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Seabird and dolphin associations: do seabirds benefit from feeding in association with dusky dolphins in Patagonia?

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The objective of this study was to describe associations between several species of seabirds and dusky dolphins. We investigated during what dolphin activities seabirds were most commonly associated, and the size of flock in relation to the number of dolphins in a group. Since both seabirds and dolphins may display different feeding strategies, we also investigated if benefits differed among seabird species. Data were collected in Golfo Nuevo (42°20′S65°00′W) on-board a research vessel between 2001 and 2008. A total of 224 mixed groups of seabirds were encountered during this study. The seabird–dolphin associations were mainly observed during dusky dolphin surface feeding. Shearwaters and kelp gulls were mainly observed in flocks that were associated with dolphins, while Magellanic penguins and cormorants were mainly observed without dolphins. Seabirds may be conditioned to the foraging strategy of dolphins, since birds are associated with dolphins only during dolphin surface feeding. This association probably helped seabirds to find prey, but there were no obvious benefits to dolphins.

Keywords: commensalism, feeding association, seabird–cetacean interaction, Peninsula Valdés

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INTRODUCTION

Seabirds associate commonly with marine vertebrates, including whales, dolphins, pinnipeds, sharks and turtles, to feed on prey made available when these animals forage near the surface (Evans, 1982; Au & Pitman, 1986; Pitman & Balance, 1992; Pitman, 1993; Clua & Grosvalet, 2001; Hebshi *et al.*, 2008; Vaughn *et al.*, 2008). These relationships may increase bird foraging efficiency and decrease energy expenditure (Dinsmore, 1973; Grubb, 1976). In some cases, the seabird and cetacean associations are probably opportunistic or incidental, and result from a concentration of shared prey (Evans, 1982). But there is also evidence of commensally feeding relationships, in which birds benefit from feeding with dolphins, while dolphins are not affected negatively (Martin, 1986). Martin (1986) reported that shearwaters (*Puffinus* sp.) feeding among herds of Atlantic spotted dolphins (*Stenella frontalis*) took mainly scraps or wounded fish, and only occasionally took whole, live prey. Seabirds have also been reported to feed on squid remains vomited by sperm whales (*Physester macrocephalus*, Clarke *et al.*, 1981) and seabirds have fed directly on cetacean skin (Thomas, 1988; Rowntree *et al.*, 1998). Cetaceans at times make prey available to birds by driving and concentrating prey close to the ocean's surface, thus enhancing the foraging opportunities for surface feeding and shallow diving birds (Ashmole, 1971; Harrison, 1979; Martin, 1986; Obst & Hunt, 1990; Vaughn *et al.*, 2008).

By contrast, other authors have examined the possibility that some baleen whales take advantage of seabird feeding activity (Pierotti, 1988; Hoelzel *et al.*, 1989; Anderwald *et al.*, 2011). Anderwald *et al.* (2011), indicate that the interaction between minke whales (*Balaenoptera acutorostrata*) and auks is best described by the pirate theory, with the whales stealing entire bait balls herded by auks.

Dusky dolphins, *Lagenorynchus obscurus* (Gray, 1828) inhabit waters of the continental shelf and slope of Argentina, Chile and Peru in South America, and south-western Africa and New Zealand (Leatherwood & Reeves, 1983; Crespo *et al.*, 1997). In Patagonia, Argentina, this species is a target of cetacean watching activities in Golfo Nuevo; an activity was recently regulated in the area (Disposition 004/10, Sub Secretaria de Turismo y Areas Protegidas). Dans *et al.* (2008, 2012) showed that boats at times disrupt the normal sequence of dolphin behaviours in Golfo Nuevo, particularly during diurnal feeding activities.

