

Cooperation between Response Crews and Land Managers Protects Snowy Plovers during the Refugio Oil Spill

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ABSTRACT

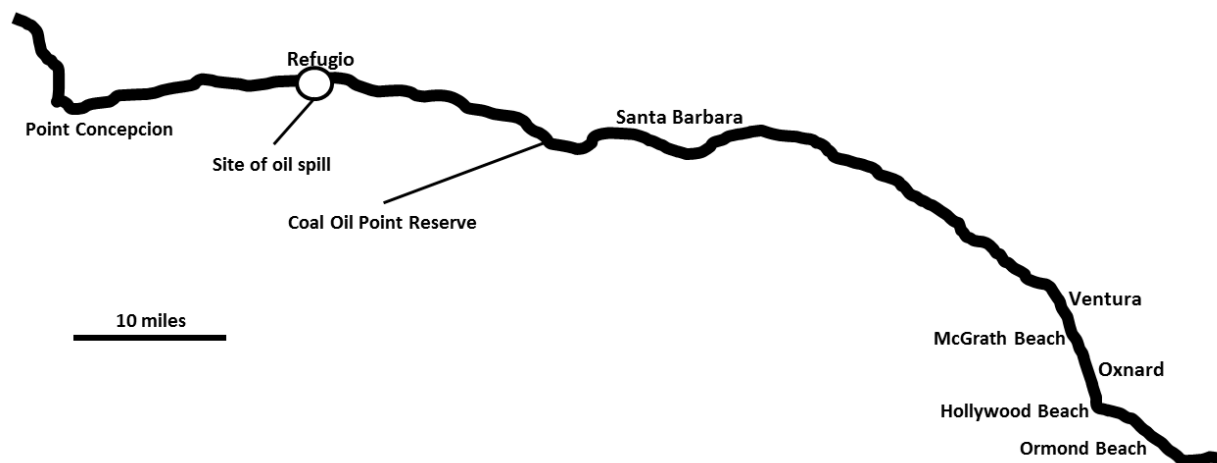
During the Refugio oil spill of May 2015 along the southern California coast, thousands of cleanup crews scoured beaches for oil, tar patties, and oiled wrack (washed-up kelp and seaweed). At the same time, federally threatened Western Snowy Plovers were feeding with their recently hatched chicks. Because they primarily forage on invertebrates in the wrack and wave-washed swash zone, they were directly threatened by both the oil and the actions of the cleanup crews. At several sites, land managers worked cooperatively to educate cleanup crews, monitor the birds, and develop cleanup strategies that balanced the benefits and impacts of the response actions. This included limiting the presence of cleanup crews to allow time for the birds to forage at regular intervals, and adopting techniques that left some unoiled wrack in place. This careful management served to minimize impacts to the birds. At Coal Oil Point Reserve, the effects of the oil and response actions on the nesting plovers and their chicks were closely studied. The results suggest that the oil and the presence of cleanup crews both affected the birds. The birds were directly oiled and suffered reduced fertility a year later. During the spill, nest attendance and feeding behavior were impacted by the presence of response crews. Careful management and coordination between biologists and response crews helps to minimize the negative effects of disturbance while achieving the benefits of removing oil from the beaches.

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 west, heavily impacting beaches for several miles, and ultimately resulting in tar balls along some Ventura and Los Angeles County coastlines.

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. Snowy Plovers are among very few species that nest directly on sandy beaches, which makes them vulnerable to conflicts with human activities. In the spill zone, there are several locations where plovers nest: Coal Oil Point Reserve (COPR) at University of California Santa Barbara, McGrath State Beach, Hollywood Beach, and Ormond Beach, and a few additional locations (Figure 1). The total breeding population for these beaches combined is typically 20 to 40 pairs. At each of the locations listed, they are closely monitored each year.

Figure 1: Map of oil spill site and affected Snowy Plover nesting areas



All of the beaches listed received tar balls and liquid oil in varying degrees during the spill. The maximum amount of oil observed by Shoreline Cleanup Assessment Teams (SCAT) ranged from heavy at COPR to very light at Ormond. The presence of cleanup crews corresponded to the degree of oiling (Table 1).

Table 1: Oiling and Response Activities by Beach

Beach	SCAT max oiling	Cleanup crews present
Coal Oil Point Reserve	heavy	9 of 20 days May 24 – June 12
McGrath	light	6 of 9 days May 31 – June 8
Hollywood Beach	light	7 of 9 days May 31 – June 8
Ormond Beach	very light	3 of 4 days June 4 – June 7

Because the plovers forage on invertebrates that live in the beachcast wrack, resource managers sought to protect the plovers from four different impacts: 1) direct exposure to 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 cleanup crews.

