

# The influence of human disturbance on California sea lions during the breeding season

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## Abstract

California sea lions *Zalophus californianus* occupy 26 islands in the Gulf of California (GoC), Mexico. Although human presence is prohibited on these islands without a government permit, the law is not enforced and tourism to the islands is increasing. Tourists, along with local fishermen, often come ashore to get close to the animals, which may disrupt behaviors critical for reproduction. In this paper, we report the results of an experimental study on the behavioral effects of human disturbance on California sea lions in the GoC. To document effects, we recorded sea lion behavior immediately before and in 10-min intervals for up to an hour after experimental human disturbance. Our results showed few behavioral responses of sea lions to human disturbance. Adult females and juveniles demonstrated immediate responses, but these were not consistent between years, apparent an hour after disturbance, or evident across other age and sex classes. These results suggest that California sea lions may be resilient to human disturbance and a possible flagship species for ecotourism, but further studies of the physiological and population-level effects of human disturbance are needed.

## Introduction

Human disturbance can negatively influence the breeding success (Giese, 1996) and individual and population health of wildlife (Rode *et al.*, 2007). Ecotourism and fisheries (sport, commercial and artisanal) are key sources of disturbance across the islands of the Gulf of California (GoC), Mexico (Tershy, Breese & Croll, 1997; Auriolos-Gamboa, Garcia Rodriguez & Hernandez-Camacho, 2003). The islands are also used by researchers who are likely an additional source of disturbance (Tershy *et al.*, 1997). All islands in the GoC are protected under the Islas del Golfo de California Reserve, prohibiting humans from landing on them without a permit (SEDUE, 1989). However, a lack of enforcement leaves the islands vulnerable to human perturbations (Tershy *et al.*, 1997).

An increase in human activities, such as wildlife viewing and sport fishing, around the islands in the GoC (Tershy *et al.*, 1997; Labrada-Martagon, Auriolos-Gamboa & Martinez-Diaz, 2005) highlights the need for quantitative studies of the effects of human disturbance on species endemic to the islands, such as California sea lions *Zalophus californianus*. Previous research on this topic has focused on behavior (Nowacek *et al.*, 2004), stress hormone levels (Romero & Wikelski, 2002; Walker, Boersma & Wingfield, 2005) and reproductive responses (Giese, 1996). However, independent factors such as habitat type, distance from the disturbance (Nowacek *et al.*, 2004), type of disturbance, behavior of the animal before disturbance (Boren, Gemmill & Barton, 2002) and behavior of the humans during the

study (Cassini, 2001) may also affect how species respond to human disturbance and controlling for these variables is important in understanding the full extent to which human disturbance may influence behavior. Yet, experimental research of this type is difficult on wild mammal populations.

Here, we report the results of an experimental study on how human disturbance affects the behavior of California sea lions in the GoC during the breeding season. By using an experimental design, we were able to control for several of the independent variables that may have confounded findings from other studies of human disturbance. California sea lions were selected for this study because their amphibious and gregarious nature makes them popular with tourists on many islands in the GoC. We designed our study to document the 'recovery time' to baseline behaviors following an experimental disturbance. Recovery was defined as a similar proportion of our sample population engaging in the same behaviors observed before disturbance. Based on observational studies of other marine species (Cassini, 2001; Boren *et al.*, 2002; Cassini, Szteren & Fernandez-Juricic, 2004; Nowacek *et al.*, 2004; Williams, Lusseau & Hammond, 2006), we expected that California sea lions would need up to an hour to recover from terrestrial human disturbance. We also expected an increase in behaviors that are more energetically costly (i.e. active and aggressive behaviors) and a decrease in behaviors that likely enhance individual fitness (i.e. inactive and offspring care). Further, we expected animals on land to move to the water after a disturbance event (Suryan & Harvey, 1999).