Associations of seabirds and dusky dolphins were described in Admiralty Bay (New Zealand), where Vaughn *et al.* (2008) investigated how dolphins influence prey accessibility for seabirds that commonly feed with them. In addition, in Golfo San José (Argentina), Würsig & Würsig (1980) reported that dusky dolphins drove anchovies (*Engraulis anchoita*) to the surface where thousands of seabirds sometimes gathered to feed for hours. In Golfo Nuevo (Argentina) the presence of birds foraging with or following a group of dolphins was indicative of dolphin feeding behaviour (Degrati *et al.*, 2008, 2012). Seabirds that were commonly observed were shearwaters (*Puffinus gravis*), kelp gulls (*Larus*

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dominicanus) and several species of terns (*Sterna* sp.). Seabirds that were occasionally observed were Magellanic penguins (*Spheniscus magellanicicus*), black-browed albatross (*Diomedea melanophrys*), two cormorant species: rock shags, imperial cormorants (*Phalacrocórax magellanicicus* and *Phalacrocorax atriceps*) and giant petrels (*Macronectes giganteus*). The importance of these feeding events to seabirds is not currently known.

The objective of this study was to describe seabird–dolphin associations. We investigated during what dolphin activities the birds were most commonly associated and the size of flock in relation to the number of dolphins in a group. We also quantified how frequently seabirds fed with dolphins or without them. Since seabirds may display different feeding strategies, we also investigated if benefits differ among seabird species.

MATERIALS AND METHODS

Study area

The study area consisted of a roughly 1600 km² region in the western portion of Golfo Nuevo, Argentina (42°20′–42°50′S64°20′–65°00′W, Figure 1), in northern Patagonia, Argentina. It is surrounded by Península Valdés, a protected area that was declared a World Heritage Site by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1999. The gulf is a semi-closed basin approximately 70 km long and 60 km wide with a total area of 2500 km². The average depth is 80 m with a maximum depth of 184 m (Mouzo *et al.*, 1978). The mouth of the gulf is 16 km wide. The gulf is connected to the Atlantic Ocean by shallow waters that have an average depth of 44 m (Mouzo *et al.*, 1978).

Data collection and analyses

Data were collected during all seasons from 2001 to 2008. Surveys were carried out from either a 6 m fibreglass boat powered with a 50 hp outboard engine, a 7.2 m fibreglass boat powered with a 105 hp outboard engine or a 6 m fibreglass boat powered with a 90 hp outboard engine. The mean duration of trips was 5.5 h ± 1.30 SD (range = 1.30–9 h), with the duration of a given survey determined by sea and weather conditions (Beaufort Sea State ≤3).

A non-systematic search method was used to locate seabirds and dolphins, with a search speed of 10–12 knots. All groups of seabirds were recorded while driving along a transect. A seabird group was defined as an aggregation of >10 individuals of one or more species. Number, specific composition (proportion of individuals of each species), location and behaviour were recorded for each group. Seabird's behaviour was divided into three categories: feeding, resting and flying. Feeding was defined as seabirds swooping down to the water's surface from the air or looking down into the water and then submerging to capture the prey. Resting behaviour was defined as floating on the water's surface. Once information on a seabird group was collected, the transect was resumed.

A group of dolphins was defined as any collection of individuals located in close proximity (<10 m) to one another (Smolker *et al.*, 1992). Once a dolphin group was detected, the transect was abandoned, and the group was followed for as long as possible. The group was observed continuously, and the predominant activity was recorded at 2 min intervals using an instantaneous sampling protocol (Altmann, 1974). Six predominant activities were identified (Table 1). These activities were defined to be mutually exclusive and, collectively, they described effectively the entire behavioural repertoire of the study animals. At the end of each interval the

