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Kelp gulls attack Southern right whales: a conservation concern?

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Abstract Kelp gulls (*Larus dominicanus*) feed on pieces of skin and blubber they rip from Southern right whales' (*Eubalaena australis*) backs in their breeding areas at Península Valdés, Argentina, producing injuries. This behavior has increased since the first record in 1972, and some authors have suggested that constant gull harassment could have a negative effect on right whale population. The main goal of this study is to assess the variables that most affect the gull attacks. We analyzed 5359 whale-watching sightings made during trips from Puerto Pirámides (42°34′S, 64°16′W) along the whale breeding seasons (June–December) 2005 to 2007. The most important factors affecting the attacks include the presence of a mother–calf pair, the time within the season, the distance to the coast and the wind velocity. There is also concern of possible transmission of infectious diseases in the attacks since increasing number of whales with different patterns of skin lesions have been observed.

Introduction

The kelp gull (*Larus dominicanus*) is a generalist and opportunistic seabird that feeds mainly on intertidal invertebrates and fishes (Bertellotti and Yorio 1999; Bertellotti 2002). The population has increased in the Patagonian coastal region during the last 25 years (Yorio et al. 1998; Lisnizer et al. 2011). Even though there is no information about the causes of this population increase, it is likely that exploitation of human feeding sources, especially dumps and fishery discards (Giaccardi et al. 1997; Bertellotti and Yorio 2000; Bertellotti et al. 2001), have played a main role in this increase. At present, kelp gulls are the most abundant birds in many coastal Patagonian localities (Bertellotti and Yorio 2000; Bertellotti et al. 2001; González-Zevallos and Yorio 2006, 2011).

In the coastal waters of Península Valdés, Argentina, kelp gulls attack Southern right whales (*Eubalaena australis*) to feed on pieces of skin and blubber ripped from their backs (Thomas 1988; Rowntree et al. 1998), during the whale breeding season (June to December). This behavior was first reported by Cummings et al. (1972), who pointed out that kelp gulls and brown-hooded gulls (*Larus maculipennis*) were occasionally seen pecking at the back of the whales. A decade later, Thomas (1988) described kelp gulls as parasites of whales in Patagonia. It is not known whether the gulls responsible for the attacks are specialists or whether larger numbers of individuals are involved (Sironi 2004). In addition to the kelp gull population growth, interactions between gulls and whales have also increased (Rowntree et al. 1998). This increase could be due to either growth in both the gull and whale populations and/or a learned behavior in kelp gulls.

In the 1990s, the number of gull attacks increased five times compared with the previous decade, and mother–calf pairs were under stress around 24 % of their daylight hours due to the gull pecking (Rowntree et al. 1998). Today, most whales that utilize the breeding area around Península Valdés present gull-peck-wounds (Bertellotti et al. 2008). The percentage of whales with lesions produced by gulls

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increased from 1 % in 1974 to 68 % in 2000 (Sironi 2004) and 77 % in 2008 (Sironi et al. 2008).

A new concern about these interactions is that kelp gulls could act as vectors in the transmission of pathogens when pecking on whales. For example, some studies in Africa by Curasson and Mornet (1941) and Bugyaki (1959) suggest that red-billed oxpeckers (*Bufhagus erythrorhynchus*) provoked streptothricosis lesions in cattle at the sites where they pecked to remove ticks. These birds feed not only on ungulate parasites, but also on tissue and blood of the cattle (Weeks 2000). Southern right whale adults and calves present skin lesions similar to those founded by Hamilton and Marx (2005) in Northern right whales (some of these compatible with skin diseases), including injuries produced by kelp gull attacks (Bertellotti et al. 2008). Pathogens such as *Klebsiella, Salmonella* and *Shigella* have been identified in kelp gull feces sampled in garbage dumps at Puerto Madryn, Rawson, and Puerto Deseado (all these located in Patagonia, Argentina) (Yorio and Caille 2004).

Recently, government authorities in Chubut province have decided to implement management actions to mitigate gull attacks on whales. These actions include the elimination of attacker gulls in the whale-watching area. It is important to know in detail which variables affect the gull attacks in order to determine how and when it is more convenient to apply a culling action.

This paper presents information on kelp gulls attack on Southern right whales and its spatial and temporal distribution during three consecutive years around Puerto Pirámides, Península Valdés, Argentina, during the whale breeding season. The main goal of this study is to find the variables that most affect the attack behavior of the gulls. Interactions between gulls and whales increased in the last decades, and this study also proposes to determine whether this increase continued in recent years. In addition, we also investigated seasonality patterns in the intensity of the attacks.