California sea lions may be an ideal flagship species for ecotourism, if they show limited or no behavioral responses to human disturbance (Rode *et al.*, 2007). However, if our predictions are correct and sea lions exhibit a clear shift in behavior after disturbance, then further studies investigating the relationship between behavioral responses and population dynamics are necessary to determine if stronger enforcement of existing protection laws is required.

## Materials and methods

California sea lions occur on 26 islands in the GoC (Szteren, Aurioles & Gerber, 2006), 13 of which have breeding colonies. Observations took place at a rookery on Granito Island (29°34'N, 113°32'W) in the Midriff island region of the GoC, Mexico (Fig. 1). Granito was selected because it is more remote and has a lower rate of human disturbance than many other rookeries (L. R. Gerber, unpubl. data); human presence on the island is prohibited (SEDUE, 1989) but not enforced. The two most common types of human disturbance on Granito are artisanal fisheries coming close to shore and inland disturbance from fishermen, tourists and researchers. The lower rate of tourist and fisherman visitations allowed us to assess responses to human disturbance with a population of sea lions that are unlikely to already be habituated to such disturbances.

Our study population was on the west side of the island and consisted of 15–75 animals, depending upon the time of day. We conducted behavioral observations on 9–14 July and 7–10 August in 2006 and 18–23 June and 21–26 July in 2007. One observation was conducted per day for a total of 22 observations. Observations were performed at 09:00 or 15:00 h on alternating days, to work around the schedule of other research taking place on the island and to ensure that sea lions had been undisturbed for at least 8 h before our

experimental human disturbance. Individual animals were not marked, so it is unknown whether the same animals were present at the experimental site every day. However, it is unlikely that sea lions moved between sites on Granito, because they have high site fidelity (Campbell *et al.*, 2008; Robertson *et al.*, 2008).

## Experimental design

Flight-initiation distance, the distance animals flee an approaching predator or other threat, is often used to quantify human disturbance on wildlife (Carney & Sydeman, 1999). It is also used to determine the distances within which human disturbance has the greatest effects (Blumstein *et al.*, 2003). We first determined the farthest distance from the animals in our study at which disturbance occurred and the best method of disturbance based on the topography of the island. We accomplished this by obtaining the average flight distance of a group of California sea lions as approached by a boat from the ocean ( $15.2 \pm 0.1$  m) and a human from land ( $11.0 \pm 0.4$  m). Based upon these findings, a person walked along the shoreline 5–15 m away from the most inland animal for all experimental disturbances. Thus, the person walking was not always able to follow the contour of the shoreline but typically remained within 0–15 m of the water to keep within 5–15 m of the nearest sea lion. The person walked across the study site and back again while waving their arms and talking loudly. One of three researchers was used on a rotational basis to disturb the animals and to simulate variance and unpredictability in tourist activity.

A second person acted as the observer and remained out of sight on a slope above the animals. The observer conducted scan samples of the sea lions before and after the disturbance. The first scan sample was taken immediately



**Figure 1** Location of Granito Island in the Gulf of California, Mexico (Ulloa *et al.*, 2006). The study took place at a rookery site along the west by north-west shore.

**Table 1** Behavioral categories and behavioral definitions assigned for each age/sex class and used to analyze the response of California sea lions to human disturbance.