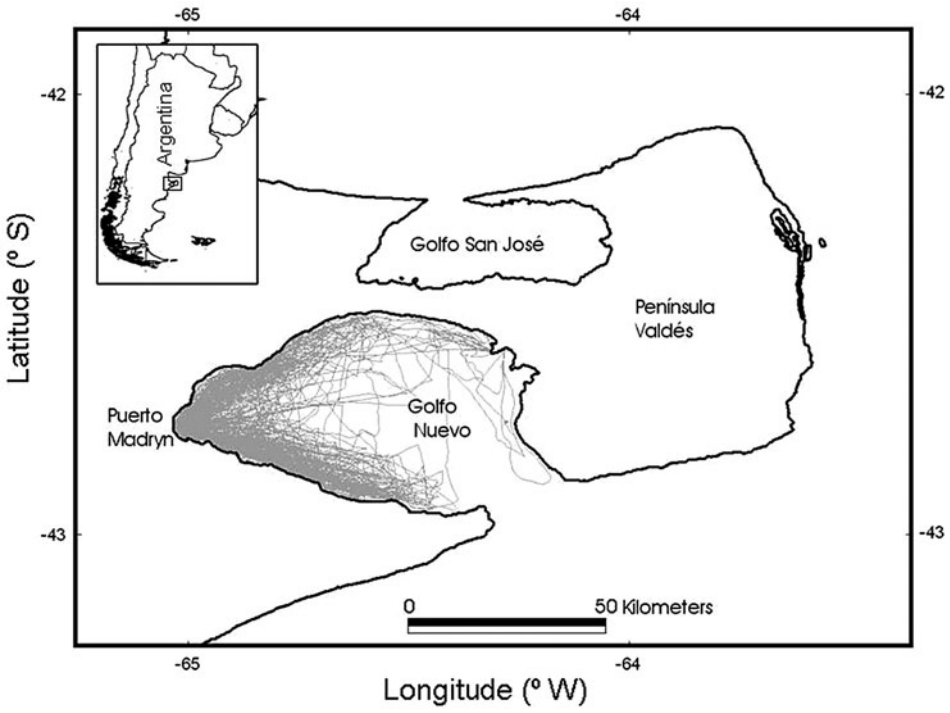

Fig. 1. Map of the study area in Golfo Nuevo, Argentina. Grey lines show paths followed by the research boat.

Table 1. Behavioural states or activities of dusky dolphin (*Lagenorhynchus obscurus*) groups in Golfo Nuevo.

Activity	Description
Feeding	Dolphins move fast, diving and emerging in all directions. At times it is possible to see dolphins harassing fish, fish jumping out of water, and marine birds like terns, gulls, albatrosses, giant petrels, shearwaters, cormorants, jaegers, and others, feeding at the same time. Dolphins move fast but the group does not change location
Travelling	Persistent movement, with all group members swimming in the same direction
Socializing	Frequent interactions between two or more individuals, usually in the form of body contact accompanied by high-speed movements, frequent changes in direction. Aerial displays such as leaps, tail-over-head leaps, back-slaps, head-slaps, and tail-slaps are common
Resting	Low level of activity, with individuals remaining stationary, at times floating motionless on the surface, with occasional slow forward movement
Milling	Low-speed movement with frequent changes in direction, resulting in little overall directional movement by the group
Diving	Entire dolphin group submerged under water in a coordinated movement, presumably encountering prey

species and number of seabirds associated with dolphins were also registered.

For the analyses, each dolphin group-follow was considered an independent observation and only one group per day was considered. Because behaviour at consecutive 2 min intervals was not independent, the proportion of time spent in each of the six defined activities was calculated from each group-follow (for methodology details see Degrati *et al.*, 2008, 2012a). The number of seabirds was classified into four categories (<50, 50–100, 100–200 and >200) and from each seabird group, the category that was mainly recorded during the instantaneous sampling was assigned. Descriptive statistics and Chi-square tests were used to analyse the data. A Spearman correlation was used to examine the relationship between number of dolphins and number of associated seabirds. A significance level of $\alpha = 0.05$ was used for all tests (Siegel & Castellan, 1995; Conover, 1999).

RESULTS

A total of 224 mixed groups of seabirds were encountered during this study, 115 of which were associated with dolphins (Figure 2). For some groups, behaviour or size of group could not be determined. In most of seabird–dolphin groups, seabirds were feeding (81%, χ^2_1 equals 56.24, $P < 0.001$, Figure 2). On the other hand, only 30% of seabird groups not associated with dolphins were feeding, while most were resting (54%, Figure 2).

Groups of seabirds in association with dolphins were bigger than those that were not associated with dolphins (χ^2_3 equals 39.20, $P < 0.001$, Figure 3). A correlation was found between the number of birds and the number of dolphins in the group (Spearman rank correlation $r_s = 0.54$, N = 114, $P < 0.001$).