These goals led to tradeoffs between competing strategies. Cleanup crews remove oil from the beach, but also cause disturbance to both adult plovers and young chicks. Wrack

removal reduces the risk of exposure to oil, but also destroys their primary foraging habitat. Resource managers sought to balance these tradeoffs by intensive monitoring of the plovers and close communication with and education of cleanup crews.

This paper describes the results of this work specifically at Coal Oil Point Reserve.

METHODS

Cleanup efforts started at COPR on May 24 after the staff at COPR determined that there was enough oil on the beach to warrant cleanup. Cleanup crews were used at COPR on May 24-29, and June 8, 11, and 12. The crews were briefed at the beginning of each day and a crew of 20 individuals was broken into smaller groups of 5. Each small group worked on a 100-meter section of the beach.

Individuals from the crew were given a rake, a shovel, and plastic bags. They were instructed to remove only tarballs and kelp containing oil, and to leave clean kelp on the beach. Minimizing the amount of beachcast kelp removal protects the invertebrates that live in it, which are the primary food for plovers. At Ormond Beach, oiled kelp was hand clipped with scissors, leaving the unoiled kelp on the beach. Cleanup crews at COPR raked oil and tarballs along the high tide line and formed small piles, while another individual shoveled the oiled sand into plastic bags. The bags were then carried out by hand and removed from the beach. Vehicles were not allowed on the beach. At COPR, crews left clean pieces of kelp behind and collected new clean kelp found at the ocean's edge and deposited them at the high tide line.

On a normal day at COPR, volunteers ask people to stay away from the fenced nesting area and walk along the ocean's edge. This reduces the disturbance from beach goers on nesting and foraging behavior. To reduce the impact of the oil spill cleanup activities on the plovers, each cleanup crew was supervised by an observer, a biologist, or a volunteer birder. A map with

all the nest and chick locations was given to each observer and the supervising biologist assigned each observer to nests and chicks to observe. The observers asked the crew to move away if the females incubating the nest left the nest for more than five minutes. After the female returned to the nest, the crew was allowed to come back, often with fewer crew members to avoid another disturbance.

To study whether the oil spill or cleanup efforts affected the population of plovers at COPR, we counted all individuals, adults, chicks, and nests, several times each week, during the entire breeding season in 2015. The counts were made by an observer using binoculars and scope. The beach at COPR is narrow, so the observer can easily count by walking along the wet sand while looking towards the upper beach where the nests and chicks rest. The COPR staff has surveyed the plover population three times a week every breeding season since 2000. This data is available in annual reports.

During the last three cleanup days in June, COPR staff did not interfere with the cleanup efforts in order to study how the cleanup activities affected the plovers. Instead, the observers recorded the time that an incubating plover was on and off the nest on days with or without crews at approximately the same time of the day and under the same weather conditions. If the cleaning activities affected incubating behavior, we expected that the nests would be left unattended more often and for a longer duration than when the crews were present. Table 2 shows the observation periods with and without cleanup crews. The nesting area of COPR is marked every five meters with a post and number so the locations of nests and crews can be noted.

Table 2. Observation periods by observers during the study of incubation behavior of plovers with and without a cleanup crew on the beach.

Day	With Cleanup	No Cleanup crew	Meter mark of focal nest	Notes
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	crew			
6/8/2015	12:45 PM-14:40 PM	14:45 PM-15:20 PM	Nest 423	Groups of 5 crew members every 100 meters. Working 20-30 m from fence.
6/8/2015	12:40 PM-14:40 PM	---	Nests 277, 278, 287, 297	Groups of 5 crew members every 100 meters. Working 20-30 m from fence.
6/10/2015	---	14:05 PM-15:10 PM	Nest 423	
6/11/2015	9:40 AM-10:35 AM	10:40 AM-11:00 AM	Nest 423	Groups of 5 crew members every 100 meters. Working 10-20 m from fence.

We also conducted observations of plovers that were not incubating. These were single adults or adults already with hatched broods. Again, we repeated the observations during similar periods with and without cleanup crews present. During the observation periods (Table 3), we recorded the behaviors of any adult or chick within sight of two 100 meter sections of the beach every five minutes. The behaviors recorded were B (brooding), FD (feeding), FL (flying), FT (fighting), S (standing), W (walking), or M (mating). We also recorded if the Snowy Plover was a chick or adult, the weather condition, and made notes on the occasional natural disturbances, the location of the crew, and the number of crew members.