Category	Behavior	Definition	Age/sex class
Active	Aggression	Open mouth displays and vocalizations from one individual to another without actual physical contact	All <sup>a</sup>
	Fidgeting	Moving around and accommodating their posture, not directional locomotion, but not resting either	Pups
	Fighting	Individuals grabbing, pushing or biting one another	All <sup>a</sup>
	Locomotion	Movement from one place to another (walking, running or swimming)	All
	Playing	Simulating adult behavior such as fighting, or swimming together near shore or splashing	Pups, Juveniles
Inactive	Scratching self	Grooming or scratching self, also if against substrate	All
	Flipper up	Animal in a resting position but with front and/or hind flippers elevated vertically.	All
	Resting	Animal is lying down, both front and hind flippers resting on ground	All
Maternal	Sitting	The animal front flippers are holding upper body, lower body resting on ground	All
	Female-pup call	Female and pup calling for each other	Adult females, Pups, Juveniles
	Nursing	Offspring feeding from female	Adult females, Pups, Juveniles
	Nursing intent	Offspring touching or pushing females with nose trying to get nipples	Adult females, Pups, Juveniles
Territorial	Nuzzling	Nudges, passes snout repeatedly over another, sniffing others, scratching, or females and pups touching noses as in a 'recognition' behavior	Adult females, Pups, Juveniles
	Herding	Being aggressive, vocalizing and pushing or blocking females to prevent them from leaving territory	Adult male
	Patrolling	Delimiting land or water territories; patrolling includes swimming and resting/walking with occasional vocalizing	Adult male
	Peace keeping	Approaching, vocalizing, sniffing or nuzzling females in attempt to minimize aggression between them in his territory	Adult male

<sup>a</sup>Territorial category for adult males.

before disturbance; the observer then signaled for the disturber to walk. The second scan was taken immediately after the researcher had completed the disturbance and moved out of sight from the sea lions. Four more scans (scan three through six) were taken in 10-min increments after scan two, for a total of six scans recorded each day. We were unable to complete all six scans during 2 experimental days because of uncontrolled disturbances (e.g. fishing boat came to shore). In these two instances, we only include data in analysis from scans before the uncontrolled disturbance occurred.

Scan samples were used to document the behavior of each animal when it was first observed (Altmann, 1974). The behavior (Table 1), location (water or land) and sex/age category of each animal at the study site was recorded during each scan. All behaviors were placed into three to five categories for each age class. The categories were inactive, active, maternal, aggression and territorial behaviors (Table 1). Following Le Boeuf *et al.* (1983), we divided the sea lion population into six age/sex categories: pup, juvenile, subadult, adult female, adult male and unknown. Animals were classified as unknown if we were unable to identify the age/sex class.

## Statistical analysis

Sex and age categories that included few individuals were excluded from analysis. Thus, behavioral responses of animals within the unknown category were excluded

( $3.3 \pm 0.4$  animals per scan). Additionally, the behavioral responses of animals within the subadult category were not analyzed because there were none present during most scans and a maximum of two subadults were present at the study site during any scan. We also pooled data between years for juveniles because of small sample sizes per scan ( $1.5 \pm 0.1$  animals per scan).

For all other age/sex categories, we first determined if there were differences in behavior between years by a  $\chi^2$ -test. We pooled all scans within each age/sex category for this analysis. To determine whether sea lions behaved differently pre- and post-disturbance, we next used  $\chi^2$ -tests to compare the number of animals per behavioral category for scan one versus scans two through six.  $\chi^2$ -tests were repeated for each age/sex class independently. Because of large sample sizes, we were able to assess adult females collectively and based on whether they were on land or in the water. We compared the behavioral responses of adult females on land and in water through  $\chi^2$ -tests that compared scan one to scans two through six. Finally, we used  $\chi^2$ -tests, with Bonferroni adjustments, to compare the response of females from our scan two (the scan immediately following our human disturbance episode) of the first day of each field trip to the scan two of the last day of each field trip. This tested for habituation of the sea lions to the presence of researchers.

Human disturbance may also affect sea lion distribution by forcing the animals to leave the site of disturbance. To evaluate the influence of time since disturbance (i.e. scan

number) on the number of sea lions at the site, we used generalized linear models – PROC GENMOD with normal distribution in SAS. We used day and year as repeated measurements, such that there were up to 22 repeated periods. Repeated measures were typed as autoregressive. Autoregressive is appropriate for time-sensitive variables because it assumes measurements that are farther apart have lower correlation. We only evaluated the number of females at each scan for this analysis because of limited sample sizes for other age/sex categories.

