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Investigation of Non-Lethal Electric Shock on American Crows as a Predator Aversion Treatment for Reducing Depredation on California Least Tern Eggs

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Summer July 2015

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Investigation of Non-Lethal Electric Shock on American Crows as a Predator Aversion Treatment for Reducing Depredation on California Least Tern Eggs

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Table of Contents

Introduction……………………………………………………………………………Page 1
Methods……………………………………………………………………………Page 8
    Study Site…………………………………………………………………………Page 8
    Electrified Egg Design and Construction………………………………………Page 10
    Electrified Egg Deployment……………………………………………………Page 13
    Data Collection from Game Cameras……………………………………………Page 16
    Crow Trapping and Banding……………………………………………………Page 16
    Data Collection from Field Observations………………………………………Page 18
Results……………………………………………………………………………Page 19
    Percentage of Conditioned Crows per Week……………………………………Page 19
    Population Flux……………………………………………………………………Page 20
Discussion…………………………………………………………………………Page 21
    Period of Conditioning……………………………………………………………Page 21
    Population Flux……………………………………………………………………Page 22
    Weekly Predation Rate……………………………………………………………Page 23
    Fledging Success…………………………………………………………………Page 24
Acknowledgements…………………………………………………………………Page 28
References…………………………………………………………………………Page 29
Appendices…………………………………………………………………………Page 33
    Appendix I…………………………………………………………………………Page 33
    Appendix II………………………………………………………………………Page 34

List of Tables and Figures

Table 1: Fledging per pair ratio for all the California least tern colonies in 2013 and 2014……………………………………………………………………………………………………Page 27

Figure 1: California least tern and chick……………………………………………………….....Page 1
Figure 2: Map of all 30 California Least Tern nesting sites in 2013 (Frost 2014)………..Page 2
Figure 3: Christmas Bird Count data measuring American crow population in the Los Angeles area from 1947-2011 (National Audubon Society 2010)……………………...…Page 4
Figure 4: Crow within the tern colony foraging among *Camissonia cheiranthifolia*……..Page 5
Figure 5: Emetic egg deployed for 2013 CTA study at Venice Beach least tern colony...Page 7
Figure 6: Map of the location of the Venice Beach least tern colony………………………...Page 8
Figure 7: Fencing of the Venice Beach least tern colony………..………………………...………Page 9
Figure 8: Habitat composition within the Venice Beach tern colony after expansion of fence in March 2006 (Ryan and Vigallon 2010)…………………………………………………………..Page 10
Figure 9: Painting of the interior of the eggshell with conductive glue……………………..Page 11
Figure 10: Steel plate with a 5-inch hole in the center that was connected to the "ground end" of the fence energizer……………………………………………………………………...……..Page 11
Figure 11: Bolt placed through a hole at the corner of the steel plate with a washer and speaker wire attached. The speaker wire was stripped and wrapped around the bolt with the washer tightened to secure the wires in place……………………………………………….....Page 12
Figure 12: Diagram of the shocking system. A crow is expected to stand on the steel plate buried underneath the sand and peck at the charged egg to receive an electric shock………Page 12
Figure 13: Underside of completed electrified egg. The egg contained an inner painting of conductive glue and was filled with copper mesh and epoxy glue, with speaker wire extending outward……………………………………………………………………………………………...Page 13
Figure 14: Two electrified eggs each connected to the network of speaker wires connecting all the electrified eggs to each other and the shocking unit. The connection of the electrified eggs to the network of speaker wires was soldered and covered with a heat shrink tube………...Page 13
Figure 15: Damaged eggs from sun exposure, crow pecks and glue discoloration…….Page 14
Figure 16: Pair of deployed electrified eggs within a depression in the sand to resemble a tern nest……………………………………………………………………………………………………….Page 15
Figure 17: Steel plates and shocking unit with attached wires, laid on top of the sand prior to burying the items underneath the sand. The game camera fixed on the wooden stake laid on the sand prior to deployment…………………………………………………………………………Page 15
Figure 18: A snapshot taken from the video clips collected by the deployed game cameras of an unconditioned crow pecking at an electrified egg…………………………………...…Page 16
Figure 19: Crows confined in the deployed trap…………………………………………………..Page 17
Figure 20: CDFW employee Thomas Ryan, attached color bands on a crow captured during one of the trapping events…………………………………………………………………………………..Page 17
Figure 21: Banded crow perched on the fence of the tern colony…………………………......Page 18
Figure 22: Observer within the tern colony using a spotting scope to detect whether crows are banded…………………………………………………………………………………………………...Page 19

Figure 23: Percentage of conditioned crows over the 20 weeks of the experiment following a polynomial distribution……………………………………………………………………………...Page 20
Figure 24: Population flux estimate for American crows within the Venice Beach tern colony. The 0 vertical line represents the average population estimate for all the observation period using the Lincoln Index. Each graphed point illustrates the extent to which the Lincoln Index measured for each observation period, differs from the estimated population average……………………………………………………………………………...……..Page 21
Figure 25: Weekly percent predation rate of actual California least tern nests for the 2014 Venice beach nesting colony…………………………………………………………………...………..Page 24
Figure 26: Number of nests and percentage of total eggs lost to predators for the Venice Beach colony from 2002-2014…………………………………………………………………...……..Page 25
Figure 27: Total number of fledglings and fledgling per pair ratio for the Venice beach tern colony from 1977-2014…………………………………………………………………………….....…Page 25

Abstract

The response of American crows (*Corvus brachyrhynchos*) to electrified eggs at the Venice Beach California least tern nesting colony was monitored throughout the 2014 season. Game cameras were deployed beside the artificial nests to record crow behavior towards the electrified eggs. Conditioned crows were defined as crows that were present within <15 feet but >1 foot of the electrified eggs and unconditioned crows were considered crows that were present within 1 foot of the eggs. The number of conditioned crows observed in the video clips significantly differed from a homogenous distribution using a chi-square test ($p<0.001$). The first 5 weeks of the experiment experienced a larger number of unconditioned crows than the remaining weeks of the experiment. A modified approach to the Lincoln index was also used to estimate population flux of crows at the Venice Beach colony. The nesting California least terns at Venice Beach successfully produced fledges when this predator aversion experiment was deployed, after 5 years of no reproductive success and the 2014 fledging per pair ratio was the second highest ratio recorded in 2013 and 2014. Further multi-year research is needed to clarify the efficacy of this management intervention as there may be associated confounding variables.

Introduction

The California least tern (*Sternula antillarum browni*) is a federally endangered species that nests on the beaches of the Pacific Coast ranging from San Francisco, CA to Baja California, Mexico (American Ornithologists' Union 1957; Figure 1). The California least tern winters in presumed to be Central America and breeds in North America between April- September (Akcakaya et al. 2003). The diving birds most commonly prey on northern anchovies (*Engraulis mordax*), topsmelt (*Atherinops affinis*) and jacksmelt (*Atherinopsis californiensis*) but have also been found to prey on deepbody (*Anchoa compressa*) and slough anchovies (*Anchova delicatissima*) less frequently (Atwood and Kelly 1984). Historically the California least tern nested in small, scattered groups on the sandy beaches along the coast, laying 2 eggs per nest and hatching chicks after 3 weeks of incubation (Chambers 1908, Arkcakaya et al. 2003). Both sexes minister to the chick and nest (Arkcakaya et al. 2003).

Figure 1: California least tern and chick.

Development growth along the coast in the first half of the 20th century caused suitable undisturbed nesting sites to disappear, which led to a reduction of nesting pairs (Chambers 1908). In 1970 the California least tern was enlisted as endangered mainly due to habitat destruction (Arkcakaya et al. 2003). In an effort to preserve suitable habitats for future nesting colonies, about 30 sites were set aside mainly in San Diego and Los Angeles counties and are monitored by California Department of Fish and Wildlife (CDFW) (Butchko 1990; Figure 2). These colonies are used each year by the least terns due to the birds' tendency to exhibit colony site fidelity (Atwood and Massey 1988). Nonetheless, heavy predation and ecological instability can deter a least tern from returning to the same site as the previous year (Atwood and Massey 1988). In addition, small sites suffer additional loss of reproductive success as the low density of adult terns impedes the colony's ability to defend through mobbing (Butchko 1990).

Both avian and mammalian predators are recognized as limiting factors for tern recovery (Burr 1988; Massey 1988; U.S. Fish and Wildlife 1988). The predators found to depredate the most eggs in the 2013 California least tern nesting season were the common raven *(Corvus corax)*, gull spp. *(Laridae)* and American crow *(Corvus brachyrhynchos)* while the peregrine falcon *(Falco peregrinus)*, domestic cat *(Felis catus)* and red-tailed hawk *(Buteo jamaicensis)* were the most common reported predators of fledges (Frost 2014). American kestrel *(Falco sparverius)*, peregrine falcon *(Falco peregrinus)* and Northern harrier *(Circus cyaneus)* depredated the greatest amount of chicks in the 2013 nesting season while the great-horned owl *(Bubo virginianus)*, peregrine falcon *(Falco peregrinus)* and Cooper's hawk *(Accipiter cooperii)* depredated the greatest amount of adults (Frost 2014). Heavy predation can be detrimental to the perseverance of the colony sites and are managed by CDFW carefully.

