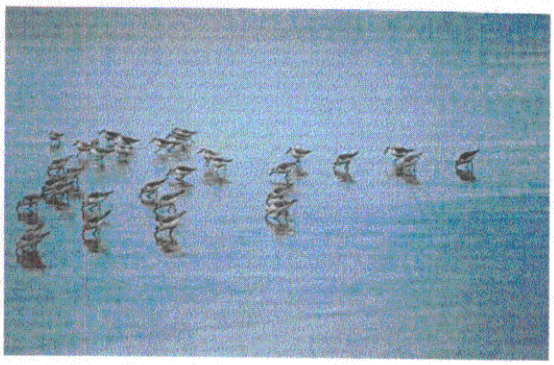
The Effects of Human Activity on the Foraging Behavior of Sanderlings *(Calidris alba)*



A Capstone Project

Presented to the Faculty of Earth Systems Science and Policy

in the

Center for Science, Technology, and Information Resources

at

California State University, Monterey Bay

In Partial Fulfillment of the Requirements for the Degree of

Bachelor of Science

by
Kate Thomas
1 May 2000

Table of Contents

Cover letter:

To ESSP Faculty:

My capstone stemmed from research I was participating in as part of my work on Rikk Kvitek's ECOHAB research grant. We were studying how paralytic shellfish poisoning toxins affect the foraging behavior of shorebirds along the Central California Coast. While observing shorebirds I noticed that their foraging was frequently interrupted by humans using the same beaches.

Because coastal areas are such prime vacation locations and the residency in coastal areas is increasing it is becoming more likely that human/shorebird interactions will continue to increase. If this is true and interference becomes more regular, then are we interfering with the health and well being of these species? This is when I decided to do my project on how human activity affects the foraging behavior of shorebirds. I chose Sanderlings because studies have already been conducted on human/Sanderling interactions on the East Coast and results showed that humans do decrease the foraging time of Sanderlings. However, I intended to take this project a step further by designing a study specifically to collect data needed to make policy recommendations for governing human behavior on beaches.

While designing the project I attended the First Annual Monterey Bay Bird Festival at Elkhorn Slough. I meet numerous people there that have spent many years observing and studying shorebirds both in their nesting habitats and during their migrations. During discussions I had with people at the Festival, I found that certain people believe the shorebird population in Monterey has decreased over the past 20 years or so. From those same discussions I was informed of some beaches that would helped me in my study because of the large Sanderling populations that forage there. From the recommend beaches I found my study sites, Monterey State Beach (Seaside Unit), by the Monterey Beach Hotel, and Moss Landing State Beach.

The California Department of Parks and Recreation was very helpful in helping me find regulations that govern human activity on beaches. I received copies of these regulations from the main office in Seaside. I talked to Dave Dixon about the regulations that currently exist and how strictly they are enforced. I also discussed with him some regulations they are trying to get passed to help the snowy plovers populations recover. Over all he was very helpful in informing me on all aspects of regulations and enforcement that they deal with on a daily bases at the Department of Parks and Regulations.

When designing and conducting this project I had to overcome many problems and biases. One of the major problems, or biases, that I had from the beginning was trying to identify if Sanderling behavioral changes were due to people or because the Sanderling "felt" like doing something different than foraging. While trying to determine the best site for my control beach (little to no people determined the control site), I spent time watching the Sanderlings trying to recognize their behavioral patterns. I realized that when Sanderlings foraged they did run a lot but the movement was usually in the same that they were foraging. Sanderlings rarely flew while they foraging unless responding to another bird taking flight or to humans. Of course there were times when the birds just flew for no reason that I could determine. However, by watching the Sanderlings before I

started the collection of data, I felt like I had more confidence in my ability to determine if the behavioral change was due to humans or not.

The second problem was trying to determine if humans were actually the cause of decreased foraging time and not other factors like tide or prey abundance. For this reason I collected data on weather, tide and prey abundance. The only problem is that my methodology for prey abundance did not work. By my calculations there were no Emerita on the either of the beaches. I tried to make adjustments in my methodology but still no Emerita and I knew they were there because the birds were eating them! Other than the methodology I thought it might be the time that I was collecting. Originally I was waiting for the Sanderlings to stop foraging and then I would try collecting Emerita. So I tried collecting the prey when I first arrived at the beach a half-hour before low tide and then half way through the observation period. Neither of these proved successful. So needless to say I would have starved if I were a Sanderling...

