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Predator Management for the Protection of the Endangered California Least Tern (*Sterna antillarum brownii*) and Documentation of Bullsnake (*Pituophis catenifer*) Predation in San Diego County, California

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ABSTRACT: The endangered California least tern is a seasonal migrant that nests in colonies on coastal estuaries and beaches of California. A variety of native and non-native predators prey on nesting terns and have the potential to devastate nesting colonies. USDA APHIS Wildlife Services (WS) conducts an annual program to reduce predation and protect nesting terns. Management activities include monitoring and removing known and potential predators with the selective use of various trapping and removal techniques. The most common predators managed at nesting colonies include feral cats, striped skunks, Virginia opossums, California ground squirrels, common ravens, western gulls, American kestrels, and barn owls. However, during the 2003 nesting season, WS documented the loss of 61 least tern nests due to predation by bullsnakes at a colony at North Fiesta Island in Mission Bay, San Diego County. This paper gives an overview of the WS predator management program for the protection of the endangered least tern and describes the nature and management of predation by bullsnakes.

KEY WORDS: bullsnake, California least tern, endangered species, *Pituophis catenifer*, predator management, *Sterna antillarum brownii*

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INTRODUCTION

The California least tern (*Sterna antillarum brownii*; LETE) is one of three subspecies of least tern that breeds in North America, from April through August. The LETE once nested in large, loose colonies on beaches from Baja California, Mexico, north to the San Francisco Bay area (Patton 2002). The subspecies was listed as endangered under the federal Endangered Species Act on October 13, 1970 and under the California Endangered Species Act on June 27, 1971 (Keane 1997).

LETE historically nested on sandy beaches and salt flats along the coast of California. With the increasing human population and habitat loss due to urbanization, combined with predation by native and non-native birds and mammals, the population of least terns has declined and much of the traditional nesting has shifted to smaller colonies. Lacking size, power, or other effective individual defenses, adult terns protect their eggs and chicks by flocking and diving in mass at potential predators, often pelting the intruder with waste (Patton and Opdycke 2003). In this report I provide an overview of Wildlife Services predator management for protecting LETE and describe the predation incidents involving bullsnakes and the control measures implemented at a colony in Mission Bay, San Diego, CA.

PREDATOR MANAGEMENT

The USDA APHIS Wildlife Services Program (WS) has managed predation to protect the federally endangered California least tern at various nesting colonies along the coast of California since 1988. Since that time, much has been learned about the variety of animals that prey on LETE; the threat they pose to eggs, chicks, fledglings, and adults; and the management of predators

to prevent or minimize damage. Management activities included monitoring predator activity and using various trapping and removal techniques to eliminate known and potential predators from nesting colonies and surrounding properties. Like many ground nesting birds, LETE are susceptible to predation by a variety of native and non-native animals that can potentially devastate a colony in a relatively short period. Predation on LETE can be caused by a single individual predator, several individuals of a species, or a culmination of several incidents involving several different species that can occur at anytime during the day or night, depending on the depredating species.

Species Managed

The following are lists of mammalian and avian species recognized by WS as predators of LETE eggs, chicks, fledglings, and adults. WS has made no attempt to prioritize the species in any order of significance, due to the fact that each nesting site is unique and species vary from site to site and year to year.

Mammalian Predators

feral cat, *Felis domesticus*
bobcat, *Lynx rufus*
red fox, *Vulpes vulpes*
grey fox, *Urocyon cinereoargenteus*
coyote, *Canis latrans*
feral dog, *Canis domesticus*
raccoon, *Procyon lotor*
striped skunk, *Mephitis mephitis*
Virginia opossum, *Didelphis marsupialis*
longtail weasel, *Mustela frenata*
California ground squirrel, *Spermophilus beecheyi*
Norway rat, *Rattus norvegicus*

black rat, *Rattus rattus*
black-tailed jackrabbit*, *Lepus californicus*
cottontail rabbit*, *Sylvilagus auduboni*
*have caused indirect damage by trampling LETE nests and eggs

Avian Predators

common raven, *Corvus corax*
American crow, *Corvus brachyrhynchos*
American kestrel, *Falco sparverius*
peregrine falcon, *Falco peregrinus*
red-tailed hawk, *Buteo jamaicensis*
Cooper's hawk, *Accipiter cooperi*
northern harrier, *Circus cyaneus*
barn owl, *Tyto alba*
burrowing owl, *Athene cunicularia*
great horned owl, *Bubo virginianus*
loggerhead shrike, *Lanius ludovicianus*
great blue heron, *Area herodias*
black-crowned night heron, *Nycticorax nycticorax*
great egret, *Casmerodius albus*
gull-billed tern, *Sterna nilotica*
European starling, *Sturnus vulgaris*
western meadowlark, *Sturnella neglecta*
greater roadrunner, *Geococcyx californianus*
rock dove, *Columba livia*
gulls, various, *Larus* spp.