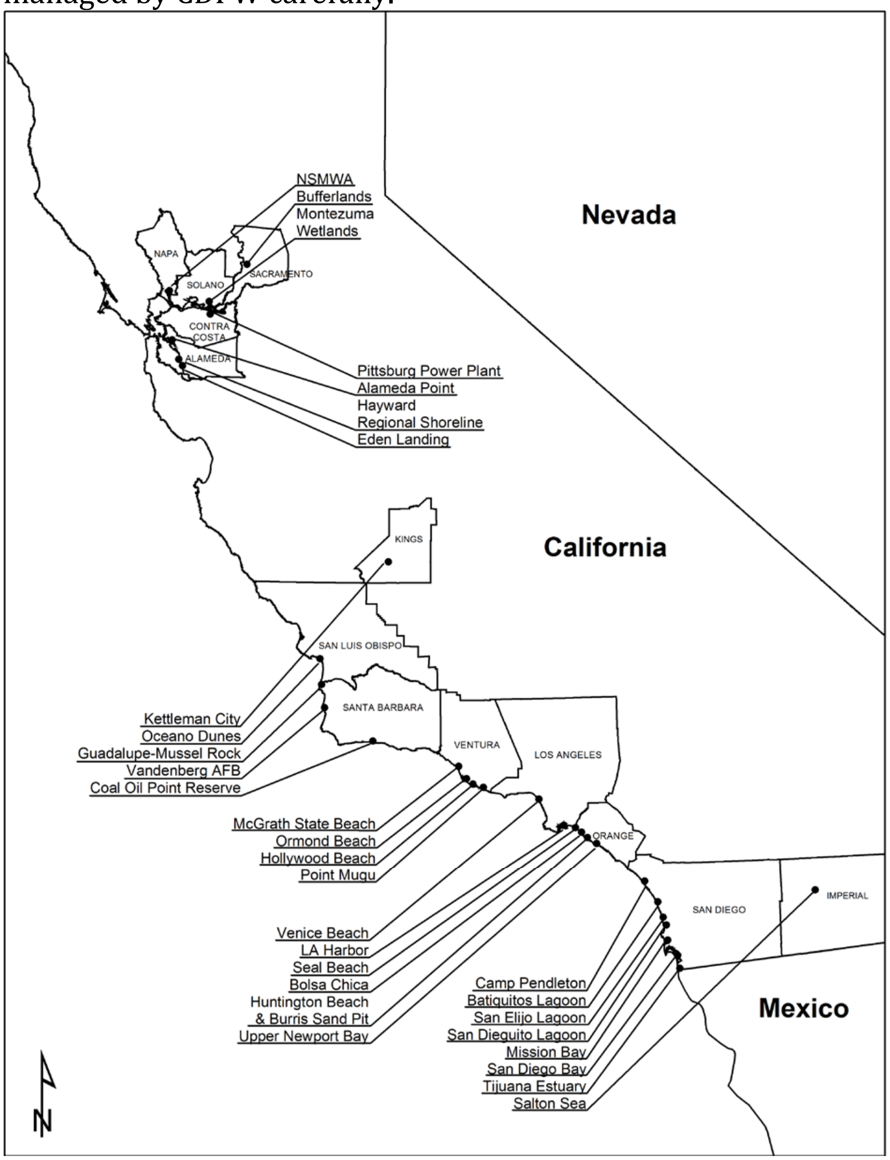

Figure 2: Map of all 30 California Least Tern nesting sites in 2013 (Frost 2014).

Predator control is actively managed at each site in a variety of ways, especially at the study site of Venice Beach, California. The colony contains a fence around its perimeter that protects against mammalian predators such as dogs and protects the nesting birds against human interference (Ryan and Vigallon 2010). Recently the most devastating predator to tern success has been the American crow that reportedly consumed 100% of the eggs laid in 2002, 2004, 2005 and 2009-2013 (Ryan and Vigallon 2010; Ryan et al. 2013). Carolee Caffrey, manager of the Venice Beach tern colony at the time, stated in her 1994 report that, "Crows have historically been the main predators at Venice Beach" (Caffery 1995). Predator control efforts against crows began in 1990 when crow carcasses were placed along the fence and within the colony in order to deter the crows away from the colony, which proved to be initially successful (Caffrey 1995). Efforts increased in the 2000's to lethal control using quail eggs as bait to trap and remove naïve crows (Ryan et al. 2013). The removal of trapped crows produced an initial decrease in crow population but more importantly, discouraged other crows from entering the site for several days (Ryan et al. 2013). This action provided an opportunity for the terns to produce more nests and increase the number of adults defending the colony (Ryan et al. 2013).

Despite these efforts, crows remained the most destructive predator the terns faced for egg laying success. The terns have not been able to reproduce at the Venice Beach colony in the last 5 years prior to this 2014 study, due to the immediate cause of heavy predation by American crows (Ryan and Vigallon 2013). Lethal predator removal may not have been successful at the site because of the immense crow population that was estimated for the Los Angeles area through Christmas bird counts that involved birders counting number of species and individual birds for a given hour sometime between December 14 and January 5 (Ryan et al. 2013, National Audubon Society 2010, Figure 3). It has also been reported that by removing individual crows, the territorial structure that governs families of crows can be disrupted by causing an influx of replacement crows from adjacent territories to attempt to reclaim the newly available area (Draulans 1987, Reynolds et al. 1993, Cox et al. 2004). Therefore lethal control may have inadvertently encouraged an inundation of crows from the surrounding areas to occupy the Venice Beach colony and remain predators of the least tern eggs.

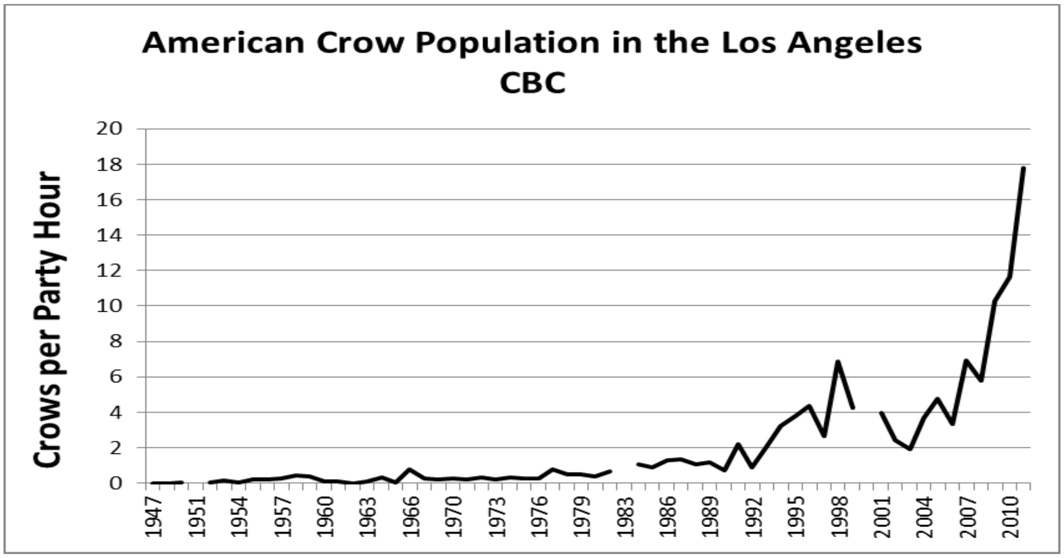

Figure 3: Christmas Bird Count data measuring American crow population in the Los Angeles area from 1947-2011 (National Audubon Society 2010).

Mobbing behavior by nesting terns to drive off predators like crows, may be reduced at Venice beach since the birds possibly need to forage further to sea for prey (Ryan and Vigallon 2013). Current Venice colony managers suspect that a lack of foraging resources within close proximity to the colony is causing adult terns to spend most of the day away from the colony in search of food (Ryan and Vigallon 2012). This leaves the nests undefended for the majority of the day as terns have been observed leaving the colony in the early morning and not returning until after sunset (Ryan and Vigallon 2013). This change in nesting settlement patterns has left the colony vulnerable to predation by crows. The colony is also an attractive foraging location for the crows because the site supports native plant species that encourages the establishment of arthropods, while the area surrounding the site is surrounded by development that removed native dune, wetland and scrub habitat (Ryan and Vigallon 2010; Ryan et al. 2013; Figure 4). The crows enter the site not only for tern eggs, but also to consume arthropods and cache food resources. Therefore lethal control has proven to be unsuccessful as a long-term predator control tactic due to the: large crow population, lack of defense from the terns due to foraging behavior, attractiveness of the colony's unique natural landscape and disruption of crow territorial structure.


Figure 4: Crow within the tern colony foraging among *Camissonia cheiranthifolia*.

Other options beyond lethal control are also worth investigating because public support for lethal outcomes is diminishing (Reiter et al. 1999). Wildlife managers must look to alternative non-lethal methods to maintain support from the general public while still, maintaining credibility to perform their mandated tasks (Shivik and Martin 2000). Management actions that are taken without consideration for the public's opinion discredits the belief that Americans hold a strong personal interest towards wildlife (Conover 1997). Furthermore, ignoring the public's opinion can lead to political backlash from citizens who disagree with the actions of the wildlife managers rather than their expertise (Reiter et al. 1999). Therefore it is in the best interest of wildlife managers to act in the interest of the general public. A nationwide public survey revealed that research on non-lethal control was rated as highly important and non-lethal methods were ranked as humane while lethal methods were ranked inhumane (Reiter et al. 1999). When asked to rate factors that should guide wildlife damage management, animal suffering not only ranked second highest, but also scored higher than lethal techniques, except for rodent poisoning (Reiter et al. 1999). While exceptions do exist, the survey found the public willing to accept methods that cause minimal animal suffering, pose little risk to humans and are effective (Reiter et al. 1999).

