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Recommended Citation

Piechota, Connor M.; Watson, Kevin R.; and Fuxa, Ryan J., "Galápagos sea lion behavior differences in relation to human exposure" (2015). *Celebrating Scholarship & Creativity Day*. 58.

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Galápagos Sea Lion Behavior Differences in Relation to Human Exposure

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Abstract

Our study examined the behavioral differences of the Galápagos sea lion (*Zalophus wollebaeki*) in relation to human presence. Our main goal was to determine whether sea lions would be more aggressive as a result of high frequencies of human exposure. We hypothesized that sea lions would behave differently in relation to varying rates of human exposure and we predicted that there would be more aggressive and interactive behaviors on beaches with higher frequencies of human exposure (as the humans may disturb the normal behavioral patterns of the sea lions). Data was collected daily at low tide in two-hour intervals. Our study took place during July 2014 on Isla San Cristóbal on three beaches near Puerto Baquerizo Moreno, Galápagos Islands, Ecuador. We recorded the number of people and sea lions on each beach during each data collection, as well as any observed behavioral characteristics of sea lions. We categorized behavioral characteristics of sea lions as aggressive, interactive but non-aggressive, and non-interactive both on terrestrial and aquatic environments. In addition, we accounted for the frequency of interactions in relation to the size of the beach in which data was collected. Results from a Chi-squared goodness of fit test showed that there was a significant difference in the sea lions' behavior in relation to human exposure ($p < 0.0001$). Further analysis showed that sea lions tend to be more aggressive in response to higher frequencies of human exposure ($p < 0.0001$). Previous studies have shown that high rates of human exposure in sea lion habitats can result in a decrease of sea lion populations (French et al., 2011). With regards to these results, there should be a consideration for how human exposure can affect the behavior of sea lions. Tourism in the Galápagos Islands remains

prevalent, which can potentially disrupt the natural behavior of protected species if humans disrupt the animals' natural behavior.

Introduction

As an endemic species to the Galápagos Islands, the Galápagos sea lion, *Zalophus wollebaeki*, plays an important role in maintaining a balanced marine ecosystem. For instance, Galápagos sea lions help with the exchange of nutrients between marine and terrestrial environments. The surrounding environment, as well as the plant and animal species within that environment, benefit from the nutrients passed on via sea lion waste products (Fariña, 2003). In general, sea lion populations consist of one dominant bull, commonly referred to as the beach master, as well as several adult females, adolescents, and pups. The beach master will lay claim to his territory for two to three weeks at a time and defend or chase off other challenging males that try to invade his territory (Timmerman, 2014). The Galápagos sea lions' diet mainly consist of fish, particularly sardines, but squid and other sea life could potentially be eaten as well. Although the sea lion is predacious, it is not considered to be at the top of the food chain. The Galápagos sea lion is a crucial source of food for other larger marine organisms in the Galápagos area such as sharks and the orca whale.

According to the International Union for Conservation of Nature (IUCN), *Z. wollebaeki* is considered an endangered species with a declining population (The IUCN Red List of Threatened Species, 2014). And, as illustrated by French et al., the exposure to humans can be said to disturb populations of sea lions by decreasing their reproductive and population growth rates as human exposure increases (2011). With this in mind, the impact of a human exposure should be brought into consideration in how it affects the behavior of these marine mammals. The Galápagos Islands, with its unique wildlife and geography, is consistently able to generate high amounts of tourism. The Galápagos National Park declares that no person is to be within two meters of any animal. However, not every person abides by

that rule, which can result in people directly disturbing the behavior of animals. These negative interactions often time include the leaving of waste at a beach, the interrupting of mating rituals, the kicking of sand at the sea lions, and even the throwing of small stones. More often than not these kinds of interactions end with an agitated animal; it is important to note though that negative interactions, like the ones previously stated, can also lead to injury of the sea lion and the human if continued.

Given this information, it could be possible that sea lions behave differently in locations that have different concentrations of humans. This sparked the hypothesis that sea lions will behave differently in relation to the number of people on respective beaches. Through this hypothesis it was then predicted that sea lions' behavior will differ on beaches with a higher number of human visitors than beaches that are visited less frequently by humans.

