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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'S, 65°00'W) onboard 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 (*Physeter macrocephalus*, Clarke *et al.*, 1981) and seabirds have fed directly on cetacean skin (Thomas, 1988; Rowntree *et al.*, 1998). Cetaceans at time 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 taking 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, *Lagenorhynchus 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 time 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 and 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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64 *dominicanus*) and several species of terns (*Sterna sp.*). Seabirds
 65 that were occasionally observed were Magellanic penguins
 66 (*Spheniscus Magellanicus*), black-browed albatross
 67 (*Diomedea melanophrys*), two cormorant species: rock shags,
 68 imperial cormorants (*Phalacrocorax magellanicus* and
 69 *Phalacrocorax atriceps*) and giant petrels (*Macronectes gigan-*
 70 *teus*) The importance of these feeding events to seabirds is not
 71 currently known.

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

81 MATERIALS AND METHODS

84 Study area

85 The study area consisted of a roughly 1600 km² region in the
 86 western portion of Golfo Nuevo, Argentina (42°20'–42°50'S,
 87 64°20'–65°00'W, Figure 1), in northern Patagonia, Argentina.
 88 It is surrounded by Península Valdés, a protected area that was
 89 declared a World Heritage Site by the United Nations
 90 Educational, Scientific, and Cultural Organization
 91 (UNESCO) in 1999. The Gulf is a semi-closed basin approxi-
 92 mately 70 km long and 60 km wide with a total area of
 93 2500 km². The average depth is 80 m with a maximum
 94 depth of 184 m (Mouzo *et al.*, 1978). The mouth of the Gulf
 95 is 16 km wide. The Gulf is connected to the Atlantic Ocean
 96 by shallow waters that have an average depth of 44 m
 97 (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 fiber-
 glass 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 sea-
 birds and dolphins, with a search speed of 10–12 knots. All
 groups of seabirds were recorded while driving along a trans-
 ect. A seabird group was defined as an aggregation of >10
 individuals of one or more species. Number, specific compo-
 sition (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 infor-
 mation on a seabird group was collected, the transect was
 resumed.

A group of dolphins was defined as any collection of indi-
 viduals 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 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, collec-
 tively, they described effectively the entire behavioural reper-
 toire of the study animals. At the end of each interval the

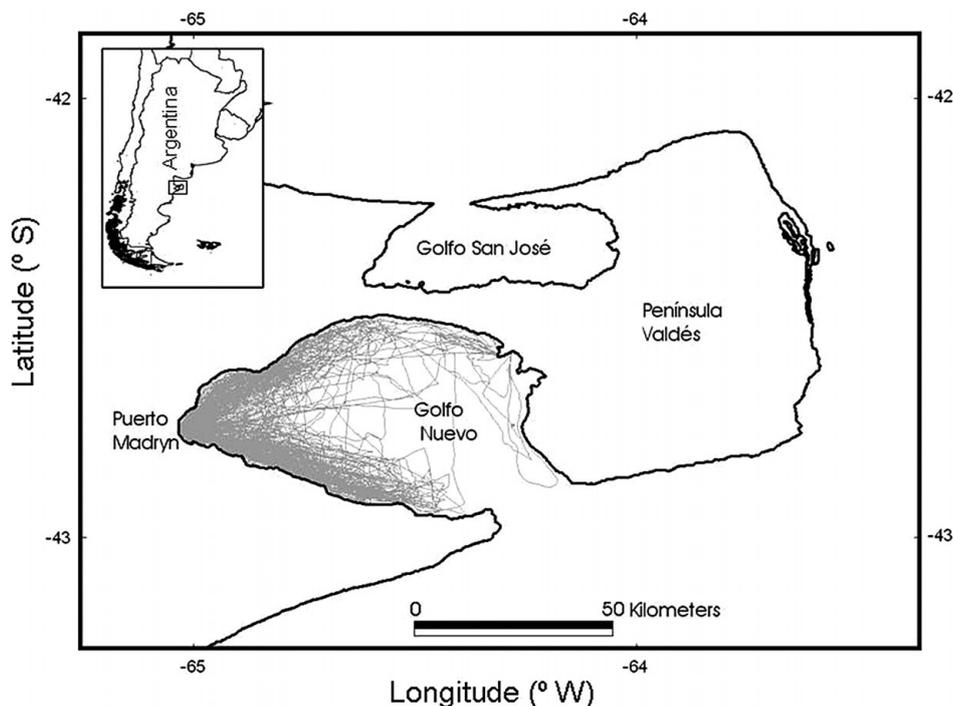


Fig. 1. Map of the study area in Golfo Nuevo, Argentina. Grey lines show paths followed by the research boat

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 Degradi *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 (Conover, 1999; Siegel & Castellan, 1995).