Table 3. Observation periods by 2 observers to study behavioral differences of plover adults and chicks with and without a cleanup crew on the beach.

Day	With Cleanup crew	No Cleanup crew	notes
6/10/2015		14:05 PM-15:10 PM	
6/11/2015	9:45 AM-10:50 AM	11:20 AM-11:55 AM	22 crew members working near ocean edge, 30-40 m from plover fence
6/11/2015	9:40 AM-10:35 AM	10:40 AM-11:00 AM	22 crew members working near ocean edge, 30-40 m from plover fence
6/12/2015		13:20 PM-14:20 PM	
6/12/2015		13:20 AM-14:20	

		AM	
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Unlike birds that dive in the water, 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 for 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. To estimate the percent of the body oiled, the areas of the body that were oiled were digitized and were analyzed using ImageJ software. Because the photographs typically captured just one side of a bird, the estimated area of body oil is for one side of the bird only.

Each year, plover eggs that do not hatch are opened to determine if they were infertile (yolk intact), or had dead embryos. This procedure was continued during the oil spill season (2015) and the following year (2016).

For each individual nest observed during the nest disturbance study, the average number of times/hour the parent left the nest was calculated, as well as the average number of minutes/hour the parent stayed off the nest. Overall, a total of five focal nests were included in these analyses. Tests for normality and homogeneity of variance of both datasets indicated that parametric analysis of variances (ANOVA) were appropriate. The final analysis used a Student's t-test to determine the effect of the two treatments (with or without crew) on the number of nest disturbances and time away from the nest.

ANOVAs were used to test the effects and interaction effects of crew presence, date, and observer on behavior counts. Because there were no effects of date or observer, these variables were removed from the model. The final analysis used Student's t-tests to determine the effect of the two treatments (with or without crew) on average counts of all behaviors observed during an

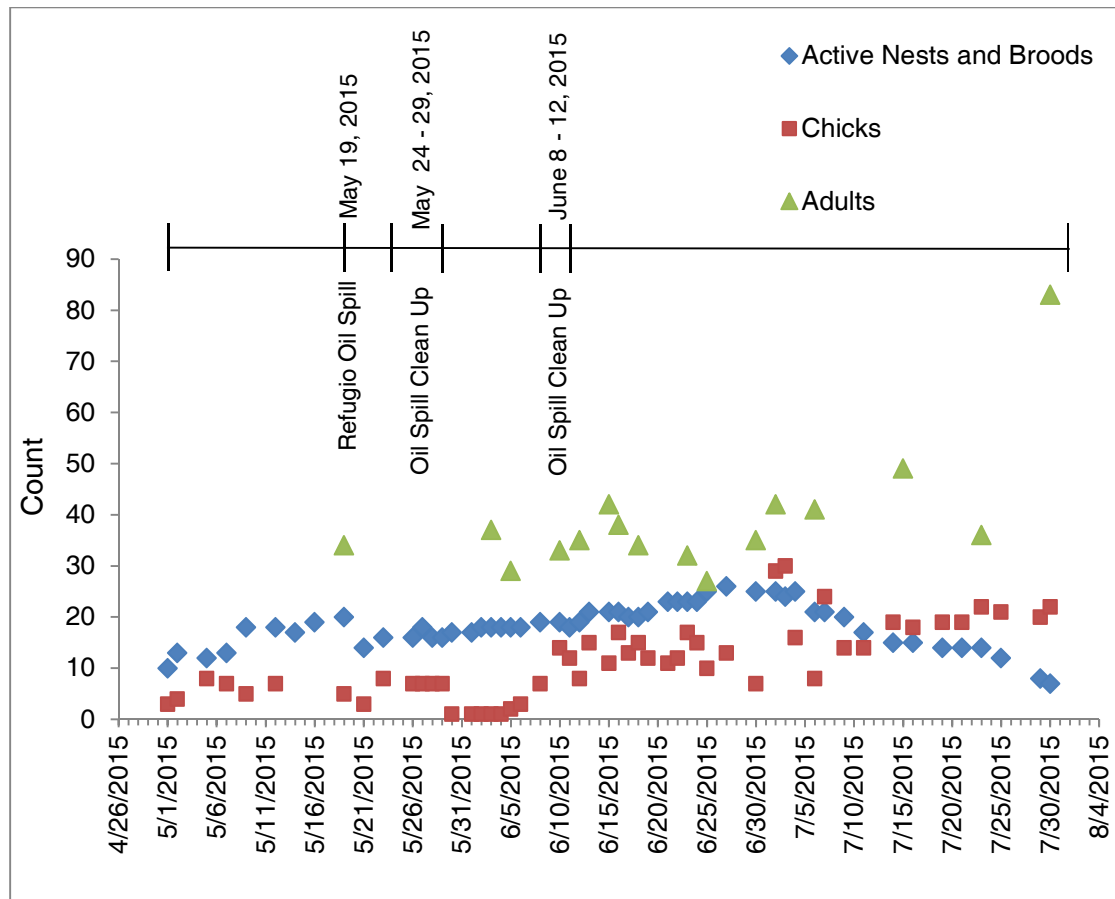
observation period. Data from June 10 was eliminated because only one of the two focal areas was observed on that date. In order to eliminate unusual confounding factors in our analyses, observations were excluded if a hawk, vulture, or unleashed dog was present in the focal area. Data were analyzed using JMP version 12.0.1.

