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MOVEMENT PATTERNS OF FRANCISCANA DOLPHINS *(PONTOPORIA BLAINVILLEI)* IN BAHIA ANEGADA, BUENOS AIRES, ARGENTINA

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Abstract - From January 1993 to July 1999, systematic sightings of franciscana dolphins were conducted from four shore-based stations in Bahia Anegada, Argentina. Data were recorded using focal animal/group sampling methods. This study tested the hypothesis that dolphin movements within Bahia Anegada were random, assuming independence of sightings. The trend in dolphin swimming movement was defined as a direction scored as "coming in", "neutral", and "going out". In total 338 sightings were recorded, with a total effort of 2674 hours. The relative frequency of franciscana sightings demonstrated that movement was significantly dependent on tidal state, rejecting the hypothesis that dolphin swimming directions within the study area are random. Significant associations were also observed in the relative frequency of sightings in relation to the shore-based stations, suggesting a differential use of the bay's habitats perhaps due to location of prey, tidal current speed, depth, and topography of the coast.

Resumen - Avistajes sistematicos de delfines franciscana fueron realizados desde cuatro estaciones de observacion en Bahia Anegada, Argentina, entre Enero 1993 y Julio 1999. Los datos fueron registrados usando muestreo focal de individuos y/o grupos. El presente estudio testeo la hipotesis que el movimiento de los delfines en Bahia Anegada fueron al azar, asumiendo independencia en los avistajes. La tendencia en el movimiento de natacion de los delfines fue definida como "entrando", "neutral" y "saliendo". En total, 338 avistajes fueron registrados con un esfuerzo de 2674 horas. La frecuencia relativa de avistajes demostro que el movimiento fue significativamente dependiente del estado de marea, rechazando la hipotesis que el movimiento de los delfines en el area de estudio es al azar. Asociaciones signifiucativas tambien fueron observadas en la frecuencia relative de avistaje en relacion a las estaciones de observacion, sugiriendo un uso diferencial del habitat debido a la ubicacion de presas, velocidad de corriente de marea, profundidad y topografia de la costa.

Keywords: South Atlantic, franciscana, *Pontoporia blainvillei*, ecology, diurnal movements.

Introduction

The franciscana dolphin *Pontoporia blainvillei* is endemic to the coastal waters of the central South Atlantic. Its coastal distribution makes it vulnerable to anthropogenic activities. Currently, the franciscana is one of the most heavily impacted cetaceans in the southwestern Atlantic coast. Incidental captures in coastal gillnets seem to pose the greatest threat to the species' survival (e.g. Praderi *et al.,* 1989; Secchi *et al*., in press). An annual catch of 500 dolphins was estimated from the fisheries of the Buenos Aires coastal area in Argentina (Corcuera, 1994). Little is known of franciscana population dynamics, and despite some progress, no complete population abundance estimate along its entire range is available (Bordino and Tausend, 1998; Secchi *et al.,* 1999). The number of discreet populations is still unknown, as are the chances for its long-term survival. Most of the biological information on this species comes from studies of specimens incidentally killed in fishing nets or found on beaches. Although franciscana matures early, between 2 and 4 years, like other cetaceans it has a low reproductive potential (Brownell, 1989; Danilewicz *et al.,* 2000). Life span is around 20 years, however only a few individuals are likely to reach this age (Pinedo and Hohn, 2000). Consequently, the species has a low potential rate of population growth (Secchi, 1999).

Studies on wild franciscana dolphins have been scarce (Bordino *et al.,* 1999). Due to the high levels of recorded bycatch, the absence of abundance estimates throughout its entire distribution, and biological characteristics which make it more vulnerable, this species is of special concern and warrants further research. Despite some recent progress on the species' biology, ecology and conservation issues, franciscana is still listed as "Data Deficient" in the IUCN Red Data Book (IUCN, 2000).

This study presents data on the movement patterns of franciscana in Bahia Anegada and tested the hypothesis that dolphins' movements were random, assuming independence of sightings.

Material and Methods

The study area is a coastal marsh zone which includes a group of five islands and sand embankments. However, sometimes the coast drops off steeply with depths of up to 5 meters (m) at distances of only 10m from the coastline. The tidal cycle peaks about every 12 hours (hrs), with a mean annual amplitude of about 2.5m. This area includes Bahia San Blas, the only developed zone in the region, where at least 20 vessels operate in shark sport fishery.