Research has been conducted on nonlethal predator control techniques to better support wildlife management plans that reflect the new priorities of research managers and the public. Studies have shown that predator aversion through non-lethal conditioned taste aversion (CTA) on American crows has the potential to serve as an effective, humane management technique (Nicolaus et al. 1983, Nicolaus and Nellis 1987, Conover 1990, Cox et al. 2004). An animal may form a CTA by ingesting a harmful food item that produces an illness that is associated with the identity cues of that food, such as color, shape, smell or size (Nicolaus and Nellis 1987; Ryan et al. 2013). American crows contain complex cognitive capabilities such as flexibility, which is the ability to extract general rules from a learned experience and apply those rules to novel situations (Emery and Clayton 2005). The complex cognition capacity of crows, coupled with a long lifespan (Hageman 2010), allows the animal to make the necessary association between the illness and the appropriate food source that makes this species a suitable candidate for conditioning.

American crows are also an ideal species for conditioning because they are cooperative breeders that socialize within extended family groups (Yorzinski and Vehrencamp 2009). Family groups defend group territories, protect and feed dependent young and guard one another when foraging together (Serrell 2003). Individuals in the family groups can identify members from their alarm calls because they interact constantly and have known each other for most of their lives (Yorzinski et al. 2006). Since these family groups are very sociable amongst themselves, an assumption is that one conditioned individual may be able to communicate the learned behavior with the rest of the group and increase the rate of conditioned individuals without having each member experience illness (pers. comm. P. Auger). Also since crows live in groups that defend territories, this behavior suggests the number of unconditioned migrants would be limited and would make crows a suitable target species for conditioning (Caccamise et al. 1997; Kilham 1984, 1990; Chamberlain-Auger et al. 1990, Nicolaus and Nellis 1987).

Crows are a suitable species for CTA to limit egg predation because they are omnivorous, opportunistic generalists that are consuming bird eggs because of their availability and not because it is essential to their diet (Rodewald et al. 2011, Ryan et al. 2013). Studies involving egg predation from corvids have shown modified aversive behavior through conditioning. Carrion crows were found to avoid colored emetic eggs while increasing consumption of non-toxic eggs after conditioning (Cox et al. 2004). Similar results were found when colored toxic eggs were presented to free-ranging crows in Fargo, North Dakota who avoided the previously toxic colored eggs during the post-conditioning phase and moved to new areas if an alternative colored egg was not presented (Nicolaus et al. 1983). Both studies illustrated conditioning behavior among crows is attainable and has the potential to be used as a predator management tool in reducing egg predation.

A CTA experiment was conducted at the Venice Beach colony in 2013 with limited success. A total of 466 quail eggs and 131 tern eggs were filled with 70mg of Methiocarb, a federally registered emetic for taste aversion, and then deployed in the beginning of the nesting season from March 18 2013- June 15 2013 (Ryan et al. 2013; Figure 5). Researchers measured a decrease in the number of consumed toxic eggs over the conditioning period, yet the nesting least terns continued to experience heavy egg predation and did not result in fledging (Ryan et al. 2013). The failure to condition the crows as a conservation effort for the endangered least terns was attributed to a delay in association between the consumed egg and the adverse effect (Ryan et al. 2013). The delayed response has the potential to cause the source of illness to be ambiguous to the animal. In addition, the intensity of the negative reinforcement is a factor in the acquisition of conditioning (Nicolaus and Nellis 1987). Therefore the experiment resulted in a recommendation to redesign the egg in order to deliver an immediate, strong negative response upon contact from the crow (Ryan et al. 2013).

Figure 5: Emetic egg deployed in the 2013 CTA study at Venice Beach least tern colony.

The study described in this thesis used electrified eggs to deliver an immediate non-lethal electric shock to condition American crows from eating California least tern eggs in the Venice Beach colony. Electric shock treatment as aversive stimuli to modify animal behavior has been extensively studied, especially in field environments (Krane and Wagner 1975, Linhart et al. 1976, Quigley et al. 1990, Tiedeman et al. 1997). Initial observations of wolves strapped with electric collars suggest aversive stimulus is effective for the reason that wolves did not attempt to attack free-ranging calves after just one conditioning event (Shivik and Martin, 2000). Cattle were conditioned to avoid specified areas of pastures with use of electronic collars and electronic ear tags (Quigley et al. 1990, Tiedemann et al. 1997). In another study, electric collars were used to successfully train 3 out of 4 coyotes to avoid black rabbits while continuing to prey on white rabbits (Linhart et al. 1976). Coyotes were found to quickly associate shocks from an electronic collar to their attempted attacks on lamb and avoided the prey for over 4 months until the end of the study, indicating a lasting effect (Andelt et al. 1999). Electric shock has been demonstrated as a successful nonlethal predator control method and was applied to egg depredating crows due to its potential in serving as a conservation technique. Therefore the study described in this thesis investigates whether American crows can be conditioned to avoid attacking electrified California least tern eggs within the Venice Beach Least tern colony. It is hypothesized that during the span of the nesting season, an increase in conditioned crows will be observed with a simultaneous decrease in unconditioned crows.

The general approach to address this question was to develop an electrified egg design, then distribute these eggs throughout the tern colony during the 2014 nesting season in the Venice Beach colony. Observations were made both directly and using motion detecting cameras to determine if crow predation on least tern nests was reduced. The population flux of crows throughout the experiment was measured to determine if the crow population at the site is suitable for conditioning. If the number of crows surrounding the colony were found to fluctuate minimally, the population would be more suitable for conditioning because there would not a fluidity of new individuals to the area that must be conditioned. However should the population of crows fluctuate greatly, the colony would be less likely to successfully condition the population because the constant introduction of new individuals would not permit the population to learn aversive behavior. This experiment aspires to serve as a proof of concept to eventually be expanded upon as a method of conservation for the California least terns.

Methods

Study Site

The study site is a fenced enclosed area of 3.3 hectares on Venice Beach, California designated as a California Least tern nesting colony since 1977 (Ryan and Vigallon 2013; Figure 6). The area was enclosed in 1977 when 3 pairs of California least terns nested in the area north of Ballona Creek and has stayed within the general proximity ever since (Atwood et al. 1977). The site is enclosed by 5-sides of 6-ft tall chain-link fence, coated with sand colored rubber (Figure 7). The area surrounding the site is visited by people year round due to its close proximity to Marina Del Rey and the row of condominiums just east of the shoreline.

Figure 6: Map of the location of the Venice Beach least tern colony.


Figure 7: Fencing of the Venice Beach least tern colony.

The colony's habitat is managed by the CDFW, which conducted a recent experiment to ensure the colony is conducive to tern nesting (Ryan and Vigallon 2010). All permits required to enter the colony, handle the crows, and conduct the experiments were provided to the site Principal Investigator, Thomas Ryan through the CDFW and were conducted under his supervision and CDFW authority. The study showed that terns prefer to nest within sand dunes of 20-40% of vegetation cover (Ryan and Vigallon 2010). Surrounding the dunes are vegetated flats that support a smaller percentage of nests, but are also managed and found to be optimal habitat at 30% vegetation cover (Ryan and Vigallon 2010; Figure 8). Vegetation height is carefully managed to the optimal limitations of the study.

The dominant native vegetation is native beach primrose (*Cammisonia cheiranthifolia*), silver beachweed (*Ambrosia chamissonis*) and sand verbena (*Abronia maritime*) (Ryan and Vigallon 2010). Non-native and invasive sea rocket (*Cakile maritime*) is also found in large numbers (Ryan and Vigallon 2010). Sea rocket is managed through annual vegetation removal because it is found to dominate other plant species and grows taller than the vegetation height adult least terns prefer to nest in (Ryan and Vigallon 2010). Sea rocket was cleared from dune habitat in October 2013, prior to this experiment (Ryan and Vigallon 2013). The sand surrounding the colony is regularly groomed by County of Los Angeles' Department of Beaches and Harbors and as a result, does not support vegetation.

Figure 8: Habitat composition within the Venice Beach tern colony after expansion of fence in March 2006 (Ryan and Vigallon 2010).

Electrified Egg Design and Construction

Two egg designs were used in the duration of the experiment. The first egg design was used to test the shocking capabilities of the system and observe the initial crow response to the electrified eggs. The second egg design was an improvement on the first design in that the eggs created were more durable, conductive and produced a more intensive electric shock. The first egg design used both least tern and quail eggs. The least tern eggs were actual eggs abandoned by terns in a previous season at a different colony. The quail eggs were purchased from a grocery store. The eggs were made conductive by first cutting a 0.5-1 inch hole on the long side of the egg to remove the internal contents and the interior of the shell was painted with Anders Product wire glue (Figure 9). A 5-inch segment of 16-gauge speaker wire was stripped using a wire stripper and one end was connected to the interior of the shell. The speaker wire was glued with a hot glue gun to the edge of the hole in order to secure the wire in place.

Figure 9: Painting of the interior of the eggshell with conductive glue.

The 5-inch length of speaker wire was connected to a network of about 50 feet of speaker wires that attached all 3 pairs of eggs to each other and to the “hot end” of a Havahart Model SS-2 Electric Fence Energizer powered by 2 D batteries that released 0.05-0.1J to the eggs. The wires were soldered together and wrapped with a NTE Electronics, Inc. thin wall heat shrink tube. The “ground end” of the fence charger was attached with speaker wire to a bolt and washer at the corner of an 18x18 inch square sheet of steel with a 5in circle removed from the center (Figure 10). At a different corner, the sheet had another bolt and washer that was attached to another plate by additional speaker wire to form a network of plates (Figure 11). The plates were connected to each other and ultimately, to the “ground end” of the fence energizer. Therefore when a crow stood on top of the sand covering the steel plate and opened its mouth to peck at the charged eggs, the circuit would be completed and the crow would receive a non-lethal shock (Figure 12). A MCM Electronics Model 72-7940 voltmeter was used to ensure the eggs were conductive.