RESULTS

Population

The oil spill occurred within the first month of the Snowy Plover breeding season and the clean up continued through the first half of the season. Figure 2 illustrates the timeline of the oil spill in relation to the population counts of plover adults, chicks and nests. The adult count includes males and females, whether they are incubating or not. The chick count includes any chick before fledgling age. The active nests and brood count includes the number of nests with eggs plus the number of males with chicks. The population of adult Snowy Plovers at COPR remained around 20 pairs throughout May, June, and July. It was not possible to track if any individual died because the observers did not enter the fenced nesting area to avoid disturbing the nests and chicks. Additionally, the small size and camouflaged plumage of Snowy Plovers makes discovery of a carcass difficult. Finally, because these plovers are unbanded, individuals could not be tracked.

Figure 2: Snowy Plover adults, chicks, and broods at COPR May through July 2015



Nest Attendance

The presence of the cleanup crew appeared to influence the behavior of nesting parents. We investigated two metrics: (1) the number of times a parent fled their incubating nest and (2) once disturbed, the amount of time a parent remained off their nest.

Snowy Plovers were twice as likely to leave their nest during oil spill cleanup (Figure 3). The Student's t-test shows that the average number of nest disturbances per hour with cleanup crew (4.1551 ± 0.65888 , $M \pm SE$) was significantly higher than during the period without a cleanup crew (2.0825 ± 0.3274), ($t_8 = -2.8171$, $P = 0.0226^*$) (Table 3).

Figure 3. Average number of times Snowy Plovers left their nest per hour. Data are means ± 1 standard error.

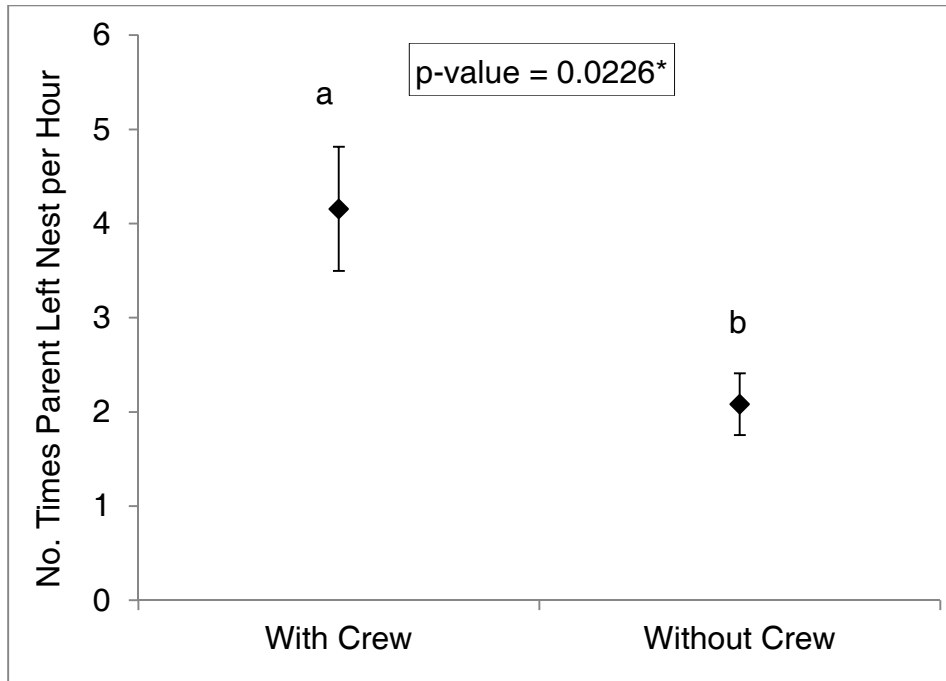


Table 3. Student's t test of the effect of crew presence on the average number of times Snowy Plovers left their nest.

