Ecology and behaviour of the franciscana (*Pontoporia blainvillei*) in Bahía Anegada, Argentina

PABLO BORDINO* +†, GUSTAVO THOMPSON+ AND MIGUEL IÑÍGUEZ‡

AquaMarine-CECIM, Diaz Velez 315 1°C (1636) La Lucila, Buenos Aires, Argentina
Contact e-mail: imspb@hotmail.com

ABSTRACT

From January 1993 to July 1997, franciscana sightings were recorded from shore-based stations and vessels at Bahía Anegada, Argentina. In total, 321 hours were spent in direct observation of dolphins following the *Ad libitum* and *Focal* sampling methods. The present study provides information on the ecology and behaviour of the franciscana in the study area. A total of 251sightings were made and the number of sightings per unit effort (SPUE) was significantly greater during spring ($p = 0.001$). Dolphins were recorded at a mean distance from shore of 3.2km (0.4km-10.7km), although they were found at a significantly greater mean distance from shore during winter ($p = 0.005$). More sightings were recorded during flood tide than during ebb tide ($p = 0.016$). A higher SPUE was also recorded from a sailboat than from a motor boat ($p = 0.005$). Group size was small, ranging from 1 to 6 individuals. Calves were recorded during spring and summer and only one calf was observed per group. The behaviour showed a seasonal pattern with co-operative feeding and travelling activities increasing during winter. Tide and depth also influenced behaviour. Co-operative feeding increased during flood tide, while travelling decreased. The behavioural ecology of the franciscana appears similar to that of other coastal and river dolphins. This study represents the first attempts to understand the behaviour of the franciscana in its natural habitat.

KEYWORDS: FRANCISCANA; ECOLOGY; BEHAVIOUR; SURVEY-COMBINED; SOUTH ATLANTIC; CONSERVATION

INTRODUCTION

The franciscana, *Pontoporia blainvillei*, also known as the La Plata dolphin or toninha, is one of the rarest South American dolphins and one of the most poorly known. Related to the Platanistoid river dolphins, it is primarily an estuarine/marine species inhabiting only the coastal areas of the southwestern Atlantic Ocean, from Itaúnas, Brazil (18°25'S) to the southern Province of Río Negro, Argentina (41°09'S). It is one of the smallest cetacean species; adult males range between 121-158cm in length, and adult females between 134-177cm. Calving occurs during spring and early summer. Little is known of its social or reproductive behaviour. Most of the biological information on this species comes from studies of dead specimens caught in fishing nets; incidental captures represent the major threat to the species. Information on the fishery impact on this dolphin has been recorded by Brownell (1975), Crespo *et al.* (1986; 1994), Pinedo *et al.* (1989), Praderi *et al.* (1989), Albareda and Albornoz (1994), Corcuera (1994) and Secchi *et al.* (1997). A minimum annual catch of 340-350 dolphins was estimated from the fisheries of the Buenos Aires coastal area in Argentina (Perez-Macri and Crespo, 1989). No population estimates are available. Based on osteology, Pinedo (1991) proposed that two different forms of this dolphin were found in southern Brazil and variation in the mitochondrial D-loop DNA between these two forms suggests the existence of at least two populations (Secchi *et al.*, 1996). Further information on the abundance, distribution and population structure of the franciscana is necessary to determine the effect of mortality in fishing nets.

This study presents the first description of aspects of the general ecology and behaviour of the franciscana dolphin in the wild in Bahía Anegada, Argentina (40°32'S).

MATERIALS AND METHODS

The Bahía Anegada extends over 1,800km^2 and includes a group of five islands and sand embankments (Fig. 1). Generally, the coast drops off steeply with depths of up to 5m at distances of only 10m from the coastline. The study area is a coastal marsh zone with water temperatures of between 6ºC-21ºC throughout the year. The tidal cycle peaks about every 12 hours, with a mean annual amplitude of about 2.5m. The mean tidal current in the area is about 0.8m/sec. The study area includes Bahía San Blas, the only developed zone in the region, where at least 20 vessels operate in the sport shark fishery in the warmer months. Between January 1993 and July 1997 a total of 321 hours were spent on the direct observation of franciscanas. Effort was continuous from sunrise to sunset for a total of 212 days, and took place throughout the year. Observations were obtained from shore-based stations (268h) and vessels (53h). The shore-based stations were located approximately 2m above sea level. Boat-surveys were carried out no more than 12km offshore. Four vessels were used; an inflatable and a motorboat powered by 35 and 90HP outboard engines respectively, and a Lightning and a Finn Class sailboat. The vessels were not used simultaneously and only one type of boat was used during any one season. On all vessels, two observers continuously recorded sightings on both sides and in front of the vessel. Observations from the powerboats were made with the engine turned off to minimise interference with the dolphins. The position of each sighting was recorded by GPS and subsequently plotted onto marine charts. Data were recorded using the *Ad libitum* and *Focal* sampling methods (Altman, 1974), and events and states were measured to determine the rate of behavioural activities. Once dolphins were sighted by naked eye, reticule 7 × 50 binoculars (for distance), chronometers (± 0.3sec)

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* *AquaMarine-CECIM, Diaz Velez 315 1°C, La Lucila (1636), Buenos Aires, Argentina.*
+*Fac. Cs. Exactas y Naturales (UBA), Ciudad Universitaria, Pabellón II, Dpto. Biología, Lab. 36, (1428) Buenos Aires, Argentina.*
† *Museo Argentino de Ciencias Naturales 'B. Rivadavia', Lab. Mamíferos Marinos, Av. A. Gallardo 470 (1405), Buenos Aires, Argentina.*
‡ *Fundación Cethus, Garay 2860, Olivos (1636), Buenos Aires, Argentina.*