The third problem that I encountered was inquisitive people. I liked the fact that people were interested in what I was doing but it did interfere with my work. I found that when I took the time to explain to people what I was doing, their behavior would change. They would say things like "we will stay away from the birds so that we don't disturb them." This of course is not what I wanted. So I decide if people asked what I was doing while I was actually collecting data, I would tell them I was just interested in birds and documenting the type of birds on the beach. If they were to asked when I was close to be being done I would take the time and explain what I was doing. This was the only thing I could think to do so that people did not alter the way they acted on the beach.

There are a few recommendations I would like to make for people who are interested in duplicating this study and for future work. First, to better this study... There has to be a better way to determine prey abundance, although I couldn't find it. The observation portion of this study was set up well and there are not any recommendations that I can think of at this point.

The changes, or recommendations, I would make come in the minimal approach distance experiments. I would add more activities and different size groups of people. Due to time I could not do this. I would also recommend documenting if the waves were going in or out at the time the Sanderling was disturbed. I noticed that the Sanderlings seemed to fly more when the wave was coming in. My guess would be they felt trapped because they had no place to run. The last recommendation I would make would be to document if the reaction of the Sanderling was due to the reaction of another bird. For example there were times when I was approaching a foraging Sanderling and a flock of Gulls would take to flight. The Sanderlings reacted to the Gull by taking flight as well.

As far as future research, I think it would be important to document Sanderling foraging behavior in other habitats. This project focused on one small area of their foraging habitat. Sanderlings also forage on mud flats, along riverbanks, in marshes, and on other zones of the beach (this project focused just on the foraging events within the swash zone.)

It would also be interesting to determine the Sanderlings energy intake and compare it to their energy expenditure. This would allow us to determine if Sanderlings are able to get the necessary amount of energy so that they are successful in their migration.

I believe that my capstone fulfills all four of the ESSP concentrations. First for the applied science category; I have two different set of methods that were designed to help me answer my questions and propose recommendations for human behavioral modifications. I then collected data through 1999 on two beaches with in Monterey County giving me the experience of conducting my own fieldwork to answer my questions. Second, I have conducted an ANOVA test, multiple regression test, and z test on the data that I collected, giving me an understanding of statistics, how they are applied to data, and that I need more education in this area. The results from these tests gave me the support that I needed in order to propose the policy recommendations to reduce human impact on foraging shorebirds. Third, one of the major outcomes of my project is to look at existing policy and determine what can be done to allow the shorebirds undisturbed foraging while on the beaches. There are three policy recommendations that I have made as a result of my study. Please see *Discussion and Policy Recommendations* in chapter 1 for general recommendations, chapter two gives a more in depth look at existing policy and my proposed recommendations. By writing these recommendations I was better able to understand how science can and is used in policy making. Fourth, I will and have disseminated this information to the public. I presented a poster of my work at the Sanctuary Conference in May in Santa Cruz. I will also be producing a pamphlet that can be handed out to the general public. I talked to Dave Dixon at the Department of Parks and Recreations and he said that they would like to look at the handout, add some information in needed, and then maybe even throw some money at it to make it something people will read and keep for future references.

There are two chapters within the following document. The first is related to the science of the project. It discusses my methods and results from a year's worth of field data collection. The second section focuses primarily on existing policy and my recommendations or human behavioral modification.

Although there were times that I found myself frustrated with this project, it has been an incredible experience. I learned a tremendous amount about what it takes to propose and execute a research project. I believe that the capstone process is an invaluable experience, especially for those that are planning a career as a research scientist. Because of the support I received, it was also a very comfortable environment to have this learning experience and I hope that others can have this type of experience as well.