Birds mainly associated with dolphins when dolphins were feeding (Figure 4). Seabirds were never associated with dolphins when dolphins were diving.

The species composition of bird flocks changed depending on if they were associated with dolphins or not ($\chi^2_4 = 55.83$, $P < 0.001$, Figure 5). Shearwaters and kelp gulls were mainly observed in flocks that were associated with dolphins, while Magellanic penguins and cormorants were generally not associated with dolphins.

DISCUSSION

Dusky dolphins in Golfo Nuevo appeared to increase prey accessibility for some seabirds during their surface feeding tactics. The frequency with which shearwaters, kelp gulls and terns fed with dolphins suggests that feeding with dolphins is important to these apex predators. Groups of seabirds in association with dolphins were larger than those that were not associated with dolphins. In addition, larger dolphin groups had more associated seabirds. Additionally, previous studies of dusky dolphin behaviour show that longer

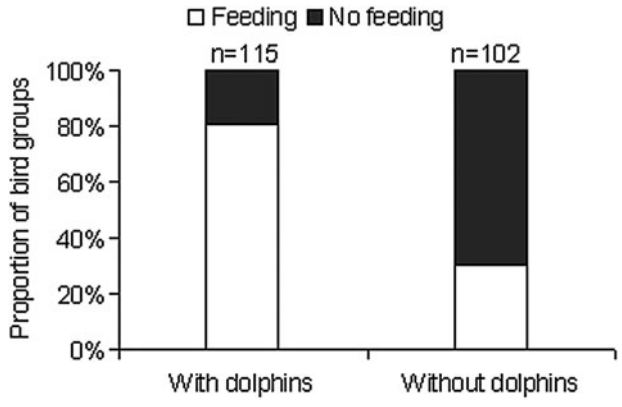

Fig. 2. Proportion of seabird groups in feeding and non-feeding (other behaviour different to feeding) activity, recorded in association with dolphins or not.

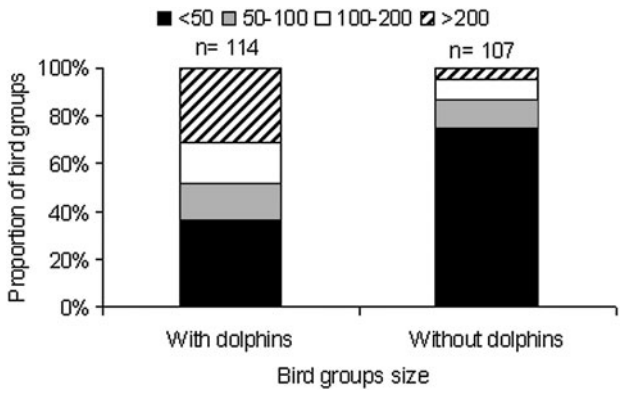

Fig. 3. Proportion of seabird groups, classified by their size and recorded in association with dolphins or not.

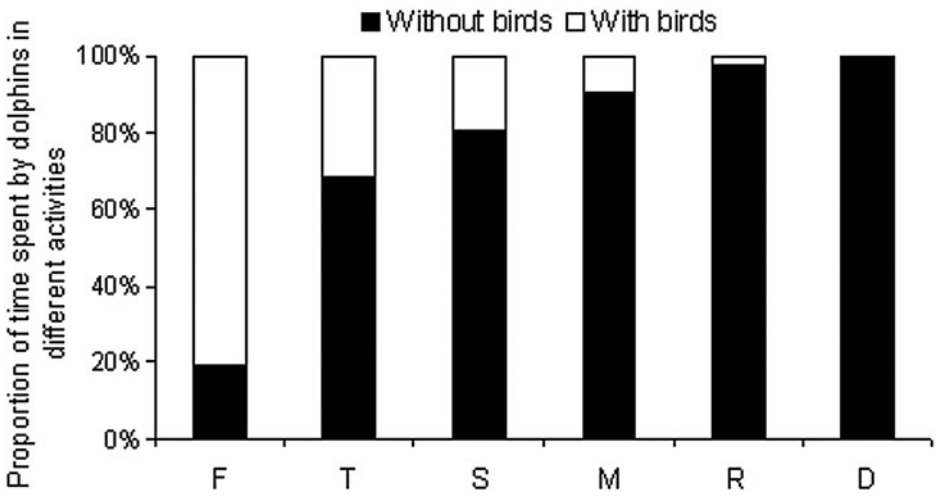

Fig. 4. Proportion of time spent by dolphins in different activities, with and without birds ($N = 4921$ two minute intervals). F, feeding; T, travelling; S, socializing; M, milling; R, resting; D, diving.