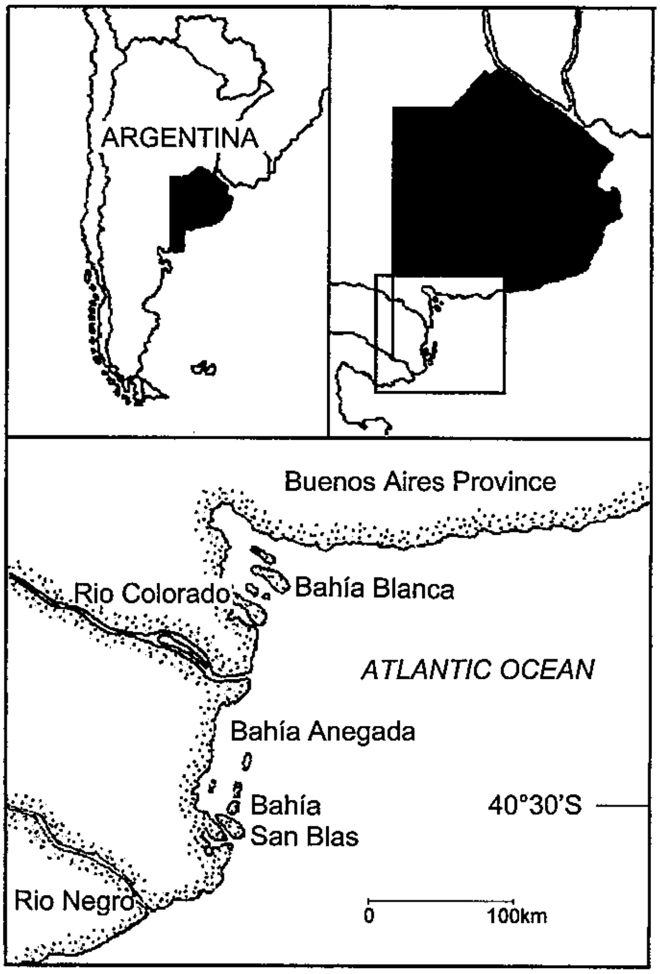

Fig. 1. Location of Bahía Anegada, Northern Patagonia, Argentina.

and an electronic compass were used for data logging. The numbers of individuals per group, presence of calves, surfacing and diving time, behaviour (according to categories defined by the authors as described below) and swimming direction were recorded. Depths, surface water temperature, tide and environmental conditions such as weather and sea state were also noted in each case. Photographs were taken with a 35mm SLR camera using a 200mm lens.

On occasions, observations on behaviour were based on the same group; these were assumed to be independent episodes. To maximise independence, dolphin groups of equal size sighted in the same area during a one hour observation period were excluded from the analysis; this represented only 2% of total sightings.

In order to correlate the behaviour of the dolphins with the depth, marine chart data were used to divide the study area into shallow waters ($<$8m depth) and deep waters ($>$8m depth). Dolphins sighted from land at more than 30m from shore were considered as swimming in deep water as reported from marine charts. All data recorded were analysed to evaluate seasonal influences on the distribution and activities of dolphins.

A dolphin group was defined as an association of individuals swimming together within an area of less than 50m and engaged in the same activity. If two individuals swam within 10m of each other, and one was no more than half the size of the other, they were assumed to be a mother and calf.

The number of sightings per unit effort (SPUE) was defined as the mean number of sightings (groups or single individuals) per hour of observation. A mean SPUE was calculated for each season and year.

Swimming speed was estimated from the time taken to cover a known distance. These data were recorded in shallow waters from the land stations. For the dive and respiration data analyses, only sequences greater than 15 minutes were used. A dive was arbitrarily considered to be any submergence $>$3sec.

Data were clustered by season when homogeneity was accepted and analysed using non-parametric tests when normality and homogeneity were rejected.

RESULTS

Sighting and distribution

A total of 251 sightings was recorded of which 91% occurred in sea states less than Beaufort 4. Dolphins were detected by naked eye at a maximum distance of 60m during calm weather (Beaufort 0-2). There was a negative correlation between sighting and Beaufort state (Pearson: -0.995 $p<0.001$). Dolphins were seen in water depths from 2-20m, usually in areas with counter currents. Sightings were seasonal with a maximum in spring (Fig. 2). Dolphin

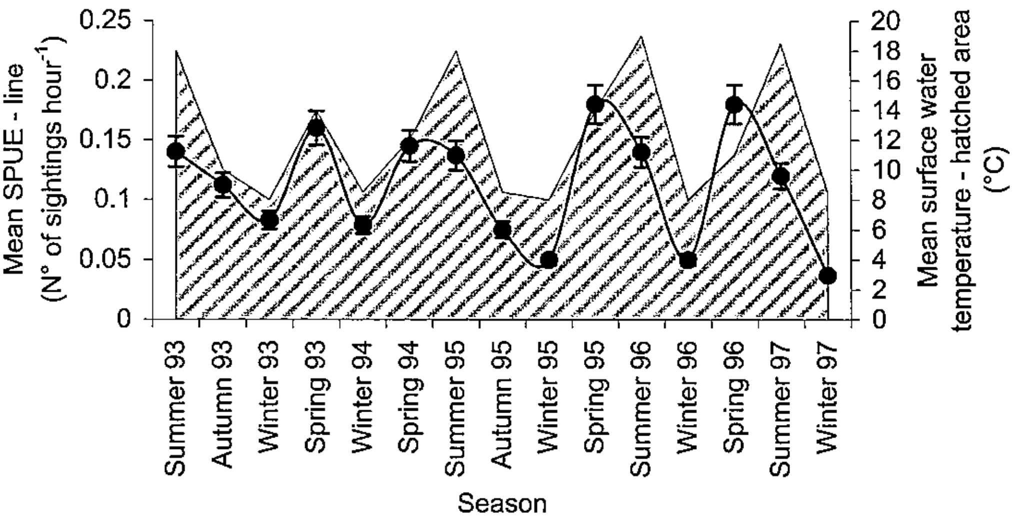

Fig. 2. Seasonal occurrence of the franciscana dolphin, *Pontoporia blainvillei*, in Bahía Anegada ($n = 251$). Error bars represent the standard deviation of the mean.