Materials and methods

During the 2005, 2006 and 2007 Southern right whale breeding seasons (June to December) at Puerto Pirámides, a total of 1467 whale-watching trips were carried out within the Punta Pirámide Provincial Wildlife Reserve, between Punta Piaggio ($42^{\circ}32'$S, $64^{\circ}21.5'$W) and Punta Alt ($42^{\circ}41'$S, $64^{\circ}15.1'$W), where a small kelp gull colony is also located (Fig. 1). The total kelp gull population of Península Valdés is about 7202 pairs distributed in five colonies. Two of these are the most relevant for this study because of their size or location. The largest colony, located on Islote Notable, has a population of around 4,044 breeding pairs. It is located 25 km from Puerto Pirámides, in Golfo San José (Lisnizer et al. 2011). The other colony, located in Punta Pirámide, has a population of around 481 breeding pairs and is only 2 km from Puerto Pirámides, in Golfo Nuevo (author's unpublished data). The colony located in Punta Pirámide is relevant for this study, considering that there is no other gull aggregation point in the vicinity. However, there are many non-breeder gulls (juvenile and immature stages) spreading along the whale-watching area.

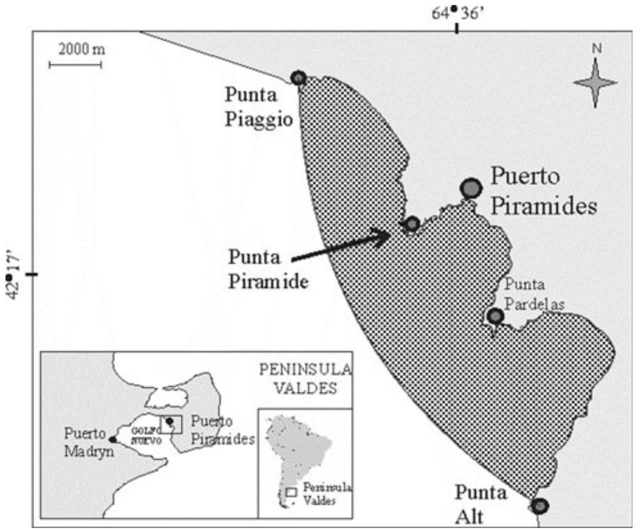

Fig. 1 Study area represented with dots (*shaded*)

The observations (1,072 h) were carried out from fiberglass or inflatable boats 9–17 meters long with one or two outboard engines. The observer used a digital camera (Canon, EOS20D with a 70–300 mm lens) in order to record the age of the attacking gull in cases where naked eye identification was difficult. Most of the trips were carried out by the same observer, but 30 % of them were performed by one or two additional non-trained observers. Trip duration and weather conditions were recorded on each trip.

The boats often stopped to observe a whale or group of whales. A *sighting* was defined as an observation that took place when the boat stopped or remained at least 1 min with one or more whales (*target whales*) located closer than 50 m from the boat. The mean duration of sightings was 12 min ($SD = 9.4$, $N = 5359$). In the three study years, 1,011, 2,304 and 2,044 whale sightings, respectively, were recorded. Sightings were categorized as *presence of mother–calf* (MC $= 1$) when there were one or more pairs of a mother and a calf born in the current season (<1 year old) and *absence of mother–calf* (MC $= 0$) when there were mating groups, solitary animals or any combination of both. Following the methods proposed by Sironi et al. (2008), mother–calf pairs were considered as a unit for the analysis, since mothers never travel very far away from their calves in the nursing area.

For each sighting, we recorded the following: duration (less than one-minute sightings were not included in the analysis because the first approach to a whale did not always result in a sighting); start time, when the boat was approximately 50 m from the target whale (in order to register any change in behavior the boat itself could cause); end time, when the boat reached 50 m from the whale; location (using a GPS Garmin eTrex Legend); wind velocity (measured with a SKYWATCH Xplorer 1 anemometer); number of whales (within 50 m to the boat); presence or absence of whale breaching (when one or more target whales jump at least once); number of associated kelp gulls (considered when floating on the water surface <50 m away from the target whales, or any kelp gull observing target whales while flying in the vicinity, therefore having the opportunity to attack); age of kelp gulls; number of gulls attacking; and number of attacks. Age of the gulls can be determined on the basis of plumage characteristics in three age classes, juvenile (first-year bird), subadult (second- and third-year bird) and adult (Steel and Hockey 1995). In bad weather conditions on board, sometimes it could be difficult to distinguish between different immature stages; then, we classified gulls in only two categories: adult and non-adult (grouping stages juvenile and subadults). Ranges and categories of some variables are described in Table 1. An attack was defined as a gull pecking any part of the whale's body one or more times (they usually land on the back and peck several times). Attack rate (attacks hr^{-1}) was defined as the number of attacks in a single sighting divided by the duration of the sighting in hours.

