

STATUS OF THE WESTERN SNOWY PLOVER IN COASTAL LOS ANGELES AND ORANGE COUNTIES, CALIFORNIA

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ABSTRACT: From 2004 to 2021 we monitored the Western Snowy Plover (*Charadrius nivosus nivosus*) in coastal Los Angeles and Orange counties, California. Following an absence of 68 years, it returned to nest in 2017. Since then, the plovers have nested at three locations in Los Angeles County and four in Orange County, where numbers of nests at Anaheim Bay, Bolsa Chica State Beach, and Huntington State Beach increased. Protective beach management and nest enclosures presumably contributed to the increase of nests and hatching success at these sites. However, the number of nonbreeding Snowy Plovers in coastal Los Angeles County has declined, most steeply at Zuma Beach. At nonbreeding roosts in Orange County numbers at Balboa Beach and San Onofre State Beach declined, but countywide numbers were stable. All sites at which plovers roost experience human-related disturbance, which may include vehicles driving through them regularly, beach grooming that removes wrack and foraging resources, dogs chasing and flushing roosting plovers, and nearby large recreational events and summer camps as nonbreeding plovers return in July. Most sites lack consistent protective measures. Plover mortality has resulted from vehicle strikes and dogs. We recommend management that includes the establishment of special protection zones, restrictions on sand grooming, wrack removal, and vehicle traffic, and installation of protective enclosures around roost sites.

Historically, the Western Snowy Plover (*Charadrius nivosus nivosus*) nested on beaches throughout Los Angeles and Orange counties (Grinnell and Miller 1944, Page and Stenzel 1981, Allen et al. 2016). Known historical nesting sites in Los Angeles County included Malibu, Santa Monica, Ballona (Venice/Marina Del Rey), Los Angeles (today's Playa del Rey and Dockweiler State Beach), Manhattan Beach, and Redondo Beach (Allen et al. 2016). Densities were once high: in 1903, a collector noted 50 pairs along a 2-mile segment between Santa Monica and Ballona (U.S. National Museum of Natural History egg set 31481, Page and Stenzel 1981) and six nests among Least Terns 8 km north of Malibu (possibly Zuma Beach) (Western Foundation of Vertebrate Zoology egg set 3497, Page and Stenzel 1981). Before 1940, plovers nested in Orange County at Anaheim Landing, Sunset Beach bay fill, Sunset Beach, Bolsa Chica beach and salt flats (Bolsa Chica Ecological Reserve), Newport Beach, and Balboa Beach (Page and Stenzel 1981, Stenzel

et al. 1981). During their 1978–79 survey, Page and Stenzel (1981) found that Orange County supported 2% of the pairs on the mainland coast of California, all at the Bolsa Chica oil fields (previously Bolsa Chica salt flats, currently Bolsa Chica Ecological Reserve). They concluded that the only other likely nesting location was at the Sunset Aquatic Park and that the lack of nesting plovers elsewhere was due to beach raking and heavy human use (Page and Stenzel 1981).

By 2021, the greater Los Angeles metropolitan area straddling these two counties had 13 million residents (<https://www.census.gov/data/tables/time-series/demo/popest/2020s-total-metro-and-micro-statistical-areas.html>), and it hosts millions of tourists annually. Beach recreation is widespread, and much of the coastline is developed for recreational and residential use. Human use of sandy beaches brought disturbance from development and recreation, introduced predatory domestic animals, and provided anthropogenic food sources for native and non-native predators. Beach recreation in this region entails a suite of activities for public safety and sanitation, including vehicular beach patrols and mechanized sand grooming. All these factors deterred plovers from nesting. From 1949 to 2016, there were no documented cases of a Snowy Plover nesting in coastal Los Angeles County (Page and Stenzel 1981, Allen et al. 2016). However, there was no comprehensive survey of suitable beaches in that county from the 1970s to 2004 (G. Page pers. comm. 2010, Ryan et al. 2010). Subsequently, monitors detected single pairs nesting in dunes at Balboa Beach in 2008, 2009, and 2013, then nesting resumed more widely in both counties in 2017 (Ryan et al. 2019).

Nonbreeding roosting and foraging represent another important stage of the plover's annual cycle, which on southern California beaches extends from July to March. The beaches in coastal Los Angeles and Orange counties support up to 11% of the population wintering along the U.S. Pacific coast (USFWS unpubl. data). As during nesting, human activities' chronic disturbance of the plovers at these roosting areas reduces time for foraging, resting, and preening, increases energy expenditures, and eliminates potential habitat. For some individuals, these energetic costs could lead to increased mortality by starvation and predation (Davidson and Rothwell 1993, Burger 1997, Pfister et al. 1998, Harrington 2003) and abandonment of winter roosts (Mitchell et al. 1989).

Although they ceased nesting for 68 years in coastal Los Angeles County, nonbreeding plovers continued wintering on the county's sandy beaches. Surveys of nonbreeding roosts from 1979 to 1985 by Page et al. (1986) found a yearly average of 105 plovers in Los Angeles County and 27 in Orange County. In addition, the Santa Monica Bay Audubon Society (unpubl. data) surveyed Los Angeles County from 2004 to 2006 and found 260 to 334 wintering plovers.