When known predators frequent nesting colonies, they are usually there to forage on what has drawn them into the area—in this case the LETE. As an opportunist, a predator's survival depends on its ability to seek out and exploit food resources while expending the least amount of energy and time. During the nesting season from April thru August, many predator species are also raising young, which makes them even more aggressive in their foraging activity. It is important to understand that once a predator has located a food resource (e.g., eggs, chicks), it will continue to utilize until it is exhausted or is removed.

Equipment Utilized

The principal equipment and techniques used to manage the above species include: cage traps, raptor traps (pole traps, bal-chatri traps, pigeon harness, bow nets), padded-jaw leg-hold traps, neck snares, conibear traps, snap traps, decoy traps, shooting, spotlighting/shooting, calling/shooting, gas cartridges, and the avicide DRC-1339. All trapping devices described are used in accordance with all applicable laws and regulations, which include Title 14, section 465.5 of the California Code of Regulations and Wildlife Services Directive 2.450 (sections 3a through 3d). These methods, techniques, and tools are applied at all sites. Their placement and usage is based on predator observations and sign found in and around LETE nesting colonies.

Besides using predator removal techniques, several methods can be employed to minimize and prevent predation on nesting LETE. Fencing around nesting sites can limit the amount of human disturbance and prevent access by certain predators, although it can also create excellent hunting perches for raptors. Chick fencing around nesting sites prevents dispersal of LETE chicks into unsafe areas (e.g., rip-rap, vegetation, water, etc.), but

it to can also increase predation because chicks tend to congregate on the edge of the fence. Prior to the implementation of these methods, the benefits and impacts should be considered carefully.

Predator Management Strategy

The WS predator management program for the protection of LETE follows a general set of guidelines established through strategies developed over the past 16 years. Typically, the timing of control efforts coincides with the LETE breeding stages (e.g., egg, chick, fledgling) (Butchko and Small 1992). The following guidelines are utilized in the management of the various mammalian and avian predators:

1. Due to the ability of mammalian and avian predators to disrupt LETE during site selection and nest construction, known and potential predators are removed prior to the arrival of the LETE in April. They are managed through the end of the breeding season, which lasts until the end of August. Predator management activities are conducted within the tern colonies and in surrounding areas to remove predators from the colonies, and to prevent them from entering the nesting sites.

2. Raptor management is initiated after LETE eggs have begun to hatch and the threat for predation exists. Non-lethal methods are applied whenever possible. The decision to lethally control any raptor is accompanied by documentation (e.g., visual observation, written or other communication) that the individual has caused, or is likely to cause depredation. Some species of raptors are listed by California Department of Fish and Game as "Species of Special Concern" (State of California 2002), and management of these species must be accompanied by documentation of predation and discussions with site managers, monitors, and other key individuals for a decision on their management.

3. WS responds to all predation incidents immediately following receipt of notification from site monitors that predation has occurred. This allows for the gathering of information from site monitors on locations, observations of possible predators, and information on the type of predation that has occurred (e.g. egg, chick, fledgling, adult). If possible, WS determines the predator species responsible by investigating the predation site, examining the damaged LETE remains, and identifying predator tracks and/or scat. After a determination of the predator responsible is made, an appropriate method is selected and implemented in an attempt to remove the offending predator.

4. A system of communication between site monitors and WS personnel is critical (Butchko and Small 1992). In many situations, the monitors are the only personnel that access the nesting colonies on a regular basis. During the monitoring process, site monitors are usually the first to document the presence of a predator in a colony and the first to identify depredated nests and LETE remains. When personal communication is not possible, site monitors use a log book to relay pertinent information regarding predator observations and nesting activities. Log books are also used to prepare year-end reports.

