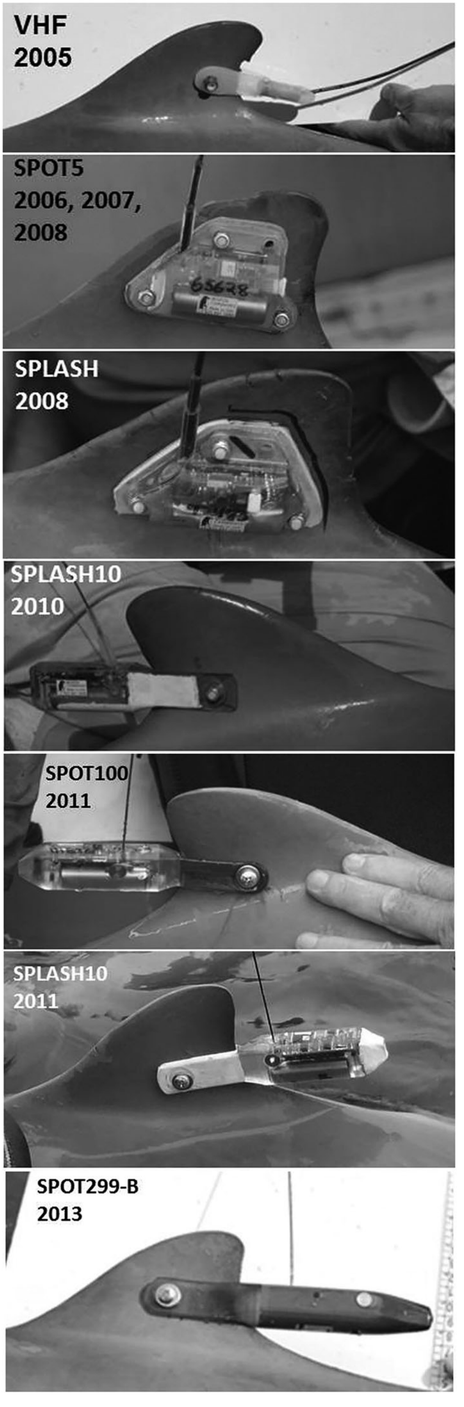

FIGURE 2 Electronic tags deployed on franciscanas: (a) VHF tag deployed in 2005 in Argentina; (b) 3-pin sidemount SPOT5 location-only tag deployed in 2006, 2007, and 2008 in Argentina; (c) 3-pin sidemount SPLASH depth-transmitting tag deployed in 2008 in Argentina; (d) single-pin finmount SPLASH10 depth-transmitting tag deployed in 2010 in Argentina; (e) single-pin finmount SPOT100 location-only tag deployed in 2011 in Brazil; (f) single-pin finmount SPLASH10 depth-transmitting tag deployed in 2011 in Brazil; and (g) single-pin finmount SPOT299-B location-only tag deployed in 2013 in Brazil.

The two kinds of satellite-linked transmitters were used in two different configurations: side-mount and single-point fin-mount. Within each configuration, the tags were nearly identical in terms of size, shape, and weight. The SPLASH tags were slightly larger than the SPOT tags due to the additional space required for depth sensing and processing components. Side-mount SPOT (Figure 2b) and SPLASH (Figure 2c) tags were used in 2006, 2007, and 2008. SPOT5 tags (Figure 2b), which provide location information only, were applied to four dolphins in Bahía Samborombón in 2006, four in Bahía San Blas in 2007, and one in Bahía San Blas in 2008. SPLASH tags (Figure 2c), which provide both location and dive information, were attached to three dolphins in Bahía San Blas in 2008. Each tag was designed for water depths of up to 1,000 m (8.0 cm L × 4.5 cm H × 2.2 cm W, 64 g; 20 cm semirigid antenna). The tags were powered by a single AA battery, generating 0.5 W of radiated power, controlled by a seawater switch, with estimated battery life of 25,000–30,000 transmissions. The SPLASH tag also included a pressure transducer.

Single-point finmount tags were used in 2010, 2011, and 2013, as improvements to electronics allowed tag size and fin coverage to be reduced while retaining or improving the tracking duration of earlier tag designs and attachments (Balmer et al., 2011, 2014). Three SPLASH10 tags (Figure 2d) were deployed in Bahía Samborombón in 2010, and two modified SPLASH10 tags (Figure 2f) were deployed in Baía Babitonga in 2011. Three SPOT100 tags (Figure 2e) were deployed in Baía Babitonga in 2011, and one SPOT299-B tag (Figure 2g) was deployed in Baía Babitonga in 2013. The latter tag design had been tested extensively on bottlenose dolphins in Florida and demonstrated to have minimal impact on the animals (Wells, 2013), and has been deployed on bottlenose dolphins and other small cetaceans elsewhere (Mullin et al., 2017; Pulis et al., 2018; Tyson Moore et al., 2020; Wells et al., 2017). SPLASH10 tags (21.2 cm L × 2.1 cm W × 3.1 cm H, 90 g) are slightly larger than SPOT tags (20.8 cm L × 2.0 cm W × 2.4 cm H, 65 g). Attachment wings on each single-point finmount tag that are trimmed to fit each fin account for ~40% of the nominal length.

The tags were programmed to transmit for 8 hr each day. During 2006 and 2007, duty cycles were staggered to provide information on possible diurnal patterns of movement. In 2008, 2010, and 2011, all tags were set on the same duty cycle each year in order to provide information on patterns of social association. The tags were programmed for 250 (SPOT5, SPOT100, SPOT299-B), 400 or 500 transmissions each day (SPLASH, SPLASH10).

The Argos Data Collection and Location System (https://www.argos-system.org/) was used to collect the location and dive data for this project. Least-squares filtering was used by Argos for processing location data through 2010, and Kalman filtering was used thereafter. Locations for all movement analyses were selected based on quality as measured by standard error radius estimates provided by Argos: LC3 < 250 m, LC2 < 500 m, LC1 < 1,500 m. Lower quality location classes (LC0, LCA, LCB) have no predicted accuracy and were therefore removed to maintain high data integrity and confidence in location data (Hobbs et al., 2005). While several empirical studies have demonstrated that the actual accuracy of Argos locations is somewhat less than what is presented by Argos (Costa et al. 2010; Douglas et al. 2012), we chose to limit our analyses to those data with measures of error, rather than including additional data from plausibility analyses, with no estimates of error.

2.3 | Tag data analyses

2.3.1 | Home range analyses

Satellite-linked location data were used as input data to calculate overall home (95% utilization distribution [UD]) and core (50% UD) ranging areas. We selected a threshold minimum number of locations for calculating home range sizes based on visual examination of the distribution of range sizes vs. the number of locations used to calculate them. Approximately 25 locations of acceptable quality (LC 1–3) were typically required before home range sizes no longer increased with additional locations. Home range sizes were calculated for all animals, with the finding that dolphins with fewer than 25 locations may have underestimated home range sizes; individuals with fewer than

25 locations were excluded from summary analyses. To remove the potential for autocorrelation, only one randomly selected location per day was retained for home range analysis. Home and core ranging areas were calculated using a fixed-kernel density (Worton, 1989) while accounting for land barriers using methods suggested by MacLeod (2013). A utilization distribution (UD) represents a probability of finding a given individual in a plane and describes an animal's use of space (White & Garrott, 1990). UDs measure areas of intense use; therefore, the resulting ranging areas may not be continuous and may not indicate the connectivity between areas of use (Kie et al., 2010; Powell, 2000). The smoothing parameter (*h*) or bandwidth determines the size and shape of spatial use (Kie, 2013; Wand & Jones, 1994). Bandwidths were calculated using a rule-based *ad hoc* method as described in Rodgers and Kie (2011). Analyses of estimated *h* parameters were completed using the Home Range Tools for ArcGIS (HRT) extension for ArcGIS 9.0 (ESRI, 2004). All other ranging pattern analyses were completed using ArcGIS 10 (ESRI, 2020).

2.3.2 | Movements relative to tides

The influence of tides on habitat use in Argentina and Brazil was examined by relating Universal Transverse Mercator (UTM) coordinates from tag data (LC 1–3) to tidal state. Because of the essentially north–south orientation of the coast at each Argentine study site, measures of locations relative to being inside or outside of bay systems were indicated by longitude, with more westerly locations being more inside, typically in shallower habitat, while latitude measures represent north–south movements along the coast. In Baía Babitonga, Brazil, the longitude measures represent a good indicator of movement of the franciscanas in relation to the flow of tidal currents due to the elongated morphology of this estuary in the east–west direction, with its only connection to the open sea to the east. Tide data were obtained from publicly available tide prediction tables for each bay (Brazil: Brazilian Navy: https://www.marinha.mil.br/; Argentina: Servicio de Hidrografía Naval: http://www.hidro.gov.ar/oceanografia/tmareas/form_tmareas.asp).

We classified the tides into four categories: E1 (first half of the ebbing tide, from slack high tide halfway to slack low tide); E2 (second half of the ebbing tide, culminating in slack low tide), F1 (first half of the flood tide, from slack low tide halfway to slack high tide) and F2 (second half of the flood tide, culminating in slack high tide). Each category (flood and ebb tide) was defined as the mean time between the high tide and the low tide. To analyze the influence of tide on franciscana movements, we used linear Gaussian mixed-effects models adjusted with restricted maximum likelihood, using the *nlme* v3.1–152 R package (R Core Team, 2020). Two models were created for each location, one for latitude and one for longitude. We chose not to combine these two explanatory variables in a single spatial metric, so that we could identify the directionality of affected movements of the franciscanas, facilitating the interpretation of the tidal results. As the goal was to identify general movement patterns of the populations, while accounting for individual variation in movement patterns, the variable "individual" was included in the models as a random effect. To deal with residual autocorrelation in satellite-linked tag locations, an AR1 (autoregressive function of order 1) error structure was added to the models. AR1 requires the specification of parameter ρ (the AR1 correlation parameter). For each model, the corresponding ρ was calculated by fitting models without correlation structure and measuring the first lag in the autocorrelation function (*acf*, R function within package *nlme*).