Factors contributing to the degradation of winter roosting habitat and the extirpation of the nesting population include vehicles regularly driving through roosts, grooming of beaches, dogs chasing and flushing roosting plovers, large recreational events and summer camps near roost sites when the plovers return in July, and continuing coastal development. In Los Angeles County, all beaches where plovers roost, except Malibu Lagoon State Beach, are groomed daily. In Orange County, Surfside, Sunset, and Salt Creek beaches

are groomed. Daily beach grooming removes microhabitats favorable for nesting and likely destroys plovers' nest scrapes and eggs (Page et al. 2009). While removing trash, beach grooming also removes naturally occurring kelp and wrack. This drastically reduces the population of invertebrates adapted to breaking down kelp, including many of the plover's favored prey (Dugan et al. 2003, Page et al. 2009).

Dugan and Hubbard (2009) found a positive correlation between the plover's abundance, the mean cover of wrack, and the abundance of wrack-associated invertebrates on southern California beaches. Furthermore, Dugan (2003) and Dugan and Hubbard (2009) demonstrated that grooming increases the rate of beach erosion, increasing the need for sand replenishment. Human development of the upper beach habitat removes cover and foraging resources and brings domestic animals—cats and dogs that prey on plovers. Besides killing plovers outright, vehicular traffic crushes the kelp, vegetation, and wrack supporting the plover's prey and regularly flushes resting plovers from their roosts. Sunbathing, swimming, dog walking, exercising, and playing sports, ~53 million and 37 million people per year visit Los Angeles and Orange County beaches, respectively (County of Los Angeles 2023, Dwight et al. 2007). Requisite support services, such as police and lifeguard patrols, water-quality monitoring, erosion control, and trash collection, entail driving vehicles on the beach. Human activity also favors native predators, especially the American Crow (*Corvus brachyrhynchos*).

The U.S. Fish and Wildlife Service listed the Pacific coast population of the Western Snowy Plover as threatened in 1993 (USFWS 1993) and completed a recovery plan in 2007. Its goals include protecting wintering plovers and increasing the breeding population of Recovery Unit 6 (Los Angeles, Orange, and San Diego counties) from the 2005–2009 average of 243 to 500 (USFWS 2007, unpubl. data). In June 2012, the USFWS revised its designation of critical habitat for the plover to include six beaches in Los Angeles County and three in Orange County (USFWS 2012). The Snowy Plover is also a California bird species of special concern (Shuford and Gardali 2008).

In our study on Los Angeles and Orange County beaches, we documented (1) the year-round patterns of the plover's attendance at its main nonbreeding roosts, (2) the sizes and locations of these roosts, and (3) nesting. We also describe our efforts to monitor and protect nests and recommend means for improving the protection of nests and winter roosts.

METHODS

Our program comprised three types of surveys: comprehensive county-wide coastal surveys covering all suitable sandy beaches four times per year, monthly surveys of the main roost sites (Figure 1) during the other eight months, and nest surveys at the main roosts from April to July. The county-wide surveys reveal any changes in the location of main roosts or potential breeding pairs away from known roost locations. County-wide and roost surveys yield an overall estimate of the population and track trends from month to month and year to year. Surveyors consisted of both biologists with permits from the USFWS and trained community volunteers. In addition, permitted biologists searched for nests.

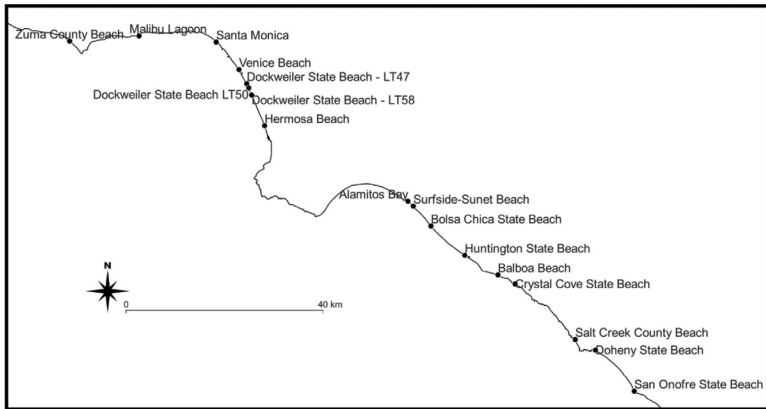


FIGURE 1. Main beaches for roosting and nesting of the Snowy Plover in Los Angeles and Orange counties, California.

Following recommendations from the draft recovery plan (USFWS 2007) and the Western Snowy Plover Winter Window Survey Protocol (Elliott-Smith and Haig 2006), volunteers and biologists walked a pre-defined segment of beach. Most surveys were completed during the morning on rising tides under suitable conditions; surveyors were instructed not to survey during rain, heavy wind, or atypically cold mornings. Surveyors walked beaches in one direction, typically with the sun at their back. They searched the sand visually and with binoculars, stopping approximately every 30 meters to scan for plovers. Surveyors walked alongside each other on broad beaches and/or zigzagged. We used standardized datasheets, and surveyors marked the presence of plovers and the area covered on a map or aerial photograph. Data recorded on each survey included the number, location, and sex of all plovers, color band combinations, each survey's time and weather conditions, the presence of dogs on and off leash, any unusual tarballs or oiling, the presence of vehicles and beach-grooming equipment, and the presence of potential diurnal predators. Volunteer observers did not always record all data requested.