Methods

The study was conducted on three different beaches in the southwest region of the island of San Cristóbal. The beaches included Playa Mann, which is nearby the Galápagos Academic Institute of Arts and Sciences in Puerto Baquerizo Moreno, Punta Carola, which is approximately 1 km north of Playa Mann, and La Loberia, which is approximately 3.5 km southeast of Playa Mann. The area of the beaches was measured by having an observer walk the length and width of each beach, measuring out the average stride length and multiplying that number with the total number of steps taken for length and width. Data was collected from Saturday, July 12, 2014 to Friday, July 18, 2014. The total number of sea lions (adult and adolescent/pup) and the number of people on the beaches were counted twice a day; once at the beginning of observation, and again at the end of observation. The numbers were then averaged in order to receive a relative number of the sea lions and people on each beach during low tide. The weather conditions for each day were also recorded.

Sea lion behavior was collected for approximately two hours at low tide, both on land and in the water. Specific sea lion behaviors recorded included: basking, scratching, nursing, calling or begging, walking, noticing, growling, barking, and charging. Basking can be described as resting on the beach, sometimes covered in sand in order to maintain optimal body temperatures. A scratching behavior is when a sea lion will rub its snout or fin against another part of its body. Nursing is the act of a pup suckling from an adult female sea lion. Calling or begging is when a sea lion will audibly seek out other sea lions, usually in search for food or nurture. Walking is the act of a sea lion moving or switching positions while remaining on the land. Noticing can be described as a sea lion picking up its head and looking at other sea lions, animals, or humans. Growling is the sound that a sea lion will make if it becomes agitated, usually in response to other sea lions or humans being in too close of a proximity to the sea lion. Barking can be described as short bursts of shouting that a sea lion (usually a dominant male) will make if its territory is invaded, or if they are trying to establish dominance. A charge is the act of a sea lion running towards or chasing off other sea lions or humans, typically in a defensive or aggressive manner. In the water, behavior includes thermoregulation, playing, mating rituals, approaching, exhaling, pecking, and slamming. Thermoregulation can be described as sea lions lying still in the water with a flipper held above the surface with the purpose of maintaining optimal body temperatures. Playing is the act of sea lions swimming around each other as well as other marine life (sea turtles, fish, etc...). Mating rituals are when two sea lions circle around each other in the water in addition to occasionally grasping each other with their flippers. Approaching is the act of a sea lion coming up to a human being in the water. Exhaling is when a sea lion will blow out bubbles in the direction of other sea lions or people. Pecking can be described as a sea lion snapping its face in the direction of people or other sea lions in an aggressive/non-playful manner. Slamming is the act of a sea lion throwing the force of its body into a human being. The behaviors were then sub-divided into categories ranging from non-aggressive to aggressive behavior. The non-aggressive, non-human related

behaviors included the land behaviors of basking, scratching, nursing, calling, and walking, with inclusion of thermoregulation, playing, and mating rituals as the water behaviors. Interactive and non-aggressive behaviors included noticing on the land and approaching and exhaling in the water. Aggressive behaviors were those that were directed towards humans, including growling, barking, and charging on the land, and pecking and slamming in the water. The behaviors were recorded with consideration of the number of people and their proximity to the sea lions. Changes in sea lion behavior due to a human presence (within 2 meters of a sea lion) were noted.

The differences in sea lion behavior on the different beaches were compared per unit area on each beach (Chi-square Goodness of Fit test for significance). In order to receive an accurate account of the number of behaviors that occurred on each beach, the total number of behaviors was divided by the total area of their respective beaches. That number was then adjusted to accommodate the observation unit, which was one thousand square meters. To receive the expected number of behaviors for each beach, the total number of behaviors on both land and in the water (aggressive, interactive/non-aggressive, and non-human related) were added together and reduced based on what proportion of the total beach area each beach deserved. Then, the differences between the populations of sea lions and the number of people on each beach were also compared with regard to beach area using a Chi-squared test. This was done by dividing the average number of sea lions and humans on a particular beach by the area of each respective beach in square meters. In order to receive an accurate depiction of the number of sea lions and humans, the observation unit was set to one thousand square meters. To receive the expected values of sea lions and humans for each beach, the mean number of sea lions and humans on the three beaches were added together and reduced based on the total area of each beach and what proportion of the total area each beach deserved.