2.3.3 | Dive analyses

Dive data (time-at-depth histograms) were collected during 2008 in Bahía San Blas, during 2010 in Bahía Samborombón, and during 2011 in Baía Babitonga. These data were collected throughout the day, stored in 6 hr blocks, and were transmitted during daily transmission windows designed to maximize the life of the battery while still providing sufficient transmissions to define movement patterns.

Data on the proportion of time spent within selected histogram depth bins were available for all of the franciscanas tagged with SPLASH tags; bins varied by site depending on available depth. For 2008, time-at-depth histogram bins were defined as: ≤1 m, 1–2 m, 2–3 m, 3–4 m, 4–5 m, 5–10 m, 10–15 m, 15–20 m, 20–25 m, 25–30 m, 30–35 m, 35–50 m, 50–100 m, and > 100 m. For 2010, time-at-depth histogram bins were defined as: <2 m, 2–3 m, 3–4 m, 4–5 m, 5–10 m, 10–15 m, 15–20 m, 20–25 m, 25–30 m, 30–35 m, 35–50 m, 50–100 m, 100–150 m, and > 150 m. For 2011, time-at-depth histogram bins were defined as: 1–2 m, 2–3 m, 3–4 m, 4–5 m, 5–10 m, 10–15 m, 15–20 m, 20–25 m, 25–30 m, 30–35 m, 35–40 m, 40–50 m, 50–200 m, and > 100 m. Data were combined into 5 m bins for comparisons across sites. For each dolphin, mean proportion of dive time spent within a particular dive depth bin was calculated.

Franciscana habitat use patterns relative to water depth were assessed by graphically examining the distribution of water depth associated with high quality satellite-linked tag locations (LC 1–3). Raster files containing depth data for Bahía Samborombón and Bahía San Blas were downloaded from the General Bathymetric Chart of the Oceans database (GEBCO Bathymetric Compilation Group, 2020); a depth raster file for Baía Babitonga was accessed from Vieira et al. (2008). Depth data were associated with high quality locations using the "Extract values to points" tool in ArcGIS (ESRI, 2020). All histograms were created using program R (R Core Team, 2020).

2.4 | Effects of the tags

The direct monitoring of tagged individuals was done in Baía Babitonga. The observations began when the tagging procedures ended and continued over nine months for each tagging event (2011 and 2013). Searches were conducted almost daily on the first month and weekly after this, with a small boat, in the same area where they were tagged. When a tagged animal was identified, location and group size were recorded. Whenever possible, photos were taken of the tagged dolphin, and the animal was observed for as long as possible. In 2011, the animals received tags with different color patterns that allowed us to identify the individual in the field. In 2013, we tagged just one individual. In the laboratory the photos were analyzed to verify the position of the tag on the dorsal fin, the dorsal fin healing condition, and the presence of algae on the tag. We considered the minimum duration of tag attachment as the time between the deploy date and the last sighting of the animal with the tag.

3 | RESULTS

3.1 | Capture, tagging, and release procedures

Overall, the shallow-water seine net encircling technique modified from bottlenose dolphin research worked satisfactorily for catching franciscanas. The mean time from net encirclement to release was 32.5 min ($SD = 14.8$, range = 11–57), the total time out of the water was 6.6 min ($SD = 4.5$, range = 2.5–21), and the time for tagging was 5 min ($SD = 1.8$, range = 2.5–10). During 2005 through 2013, 29 franciscanas were captured and released, 20 in Argentina, and 9 in Brazil. Across both countries, 24 were tagged with electronic tags, and these were tracked for 7–258 days (Table 1). One calf of a tagged dolphin received a roto tag (Wells, 2018). Location data are available through the U.S. Animal Telemetry Network (Wells et al., 2020).

Blood gas measurements obtained for five franciscanas in Argentina included lactate (16.19–27.84 mmol/L, $M = 19.90$, $SD = 4.55$), pH (7.0–7.3, $M = 7.1$, $SD = 0.09$), and base excess (−25−−5 mmol/L, $M = -16$, $SD = 7.19$) (Table 2). These dolphins were subsequently tracked for 36–176 days. Notes from veterinarians monitoring the dolphins on the tagging vessel considered 85% (of 13 recorded cases) of the dolphins as exhibiting satisfactory behavior during handling, 67% (of 15 recorded cases) exhibited satisfactory respiratory patterns (most returned to normal upon being returned to the water), and 93% (of 14 recorded cases) swam away satisfactorily upon release.

TABLE 2 Handling responses for franciscanas for which blood gases were measured.

Deploy date	Site	Tag type	ID	SEX	TL (cm)	Track days	Handle time (min)	Heart rate	Lactate (mmol/L)	pH	Base excess (mmol/L)	Comments
March 4, 2008	BSB	SPLASH	Tunkën	M	128	118	21 (4 for tagging)	good	18.52	7.1	−17	swam off well, good respirations
March 4, 2008	BSB	SPLASH	Kurë	F	147	82	14 (5 for tagging)		27.84	7.0	−25	behaved well on boat; swam off very strongly with Aylen (calf)
March 7, 2008	BSB	SPLASH	Nahuel	M	132	84	16 (5 for tagging)	120, no sinus arrythmia	18.23	7.1	−18	
March 7, 2008	BSB	SPOT5	Kona	F	147	176	10 (3 for tagging)	120, no sinus arrythmia (initial spike of 160–180)	18.70	7.1	−16	feisty, did not settle onboard; left slowly at first, then picked up speed and made longer dives
March 20, 2010	BS	SPLASH10	El Tio	M	127	36	5		16.19	7.3	−5	good respirations

Not all capture-release efforts were successful. In Argentina in 2010, one dolphin tagged with a SPLASH10 tag swam off slowly upon release. No signals were received from this dolphin, and its floating carcass was recovered the next day. Necropsy indicated capture myopathy as the cause of death. The dolphin had to be transported a short distance from the capture site for tagging because of breaking waves at the capture site, resulting in capture/handling time (53 min total, 33 min handling on-boat and in-water) that was nearly the longest of all dolphins handled. In Brazil in 2013, three dolphins, including one with a SPOT299-B tag, were released before capture net retrieval was completed. The tagged 112 cm subadult male, 134 cm lactating female, and 83 cm male calf entangled in the remaining net that was in the water without being detected until too late, and died.

3.2 | Tracking duration

Tracking duration varied with tag type, model, and version, as summarized in Table 1. The three VHF tags were tracked over a period of 6 weeks, exceeding the expected tracking duration. The maximum possible range (line-of-sight) from the highest receiving station was about 20 km. The satellite-linked tags attached with three pins performed better than did the tags attached by a single pin, on average. The 3-pin SPOT tags transmitted for an average of 114.7 days ($SD = 88.57$, range = 7–258, $n = 9$), as compared to 72.6 days ($SD = 81.45$, range = 12–191, $n = 4$) for the single-pin SPOT tags. Given the increased energy demands for transmitting the longer dive data messages, the SPLASH tags did not transmit for as long as the SPOT tags. The 3-pin SPLASH tags transmitted for an average of 94.7 days ($SD = 20.23$, range = 82–118, $n = 3$), as compared to 38.0 days ($SD = 20.45$, range = 13–67, $n = 5$) for the single-pin SPLASH tags.

In Brazil, it was possible to resight tagged dolphins postrelease and obtain information on tag condition and fate that was not possible to obtain for dolphins in Argentina. For dolphins tagged in 2011, visual monitoring totaled 7 hr 42 min of direct observation, from October 7, 2011, through June 10, 2012. We were not able to define precisely the tag attachment duration, but tags remained on the dolphins for at least 12–214 days in 2011, including three that remained attached after the period that transmissions were received (Table 3). We obtained 346 photographs of tagged individuals. Throughout the period of tag attachment all the animals were engaged in normal behaviors and no behavioral changes were observed in dive patterns. Two individuals (males Samba and Babi) were captured and tagged in the same group, and they were photographed together in 73% of their subsequent records ($n = 19$). Four of the five 2011 dolphins were seen after the tags were shed, and their tags migrated posteriorly leaving torn fins, but all showed good healing. Three of these dolphins (Samba, Babi, Carijó) were observed in Baía Babitonga for extended periods (up to 3,183 days) after they were tagged, in good condition.

Fishery interactions were probable sources of transmission cessation for the two 2011 tags seen for the shortest periods of time. Female Pitanga transmitted locations in the area frequented by franciscanas during October 4–10, 2011, but then signals ceased until October 14–15, when high quality signals began to be received from near the entrance of the bay. Several days later her carcass was recovered on the beach, and fishing net marks were observed on her head, suggesting she might have been killed in a fishing net on October 10, and then drifted until she washed ashore on October 14. Another 2011 dolphin, male Bill, was not seen after transmissions ceased. He was not observed after October 23, 2011. No regular dive data were obtained from Bill after October 26, 2011. Subsequent intermittent locations through January 29, 2012 were from a very small river, near boat houses used by fishermen, far from the franciscana home range in the bay, and opposite to any predominant current, suggesting he had been caught or his tag had been recovered by fishermen.

In several cases, tags ceased transmitting but remained on the dorsal fins, in some cases exhibiting biofouling. Observations of males Babi and Carijó showed that their tags accumulated algae, which may have compromised transmissions by fouling sensors. Algae had covered Babi's tag within 78 days of tagging, and by 101 days, the algal

TABLE 3 Conditions and fates of tags on franciscanas in Brazil.