During the breeding season surveys, surveyors noted breeding behaviors such as copulation, nest construction, incubation, or signs of agitation such as a broken-wing display. They mapped all detections of plovers and their nests on either paper maps or with the GPS.

We did not survey rocky or cobble shorelines at Malibu, Palos Verdes, Laguna Beach, San Juan Capistrano, and San Clemente or where the high tide reaches cliffs and house pilings. Neither did we survey in the shipping ports of Los Angeles and Long Beach or marinas at Marina del Rey, Newport, and Dana Point.

Countywide Surveys

Completion of countywide surveys relied primarily on community volunteers, often working in teams, and trained by biologists. They surveyed

from January to April in 2007, then switched to January, March, May, and September from 2008 to 2021. Volunteers recorded the same information described above and recorded the level of human activity at each beach, such as numbers of walkers, joggers, and persons engaged in other recreational activities, as well as habitat type, beach width, and changes in the beach. During the summer and fall, they recorded the number of juveniles and adults. During the breeding season surveys in March and May, they recorded the presence of potentially breeding adults for follow-up by nest surveyors.

Roost Surveys

In these surveys, trained biologists focused on known roosts and roosts detected during previous countywide surveys. These targeted surveys encompass over 95% of the plover population (Ryan et al. 2010). From 2007 to 2021, biologists surveyed the main roost sites (Figure 1) once each in February, April, June, July, August, October, November, and December. From 2007 to 2009 and from 2017 to 2021, the surveys were weekly from 15 February to 30 April unless the plovers had departed the site for two consecutive weeks. Monthly roost surveys were suspended from May 2014 to September 2014 and April 2017 to August 2018, and some sites were not surveyed from April to June 2020 because of closures due to the covid-19 pandemic.

Biologists mapped roosting areas by walking the perimeter at a distance that did not disturb the birds (typically 6–9 m). The surveyed beaches were Zuma County Beach at lifeguard tower 9 and Zuma Lagoon, Malibu Lagoon State Beach, Santa Monica State Beach (Santa Monica), Dockweiler State Beach lifeguard towers 47 and 58, and Hermosa Beach in Los Angeles County and Surfside Beach, Bolsa Chica State Beach, Huntington State Beach, Balboa Beach, Crystal Cove State Park, Salt Creek, and San Onofre State Beach (“Trestles”) in Orange County.

Nest Surveys, Monitoring, and Protection

Nest surveys, by permitted biologists only, were confined to nongroomed beaches, beaches with enclosed areas, and beaches where other surveys revealed plovers whose behavior suggested nesting. These surveys took place weekly from April to July, being discontinued when no plovers were detected for two consecutive weeks. We searched for nests and signs of nesting, such as nest scrapes, and inspected locations where plovers were observed sitting as if incubating. Biologists noted the location of nests by GPS, recorded the number of eggs (if present), and checked adults for bands. Over the nests, we installed mini-enclosures made of 5×10 cm wire mesh in the configuration of cubes 70 cm on a side or circles 70 cm in diameter. These were sunk up to 10 cm into the sand and secured with aluminum or plastic tent stakes. Biologists monitored nests a minimum of every three days to determine their outcome. In Orange County, we banded a portion of the hatched chicks at or near their nests. After the eggs hatched, biologists, park staff, and trained volunteer monitors checked the nests’ vicinity for chicks and fledglings.

We calculated the birds’ reproductive performance as breeding efficiency, the ratio of the number of fledged chicks to eggs laid (or tended) by an individual (Colwell et al. 2017). This metric thus ranges from 0.0 for none to 1.0 for all chicks fledging.

Human Activities and Disturbance

We quantified the level of disturbance during countywide surveys of the main roosting beaches by dividing the counts of the various types of disturbance by the number of surveys and the distance surveyed in kilometers. We excluded Hermosa Beach from the analysis because at that site these data were taken and reported inconsistently. To compare Los Angeles and Orange counties, we standardized the data by dividing the counts reported by volunteers by the number of surveys and the distance surveyed in kilometers.

RESULTS AND DISCUSSION

Nonbreeding Population Distribution and Trends

Snowy Plovers occurred in both Los Angeles and Orange counties in all months (Table 1, Figure 2). Their numbers were greatest from August to March. Most departed for nesting areas in March or April, then returned from July to September (Table 1, Figure 2). The wintering or nonbreeding population was relatively stable between August and February. Since 2017 higher numbers have remained and nested.

From 2007 to 2021, we observed plovers on 26 of 36 beach segments in Los Angeles County. However, 95% of these observations are from six main roosting sites at Zuma, Malibu Lagoon, Santa Monica, Dockweiler State Beach, and Hermosa Beach (Figure 1). From 2012 to 2021, we detected plovers on 18 of 27 beach segments in Orange County. We observed 97% at seven main roosting sites at Surfside, Bolsa Chica State Beach, Huntington State Beach, Balboa Beach, Crystal Cove State Park, Salt Creek, and San Onofre State Beach. Plovers also used small roosts and foraged at Seal Beach, Sunset Beach, Huntington City Beach, Newport Beach, Doheny State Beach, and San Clemente City Beach (Figure 1). There has been a declining trend at the northern roosts since 2014.