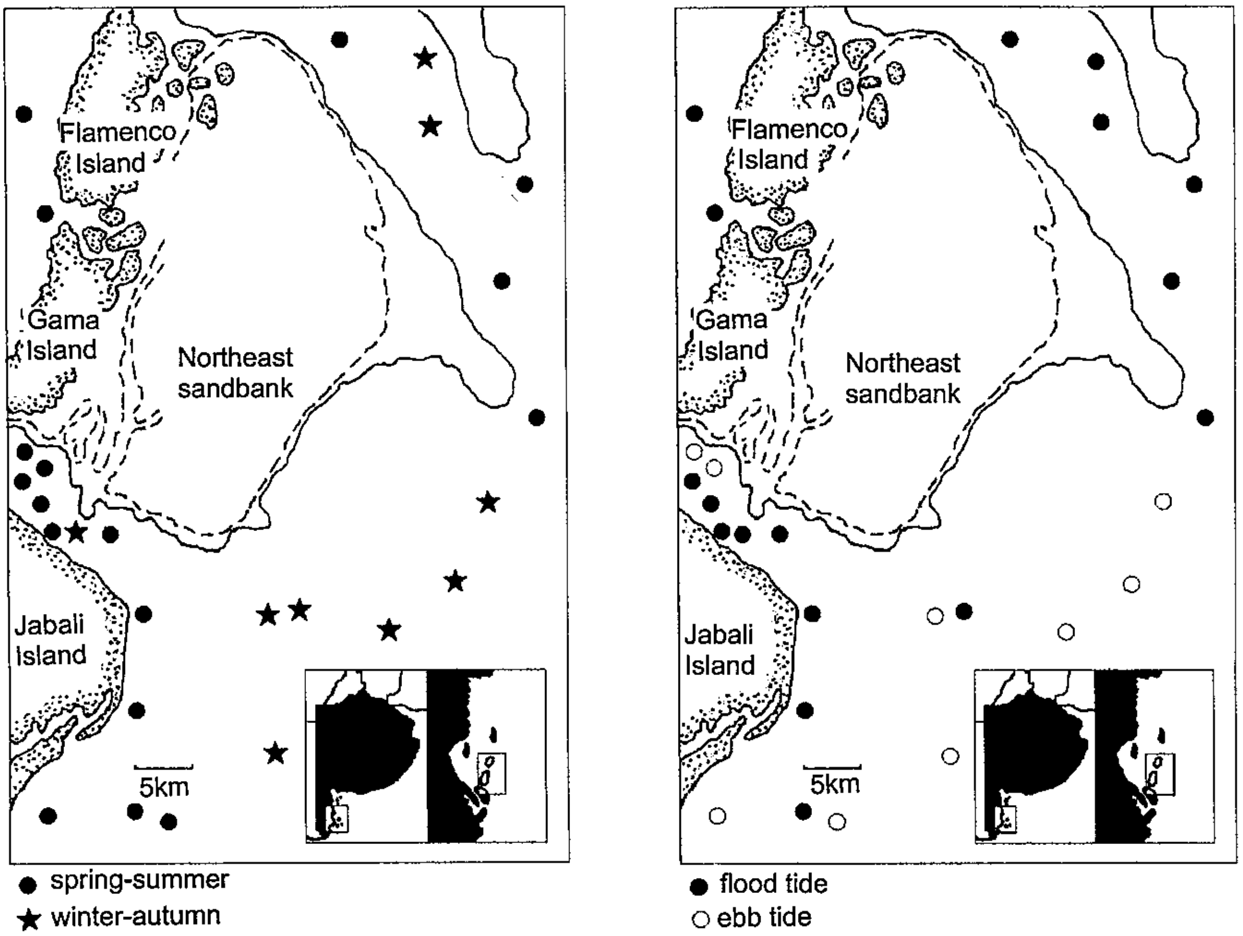

Fig. 3. Sightings recorded from boats and distribution of the franciscana dolphin, *Pontoporia blainvillei* in relation to season and tidal cycle in Bahía Anegada.

sightings were positively correlated with surface water temperature (Pearson: 0.679 $p = 0.021$) and were associated with temperatures between 7°C and 18°C. A total of 82% of nearshore sightings ($n = 201$) occurred during flood tide ($p = 0.016$).

In Bahía Anegada, franciscanas were recorded (from vessels) at a mean distance from shore of 3.2km (0.4km-10.7km). They were found closer to the coast in summer and further away in winter (Mann Whitney, $p = 0.005$), and usually were found close to the coast during flood tides (Fig. 3). The SPUE values recorded from the sailboats were significantly higher than those recorded from the motor boats (Mann Whitney, $p = 0.050$), although while under observation the dolphins made no obvious effort to avoid any vessel used during the study.

Group size and composition

Group sizes ranged from 1-6 (2.8 ± 1.3, $n = 251$; Fig. 4). In spring 1995, at least 13 individuals in mutual approach were recorded simultaneously in the same area. The pod comprised four groups that occasionally showed independent behaviour. It was not possible to determine if there was interaction among them.

The mean number of individuals per group did not differ significantly between seasons (Kruskal Wallis, $p = 0.978$), or between shallow and deep water (Mann Whitney, $p = 0.519$). Calves were observed from November to March and closely associated with adults (side by side, behind or in front). Mothers and calves represented 13% of the total groups recorded. Only one calf was observed per group. There was generally no clear difference between the colour pattern of the calf and adult, although some newborn calves ($n = 4$) were dark brown. Most of the mother-calf pairs (87%; $n = 26$) and single animals (60%; $n = 48$) were sighted nearshore in shallow waters.

Swimming speed and behaviour

The average swimming speed of the dolphins was 1.3 ± 0.09m/sec ($n = 37$). Swimming speed was uniform throughout the seasons (t test, $p = 0.918$), and it did not exceed 1.8m/sec.