Deploy date	Tag type	ID	Last sight with tag	First sight without tag	Most recent sight	Days from tagging to most recent sight	Minimum days tag on fin	Maximum days tag on fin	Track days	Tag condition
October 2, 2011	SPLASH10	Bill	October 23, 2011	na	October 23, 2011	21	27	na	27	Tag intact, signals continued intermittently through January 29, 2012
October 3, 2011	SPLASH10	Samba	October 3, 2011	October 18, 2011	August 23, 2012	325	13	15	13	October 18, 2011 - major fin tear from pin migration
October 3, 2011	SPOT100	Babi	February 8, 2012	April 18, 2012	November 24, 2017	2,244	128	198	27	December 20, 2011 - algae-covered; April 18, 2012, minor fin tear from pin migration
October 4, 2011	SPOT100	Pitanga	October 4, 2011	na	na	na	12	12	12	Oct 15, 2011 - carcass found, fishery interaction, fin tear from tag removal (anthropogenic?)
October 6, 2011	SPOT100	Carijó	May 7, 2012	June 28, 2012	June 23, 2020	3,183	214	266	61	February 11, 2012 - algae-covered, April 18, 2012 - antenna missing; fin tear from pin migration
April 10, 2013	SPOT299-B	Chico	March 7, 2014	March 26, 2014	January 7, 2020	2,463	331	350	191	September 12, 2013 - algae on antenna; Jan 17, 2014 - antenna missing, algae on attachment screw head; March 7, 2014 - tag body algae-covered; March 26, 2014 - healing hole at attachment site

coating was sufficiently thick as to limit the antenna's ability to clear the water. Babi's tag remained on his fin for 128–198 days, but the tag only transmitted high quality signals for 27 days. Carijó's tag remained on his fin for 214–266 days, but the tag only transmitted high quality locations for 61 days. After fewer than 128 days, both the transmitter and antenna were covered by algae, and his antenna was missing after 195 days. Either fouled sensors or antenna loss would adversely impact transmissions.

The SPOT299-B tag used in Baía Babitonga in 2013, with a new tag design and an antifouling coating, was tracked for the longest period. Male Chico transmitted for 191 days. An algal covering was first noted on the (uncoated) antenna 155 days after tagging, and the antenna was missing by 282 days posttagging. He was observed with the tag still attached, but covered with algae by 331 days posttagging. The tag was no longer on the fin when he was seen 350 days posttagging, leaving a small, healing hole through the fin at the attachment site, as designed. Chico had continued to be observed in the same area until at least January 7, 2020, more than 6.7 years posttagging. The tag hole was fully healed, and small healed indentations on the trailing edge of the fin were visible, resulting from the up and down movement of the tag.

3.3 | Ranging patterns

The dolphins exhibited very limited movements at each of the three study sites, with home range size varying from site to site. None of the tagged dolphins ranged far from the capture site.

3.3.1 | Bahía Samborombón

Localized movements of franciscanas in Bahía Samborombón and vicinity were indicated by the VHF tracking results for three females tagged in March 2005. Tracking occurred on 42 days and signals were received from at least one of the tagged dolphins daily, from two individuals on 71% of tracking days, and from all three individuals on 40% of the tracking days. The longest daily continuous tracking sequence was 6.5 hr. Although most of the data recorded were simply bearings and relative intensities of signals, five triangulations were obtained, and a tagged franciscana was reported by a fisherman, swimming with two nontagged individuals in the southern-most sandbank close to the capture area. Taken together, these data suggested site fidelity, mainly in the area of sandbanks where they were caught.

Building on the preliminary evidence of site fidelity from the 2005 feasibility study, satellite-linked, location-only tags were deployed on two male and two female franciscanas in the same region of Bahía Samborombón in March 2006, and tracked for up to 258 days (Table 1). All the locations were in the southeastern portion of Bahía Samborombón or along the Cabo San Antonio coast immediately to the south, in waters <10 m deep, centered roughly on Punta Rasa, near the sandbanks where they were caught for tagging (Figure 3).

Ranging patterns similar to those of the 2006 dolphins were found for the three males caught in the same area and tagged with satellite-linked, depth-transmitting tags in March 2010, deployed to increase the sample size for Bahía Samborombón dolphins, and to describe franciscana use of the water column (Figure 3). These SPLASH10 tags transmitted for up to 67 days (Table 1). Dolphin movements were localized, as had been demonstrated previously (Figure 3). The males' ranging patterns were different from one another during the tracking period, suggesting a lack of strong social relationships. Their ranges differed from one another, but exemplified site fidelity, overlapping the sandbanks at the southern mouth of Bahía Samborombón (Figure 3).

The mean home range size for Bahía Samborombón franciscanas with more than 25 locations was 132.9 km^2 (SD =102.8 km^2, range = 51–312 km^2, n = 5). Mean core area was 23.4 km^2 (SD = 14.0 km^2, range = 12–46 km^2, n = 5).

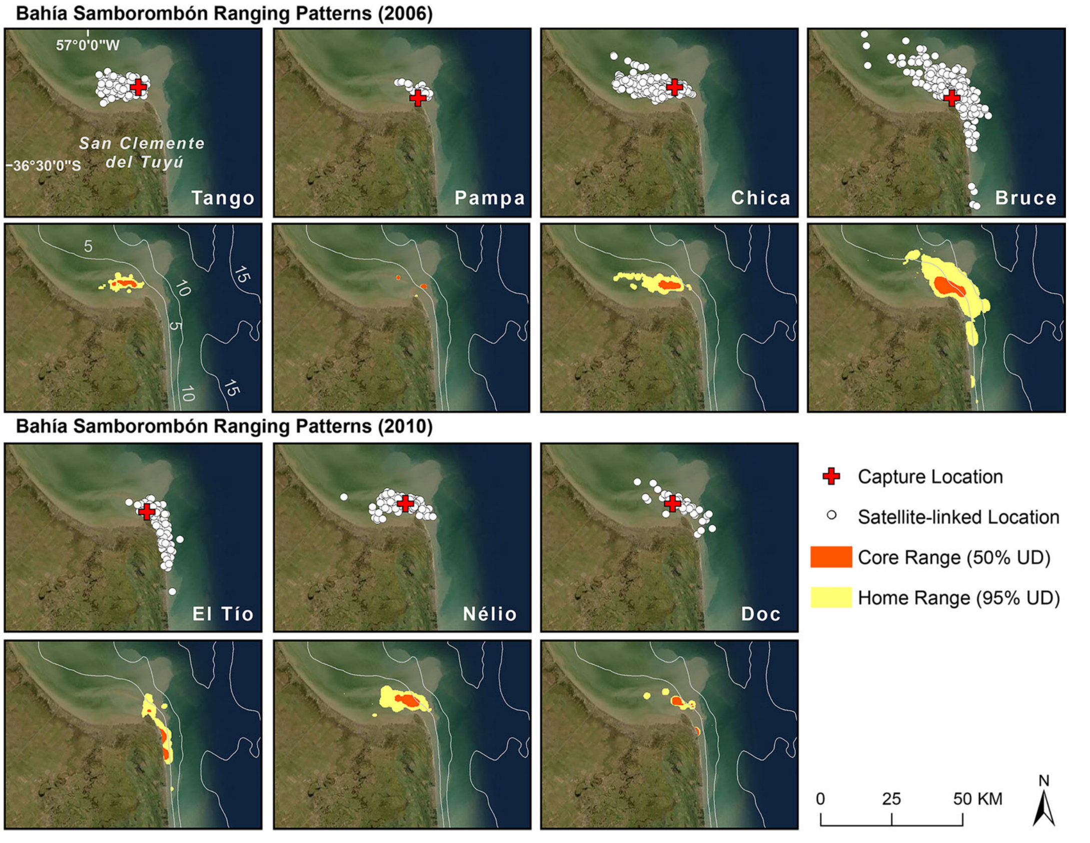

FIGURE 3 Ranging patterns of individual franciscanas in Bahía Samborombón, Argentina, from satellite-linked tracking in 2006 and 2010. White dots indicate all LC 1–3 tracking locations (i.e., with an estimated error radius <1,500 m). Dolphins Doc and Pampa had fewer than 25 locations for home range analysis. Individual home ranges are described by 95% utilization distributions; core areas within the home ranges are indicated by 50% utilization distributions. Bathymetry is indicated by contours at 5 m increments. "World Imagery" base map accessed via ESRI (2020); bathymetry data accessed via GEBCO (GEBCO Bathymetric Compilation Group, 2020).

3.3.2 | Bahía San Blas

Satellite-linked location-only tags were deployed on three females and one male in 2007 and on one female in 2008, and transmitted for up to 189 days (Table 1). Three franciscanas tagged in 2007 remained inside the bay in shallows and channels (Figure 4). Five franciscanas, including one from 2007 and all four tagged during 2008 ranged through shallow interior waters including Bahía Anegada, as well as moving through deep channels and extensively through coastal waters to the north and south of Bahía San Blas. The eight franciscanas overlapped in their use of sandbanks and channels inside Bahía San Blas. The mean home range size for Bahía San Blas franciscanas with more than 25 locations was nearly three times greater than for Bahía Samborombón dolphins, at 463.5 km^2 (SD = 344.1, range = 49–1,013, n = 7). Mean core area was 79.3 km^2 (SD = 47.8, range = 16–151, n = 7).