TABLE 1 Average Monthly Detections of Snowy Plovers in Los Angeles and Orange Counties, 2007–2021

Month	Los Angeles County			Orange County		
	Average	SE	n ^a	Average	SE	n ^a
January	219.0	15.65	18	177.1	10.26	8
February	188.4	15.16	14	146.5	15.91	8
March	141.6	13.83	14	151.4	21.40	8
April	39.4	8.53	10	27.0	4.78	8
May	2.2	0.71	11	9.2	2.47	6
June	1.7	0.97	7	7.0	2.20	7
July	56.8	8.46	12	37.9	10.56	7
August	143.6	12.41	12	142.4	15.26	7
September	182.5	11.33	15	179.6	13.09	8
October	210.2	14.85	14	182.1	9.43	8
November	201.2	19.60	14	149.3	17.48	8
December	190.9	17.74	14	163.3	17.56	8

^aNumber of surveys.

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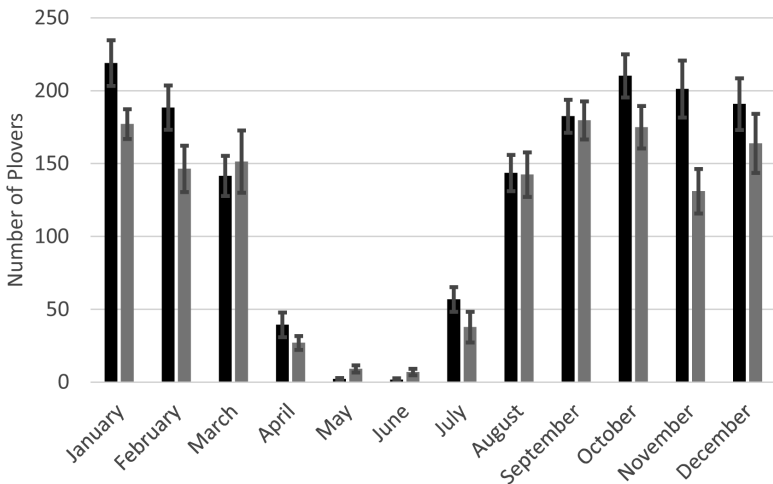


FIGURE 2. Average number of Snowy Plovers detected per month at roost sites in Los Angeles County 2004–2021 (black bars) and Orange County 2012–2021 (gray bars). Error bars, 1 standard error.

The population of nonbreeding plovers in Los Angeles County has fluctuated from approximately 140 to 330, with the number present during peak periods declining over the study period (Figures 3, 4). Over time, lower high counts and lower low counts varied in a cycle of about 6–8 years (Figure 3). A similar pattern is reflected in mean roost counts (Figure 4). Variation in Orange County mirrored trends in Los Angeles County, so the cycle was regional. We detected fewer plovers from 2015 to 2017, with recovery in winter 2018, then the decline resumed through 2021 (Figures 3, 4).

The decline from 2005–06 to 2006–07 extended throughout California and the range of the Pacific coast population, with winter populations falling by 17% (USFWS unpubl. data). The cause was not determined, but an unusually cold spell along the Pacific coast of Oregon and California in December 2006 and January 2007 may have contributed. In 2006 there was also a die-off, from unknown causes, on the breeding grounds in San Diego (E. Copper pers. comm. 2009).

During this second local decline (2012–16), the number of plovers within California as a whole remained stable and near its high (3762–4561) (USFWS unpubl. data). Within Recovery Unit 6, the number declined from 1115 to 742, while in central and northern California (recovery units 2, 3, and 4) it increased. There appears to have been a shift toward nonbreeding roosts farther north. Since 2016, winter counts in Recovery Unit 6 increased to 935 in 2020 and have remained stable since 2018 (USFWS unpubl. data).

Within Los Angeles County, the roosts at Zuma Beach, Malibu Lagoon, and Santa Monica have declined, while those at Dockweiler State Beach and Hermosa Beach have increased. Of these, the roost at Zuma Beach, formerly the largest, has declined significantly ($R^2 = 0.40$, $p < 0.01$; Figure 5). In winter 2005–06 it had 133–213 plovers, 27.5% of the Los Angeles County population,

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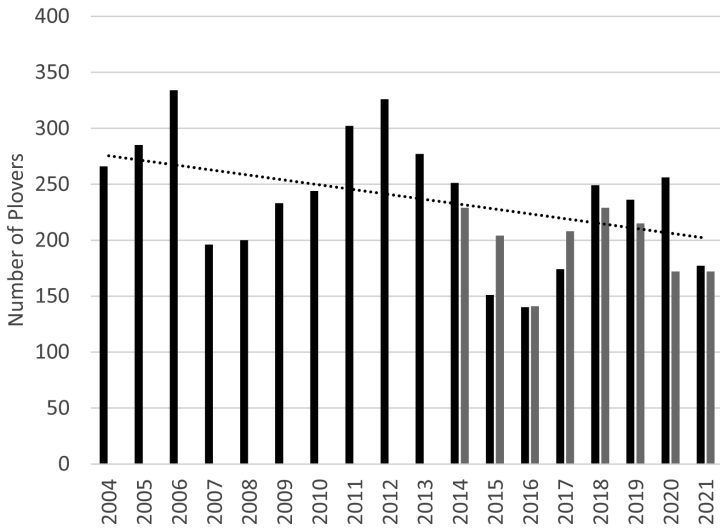


FIGURE 3. Numbers of Snowy Plovers counted during January winter window surveys in Los Angeles County 2004–2021 (black bars) and Orange County 2014–2021 (gray bars). The dotted line represents the linear trend on Los Angeles County counts.