Group	N	Mean number off nest	SD	Std Err Mean	DF	t-ratio	p-value
With Crew	5	4.16	1.4733	0.65888	8	-2.817	0.0226*
Without Crew	5	2.08	0.73211	0.32741			

Nesting Snowy Plovers remained away from their nest nearly three times longer when the cleanup crew was present (Figure 4). During the oil spill cleanup, the length of time the Snowy Plovers spent away from the nest was significantly higher (8.2519 ± 1.8916) than when cleanup crews were absent (3.0213 ± 0.7066), ($t_8 = -2.5904$, $P = 0.0321^*$) (Table 4). There were no observed nest or brood abandonments.

Figure 4. Average number of minutes Snowy Plovers remained away from the nest per hour. Data are means \pm 1 standard error.

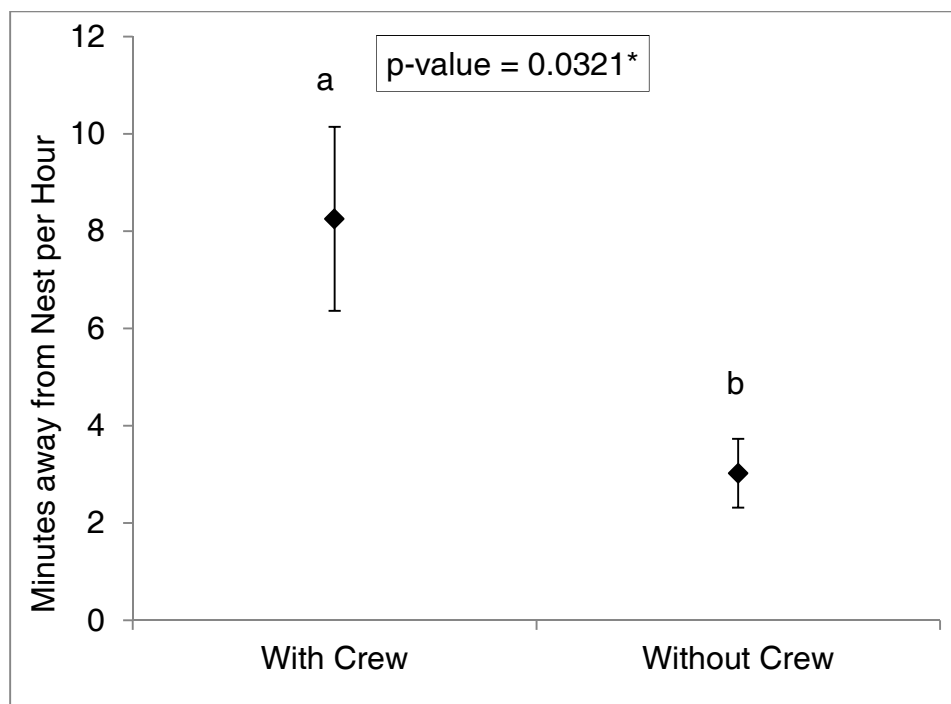


Table 4. Student's t test of the effect of the crew presence on the average time the Snowy Plovers remained away from the nest.

Group	N	Mean minutes off nest	SD	SE Mean	DF	t-ratio	p-value
With Crew	5	8.25	4.22969	1.8916	8	-2.5904	0.0321*
Without Crew	5	3.02	1.5801	0.7066			

Feeding Behavior

Snowy Plovers were approximately eight times less likely to feed when cleanup crews were present (Figure 3). An average of 0.43 plovers fed per observation when crews were present, compared to 3.43 when crews were not present (Table 5).

Figure 5. Average number of plovers feeding per observation.