Two analyses were performed. We first studied the probability of an attack occurrence in a single sighting without taking into account the duration. Second, we studied the intensity of the attacks in each sighting using the attack rate as an indicator.

Table 1 Range or categories of some variables recorded for each sighting

Variables	Range or categories
Wind velocity	0 = no wind
	1 = low velocity wind—from 1 to 8 kn
	2 = moderate velocity wind—from 9 to 15 kn
	3 = strong wind—from 10 to 22 kn
	4 = very strong wind—more than 22 kn
Number of whales	1–16
Number of associated kelp gulls	1–50
Age of kelp gulls	non-adult = 1–3 years old
	adult = 4 or more years old

Presence/absence of attacks and attack rate were analyzed with generalized linear mixed-effect models (GLMMs) and with generalized linear models (GLMs) that are flexible statistical tools that allow for nonlinearity and non-constant variance structure in the data (Hastie and Tibshirani 1990). Therefore, generalized GLMMs were fitted to analyze the presence/absence of an attack (response variable), and then GLMs were used to study the attack rate (response variable). The parameters included in the global models were defined according to hypotheses we wanted to assess. Months 6 (June) and 12 (December) were discarded for both analyses because year 2005 had no data, and the other 2 years had only a few. Sightings without gulls were discarded in both analyses since there was no possibility of an attack (Table 2).

All statistical analyses were performed using R 2.13.0 (R Development Core Team 2011), the editor Tinn-R (Faria 2009), and the libraries lme4 (Bates et al. 2011) and bbmle (Bolker and R Development Core Team 2011) developed for R.

To analyze the presence/absence of an attack in a sighting we fitted a GLMM with a binomial distribution for the response variable and the logit as the link function. The explanatory variables included in the models were presence of a mother–calf pair (MC), month, distance to the coast (Dist.coast—ranging from 0 to 8330 m) and year as the random term (denoted in the models as 1|Year). The attack rate was analyzed with a GLM with a gamma distribution and an inverse link function. The explanatory variables were presence of a mother–calf pair (MC), month, wind velocity (*WV*), year, distance to the coast (Dist.coast), number of whales in the sighting (*N* of whales) and number of associated gulls (*N* of gulls).

Model selection was performed using second order Akaike's information criterion for small sample sizes (AICc, Burnham and Anderson 2002). We also calculated the delta AICc (ΔAIC_i; models with a ΔAIC_i higher than 10 were discarded, according to the Symonds and Moussalli (2011) criterion), the relative weight of each model (w_i)

Table 2 Percentages of sightings with no attack (0), with one to five attacks (1–5), and with more than five attacks (>5) on each study year

N Attacks	% Sightings with attacks		
	Years		
	2005	2006	2007
0	78.34	82.81	81.26
1–5	16.42	14.67	14.77
>5	5.24	2.52	3.96

(Burnham and Anderson 2002) and the number of parameters of each model including the intercept (K).

Model weights can also be used to estimate the relative importance of the variables under consideration. This is done by summing the Akaike weights for each model in those where variables appear. The performance of the models was evaluated by checking for homoscedasticity in plots of deviance residuals against the fitted values.

Results

Considering all sightings ($N = 5359$), gulls were present in 38.6 % of these. However, this proportion significantly varied between months during the whale season. The percentage of sightings with gulls from July to September (47.74 %) was significantly higher than that in October and November (29.95 %) ($G_1 = 267.67$, $P < 0.001$; Fig. 2).

During the three-year monitoring of whales gull attacks, the percentage of sightings with attacks was slightly different ($X_2^2 = 9.3$, $P = 0.01$), and most of those sightings did not surpass five attacks (Table 2). Even though <42 % of the sightings had at least one associated gull (Table 3), around half of those involved attacks (18.5 % of the total number of sightings). What is more, in 66 % of the sightings with attacks and more than one associated gull ($N = 586$), only a single gull was responsible for the attacks (Table 3). During the 2006 and 2007 seasons, we classified the aggressor age class ($N = 1048$), finding that the percentage of attacks performed by non-adult gulls differed between years (3.7 % in 2006 and 16.9 % in 2007). The proportion of non-adult attackers was significantly different between years (chi-square test, $G_1 = 52.27$, $P < 0.001$; Table 3).

The gulls also feed on pieces of skin and ectoparasitic cyamids that whales release when they jump. We found that the average number of gulls in sightings with whale breaching was significantly higher ($X \pm SD = 6.25 \pm 7.59$, $N = 658$) than that without ($X \pm SD = 0.83 \pm 2.94$, $N = 4701$) (Z-Kolmogorov–Smirnov = 12.72, $P < 0.001$). Attacks occurred in 39.65 % of the sightings where a jump and at least a gull were present. In 78.6 % of the sightings where a jump occurred there was at least one associated gull, while this percentage was only 32.6 % in sightings were a jump did not occur.