Between January 1993 and July 1999, sightings of franciscana dolphins were made from four shore-based sites surrounding Bahia San Blas. Observations were obtained from Isla Gama, Banco Nordeste, and two sites from Isla Jabali (Figure 1). Each shore site was located more than 5km from each other. Observations were carried out from sighting platforms approximately 2m above sea level. Effort was continuous from sunrise to sunset over 10hr periods covering almost complete tidal cycles. Due to seasonal variation in daylight, equal effort in each tidal state was not possible. Observations were discontinued when wind speed was greater than 35km/hr or by rain. Two observers were placed on each platform,

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and at least one of the observers had some previous experience in sighting franciscana dolphins. Observers rotated between the different sites twice a week throughout the fieldwork.

Due to logistic problems it was not possible to achieve the same effort levels at each site. Observers completed sampling scans by naked eye and with 7x50 reticule binoculars every 10 minutes (min). Once dolphins were sighted, the number of individuals per group, presence of calves, surfacing and diving time, behavior, swimming direction, distance from shore, and time, were recorded utilizing a chronometer and electronic compass. Weather records were also kept during all observation periods. Data were recorded using focal animal/group sampling methods. The dolphins' swimming directions were defined as "coming in" or "going out" of the bay when first sighted. Dolphin swimming directions were also scored as "neutral" if dolphins were swimming obliquely to the coastline or if they were stationary. A sighted dolphin was observed for a minimum of 30 seconds (s) and a maximum of 5min to determine swimming direction. The number of sightings per unit effort (SPUE) was defined as the mean number of sightings, groups or single individuals, per hour of observation. To explore the effect of tide on the dolphin's movement, sighting data were classified into one of the four 3hrs categories of tidal state: low, rising, high and falling tides.

To maximize independence of sightings data, dolphin groups of equal size sighted in the same area during an one hour observation period were excluded from the analysis. Data were clustered by year when homogeneity was accepted, and analyzed using non-parametric tests when normality and homogeneity were rejected.

Results

In total, 338 sightings were recorded from the four shore-based stations. A total of 2674hrs were spent on direct observation of dolphins. Seventy-eight percent of sightings occurred during high and falling tides (Figure 2). The SPUEs recorded for each tidal state according to year are shown in Table 1. These SPUEs were not significantly different (P = 0.990, Kruskal-Wallis test). The movement sightings and SPUEs recorded in relation to tidal cycle and shore-based station are shown in Tables 2 and 3, respectively. The mean SPUE was six times higher during high tide than low tide. The relative frequency of sightings