3.3.3 | Baía Babitonga

Satellite-linked location-only tags were deployed on one female and two males in 2011 and on one male in 2013, and transmitted for up to 191 days (Table 1). Satellite-linked, depth-transmitting tags were deployed on two males in

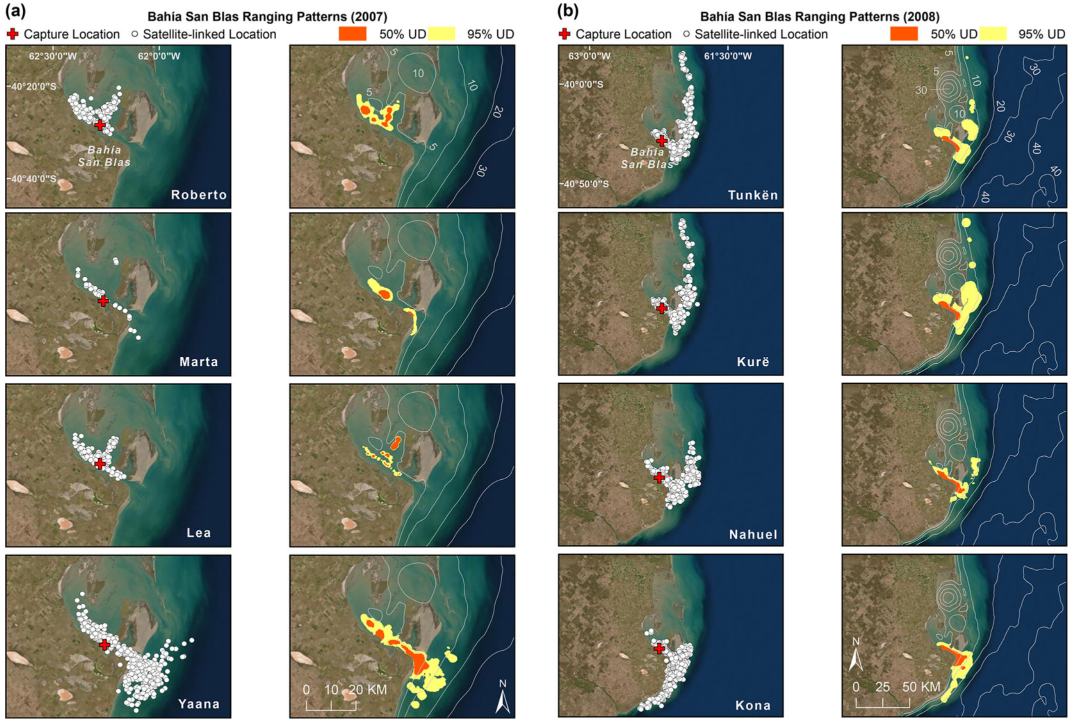

FIGURE 4 Ranging patterns of individual franciscanas in Bahía San Blas, Argentina, from satellite-linked tracking in (a) 2007 and (b) 2008. White dots indicate all LC 1–3 tracking locations (i.e., with an estimated error radius < 1,500 m). Dolphin Marta had fewer than 25 locations for home range analysis. Individual home ranges are described by 95% utilization distributions; core areas within the home ranges are indicated by 50% utilization distributions. Bathymetry is indicated by contours at 5 m, 10 m, and 10 m increments thereafter. Due to scaling issues with available bathymetry data, the narrow, deep entrance channel to Bahía San Blas is not evident from isobaths. The dark green channel shown just to the northeast of the label "Bahía San Blas" in Figure 4a reaches depths of up to 35 m. "World Imagery" base map accessed via ESRI (2020); bathymetry data accessed via GEBCO (GEBCO Bathymetric Compilation Group, 2020).

2011, transmitting for up to 27 days (Table 1). Movements by franciscanas were very limited in Brazil. All six tagged dolphins showed very similar patterns of movements, remaining in a very small portion of Baía Babitonga, primarily over or near shallow interior flats, ranging into adjacent channels (Figure 5). Discounting one apparently erroneous location for Carijó, none of the tagged dolphins left the bay during the tracking period, and one was observed repeatedly in the bay over the next 6 years. The one location for Carijó in the Atlantic Ocean is believed to be erroneous for several reasons. It is the only high-quality location for any of the dolphins tagged in Baía Babitonga that was outside of the inner bay. For the animal to return to the next high-quality location, in the inner bay, would mean maintaining a speed of at least 11.3 km/hr, 2.4 times the typical traveling speed of franciscanas (Bordino et al., 1999), for 3.3 hr to round the peninsula to the north and enter the bay. This is an unreasonable expectation for a small, slow-moving dolphin that does not engage in energetic behaviors to the same degree as other dolphin species. Subsequent plausibility analyses flagged this oceanic location and the next eastern-most location for Carijó for removal from the data set (Douglas et al. 2012). The mean home range size for Baía Babitonga franciscanas with more than 25 locations was much smaller than for dolphins at either Argentine site, at 6.4 km^2 (SD = 0.7, range = 5.5–7.0, n = 4). Mean core area was 1.6 km^2 (SD = 0.4, range = 1.1–2.0, n = 4).

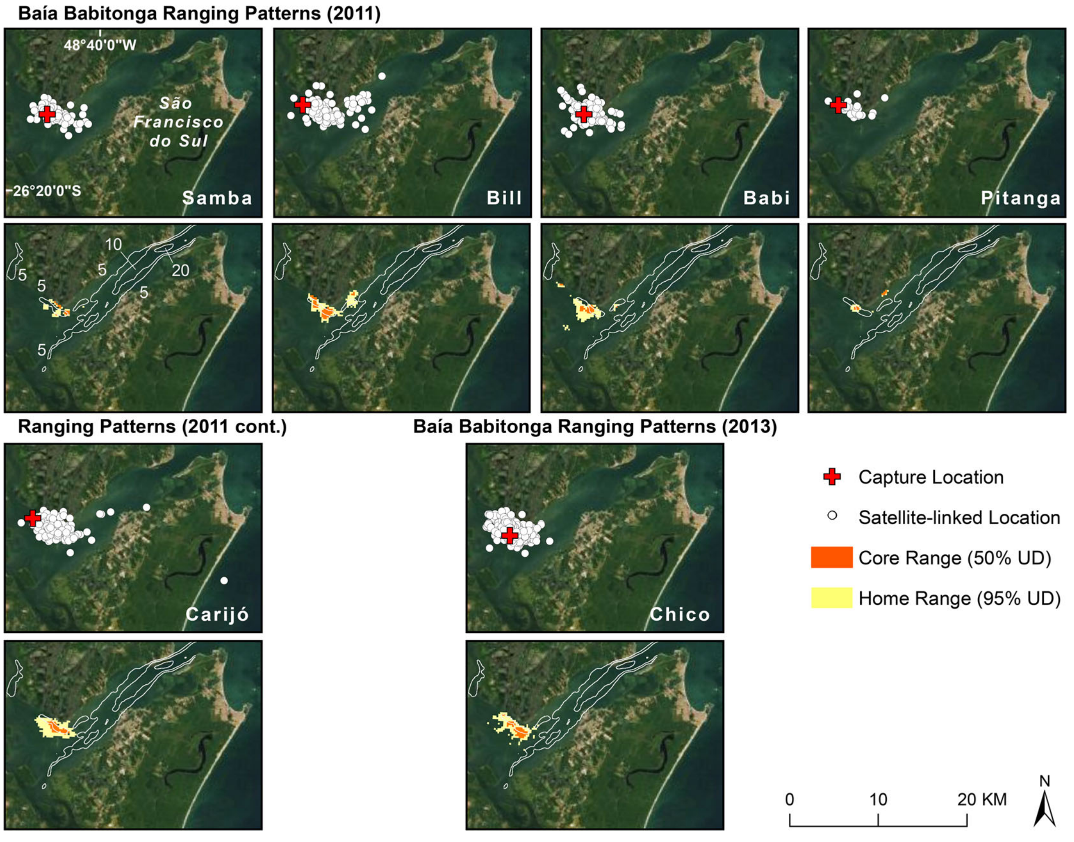

FIGURE 5 Ranging patterns of individual franciscanas in Baía Babitonga, Brazil, from satellite-linked tracking in 2011 and 2013. White dots indicate all LC 1–3 tracking locations (i.e., with an estimated error radius <1,500 m). Note that the two easternmost locations for Carijó were flagged for removal from the dataset through subsequent plausibility filtering analyses (Douglas et al. 2012). Dolphins Samba and Pitanga had fewer than 25 locations for home range analysis. Individual home ranges are described by 95% utilization distributions; core areas within the home ranges are indicated by 50% utilization distributions. Bathymetry is indicated by contours at 5 m increments. The deepest waters of the main shipping channel in the bay, reaching 28 m, is to the northeast, beyond the view of the map. "World Imagery" base map accessed via ESRI (2020); bathymetry data accessed via Vieira et al. (2008).

3.4 | Movements relative to tides

3.4.1 | Argentina

The data recorded for the three VHF-tagged dolphins in 2005 provided preliminary evidence of movements associated with the tidal current flow in Bahía Samborombón, with dolphins coming into the bay for high tide and going to the open sea for low tide. The three dolphins were mainly to the north and northwest during high tide, and to the northeast, east, and south during low tide. This pattern was confirmed in the present study in Bahía Samborombón and Bahía San Blas through analysis of locations from satellite-linked tags showing dolphins farther inside the bays and further north during high tides and farther to the east and to the south, closer to the mouths of the bays during low tides (Figure 6). The east–west and north–south locations of the dolphins varied (Table 4) depending on tidal state, with the pattern being most clear in Bahía San Blas, where the daily tidal excursion was greatest.

