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Short Communication

Living in an estuary: Commerson´s dolphin (*Cephalorhynchus commersonii* (Lacépède, 1804)), habitat use and behavioural pattern at the Santa Cruz River, Patagonia, Argentina

Rocio Loizaga de Castro[1, 2], Silvana Laura Dans[1, 2], Mariano Alberto Coscarella[1, 2] & Enrique Alberto Crespo[1, 2]
[1]Laboratorio de Mamíferos Marinos, Centro Nacional Patagónico (CONICET)
Blvd. Brown 2915, CP U9120ACV, Puerto Madryn, Argentina
[2]Universidad Nacional de la Patagonia San Juan Bosco, Blvd. Brown 3600
CP U9120ACV, Puerto Madryn, Argentina

ABSTRACT. Commerson's dolphins, *Cephalorhynchus commersonii*, suffer bycatch in fisheries and are target of dolphin-watching activities along Patagonia. Here we described dolphins' habitat use and behavioural pattern at the estuary of Santa Cruz River. Behavioural observations were made from vantage points using a spotting scope. Boat surveys were conducted randomly from Puerto Santa Cruz to the mouth of the river to analyze the habitat use. The survey area was divided into 1 km^2 cells and characterized with depth and benthic slope. The described behaviours for the Commerson's dolphin were: travelling, slow travelling, milling, resting, socializing, stationary swimming and diving. A new behavioural context was assigned to diving, a behaviour that showed a high frequency during downing tide, suggesting a benthic foraging strategy. Additionally, we found a strong influence of the tide on Commerson's dolphin behaviour. Habitat use models indicated that dolphins prefer shallow water inside the estuary. The knowledge of the behavioural patterns and the habitat use of these endemic species, in this unexplored area, provide tools for management and conservation purposes.

Keywords: Commerson's dolphin, habitat use, models, behaviour, tide, Argentina.

Viviendo en un estuario: uso de hábitat y patrón de comportamiento de la tonina overa (*Cephalorhynchus commersonii* (Lacépède, 1804)) en el río Santa Cruz, Patagonia, Argentina

RESUMEN. La tonina overa, *Cephalorhynchus commersonii*, sufre captura incidental en redes de pesca y es blanco de actividades turísticas a lo largo de la costa de Patagonia. En este trabajo, se describe el uso de hábitat de los delfines y su patrón de comportamiento en el estuario del río Santa Cruz. Se realizaron observaciones desde puntos panorámicos usando un telescopio y transectas al azar en embarcación, desde Puerto Santa Cruz hasta la boca del río, para analizar el uso de hábitat. El área de estudio fue dividida en celdas de 1 km^2 que fueron caracterizadas con la profundidad y el gradiente de profundidad. Los comportamientos observados para la tonina overa fueron: traslado, traslado lento, nado errático, descanso, socialización, nado estacionario y buceo. Por otro lado, se asignó un nuevo contexto comportamental al buceo, este comportamiento mostró una alta frecuencia durante la marea baja, sugiriendo una estrategia de alimentación bentónica. Adicionalmente, se encontró una fuerte influencia de la marea sobre el comportamiento de las toninas overas. Los modelos de uso de hábitat indicaron que las toninas overas prefieren aguas someras dentro del estuario. El conocimiento del patrón de comportamiento y uso de hábitat de esta especie endémica, en esta zona inexplorada, proporciona herramientas para el manejo y la conservación de la especie.

Palabras clave: tonina overa, uso de hábitat, modelos, comportamiento, marea, Argentina.