feeding-bout durations are associated with larger dolphin groups (Vaughn *et al.*, 2010). Dolphin group size and duration of the feeding bout may be important for long-range detection by the birds as well as potential profitability for them. Larger dolphin groups probably are easier for birds to see at longer distances. Hovering seabirds are likely to be used as a cue to indicate a good foraging opportunity to other birds. Larger dolphin groups could be indicative of larger prey concentrations. A similar result was reported for gannets (*Morus serrator*) and shearwaters (*Puffinus* sp.) in association with dusky dolphins in New Zealand (Vaughn *et al.,* 2008) and for terns in association with Hector's dolphins (Bräger, 1998).

Shearwaters, kelp gulls and terns were associated with dolphins most often. Gulls and terns catch fish at the surface (dipping, surface plunging) (Duffy *et al.,* 1984; Burger, 1988; Gochfeld & Burger, 1996). Thus, the herding behaviour of dolphins appeared to be most important for these species, since it may have made prey more accessible to them. In Bahía Engaño, three tern species were identified interacting with Commerson's dolphins (*Cephalorhynchus commersonii*). From the total number of groups with which the terns interacted, those engaged in feeding activities accounted for 72.53%, reaching a proportion of 84.62% when only the groups of dolphins engaged in cooperative feeding are considered (Coscarella *et al.,* 2010). Although shearwaters dive deep to catch prey, dolphins may have also increased prey accessibility for these seabirds by decreasing how deeply they had to dive for prey (Vaughn *et al.*, 2008). Other factors also may influence prey accessibility for shearwaters. Dolphins may make it easier for birds to capture prey by increasing compaction of prey balls, or may make it easier for birds to initially locate prey (Vaughn *et al.,* 2008).

Penguins and cormorants appeared in lower proportions in the bird assemblages. There are no Magellanic penguin colonies inside Golfo Nuevo, and this gulf was not reported as a foraging area (Wilson *et al.*, 1995; Stoke & Boersma, 1999). Therefore, most of the penguins could be foraging outside the gulf, in open waters, and they were being part of the seabird–dolphin associations in a few occasions. Given that penguins do not fly, they probably did not benefit from dolphins by finding prey more easily. It is more likely that they co-occurred in the same area due to prey presence. Maybe penguins benefit also from the behaviour of dolphins in terms of finding more prey close to where dolphins are feeding.

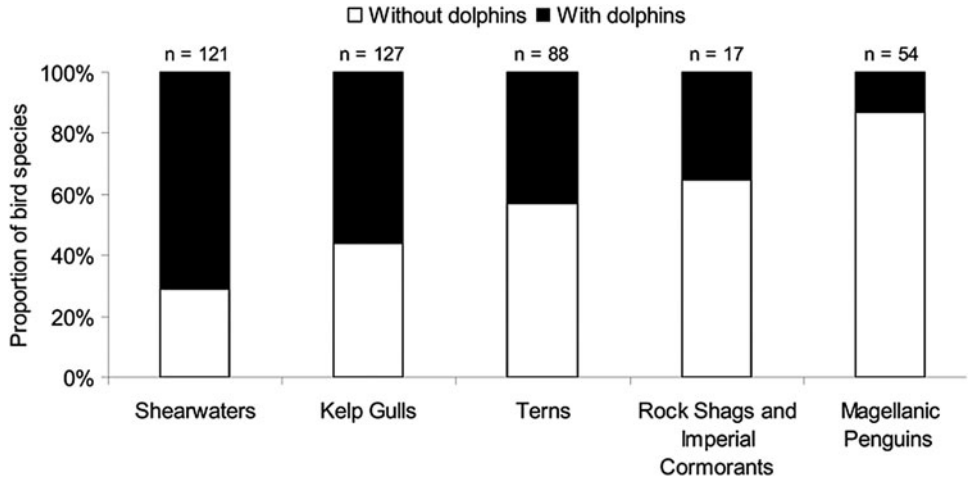

Fig. 5. Proportion of bird species present in the mixed flocks, observed in association with dolphins or not.