Sincerely,
Kate Thomas

Abstract:

Urbanization and coastal development has dramatically reduced the beach habitat available for foraging shorebirds worldwide. Additionally, human recreational use of beaches has increased with the rise in coastal population density, which may pose a further threat to migratory and resident shorebird foraging. Here I tested the general hypothesis that recreational uses of shorebird foraging areas by people adversely effect the foraging behavior of Sanderlings *(Calidris alba)*. Observations were conducted during January through May and September through December of 1999 on Moss Landing State Beach and Monterey State Beach (Seaside Unit) in Central California. Each focal Sanderling was observed for one minute while foraging within the swash zone. Observation data recorded included number, activity, and distance of people, day of the week, presence of dogs, and site. Observations showed the number, activity, and the proximity of people significantly reduced the amount of time Sanderlings spent foraging. Although the sample size was low, the most significant negative factor was the presence of free running dogs on the beach. Despite these differences, the experimentally determined minimal approach distance (14 m) did not vary significantly with the type of human activities tested (e.g. running versus walking, singly and in groups). Based on these result, policy recommendations for minimizing the impact of human beach activities on foraging shorebirds are: 1) for people to maintain a minimum distance of 15 meters from all birds, 2) to strictly enforce leash laws for dogs on beaches and 3) to restrict the area available for use of wind powered vehicles on the beaches.

Introduction:

Many shorebirds seen along the California Coast are migratory birds. In fact nearly two-thirds of the species found in North America spend their summers nesting in the Arctic and wintering in Central or South America (Ehrlich et al., 1988). The beaches between the Arctic and South America are used as staging areas by migratory birds. Staging areas are very important in the migration of shorebirds because the birds feed intensively to acquire the fat needed for their long migration (Pfister et al., 1992).

People also use these same beaches for recreational activities. Since shorebird foraging is dependent on accessibility to their foraging sites, as the human population on beaches increase the space for the shorebirds to forage may decrease.

Several studies have demonstrated that human activity on beaches effects shorebird foraging activities. Burger (1993) found that shorebirds devote nearly 70% of their time foraging and 30% of their time watching for people or predators. However, when the population of people increases, shorebirds forage less then 40% of their time while the rest of their time is spent avoiding people. Since shorebird energy intake is reduced and their rate of energy expenditure is increasing in order to avoid humans, they must be finding food somewhere else or at some other time. Vines (1992) reported that Oystercatchers *(Haematopus palliatus)* have been shown to shift their foraging and nesting activities to off shore islands in response to the increase of people on the beaches in Florida. Burger and Gochfeld (1991) found Sanderlings *(Calidris alba)* are concentrating their foraging activities in areas with fewer people.

In this study I was interested in two main questions. Does human beach activity affect the foraging behavior of Sanderlings and do different types of human beach activity affect Sanderlings differently. To answer these questions I tested the hypotheses: that human activity has an adverse affect on the forging behavior of Sanderlings and that humans running will have a greater affect on Sanderling foraging behavior than walking.

I tested these hypotheses in two ways: first, by observing individual Sanderlings for one-minute documenting the time Sanderlings foraged and were disturbed by people. I documented the type of human activity, the number of people, the estimated distance the person was from the bird, and the type of response the Sanderling had to the approacher. Second, I conduced a minimal approach distance experiment to determine the distance a person or group of people could get to a foraging Sanderling before the Sanderling stopped foraging. From this information I hope to verify that humans do have an adverse effect on Sanderling foraging time. I will also propose policy recommendations based on my experimental outcome, regarding human impact on foraging shorebirds.

Methods:

Sites:

This study was conducted on two beaches on Monterey Bay in Central California (Figure 1). Monterey State Beach (Seaside Unit) in Seaside, CA. was chosen because of its large population of people during the week with an increasing human population on the weekend. Moss Landing State Beach in Moss Landing, CA. was chosen because of the low population of people both during the week and on the weekend. Both beaches are long linear habitats that are backed by sand dunes and have a fresh water stream or river running through them. Both beaches are used by Sanderlings as foraging habitats.