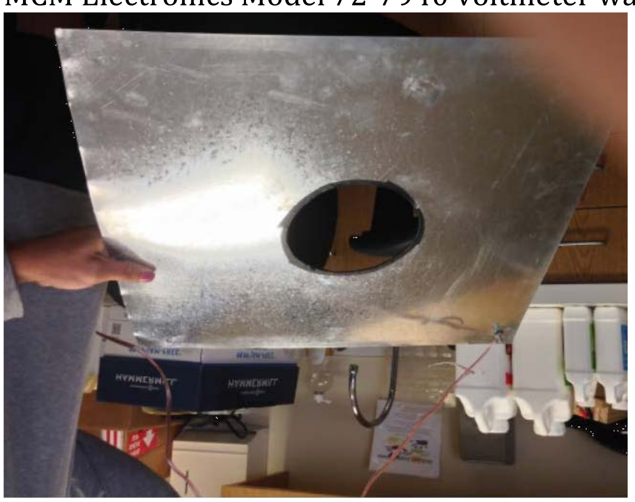

Figure 10: Steel plate with a 5-inch hole in the center that was connected to the “ground end” of the fence energizer.

Figure 11: Bolt placed through a hole at the corner of the steel plate with a washer and speaker wire attached. The speaker wire was stripped and wrapped around the bolt with the washer tightened to secure the wires in place.

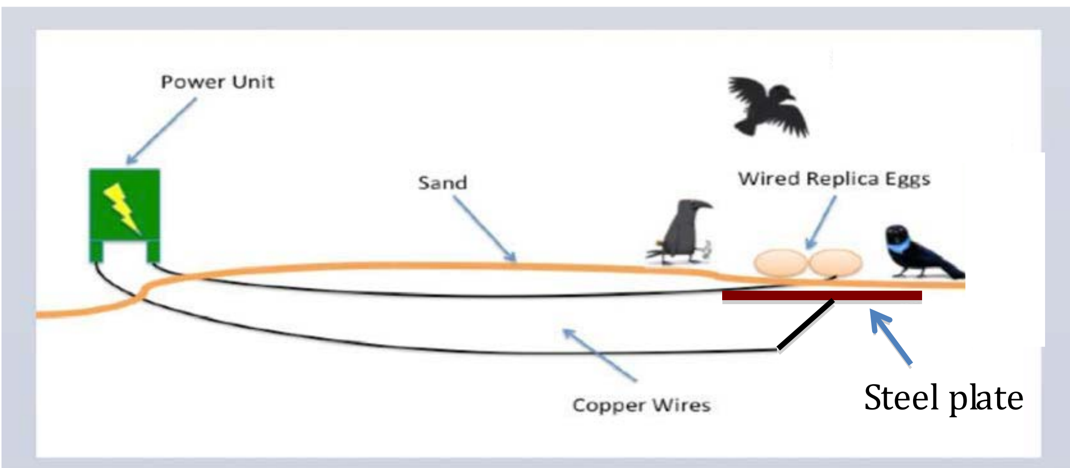

Figure 12: Diagram of the shocking system. A crow is expected to stand on the steel plate buried underneath the sand and peck at the charged egg to receive an electric shock.

The second and final egg design was an improvement of the first design. The focus of the second design was to create the most efficient shocking system for the remainder of the experiment. The final egg design only used actual least tern eggs that were abandoned from a different site the previous season. The contents of the tern eggs were again removed by cutting a 0.5-1 inch hole into the shell and the interior of the shell was painted with Anders Product wire glue. A 5-inch square of Flybye copper mesh was stuffed into the eggshell to increase conductivity by improving the amount of metal that came in contact with the surface area of the interior of the shell. A 5-inch piece of speaker wire was then stripped and connected to the Flybye copper mesh. Hot glue secured the speaker wire to the edge of the hole on the shell. To increase durability, Loctite Epoxy heavy duty glue was mixed and poured into the egg to harden the entire inner shell of the egg (Figure 13). The segment of speaker wire connected to the egg was soldered then wrapped with a NTE Electronics, Inc. thin wall heat shrink tube to a network of speaker wires that connected all the eggs to each other and to the "hot end" of the fence energizer. (Figure 14). The "ground end" of the electric fence energizer was again connected to the steel plates as described in the first egg design.

Figure 13: Underside of completed electrified egg. The egg contained an inner painting of conductive glue and was filled with copper mesh and epoxy glue, with speaker wire extending outward.

Figure 14: Two electrified eggs each connected to the network of speaker wires connecting all the electrified eggs to each other and the shocking unit. The connection of the electrified eggs to the network of speaker wires was soldered and covered with a heat shrink tube.

Electrified Egg Deployment

The first egg design was deployed from April 5th to April 26th 2014 with 3 nests. Each nest contained a pair of eggs for a total of 6 eggs distributed as: 2 nests of quail eggs and 1 nest of California least tern eggs. Each pair of eggs was placed in a depression in the sand to resemble a real tern nest and each nest was placed about 3-7 feet apart from each other. The wires connecting the fence energizer to the eggs and the wires connected to the steel plates were buried underneath the sand. The fence energizer was placed in a standard plastic toolbox then buried in the sand order to prevent sand damage. Three Bushnell Trophy Cam game cameras were placed beside the 3 nests to record 1-minute videos whenever the cameras were triggered by motion to monitor crow interactions with the eggs. Each game camera was attached with a 15-inch cable tie to a 1-foot wooden stake implanted into the sand.

The final egg design was deployed using shocking units that each powered 4-5 nests containing 8-10 single and pairs of electrified eggs. The 5 fence chargers were deployed gradually from April 15th 2014 to April 26th 2014. A total of 5 fence chargers were used to power 18-25 nests from initial deployment in April until the systems were removed at the end of the experiment on September 16th 2014. Four of the shocking units used were Havahart Model SS-2 electric fence energizer and one was Kencove Farm Fence Supplies KF 350B low impedance electric fence charger.

The energizers were selected based on the recommended output energy allotted for poultry by manufacturers. For poultry, Elephant recommended energizers of 0.1 joule while Premier 1 Supplies recommended energizers of 0.5 joule (Elephant B.V. 2015; Premier 1 Supplies 2015). This information was used as a guideline to help ensure the electric shocks would not be lethal to crows. Both energizers used in this experiment were below 0.1 joule in order not to exceed the recommended energy. The Kencove fence energizer released more energy (0.35 joule for a 5 mile length) than the Havahart fence energizer (0.05-0.1 joule for a 1 mile length).

The number of deployed eggs varied because dilapidated eggs that were considered poor decoys after damage from sun exposure and crow pecks were replaced or hidden beneath the sand (Figure 15). Ensuring the electrified eggs were effective mimics of natural eggs was a priority throughout the experiment. Researchers did not want the crows to distinguish between the electrified eggs and the actual eggs in fear of delaying conditioned learning. Careful attention was used to avoid damaging the top exterior of the eggs during construction. Hot glue that splattered on the top of the eggshell, darkened to deep yellow after sun exposure making the egg a poor decoy. Regular monitoring of the appearance of the deployed eggs was done throughout the season.

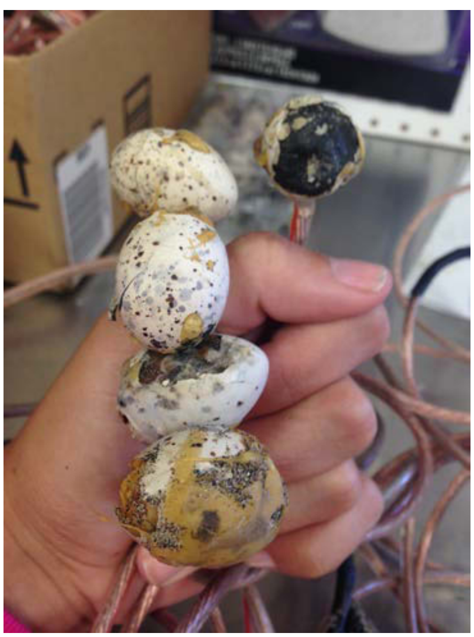

Figure 15: Damaged eggs from sun exposure, crow pecks and glue discoloration.

Nests were made by placing 1 to 2 eggs in a 2-4-inch depression in the sand to resemble a real tern nest (Figure 16). The nest was planted within the hole of the metal plate and the metal plate was buried beneath the sand, along with the wires (Figure 17). Whenever a crow stood on the sand above the metal plate and opened its mouth to peck at the charged egg, the crow would complete the circuit resulting in a non-lethal electric shock. The electric chargers released electric currents in pulses. The Kencove and Havahart electric chargers were set to release 60 pulses of electric current every minute. If a crow quickly pecked at an egg without opening its mouth or physically contacting the egg for 1 second minimally, the crow would most likely not receive an electric shock. This shocking system design required the moisture from within the crow's mouth to contact the egg in order to send an electric current through the crow. The current has the potential to shock the crow from just physically contacting the beak, but the crow must hold its beak to the egg for 1-2 seconds. Additionally, as the battery power diminished in the Havahart electric charger, the pulse interval elongated noticeably. The Kencove electric charger contained more power than the Havahart electric charger, and exhausted the batteries quicker. Battery power within the chargers was regularly monitored.

Figure 16: Pair of deployed electrified eggs within a depression in the sand to resemble a tern nest.