Corresponding author: Rocío Loizaga de Castro (rocio@cenpat.edu.ar)

The social and foraging ecology of dolphins vary in relation to different habitats (Whitehead & Dufault, 1999). Environmental features influence behaviour, social structure and migration patterns, which in turn are the results of balancing costs and benefits of living in a particular habitat (Gowans *et al.*, 2008). Further, individual differences in habitat use had been associated with some specific foraging strategies (Torres & Read, 2009). Commerson's dolphin (*Cephalorhynchus commersonii*) occurs all along the Patagonian coast of Argentina in the southwestern Atlantic 41º30'S to 55º00'S, including waters around the Falkland (Malvinas) Islands (Goodall, 1994). A separate subspecies is found off the Kergüelen Islands in the Indian Ocean (Robineau *et al.*, 2007). Commerson's dolphin inhabits coastal waters, including fiords, bays, river outlets, and occasionally they swim upstream rivers. They usually prefer areas with wide continental shelf, wide tidal cycles and cool waters influenced by the Malvinas' Current (Brownell & Donovan, 1988; Goodall *et al.*, 1988; Goodall, 1994; Pedraza, 2008). The environmental heterogeneity along the distribution range of the Commerson´s dolphin could have strong effects on its ecology. Additionally, Commerson's dolphins are caught incidentally in both coastal and high sea fisheries along the Argentine coast (Crespo *et al.*, 1997; Iñíguez *et al.*, 2003). Also, the boat-based cetacean watching industry developed along the Patagonian coast (Coscarella *et al.*, 2003), potentially adds further disturbance. The species exhibits high philopatry at a small geographical scale (Pimper *et al.*, 2010; Coscarella *et al.*, 2011). To date, information on the behavioural pattern of this dolphin is limited to open bays areas at the northern part of its distribution (Mermoz, 1980; Coscarella & Crespo, 2010; Coscarella *et al.*, 2010). In the present study we analyze habitat use and behaviour of the Commerson's dolphin and its potential relationships with environmental features within an estuary.

The study area includes the ria of Santa Cruz River (50º07'S, 68º25'W), which constitutes one of the four estuaries along Santa Cruz coast (Piccolo & Perillo, 1997) (Fig. 1). The Santa Cruz River has the largest continental discharge of the Patagonian coast, with an annual mean value of approximately 710 $m^3 s^{-1}$, and a maximum of 1250 $m^3 s^{-1}$ at the end of the austral summer (March) (Sabatini *et al.*, 2004). This estuarial area has a semidiurnal tidal regime with an extreme amplitude tide, 9.5 m spring tide and 5.4 m neap tides (Piccolo & Perillo, 1997). Land-based observations were carried out during the austral summer 2004-2005. The station was established at Punta Quilla harbour. This location was selected for its easy access, height (11 m above sea level) and visual field over the estuary. During daylight hours (08:00-12:00 h; 14:00-18:00 h), the study area was systematically scanned every 30 min using a Spacemaster Bushnell spotting scope with an 18x36 lens. For each scan, the duration of the scan as well as the number of dolphin sighted were recorded. Scans were limited to Beaufort sea state of 3 or less. Groups were followed until behaviour was determined for the group (Altmann, 1974). A group was defined as all dolphins engaged in the same activity and spread no more than five body length apart (Mann, 1999).

