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Western Snowy Plover Reproductive Effects Associated with the Refugio Beach Oil Spill

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ABSTRACT

During the May 2015 Refugio Beach oil spill, federally threatened western snowy plovers (*Charadrius nivosus nivosus*) were feeding with their recently hatched chicks on southern California beaches. They primarily forage on invertebrates in the wrack and wave-washed swash zone and were directly threatened by both the oil and the actions of the clean-up crews. During the spill, the extent and location of oiling observed on western snowy plovers at Coal Oil Point Reserve, in Santa Barbara, were documented. In addition, annual monitoring of reproductive success was conducted (i.e., number of nests, number of eggs laid, number of chicks fledged, etc.), contributing to data collected on this population since 2001. Although no direct mortality of western snowy plovers was observed during the spill, a spike in the percentage of infertile eggs was observed in the year following the spill. As part of the Natural Resource Damage Assessment, estimated oil ingestion rates were compared to exposures associated with reproductive harm in other avian oil toxicity studies. A plausible connection between oil ingestion via preening and feeding and the increase in egg infertility in western snowy plovers at Coal Oil Point Reserve was demonstrated.



Figure 1. Map of the spill origin, spill extent, and study location. Red triangles represent forensic matches to incident oil.

INTRODUCTION

On May 19, 2015, a break in the Plains All-American Pipeline Line 901 near Refugio State Beach, Santa Barbara County, California, resulted in crude oil entering the Pacific Ocean. Due to strong west winds, the oil primarily moved downcoast, heavily impacting beaches for several miles, and ultimately resulting in tar balls along some Ventura and Los Angeles County coastlines (Figure 1). At the same time, Western snowy plovers, a federally threatened shorebird, were in the midst of their breeding season, with many chicks recently hatched and foraging on sandy beaches (Figure 2). Snowy Plovers are among very few species that nest directly on sandy beaches, which makes them vulnerable to conflicts with human activity. Western snowy plovers forage on invertebrates that live in the beachcast wrack, and resource managers worked to protect the plovers from four different impacts: 1) direct exposure to the oil; 2) exposure via the ingestion of oiled prey; 3) the loss of wrack which serves as the primary habitat for their prey; and 4) disturbance by clean-up crews. This poster focuses primarily on the direct exposure and ingestion pathways. Please see Nielsen et al. 2017 for a summary of the full study.



Figure 3. Western snowy plover without oil on body and beak (top) and with oil on body and beak (bottom).

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Figure 2. Cleanup operations at Coal Oil Point Reserve occurred during nesting season for western snowy plovers.

METHODS

To study whether oil exposure through direct oiling and ingestion affected the population of western snowy plovers at Coal Oil Point Reserve (COPR), we collected: 1) standard annual breeding season data to assess the western snowy plover breeding population and nesting success; and 2) data to determine oil exposure during and following the spill. Standard annual data collection included counts of all adults, chicks, and nests, several times each week, to determine the number of nests, eggs per nest, hatches, and fledges. Eggs that did not hatch well beyond their expected hatch date were opened to determine whether the egg contained a dead embryo or was infertile. Plovers may become oiled by touching oil while walking on the beach, bathing in shallow water, or foraging in the beachcast kelp. To measure the amount of oiling on the plovers, we photographed each adult bird five times during a five-week period following the oil spill, and again two months later. Viewing each photograph on a large computer monitor, we examined and recorded the presence or absence of oil on beaks and feet for each image (Figure 3). To estimate the percent of the body oiling, the areas of the body that were oiled were digitized and were analyzed using ImageJ software. We also analyzed concentrations of 45 polycyclic aromatic hydrocarbons (PAH-45) in the tissues of beach hoppers [talitrids (*Megalorchestia spp.*)], which are prey for western snowy plovers. Finally, we conducted a literature review focusing on the effects of crude oil exposure to birds to assess possible effects related to direct oiling and ingestion exposure pathways. We conducted a screening level risk assessment using toxicity reference values identified in literature, and calculated oil exposure estimates by summing adult daily dietary and preening doses as follows:

$$\text{Daily Diet Dose (mg /kg /d)} = \frac{\text{C prey (mg/kg)} \times \text{IR prey (kg/d)}}{\text{Body Weight (kg)}}$$