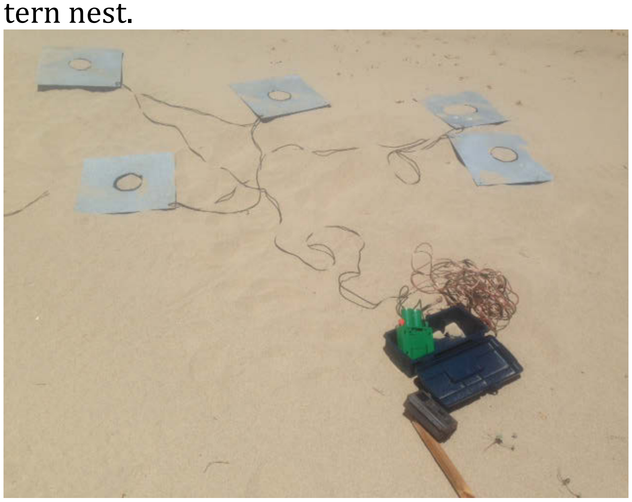

Figure 17: Steel plates and shocking unit with attached wires, laid on top of the sand prior to burying the items underneath the sand. The game camera fixed on the wooden stake laid on the sand prior to deployment.

Each fence charger powered 3-5 nests that were spaced 3-7 feet apart and monitored by 2 motion sensing game cameras. A MCM Electronics Model 72-7940 voltmeter was used to ensure the eggs were conductive. The nests were placed throughout the enclosure with a denser distribution in the vegetated flat habitat of the colony. Electrified nests that were found to be too close to actual tern nests by CDFW were relocated.

Data Collection from Game Cameras

Video clips from the deployed game cameras were thoroughly reviewed and sorted as conditioned crow behavior and unconditioned crow behavior (Figure 18). The crows that were seen walking within 15 feet from the egg but not closer than 1 foot, were considered unconditioned. Crows that walked closer than 1 foot to the electrified eggs during any point of the video clip were considered conditioned. The number of crows found exhibiting each behavior was tallied throughout the season to analyze the progression of conditioning. The chi-square test was used to determine the statistical significance between the percentage of conditioned crows per the total number of crows seen each week of the season versus an homogenous distribution of 50% conditioned crows over total number of crows seen each week.

Figure 18: A snapshot taken from the video clips collected by the deployed game cameras of an unconditioned crow pecking at an electrified egg.

Crow Trapping and Banding

In order to estimate the crow population flux throughout the span of the experiment, a modified approach of the Lincoln Index was used. The Lincoln index requires an initial trapping event in which all trapped individuals are marked (Lincoln 1930). An Australian crow trap was used to capture crows within the center of the dunes in the enclosure on April 1st 2013, February 23rd 2014 and March 22nd 2014 (Figure 19). The total number of trapped and banded crows on all 3 trapping events was inputted as the initial trapping event in the Lincoln Index equation.


Figure 19: Crows confined in the deployed trap.

The crows were baited to the trap by placing peanuts on top of the wooden frames of the trap, within and surrounding the trap. The trap was deployed with water bowls at about 7am and trapped crows were individually removed with a net at about 12-2pm. Once removed, the wings were measured and an individually coded anodized USFWS metal band was attached to the right ankle. On top of the metal band, 2 colored plastic stripes, referred to as car stripes, were placed in either: black, blue, red, gold or green (Figure 20). On the left ankle, a solid colored metal bad was attached in either: blue, purple or silver. The color combination and stripe placement was unique to each banded crow and used for identification (Figure 21). After banding the crows was released.


Figure 20: CDFW employee Thomas Ryan, attached color bands on a crow captured during one of the trapping events.

Figure 21: Banded crow perched on the fence of the tern colony.

Data Collection from Field Observations

After the initial trapping and banding event, the Lincoln Index dictates a second trapping event of equal effort is necessary to estimate the population (Lincoln 1930). Each day of field observations, the number of verified banded crows and total crows that flew over or landed within the nesting site was considered a second trapping event in this experiment. Field observations were made throughout the nesting season from within the enclosed area. All crows that flew over or landed within the nesting site were inspected with Eagle Optics Shrike 8x42 binoculars and with an Alpen 20x-60x or Bushnell 45x spotting scope to determine whether it was possible to verify if the crow was banded (Figure 22).

Crows were not always easily identifiable as banded or not banded due to the large area of the colony, dune habitat within the enclosure, reflection from the sun and rapid movements of the crows. Consequently each bird that was encountered during a field observation was identified as verified banded or not verified, in which case it is unknown if the crow contained bands or not. For the purposes of this analysis, the assumption was made that all unverified birds were not banded. It is understood that a portion of those unverified sightings likely contained a small proportion of banded crows. However, the assumption was made that the proportion of error would be consistent across sightings, thus allowing for a rough population estimate to be made.

A strict application of the Lincoln Index requires that each animal captured in the second trapping event, be confirmed as a previously caught individual, which would be a banded crow, or a new individual that was not previously captured and would not contain bands. Due to the limitations of the environment, the Lincoln index was not applied in its strict, most accurate form but included in this thesis because of its importance of serving as the initial attempt to estimate the population flux of the crow population at the Venice Beach tern colony. The group of unverified, unknown crows that were used in the Lincoln Index may contain crows that were banded but were not verified by the researchers. Therefore the data used to calculate of the Lincoln index may contain inaccuracies in that the index is greater than the actual population size in Venice beach. Nonetheless, the population flux data was used as the first estimate of its kind for this colony.

The number of verified banded individuals was compared to the total number of birds seen in each observation event in order to use the Lincoln index to determine population flux. The second trapping event of this experiment was not of the same effort as the first trapping event. Therefore the Lincoln Index could not be used to measure population in its traditional manner. However, a modified approach of the Lincoln Index was used to estimate crow population flux throughout the span of the experiment. This was done by using the traditional Lincoln index equation for each observation event where the "first trapping event" in the equation was the number of banded crows captured in the 3 trapping events when the Australian crow trap was used and the second trapping event was the observation events of crow fly overs and land ins.

$$\text{Lincoln Index} = \frac{n_1 + n_2}{n_3}$$

n_1= Total birds banded in the first trapping event

n_2= Total birds trapped the second trapping event

n_3= Number of banded birds trapped in the second trapping event

The average of the Lincoln Index for all the observations was taken and subtracted from each Lincoln index value for each of the observations. If no banded individuals were seen flying over or landing in the colony, the Lincoln Index could not be calculated for that observation event because the equation would attempt to divide by 0. The calculated values offer a preliminary estimation of the crow population flux from the average estimated crow population for each observation event throughout the experiment.

Figure 22: Observer within the tern colony using a spotting scope to detect whether crows are banded.

Results

Percentage of Conditioned Crows per Week

The total number of video clips that recorded unconditioned and conditioned crows was 354. Of those video clips, 448 birds were recorded of which 164 were unconditioned crows and 284 were conditioned crows. The percentage of conditioned crows per total number of crows observed in the video clips was measured for each week of the experiment. The percentage of conditioned crows for each week was found to resemble a polynomial distribution and significantly differed from a homogenous distribution (1, N=20, p<0.001; Figure 23). The only weeks that found the percentage of conditioned crows to be below a homogenous distribution of 50% was weeks: 1 (27%), 2 (27%), 5 (48%) and 15 (39%). In each of the other weeks of the season, the ratio of conditioned crows was found above the expected homogenous distribution. The greatest percentage of unconditioned crows was in weeks 1, 2, 5 and 15 of the experiment. The first 2 weeks reported the lowest percentage of conditioned crows (27%) than any other week of the experiment.

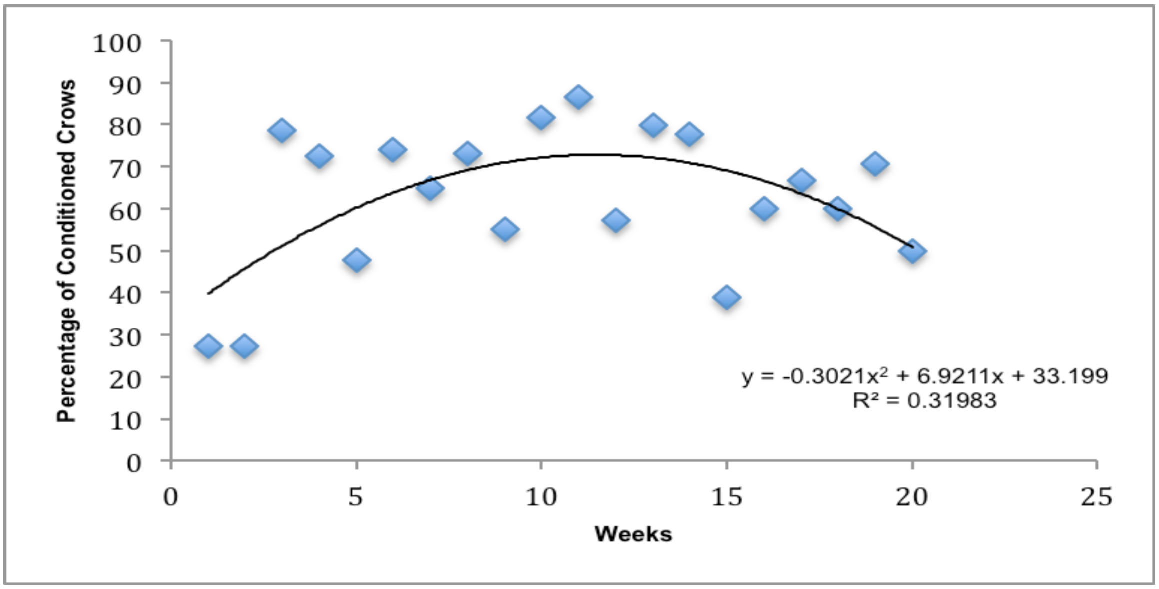

Figure 23: Percentage of conditioned crows over the 20 weeks of the experiment following a polynomial distribution.