## Results

Over both years, we observed an average of 16.9 ( $\pm 1.0$ ) pups, 1.5 ( $\pm 0.1$ ) juveniles, 18.7 ( $\pm 0.7$ ) adult females and 3.3 ( $\pm 0.1$ ) adult males per scan. Each year was analyzed separately for adult males, adult females and pups because although we did not find differences in behaviors after disturbance between years for adult males ( $\chi^2 = 6.94$ ,  $P = 0.10$ ) there were differences in behavior between years for adult females ( $\chi^2 = 31.14$ ,  $P < 0.05$ ) and pups ( $\chi^2 = 180.88$ ,  $P < 0.05$ ). Our  $\chi^2$ -tests revealed few significant differences in behavioral responses of sea lions before and after human disturbance (Table 2). However, a few isolated behavioral responses are worth noting; our  $\chi^2$ -tests showed immediate behavioral differences (between scan one and scan two) for pups in 2007, adult females in 2006 when animals in both land and water were considered and juveniles with both years combined (Table 2). In most cases where an immediate response was observed, the age/sex class fully recovered within 10 min of the disturbance. No immediate responses were seen for both 2006 and 2007 in any age/sex class, and no responses were observed in adult males.

When adult females were analyzed based on location,  $\chi^2$ -tests revealed a difference in behaviors immediately following a disturbance, both for adult females in the water and on land in 2006, but these results were not seen in 2007 (Table 3). Behavioral differences between scan one and later scans (e.g. scan six) were observed for adult females in water in 2007 (Table 3), pups in both years, males in 2007 and juveniles (Table 2).  $\chi^2$ -tests for habituation indicated there was no difference in post-disturbance behavioral responses of adult females between the first and last day of experiments during the first trip in 2006 ( $\chi^2 = 6.153225$ ,  $P < 0.001$ ) and 2007 ( $\chi^2 = 3.938394$ ,  $P < 0.001$ ), but did reveal significant difference in responses of adult females during the second trip in both years (2006:  $\chi^2 = 13.76471$ ,  $P > 0.05$ ; 2007:  $\chi^2 = 14.46979$ ,  $P > 0.05$ ). In addition, our general linear mixed model indicated there was no difference in the number of adult females at the site based on time since human disturbance ( $\chi^2 = 0.04$ , d.f. = 1,  $P = 0.83$ ).

## Discussion

Contrary to our predictions, our results demonstrate that California sea lions exhibit little or inconsistent measurable behavioral responses to isolated episodes of terrestrial human disturbance at rookeries. Although some behavioral

**Table 2**  $\chi^2$ -results and associated  $P$  values for the pre-disturbance scan versus each post-disturbance scan for California sea lions *Zalophus californianus* in different age/sex categories

Year	Age/sex class	Scans	$\chi^2$ value	$P$ value		
2006	Pups	1–2	5.112632	NS		
		1–3	3.5304	NS		
		1–4	4.4262	NS		
		1–5	6.9581	<0.05		
		1–6	1.6157	NS		
		1–6	14.61204	<0.005		
2007	Pups	1–2	6.1012	<0.05		
		1–3	0.171462	NS		
		1–4	7.518641	<0.025		
		1–5	5.630388	NS		
		1–6	49.64094	<0.005		
		1–6	2.7298	NS		
2006	Adult females	1–4	0.301	NS		
		1–5	1.816443	NS		
		1–6	1.3002	NS		
		2007	Adult females	1–2	4.872611	NS
				1–3	6.641928	NS
				1–4	0.251203	NS
1–5	3.41543			NS		
1–6	4.540479			NS		
1–6	4.169915			NS		
2006	Adult males	1–3	2.5641	NS		
		1–4	1.711111	NS		
		1–5	0.6918	NS		
		1–6	0.5495	NS		
		2007	Adult males	1–2	0.157518	NS
				1–3	1.005521	NS
1–4	3.304327			NS		
1–5	2.576328			NS		
1–6	2.154374			NS		
1–6	85.99892			<0.005		
2006/2007	Juveniles	1–3	3.601591	NS		
		1–4	1.439466	NS		
		1–5	4.995587	NS		
		1–6	9.606518	<0.01		

NS, non-significant.