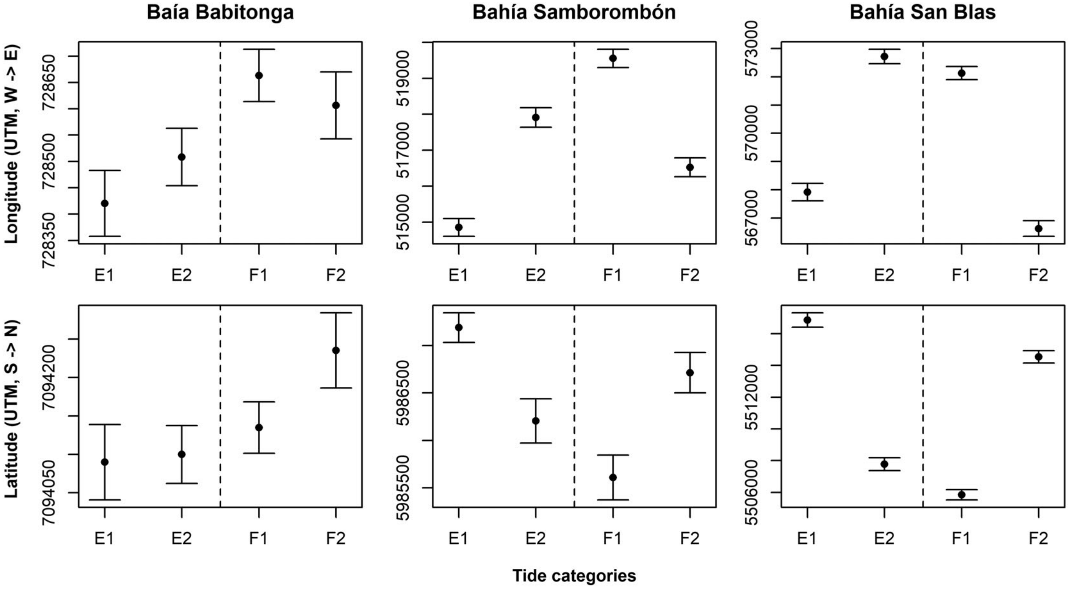

FIGURE 6 Franciscana movements defined by average longitude (top) and latitude (bottom) relative to tidal state (early ebb = E1, late ebb = E2, early flood = F1, late flood = F2; vertical dotted line indicates low tide). Error bars: 95% CI.

TABLE 4 Linear Gaussian mixed-effects model coefficients describing franciscana movements in relation to the tides.

Data set	Coefficients	(Intercept)	Tide E2	Tide F1	Tide F2
Baía Babitonga, longitude ($df = 1{,}154$)	Estimate	728,568	86	132	14
	SE	141	115	110	115
	t	5,130.84**	0.75	1.20	0.12
Baía Babitonga, latitude ($df = 1{,}154$)	Estimate	7,094,252	118	121	191
	SE	127	70	67	70
	t	55,732.89**	1.68	1.79	2.69*
Bahía Samborombón, longitude ($df = 1{,}368$)	Estimate	515,917	3,314	5,465	2,314
	SE	1,870	347	361	373
	t	275.81**	9.54**	15.12**	6.20**
Bahía Samborombón, latitude ($df = 1{,}368$)	Estimate	5,985,959	−681	−1,562	−717
	SE	1,827	300	312	322
	t	3,276.08**	−2.27*	−5.00**	−2.22*
Bahía San Blas, longitude ($df = 3{,}258$)	Estimate	565,209	4,201	3,490	−167
	SE	2,114	217	231	216
	t	267.29**	19.28**	15.09**	−0.77
Bahía San Blas, latitude ($df = 3{,}258$)	Estimate	5,516,828	−5,810	−6,658	−1,070
	SE	2,581	235	250	233
	t	2,137.25**	−24.68**	−26.62**	−4.58**

*$p < .05$. **$p < .005$.

3.4.2 | Brazil

In Baía Babitonga, although it is possible to observe a movement trend similar to that of other areas in the east–west direction (Figure 6), with the animals moving more inside the bay with the flood tide progressing, no statistically significant differences were detected (Table 4). This is possibly related to the spatial scale of the distribution of this population, which is much more restricted. Regarding latitudinal displacements, only at the end of the flood tide was there an explicit tendency for the animals to move further north (Figure 6, Table 4).

3.5 | Diving patterns

Use of the water column was fairly consistent within and across sites, with variations related to available water depth. Across all three sites, franciscanas spent nearly all of their time-at-depth <10 m, and mostly <5 m (Figure 7). Maximum dive depths varied from site to site, as did available water depth. Franciscanas occasionally dove to 10–

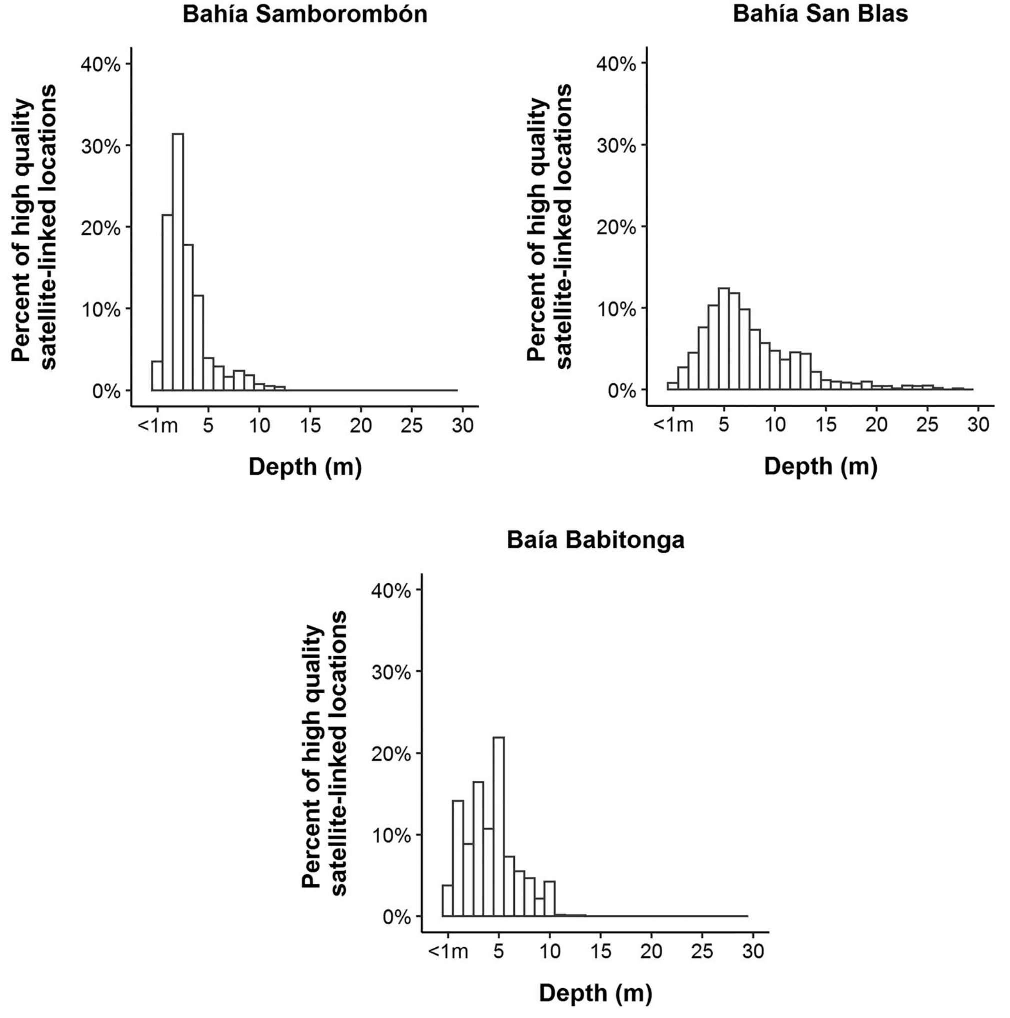

FIGURE 7 Water depths associated with high-quality franciscana locations.

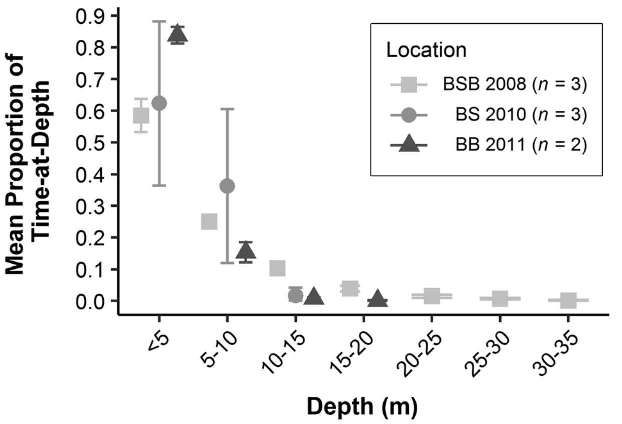

FIGURE 8 Comparison of mean (±*SD*) proportions of time spent within specified depth ranges across all three study sites.

15 m in or near Bahía Samborombón, to 30–35 m in or near Bahía San Blas, and to 15–20 m in Baía Babitonga (Figure 8). The average water depth from the high-quality locations of the tagged animals in Bahía Samborombón was 2.9 m ($SD = 2.1$), and the maximum depth was 12 m. The average depth of tag locations for franciscanas in Bahía San Blas was 7.6 m ($SD = 4.7$), and the maximum water depth was 28 m. The average depth of tag locations for franciscanas in Baía Babitonga was 4.2 m ($SD = 2.5$), and the maximum depth was 13 m. The apparent discrepancies between maximum dive depths and available depth are likely due to estimated error radii of tag locations, and steep drop-offs at the edges of franciscana ranges, allowing somewhat deeper dives than suggested by estimated water depths. In each case, maximum dives were sufficient to reach the seafloor in the deepest portions of their home ranges, but their home ranges did not necessarily include the deepest waters in the bays. Water depth was greatest in open ocean waters off Bahía Samborombón (10–15 m, Figure 3), in the entrance channel and offshore of Bahía San Blas (up to 35 m; Figure 4a,b), and in the main shipping channel in Baía Babitonga (up to 28 m; Figure 5).

4 | DISCUSSION

The application of approaches and tools previously developed for conservation research on other species of small cetaceans allowed us to obtain much needed information on the ranging patterns and behavior of franciscanas. Through the tracking of tags applied to dorsal fins during brief capture-release efforts, we were able to determine that franciscanas exhibit site fidelity in all three bays where tagging was performed in Argentina and Brazil, their movements are strongly influenced by tidal currents, and they use the entire water column.