<u>Population Flux</u>

The average population estimate for the season was used to measure the relative flux of the population. Observations in which no banded crows were encountered were not calculated in the population flux because the equation would erroneously equal zero. The average population estimate calculated from the Lincoln index is illustrated as 0 on the vertical axis (Figure 24). Each point on the graph represents the extent to which the population estimated for each observation event, differs from the calculated average using the Lincoln index. The graph should not be used as a numeric measurement, due to the modified usage of the Lincoln Index. Rather the graph should be used as relativized depiction of how the Lincoln index estimated for each observation event, diverges from the 0 line. The population flux was measured below the average population estimate for each observation event except for April 29th, May 29th, July 25th, July 30th and August 16th. The population was found relatively stable throughout the experiment besides a major increase of crows on July 30th, week 15.

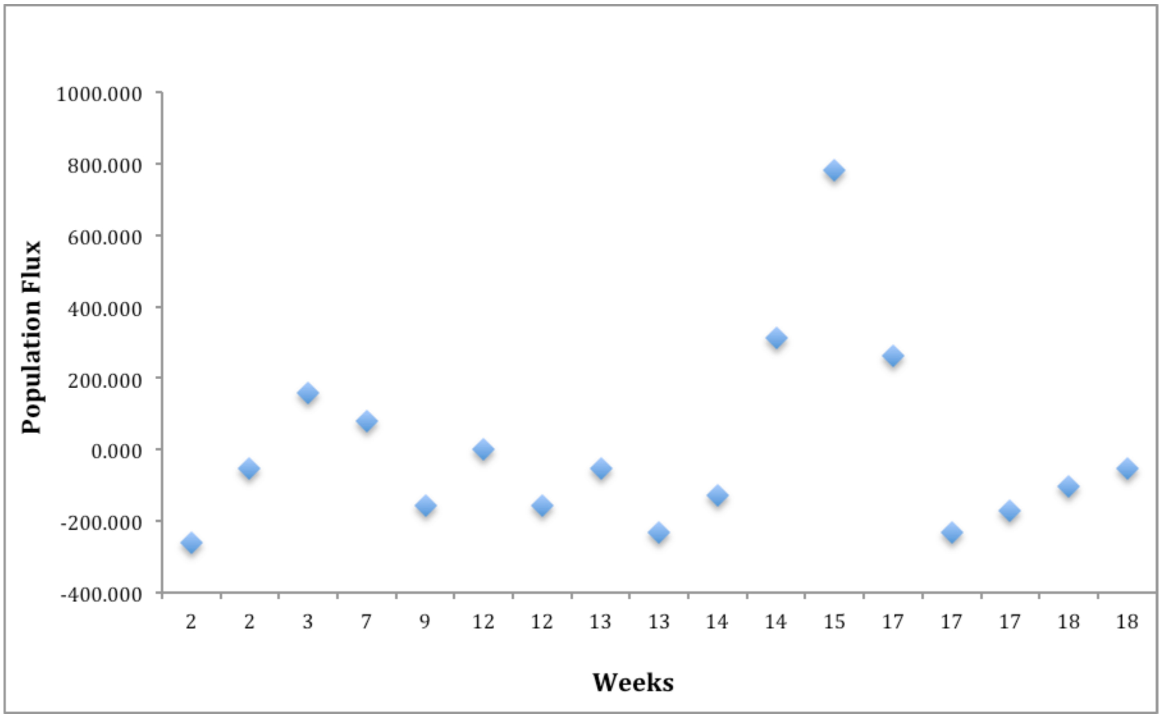

Figure 24: Population flux estimate for American crows within the Venice Beach tern colony. The 0 vertical line represents the average population estimate for all the observation period using the Lincoln Index. Each graphed point illustrates the extent to which the Lincoln Index measured for each observation period, differs from the estimated population average.

Discussion

Period of Conditioning

With the specified definition of each category, the crows detected in the video clips of game cameras were more frequently conditioned crows than unconditioned crows. A conditioned crow was determined as a crow that stood or walked within 15 feet of an electrified egg but was not present within 1 foot of the eggs. A conditioned crow was assumed to demonstrate the learned aversive behavior by avoiding the electrified eggs by at minimum 1 foot. An unconditioned crow was presumed not to contain the knowledge to avoid electrified eggs and would therefore, naively walk or stand within 1 foot of an electrified egg, including physically contacting the egg. These definitions may not be entirely applicable for each crow that is seen in the video clips. For instance a previously shocked crow may know to avoid the eggs but still decide to walk within 1 foot of the eggs in order to forage for other food sources in the colony. The actual intent of the crows can never be certain, however these definitions are attempts to interpret animal behavior and are based on the assumption that if a crow is able to view a least tern egg, electrified or not, the crow will attempt to consume the egg because a crow's ability to survive lies in its ability to constant forage for food (pers. comm. Dr. Strauss). If the crow does not attempt to consume the egg, it is because the crow has become conditioned not to do so.

Based on the established definitions, more conditioned crows were seen each week of the experiment than unconditioned crows. The lowest percentages of conditioned crows were measured within the first 5 weeks of the experiment (weeks 1, 2 and 5) as well as week 15. After week 5, conditioned crows were found at greater percentages than unconditioned crows until the end of the experiment, with the exception of week 15. These results suggest that conditioning occurs within the first 5 weeks of the first deployed eggs at the Venice Beach colony. Other studies found free ranging American crows were conditioned to avoid toxic green colored chicken eggs after just 10 days (Nicolaus et al 1983). Another experiment studying raven predation on California least tern eggs, suggested deploying the experiment for conditioning 2-3 weeks before terns begin nesting to ensure the predator encounters the modified least tern eggs that is necessary for conditioning (Avery et al. 1995). The Venice beach site is in a heavily urbanized setting with a large population of crows that may require a longer period of conditioning due to the amount of crows that need to experience the learned behavior. Early deployment may encourage more rapid crow conditioning and eventually serve as a conservation tactic for colony managers.

Population Flux

The average number of crows observed landing in and flying over the colony fluctuated minimally for the majority of the experiment. Often the estimated number of crows measured during each observation event, was below the observed average from the Lincoln Index. This represents that there were fewer crows present than the expected average for most of the experiment. Notably, not all of the crows flying over or landing within the colony were verified as banded and assumptions were made using the rationale offered above. Therefore the population flux does not illustrate that the crows visiting the site are the same individuals visiting the site throughout the nesting season. Rather the population flux indicates that the number of crows present is fairly consistent. As a result while the number of crows surrounding the colony may be stable for most observation events, it is possible that each observation event may experience visitations from different individual crows.

Nonetheless since the colony was not found to experience large fluctuations of crows throughout the experiment, this suggests the crow population surrounding the site may be more stable than previously considered. A more stable crow population would increase the likelihood of achieving aversive conditioning at Venice Beach. Areas that have established successful aversive conditioning are not likely to contain frequent new individuals that must themselves learn conditioning (Nicolaus et al. 1989). Thus a large fluctuating population would indicate the area is unstable and unsuitable for conditioning because new individuals would be too fluid to develop a learned behavior. A more consistent number of crows in the vicinity of the colony may be the first indication that the crow population is stable or that a family group is defending the area. More studies are needed to analyze the crow ecological structure surrounding the tern colony.

The Lincoln index was not used in its traditional manner with 2 trapping events of equal effort. The second trapping event considered for the index was purely observational and involved binoculars in addition to a spotting scope, to determine if the observed crows were banded. This approach cannot accurately estimate population size as the traditional usage of the Lincoln index. Therefore the modified approach was used to estimate population flux by relativizing each observation event with the average Lincoln index value taken from all the observation events. In future research efforts, the Lincoln Index should be applied to a data set in which the trapped individuals in the second trapping event were confirmed as banded or not. The data set for this experiment involved verified banded crows and unidentified crows that may produce results that are inaccurate of the population structure at Venice Beach. The group of unidentified crows may include banded crows that were not verified by the researchers and would alter the calculated Lincoln index. Despite its untraditional applications, the modified approach of the Lincoln index was the first attempt to study population flux for the Venice Beach colony. Additional studies involving Venice beach crow tracking and bandings are needed to consolidate the accuracy of the data measured from the population flux.

While the population flux varied slightly for most of the experiment, the greatest increase of crows was measured on the weeks before, on and after week 15. Week 15 was the only week that observed a lower percentage of conditioned crows than unconditioned crows outside of the first 5 weeks of the experiment and was also the week that experienced the greatest increase in population flux. The ecological source of the influx of new individuals is unknown, as few studies have been done on the crow population at Venice Beach. It is speculated that the new individuals could be recent fledges since American crows have been observed to produce fledges between May thru July (Chamberlain-Auger et al. 1990; McGowan 2001). Nonetheless, further studies of population dynamics is needed to better understand the crow structure at the Venice Beach colony.

Weekly Predation Rate

In order to determine if the increase in population flux and unconditioned crows on week 15 led to an increase on predation of actual tern nests, predation rates were calculated for the duration of the experiment. Thomas Ryan from the CDFW, arrived at the site periodically throughout the season to monitor the status of the least tern nests. Each nest Ryan detected was mapped and the location was revisited during his succeeding surveys of the site. Every nest he found was tracked throughout the season until it was lost to predation, resulted in chicks or was a potential hatch. The fate of each nest was used to determine weekly predation rates. The weekly predation rates are an underrepresentation of the actual rate of predation that occurs at the site due to the sporadic nature of monitoring visitations and should only be used as an estimation (pers. comm. Thomas Ryan). Additionally, predators were not observed consuming the eggs of the depredated nests. However, crows were often observed foraging within close proximity to the natural nests and in the past, and crows have been the reported main predators of least tern eggs at Venice (pers. comm. Mr. Ryan; Ryan and Vigallon 2013). Therefore crows are considered the predators of the depredated nests.