Behaviour was classified into one of the four categories described below.

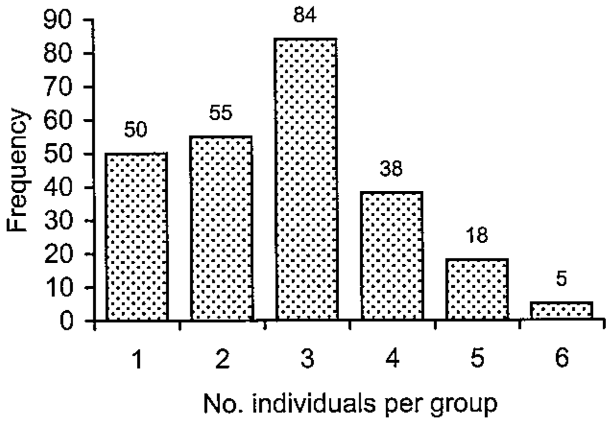

Fig. 4. Group size of the franciscana dolphin, *Pontoporia blainvillei*, in Bahía Anegada ($n = 251$).

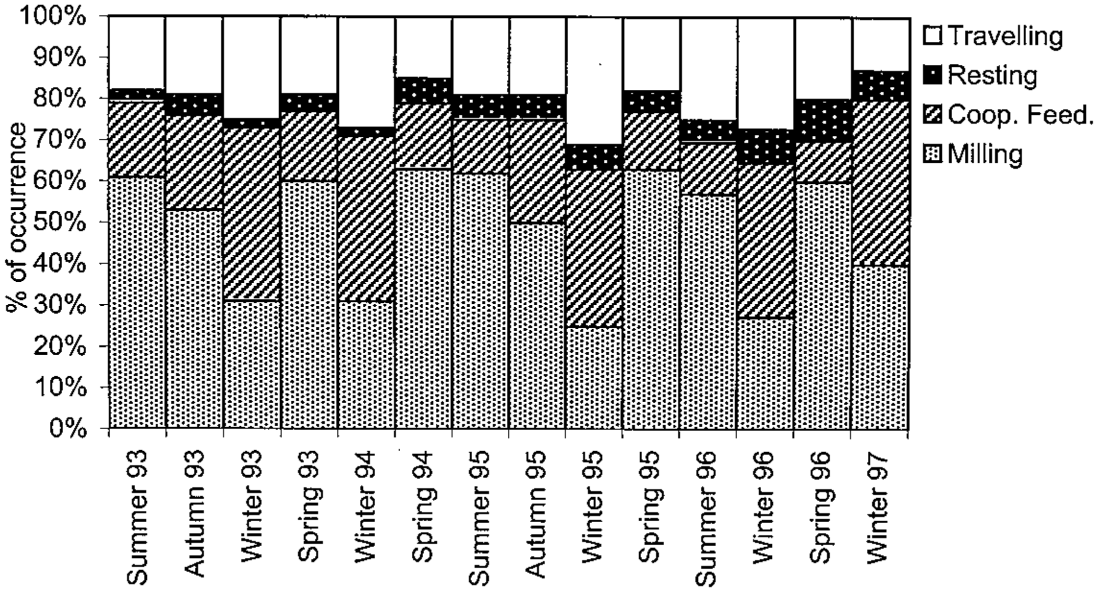

Fig. 5. Seasonal pattern behaviour of the franciscana dolphin, *Pontoporia blainvillei*, in Bahía Anegada ($n = 336$).

Milling

Dolphins usually moved in an erratic pattern with sudden changes of direction or short sprints by an individual or group. Those movements alternated with swimming parallel to the coastline (with changes of 180°) when dolphins were close to shore. Occasions where animals remained in the same location whilst swimming against the current were also recorded. Individuals within a group were observed to change their parallel course in synchrony at a mean time of 12 ± 2.04min. ($n = 62$). Both short and long dives were observed (see below) but there was little synchrony between the dive and surfacing time of the dolphins. Milling was observed in both shallow and deep water. This non-directional movement was associated with the presence of seagulls in 42% of episodes ($n = 135$).

Travelling

Dolphins swam at a steady speed of approximately 1.5m/sec. This directional movement was observed in both single animals and groups. A regular pattern of diving was observed and all individuals of a group exhibited synchronous respiratory and diving behaviour. Travelling was observed in both shallow and deep waters.

Cooperative feeding

The dolphins moved in a coordinated group with a circular (both clockwise and anti-clockwise) pattern. These circles were approximately 70 ± 8.0m in diameter. On occasions, dolphins were recorded surfing over the waves and fish were seen leaping into the air. Synchronous short and long dives were observed. Cooperative feeding was mainly recorded in shallow waters. Seagulls were associated with 65% of episodes ($n = 56$).

Resting

Dolphins swam slowly with and against the water current. During calm weather, the dolphins were observed floating at the surface for up to 5s. This behaviour was observed in both solitary animals and groups. During slow swimming, all individuals in a group exhibited synchronous respiration and diving. Slow movements in a consistent direction were recorded only close to shore in shallow waters.

A total of 336 recognisable behavioural episodes were recorded. A seasonal pattern in behaviour category was found during the year (Fig. 5). The mean times of

Table 1

Mean times (min ± SD) of behavioural episodes of the franciscana dolphin (*Pontoporia blainvillei*) in relation to season. (*) Travelling duration was higher during winter (Kruskall Wallis ANOVA, $p<0.001$)

Behaviour	Winter	Spring	Summer	Autumn
Milling				
Mean	68±3.8	68±10.4	67±3.9	66±18.2
Range	[37-99]	[61-112]	[59-97]	[5-122]
	n=49	*n*=49	*n*=38	*n*=31
Cooperative feeding				
Mean	50±8.7	49±2.3	51±2.6	50±13.1
Range	[6-96]	[6-78]	[6-81]	[15-84]
	n=30	*n*=18	*n*=14	*n*=12
Travelling				
Mean	32±5.2*	15±8.1	16±3.2	19±8.6
Range	[4-36]	[4-47]	[6-24]	[6-38]
	n=27	*n*=16	*n*=17	*n*=12
Resting (slow swimming)				
mean	12±6.3	10±7.7	15±9.3	14±8.4
Range	[6-19]	[6-17]	[5-22]	[5-20]
	n=8	*n*=5	*n*=6	*n*=4

Table 2

Mean times (min ± SD) of behavioural episodes of the franciscana dolphin *Pontoporia blainvillei* in relation to depth. (*) Behavioural episode durations were different depending of the water depth (Mann Withney ANOVA, *p:* 0.001).