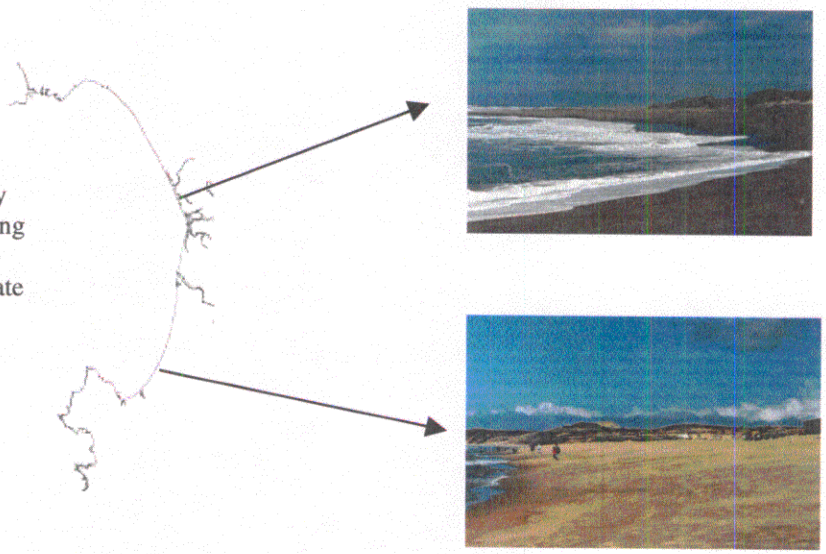


Figure 1: Study sites on Monterey Bay, Moss Landing State Beach (top) and Monterey State Beach (Seaside Unit) (bottom)

Observations:

Observations were made on Monterey State Beach (Seaside Unit) and Moss Landing State Beach January - May and September - December of 1999, corresponding with spring and fall shorebird migration. Observations were conducted on a weekday and weekend day during the same week to avoid tidal variations within a sampling period. Observation periods were three hours long, starting a half-hour before low tide, corresponding with the prime foraging time of Sanderlings.

At the start of each observation period the following data were collected: date, day, time of low tide, level of low tide, number of Sanderlings on the beach, number of people on the beach, and the number and species of other birds on the beach.

Focal Sanderlings were haphazardly chosen. The only criteria for a focal Sanderling were that they were foraging within the swash zone. A one-minute sampling approach was used for each focal Sanderling based on work by Burger and Gochfeld 1991. (Due to differences in hypothesis there were modifications made in the type of data that was collected in this study that differed from the Burger and Gochfeld.) Within that minute the following data were collected:

- The amount of time that the Sanderling foraged,
- The amount of time the Sanderling was disturbed by humans,
- The number of times the Sanderling moved due to disturbance,
- The resulting activity of the Sanderling due to disturbance (running or flying),
- An estimation of the distance the Sanderling moved due to disturbance,
- The number of people causing the disturbance,
- The type of activity that the people were engaged in when disturbance occurred; and
- An estimate of the distance from the person at the time of disturbance.

If the Sanderling flew out of view within the minute it was eliminated from the study. If a Sanderling moved to the upper beach and started foraging on beach wrack, they were also eliminated from the study.

Multiple regression was used to predict which variables would impact Sanderling foraging time. An analysis of variance was used determine if the variables day, beach, number of people, people activity, and distance of people have a significant effect on the foraging time, number of Sanderling moves, the distance the Sanderling moved, and the type of Sanderling movement (flying or running).

Minimal Approach Distance:

A minimal approach distance experiment was conducted to determine how close a person or people can get to a foraging Sanderling before the foraging behavior was changed.

To determine the minimal approach distance a Sanderling was haphazardly chosen from the flock by the first observer. Once a Sanderling was identified a second observer approached the flock without knowing which Sanderling the first observer was watching. When the first observer noticed a change in the foraging behavior of the

Sanderling the second observer was told to stop. The distance from the Sanderlings last position before the foraging behavior changed, to where the second observer stopped, was measured (Figure 2). Communication between the observers and the approachers were conducted via radio headsets to limit the effects of vocalizations on foraging Sanderlings. Two different human activities were tested, walking and running. Both of these activities were conducting with one and two people.

A z test was run to determine if there were significant differences within the minimal approach distances and the percentage of Sanderling reactions.

Figure 2: Measuring the distance from the second observer to where the Sanderling foraging behavior changed

Results:

Observations:

Observations were done to test the following hypotheses: first to determine if human activity has an effect on foraging Sanderlings and second to see if there is a difference between foraging behavior on crowded weekends versus weekdays when there are generally few people.