The predation rate for each of Ryan's monitoring events did not show a drastic change during the period of week 15 despite the measured increase in population flux and unconditioned crows. The predation rates of weeks 5-9 were much higher than the predation rates of weeks 11-15 (Table 25). The number of depredated eggs per total number of eggs for week 15 was calculated to be 10%, which is identical to the predation rate of week 13. Predation rates did not increase during week 15 despite the increase of crows in the area and unconditioned crows observed in the video clips from the game cameras.

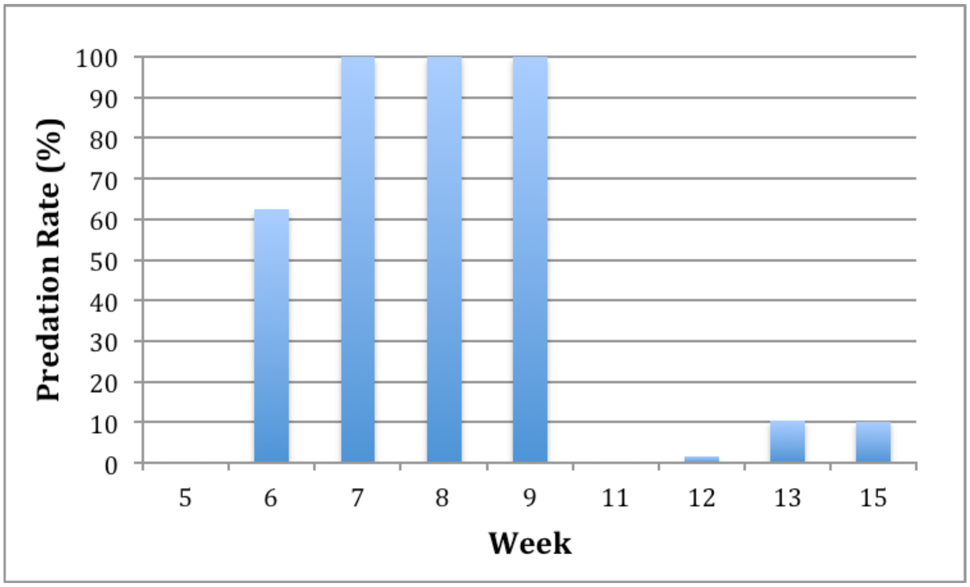

Figure 25: Weekly percent predation rates of actual California least tern nests for the 2014 Venice beach nesting colony.

Although crows were in the area, they did not consume tern eggs at great numbers perhaps due to defensive tern behavior and the placement of the electrified eggs. During observation events, terns were very aggressive towards crows after week 11 when a total of 9 nests were present. Aggressive behavior from the terns continued until the end of the season when up to 66 nests were laid. Terns use mobbing behavior as a tactic to defend nests or chicks against predators (Butchko 1990). The more nests present, the greater number of adult terns are likely to defend their nests through mobbing in order to protect their unhatched offspring or young. The actual tern nests were located in the dune area of the site while the electrified eggs were deployed on the outskirts of this area to avoid electrifying chicks or adult least terns. Since the least terns laid few, if any, nests in the outskirt area of the dunes, this area was not defended as well as the dune area that contained a denser amount of nests. Therefore the outskirt area was left more vulnerable to crow attacks. This may explain how more unconditioned crows were seen in the video clips of the electrified eggs but the predation rates did not increase. Also it is possible the unconditioned crows were new to the area, as the population flux indicated, and were naïve to come in contact with the electrified eggs but soon learned to avoid the actual tern eggs.

Fledging Success

The 2014 nesting season at Venice Beach was a reproductively successful year for the colony. The successful fledging year was a relief to the colony's managers as the site had not produced fledges in the last 5 years from 2009-2013. The percentage of eggs lost to predation in 2014 (29.4%) was inconsistent with the 100% yearly predation rates from 2009-2013 (Figure 26). The fledgling per pair ratio for 2014 (1.25-2.13) was also inconsistent with the fledging per pair ratios of the last 20 years (Figure 27). The 2014 nesting season differed from recent nesting seasons at Venice Beach and was also the first year the electrified eggs were deployed.

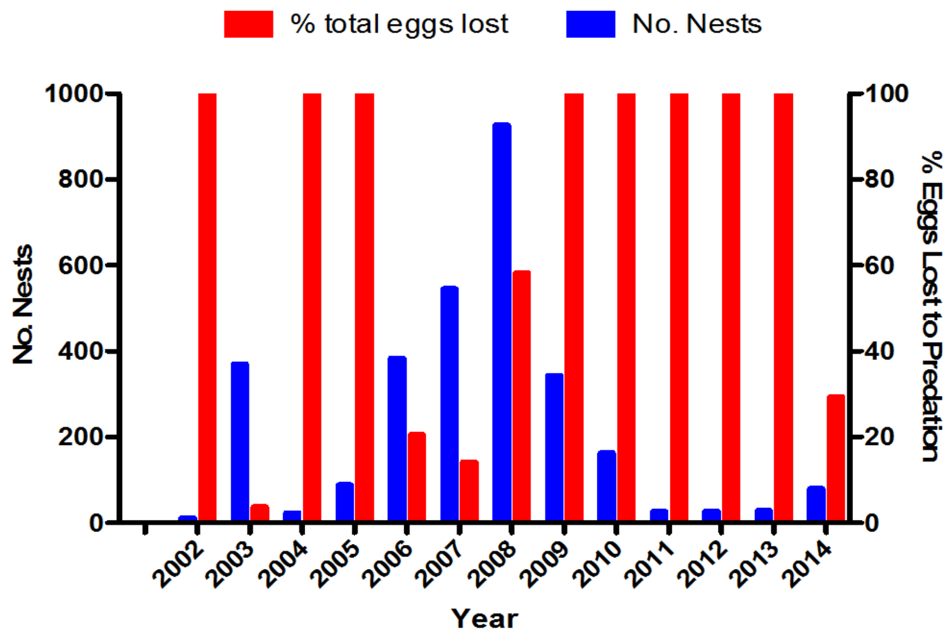

Figure 26: Number of nests and percentage of total eggs lost to predators for the Venice Beach colony from 2002-2014.

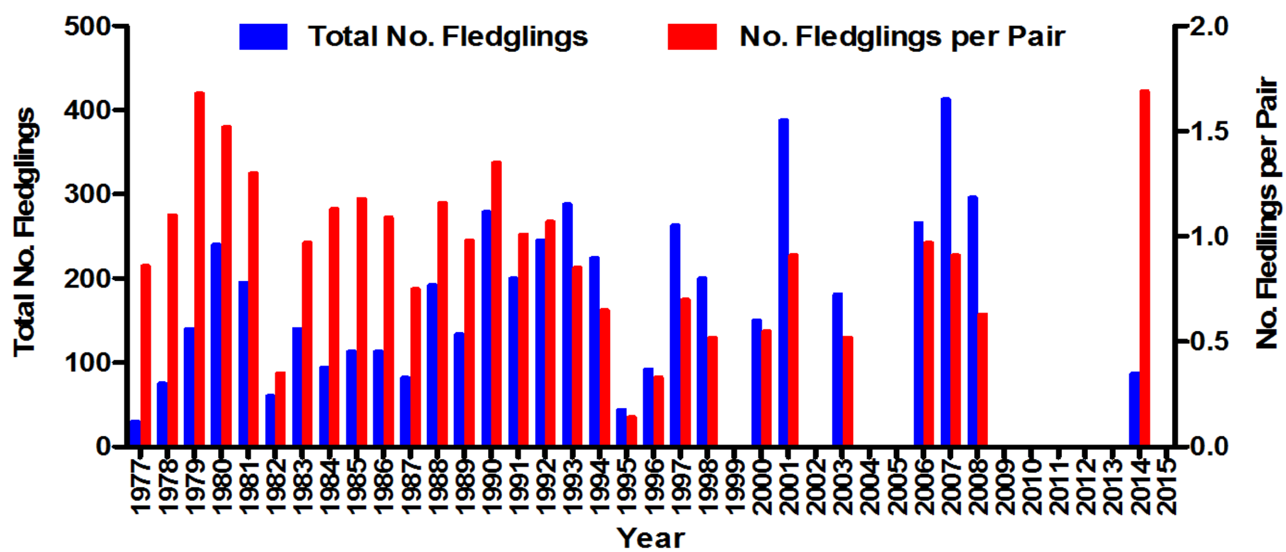

Figure 27: Total number of fledglings and fledgling per pair ratio for the Venice beach tern colony from 1977-2014.

The fledging per pair ratio of the 2014 season at Venice Beach was compared to the fledging per pair ratio of all the colonies in California for 2013 and 2014 in an effort to evaluate the degree to which the season was successful in the past 2 years. Overall the fledging per pair ratio of the 2014 season (minimum: 0.37, maximum: 0.58) was more successful than the fledging per pair ratio of the 2013 season (minimum: 0.25, maximum: 0.38) (Table 1). The fledging per pair ratio maximum for the 2014 Venice Beach season (2.13) was the second highest ratio to be recorded in the past two years, following after only Napa Sonoma Marsh Wildlife Area (2.80). The 2014 Venice Beach fledging per pair ratio minimum was the sixth highest fledging per pair ratio minimum reported for all the colonies in 2013 and 2014. Furthermore the colony's 2014 fledging per pair ratio was the highest for all colonies south of Ventura County in 2014 and the second highest fledging per pair ratio for colonies south of Ventura in 2013 (after NI18 with 1.71). The fledging per pair ratio for Venice Beach was among the highest fledging per pair ratios reported for 2013 and 2014.