Behaviour	Shallow water	Deep water
Milling		
Mean	54±6.4	71±7.5*
Range	[5-91]	[12-122]
	n=86	*n*=81
Cooperative feeding		
Mean	58±6.2	18.5±2.5*
Range	[15-96]	[16–21]
	n=68	*n*=6
Travelling		
Mean	17±4.0	39±2.1*
Range	[4-22]	[5-47]
	n=28	*n*=44
Resting (slow swiming)		
Mean	18±8.6	
Range	[5-33]	
	n=23	

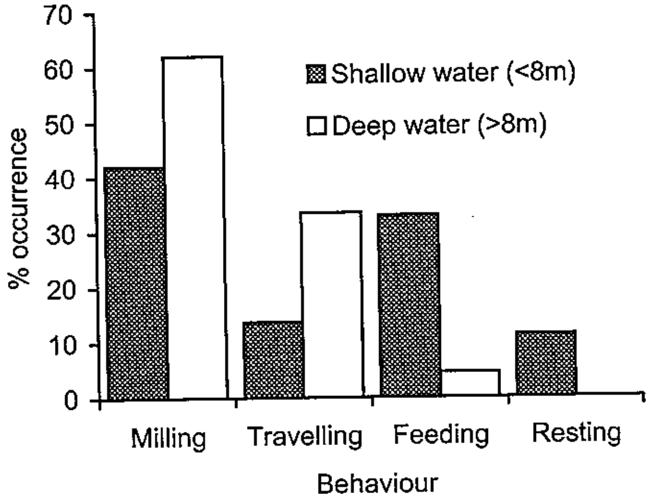

Fig. 6. Behavioural episodes of the franciscana dolphin, *Pontoporia blainvillei*, in relation to depth.

behavioural episodes are shown in relation to season (Table 1) and water depth (Table 2 and Fig. 6). The mean time spent in deep water (58 ± 16.3min, $n = 131$) was significantly higher than that spent in shallow water (46 ± 13.7min, $n = 205$), (Mann Whitney test, $p = 0.001$). Feeding and travelling activities were correlated with the tidal cycle (Fig. 7).

Surfacing frequency and diving

Franciscana generally surfaced three to four times per minute. Surfacing lasted a mean of 1.2 ± 0.4s ($n = 721$). Typically, when an animal emerged, it first exposed its beak and then curved its body, exposing the dorsal fin (Fig. 8). The beak was exposed in 84% of surfacings ($n = 721$). Synchronised surfacing patterns were recorded in 67% of individual adults in a group ($n = 125$), and 100% of mother-calf pairs ($n = 18$).

Normal dives lasted from 3 to 82s (Fig. 9). The mean dive duration was 21.7 ± 19.2s ($n = 2267$). Almost all (93%) dives were less than one minute long. However, apnoeas as long as 135sec were recorded, usually in association with the presence of a fishing vessel running powered by a 90 HP outboard motor. The mean dive duration of mother-calf pairs (13.2 ± 10.5s, $n = 468$), was significantly lower than that of adult individuals (22.5 ± 19.7sec, $n = 1799$; Mann Whitney, $p < 0.001$).

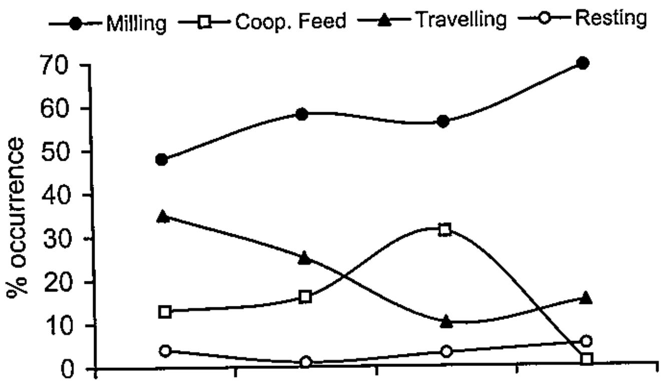

Fig. 7. Behavioural episodes of the Franciscana dolphin, *Pontoporia blainvillei*, in relation to the tidal cycle.

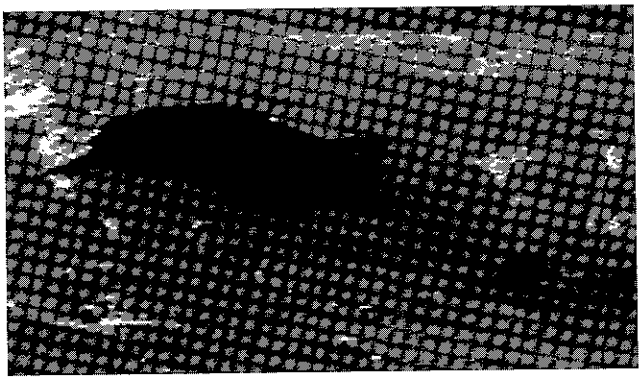

Fig. 8. Surfacing in the franciscana dolphin, *Pontoporia blainvillei*.