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

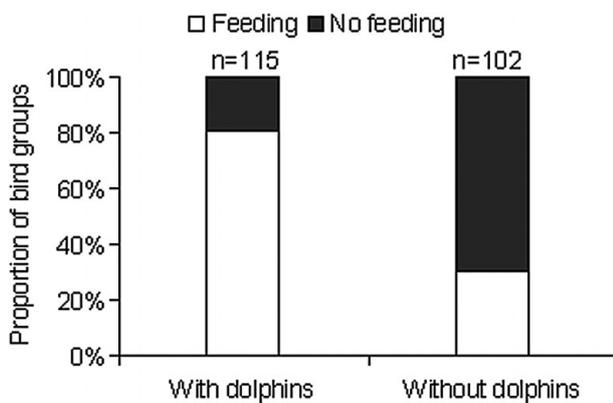


Fig. 2. Proportion of seabird groups in feeding and non-feeding (other behaviour different to feeding) activity, recorded in association with dolphins or not.

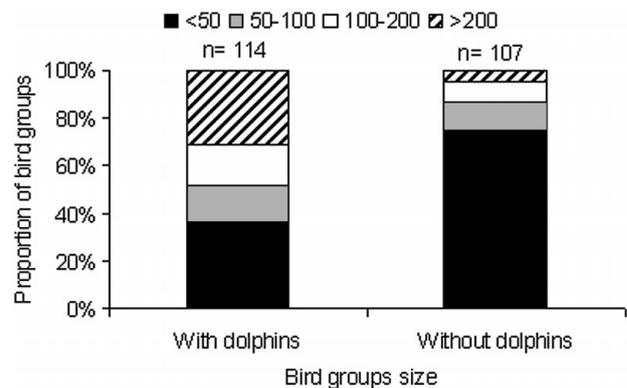


Fig. 3. Proportion of seabird groups, classified by their size and recorded in association with dolphins or not

Fig. 4 - B/W online, B/W in print

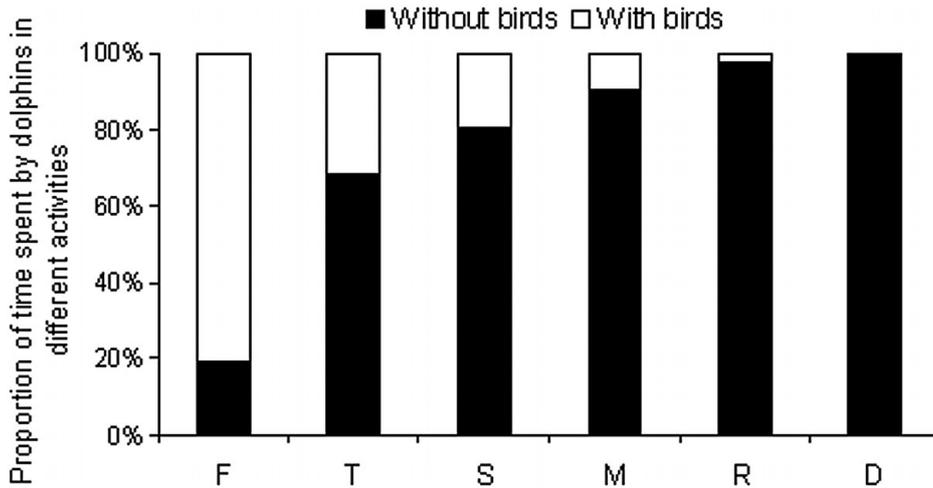


Fig. 4. Proportion of time spent by dolphins in different activities, with and without birds ($n = 4921$ two minute intervals). F = feeding, T = travelling, S = socializing, M = milling, R = resting, D = diving.

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 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 where dolphins are feeding.