In the present study we used behavioural categories previously defined for Commerson's dolphins and other species within the genus *Cephalorhynchus*: travelling, slow travelling, fast travelling, surface feeding, socializing, resting, milling and stationary swimming (*e.g.*, Goodall *et al.*, 1988; Goodall, 1994; Slooten, 1994; Bedjer & Dawson, 2001; Coscarella, 2005; Coscarella *et al.*, 2010). Additionally, boat surveys were conducted randomly from Puerto Santa Cruz to the mouth of the river, covering an area of 70 km^2 using a 6-m rigid-hull inflatable 4-stroke engine. Transects were limited to Beaufort sea state of 3 or less. Typically, searching effort lasted between 45 min $survey^{-1}$ to 3 h $survey^{-1}$ (mean = 2h 50 min). Vessel speed was maintained at 12 kts h^{-1} during survey effort. The position of each Commerson's dolphin group encountered was recorded using a hand-held global positioning system (GPS). The survey area was divided into 64 cells of 1 km^2; each cell was identified with a number and characterized by environmental factors (depth and benthic slope). Both depth and benthic slope were derived from a nautical chart (Nautical Chart Nº2, Puerto Santa Cruz, Argentina, Servicio de Hidrografía Naval). The depth of each cell was considered as the average of all the depth points in each cell. The benthic slope was obtained as the angle existing between the minimum and maximum depth of each cell, expressed in decimal degrees. To determine potential relationships between behavioural pattern and environmental factors, contingency tables were built. Each sighted group was considered as a sample unit. Data were then classified according to group activity, tide (flood, ebb), and time block (morning, 08:00-12:00 h; afternoon, 14:00-18:00 h). Several hypotheses were tested using log-linear models, with the behavioural activity (B) being the response variable and time blocks (Tb) as well as tide (Td) being the explanatory variables (Caswell, 2001). Here, in the null model, B was independent of Tb and Td. Hypotheses were then tested by incorporating the corresponding interaction to the null model (Caswell, 2001). Generalized Additive Models (GAM) was used

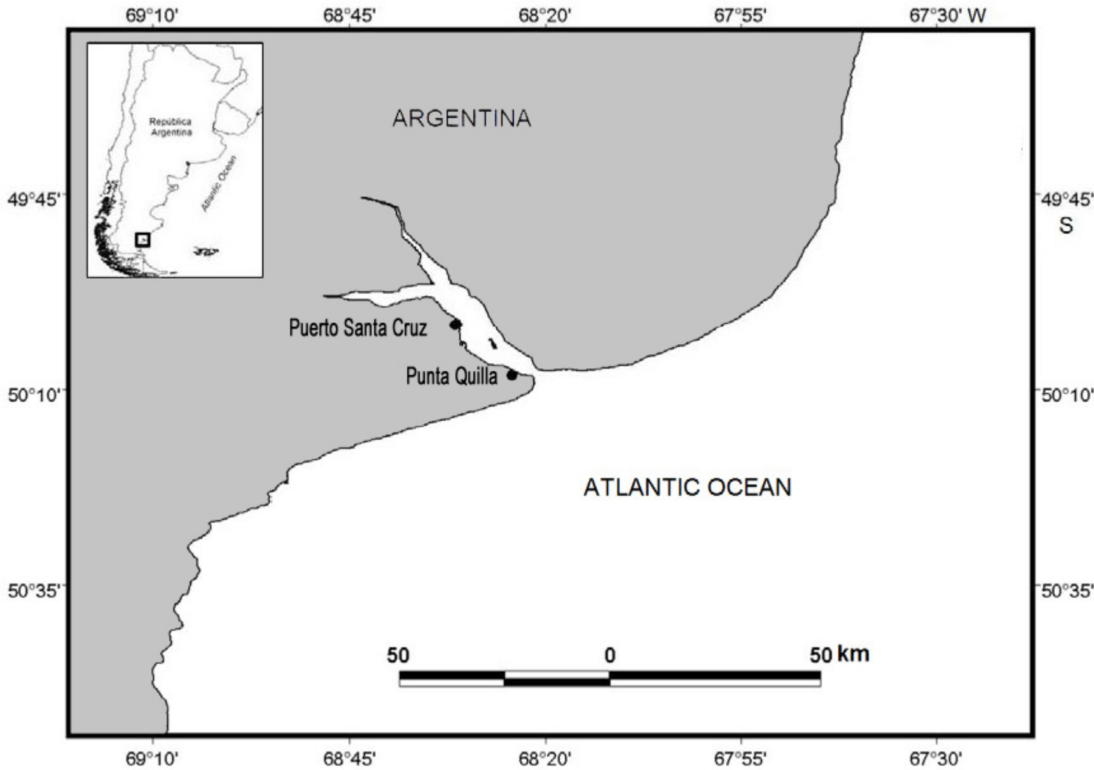

Figure 1. Study area at estuary of San Cruz River, southern Argentina.