The preceding guidelines provide the framework for

implementing an effective predator management program. Since wildlife species are dynamic and readily adapt to the ever-changing environment, WS personnel must adapt and modify their strategies to manage predators.

PREDATION EVENT AT NORTH FIESTA ISLAND, MISSION BAY, SAN DIEGO

From April 14 through August 29, 2003, under a Cooperative Agreement, WS conducted predator management activities at three nesting sites: North Fiesta Island (NFI); Mariners Point; and Stoney Point located in Mission Bay, San Diego County, California. The NFI nesting site in this discussion encompasses 8.1 ha (20 ac) on the northeastern point of Fiesta Island and is the largest LETE nesting site within Mission Bay. The following general description of events that occurred from May 2003 to July 2003 led to the identification of bullsnakes as the primary predator of LETE nests and chicks at NFI.

On May 9, 2003, the site monitor reported that the first nest had been located at NFI. By May 15, 2003 there were 19 LETE nests established. On May 17, 2003, the site monitor reported the first nest predation incident. It was reported that one egg was missing from the nest. A WS biologist investigated the predated nest but was unable to find any evidence indicating the species of predator responsible. On May 21, 2003, the site monitor reported that additional nests had been located, bringing the total to 50 nests established. The monitor also reported that two additional LETE nests had been depredated by an unknown predator. On May 23, 2003, the site monitor reported that an additional nest had been depredated by a predator, and additional nests were located bringing the total to 58 nests established. In both cases, WS responded but were unable to locate any evidence as to the predator or predators responsible.

On May 24, 2003, WS discovered dog tracks within the NFI nesting site. In an attempt to remove this dog from the nesting site, cage traps were placed in the vicinity of the sign observed. On May 25, 2003, the site monitor contacted WS and reported that a feral dog was on the nesting site and that five additional nests had been depredated, bringing the total to eight. WS responded and observed a small, white terrier as it left the nesting site. None of the depredated nests showed any evidence as to the predator responsible, although the feral dog was suspected, as it was seen repeatedly on the site. On May 27, 2003, WS observed the feral dog within the site. After making several attempts to live capture the dog, it was removed by shooting. Although predation had occurred during this period, WS was unable to determine if this animal was responsible for the losses.

On May 26, 2003, while inspecting several depredated nests, WS observed a bullsnake (*Pituophis catenifer*) foraging in the nesting site. Due to this species' propensity to prey on eggs and chicks, the bullsnake was captured and removed from the nesting site. At that time there was no evidence that snakes had been involved in the earlier predation events. On May 27 and 29, 2003, the site monitor reported that eggs were missing from 12 nests. On May 29, 2003, additional cage traps were set in

the vicinity of the depredated nests to try and remove the offending predator.

From May 17 through May 31, 2003, the site monitor reported that 22 of the 93 LETE nests that had been established had been lost to unknown predators. WS inspected each of the depredated nests but due to the lack of evidence, a positive determination as to the predator responsible could not be made.

As a result of the predation events, WS continued to monitor the site for both avian and mammalian predators. To increase the effort in removing the offending predator, additional equipment was utilized to remove mammalian and avian predators, without success. However, on June 2, 2003, the site monitor reported observing a large bullsnake near a cage trap. The monitor also reported that 12 additional nests had been depredated by an unknown predator or predators, bringing the total to 34. WS personnel responded on June 2, 2003 but were unable to locate the bullsnake. On June 3, 2003, WS again searched the nesting site but were unable to locate any bullsnakes. With predation still occurring, and having recently removed one bullsnake, WS suspected that snakes were likely responsible for the depredated nests.

On June 4, 2003, three WS personnel performed a grid search of the nesting site. The search resulted in the location and capture of three bullsnakes from the colony. It was determined that all three snakes had distended stomachs. Suspecting that the stomachs were full of tern eggs, all three snakes were euthanized and necropsied. It was discovered that the two smaller snakes each contained two LETE eggs, while the larger snake contained six LETE eggs. As a result of this discovery, WS personnel determined that additional searches would be necessary to stop the predation. On June 5, 2003, WS performed another grid search of the nesting site and found three additional bullsnakes, two of which contained no evidence of LETE predation, but the third snake contained one large LETE chick.