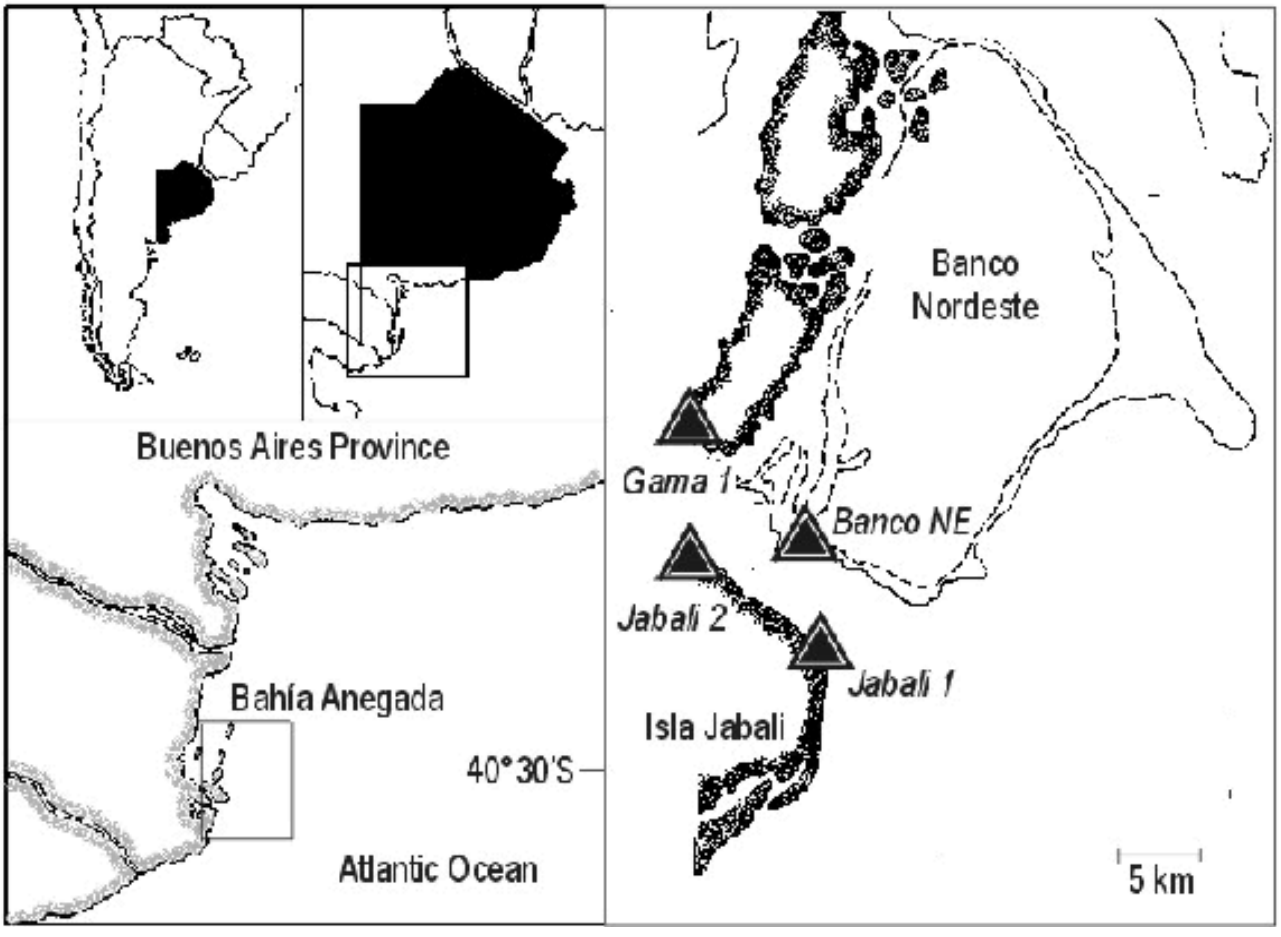

Figure 1. Locations of Bahia Anegada and shore-based positions in the study area.

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Table 1. Sightings per unit effort (SPUE) of franciscana dolphins recorded in Bahia Anegada according to tidal state and year.

Tide State	1993	1994	1995	1996	1997	1998	1999
Low	0.03	0.05	0.01	0.08	0.07	0.04	0.03
Rising	0.07	0.06	0.07	0.07	0.05	0.04	0.10
Falling	0.12	0.08	0.09	0.11	0.10	0.16	0.23
High	0.28	0.24	0.31	0.30	0.23	0.28	0.24
Total	0.5	0.43	0.48	0.56	0.45	0.52	0.6

Table 2. Total movement sightings and SPUEs of franciscana dolphins recorded in Bahia Anegada according to tidal state.

Tide state	Sightings				SPUE				
	Coming in	Neutral	Going out	Total	Coming in	Neutral	Going out	Total	Effort (hs)
Low	8	6	16	30	0.01	0.01	0.02	0.04	662
Rising	7	12	24	43	0.01	0.02	0.03	0.06	673
Falling	37	27	12	76	0.06	0.04	0.02	0.12	648
High	116	59	14	189	0.17	0.08	0.02	0.27	691
Total	168	104	66	338	0.25	0.15	0.09	0.49	2674

Table 3. Total movement sightings and SPUEs of franciscana dolphins recorded in Bahia Anegada according to shore-based station.