A total of 492 focal birds were observed between January - May and September - December of 1999, of which 6.7% were observed to have responded to passing humans (Appendix Table 1). Sanderlings responded to human activity by either running or flying. The percentage of the birds responding to approaching humans by running was 42% whereas 58% flew. There were times when the focal bird moved more than once within the one-minute sampling time, although the majority of time the focal individuals moved only once due to human disturbance (n = 19).

Five different human activities were observed on the two beaches, although not all activities occurred on both beaches. Walking was the most common human activity (53%), followed by running (28%) and stationary activities (9%) (Appendix Table 2). Stationary activities include fishing, kite flying, and standing looking at the ocean. On two separate occasions a person was observed throwing an object at a flock of Sanderlings, and on one occasion a wind powered 3-wheeled vehicle was observed interfering with Sanderling foraging. Shorebirds were rarely present whenever these high-speed, wind powered vehicles were observed at Monterey State Beach (Seaside Unit). The estimated average distance that the focal Sanderling moved due to human disturbance was approximately 4 meters.

Overall Sanderlings spent 98% of the time foraging and 2 % of their time avoiding human interaction (Appendix Table 3). However, when looking at Moss Landing State Beach and Monterey State Beach (Seaside Unit) separately, it was found that Sanderlings spent more time foraging when there were less people. On Moss Landing State Beach Sanderlings foraged 99.8 % of the time while avoiding people 0.2% of the time. On Monterey State Beach (Seaside Unit) Sanderlings foraged 96.4% percent of the time and avoided people 3.6% of the time.

An ANOVA was performed on the following dependent variables: Sanderling foraging time, the number of time the Sanderlings moved, The distance the Sanderling moved, and the Sanderlings response activity. The independent variables in the models were: the day of the week (weekend or weekday), the beach, the number of people, the distance the people are away from the Sanderling, the type of activity that people are engaged in while approaching the Sanderling, and the interaction between beach and day.

Results indicate that the number of people, the type of human activity and the distance that people are away from the Sanderling had an effect on the foraging time of Sanderlings. The same variables also had significant effects on the distance that the Sanderling moved, the number of times that the Sanderling moved, and how the Sanderling responded (running or flying) to the approaching human (Table 4). The day of the week and the combination of site and day showed no significant difference on the foraging time of Sanderlings.

Table 4: Results from ANOVA, p values of human disturbance without dogs on Sanderling behaviors

	Foraging	**Number of Moves**	**Distance moved**	**Sanderling movement**
Beach	0.877	0.811	0.797	0.923
Day	0.823	0.683	0.502	0.330
Activity of people	<<< 0.0001	<<< 0.0001	<<< 0.0001	<<< 0.0001
Distance of people	<<< 0.0001	<<< 0.0001	<<< 0.0001	<<< 0.0001
Number of people	<<< 0.0001	<<< 0.0001	<<< 0.0001	<<< 0.0001
Beach/Day	0.923	0.536	0.367	0.362

When the presence of dogs and the interactions between dogs and number of people were added to the model, the number of people no longer had a significant effect on any of the dependent variables. However, the interaction between the number of people and the presence of dogs did significantly effect the amount of time that the Sanderlings foraged. Results showed that the type of human activity, the distance that people are from the Sanderling, and the combination of the number of people and dogs did significantly effect the foraging behavior of Sanderlings. The number of times the Sanderling moved was significantly effected by the number of people and the type of human activity that occurred while approaching the Sanderlings. The type of human activity, the distance of the person from the Sanderling and the combination of dogs and people significantly effected the distance that the Sanderling moved and the type of activity that the Sanderling responded with (Table 5).