**Table 3**  $\chi^2$ -results and associated  $P$  values for the pre-disturbance scan versus each post-disturbance scan for female sea lions *Zalophus californianus* observed in water or on land

Location	Year	Scans	$\chi^2$ value	$P$ value
Water	2006	1–2	8.23	< 0.05
		1–2	6.01	NS
	2007	1–3	8.39	<0.05
Land	2006	1–2	21.07	< 0.05
		1–2	0.47	NS
	2007	1–3	0.17	NS

NS, non-significant.

changes occurred after an experimental human disturbance episode, most were observed several scan intervals after the disturbance (e.g. adult males in 2007, Table 2), suggesting that these observations reflected normal behavioral

variations over time and were unrelated to the experimental human disturbance events.

While our results suggest that behavior of sea lions is not significantly influenced by human disturbance, the results were inconsistent between years, and adult females, pups, and juveniles may show immediate behavioral responses to human disturbance. It is common for marine mammals to show variable and somewhat unpredictable responses to human disturbance (Boren *et al.*, 2002). Many environmental and physiological factors determine how an animal will respond to a disturbance and may help explain inconsistencies in our results between years (Cassini, 2001; Boren *et al.*, 2002; Nowacek *et al.*, 2004). Common factors that are thought to influence the response of marine mammals to human disturbance include previous exposure to the disturbance, behavior before disturbance, stage in the breeding cycle and the type of approach (Boren *et al.*, 2002; Van Polanen Petel, 2007), as well as differences in weather and food supply (Beale & Monaghan, 2004a). Whereas our experimental approach controlled for many of these factors (i.e. stage in breeding cycle and type of approach), some factors may have occurred between our trips to Granito (i.e. other exposure to human disturbance) and would have been unaccounted for in our analyses.

Inconsistencies across years may have resulted from observation error in classifying all individual sea lion behaviors at the site (i.e. some may be resting and difficult to see). Variability in observer classification can influence results but decreases significantly with training (Stenson & Myers, 1988). Only two different observers recorded data for this study and were provided with the same intensive training, so observer classification is assumed to be consistent. Hidden and hard-to-see animals are not likely to have significantly influenced our results, as observers used spotting scopes and binoculars to count animals and the research site was chosen based on ease of observation (i.e. reduced obstacles).

It is also possible that our disturbance occurred too far from the sea lions to have an effect, although studies on similar species (Boren *et al.*, 2002) and our flight-initiation distance tests suggest we used an appropriate distance. A more likely explanation is that sea lions failed to perceive any threat (Blumstein & Daniel, 2005) or viewed the threat as insignificant. This may be because sea lions on GoC islands lack terrestrial predators and may not perceive humans on land as a threat. Parker *et al.* (2008) noted that female sea lions will change locations if the danger of remaining is perceived to outweigh the benefits. We were unable to determine whether individual animals moved during the day because most study animals were not marked. However, results from the generalized linear mixed model showed a relatively stable number of females present at the site for each day. Because some immediate behavioral responses were observed but a consistent number of animals were present throughout the experiment, it is likely that sea lions were alarmed but not sufficiently threatened by our disturbance to illicit abandonment of the site (Blumstein *et al.*, 2003). Females invest significant energy in maternal care and may avoid unnecessary behavioral responses, such

as movement, while the pups are relatively immobile (Garcia-Aguilar & Auriolos-Gamboa, 2003; Parker *et al.*, 2008).