Position	Sightings				SPUE				
	Coming in	Neutral	Going out	Total	Coming in	Neutral	Going out	Total	Effort (hs)
Jabali 1	99	54	14	167	0.07	0.04	0.01	0.12	1399
Jabali 2	52	31	11	94	0.07	0.04	0.02	0.13	698
Gama 1	11	9	22	42	0.03	0.03	0.07	0.13	330
Banco NE	6	10	19	35	0.02	0.04	0.08	0.14	247
Total	168	104	66	338	0.19	0.15	0.18	0.52	2674

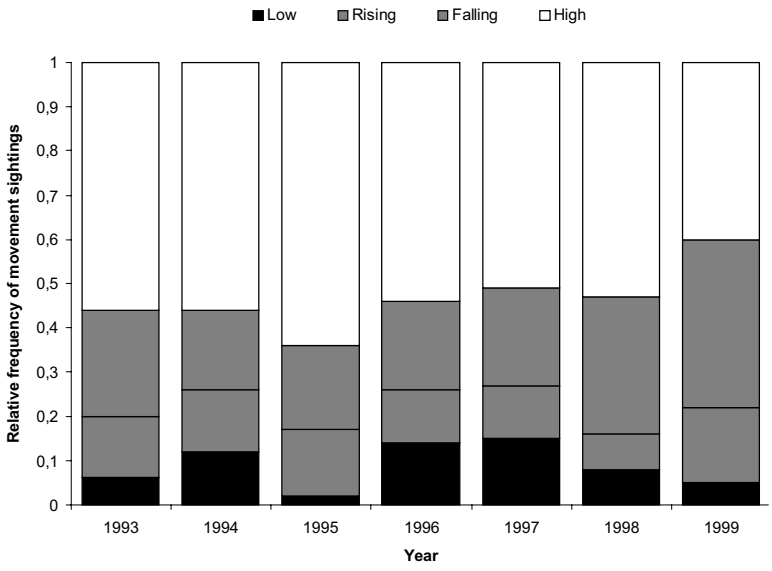

Figure 2. Relative frequency of movement sightings of franciscana dolphins according to tidal state and year.

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showed that movements of franciscana were significantly associated to tidal state (P = 6.4.10^{-5}, RxC test, Figure 3). Movement data provided strong evidence that dolphins were not swimming randomly inside the bay (P=0.001, X^2 test). Significant dependencies were also observed in the relative frequency of movement sightings in relation to the shore-based stations (P = 4.5.10^{-6}, RxC test, Figure 4), suggesting that the majority of dolphins are coming into the bay close to Isla Jabali, and coming out close to Isla Gama and Banco Nordeste.

Discussion

In Bahia Anegada, the association between franciscana dolphins' diurnal swimming movements and tide is strong. A higher mean SPUE was recorded during high tide than low tide, and this association was consistent throughout different years. Increased sightings of dolphins when the tide is coming in may be associated with greater prey species abundance. The movements of coastal dolphin species are often associated with the

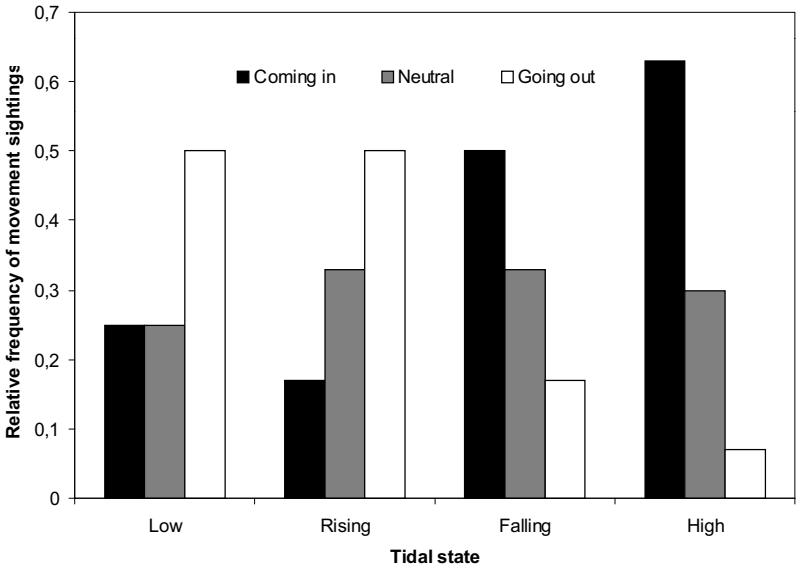

Figure 3. Relative frequency of movement sightings of franciscana dolphins in relation to tidal state.