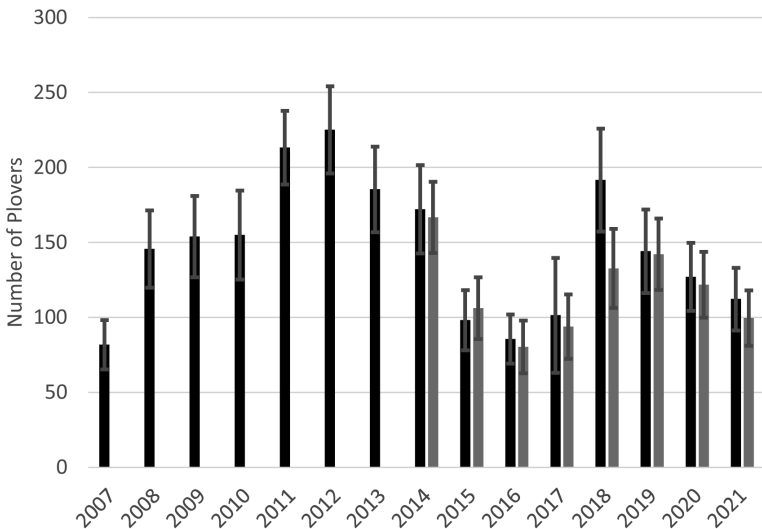


FIGURE 4. Mean number of Snowy Plovers counted per year at roosts in Los Angeles County 2007–2021 (black bars) and Orange County 2014–2021 (gray bars). Error bars, 1 standard error.

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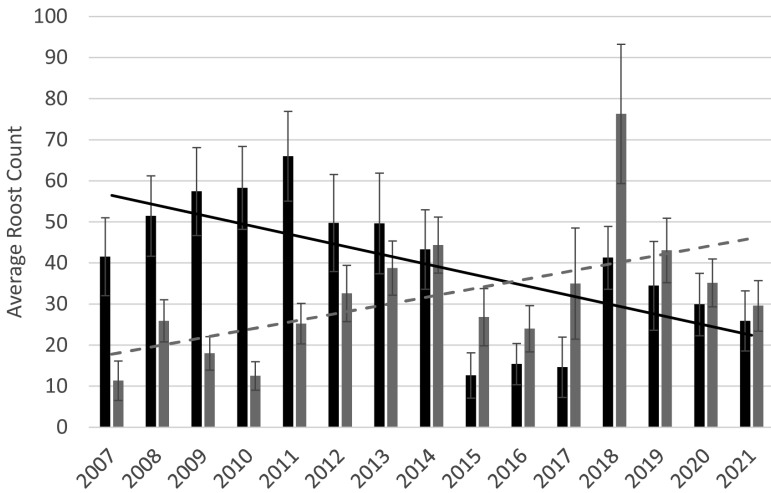


FIGURE 5. Average number of Snowy Plovers counted per year at Zuma Beach (black bars and trend line) and Hermosa Beach (gray bars and dashed trend line) 2007–2021. Error bars, 1 standard error.

but it has no protective enclosure and is heavily disturbed. The population at Malibu Lagoon was variable, typically tracking the overall trend for Los Angeles County, but also dropping in years when the sandbar narrowed or disappeared entirely. From 2010 to 2014, we recorded 47 to 78 plovers roosting there; since the countywide decline in 2015, these numbers have fallen to 0 to 41. At Santa Monica Beach, with two fenced enclosures, typically, 25 to 45 plovers roost, with a peak of 58 in 2011–12. Venice Beach, between the pier and enclosure for the Least Tern colony, supported a small roost of 2 to 11 plovers in 8 of 14 years. Dockweiler State Beach, south of the Ballona Channel, comprised three roosting areas, near lifeguard towers 47, 50, and 58. Being protected by a fenced enclosure since 2008, the roost at tower 47 was the largest, occupied every year and supporting an average of 15% of the roosting plovers in Los Angeles County. Used since 2020, the roost at tower 50 appeared after several years of heavy disturbance at the enclosure near tower 47 (Ryan et al. 2019). The roost at tower 58 supported an average of 4% of Los Angeles County’s plovers and was occupied for 8 of 14 years, but it has been used only occasionally since 2012. The number of plovers at Dockweiler State Beach has fluctuated between 20 and 50. Hermosa Beach typically supports 30 to 50 roosting plovers, an average of 19% of Los Angeles County’s total. This roost is the only one in that county that increased significantly from 2004 to 2021 ($R^2 = 0.26$, $p = 0.03$; Figure 5). The roost shifts between 18th to 22nd streets and 26th to 28th streets.