Indeed, our lack of consistent results between years, a lack of an effect within 10 min of the disturbance event for all age/sex classes, and no evidence that sea lions responded by leaving the study site suggest that California sea lions tolerate small amounts of human disturbance. Although the number of sea lions was small within our study site, the proportion of sea lions observed within each age and sex category was representative of typical age structure for sea lions throughout the GoC (Szteren *et al.*, 2006), suggesting our results may be applicable to other rookery islands. Our results are consistent with field observations of sea lions at non-breeding areas. Male California sea lions off the coast of California are often seen in areas of high human activity, such as on boat docks and piers, and so are likely to adapt easily to human presence. Thus, our results suggest sea lions exhibit behavioral plasticity because they appear to be able to adapt well to human presence (Boydston *et al.*, 2003). Animals that possess behavioral plasticity should be able to cope with and adapt to a wide range of changes to their environment (Rode *et al.*, 2007). In fact, decreased sensitivity to frequent human disturbance has been demonstrated in species showing behavioral plasticity (Griffin *et al.*, 2007). Previous exposure to tourists was the most important factor in influencing how New Zealand fur seals *Arctocephalus forsteri* reacted in a study of human disturbance similar to ours (Boren *et al.*, 2002), and Magellanic penguins *Spheniscus magellanicus* habituated to human disturbance within 5 days (Walker, Dee Boersma & Wingfield, 2006). Habituation will only occur if the same animals are present at the site during repeated disturbances within or across field seasons; a likely scenario for sea lions because of their high site fidelity (Robertson *et al.*, 2008).

By comparing immediate behavioral responses to disturbance within a field trip, we were able to assess whether sea lions were habituating to our experimental disturbance. Because our studies required researchers to be present on the island for more than one week, two to three times each summer (Gerber, 2006), it is possible that the sea lions habituated to humans on land and did not perceive researchers as a threat. Observers were careful to minimize disturbance to the sea lions and did not behave in the same manner as experimental disturbers did, to mimic tourist activity, for this experiment. We found no difference in the immediate behavioral response of female sea lions within a trip during the first trip of each year, whereas responses differed within the second trip of each year. The timing of trips differed slightly across years to make it unlikely that different results were related to temporal factors (i.e. pup development stage). Our results suggest sea lions did not change response within a trip, but rather may habituate to human disturbance in general.

## Conservation implications

Behavior measures allow researchers to quantify the effects of human disturbance on wildlife in a relatively simple way

(Williams *et al.*, 2006). It is important to keep in mind, however, that behavior might not accurately represent the stress levels of the animals (Gill, Norris & Sutherland, 2001; Beale & Monaghan, 2004a,b). For example, animals might be affected by the disturbance, but unable to respond behaviorally due to poor body condition (Beale & Monaghan, 2004a). Thus, further studies should consider subtler, more physiological responses, such as stress hormones (Holmes, Giese & Kriwoken, 2005).

In addition to using caution when interpreting behavioral results to quantify disturbance, one must also note differences between long- and short-term studies. While our results demonstrate that California sea lions do not show strong, short-term behavioral responses to experimental human disturbance, using this information to predict long-term impacts might lead to premature, and possibly erroneous, conclusions that human disturbance has no impact on sea lion population dynamics (Williams *et al.*, 2006). Long-term research is still needed on behavioral and physiological responses before concrete conclusions can be drawn about the effects of human disturbance on California sea lions.

Behavioral plasticity has been proposed as an important criterion for choosing flagship species for ecotourism (Rode *et al.*, 2007). Ecotourism is an important part of conservation, as it has the potential to educate the public and increase awareness about environmental issues and wildlife. However, ecotourism also has the potential to negatively impact wildlife populations when it is not controlled or managed properly (Kruger, 2005). Considering behavioral plasticity in identifying focal organisms for ecotourism may minimize the potentially detrimental effects of human disturbance. Although California sea lions appear to be relatively resilient and thus ideal organisms for ecotourism, we do not recommend decisions regarding sea lions and human interaction based on behavioral experiments alone. Instead, behavioral responses should be viewed as a first step in assessing population risks associated with human presence.

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