Fig. 5 - B/W online, B/W in print

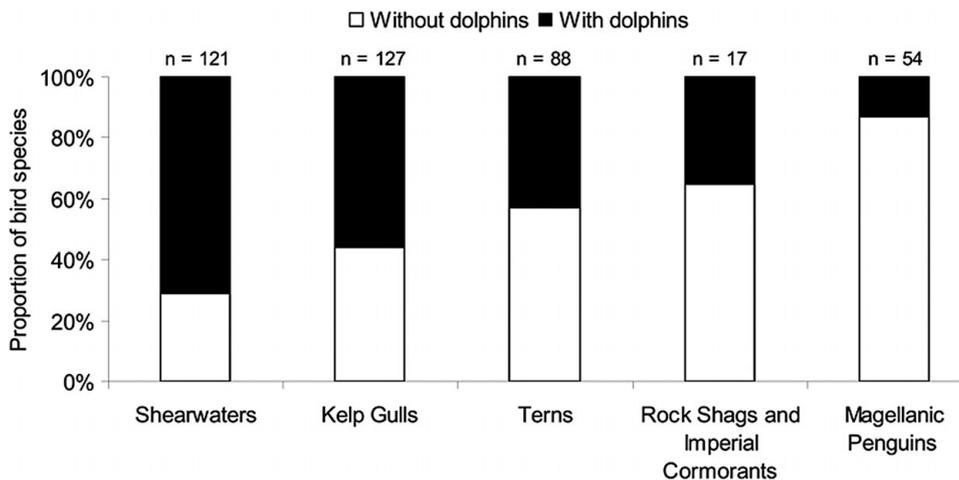


Fig. 5. Proportion of bird species present in the mixed flocks, observed in association with dolphins or not.

Cormorants, in general, show a characteristic bottom diving pattern (Quintana *et al.*, 2002; Sapoznikow & Quintana, 2003; Quintana *et al.*, 2007). 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 (*Merluccius 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 more 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 and 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, Peninsula Valdes 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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REFERENCES

- Altmann J. (1974) Observational study of behaviour: sampling methods. *Behaviour* 49, 227–267.
- Anderwald P., Evans P.G.H., Gygas L. and Hoelzel A.R. (2011) Role of feeding strategies in seabird–minke whale associations. *Marine Ecology Progress Series* 424, 219–227.
- Ashmole N.P. (1971) Seabird ecology and the marine environment. In Farner D.S., King D.R. and Parkes K.C. (eds) *Avian biology*. New York: Academic Press, Vol 1, pp. 223–286.
- Au D.W. and Pitman R.L. (1986) Seabird interactions with dolphins and tuna in the eastern tropical Pacific. *Condor* 88, 304–317.
- Bräger S. (1998) Feeding associations between white-fronted terns and Hector's dolphins in New Zealand. *Condor* 100, 560–562.
- Burger J. (1988) Foraging behaviour in gulls: differences in method, prey and habitat. *Colonial Waterbirds* 11, 9–23.
- Clarke M.R., Crow J.P. and Princep A. (1981) Cephalopod remains in regurgitations of the wandering albatross *Diomedea exulans* at South Georgia. *British Antarctic Survey Bulletin* 54, 9–21.
- Clua E. and Grosvallet R. (2001) Mixed-species feeding aggregations of dolphins, large tunas and seabirds in the Azores. *Aquatic Living Resource* 14, 11–18.
- Conover W.J. (1999) *Practical nonparametric statistics*, 3rd edn. Hoboken, NJ: John Wiley and Sons.