to investigate the distribution of each Commerson's dolphin group in relation to environmental explanatory variables. The response variable was the number of groups sighted in each cell. Survey effort, measured as number of visits in each cell, was included as another explanatory variable, because it can help to explain the variance observed in the data. The models were fitted assuming a Poisson error distribution, with a log-link function (Hastie & Tibshirani, 1986; Zuur *et al.*, 2009). Data were checked for collinearity (VIF < 3 for each variable) and overdispersion (gamma = 1.2) (Zuur *et al.*, 2009). The best model was selected using the Akaike information criterion (AIC; Akaike, 1973).

From a total of 17 days with good sighting conditions (12 days during summer 2004 and 5 days in summer 2005), Commerson's dolphins were recorded on every scan session. In summer 2004, 166 Commerson's dolphin groups were recorded and 164 dolphin groups in summer 2005.The mean scan lasted 12:17 min. The mean group size was 1.5 (range 1-4 dolphins per group). Twenty individual follows were conducted from the land-based station allowing the description of Commerson's dolphin behaviours. The observed behaviours for the Commerson's dolphin were: travelling, slow travelling, milling, resting, socializing, stationary swimming and diving. During ebb tide, diving was the most frequently observed behaviour throughout the day, followed by slow travelling (Fig. 2a). Conversely, the most frequent behaviour recorded during flood tide was travelling, followed by diving and milling (Fig. 2b). Log-linear analysis revealed a significant influence of the tide on behaviour ($P = 0.0013$, Table 1), but none of the time block ($P = 0.1368$, Table 1).

During vessel surveys, 103 Commerson's dolphin groups were sighted within the study area. Out of the 64 cells defined for the survey area, 45 were visited. The number of visits per cell ranged between one and six times. The mean depth of the cells was 6.6 m, ranging from 1.10 to 25.70 m. The slope average per cell was 0.64 decimal degrees (range: 0.01 to 1.88). A series of GAM models were fitted to the number of groups of Commerson's dolphin sighted accounting for each selected explanatory variable. All the proposed models are shown in Table 2. The best-supported models by data (GAM0 and GAM1) showed that each explanatory variable influence the number of groups (Table 2). The difference between the two top selected models is the nature of the relationship between the number of groups and the number of visits to a particular cell. GAM1 relates the number of groups sighted trough a smoother, while