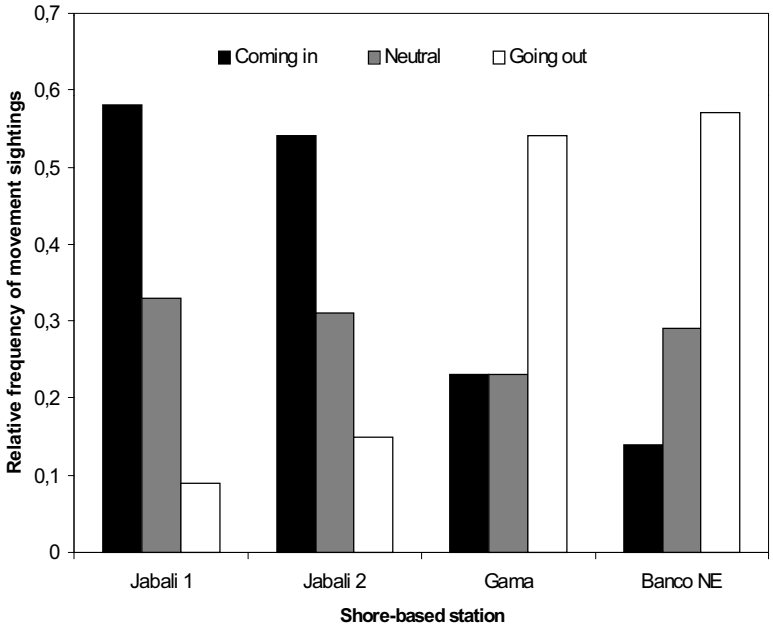

Figure 4. Relative frequency of movement sightings of franciscana dolphins in relation to shore-based stations.

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movement of prey (Gaskin, 1982). Bordino *et al.* (1999) demonstrated that foraging activity in franciscana dolphins was significantly higher during high tide in Bahia Anegada. The effect of the tide appears to be a decisive factor in the short-term movements of several coastal dolphin species (Caldwell and Caldwell, 1972; Wells *et al.,* 1980; Bloom *et al.,* 1995; Stone *et al.,* 1995). Movement patterns in association with tidal cycles could partially explain the mechanism of entanglement in many dolphin coastal species, even in those which are not preying on fisheries targeted species as seems to be the case for franciscana dolphins. There were fewer sightings during low tide than expected, but there is no complete explanation for this difference.

Differences in the relative frequencies of movement sightings recorded from different shore-based stations may be connected to environmental factors such as current and flow patterns, current speed, depth and bottom type. These factors could have influenced the dolphins' movement inside the study area as suggested by the decrease in sightings during low tide. The average minimum swimming speed for franciscana is about 1.3m/s (Bordino *et al.*, 1999), while the tidal current in the study area is up to 1.8m/s (Alvarez and Rios, 1988). It would then be expected that this strong tidal current may influence the swimming speed and the movements of franciscana dolphins in Bahia Anegada. Although swimming against the current has been suggested as a feeding activity (Shane *et al.,* 1986), swimming with a tidal current could be also used as an energy efficient strategy for foraging activities.

The influence of topography of coasts and bottoms on the movements of coastal dolphins has been previously reported (Gaskin, 1982; Evans, 1987). The coasts along Isla Jabali, Isla Gama and Banco Nordeste present topographical differences (Alvarez and Rios, 1988). Isla Jabali's coast is characterized by sand and rock beaches. This coastal area has a significantly higher mean depth than the other study areas. The coasts of both Isla Gama and Banco Nordeste are characterized by sand beaches. Differences in tidal current have been also recorded within this study area. The bottom morphology close to Isla Gama and Banco Nordeste shows evidence of strong bottom currents (Alvarez and Rios, 1988).

The relative frequency of movement sightings in relation to tide state and shore-based stations suggest that dolphins are coming in to the bay close to Isla Jabali and going out close to Isla Gama and Banco Nordeste.

As expected for most mammals, the movements of franciscana dolphins were not random inside Bahia Anegada. The movement of prey, as well as tidal current speed, depth and bottom type may produce a differential use of the habitat by this species in the study area. A long term study in Bahia Anegada may help test some of these hypotheses as well as aid in the development of effective conservation and management strategies for franciscana dolphins in Argentina.

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