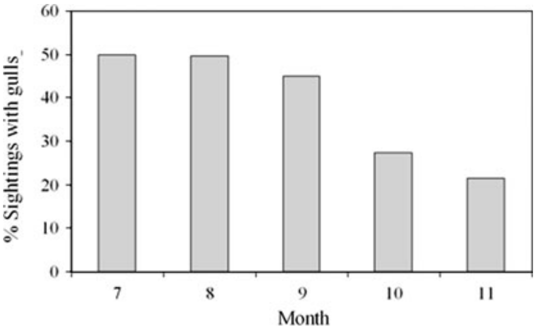

Fig. 2 Proportion of sightings with gulls along the whale breeding season

Table 3 Summary of some data collected on the three study years

	Years		
	2005	2006	2007
% Sightings with at least one associated gull	36.20	35.85	42.07
% Sightings with only one attacker of sightings with attacks and more than one associated gull	ND	66.67	65.18
% Non-adult gulls of the total attackers	ND	3.73	16.88

ND No data

Attacks were observed in 21.9 % of the total number of sightings comprising mother–calf pairs ($N = 3270$) and 13.5 % of sightings of mating groups, other groups or solitary animals ($N = 2089$). Kelp gulls did not attack all categories of whales uniformly; they directed attacks significantly more frequently than expected by chance on mother–calf pairs (chi-square test, $X_1^2 = 59.8$, $P < 0.001$). On the other hand, the frequency of sightings with attacks was not homogeneous throughout the season, analyzing the 3 years together (chi-square test, $X_6^2 = 115.3$, $P < 0.001$) or separately (chi-square test, 2005: $X_5^2 = 11.1$, $P < 0.05$; 2006: $X_6^2 = 99.6$, $P < 0.001$, and 2007: $X_6^2 = 34.2$, $P < 0.001$). The percentage of sighting with attacks from July to September ranged from 21 and 26 %, while from October to November these percentages ranged from 4 to 15 %, considering each year separately. Finally, Fig. 3 shows that most sightings taking place farther from the coast did not involve attacks.

Considering only the sightings with attacks, attack rate did not vary between years (Kruskal–Wallis test, $X_2^2 = 2.315$, $P = 0.314$) with a median of 12 attacks h^{-1} (range = 5.45–30, $N = 998$). Sightings with mother–calf pairs had higher attack rates than the other groups (median = 15 attacks hr^{-1}, range = 1.25–390, $N = 718$, and median = 7.50 attacks hr^{-1}, range = 1.03–120, $N = 280$, respectively; Mann–Whitney U test, $U = 67330$, $N_1 = 718$, $N_2 = 282$, $P < 0.001$). Within the season (from July to November), there were significant differences in attack rates between months (Kruskal–Wallis test, $X_4^2 = 38.549$, $P < 0.001$) with higher attack rates in August and September (the only significant differences were observed when comparing months 8 with 10, 8 with 11, and 9 with 11; T3-Dunnet, $P = 0.014$, $P < 0.001$ and $P < 0.001$ respectively; Fig. 4). Finally, the attack rate varied with wind velocity (Kruskal–Wallis test, $X_4^2 = 19.2$, $P = 0.001$; T3-Dunnet, $P = 0.007$ only comparing WV = 0 with WV = 2; Fig. 5).