Cormorants, in general, show a characteristic bottom diving pattern (Quintana *et al.*, 2002, 2007; Sapoznikow & Quintana, 2003). The rock shags breed in two colonies inside Golfo Nuevo but their diet consists mainly of benthic fish and invertebrates of small size and low energetic value (Malacalza *et al.*, 1997). Therefore, a low association of cormorant with dolphins is expected since their foraging behaviour and prey are different. The imperial cormorant consumes a significantly larger proportion of pelagic or demersal fish, such as anchovy, hake (*Merluccious hubbsi*) and silverside (*Odontesthes* sp.), than do rock shags (Punta *et al.*, 2003), but there are no breeding colonies inside the gulf (Frere *et al.*, 2005), so a low association of cormorants with feeding dolphins groups would be expected here.

Birds are associated with dolphins only during feeding at the surface; therefore feeding opportunities and potential benefits to seabirds will depend on delphinid feeding tactics. Behavioural analyses of dusky dolphins show that dolphins may use different feeding tactics (Degrati *et al.*, 2012a, b). During the warm season, dolphins mostly forage using a feeding–travelling sequence. However, in the cold season, a greater proportion of diving activity appeared and surface feeding decreased (Degrati *et al.*, 2012a, b). These strategies could be related to the abundance and distribution of dolphin's prey. Hydro-acoustic surveys of prey, in the study area showed that, in the cold season, anchovy schools are widely dispersed and deeper in the water column (Degrati *et al.*, 2012a). Then, dolphins would need more time travelling longer distances between prey patches, and would spend more energy to carry the school to the surface. It is expected that, during the cold season, dolphins explore an alternative strategy allowing them to get the required energy at lower costs than using anchovies. Squid may be the target, as the second most important prey in their diet (Koen Alonso *et al.*, 1998), while diving could be the strategy to catch them.

Our results are in concordance with previous assessments of the importance of surface predators to the foraging ecology of many species of seabirds (Au & Pitman, 1986; Harrison & Seki, 1987; Jaquemet *et al.*, 2004; Hebshi *et al.*, 2008; Vaughn *et al.*, 2008). The seabird–dolphin associations we observed may have assisted the seabirds in finding prey, but the associations gave no obvious benefit to dolphins. Hence, the association appears to be one of facultative commensalism. This type of feeding relationship was also described by Bräger (1998) in his observations of seabirds associating with Hector's dolphins, and by Fox & Young (2012), who found a commensal relationship between two apex predators, one terrestrial (wading birds) and one marine (strand-feeding dolphins). In this case, the foraging activities of the dolphins regularly allow individual birds to meet their energy requirements by providing access to normally inaccessible prey. In Patagonia, further studies on local seabird feeding habits, distribution and abundance will certainly add new pieces to the puzzle regarding the ecological aspects that drive the feeding associations between dusky dolphins and seabirds.

Finally, it is necessary to place the results of this study within a management and conservation context. Groups of dusky dolphins in Golfo Nuevo are subject to tourism activities and showed a short term response to dolphin-watching boats (Coscarella *et al.*, 2003; Dans *et al.*, 2008, 2012). These boats mainly located dolphin groups using seabirds as a cue for the presence of dolphins. The tourism trips may have not only interfered with dolphin feeding activity, but indirectly with the activity of associated seabirds. At present, Península Valdès constitutes a protected area with managed resources, and dolphin watching was recently regulated. However, the code of conduct does not include any management aspect that pertains to seabirds. Seabirds should also be considered within the management scheme of dolphin watching activities in Golfo Nuevo.

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