- 316 **Coscarella M.A., Dans S.L., Crespo E.A. and Pedraza S.N.** (2003)
 317 Potential impact of dolphin watching unregulated activities in
 318 **Q3** Patagonia. *Journal of Cetacean Research and Management* 77–84.
- 319 **Coscarella M.A., Pedraza S.N. and Crespo E.A.** (2010) Behaviour and
 320 seasonal variation in the relative abundance of Commerson's
 321 dolphin *Cephalorhynchus commersonii* in northern Patagonia,
 322 Argentina. *Journal of Ethology* 28, 463–470.
- 323 **Crespo E.A., Pedraza S.N., Coscarella M., Garcia N.A., Dans S.L.,**
 324 **Iñiguez M., Reyes L.M., Koen Alonso M., Schiavini A.C.M. and**
 325 **González R.** (1997) Distribution of dusky dolphin *Lagenorhynchus*
 326 *obscurus* (Gray, 1828) in the southwestern Atlantic Ocean. *Report of*
 327 *the International Whaling Commission* 47, 693–698.
- 328 **Dans S.L., Crespo E.A., Pedraza S.N., Degrati M. and Garaffo G.V.**
 329 (2008) Dusky dolphins and tourist interaction: effect on diurnal
 330 feeding behaviour. *Marine Ecology Progress Series* 365, 273–285.
- 331 **Dans S.L., Degrati M., Pedraza S.N. and Crespo E.A.** (2012) Effects of
 332 tour boats on dolphin activity examined with sensitivity analysis of
 333 Markov chains. *Conservation Biology* 26, 708–716.
- 334 **Degrati M., Dans S.L., Pedraza S.N., Crespo E.A. and Garaffo G.V.**
 335 (2008) Diurnal behaviour of dusky dolphins, *Lagenorhynchus*
 336 *obscurus*, in Golfo Nuevo. *Journal of Mammalogy* 89(5), 1241–1247.
- 337 **Degrati M., Dans S.L., Garaffo G.V., Cabreira A.G., Castro Machado F.**
 338 **and Crespo E.A.** (2012a) Predator behaviour related to prey distri-
 339 bution: sequential foraging of dusky dolphins. *Marine Mammal*
 340 **Q4** *Science*.
- 341 **Degrati M., Dans S.L., Garaffo G.V. and Crespo E.A.** (2012b) Diving for
 342 food: a switch of foraging strategy for dusky dolphins in Argentina?
 343 *Journal of Ethology* 30(3), 361–367.
- 344 **Dinsmore J.J.** (1973) Foraging success of Cattle Egrets, *Bubulcus ibis*.
 345 *American Midland Naturalist Journal* 89(1), 242–246.
- 346 **Duffy D.S., Duffy D.C. and Wilson R.P.** (1984) Kelp Gull *Larus domin-*
 347 *icanus* catches fish by plunging. *Cormorant* 12, 106.
- 348 **Evans P.G.H.** (1982) Associations between seabirds and cetaceans: a
 349 review. *Mammal Review* 12, 187–206.
- 350 **Fox A.G. and Young R.F.** (2012) Foraging interactions between
 351 wading birds and strand-feeding bottlenose dolphins (*Tursiops*
 352 *truncatus*) in a coastal salt marsh. *Canadian Journal of Zoology* 90,
 353 744–752.
- 354 **Frere E., Quintana F. and Gandini P.** (2005) Cormoranes de la costa
 355 patagónica: estado poblacional, ecología y conservación. *Hornero* 20,
 356 35–52.
- 357 **Gochfeld M. and Burger J.** (1996) Family Sternidae (Terns). In Del Hoyo
 358 J., Elliott A. and Sargatal J. (eds) *Handbook of the birds of the world,*
 359 *Hoatzin to Auks*. Vol. 3. Barcelona: Lynx Edicions, pp. 624–667.
- 360 **Gray J.E.** (1828) *Spicilegium Zoologica; original figures and short systematic*
 361 *descriptions of new and unfigured animals*. London: Treüttel, Würtz
 362 and Co. and W. Wood.
- 363 **Grubb T.C.** (1976) Adaptiveness of foraging in the Cattle Egret. *Wilson*
 364 *Bulletin* 88(1), 145–148.
- 365 **Harrison C.S.** (1979) The association of marine birds and feeding gray
 366 whales. *Condor* 81, 93–95.
- 367 **Harrison C.S. and Seki M.P.** (1987) Trophic relationships among tropical
 368 seabirds at the Hawaiian Islands. In Croxall J.P. (ed) *Seabirds: feeding*
 369 *ecology and role in marine ecosystems*. Cambridge: Cambridge
 370 University Press, pp. 305–326.
- 371 **Hebshi A.J., Duffy D.C. and Hyrenbach K.D.** (2008) Associations
 372 between seabirds and subsurface predators around Oahu, Hawai.
 373 *Aquatic Biology* 4, 89–98.
- 374 **Hoelzel A.R., Dorsey E.M. and Stern S.J.** (1989) The foraging specializ-
 375 ations of individual minke whales. *Animal Behaviour* 38, 786–794.
- 376 **Jaquemet S., Le Corre M. and Weimerskirch H.** (2004) Seabird commu-
 377 nity structure in a coastal tropical environment: importance of natural
 378 factors and fish aggregating devices (FADs). *Marine Ecology Progress*
 379 *Series* 268, 281–292.
- 380 **Leatherwood S. and Reeves R.R.** (1983) *The Sierra Club handbook of*
 381 *Whales and dolphins*. San Francisco, CA: Sierra Club Books.