Table 5: Results from ANOVA, p values of human disturbance with dogs on Sanderling behaviors

	Foraging	Number of Moves	Distance moved	Sanderling movement
Beach	0.888	0.802	0.767	0.939
Day	0.741	0.657	0.387	0.222
Activity of people	<<< 0.0001	<<< 0.0001	<<< 0.0001	<<< 0.0001
Distance of people	<<< 0.0001	<<< 0.0001	<<< 0.0001	<<< 0.0001
Number of people	0.728	0.415	0.778	0.849
Beach/Day	0.827	0.507	0.258	0.238
Dogs	0.824	0.202	0.698	0.458
Dogs/People	.014	0.417	<<< 0.0001	<<< 0.0001

Minimal Approach Distance:

Minimal approached distance was used to test the hypothesis that different human activities will have different effects on Sanderling foraging. The two different human activities tested were running and walking. This was performed with a single person and in a group of two. Sanderlings responded to the approacher by either running or flying. Two people running caused more Sanderlings to fly at 40% while one person running made more birds fly at 80%. Figure 3 shows the percentages of times the Sanderling responded by either running or flying to an approacher. A z test showed that there were no significant differences between these Sanderling responses.

Although there are differences in the percentages of the number of birds that flew and ran from the "approacher", there is not much difference between the minimal approach distances. Two people walking had the minimum distance to make the Sanderling fly at approximately 11 meters and run at approximately 9 meters. Figure 4 shows the average minimal distances from humans to a foraging Sanderling before the bird's behavior changed. There were no significant differences between these distances based on the results of a z test.