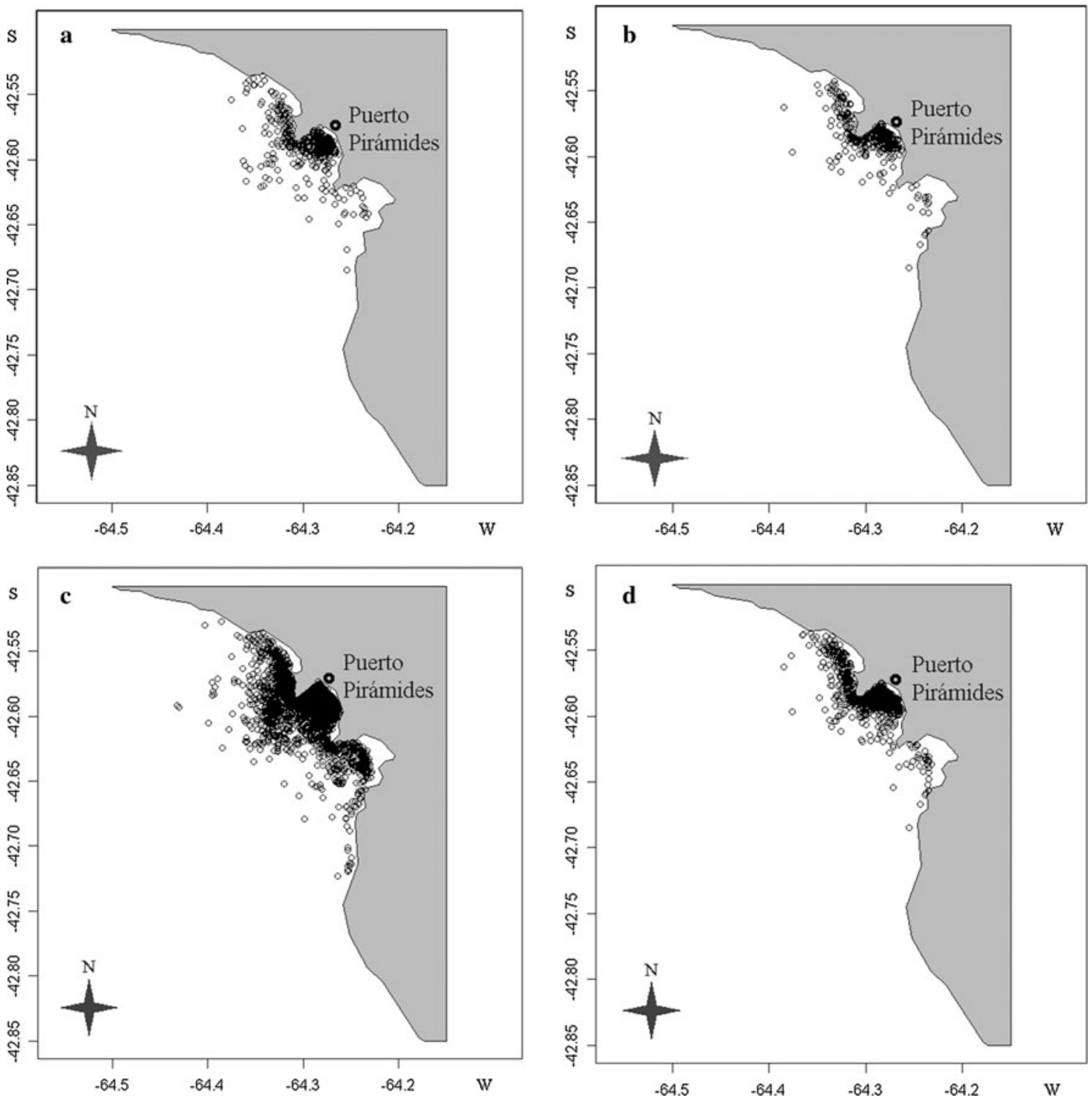

Fig. 3 Black circles represent sightings from months 6 to 11 of the years 2005, 2006 and 2007, together **a** without attacks and with at least one gull associated, **b** with attacks provoked by a single gull, **c** without attacks and **d** with attack

Presence/absence of attacks

Table 4 shows the results of model selection by Akaike information criterion (AIC) ($N = 1910$; sightings without gulls were discarded). The best model had a w_i of 0.892, which can be interpreted as there is 89.2 % chance that it really is the best approximating model describing the data given the candidate set of models considered. In this case and according to the Akaike's weight, "MC" and "Month" have the same relative importance, but following the procedures proposed by Grueber et al. (2011), the most important variable in the model was "MC."

The selected model was

$$\text{Attack\_0-1} \sim \text{MC} + \text{Month} + \text{Dist.coast} + (1|\text{Year})$$

Table 5 shows the estimated coefficients of the parameters of the selected model.

A posteriori analysis of the variable month did not show any clear monthly pattern in the occurrence of attacks.

Attack rate

Table 6 shows the results of model selection by Akaike information criterion (AIC) ($N = 932$; sightings with no

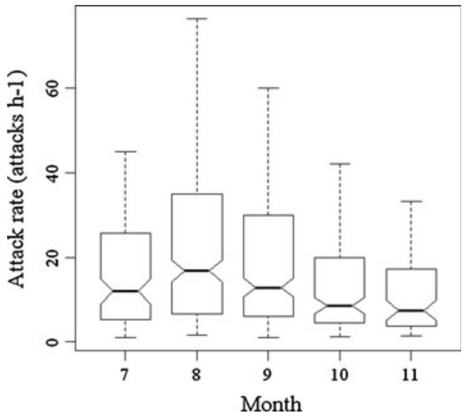

Fig. 4 Distribution of attack rate per month during 2005, 2006 and 2007 whales' breeding seasons together. Months 6–12 were not included because they have few data. The *dark horizontal line* in the *box* provides the median; the lower and upper lines in the *box* represent the first and third quartile, respectively, and whiskers are minimum and maximum of the data set. Notches indicate 95 % confidence interval about each median