C prey (mg/kg) = concentration of oil in prey as mg total PAH-45/kg food on a wet weight basis

IR prey (kg/d) = wet weight of food ingested by the bird each day

Body Weight (kg) = body weight of Snowy Plover

$$\text{Daily Preening Dose (mg /kg /d)} = \frac{\text{Mass of oil on body (mg)} \times \text{Proportion Ingested by Preening}}{\text{Body Weight (kg)}}$$

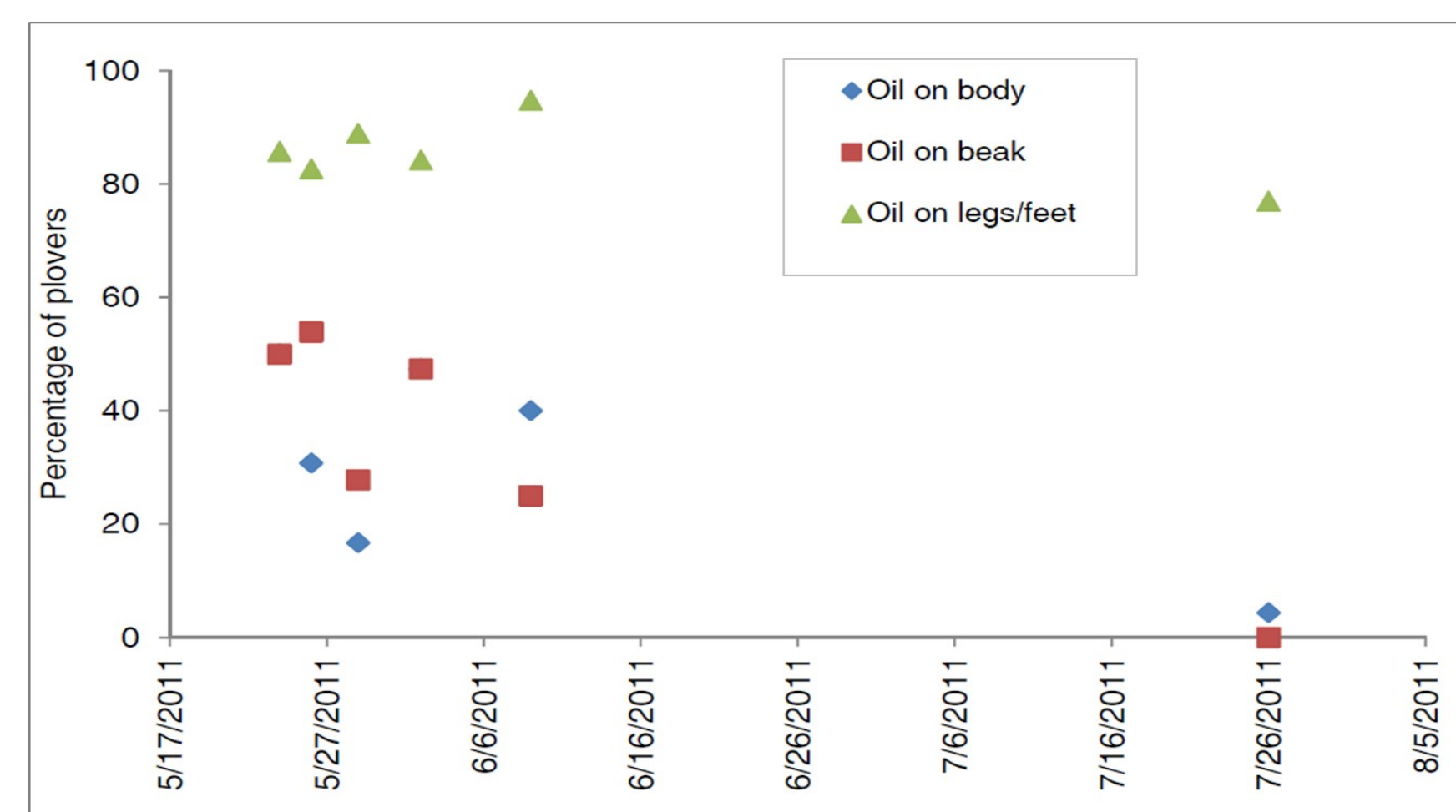


Figure 5. Results of photographic monitoring of western snowy plover oiling on body, beak, and legs/feet.

RESULTS

Population & Nesting: The population of adult western snowy plovers at Coal Oil Point Reserve remained around 20 pairs throughout May, June, and July 2015 (Figure 4, top). No mortality was observed; however, the small size, camouflaged plumage, and limited access to the nesting area, could have precluded the identification of carcasses. During the 2015 breeding season (March to August), 62 nests were laid and 34 nests hatched, resulting in an above-average hatching rate of 55% (COPR 2015).

Direct oiling: Photo surveys during and after the spill show that in the period following the spill through early June, the average percentage of western snowy plovers with oil on the body and beaks was 37% and 41% respectively. In late July, the percentage of western snowy plovers with oil on their body reduced to 4% and no plovers were detected with oiled beaks (Figure 5). The maximum body surface oiling was 15.7%.

Oil ingestion: Oil ingestion was estimated by combining exposure from food ingestion and preening, and resulted in a maximum dose of 40,279 mg/kg/day.

Toxicity literature: Fry et. al (1986) showed a negative relationship of external oiling of Santa Barbara crude oil on long-term fertility of wedge-tailed shearwaters (*Ardenna pacifica*). Based on this study, we derived a toxicity reference value of 5,000 mg/kg/day for adverse effects on reproduction.

Egg Infertility: The year following the spill (2016), the rate of egg infertility was 9.3%. This is more than four times the long-term average of 2.13% (between 2001 and 2015). In 2017, infertility was 3.95%, which is within the range of natural variation observed prior to the spill (Figure 4, bottom).