4.1 | Capture, tagging, release procedures and tracking duration

We demonstrated, for the first time, the feasibility of using capture-release techniques and telemetry tagging to study franciscanas. In most cases, the tagged dolphins responded reasonably well to brief handling, swam off strongly upon release, and were subsequently tracked for days to months. However, this species presents more challenges for handling than do other, larger, and more robust species, such as bottlenose dolphins. The small size of the franciscanas makes it much more difficult to detect the animals when they entangle in the net, with less deflection of the net circle and less ability to submerge the float line. Calm waters and extremely careful monitoring of the net perimeter are required to ensure safe capture and release. The three dolphins lost in 2013 in Baía Babitonga had been disentangled from the net and released, only to swim back into a section of net remaining in the water, where their second entanglement was not detected until too late. The net had been set on what was initially believed to be three larger dolphins, but was subsequently determined to be four dolphins including a mother and a calf. The mother and calf were released as soon as possible, without tagging, as we specifically did not want to put mother/calf pairs at risk. While our research protocols called for catching no more than three dolphins at a time, and avoiding mothers and calves because of their importance for the viability of a small population such as that in Baía Babitonga, this event made clear the importance of determining with as much certainty as possible what dolphins are within the capture circle before the net is deployed.

We confirmed that these animals require great care and brevity in handling. The time from net set to release ranged from 11 to 57 min, time out of the water ranged from 2.5 to 21 min, and time for tagging ranged from 2.5 to 10 min; the probability of successful outcome increased inversely with handling time. The dolphin with the longest time from restraint to release (33 min) was found dead the next day, apparently from capture myopathy.

Blood sample analyses provided an indication of development of metabolic acidosis in franciscanas as a presumptive short-term response to handling (Table 2). The values of lactate (16.19–27.84 mmol/L, $M = 19.90$, $SD = 4.55$), pH (7.0–7. 3, $M = 7.1$, $SD = 0.09$), and base excess (-25–-5 mmol/L, $M = -16$, $SD = 7.19$) were more extreme than those typically measured for other small cetaceans. For perspective, bottlenose dolphins sampled immediately after capture during capture-release health assessments performed during 2004–2019 in Sarasota Bay, Florida ($n = 221$) demonstrated the following: lactate (0.31–14.68 mmol/L, $M = 3.54$, $SD = 2.71$), pH (7.1–7.5, $M = 7.3$, $SD = 0.06$), base excess (-14–17 mmol/L, $M = 3$, $SD = 4$) (R.S.W., unpublished data). Bottlenose dolphin lactate concentrations declined with time within a single handling event (mean change $= -2.31$ mmol/L, $SD = 2.63$, $n = 48$), and with experience, as measured from recaptures. One 3-yr-old female bottlenose dolphin had a lactate concentration of >20.00 mmol/L during her first capture; during resamplings 10 years later, her lactate concentrations were 4.68 and 5.25 mmol/L. She has been observed regularly over the 15 years subsequent to her first sampling, producing four calves to date. Plasma lactate concentrations for two adult bottlenose dolphins under human care increased with exercise, to levels of 11.3–13.6 mmol/L (Williams et al., 1993). Our sampled franciscana dolphins (Table 2) were subsequently tracked for 36–176 days, indicating no immediate consequences of the metabolic changes. However, lactate concentrations and those of other blood gas parameters may be useful indicators of short-term responses.

Every effort was made to perform tagging and other procedures quickly and to release the dolphins as soon as possible. The dolphins were carefully and continuously monitored by veterinarians. Recognizing the apparent importance of support in-water, future capture-release efforts will attempt to place individuals in a soft-sided water-filled container onboard the tagging boat for procedures. In addition, individuals or mother/calf pairs will be released as quickly as possible after the capture net is removed from the water, rather than waiting to release all dolphins caught at one time as a group. Data on franciscana responses to evolving handling techniques during future catch-and-release operations will also be important to inform developing approaches to integrated conservation planning, in which both in situ and ex situ conservation efforts are considered as potential options for species of concern (Taylor et al., 2020).

Taken together, our experiences lead to the following recommendations for future franciscana catch-and-release research efforts. Given the small size and fragility of this species as well as its conservation status, great care must be exercised in selecting individuals and sites for capture. The maximum number of animals to be encircled by the net should take into consideration the number of in-water handlers available to come quickly to their aid should they become entangled in the net, but under no circumstances should more than three dolphins at a time be targeted. In Baía Babitonga, it is rare to find solitary franciscanas. Net deployment should not occur until there is certainty about how many animals are in the area where the net will be set, and that none of them are mother-calf pairs. Conditions should be calm, to allow detection of even the slightest movement of net floats indicative of one of these small animals being in the net. A team of 30–40 people (including multiple veterinarians) operating from multiple small boats should be distributed evenly around the net corral to minimize response time should entanglement be detected. Team members should concentrate both on monitoring/counting animals swimming inside the net corral at each surfacing, and looking for indications of entanglements. The net should be completely retrieved and removed from the water as quickly as possible once the dolphins are restrained – any net in the water is actively fishing. Careful monitoring of the net should continue for as long as any net is in the water, for detection of unexpected entanglements. Handling time, especially time aboard the research vessel, should be minimized, and the animals should be carefully monitored by a veterinarian during all procedures. An in-water team should remain alongside the research vessel to receive the dolphin should it not respond well to procedures on deck, as return to the water typically results in quick recovery. Dolphins should not be released until the entire net is removed from the water, but if release must happen sooner, the animals should be released as far as possible and down-current from the net, they should be oriented away from the net, and the remaining net should be carefully monitored.

Assessing the feasibility of tagging franciscanas included determining whether existing tags could be used successfully on a species with such a small dorsal fin. Tag transmission durations of up to 258 days were documented, demonstrating that telemetry can be a safe and effective tool for studying franciscanas. Tag designs used with franciscanas evolved over time, as the technology evolved based on findings at other sites and with other species, moving toward reducing the potential impacts of the tags on the animals (Wells, 2005, 2013), and tracking duration varied from one design to the next. The initial satellite-linked tags used with franciscanas during 2006–2008, were mounted on one side of the fin, and attached by three pins (Table 1). Observations of bottlenose dolphins (e.g., Balmer et al., 2010) found that pins inevitably releasing at different times led to the tag pulling partially away from the fin, increasing water flow against the tag, and pulling the remaining pins through the dorsal fin until the tag was shed. Unfortunately, resighting efforts to observe 3-pin tags deployed in Argentina were not possible, so the fates of franciscana fins, tags, and attachments were not documented.

To reduce the possibility of fin damage, newer tags (2010–2013) were designed to be smaller, to increase symmetry of attachment for improved water flow, to reduce drag, and to reduce dorsal fin surface coverage. They were designed to be attached by only a single pin, with the tag body trailing behind the fin (Balmer et al., 2011, 2014; Wells, 2013). Ongoing photographic identification research in Baía Babitonga provided opportunities to observe dolphins with single-pin tags for the duration of the tracking, and after in some cases. In at least four cases, tags remained on the dolphins beyond the end of transmissions, in some cases for months. All of the 2011 Brazilian tags ceased transmitting before the batteries were exhausted, within 12–61 days of deployment. In comparison, 25 similar tags deployed on bottlenose dolphins in Barataria Bay, Louisiana, in 2011 transmitted for 48–260 days (Wells et al., 2017). In two cases, the tags on franciscanas were observed to have lost their antennae, and three tags were observed with heavy algae growth. It is possible that this intense algae coverage observed in Baía Babitonga is a consequence of the high concentration of nutrients and productivity in this estuary (Costa & Souza-Conceição, 2009), which may have contributed to the rapid growth of the algae. Allied to this fact, franciscanas move more slowly than bottlenose dolphins, which may also have contributed to the biofouling. Heavy biofouling greatly increases drag on tags (Wells, 2013), and this may lead to attachment pin migration through a fin if the attachment screws have not yet corroded to the point of being the "weak link." Biofouling of Chico's tag, coated with an antifouling compound, was delayed relative to the 2011 tags. It is likely that by the time biofouling became an issue for Chico's tag, the attachment screws had corroded substantially to break and release the tag, leaving only a small, healing hole through the fin, as designed.

Missing antennae, antennae that do not clear the water's surface, and/or algal coverage of saltwater sensors that switch the tags "on" can terminate tracking. Design changes to further reduce drag and improve water flow over sensors, and application of an anti-biofouling coating on the tag on Chico in 2013 may have contributed to the extended attachment of the tag, and transmissions over 191 days, the second longest transmission duration of any of the tags we deployed on franciscanas. The tag transmitted until the battery voltage dropped below the transmission threshold. Although the sample size is too small to be conclusive about the effects of the tag modifications, Chico's 191-day track was near the upper end of the range of 80–197 days for eight similar tags deployed on bottlenose dolphins in Barataria Bay in 2013 (Wells et al., 2017). Chico's antenna was lost after transmissions had ceased. Subsequent versions of this tag design have incorporated physical protection for the antenna base.

4.2 | Ranging patterns

Franciscanas displayed varying home range and core range sizes across the three study sites (home range across sites = 5.5–1,013.5 km^2, core range across sites = 1.1–151.4 km^2). Within each study site, individuals displayed a high degree of range overlap; however, there were considerable differences in ranging behavior among the three sites. We found that franciscanas in our one study area in Brazil had smaller range sizes than franciscanas in either of our study sites in Argentina. While our sample size for Brazil was small ($n = 4$ for animals with minimum of 25 locations), this pattern was observed for all of the animals, with little variation in home range size observed among individuals ($SD = 0.6$ km^2). Relatively small individual home range sizes have been observed for other species of small cetaceans in Brazilian coastal waters. For example, Guiana dolphins (*Sotalia guianensis*) are reported to have home range sizes between 0.6 and 22.9 km^2 considering data obtained from photo-identification monitoring in different bays and estuarine areas in southern Brazil (Flores & Bazzalo, 2004; Oshima et al., 2010). Franciscanas in Argentina displayed more individual variation in ranging behavior than dolphins in Brazil and, on average, had larger home range sizes than what has been reported for coastal communities of common bottlenose dolphins in the Gulf of Mexico (Mullin et al., 2017; Wells et al., 2017) and of Indo-Pacific bottlenose dolphins (*T. aduncus*) in Western Australia (Sprogis et al., 2016), using the same home range calculation methods as the present study.