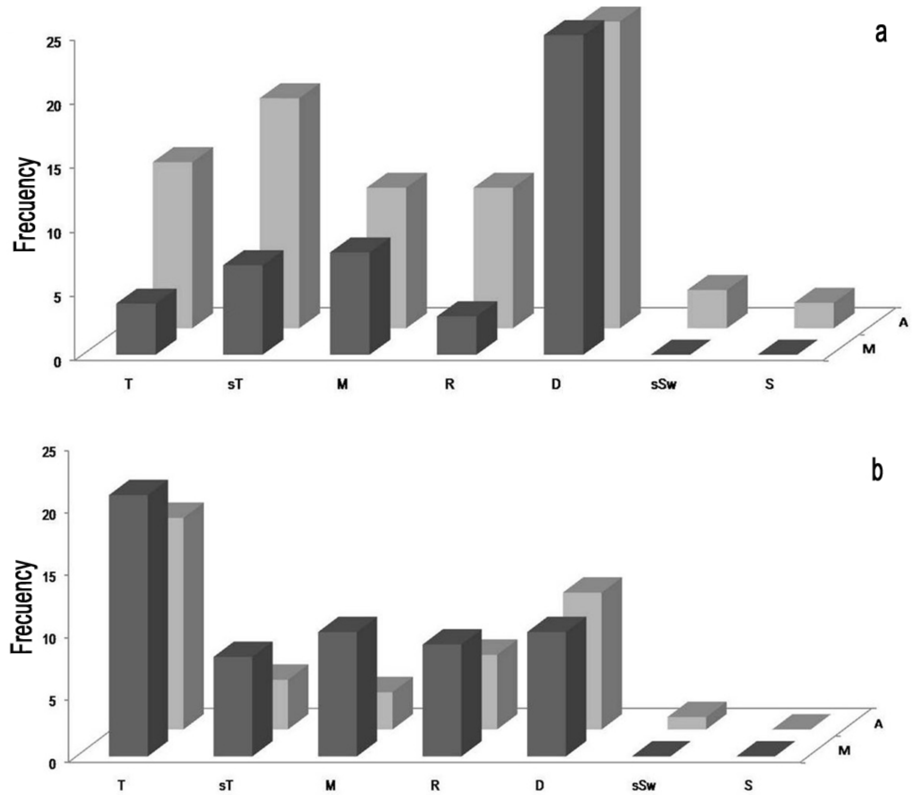

Figure 2. Occurrence of behavioural categories during a) ebb tide, and b) flood tide during daylight at the estuary of Santa Cruz River, Argentina. *x axis*, T: travelling, sT: slow travelling, M: milling, R: resting, D: diving, sSw: stationary swimming, S: socializing, *y axis*, M: morning, A: afternoon.

Table 1. Log-linear models used to test the influence of time blocks (Tb) and tide (Td) on the behaviours (B) analyzed for Commerson's dolphins at the estuary of the Santa Cruz River. *Indicate the significant values ($P < 0.001$).

Model	*G*	df	Statistic	df	*P*
B, TdTb	42,238	21			
BTd, TdTb	17,534	14	24.704	7	*
BTb, TdTb	31.197	14	11.041	7	ns
BTd, TdTb	17.534	14			
BTd, TdTb, BTb	6.1931	7	44.397	7	ns
BTb, TdTb	31.197	14			
BTb, TdTb, BTd	6.1931	7	30.734	7	*

GAM0 proposes a parametric relationship. Both models explain 78% of the deviance, and given that the smoother of the number of visits for GAM1 is almost linear (data not shown), GAM0 was selected. The analysis of explanatory variables indicates that depth was significant at this scale and that the slope was also significant. The number of visits is the most influential explanatory variable, followed by the mean depth. Patterns of the effects of topographical variables on the number of sighted groups' are shown in Figure 3 for model GAM0. The number of dolphins tends to increase at a mean depth of 6 m. The relationship with slope is more complex and with a *P*-value close to rejection. Probably, an increase in the number of observations would render this variable non significant. The GAM1 model (that allows more flexibility to the number of visits parameter) shows that the smoother for the slope is not significant.

The selected habitat use model (GAM0), indicates that inside the estuary dolphins prefer shallow water, and are prone to be found always at the same range of depth. The slope also was a factor that affect the number of dolphins inside the estuary, but its importance is lesser than the one from the depth. Consequently, depth and slope appear to be important factors in determining Commerson's dolphin habitat use. It has been argued that steeply sloping topography may provide high concentrations of prey or facilitate foraging activities (*e.g.*, Wilson *et al.*, 1997 in Ingram & Rogan, 2002). Also, tide was found to influence the Commerson's dolphin behavioural pattern. Tidal

Table 2. Generalized Additive Models (GAM) fitted to number of Commerson's dolphin groups sighted in the estuary of Santa Cruz River. Distribution error model is Poisson. In bold are indicate the significant values.