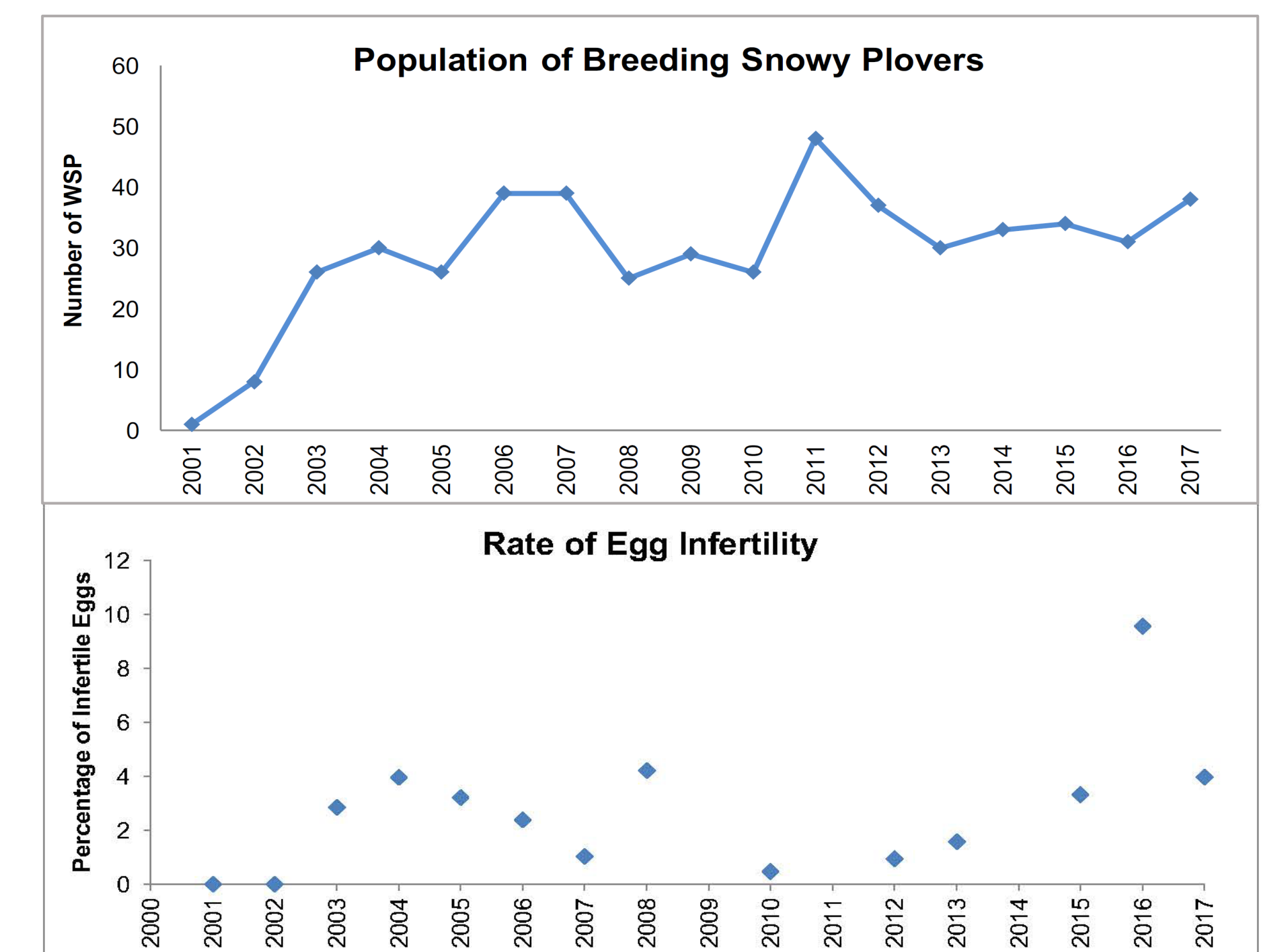


Figure 4. Top: number of breeding western snowy plovers at Coal Oil Point Reserve between 2001 and 2017. Bottom: percentage of infertile eggs at Coal Oil Point Reserve between 2001 and 2017. Source: COPR 2018

DISCUSSION & CONCLUSION

While there were no obvious indications of acute mortality of adult western snowy plovers as a result of the Refugio Oil Spill, this study demonstrates that the oil likely adversely affected western snowy plovers breeding at Coal Oil Point. Following the spill, over half of the plovers had oil on their body or beak, compared with extremely low observations of oil on the body and beak 6 weeks later. The disappearance of oil on beaks and plumage is likely due to preening, and we assumed 50% of preened oil was ingested, based on a preening study in ducks (Hartung 1963). We combined the preened oil with dietary ingestion via PAH-45 values measured in beach hoppers following the spill. This combined exposure from food ingestion and preening was estimated at 40,279 mg/kg/day. When compared to the toxicity reference value for adverse reproductive effects of 5,000 mg/kg/day derived from Fry et al. (1986), a hazard quotient of 8.1 was calculated. Ingestion of oil via preening and diet could explain the significant increase in the rate of infertile eggs in the 2016 nesting season, following the spill. Because over 70% of the season's nests were already laid by the time oil reached the beach in 2015, it is unlikely that oil ingestion affected infertility in that year. Instead, the effects manifested a year later, which was the first time most birds had laid eggs since the spill. This delayed effect of oil ingestion on infertility rates has been documented in other birds (Fry et al 1986). Because western snowy plovers at Coal Oil Point Reserve are not banded for identification, it was not possible to compare oiling on individuals to the fertility of those individuals in subsequent years. Despite the availability of fertility data for individual birds over time, a plausible connection between oil ingestion via preening and feeding and the increase in egg infertility in western snowy plovers at Coal Oil Point Reserve was demonstrated.