Differences in franciscana ranging behavior and home range size across the study sites are likely due to a variety of factors, such as habitat characteristics, including prey density. Baía Babitonga is more sheltered in comparison to the more open waters of the Argentina sites, which could explain the smaller home range sizes in Baía Babitonga. This pattern of decreased home range size in more sheltered vs. open habitat has also been suggested for coastal Indo-Pacific bottlenose dolphins (Sprogis et al., 2016). The central region of Baía Babitonga concentrates the highest densities of franciscana prey throughout the entire year (Cremer et al., 2018; Paitach, 2015). However, franciscanas occupy only a part of this high productivity region, concentrating more to the north, which leads us to believe that other factors besides the availability of prey affect the use of habitat by the species. Smaller franciscana home and core ranges in Baía Babitonga could also be explained by: (1) the availability of shallow water habitat favored by franciscanas (Figure 7), limited to the western portion of the bay; (2) the presence of resident Guiana dolphins in the middle and eastern part of Baía Babitonga (Cremer et al., 2004, 2018); and/or (3) high levels of human activity in the bay, mainly the access channel and near the harbors, as compared to the sites in Argentina.

All the animals tagged in Baía Babitonga had home ranges located along the shoreline opposite the harbor in São Francisco do Sul (Figure 5). Since 2005 the franciscanas in Baía Babitonga have been photographically identified and a high level of site fidelity has been recorded (Sartori et al., 2017). For some individuals, a residency period of at least nine years has been documented, which can be considered very high for a species with a life expectancy of up to 21 years (Pinedo, 1994; Pinedo & Hohn, 2000). Supporting the telemetry findings, photographic identification data also indicate that this population is restricted to the innermost areas of the bay.

Cremer et al. (2004) found that Guiana dolphins abandoned the harbor inlet of São Francisco do Sul, where intensive fishing activities occurred, following harbor repair and expansion in 1999 and 2000, and did not return until years later. The authors suggest that the change in habitat use was likely in response to displaced prey fish as well as a strategy to avoid noise disturbance from harbor machinery. The area occupied by both species has substantially decreased in the past 20 years and although both species occupy Baía Babitonga, there is no overlap of core areas (Cremer et al., 2018). In addition, distribution patterns of franciscanas in Baía Babitonga observed for more than 10 years show that this species does not approach the harbors (Cremer & Simões-Lopes, 2008), which may be partially due to high noise levels in these areas (Cremer et al., 2018).

Other factors that could contribute to differences in ranging behavior across study sites include competitor and/or predator density and prey distribution. These variables were not tested, but warrant further study. Few cetaceans that could be potential competitors of franciscanas occur within the inshore Argentine ranges described here. Predators in Argentina include broadnose sevengill sharks (*Notorynchus cepedianus*) and killer whales (*Orcinus orca)* in Bahía Samborombón, and sand tiger (*Carcharias taurus*), copper (*Carcharhinus brachyurus*) and broadnose sevengill sharks, along with killer whales, in Bahía San Blas (Bastida & Rodriguez, 2005; Lucifora, 2003; Lucifora et al., 2002, 2005). As described above, the core area of the only potential cetacean competitor in Baía Babitonga, the Guiana dolphin, does not overlap that of the franciscanas. There are no shark records inside the bay, only in the adjacent coastal waters (Gerhardinger et al., 2020). Killer whales were never recorded inside Baía Babitonga in more than 25 years of studies (Cremer, 2015).

One limitation of our study was that it was not designed to examine possible seasonal changes in movement patterns. In addition, the relatively short period of performance of the transmitters precluded investigation of seasonal patterns. All individuals in Argentina were only tracked during the autumn and winter seasons, with the exception of Yaana (Bahía San Blas) and Chica (Bahía Samborombón), which were both tracked into spring. For both individuals, spring locations overlapped those of the autumn and winter locations. While differences were not observed between seasons for these animals, it cannot be ruled out that seasonal differences in movement behavior may exist for these areas. For example, Bordino et al. (1999) noted frequent franciscana sightings near the coast off Bahía San Blas during spring and summer and sightings further away from the coastline in the winter.

In southeastern Brazil, franciscanas occur near the coast throughout the year (Di Beneditto & Ramos, 2001). The authors suggest that the lack of seasonal variation in movement in this region may be related to minimal water temperature change between seasons and prey resource availability year-round. In southern Brazil, Danilewicz et al. (2009) suggested that there is no segregation in franciscana distribution related to reproductive status, sex or age, based on data obtained throughout the year. However, in Baía Babitonga, Paitach et al. (2017) calculated larger franciscana home ranges during the winter than during the summer, but no difference between seasons was observed for core ranges. This may indicate that even though franciscanas in Baía Babitonga use a larger extent of their home range during the winter months, the most important areas for the population remain unchanged. Although our tagging data for Baía Babitonga reflect only spring and summer seasons, and may not represent the widest extent of individual ranges, genetic analyses confirm that this is a resident population, and movements in and out of the bay are likely to be rare or nonexistent (Cunha et al., 2020; Dias et al., 2013). Future studies should be designed to assess seasonal patterns of movements across these areas to examine possible changes in environmental stressors or anthropogenic threats by season.

4.3 | Movements relative to tides

Movements relative to tides were observed in all the studied areas, with different intensities. For Bahía San Blas and Baía Babitonga, movement patterns associated with tides were previously reported in studies based on visual observations (Bordino, 2002; Paitach et al., 2017). Movements with the current may be associated with lower energy consumption, resulting in greater travel speed, and may also be related to hunting strategies, where tidal cycle may influence the accessibility of prey or ability to capture prey in different ways, affecting habitat use of franciscana dolphins (Bordino, 2002; Paitach et al., 2017). The effects of the tide on dolphin movement patterns can be extremely variable and even different populations of the same species have different patterns in relation to tidal cycles (e.g., Lin et al., 2013). It is possible that the characteristics of each habitat determine how the tidal cycles influence the environment and, consequently, how dolphins use the habitat (Lin et al., 2013). Despite a lack of significant tidal effect on franciscana movements in Baía Babitonga, due to the physical configuration of the bay, even a short distance can lead to a considerable habitat change, moving from sand banks in the tidal plains to rocky shores around the islands. In different species that use estuarine environments, higher presence of the dolphins in inner areas during flood and high tides has been reported, and movement with the current has been commonly reported (e.g., Bordino, 2002; Fury & Harrison, 2011; Lin et al., 2013; Mendes et al., 2002), although counter-current movements have also been described for common bottlenose dolphins (Shane, 1990).

It is interesting to note that the tidal amplitude is more similar for Bahía San Blas and Baía Babitonga, with 2.5 and 2.1 m respectively, as compared to Bahía Samborombón with 0.75 m. Proportionally, the tidal amplitude in Baía Babitonga is much greater relative to the average depth of the areas used by franciscanas (53% of the water column), than in Bahía Samborombón and Bahía San Blas (27% and 26%, respectively), which might lead one to hypothesize that the tide would have a greater effect on Baía Babitonga dolphins, when the results show just the opposite. These findings lead to the conclusion that tidal amplitude alone is not a fundamental criterion that conditions observed movement patterns related to tides. It is likely that a combination of other factors may be in play, such as the physiography, prey availability, and other ecological and environmental aspects.

4.4 | Diving patterns

While franciscanas tended to frequent shallower waters (Figure 7), time-at-depth data suggest that the dolphins dove to the seafloor even in the deepest areas of the study areas, on occasion. The large variability shown in Figure 8 for Bahía Samborombón dolphins may be related to the fact that one of the three tagged dolphins (El Tío; Figure 3), captured separately from the first two, spent much time along the open ocean coastline, rather than on the shallow banks at the mouth of the bay. Given the relatively short duration of tracking, through only a portion of the year, we were unable to evaluate how dive patterns might vary on a seasonal basis. Findings suggesting use of the full water column by franciscanas are not surprising in light of the fact that they are caught in nets set on the bottom, and their stomach contents in both Argentina and Brazil include bottom-dwelling fish (Paitach, 2015; Rodríguez et al., 2002). In Baía Babitonga, the rake stardrum (*Stellifer rastrifer*), an epibenthic fish that forms small shoals, is intensely preyed on by the franciscanas, reaching almost 70% of relative importance in their diet (Paitach, 2015). On the other hand, the second-ranked prey consumed by franciscanas in Baía Babitonga, with a relative importance value of nearly 20%, is the American coastal pellona (*Pellona harroweri*), a species of epi-mesopelagic habits, demonstrating that the franciscanas feed through the entire water column (Paitach, 2015).

4.5 | Conservation considerations

Management of activities affecting franciscana conservation has benefitted greatly over the years from incorporation of information from new sources and technologies as the data become available. In 2003, four management stocks of franciscana dolphins were proposed across the entire range of the species, based on a phylogeographic approach that involved the hierarchical use of genetic, morphological, life history, and distribution data: two in Brazil, one shared between Brazil and Uruguay, and one in Argentina (Secchi et al., 2003). Cunha et al. (2014) expanded the genetic analyzes and proposed a subdivision of the FMAs. The franciscanas in Baía Babitonga, previously considered to be part of FMA II, are now in revised FMA IIb, those in Bahía Samborombón, originally in FMA IV, are now in revised FMA IVa, and those in Bahía San Blas, originally in FMA IV, are now in revised FMA IVc (Cunha et al., 2014). Tracking data from satellite-linked telemetry, along with photographic identification data from several sites, allow definition of franciscana home ranges at each site where they have been studied, and they are consistent with the proposed subdivisions of Cunha et al. (2014). These findings contribute to further discussions of subdivisions of the FMAs, and help to define more biologically meaningful management units. However, tagging and genetic studies have not occurred throughout the range of this continuously distributed species, and additional research in areas of data gaps would be of benefit to examine gene flow in greater detail. Subsequent population descriptions proposed by managers are taking the demonstrated localized movements into account. Defined ranges allow assessment of localized threats, and facilitate development of mitigation strategies.