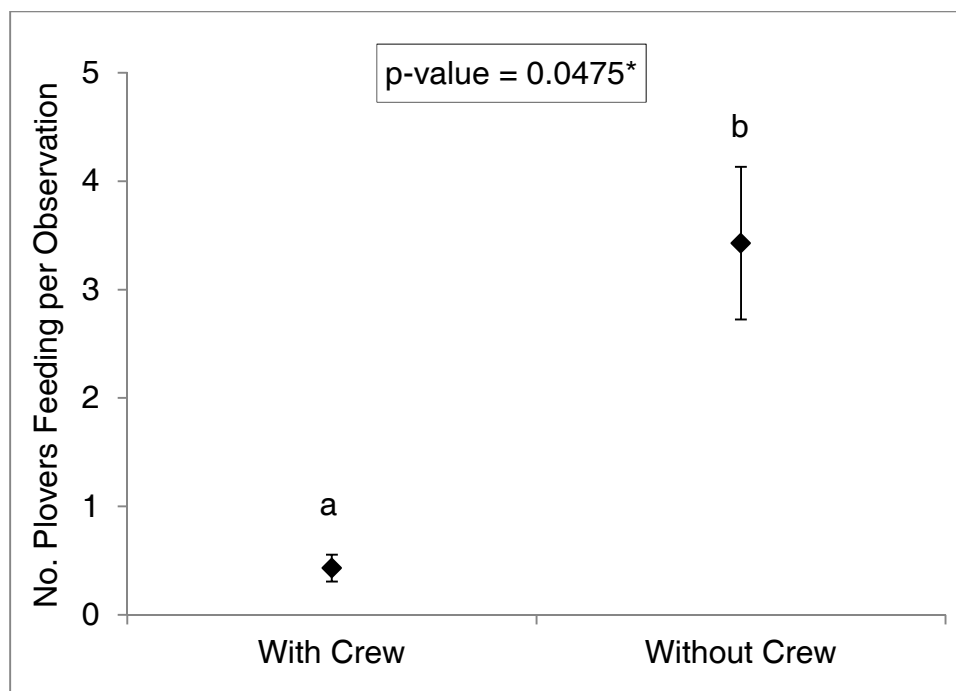


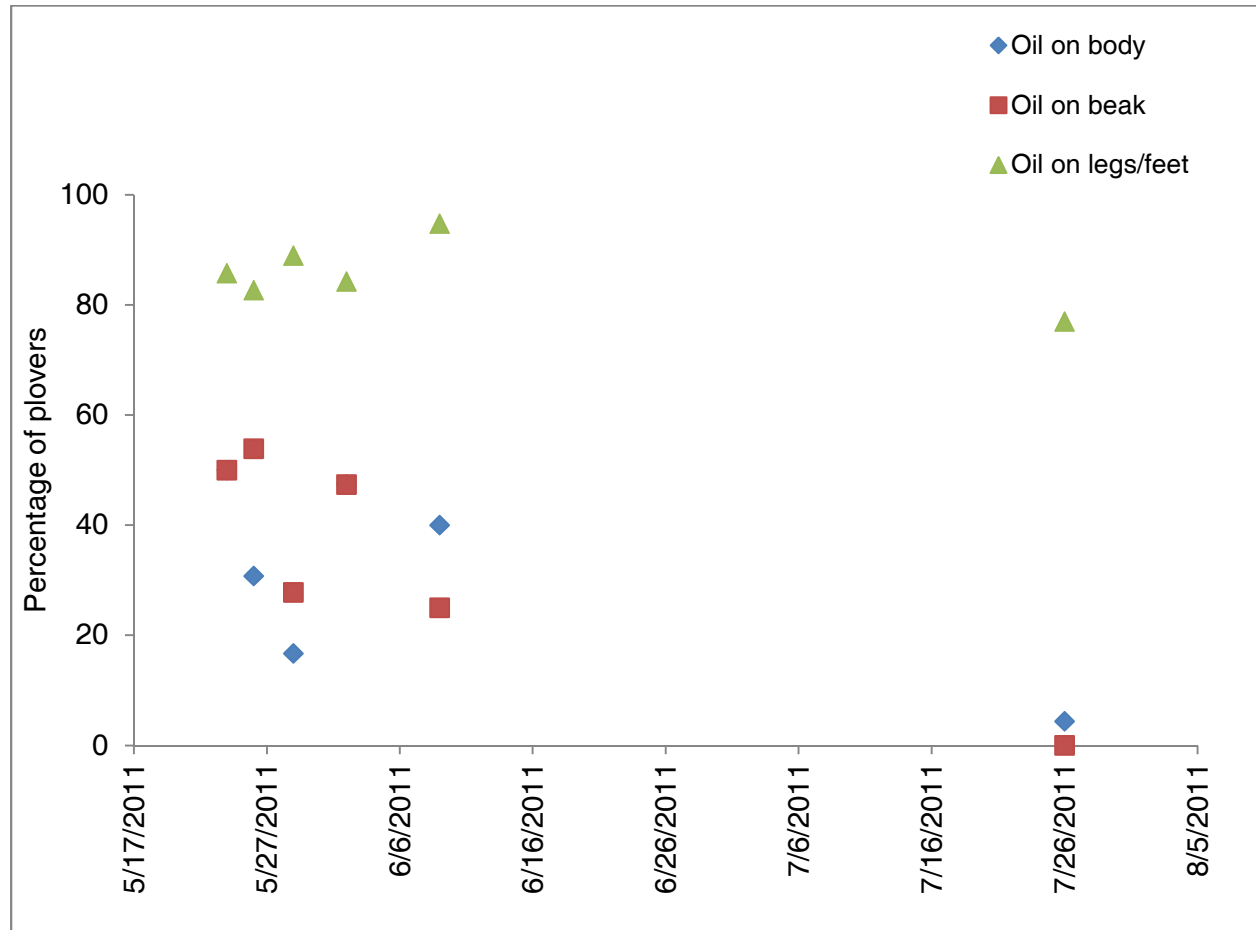
Table 5. Student's t test of the effect of crew presence on the average count of Snowy Plovers feeding at a given time.