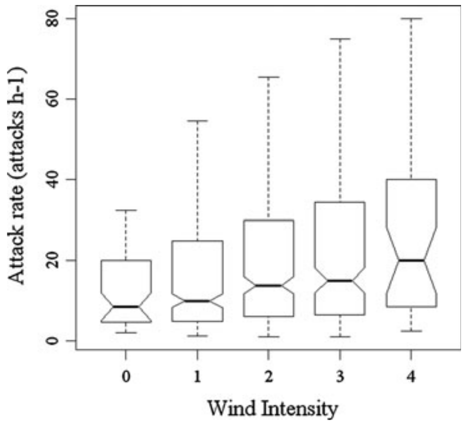

Fig. 5 Distribution of attack rate according to wind velocity during 2005, 2006 and 2007 whales' breeding seasons together. The *dark horizontal line* in the *box* provides the median; the lower and upper lines in the *box* represent the first and third quartile, respectively, and whiskers are minimum and maximum of the data set. Notches indicate 95 % confidence interval about each median

attacks were discarded). The best model had a w_i of 0.356, which can be interpreted as there is 35.6 % chance that it really is the best approximating model describing the data given the candidate set of models considered. With this relatively low weight, we cannot be confident that this model is the best. Thus, we can say that model selection uncertainty exists. According to Akaike's criterion, four models could be proposed as candidate models (Table 6), but we selected the one with the highest w_i. Thus, the selected model was:

$$\text{Attack rate} \sim MC + \text{Month} + WV$$

where "MC" and "Month" had the same relative importance according to Akaike's weights of the models.

Table 7 shows the estimated coefficients of the parameters of the selected model.

A posteriori analysis of the variable month (Table 8) and Fig. 3 showed that there were higher attack rates in months 7, 8 and 9 than in the other months (10 and 11). A posteriori analysis of the variable *WV* (Table 9) and Fig. 4 showed that when there was no wind (WI0), attack rates were lower.

Discussion

There are many factors that could influence the presence or absence of a gull associated to a whale in a particular sighting, but certainly the major reason is the month. From July to September, gulls are able to fly long distances to find food, but in October, adult gulls remain nearer the colony since first nests begin (Bertellotti and Yorio 1999). Then, in October and November, we had fewer sightings with an associated gull.

Only a single gull was responsible for the attacks in most of the sightings with attacks and more than one associated gull. This result suggests that not all the gulls may have developed and specialized in this feeding strategy or they are territorial about a whale. The attack frequency has increased since it was first observed (Sironi 2004), and kelp gulls population of Northern Chubut, which includes colonies near our study area, remained stable since the 1990s (Lisnizer et al. 2011). These two facts could indicate that the attack behavior may be spreading among the gull population. Another finding supporting this idea is that even though the major proportion of the attacks were carried out by adult gulls, non-adult gulls were also protagonists of some attacks. What is more, recently we observed groups of non-adult gulls (up to eight) jointly attacking mother–calf whale pairs, aggravating the attack effects and its spreading.

When whales jump from the water, small pieces of skin and cyamids are often released, attracting a great number of gulls that feed on them. We observed that in most of the sightings where a jump occurred, there were associated gulls, and about 40 % of those sightings involved an attack, which was double the general probability of attack. Kelp gulls are also scavengers that feed actively on dead animals, such as birds or fishes, and also stranded or floating whales. Thus, eating live whales' skin could have spontaneously emerged in some gulls as another feeding strategy. An interesting point is the well-known imitation behavior of birds (Beck 1982; Palameta and Lefebvre 1985; Bugnyar and Kotrschal 2002) that might have contributed to the spread of attack behavior. The parasitic behavior of kelp gulls on whales (Sironi 2004) has not been observed in any other location, with the exception of two isolated instances recorded off the coast of Brazil (Groch 2001).