In Argentina, where bycatch in artisanal gillnets is the primary threat to franciscanas, we found that the tagging research itself had a positive impact on some of the fishermen engaged in the capture-release project, leading to their willingness to participate in experimental studies of alternative fishing gear with the potential to reduce franciscana catches (Berninsone et al., 2020; Bordino et al., 2013). Through their work with the tagging projects, and continuing interactions with the Argentine research team, some of the fishermen came to understand that the franciscanas were essentially their neighbors, with home ranges that overlapped the areas where they fished. In addition, they learned about franciscana social structure from genetic and telemetry findings. The franciscanas caught in their nets were not random individuals, but sometimes were related individuals (mothers and their calves), or potential reproductive groups, as associations between adult females and unrelated adult males have been found to be long-term, potential breeding associations, not previously described for small dolphins (Mendez et al., 2010; Wells et al., 2013).

In Brazil, there has been much pressure for harbor development over the past 20 years, including in Baía Babitonga. One of the Baía Babitonga harbor areas is relatively limited in scale, and has existed for more than 70 years (São Francisco do Sul harbor). Construction began on a second one (Itapoá harbor) in 2007, and it began operations in 2011. Both are next to the access channel to the Atlantic Ocean. However, strong economic pressure has been occurring for the construction of at least three new harbor terminals in the innermost regions of the bay, directly affecting the franciscanas' current home range. Many direct impacts would be associated with the construction of these new harbors, including a large increase in noise pollution, degradation of habitat and communities due to dredging and explosions to deepen navigation channels, and increased levels of environmental contaminants (e.g., Domit et al., 2009; Dorneles et al., 2020; Richardson et al., 1995). In addition, the harbor and navigation areas are inaccessible to fishermen under Brazilian law, which restricts the areas available both for fishing and for both cetacean species in the area, increasing overlap and risk of incidental captures, another threat for franciscanas in Baía Babitonga (Cremer et al., 2018; Pinheiro & Cremer, 2003). Tracking data are playing an important role by clearly defining the franciscanas' living area in Baía Babitonga for decision making to evaluate the viability of the new harbors under consideration.

Home range size varies substantially among the areas analyzed. The smallest home ranges were recorded at Baía Babitonga, coinciding with the most heavily human-influenced areas, while Bahía San Blas, the least human-influenced area, was where the largest home ranges were recorded. As one possible explanation, data suggest that human activities, mainly those related to harbors, could reduce the available habitat for franciscanas, thus restricting their ranges in Baía Babitonga (Cremer et al., 2018). The species has been described as sensitive (Bordino et al., 1999; Cremer & Simões-Lopes, 2008), and noise pollution, such as that caused by vessels, can mask the echolocation clicks of these dolphins (Melcón et al., 2012).

The occupation of small ranges has also been proposed for franciscanas based on genetic data (Mendez et al., 2008), and on modeling of prey (from stomach contents) distributions relative to franciscana carcass locations (Bassoi et al., 2020). However, in Baía Babitonga small home range size reaches an extreme. Cunha et al. (2020) concluded that this population is isolated from franciscanas in the adjacent Atlantic Ocean coastal zone, about 20 km away, and suggest that gene flow was probably impacted by human activities, severely impacting the franciscanas' movements. Although our sample size is small, telemetry data did not provide strong evidence of movements by Baía Babitonga franciscanas into ocean waters. In the past, Baía Babitonga had two channels that communicated with the Atlantic Ocean, but one of the channels was closed in 1934, leaving only one access to the open sea. This access channel is considered deep, reaching more than 20 m in depth. In addition, this entrance has become extremely busy since 1955 with the construction of the São Francisco do Sul harbor, which has generated growing levels of ship traffic. It is possible that these changes caused franciscanas to gradually avoid the access channel and reduced their contact with the adjacent Atlantic coastal area. These characteristics make this Baía Babitonga population unique, and indicate an extreme degree of vulnerability, which should be considered in the management of the area.

Satellite-linked telemetry has provided important data to inform and provide better focus for conservation of franciscanas. Tagging and tracking results suggest patterns of stability in terms of residency that should be considered for management, in combination with previous data on genetics and social patterns. The data have led to greatly revised thinking about the scale at which franciscanas need to be managed and protected. Most of the information obtained from franciscanas to date is from those inhabiting estuarine and, in some cases, including adjacent coastal waters. Future research should consider franciscanas in coastal "open sea" areas, where fishing effort is different and tide patterns might have a different influence on their behavior. Future efforts should build on the lessons from capture-release, tagging and tracking to date, and take advantage of new technology as it becomes available, such as GPS tags for more precise location data. It is with a sense of urgency that efforts continue in order to learn about the needs of this at-risk species, as anthropogenic threats increase.

ACKNOWLEDGMENTS

Veterinarians Don Neiffer, Beth Nolan, and Deb Fauquier were crucial to field efforts and provided important input through application of ISTAT sampling and subsequent discussions. We greatly appreciate the efforts of the multinational research team members:

Argentina: Thanks are given to the AquaMarina staff and volunteers Natalia Asplanato, Ignacio Bruno, Agustina Caride, Agustin Echezarreta, Solange Faura, Ana Fazio, Guillermo Fidalgo, Victoria Gonzalez Carman, Diego Heredia, Ximena Merelle, Luciana Motta, Ariana Oberti, Antonio Postorivo, Gustavo Thompson, and Fernanda Zapata for all their help and assistance during different aspects of field work. Juan Francisco Javier Escudero, and Valeria Vitale provided important information about tides in Bahía San Blas for the tide analysis. Several fishermen from La Costa, Bahía Samborombón, and Pocitos made possible the safe capture and release of the dolphins, including Luis Lecler, Lucas Jorge, Cristobal Jorge, Roberto Ubieta, Claudio Silva, Andres Regueira, José Arce, Jorge Arce, Nilson Pellegrini, and Nestor Roche. Leonardo Massolo, Gabriel Battaglia, Gabriel Castresana, Pablo Rojas, Martín Sotelo, Nelly Toresani, and Cristina Rentero from Organismo Provincial de Desarrollo Sostenible provided crucial assistance during field activities. The Prefectura Naval Argentina (Argentina Coast Guard) Subprefectura de Gral Lavalle and Prefectura de Carmen de Patagones, Destacamento Bahia San Blas, provided assistance during capture procedures, especially the help provided by Jorge Toledo, Eladio Marifili, and Nestor Ibañez. The Club Nautico y Pesca Tapera de Lopez provided free space for boats and assistance in San Clemente del Tuyú. This research was undertaken under the Direccion de Areas Protegidas y Conservación de la Biodiversidad (Buenos Aires Government) scientific research permit N° 50/04, 01/06, 01/07, and 01/08.

Brazil: Thanks to Petrobras, through the Petrobras Environmental Program, which sponsored the Projeto Toninhas/UNIVILLE in the period 2011–2015, and for Fundo de Apoio à Pesquisa – FAP/UNIVILLE that supported the development of research activities in Baía Babitonga. Thanks are given also to the Brazilian team members that made it possible to carry out the work: Paulo C. Simões-Lopes, Camila M. Sartori, Beatriz Schulze, Natacha Z. dos Santos, Cláudia C. Rocha-Campos, Haydee Cunha, Carolina P. Dias, Annelise C. Holz, Ana Kássia de M. Alves, Cristiane Kolesnikovas, and Juliana Marigo. MJC thanks CNPq for a research productivity scholarship (10477/2017-4 and 313577/2020-0). This research was done under the scientific research permits SISBIO N^{O} 27647 and SISBIO N^{O} 37851.

United States: The U.S. team members included Bill Scott, Beth Nolan, Larry Fulford, James Thorson, Martha Wells, Conrad Litz, Brian Balmer, Jason Allen, Aaron Barleycorn, Katie McHugh, Wendi Fellner, Cyndi Taylor, Don Neiffer, Deb Fauquier, and Leigh Klatsky Alexander. R.S.W. is grateful to Buddy Powell for his initial introduction to Pablo Bordino, to initiate this work. We greatly appreciate the analytical assistance of David Douglas and Matthew Rutishauser. Training in Sarasota Bay was conducted under National Marine Fisheries Service Scientific Research Permit Nos. 522-1569 and 522-1785.

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Randall Wells: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; supervision; visualization; writing – original draft; writing – review and editing.

Marta Cremer: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; supervision; writing – original draft; writing – review and editing. **Leonardo Berninsone:** Formal analysis; investigation; resources; validation; visualization; writing – original draft; writing – review and editing. **Diego Albareda:** Conceptualization; investigation; methodology; supervision; writing – review and editing. **Krystan Wilkinson:** Formal analysis; methodology; visualization; writing – original draft; writing – review and editing. **Andrew Stamper:** Conceptualization; formal analysis; funding acquisition; investigation; methodology; project administration; resources; supervision; writing – original draft; writing – review and editing. **Renan Paitach:** Formal analysis; investigation; methodology; validation; visualization; writing – original draft; writing – review and editing.

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How to cite this article: Wells, R. S., Cremer, M. J., Berninsone, L. G., Albareda, D., Wilkinson, K. A., Stamper, M. A., Paitach, R. L., & Bordino, P. (2021). Tagging, ranging patterns, and behavior of franciscana dolphins (*Pontoporia blainvillei*) off Argentina and Brazil: Considerations for conservation. *Marine Mammal Science*, 1–35. https://doi.org/10.1111/mms.12879