Group	N	Mean # plovers feeding	SD	SE Mean	DF	t-ratio	p-value
With Crew	2	0.43	0.17527	0.12393	4	2.82644	0.0475*
Without Crew	4	3.43	1.41005	0.70502			

Oiling

Photo surveys conducted during and after the spill show that more plovers were oiled following the oil spill (Figure 6). In the period following the oil spill through early June, the average percentage of Snowy Plovers with oil on their body and beaks was 37% and 41%, respectively. In late July, the percentage of Snowy Plovers with oil on their body reduced to 4%, and no plovers were detected with oiled beaks. In previous years, no oil had ever been detected on the body of a plover. The percentage of Snowy Plovers with oil on their feet remained similar with 87% during the spill period and 76% in late July.

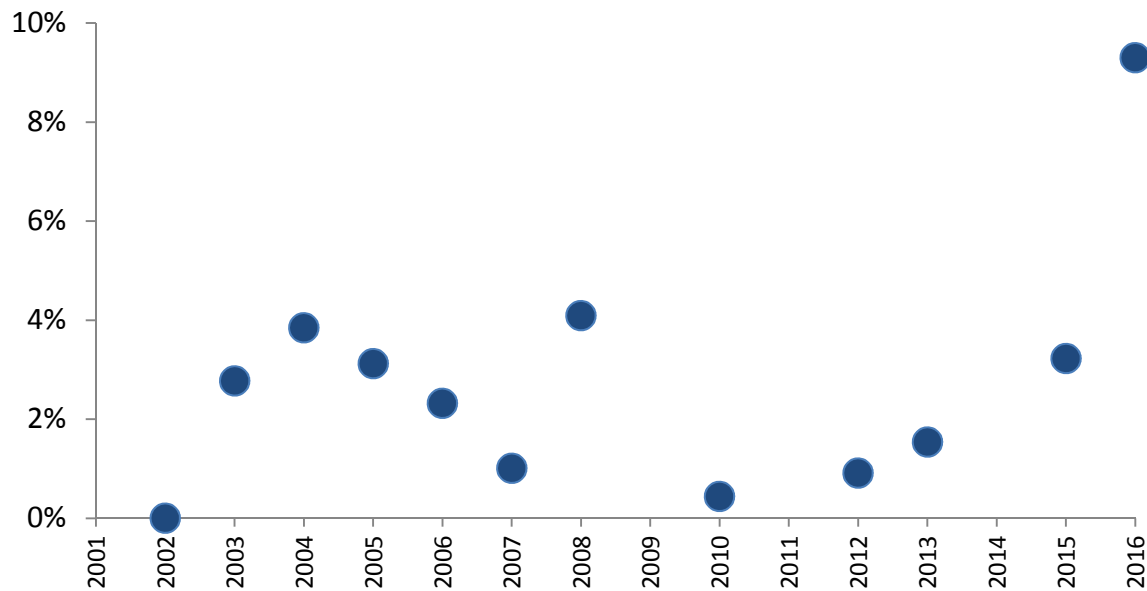
Figure 6. Percentage of plovers at COPR showing oil on the body, beak, or feet during and after the Refugio oil spill.