- 382 **Malacalza V., Bertelotti M. and Poretto T.** (1997) Variación estacional de
 383 la dieta de *Phalacrocorax magellanicus* (Aves: Phalacrocoracidae) en
 384 Punta Loma (Chubut, Argentina). *Neotropica* 43, 35–37.
- 385 **Martin A.R.** (1986) Feeding association between dolphins and shear-
 386 waters around the Azores Islands. *Canadian Journal of Zoology* 64,
 387 1372–1374.
- 388 **Mouzo F.H., Garza M.L., Izquierdo J.F. and Zibecchi R.O.** (1978)
 389 Rasgos de la geología submarina del Golfo Nuevo. *Acta*
 390 *Oceanografica Argentina* 2(1), 69–91.
- 391 **Obst B.S. and Hunt Jr G.L.** (1990) Marine birds feed at gray whale mud
 392 plumes in the Bering Sea. *Auk* 107, 678–688.
- 393 **Pierotti R.** (1988) Associations between marine birds and mammals in the
 394 Northwest Atlantic Ocean. In: Burger J. (ed.) *Seabirds and other*
 395 *marine vertebrates: competition, predation and other interactions*.
 396 New York: Columbia University Press, pp. 31–58.
- 397 **Pitman R.L.** (1993) Seabird associations with marine turtles in the eastern
 398 Pacific ocean. *Colonial Waterbirds* 16(2), 194–201.
- 399 **Pitman R.L. and Balance L.T.** (1992) Parkinson petrel distribution and
 400 foraging ecology in the eastern Pacific: aspects of an exclusive
 401 feeding relationship with dolphins. *Condor* 94, 825–835.
- 402 **Punta G., Yorio P. and Herrera G.** (2003) Temporal patterns in the diet
 403 and food partitioning in imperial cormorants (*Phalacrocorax atriceps*)
 404 and rock shags (*P. Magellanicus*) breeding at Bahía Bustamante,
 405 Argentina. *Wilson Bulletin* 115(3), 307–315.
- 406 **Quintana F., Morelli F. and Benedetti Y.** (2002) Buceo eficiente en aguas
 407 poco profundas: comportamiento de buceo y patrón de alimentación
 408 del Cormorán Cuello Negro *Phalacrocorax Magellanicus*, en dos
 409 colonias de la costa patagónica. *Ecología Austral* 12, 19–28.
- 410 **Quintana F., Wilson R.P. and Yorio P.** (2007) Dive depth and plumage
 411 air in wettable birds: the extraordinary case of the Imperial Cormorant.
 412 *Marine Ecology Progress Series* 334, 299–310.
- 413 **Rowntree V.J., McGuinness P., Marshall K., Payne R., Sironi M. and**
 414 **Seeger J.** (1998) Increased harassment of right whales (*Eubalaena aus-*
 415 *tralis*) by kelp gulls (*Larus dominicanus*) at Peninsula Valdés,
 416 Argentina. *Marine Mammal Science* 14, 99–115.
- 417 **Sapoznikow A. and Quintana F.** (2003) Foraging behaviour and feeding
 418 locations of imperial cormorants and rock shags breeding in sympatry
 419 in Patagonia, Argentina. *Waterbirds* 26, 184–191.
- 420 **Siegel S. and Castellan N.J.** (1995) *Estadística no paramétrica aplicada a*
 421 *la ciencia de la conducta*. 4th edn. México. **Q5**
- 422 **Smolker R.A., Richards A.F., Connor R.C. and Pepper J.W.** (1992) Sex
 423 differences in patterns of association among Indian Ocean bottlenose
 424 dolphins. *Behaviour* 123, 38–69.
- 425 **Stokes D.L. and Boersma P.D.** (1999) Where breeding Magellanic
 426 Penguins *Spheniscus Magellanicus* forage: satellite telemetry results
 427 and their implications for penguin conservation. *Marine Ornithology*
 428 27, 59–65.
- 429 **Thomas P.O.** (1988) Kelp gulls, *Larus dominicanus*, are parasitic on flesh
 430 of the right whale, *Eubalaena australis*. *Ethology* 79, 89–103
- 431 **Vaughn R.L., Würsig B., Shelton D.S., Timm L.L. and Watson L.A.**
 432 (2008) Dusky dolphins influence prey accessibility for seabirds

379 in Admiralty Bay, New Zealand. *Journal of Mammalogy* 89(4),
380 1051–1058.

381 **Vaughn R. L., Degradi M. and McFadden C.J.** (2010) Dusky dolphins
382 foraging in daylight. In: Würsig B. and Würsig M. (eds) *The Dusky*
383 *dolphin. Masters acrobat off different shores*. New York: Academic
384 Press, pp. 115–132.

385 **Wilson R.P., Scolaro J.A., Gerrit P., Laurenti S., Kierspell M., Gallelli**
386 **H. and Upton J.** (1995) Foraging areas of Magellanic penguins
387 *Spheniscus Magellanicus* breeding at San Lorenzo, Argentina,
388 during the incubation period. *Marine Ecology Progress Series* 129, 1–6.
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433
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437
438
439
440
441

and

Würsig B. and Würsig M. (1980) Behaviour and ecology of dusky dol-
phins, *Lagenorhynchus obscurus*, in the South Atlantic. *Fishery*
Bulletin 77, 871–890.

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