Table 4 Model selection to explain the presence/absence of gull attacks in relation to the presence of mother–calf pairs, month, distance to the coast and year

Candidate model	AICc	ΔAIC_i	b_i	K	w_i	LogLik
MC + Month + Dist.coast + (1|Year)	2498.69	0.000	1.000	8	0.892	−1241.307
(1|Year)	2638.929	140.239	0.000	2	0.000	−1317.461

AIC Akaike information criterion, *ΔAIC_i* difference between the AIC value of the best model and the AIC value for each of the other models, *K* number of fitted parameters, including the intercept, in the model, w_i Akaike weight, and *LogLik* log-likelihood

Table 5 Estimated coefficients, standard errors (SE) and confidence intervals (95 %) for presence–absence of attacks with a binomial model

Parameter	Coefficient	SE	Confidence intervals
Intercept	−2.12E−01	1.55E−01	1.16E−05; −4.23E−01
MC1	1.19E + 00	1.15E−01	−6.60E−05; 2.38E + 00
Month8	−1.66E−01	1.57E−01	−7.05E−05; −3.31E−01
Month9	−4.01E−01	1.67E−01	−1.15E−04; −8.02E−01
Month10	−3.67E−01	1.91E−01	6.80E−06; −7.34E−01
Month11	−6.24E−01	2.20E−01	−2.74E−05; −1.25E + 00
Dist.coast	−2.90E−04	7.92E−05	3.54E−08; −5.80E−04

Variance and standard deviation values of random variable Year were 0.004 and 0.065, respectively

MC1 mother–calf pair presence

Table 6 Evaluation of alternative models to explain the attack rate by Akaike's criterion

Candidate models	AICc	ΔAIC_i	b_i	K	w_i	LogLik
MC + Month + WV + Dist.coast + N of gulls + N of whales	7449.203	1.437	0.487	13	0.173	−3710.373
MC + Month + WV + Dist.coast + N of gulls	7449.368	1.602	0.449	12	0.160	−3711.486
MC + Month + WV + Dist.coast	7448.393	0.627	0.731	11	0.260	−3712.027
MC + Month + WV	**7447.766**	**0.000**	**1.000**	**10**	**0.356**	**−3712.740**
Intercept	7609.646	161.880	0.000	1	0.000	−3802.816

The best model is in bold font

AIC Akaike information criterion, *ΔAIC_i* difference between the AIC value of the best model and the AIC value for each of the other models, *K* number of fitted parameters, including the intercept, in the model, w_i Akaike weight, and *LogLik* log-likelihood

Table 7 Estimated coefficients, standard errors (SE) and confidence intervals (95 %) for attack rate with a gamma model

Parameter	Coefficient	SE	Confidence intervals
Intercept	9.90E−02	1.20E−02	−5.63E−06; 1.98E−01
MC1	−4.47E−02	5.79E−03	1.24E−06; −8.95E−02
Month8	1.86E−03	5.15E−03	3.72E−03; 1.13E−06
Month9	8.02E−03	5.47E−03	3.06E−06; 1.60E−02
Month10	2.80E−02	6.97E−03	5.76E−07; 5.60E−02
Month11	4.14E−02	1.03E−02	−1.70E−06; 8.28E−02
WV1	−2.14E−02	1.06E−02	7.27E−07; −4.29E−02
WV2	−2.44E−02	1.06E−02	−4.53E−06; −4.89E−02
WV3	−2.63E−02	1.07E−02	5.91E−06; −5.25E−02
WV4	−3.22E−02	1.18E−02	−1.35E−06; −6.45E−02

MC1 mother–calf pair presence

Table 8 A posteriory contrast of the variable month in GLM with attack rate as the variable response

	Month7	Month8	Month9	Month10	Month11
Month7	–	0.71796 NS	0.14340 NS	6.34e−05***	6.71e−05***
Month8		–	0.00668**	1.47e−07***	5.99e−06***
Month9			–	0.000580***	0.000519***
Month10				–	0.20235 NS
Month11					–

NS no significance

Significance codes: ***0, **0.001

Table 9 A posteriory contrast of the variable *WV* (wind velocity) in GLM with attack rate as the variable response

	WV0	WV1	WV2	WV3	WV4
WV0	–	0.04400*	0.02086*	0.01437*	0.00643**
WV1		–	0.440 NS	0.255 NS	0.098 NS
WV2			–	0.6513 NS	0.2202 NS
WV3				–	0.3571 NS
WV4					–

NS no significance

Significance codes: **0.001, *0.01

During a whale-watching trip, almost 40 % of the sightings had at least one associated gull, but only during approximately 20 % of the sightings, attacks were noted. Therefore, gulls attacked whales only around half of the occasions a gull–whale co-occurred.

Although the percentage of sightings with attacks differed slightly among years, the attacks varied throughout the whale breeding season. The attacks were more frequently directed at mother–calf whale pairs, and most sightings far from the coast did not present attacks even if the sighting had an associated gull.

The probability of an attack in a whale-watching sighting due the co-occurrence of a Southern right whale and a kelp gull strongly depended on the presence of a mother–calf pair. Rough skin texture (Reeb et al. 2007) of calves could make pecking easier. It also depended on the time of the whale breeding season, but without any clear trend as shown in GLMM a posteriori contrasts. However, the percentage of sighting with attacks from July to September was higher than in October to November, considering each year separately. Finally, it depended to some extent on the distance to the coast, since most sightings with attacks took place near the shore.