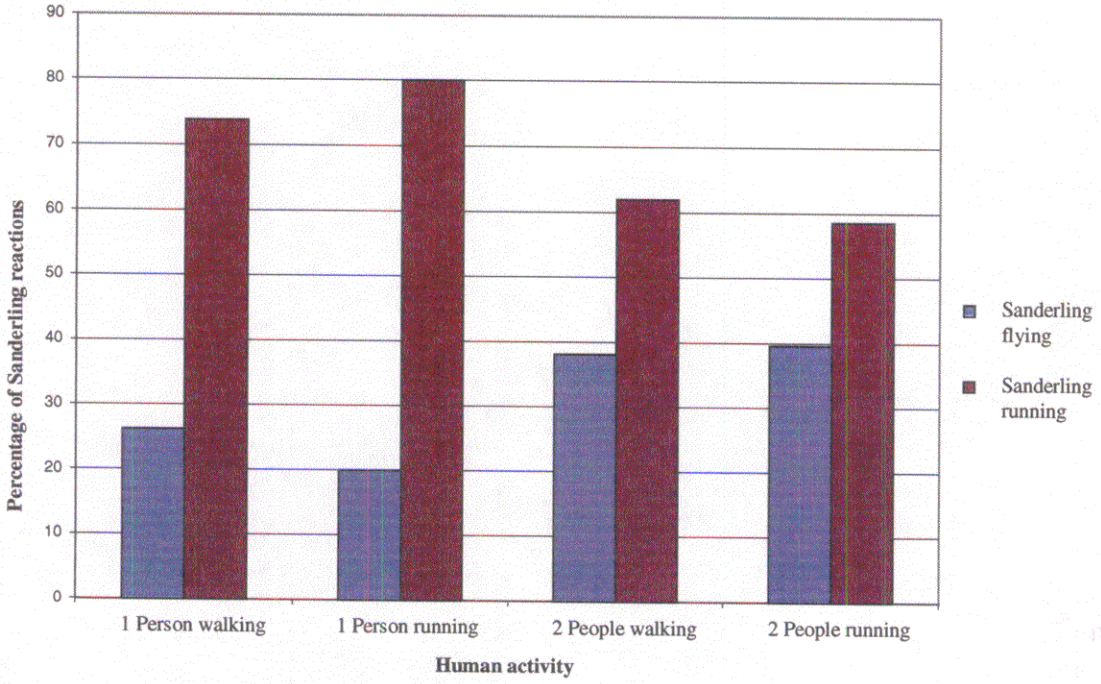


Figure 3: Percentage of Sanderlings responses to human activity

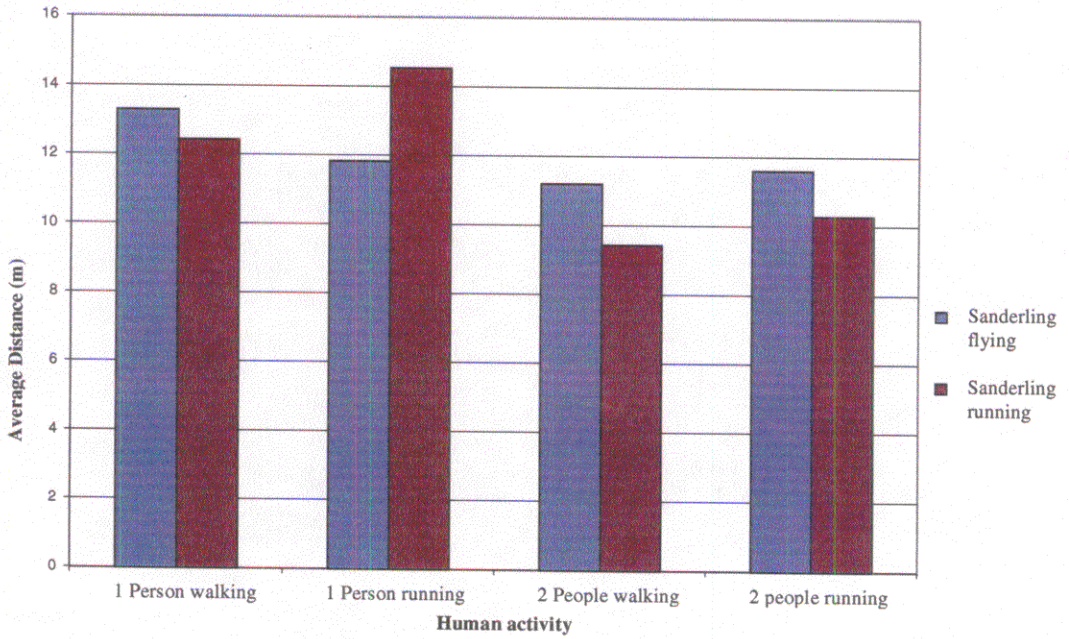


Figure 4: Average distances of Sanderling movement VS. Human activity

Discussion and Policy Recommendations:

Results indicate that the number of people, the type of activity and proximity to a foraging Sanderling can significantly reduce the time that Sanderlings spend foraging. These three variables also had a significant effect on the distances Sanderlings moved and the type of response that the Sanderling had to the approaching humans. On Moss Landing State Beach Sanderlings spent 99.8% of their time foraging, virtually undisturbed by people. However, on Monterey State Beach (Seaside Unit) where the population of people increased Sanderling foraging time decreased to 96.4%. Burger and Gochfeld (1991) found that the number of people significantly contributed to the variation of time that Sanderlings spent foraging over a four year span, and Sanderlings were spending more time running or flying from human intruders.

Interestingly, the average minimum approach distance was statistically the same (14.5m) for each of the tested activities, regardless of the number of people or their speed of approach. Although there were only a few observed dogs on the beach, their presence statistically outweighed that of the number of people considered in terms of foraging disturbance.

These results strongly suggest that the impact of humans and their pets on shorebird foraging, although considerable, can be profoundly reduced by implementing three simple policies governing human beach behavior. First, based on the minimal approach distance experiments, people should be encouraged to stay at least 15 m away from all shorebirds. Second, leash laws for dogs should be strictly enforced at major bird foraging sites. Although there are leash laws at both study sites, most people still let their dogs run free. Every dog observed off the leash went straight to where the shorebirds were and chased them away.

Third, the fact that there were virtually no shorebirds observed on the beach when wind-powered vehicles were present strongly suggests that birds are entirely excluded by this activity. The speed that these vehicles are able to travel allows them to cover a large distance of beach in a very short period of time. As a result of this observation a further recommendation might be that these vehicles are restricted to a certain portion of the beach and prohibited during the peak of the migration season.

It has been determined that populations of certain shorebirds have been decreasing since 1972. Sanderlings, Whimbrels, and Dowitcher species have all shown this decline in population (Howe et al. 1989) with the Snowy Plover making it on the endangered species list. So these three species, as well as other shorebirds, do not follow the same fate as the Snowy Plover we must closely examine our behaviors and modify them to allow shorebirds the appropriate space to forage. The above policies encouraging modest changes to human beach behavior would enable people to enjoy most of their favorite beach activities while allowing shorebirds to spend more time foraging and less time avoiding approaching humans in these habitats so critical to their survival.