On June 7, 2003, the site monitor reported that the total number of LETE nests had climbed to 101, and that an additional 16 nests had either hatched or been preyed upon by bullsnakes. This brought the total to 40 LETE nests that had been lost as a result of bullsnake predation. Following the removal of the bullsnakes, the site monitor continued to report depredated nests, and WS continued to respond to these events and concluded that bullsnakes were responsible for the predation events. On June 9, 2003, the site monitor reported that only 25 of the 101 nests that were established were active (e.g., contained eggs and were being tended by the adult LETE). By June 19, 2003, an additional 12 nests had been established for a total of 113, of which only 14 were active. The site monitor also reported that no predation had occurred during this time. On June 23, 2003, the site monitor reported that the total number of nests was now 118 and that 15 to 18 were active. The site monitor also reported low numbers of chicks being observed on site and suspected predation. On June 30, 2003, the site monitor reported to WS that the remaining nests (8 active nests and 8 abandoned nests) were gone, and the nest markers at 4 nests had been knocked over. WS inspected the missing nests and found human footprints near several of

Throughout the remainder of the nesting season, WS performed weekly grid searches of the nesting site to locate additional bullsnakes. Although dense vegetation made it difficult to locate additional snakes, one dead bullsnake was found on July 1, 2003. Following the loss of the remaining nests at NFI, monitoring for LETE activity continued at NFI until the end of July. On July 31, 2003, while collecting decoys and nest markers, the site monitor reported observing one large bullsnake in the center of the nesting site.

During the 2003 nesting season an estimated 6-10 fledglings were produced from 118 LETE nests at the NFI nesting site (G. Johnson, pers. commun.). It was reported to WS by the site monitor that bullsnakes were responsible for the predation of 61 of the 118 LETE nests produced, although only one LETE chick was confirmed lost to bullsnakes. The events described were the first predation events to be documented by WS involving bullsnakes and LETE.

Management Recommendations

The following recommendations should be implemented to prevent or minimize predation on the endangered LETE:

1. Current predator management efforts should continue to assist in the recovery of the federally-listed LETE. The period of control should start in early March and continue until the terns vacate the sites in late August.

2. At North Fiesta Island, the vegetation should be removed by mechanical control and herbicides applied to prevent the re-growth of vegetation on the site prior to the arrival of the LETE. The dense vegetation on the site may discourage the LETE from nesting and makes it difficult for monitors to locate LETE chicks. Dense vegetation also attracts a variety of predators (e.g., bullsnakes) and can make it more difficult to locate and manage certain predatory species.

3. The construction of a chick fence at the NFI nesting site should be considered. This would assist in locating the chicks and would also help prevent small mammalian predators from entering the nesting site.

4. Snake traps should be set using the chick fence as a drift fence prior to the arrival of the LETE in April. Both the snake traps and the drift fence should be maintained until the terns vacate in August.

5. Personnel should search the nesting site at least once weekly to locate and remove foraging bullsnakes.

6. The frequency of monitoring should be increased. Frequent and thorough monitoring of LETE breeding activities is a very important component of an effective predator management program. More often than not, site monitors are the first to detect a predation problem and are best able to relay this information quickly to those responsible for predator management.

SUMMARY

WS has conducted predator control to protect threatened and endangered species for the past 16 years. Since that time, the number of LETE has increased from an estimated 1,219 pairs in 1988 to 6,679 pairs in 2003. This accelerated increase in the population is a result of the refinements in monitoring and use of the predator

control efforts that began in the late 1980s (Patton 2002). Although there are many different opinions about predator management, the California Department of Fish and Game reports that the LETE population could not have reached over 4,000 pairs so quickly without the efforts of predator management (Keane 1997). Predation is the primary factor limiting the success of the LETE nesting along the coast of California, and predator management will continue to be critical to the recovery of this species.

Wildlife managers should be aware of the potential damage that can be caused by bullsnakes preying on nesting LETE. Bullsnake predation has been documented on nests of black-capped chickadees (*Parus atricapillus*) (Howitz 1986), cliff swallow (*Petrochelidon pyrrhonota*) (Thompson and Turner 1980), and waterfowl (Glup and McDaniel 1987, Imler 1945), and on long-eared owl (*Asio otus*) nestlings (Amstrup and McEneaney 1980).

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