Roosts in Orange County have also fluctuated, with numbers increasing at Bolsa Chica State Beach and Salt Creek but decreasing at Huntington State Beach, Balboa Beach, and San Onofre State Beach (Figure 6). Representing on average 6% of the plovers roosting in Orange County, a group of up to

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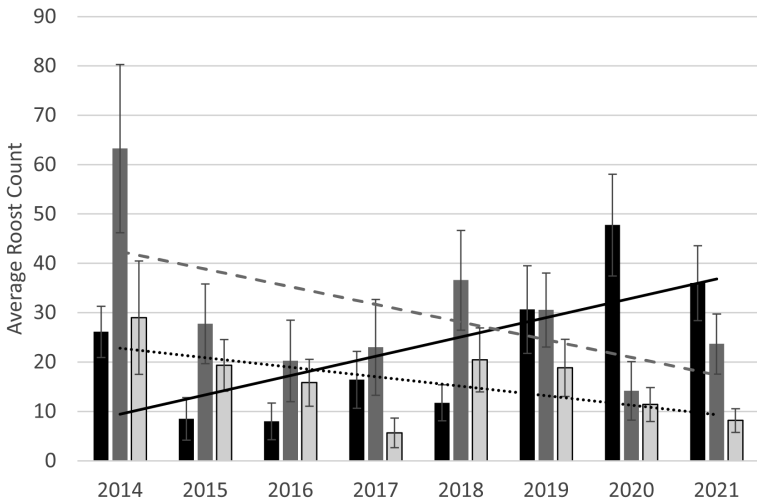


FIGURE 6. Average number of Snowy Plovers counted per year at Bolsa Chica Ecological Reserve (black bars and trend line), Balboa Beach (dark gray bars and dashed trend line), and San Onofre State Beach (light gray bars and dotted trend line) 2007–2021. Error bars, 1 standard error.

44 moved between Surfside and Sunset beaches. Bolsa Chica State Beach supports two roosts, near Warner Avenue and the park headquarters, that together constitute the second-largest aggregation (22.5%) in Orange County. This roost’s size fluctuated from 0 to 101, partly because the birds moved regularly between the beach and nearby Bolsa Chica Ecological Reserve. But the trend from 2014 to 2021 was an increase (Figure 6). In 2011 Huntington State Beach was Orange County’s largest nonbreeding roost but has since declined; with 0–90 it currently supports an average of only 12% of that county’s plovers. In most years of the study, Balboa Beach was the site of the largest roost in Orange County, with 0–127 plovers (24%). It often has the highest numbers during migration in September and October. Since 2014, the numbers roosting have declined from an average of 63 to 24 (Figure 6), perhaps because of a sidewalk extension built in 2014. The plover roost at Crystal Cove State Park fluctuated between 0 and 58 (8%) but has been active annually since 2014. The roost at Salt Creek County Beach ranged from 0 to 58 (16%), that at San Onofre State Beach from 0 to 76 (13%). In some years, the plovers at San Onofre State Beach moved south of the San Mateo Creek mouth and outside the survey area (Figure 6).

Beach Use and Disturbance

Human beachgoers use all beaches on which Snowy Plovers roost or nest in the study area for various forms of recreation. Most plover roosts are at the beach slope’s top or middle. Pedestrians and runners transit all roost areas; surfers, swimmers, and anglers cross them to reach the water. Other visitors play sports, including volleyball and soccer, or sit stationary.

Volunteers observed these activities at all roosts, the most common activities being sitting, walking, and sports. In Los Angeles County, the highest densities of these activities are at Malibu Lagoon, Venice Beach South, and Dockweiler State Beach near tower 58. In Orange County, human activity was greatest at Huntington State Beach, Balboa Beach, Doheny State Beach, and Salt Creek. Plovers typically reacted to these activities near their roost by walking or flying a short distance from the disturbance. This movement increased in frequency at beaches with high densities of these activities and when beaches were more crowded on warm days and from May to September, which coincided with migration and nesting.

With recreation comes vehicle access for safety patrols, refuse collection, wildlife rescue, maintenance, water-quality monitoring, and mechanical grooming. All beaches on which plovers roost in our study are accessible to vehicles. The most common are four-wheel drive pick-up trucks and sport utility vehicles; all-terrain vehicles, heavy equipment, and tractors are fewer. Plovers’ reactions to vehicles were similar to those to pedestrians. But vehicles are larger, faster, and more lethal: we noted vehicle strikes killing plovers at Zuma Beach (2007), Malibu Lagoon (2013), and Santa Monica (2015). In addition, vehicles can crush and bury wrack and foraging resources. In Los Angeles County and outside state parks in Orange County, beach raking can remove wrack entirely. When standardized for the number of surveys and distance, vehicle use was greater in Los Angeles than in Orange County (Figure 7). Over time, the frequency of vehicle use in both counties has been consistent (Figure 7).

With few exceptions, dogs are not authorized on public beaches in either Los Angeles or Orange County. None of the plover’s main roost beaches permit dogs off leash, and only the city of Newport Beach permits dogs on leash during certain hours. Nevertheless, volunteers observed dogs on and off-leash at all beaches in both counties. In Los Angeles County, the numbers

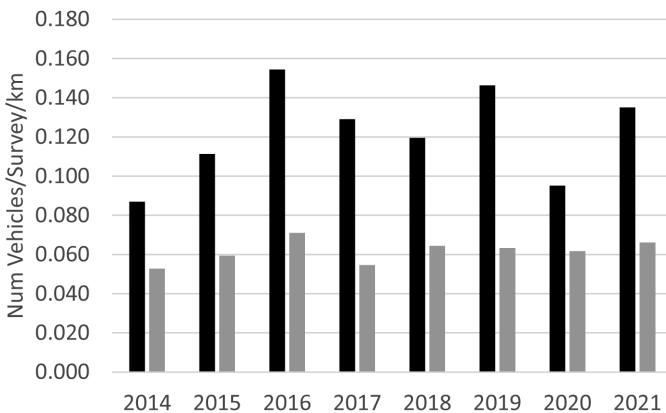


FIGURE 7. Density by year of vehicles (passenger, all-terrain, equipment) noted during beach-wide surveys at main Snowy Plover roosts in Los Angeles (black bars) and Orange (gray bars) counties, 2014–2021.

of dogs observed at roosting beaches were greatest at Venice Beach South and Malibu Lagoon State Beach. In Orange County, their numbers were greatest at Surfside, Balboa Beach, and Doheny State Beach. Overall, dogs were fewer in Orange County, but the trend since 2015 in both counties has been an increase (Figure 8). In 2009 we noted a dog capture and injure a plover at Sunset Beach.