DISCUSSION

Sighting and distribution

The franciscana was recorded throughout the year in Bahía Anegada. During winter, groups were detected further away from the shore, suggesting at least a seasonal change in distribution, although there is no direct evidence of migration. Local fishermen reported the emigration of schooling fish from the study area during winter i.e. a decreasing abundance of prey. Gaskin (1982) reported that in some species, dolphin displacements and distribution appear to be related to food availability and sea surface temperature. A positive correlation was found between sea surface temperature and SPUE in this study. Bahía Anegada's coastal waters are known to have an abundance of fish during the warm months. Dolphins with a coastal home

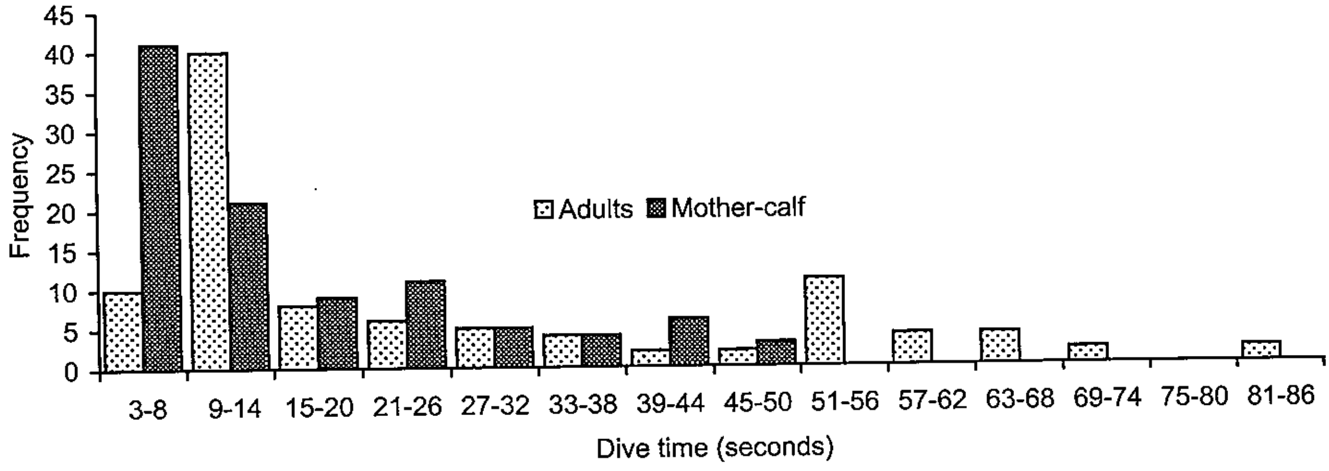

Fig. 9. Diving pattern behaviour of the franciscana dolphin, *Pontoporia blainvillei* ($n = 2267$).

range may largely depend on resident fish resources but also utilise seasonally available fish schools. The degree of plasticity in food habits may be related to short-term movements.

Movement offshore in winter is also coincident with a decrease in the presence of predators such as sharks and killer whales (*Orcinus orca*). The most common large sharks in Bahía Anegada are the *'bacota' (Carcharhinus brachyurus)* and the *'escalandrún' (Carcharias taurus)* both of which are potential predators of the franciscana (Monzón *et al.*, 1994). Remains of a juvenile franciscana were found in the stomach of an unidentified large shark captured in Bahía San Blas (Bordino, unpublished data). Large sharks are common in the study area during the warmer months and uncommon during winter (Chiaramonte, 1996). The increased use of shallow waters by the bottlenose dolphin *T. truncatus* coincided with the peak abundance of sharks and killer whales and thus may have a protective function as was reported by Wells *et al.* (1980). Avoidance of killer whales has been observed in other small dolphin species such as the Indo-Pacific hump-backed dolphin, *Sousa chinensis* (Saayman and Tayler, 1979), the dusky dolphin, *Lagenorhynchus obscurus* (Würsig, B. and Würsig, 1980) and the Dall's porpoise, *Phocoenoides dalli* (Jefferson, 1987). Thus, the franciscana may contract its home range during winter because of the distribution of predators.

The franciscana probably moves inshore in spring and summer for feeding, mating and calving. Calves were only observed in spring and summer and this corresponds to the calving season for this species in other areas. Coastal waters may provide special conditions for calves and adults, giving protection from predation and sufficient food during the costly energetic reproductive period. Mother-calf pairs were mainly recorded in shallow waters and at least some seasonal segregation in habitat use may occur. Praderi (1986) reported this species in fresh waters of the Río de la Plata, and related its presence to hydrological conditions caused by southeasterly winds. In spring 1994, we recorded one sighting of a single individual 9km upriver in the Rio Negro (40°09'S) but this may represent extreme movement for this species. Increased sightings of dolphins during flood tides may be associated with greater prey species abundance; foraging was proportionately higher during flood tides. 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; Shane *et al.*, 1986; Bloom *et al.*, 1995). Previous studies have shown that the franciscana is found up to approximately 30 n.miles offshore (Praderi *et al.*, 1989) and associated most frequently with waters of 1-20m depth (Crespo, E.A. *et al.*, 1994). Similar depths were found in this study. Sightings were usually recorded in areas with counter currents and eddies as has also been observed for the baiji, *Lipotes vexillifer* (Hua *et al.*, 1989).

The bottlenose dolphin is also common in the Bahía Anegada but no interactions between this species and the franciscana were recorded during the present study, suggesting that these dolphins have different ecological requirements.