Table 1: Fledging per pair ratio for all the California least tern colonies in 2013 and 2014.

		2013		2014	
Site Location	Site Name	Fledgling/Pair Ratio (minimum)	Fledgling/Pair Ratio (maximum)	Fledgling/Pair Ratio (minimum)	Fledgling/Pair Ratio (maximum)
Sacramento	Bufferlands	0.00	0.00	0.00	0.00
SF Bay Area	Napa Sonoma Marsh Wildlife Area	0.14	0.33	1.71	2.80
	Montezuma Wetlands	0.12	0.16	0.06	0.09
	Pittsburg Power Plant	0.00	0.00	0.00	0.00
	Alameda Point	1.07	1.08	1.33	1.33
	Hayward Regional Shoreline	1.46	1.53	1.42	1.62
	Eden Landing	0.00	0.00	0.00	0.00
Kings County	Kettleman City Evaporation Ponds	0.00	0.00	0.00	0.00
San Luis Obispo/Santa Barbara Counties	Oceano Dunes SVRA	1.04	1.30	1.23	1.23
	Rancho Guadalupe Dunes	0.00	0.00	0.00	0.00
	Vandenberg AFB	1.27	1.36	1.18	1.18
	Coal Oil Point Reserve	0.00	0.00	0.00	0.00
Ventura County	Santa Clara River/McGrath State Beach	0.00	0.00	0.50	0.50
	Hollywood Beach	0.15	0.26	0.26	0.38
	Ormond Beach	0.00	0.00	0.00	0.00
	Pt Mugu	0.00	0.00	0.27	0.28
	Saticoy United Water Conservation District	0.00	0.00	0.00	0.00
Los Angeles/Orange County	Venice Beach	0.00	0.00	1.25	2.13
	LA Harbor	0.13	0.62	0.14	1.20
	Seal Beach NWR-Anaheim Bay	0.55	0.60	0.03	0.03
	Bolsa Chica Ecological Reserve	0.23	0.49	0.27	0.74
	Huntington State Beach	0.30	0.33	0.35	0.79
	Burris Sand Pit/Burris Basin	0.04	0.24	0.63	0.63
	Upper Newport Bay Ecological Reserve	0.26	0.30	0.00	0.00
San Diego County	MCB Camp Pendleton	0.13	0.19	0.32	0.49
	Batiquitos Lagoon Ecological Reserve	0.21	0.37	0.49	0.56
	San Elijo Lagoon Ecological Reserve	0.00	0.00	0.00	0.00
	San Dieguito Lagoon Ecological Reserve	0.00	0.00	0.00	0.00
	Fairbanks Ranch	0.00	0.00	0.00	0.00
Mission Bay	FAA Island	0.05	0.07	0.25	0.25
	North Fiesta Island	0.00	0.00	0.64	0.90
	Mariner's Point	0.00	0.00	0.53	0.72
	Stony Point	0.08	0.09	0.50	0.50
	San Diego River Mouth	0.00	0.00	0.00	0.00
San Diego Bay	Lindbergh Field/Former Naval Training Center	0.32	0.37	0.34	0.51
	NI MAT	0.00	0.00	0.05	0.25
	NI 18	0.60	1.71	0.13	0.29
	Naval Base Coronado	0.17	0.22	0.13	0.26
	D Street Fill/Sweetwater Marsh NWR	0.18	0.28	0.21	0.29
	Chula Vista Wildlife Reserve	0.44	0.59	0.27	0.34
	South San Diego Bay Unit, SDNWR-Saltworks	0.05	0.07	0.33	0.61
	Tijuana Estuary NERR	0.23	0.32	0.15	0.22
Imperial County	Salton Sea	1.00	1.00	0.00	0.50
	Totals:	0.25	0.38	0.37	0.58

The role the electrified eggs partook in fledging success for 2014 is unclear because the experiment was a proof of concept and did not contain a control group. However it is speculated that the electrified eggs could have had a similar effect to discourage heavy egg predation that hanging crow carcasses in the colony did in the 1990's. It was reported that the crow carcasses scared the crows off the colony long enough to allow the terns to lay more nests, consequently increasing the amount of terns dedicated to defending the territory (Ryan et al. 2013). The electrified eggs may have worked in a similar manner to reduce egg predation by negative conditioning crows to avoid the area for a short period, thus giving the terns an opportunity to establish a more successful colony. Experiments similar to the experiment described in this thesis must be repeated at multiple colonies to determine the role conditioning plays in tern reproductive success.

Further studies are also needed to determine the role environmental variables contribute to reproductive success when coupled with conditioning treatment. Environmental factors such as food availability and human influences greatly impact tern reproductive success (Frost 2014). Colony manager Thomas Ryan has suspected a lack of tern fledging success in recent years is a result of long hours spent foraging for food sources far off the coast (Ryan et al. 2013). The unusually extended time spent foraging caused the colony to be left unprotected from predators such as crows (Ryan et al. 2013). Recent studies have not conclusively reported the location of tern prey in proximity to the tern colony. Additional studies are needed to determine how environmental factors, such as food availability, affect tern reproduction to better understand how conditioning can be used for conservation.

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Appendices

Appendix I

Weeks	Conditioned Crows	Total Crows Observed	Conditioned crows per week (%)
1	6	22	27
2	3	11	27
3	11	14	79
4	21	29	72
5	11	23	48
6	43	58	74
7	26	40	65
8	41	56	73
9	11	20	55
10	27	33	82
11	13	15	87
12	4	7	57
13	4	5	80
14	7	9	78
15	14	36	39
16	6	10	60
17	2	3	67
18	12	20	60
19	12	17	71
20	10	20	50

Appendix II

Date	Time	ime (hr.min)	ime in hours	Land in	Land ins/hr	Fly Over	Fly Overs/hr	Banded	Not Banded	Unknown	Total (n2)	Lincoln 52	Pop Flux
April													
10-Apr	9:00-10:05ar	1.05	1.08	12	11.0803324	8	7.38688827		3	17	3		
17-Apr	9:28-10:33ar	1.05	1.08	7	6.46352724	10	9.23361034	1		11	1	52	-258.98039
24-Apr	9:30-10:33ar	1.03	1.05	6	5.71428571			1	4	1	5	260	-50.980392
29-Apr	7:30-8:36am	1.06	1.10	16	14.5454546			1	8	7	9	468	157.019608
May													
22-May	9:47-10:45ar	0.58	0.97	8	8.27300931	7	7.23888314		5	10	5		
29-May	7:30-8:48am	1.15	1.25	26	20.8	5	4	2	13	16	15	390	79.0196078
June													
11-Jun	7:45-8:55am	1.10	1.17	6	5.14138818	2	1.71379606		1	7	1		
12-Jun	8:15-9:30am	1.15	1.25	9	7.2	4	3.2	2	4	7	6	156	-154.98039
July													
2-Jul	8:27-9:30am	1.03	1.05	14	13.3333333				10	4	10		
7-Jul	11:30am-3:3	4.00	4.00	4	1	10	2.5		1	13	1		
8-Jul	9:20am-12:5	3.30	3.50	6	1.71428571	4	1.14285714	1	5	4	6	312	1.01960784
10-Jul	12:20-3:00pr	2.40	2.67	5	1.87265918	1	0.37453184		2	4	2		
11-Jul	9:45-11:10ar	1.25	1.42	6	4.23519447	3	2.11759723	1	2	6	3	156	-154.98039
14-Jul	12:50-2:20pr	1.30	1.50	5	3.33333333	1	0.66666667		1	5	1		
16-Jul	7:45am-1pm	5.15	5.25	23	4.38095238	15	2.85714286	3	12	23	15	260	-50.980392
18-Jul	10am-2:45pr	4.45	4.75	4	0.84210526	2	0.42105263	2	1	3	3	78	-232.98039
22-Jul	9:45am-1:15	3.30	3.50			3	0.85714286			3	0		
23-Jul	8:10-10:15ar	2.05	2.08	12	5.76092175	10	4.80076812	2	5	15	7	182	-128.98039
24-Jul	11am-12:33p	1.33	1.55			4	2.58064516			4	0		
25-Jul	9:40am-1:40	4.00	4.00	19	4.75	2	0.5	1	11	9	12	624	313.019608
30-Jul	7:00-9:20am	2.20	2.33	27	11.5730819	14	6.00085727	1	20	20	21	1092	781.019608
August													
16-Aug	7:15-9:45am	2.30	2.50	17	6.8	21	8.4	1	10	27	11	572	261.019608
18-Aug	8:45-10:15ar	1.30	1.50	6	4	1	0.66666667	2	1	4	3	78	-232.98039
19-Aug	9:20-10:02ar	0.42	0.70	2	2.85714286	6	8.57142857	3	5		8	138.666667	-172.31373
20-Aug	8:40-9:30am	0.50	0.83	4	4.80192077	4	4.80192077		2	6	2		
21-Aug	9:36-11:46ar	2.10	2.17			3	1.3844024			3	0		
26-Aug	8:20-10:20ar	2.00	2.00	10	5	7	3.5	2	6	9	8	208	-102.98039
27-Aug	8:30-10:30ar	2.00	2.00	7	3.5	1	0.5		2	6	2		
29-Aug	7:30-10:05ar	2.35	2.58	60	23.2261061	15	5.80652654	8	32	35	40	260	-50.980392
												Average	
												310.980392	