In addition to these widespread disturbances, some disturbances are specific to certain beaches. Heavy equipment is used to build and remove protective berms annually near roosts at Zuma, Dockweiler, Surfside, and Sunset beaches. Surf camps consisting of large numbers of children are held between May and September near roosts at Zuma Beach, Malibu Lagoon, Santa Monica Beach, Dockweiler State Beach, Hermosa Beach, Bolsa Chica State Beach, Huntington State Beach, and Salt Creek. These are particularly problematic at Malibu Lagoon and Santa Monica Beach, where the activities occur within 30 m of the protective enclosures. Volleyball courts have been installed within the roosting area at Zuma Beach. Illegal beach fires burning wood slats from the protective enclosure have been set at Dockweiler State Beach. Large-scale public events held near roosts include triathlons at Zuma Beach and music festivals at Dockweiler and Huntington state beaches. Since 2016, a falconer has been hired to use a Harris’s Hawk (*Parabuteo unicinctus*) to flush gulls from the lagoon at Salt Creek. Since 2017, while plovers were present, the hawk’s use has been restricted, and it is not allowed to fly when plovers are present.

In addition to anthropogenic disturbances, extreme tides can wash over the roosting areas at Malibu Lagoon State Beach and Crystal Cove State Park. Seasonal beach erosion can also narrow the beach. Such high tides concentrate human disturbances or eliminate the roost areas at narrower beaches such as Zuma Beach, Malibu Lagoon State Beach, Surfside, Sunset, Balboa Beach, Crystal Cove State Park, Salt Creek, and Doheny State Beach.

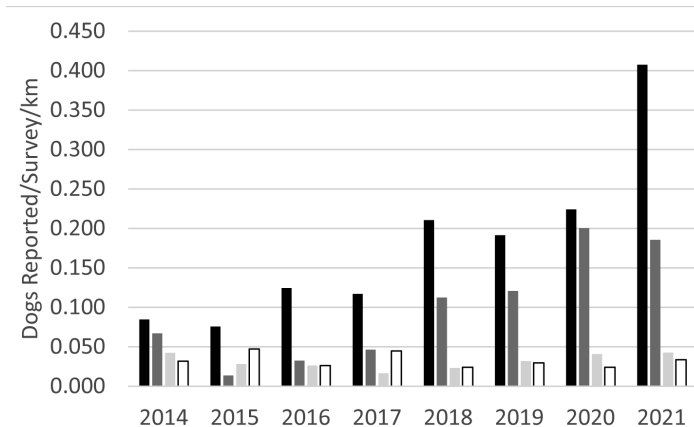


FIGURE 8. Density by year of dogs encountered during beach-wide surveys at main Snowy Plover roosts in Los Angeles (black bars, off leash; dark gray bars, on leash) and Orange (light gray bars, off leash; white bars, on leash) counties, 2014–2021.

Use of Protective Enclosures

Protective enclosures constructed of wooden slats and/or post-and-rope fencing have been erected at Malibu Lagoon, Santa Monica Beach, Dockweiler State Beach near tower 47, Bolsa Chica State Beach, Huntington State Beach, Balboa Beach, and San Onofre State Beach. Some are permanent; others are installed seasonally. These are also beaches where plovers have resumed nesting. At Malibu Lagoon State Beach, seasonal enclosures have been installed by volunteers and state park personnel since 2008. A post-and-rope enclosure protects the west-central portion of the sand spit's upper beach. It varies in size, depending on the configuration of the lagoon, but it is typically 90–120 m long; its width varies up to 50 m. The post-and-rope fence is set on the sand spit, with the lagoon forming a water barrier. It is removed during winter because of high tides and beach erosion. In years when the plovers nest plastic fencing has been installed to prevent dogs from entering the enclosure.

The city of Santa Monica has enclosed the roost site in a wood-slat fence each year since 2005. It measured 30×183 m from 2005 to 2007 and 30×91 m in 2008 and 2017 (Ryan et al. 2010). Before 2007, most plovers were seen within this enclosure, with some immediately north and south of it. In 2008, the city of Santa Monica installed a sub-enclosure of 15×46 m to protect potential nest scrapes from off-leash dogs and pedestrians, but the plovers abandoned this smaller enclosure. The original location of the enclosure was approximately 100–200 m south of the walkway of the current Annenberg Community Beach House (2005–2009). From 2010 to 2015, the city of Santa Monica moved it 120–150 m south and in 2015 an additional 75 m south into its current location. It is now 408 m south of the walkway. Since 2015, plovers have often roosted outside the enclosure, north of the current enclosure in the area where the enclosure had been from 2005 to 2009. In December 2017, the Bay Foundation began restoring dunes (Johnston et al. 2017) within an enclosure measuring 60×180 m 515 m north of the existing enclosure. This has occasionally supported roosting plovers and was the location of a nest in 2017.