Group size and composition

Our results indicated a small group size for the franciscana (typically less than 6). Similar observations were reported by Pinedo *et al.* (1989) and Brownell (1989) and from aerial surveys carried out in southern Brazil (Secchi *et al.*, 1997). However, we did sight a pod of at least 13 individuals and groups of 10 or more have been reported by Crespo *et al.* (1998), Junín and Castello (1994) and Bastida and Rodríguez (1993). The availability and distribution of food resources, pressure of predation and physical characteristics of the habitat are particularly strong ecological factors affecting the sociability of dolphins (Wells *et al.*, 1980; Evans, 1987). In general, river dolphins live alone or in small groups, but records of aggregations have been occasionally reported for the Ganges river dolphin, *Platanista gangetica indi* (Kasuya and Nishiwaki, 1975), the baiji (Chen *et al.*, 1980; Hua *et al.*, 1989) and the boto, *Inia geoffrensis* (Trujillo, 1992). Similarly small group sizes have been reported for other coastal dolphins (e.g. Wells *et al.*, 1980). The low mean number of franciscanas per group was similar throughout the year in both shallow and deep waters, suggesting that aggregations are sporadic. Aggregations of franciscanas have been generally observed during the breeding season. Similar aggregations of smaller groups during the breeding season have been reported for other dolphins and it may be a mechanism to increase opportunities for mating (Evans, 1987). In coastal species with limited home ranges, it may not be necessary to be a permanent member of a large group to bring females and males into contact. A herd with a segregated subgroup structure can ensure that suitable encounters can be made at appropriate intervals (Wells *et al.*, 1980). Brownell (1984) noted the tendency towards small group sizes in dolphin species where females are larger than males (as is true for the franciscana, see Kasuya and Brownell, 1979; Pinedo *et al.*, 1989).

The size difference does not allow the sex of animals to be determined at sea and thus there is almost no information on the sex composition of groups. Young calves are differentiated easily by length, being less that half that of an adult. However, they reach a length of around 1m at about six months (Kasuya and Brownell, 1979; Pinedo *et al.*, 1989), making it difficult to distinguish age classes after this time.

Swimming speed and behaviour

The average swimming speed observed in this study is similar to those recorded for porpoises and other coastal and riverine dolphins such as the Burmeister's porpoise, *Phocoena spinipinnis* (0.97-1.25m/sec, Würsig, M. *et al.*, 1977), the bottlenose dolphin (1.36m/sec, Mate *et al.*, 1995) and the baiji (1.6m/sec, Chen *et al.*, 1980). However, it must be remembered that in our study it was not usually possible to determine whether the animal had taken a straight path between two known points. Non-direct paths would result in underestimated swimming speeds and thus our estimate must be regarded as a 'minimum'. Water depth has been related to variations in swimming speed in the bottlenose dolphin, with slower speeds in shallower waters (Würsig, B. and Würsig, 1979) but as all our relevant data were recorded from land in shallow waters, we are not able to investigate this. However, the strong tidal current into the study area could affect swimming speed.

Non-unidirectional movements observed in this study were usually related to foraging activities. High-speed swimming and sudden changes of swim direction have been associated with the herding of prey, socialising or play in the bottlenose dolphin (Shane *et al.*, 1986) and, in open waters, as individual feeding behaviour (Leatherwood, 1975). Milling has been observed in other coastal dolphins and porpoises, such as the Commerson's dolphin, *Cephalorynchus commersonii* (Mermoz, 1980; Goodall *et al.*, 1990) and the Burmeister's porpoise (Würsig, M. *et al.*, 1977). Parallel movements to the coastline with inversions in direction and alternate erratic movement may be a searching strategy reflecting scanning for prey. Parallel patrolling of the shore has also been observed in bottlenose dolphins (Würsig, B. and Würsig, 1979). Synchronous changes of direction suggest some communication mechanism within the group. Specialised foraging patterns have been reported in dolphin species that live in small groups (Norris and Dohl, 1980). The circular movements we recorded were observed when groups swam close to schoolfish (seagulls, *Larus dominicanus, L. belcheri and L. atlanticus*, were usually present) and appear to be associated with cooperative feeding on concentrated prey. These movements have also been associated with feeding in other dolphin species (Caldwell and Caldwell, 1972; Leatherwood, 1975; Würsig, B. and Würsig, 1980; Zhou and Li, 1989). The presence of seabirds during feeding activities has been reported for many other dolphins (Evans, 1987) and seabirds are often the cue used by observers to detect dolphins and other cetaceans.

The franciscana is primarily a piscivorous species, feeding mainly on fish of the Family Sciaenidae (*Cynoscion striatus, Macrodon ancylodon, Micropogonias furnieri)*, Batrachoididae (*Porichtis porosissimus*), Trichiuridae *(Trichiurus lepturus)* and Engraulidae (*Engraulis anchoita*), as well as shrimp (*Artemesia longinaris, Pleoticus muelleri*) and squid (*Loligo sanpaulensis*), (Fitch and Brownell, 1971; Brownell, 1975; Pérez Macri, 1986; Praderi, 1986; Pinedo *et al.*, 1989; Bastida *et al.*, 1992; Ott, 1995; Perez *et al.*, 1996). Although there is no direct information on dolphin diet available for Bahía Anegada, this coast appears to be one of the most important areas for reproduction of many Sciaenidae fishes in northern Patagonia. Sciaenids are present mostly during spring-summer and clupeids are found near shore during autumn-winter in the area (A.V. Volpedo, pers. comm.). A seasonal change in the diet has been reported in the franciscana (Praderi, 1986; Brownell, 1989; Ott, 1995) and selectivity plays an important role in feeding behaviour (Fitch and Brownell, 1971).

In our study, foraging activity accounted for more than 50% of the dolphins' time budget. Cooperative feeding behaviour increased in winter, as milling decreased, suggesting that franciscana dolphins tends to feed more on schooling prey during winter in our study area. The different methods animals use to locate and catch their food are related to the nature of the prey and their own behaviour. Different strategies can be expected when dolphins prey on schooling or non-schooling fish. It may be that during the spring and summer the abundance of prey means that elaborate rounding-up procedures are unnecessary. Cooperative feeding was mainly recorded in shallow waters and the franciscana may use the coast as a wall to herd schooling fish.

Fast movements in a specific direction were linked to travelling i.e. persistent directional movement (Shane *et al.*, 1986). A greater proportion of time was spent travelling during winter, which may be related to the dolphins' farther offshore distribution at that time. The relatively short mean duration and frequent occurrence of 'travelling' behaviour suggests it is principally related to short-term movements.