Results

We predicted a significant difference in sea lions' behaviors in relation to the number of people visiting the respective beach. By using a Chi-square goodness of fit test, results suggested that there was a significant difference in the behavior of sea lions in relation to how many people were on the beaches, which supported our hypothesis. There was a significant difference in aggressive behavior ($p < 0.0001$), interactive/non-aggressive behavior ($p < 0.0001$), and for non-human related behavior ($p < 0.0001$, See Table 1.1). There was also a significant difference found with the population size of sea lions in relation to the number of people visiting the respective beaches ($p < 0.0001$, See Table 1.2). These results indicate that there is a significant difference in the number of sea lions in relation to the number of people visiting a respective beach. More specifically, data showed that the beaches with a greater number of human visitors also have a larger number of sea lions for every one thousand square meters.

Table 1.1: Number of Aggressive and Non-aggressive Interactions with Humans on Different Beaches.

Beaches	Observed					
	Number of Aggressive Land Behavior/1000m ²	Number of Aggressive Marine Behavior/1000m ²	Number of Interactive/Non-aggressive Land Behavior/1000m ²	Number of Interactive/Non-aggressive Marine Behavior/1000m ²	Number of Non-human Related Land Behavior/1000m ²	Number of Non-human Related Marine Behavior/1000m ²
Playa Mann	23.10	3.55	19.55	14.22	269.23	19.55
Punta Carola	4.95	0.27	9.07	6.05	213.92	11.82
La Loberia	20.80	3.71	15.60	23.02	176.77	42.33
Total # of Behaviors	48.85	7.54	44.22	43.29	659.91	73.71

Beaches	Expected					
	Number of Aggressive Land Behavior/1000m ²	Number of Aggressive Marine Behavior/1000m ²	Number of Interactive/Non-aggressive Land Behavior/1000m ²	Number of Interactive/Non-aggressive Marine Behavior/1000m ²	Number of Non-human Related Land Behavior/1000m ²	Number of Non-human Related Marine Behavior/1000m ²
Playa Mann	9.00	1.39	8.15	7.98	121.58	13.58
Punta Carola	29.08	4.49	26.33	25.77	392.88	43.88
La Loberia	10.77	1.66	9.75	9.54	145.45	16.25

χ^2 test of significance for aggressive behavior	χ^2 test of significance for interactive/non-aggressive behavior	χ^2 test of significance for non-human related behavior
4.81565E-14	6.94834E-16	1.38959E-73

Table 1.2: Differences in Sea Lion Populations/Human Populations on Different Beaches

Observed			
Beaches	Mean Number of Sea Lions/1000m ²	Mean Number of People/1000m ²	Total Area of Beach (m ²)
Playa Mann	50.65	16.29	1125.45
Punta Carola	29.19	2.80	3636.94
La Loberia	20.05	20.55	1346.42
Total	99.89	39.64	6108.81
Expected			
Beaches	Number of Sea Lions/1000m ²	Number of People/1000m ²	% Distribution of Total Area
Playa Mann	18.40	7.30	0.184233918
Punta Carola	59.47	23.60	0.595359816
La Loberia	22.02	8.74	0.220406266

χ^2 test of significance for number of sea lions and number of people on different beaches per 1000m²
3.08598E-26

Discussion

The results showed there was a significant difference in the behavior of sea lions on different beaches with regards to human exposure. The results indicate that the sea lions become more aggressive when there are many humans on the beaches. Sea lions on Playa Mann seemed to be less interactive with people in the water in a non-aggressive manner, but showed unexpected interactions, aggressive and non-aggressive, on land, as well as showing some unexpected aggressive interactions in the water. However, there was one day during the study in which a human antagonized a male sea lion, and all other male sea lions showed aggression towards humans after that incident. Thus, that negative interaction between a person and a sea lion may have resulted in increased aggression from that sea

lion and others as well. This type of interaction only occurred for that particular day, and male behavior seemed to return to the norm for the remainder of the study. Playa Mann contains a large population of sea lions in as well as a large number of people in relation to the total area of the beach. The beach itself does not cover a very large area, being quite narrower than the other two beaches studied, which could explain why there is a larger proportion of sea lions for every one thousand meters squared (See Fig. 1.1). Playa Mann is the most frequented tourist beach of Puerto Baquerizo Moreno due to its accessibility and sandy approach to the water. This could be why there are so many more interactions than expected between sea lions and human visitors both aggressive and non-aggressive.