Fertility

Figure 7 shows the percent of eggs that were infertile each year. Twelve eggs of 129, or 9.30%, were found to be infertile in 2016. From 2001 through 2015, only 38 of 1,785 eggs, or 2.13%, were infertile, suggesting a four-fold increase above the long-term average.

Figure 7. Egg infertility rate among Snowy Plovers at COPR, 2001-2016.



DISCUSSION

While there were no obvious indications of acute mortality of adults as a result of the spill, this study demonstrates that both the oil and the response actions nevertheless still affected the Snowy Plovers nesting at COPR. Following the spill, over half of the plovers had oil on their body or beak (Figure 6). The oil on the beak and body disappeared after about six weeks, probably as a result of preening. Interestingly, the oil on the feet remained after three months. This could be because plovers do not preen their feet or because the small amount of tar often present at COPR from natural seeps continued to contaminate their feet, even after the oil from the spill was gone. The data clearly shows a peak of oiling following the oil spill, an indication that the excessive oil was from the spill and not from the typical natural tar. Because nearly all preened oil is ingested, ingestion of oil could explain the significant increase in the rate of infertile eggs in the following 2016 nesting season (Figure 7). 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 were felt 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; Vidal and Dominguez 2016).

In response to cleanup crews, adult plovers spent more time away from their nests and each time they were away, they spent a longer time before returning (Figures 3 and 4). Chicks and adults spent less time foraging when cleanup crews were present (Figure 5). This is not surprising, as they primarily forage on the wet sand where the cleanup crews were working. As the workers approached, parents would call the chicks and move high up the beach, deep into the nesting area, to get away from the crews. Disturbances were minimized, however, because land managers watching the birds staggered the timing of the cleanup crews to provide the birds with intermittent foraging opportunities. Assessing the long-term consequences of reduced feeding and reduced adult nest attendance on the future survival of chicks and adults was beyond the scope of this study, however previous studies have shown that reduced foraging time has negative effects on fitness of shorebirds (Baker et al. 2004; Burger 1991; Puttick 1979). Presumably, such effects were somewhat mitigated in this instance, as evidenced by the relatively stable population in 2016.

CONCLUSIONS

Despite the impacts documented here, disturbances caused by cleanup crews were reduced due to the close coordination between bird biologists and cleanup crews. There are clearly pros and cons of sending responders into environmentally sensitive sites, such as an active bird nesting colony. Each situation should be carefully examined to evaluate the tradeoffs, with method of cleanup customized with the goal to minimize impacts to fragile ecosystems and rare species.

This study also has implications for Snowy Plovers nesting in close proximity to recreational activities. The reduction of feeding and disturbance to nesting adults from beach recreation could be similar to that documented here.

REFERENCES

- Baker, Allan J., Patricia M. Gonzalez, Theunis Piersma, Lawrence J. Niles, Ines de Lima Serrano do Nascimento, Philip W. Atkinson, Nigel A. Clark, Clive DT Minton, Mark K. Peck, and Geert Aarts. 2004. Rapid population decline in red knots: fitness consequences of decreased refuelling rates and late arrival in Delaware Bay. *Proceedings of the Royal Society of London, Series B: Biological Sciences*, 271(1541), 875-882.
- Burger, J. (1991). Foraging Behavior and the Effect of Human Disturbance on the Piping Plover (*Charadrius melodus*). *Journal of Coastal Research*, 7(1), 39-52.
- Fry, M.D., J. Swenson, L.A. Addiego, C.R. Grau, and A. Kang. 1986. Reduced reproduction of wedge-tailed shearwaters exposed to weathered Santa Barbara crude oil. *Archives of Environmental Contamination and Toxicology* 15: 453-463.
- Puttick, G. M. 1979. Foraging behaviour and activity budgets of Curlew Sandpipers. *Ardea*, 67(11), 1-122.
- Vidal, M., & Domínguez, J. 2015. Did the Prestige oil spill compromise bird reproductive performance? Evidences from long-term data on the Kentish Plover (*Charadrius alexandrinus*) in NW Iberian Peninsula. *Biological Conservation*, 191, 178-184.