Appendix:

Table 1: Observation results, Sanderling behavior and movement caused by human disturbance

	Moss Landing State Beach	Monterey State Beach (Seaside Unit)	Total (Both Beaches)
Number of observations	263	229	492
Number of times a Sanderling moved			
One time	3	16	19
Two times	0	9	9
Three times	0	5	5
Type of Sanderling response			
Run	10%	90%	42%
Fly	14%	86%	58%
Estimated average distance Sanderlings moved (meters)	0.8	8	3

Table 2: Observation results: Type and percentage of times and distance a certain human activity occurred that cause a behavioral change in Sanderlings

	Moss Landing State Beach	Monterey State Beach (Seaside Unit)	Total (Both Beaches)
Type and number of human activity			
Throwing (something) at the birds	100%	0	6%
Walking	6%	94%	53%
Running	0	100%	28%
Standing	0	100%	9%
3 wheeler	0	100%	3%
Dogs present	0	3	3
Estimated Distance of people from Sanderling (meters)	0.15	6.59	3.22

Table 3: Results of observations, Percentage of time Sanderling spends foraging and avoiding humans

	Moss Landing State Beach	Monterey State Beach (Seaside Unit)	Total (Both Beaches)
Average foraging time	99.8 %	96.4 %	98.2 %
Average disturbance time (seconds)	0.2 %	3.6 %	1.8 %

Acknowledgements:

I would like to thank Dr. Rikk Kvitek and Carolyn Bretz for their support and recommendations for this project. Dr. Renee Perry for her statistical advice. I would like to give special thanks to Talitha Manouki, Amanda Green, Genice Jones, and Leslie Matlack for their help in the field. Dr. Rikk Kvitek, Dr. William Head, Dr. Renee Perry, Carolyn Bretz, Zachary Knapp, and Maria Ferdin for reviewing the manuscript and providing many helpful comments and insights.

References:

Burger, J. 1984. Abiotic factors affecting migrant shorebirds, p.173. IN. J. Burger and B. L. Olla [eds.], Shorebirds: migration and foraging behavior. Plenum Press, New York.

Burger, J. 1986. The Effect of Human Activity on the Shorebirds in Two Coastal Bays in Northeast United States. Environmental Conservation 13: 123-130

Burger, J. 1993. Shorebird Squeeze. Natural History 102: 8-12

Burger, J. and M. Gochfeld. 1991. Human Activity Influence and Diurnal and Nocturnal Foraging of Sanderlings (Calidris Alba). The Condor 93: 259-265.

Burger, J. and M. Gochfeld. 1998. Effects of Ecotourism on Bird Behavior as Loxahatchee National Wildlife refuge, Florida. Environmental Conservation 25: 13-21.

De Boer, W.F. and F.A. Longamane. 1996. The Exploitation of Intertidal Food Resources in Inhaca Bay, Mozambique, by Shorebirds and Humans. Biological Conservation 78: 295-303.

Devore, Jay L., 1995. Probability and Statistics for Engineering and the Sciences. P.375 381. Duxbury Press.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1988 The Birder's Handbook A Field Guide to the Natural History of North American Birds. Simon and Schuster Inc. New York, New York.

Howe, M. A., P. H. Geissler, and B. A. Harrington. 1989 Population Trends of North American Shorebirds based on the International Shorebird Survey. Biological Conservation 49: 185-199.

Maron, J.L., and J.P. Myers. 1985. Seasonal Changes in Feeding Success, Activity Patterns, and Weight of Nonbreeding Sanderlings *(Calidris alba)*. The Auk 102: 580-586.

Myers, J.P., P.G. Connors, and F.A. Pitelka. 1979. Territory Size in Wintering Sanderlings: the Effect of Prey Abundance and Intruder Density. The Auk 96: 551-561

Pfister, C., B. A. Harrington, and M. Lavine. 1992. The Impact of Human Disturbance on Shorebirds at a Migration Staging Area. Biological Conservation 60: 115-126.

Roberts, G. and P. R. Evans. 1993. Responses of Foraging Sanderlings to Human Approachers. Behavior 126: 29-43.

Zar, J. H.. 1974. Biostatistical Analysis. P. 130-144, 163-177. Englewood Cliffs, NJ