On Punta Carola, sea lions tended to be more interactive with people on land in a non-aggressive manner, while behaving as expected non-aggressively in the water. Sea lions on Punta Carola also showed significantly less numbers of aggressive interactions with humans in comparison to the other two beaches studied. This observation could be explained by a significantly fewer number of people on the beach itself. A fewer number of human visitors could also mean that there would be less negative interactions between humans and sea lions, which would explain their relatively non-aggressive behavior. There were slightly less sea lions on Punta Carola for every one thousand square meters than originally expected. Punta Carola was the largest of the beaches studied, being significantly longer than the other two beaches, but was perhaps the least accessible of the three beaches (See Fig. 1.2). During low tide, the shore had many exposed rocks, creating dangerous swimming conditions for humans. This could further explain the limited interactions between humans and sea lions.

The sea lions on La Loberia were significantly more interactive with people in the water in a non-aggressive manner, but were somewhat less interactive with people on land in a non-aggressive manner. However, the sea lions were slightly more aggressive on land and in the water. On La Loberia, there appeared to be slightly less sea lions than expected (relative to size of the beach), along with

significantly more people than expected, which could potentially explain why there were slightly more aggressive interactions between sea lions and humans. La Loberia is approximately three and a half kilometers south of Puerto Baquerizo Moreno, but it is also near a frigate bird nesting area, which is a frequently visited area by tourists. The water on La Loberia is accessible at both low and high tides, containing entry points to the water where there are few rocks present (See Fig. 1.3). This beach is highly visited by tourists and locals due to the clear water and unique marine life, which could potentially explain further why there are significantly more interactions between humans and sea lions on this beach.



Fig. 1.1: Playa Mann



Fig. 1.2: Punta Carola



Fig. 1.3: La Loberia

Limitations of the study include an observer bias due to a possible inconsistency of the recording tendencies between each of the three observers. Another main limitation to the study was the lack of time. This study was performed over the course of a six-day period, which consisted of a two-hour observation period beginning each day at low tide. This relatively short amount of observation time may not have provided an accurate sample of sea lion behavior. The data may also have been skewed from various forms of human error throughout the study. The most common error was likely the miscalculation of the number of sea lions on a given beach, as it was difficult to keep track of which sea lions went into the water and which came to shore throughout the time of observation. There was

another inconsistency on the part of the observer in determining whether a given behavior was aggressive or non-aggressive.

Further research would include collecting data at more than one time period during the day. The best time intervals would be to collect sample data during both high and low tide. Another change would be to collect data over a longer period of time to avoid collecting seasonal behavior biases, such as behaviors that are more likely observed during the mating and breeding seasons. Other improvements would be to branch out to other beaches, which do not share such close proximities with each other. The purpose of that suggestion would be to observe differences in behaviors of sea lions that are more isolated from human contact. It would also be interesting to examine if different beach terrains, such as differing amounts of rocks and the coarseness of the sand, affect the behavior of sea lions, such as the amount of time they spend on land or in the water. Because El Niño or La Niña events can create a trophic cascade in aquatic and terrestrial ecosystems as shown through the research of Barber and Chavez in 1983, it would be interesting to study how the events affect the behavior of an organism of a higher trophic level, such as *Z. wolfebaeki*.

Conclusion

This study concludes that there is a significant difference in sea lion behavior in relation to the number of people on a given beach. There is also evidence that supports the possibility that the population size of sea lions differs in relation to human visitors at respective beaches. However, further research would need to take place in order to solidify the previous statement. From what the research has shown, sea lions may interact with humans more frequently if more people are on the beach, both in a non-aggressive and aggressive manner. Aggressive behavior shown towards humans could perhaps be a sign of sea lions defending their beach or protecting their offspring. Circumstances which involve the aggravation of sea lions from humans can lead to increased aggression from other sea lions within

the same area, as observed on Playa Mann. This sense of awareness and act of defense might suggest that sea lions could behave more aggressively towards humans in the future. However, that hypothesis has not yet been tested, and it would not be ethical to test for further research.

Another interesting finding from the study was the observation that there were more sea lions on beaches that had higher numbers of human visitors. For example, Playa Mann contained a high sea lion density along with a large human density for the given area. A possible explanation for the larger than expected number of sea lions on Playa Mann could be its location near the main port of the town; an area that contains many artisanal fishing vessels. The sea lions may be utilizing the fishing vessels to obtain a source of food with easy accessibility. However, this is only a hypothesis and would need to be further examined in order to find supporting or contradicting evidence.