We have assumed that slow swimming in a specific direction is resting and individuals were sometimes observed floating at the surface in shallow waters. Floating has also been reported as a component of resting in the baiji (Lui and Ding, 1989; Lui *et al.*, 1994) and similar behaviour has been reported for the harbour porpoise (Read and Gaskin, 1985). Although slow swimming has also be attributed to feeding behaviour in bottlenose dolphins (Shane, 1977) and harbour porpoises (Belk'ovick *et al.*, 1991) with the animal facing the current and catching fish carried by the tide, the absence of seabirds in the case of the franciscanas is consistent with the apparent lack of feeding on surface prey. Resting and/or slow swimming was not frequently recorded and the franciscanas were usually active during daylight hours in the Bahía Anegada. It was only recorded near shore and was perhaps related to predator avoidance as in other coastal dolphins (Saayman and Tayler, 1979; Norris and Dohl, 1980; Würsig, B. and Würsig, 1980).

The daily arrival of franciscanas into the study area was very variable throughout the year and there was no obvious correlation between activity pattern and time of day. However, the tidal cycle did appear to influence the daily activity schedule. Feeding increased and travelling decreased during flood tides. Franciscanas also spent more time in deep water milling and travelling; this alternated with feeding and resting in shallow water.

No obvious social or mating behaviour was recorded, and the absence of recognisable socialising behaviour in our study area, especially during the breeding season, is perhaps a little surprising. One explanation may be simply that this reflects the difficulty in sighting the animals and the relatively short time spent in mating. Pilleri (1971) had suggested strong maternal behaviour and a highly developed social structure for this species. However, this was based on only one observation of a mother-calf pair entangled in a gillnet.

Surfacing and diving

The short surfacing time exhibited by the franciscana was similar to that reported for the baiji (Zhou *et al.*, 1980). Crespo and Lauria de Cidre (1992) considered that the morphology of the extra-lung air passage in the franciscana might be associated with efficient airflow during the short time at surface. Mean diving and apnoea time ranges for this species are similar to those found in other small dolphins such as the boto (Layne, 1958; Galantsev *et al.*, 1992), baiji (Zhou and Li, 1989), harbour porpoise (Watson and Gaskin, 1983), Burmeister's porpoise (Würsig, M. *et al.*, 1977), vaquita, *Phocoena sinus* (Silber *et al.*, 1988) and bottlenose dolphin (Würsig, B., 1978; Mate *et al.*, 1995). The franciscana exhibited sequences of three to four short dives follow by a long dive, a pattern was also observed in other Platanistoid dolphins such as the boto (Galantsev *et al.*, 1992) and baiji (Zhou and Li, 1989). A similar pattern has been reported for other dolphins during feeding (Norris and Prescott, 1961; Read and Gaskin, 1985). A polymodal dive pattern has been reported for the Ganges river dolphin *P. gangetica indi* (Kasuya and Nishiwaki, 1975). Dive patterns are associated with behavioural activity (Watson and Gaskin, 1983). Our results may reflect the high percentage of time that the dolphins spent foraging.

When mother-calf pairs swim together, both individuals breathe and dive simultaneously. This may well explain the differences observed in dive frequencies between adult groups and mother-calf pairs. Studies of other species, such as bottlenose dolphins, revealed that mothers and their calves often exhibit synchronous respiratory behaviour (Würsig, B., 1978; Peddemors, 1990). It has also been found that breathing frequency decreases as the calf's age increases (Gurevich, 1977; Cockcroft and Ross, 1990). Peddemors (1990) suggested that the breathing control teaching period might reflect a K-selection strategy. The development by calves of the ability to dive for longer periods may be related to protection and suckling, whilst the synchronicity is probably related to rest and predation strategies used by dolphins (Norris and Dohl, 1980).

No particular schooling behaviour was observed when dolphins appeared undisturbed by moving vessels nor did we observe any obvious vessel avoidance by dolphins, with or without the motor turned-off. However, dolphins are probably able to hear the sound of the engine before we could sight them (as suggested by the higher SPUE recorded from sailboats than from motor boats during this study). Despite any obvious changes in behaviour, longer dive times were recorded in the presence of engine-powered boats as has been described for several dolphin species (e.g. Hua, 1987; Barlow, 1988; Hua *et al.*, 1989; Flores, 1992; Leatherwood *et al.*, 1992; Stone *et al.*, 1995; Bejder *et al.*, 1999).

From our observations, normal surfacing appears to involve the animal showing the entire beak and head above the surface before arching the body sharply prior to a long dive. Different surfacing behaviour, including keeping the beak level with the surface or raising only the melon and blowhole above the surface, has been reported in other Platanistoid dolphins (Layne, 1958; Pilleri, 1971). However, the small body size, colour of the animal with respect to turbid coastal waters and its rapid rolls make the franciscana a difficult visual object to study during brief surfacings, particularly under poor weather conditions. Further observations are required to confirm 'typical' surfacing behaviour under various activities.

CONCLUSION

In conclusion, franciscanas are found in the Bahía Anegada throughout the year but are more frequently observed during spring and summer, when the species is close to shore. The coastal shallow water seems to provide an ideal environment for feeding, resting, nursing and protection from predators. The differential use of ecological zones as defined by depth, suggests that this is an important factor in defining suitable habitat for the franciscana. The tide also appears to affect the behavioural activities in the area. Sailboats appear to be the most appropriate vessels to use when attempting to study the franciscana's behaviour, as the dolphins' reactions to them are minimal. This should also be considered when attempting to estimate density/abundance from boat surveys. The results of our study suggest that many behavioural patterns of the franciscana are similar to those of other coastal or riverine dolphins, perhaps reflecting evolutionary adaptation to life in similar environments. A long-term study of the franciscana in this area will help in the development of effective conservation and management strategies for this species.

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