The attack rate was a very useful measure to assess variations in the intensity of attacks between different situations. There are many variables that could affect this rate, and some of them were analyzed with the GLM. We found no differences in the intensity of the attacks among the three studied years. On the other hand, we found higher attack rates on mother–calf whale pairs in August and September. Lower attack rates were also associated with low wind conditions.

Mother–calf pairs were the whale group structure most affected by gull harassment. Not only the occurrence of an attack but also the intensity of attacks strongly depend on the presence of a mother and her recently born calf in a sighting. Even when mother–calf pairs were considered as a unit for the analysis, recent studies reveal that attack rates on calves were twice that on mothers (author's unpubl data).

Attack rate varied through the season, with maximum values registered from the beginning of the season to the middle of the season (July–September). The highest number of whales was found during September in the area (Crespo et al. 2008). The number of kelp gulls also increases near Punta Pirámide during September (Yorio et al. 2005), when they arrive to the colony to start mating. During this time, gulls have high energetic requirements to start the breeding season in good body condition. Both the increased number of whales and gulls and the energetic requirement of the gulls may explain the high percentage of sightings with attacks and the high attack rate registered during this period, because it is easier for the opportunistic gulls to peck a whale near the colony than find some other food farther.

Attack rate strongly decreased at the end of the whale breeding season (October and November). During this period, not only is the number of whales in the Península lower, but also gulls do not peck whales as much. The latter could be explained by the large number of fish schools (*Engraulis anchoita* and *Odonthestes* sp.) that often arrive at the area in those months, attracting the gulls, many other seabirds and marine mammals (sea lions and dolphins). On the other hand, toward the end of whale season, whales use deeper waters farther from the coast to occasionally feed (even though they are not on the main feeding ground) while gulls stay at the colony incubating the eggs (one member of the couple at a time) or rearing the small chicks.

We observed that strong wind conditions lead gulls to control their movement precisely to quickly land over a whale, peck on it and take off, without expending much energy because they stay soaring over the whale. We also noted that when there was no wind, the gulls stayed floating in the water waiting until the whale appears on the surface and then flap to fly up to the whale to peck it. In this study, we found that attack rates depended on wind velocity and were low during less windy conditions.

For decades, many authors have argued that the attacks could have a negative effect on the whale population (Rowntree et al. 1998; Sironi et al. 2008). There is as yet no conclusive data on the real long-term effect of gull attacks, but the population of whales was increasing about 7 % annually (Cooke et al. 2001); in the last 2 years, the population increasing decelerated down to about 5 % annually in Península Valdés (Crespo pers comm).

During the 2007 season, we observed from boats the presence of injuries and other non-specific lesions in 56 % of the whales ($N = 626$) (Bertellotti et al. 2008), almost twice the observed proportion by Rowntree et al. (1998) in 1990. Those caused by pathogenic agents (Hamilton and Marx 2005, Mouton et al. 2008, Van Bressem et al. 2009) can produce weakness and consequently predispose the animal to gull pecking and, what is more, can be transmitted as infectious diseases from one animal to the another. In addition, kelp gulls often feed at garbage dumps and sewers near cities (Bertellotti et al. 2001) and could carry and transmit pathogens to whales when pecking since injuries go through the blubber, where blood capillaries are. Further studies should be undertaken to determine the potential pathogens in the gull population and if there is a real risk of pathogen transmission to whales.

There is strong public pressure to mitigate the attacks to whales, and there is an important economic component associated with whale-watching. In this new scenario, where not only whales are affected (Sironi et al. 2008) but also a high density of whales and increased gull attack rate occurs, the attack behavior spreading throughout the whole gull population prompted the government authorities to implement a management action. These actions include removing attacking gulls in the vicinity of whales from a boat. These measures seek to reduce the number of gulls attack (direct effect) but also intend to discourage other gulls in the area (indirect effect).

If fishery discards are curtailed and dumps are remedied, gulls could take advantage of the high concentration of whales in the area as an alternative source of food, at least as a first reaction to a food shortage. This study provides baseline data to monitor any change in the attack rate associated with both a fishery discard and dump management strategy or the application of a gull culling plan. Moreover, these results will be needed to determine time and location for any culling project, and afterward, the monitoring of attack rates can address the "specialist gulls" question (if there are just a few individuals presenting this behavior, attack rates should decrease by killing those individuals). Finally, a disease-monitoring program would be of great value to determine whether gull attacks are a threat to the health of Southern right whale population.

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