It is important to reiterate that an increased human exposure is correlated to decreasing reproductive and population growth rates (French et al., 2011). While it may not be evident that the Galápagos sea lion population trends are decreasing, it is important to consider how human disturbance is negatively impacting the survivability of a threatened species. The Galápagos Islands contain many unique and endemic species, of which many are considered threatened or endangered. As the trend of tourism seems to be increasing, there should be a consideration of the conservation of the Galápagos Islands natural habitats.

Appendix

	Total number of Sea Lions on Playa Mann	Number of Adult Sea Lions	Number of Adolescent Sea Lions	Total number of People on Playa Mann	Land Behavior									Marine Behavior						
					1a	1b	1c	1d	1e	1f	1g	1h	1i	2a	2b	2c	2d	2e	2f	2g
Day 1	52	23	29	8	40	6	0	3	4	8	0	0	0	0	4	2	1	0	0	0
Day 2	78	37	41	17	32	10	5	8	0	8	0	3	2	0	2	0	6	0	0	2
Day 3	60	28	32	14	42	0	3	2	4	6	2	4	2	0	4	0	3	0	0	2
Day 4	41	19	22	20	35	4	2	0	0	0	0	1	1	3	2	0	1	0	0	0
Day 5	61	27	34	29	42	6	8	0	0	0	0	3	2	0	2	2	3	0	0	0
Day 6	50	23	27	22	37	0	4	6	0	0	0	4	2	0	1	0	2	0	0	0
Average	57	26.167	30.833	18.333	228	26	22	19	8	22	2	15	9	3	15	4	16	0	0	4

	Total number of Sea Lions on Punta Carola	Number of Adult Sea Lions	Number of Adolescent Sea Lions	Total number of People on Punta Carola	Land Behavior									Marine Behavior						
					1a	1b	1c	1d	1e	1f	1g	1h	1i	2a	2b	2c	2d	2e	2f	2g
Day 1	103	54	49	1	91	10	6	6	5	7	0	1	3	6	0	0	2	0	0	0
Day 2	128	75	53	21	112	11	8	4	23	9	0	1	3	10	0	0	11	0	0	0
Day 3	112	65	47	19	90	7	11	10	17	3	0	1	1	6	0	0	2	0	0	0
Day 4	96	49	47	5	86	9	5	6	13	4	0	2	2	5	0	2	2	0	1	0
Day 5	103	55	48	0	91	6	6	9	11	4	0	1	1	7	0	2	3	0	0	0
Day 6	95	47	48	15	85	11	5	8	16	6	0	1	1	3	0	2	2	0	0	0
Average	106.17	57.5	48.667	10.167	555	54	41	43	85	33	0	7	11	37	0	6	22	0	1	0

	Total number of Sea Lions on La Loberia	Number of Adult Sea Lions	Number of Adolescent Sea Lions	Total number of People on La Loberia	Land Behavior									Marine Behavior						
					1a	1b	1c	1d	1e	1f	1g	1h	1i	2a	2b	2c	2d	2e	2f	2g
Day 1	23	14	9	54	19	8	2	5	7	8	4	3	0	2	5	0	9	2	1	0
Day 2	40	16	24	31	37	6	2	3	8	7	3	4	2	3	4	1	5	0	0	0
Day 3	44	15	29	29	40	2	3	8	7	3	2	1	0	3	4	2	3	0	0	0
Day 4	26	11	15	25	23	4	2	4	3	0	2	2	0	4	3	2	6	0	1	0
Day 5	19	9	10	16	17	3	1	3	4	2	1	2	1	3	4	2	1	0	0	0
Day 6	10	4	6	11	9	2	2	1	3	1	0	0	1	3	8	4	5	0	3	0
Average	27	11.5	15.5	27.667	145	25	12	24	32	21	12	12	4	18	28	11	29	2	5	0

Behavioral Key:

Land (1)	Marine (2)
1a: Basking	2a: Thermoregulating
1b: Scratching	2b: Playing
1c: Nursing	2c: Mating Ritual
1d: Calling	2d: Approach
1e: Walking	2e: Exhale
1f: Noticing	2f: Pecking

1g: Growling	2g: Slamming
1h: Barking	
1i: Charging	
non-human related behavior	
interactive/non-aggressive behavior	
aggressive behavior	

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