Model	Intercept	N. visits	S (N. visits)	S (Mean depth)	S (Slope)	Explained deviance	AIC
GAM0	0.06153	**0.0007**	---	**0.00512**	**0.04945**	0.779	153.25
GAM0.1	0.034	**4.85e-06**	---	----	**0.00415**	0.584	166.16
GAM0.2	0.1075	**0.000481**	---	**0.000208**	---	0.65	155.91
GAM1	0.0857	---	**0.00133**	**0.00603**	0.05416	0.778	153.39
GAM1.1	**0.00603**	---	**0.000815**	**0.000769**	---	0.659	155.35
GAM1.2	**0.0099**	---	**4.74e-08**	---	**0.0271**	0.620	160.27
GAM2	0.0646	---	---	**8.6e-05**	**0.0303**	0.701	162.86

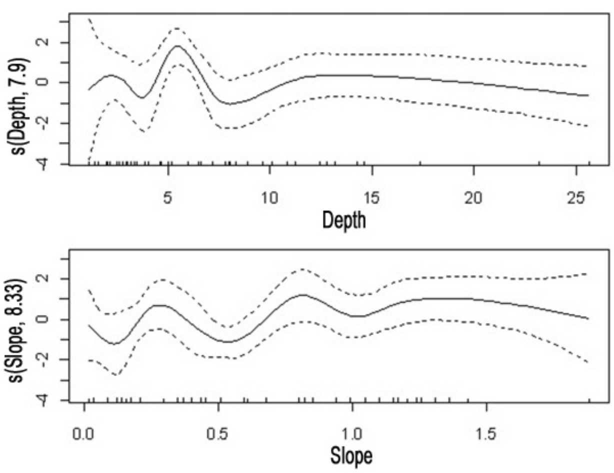

Figure 3. Smoothers for environmental variables (depth and slope) used to build Generalized Additive Models (GAM) in Commerson's dolphin at the estuary of Santa Cruz River, Argentina.

cycles and tidal fronts have been shown to affect the distribution, abundance and behaviour of delphinids (*e.g.*, Ingram & Rogan, 2002; Mendes *et al.*, 2002; Hastie *et al.*, 2003; Guilherme-Silveira & Silva, 2009). Previous research reported that Commerson's dolphins move up inside closed bays and lochs during the flood tide and move down during the ebb tide, while in open bays tide has no influence on the behaviour (Leatherwood *et al.*, 1988; Coscarella *et al.*, 2010). This observed site-depending behavioural flexibility lead us to suggest that in terms of behavioural activity, diving may have a different behavioural context for Commerson's dolphins in this area. Previously, this behaviour was included within a resting context since it was observed intermingled with drifting episodes (Coscarella, 2005; Coscarella *et al.*, 2010). In the study area, this behaviour showed a high frequency during the ebb tide at the Santa Cruz River, and could therefore be potentially related to a benthic foraging strategy. Commerson's dolphins are opportunistic feeders, exhibiting pelagic feeding strategies in northern Patagonia, at the northern end of its range. This species could change its foraging tactics by adapting to different habitats, including those with extreme tidal ranges (Koen-Alonso, 1999). A diet study of Commerson's dolphins at Tierra del Fuego (53º20'S, 68º30'W), showed the presence of benthic preys, indicating that this species feeds at or near the bottom (Bastida *et al.*, 1988). If diet were to include benthic items in the area, then an association between diving and benthic foraging strategy cannot be discarded. Garaffo *et al.* (2011), at a larger scale, found that Commerson's dolphin present a coastal distribution and Pedraza (2008) reported that depth does not seem to influence the distribution of this species, which is often found feeding at the mouths of the Patagonian rivers Chubut, Deseado, Coy Gallegos, and Bahía San Julián, all places with intense tide flows. Consequently, Commerson's dolphins living in different habitats appear capable to alter or modify their behavioural activity, including foraging strategies, in order to increase the efficiency of available resources use. Variation in foraging tactics should exist across different habitats because ecological conditions should affect the relative success rates of different tactics (*e.g.*, Rossbach & Herzing, 1997; Connor *et al.*, 2000; Sargeant *et al.*, 2007). Therefore, the knowledge of the behavioural patterns and habitat use of Commerson's dolphins in this unexplored area provides tools for management and conservation purposes for an endemic species.

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