At Dockweiler State Beach near tower 47, in August 2008 an area was marked off with cones. On 14 August 2010 these were replaced with a wood-slat fence, which was repaired in 2020. Accumulated trash was cleared by hand, and native plants and dunes were established. At the request of the Los Angeles County Department of Beaches and Harbors plants were removed in 2016 but have since recolonized the site. The Bay Foundation initiated active restoration of the dunes here in 2022, expanding the protected areas. Nevertheless, vehicle tracks were regularly observed in front of the enclosure despite signage alerting pedestrians and drivers to the plovers. In addition, dogs and dog tracks were observed at this site. Since 2020, wood slats from the fence have been frequently used as firewood for illegal beach fires near the fence, and trash and food waste have also been left.

In Orange County, at Bolsa Chica State Beach, an ~0.8-hectare area enclosing a coastal strand/dune restoration site at the southern roost near park headquarters has been protected since 2011. Degraded wood-slat fencing was removed in 2019, and temporary fencing was installed in 2020 in response to the flush of plover nesting, with permanent post-and-rope fencing and sig-

nage installed in March 2021. From May to August 2021, that beach section, including the enclosure, was closed to vehicular traffic because of the plovers' nesting. New public outreach was also initiated. At the southern end of Huntington State Beach, an ~1.2-hectare area around the roost was protected by a post-and-rope fence and signage on 15 March 2021. At Balboa Beach, a heavily degraded fenced area on the upper beach surrounds a 1.24-hectare dune-restoration area where a pair of plovers nested in 2008, 2009, and 2013. At San Onofre State Beach, the park and San Clemente High School built a 0.3-hectare post-and-rope enclosure around the vegetated dunes in 2019. The plovers were typically on the sandy beach and have not been detected roosting in the enclosed area. However, a pair nested in the enclosure in 2022, and the enclosure was expanded in 2022 to incorporate more of the roost area.

Nesting Activity

The Snowy Plover began reoccupying historic nesting locations on three beaches in Los Angeles County and Huntington State Beach in Orange County in 2017 (Ryan et al. 2019). Then nesting increased annually in Orange County, with colonization at the Anaheim Bay mouth in 2019 and at Bolsa Chica State Beach in 2020 (Table 2, Figure 9). In Orange County, the number of nests increased to 29 in 2020 and 28 in 2021 (Table 2, Figure 9). In Los Angeles County, in contrast, no nests were detected in 2019 or 2021, only one at Dockweiler in 2020 (Table 2, Figure 9). The rate of hatching was 61% in Los Angeles County and 59% in Orange County. The breeding efficiency was 0.27 and 0.18 in the two counties, respectively.

In Los Angeles County, nests were initially established only within protected areas. In Orange County, however, nests were found on sections of public beaches at Huntington State Beach from 2017 to 2021 and at Bolsa Chica State Beach in 2020. Upon discovery, the parks' staff protected nests by establishing a buffer with cones, post-and-rope fencing with signage, and mini-enclosures placed over nests. The radius of most buffers at these two sites was 30–35 m. Nest buffers at Naval Weapons Station Seal Beach have ranged from 30 to 150 m in radius, with most in 2020 measuring 75 m and those in 2021 measuring 150 m. Biologists installed mini-enclosures around nests at Seal Beach in 2019 but not in 2020 or 2021. Within the Least Tern Natural Preserve at Huntington State Beach they installed only one because the preserve's established chain-link fence protects nests from most disturbance. From late March to July 2020, most beaches were partially or fully closed to the public because of restrictions for the covid-19 pandemic. In 2021, year-round protected areas were established at Huntington State Beach and Bolsa Chica State Beach with post-and-rope fencing and signage. Plovers used these areas and adjacent, less protected public beaches.

Rates of fledging are difficult to estimate because the chicks are cryptic and move far from the nest. However, we estimate that a minimum of 40 chicks fledged from the 80 nests and 206 eggs documented, or 0.50/nest (Table 1). This is lower than the goal of 1.0 chicks per breeding male the USFWS (2007) set for Recovery Unit 6 but similar to the rate in area other areas where the plover nests in southern California.

Mini-enclosures were associated with increased hatching rates (Figure 10). Among the 80 nests we monitored, we protected 58 with such enclosures

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TABLE 2 Summary of Nesting of the Snowy Plover in Los Angeles and Orange Counties, 2017–2021

Year, county, and location	Nests	Eggs	Chicks	Fledglings
2017				
Los Angeles				
Malibu Lagoon State Beach	2	4	3	1
Santa Monica	1	3	0	0
Dockweiler State Beach	2	6	6	1
Orange				
Huntington State Beach	1	1 ^a	1 ^a	1 ^a
2018				
Los Angeles				
Malibu Lagoon State Beach	5	14	5	4
Dockweiler State Beach	1	3	3	2
Orange				
Huntington State Beach	2	6	6	4
2019				
Orange				
Anaheim Bay–Seal Beach	3	8	8	4
Huntington State Beach	5	11	7	2
2020				
Los Angeles				
Dockweiler State Beach	1	3	3	1
Orange				
Anaheim Bay - NWS Seal Beach	13	30	9	1
Sunset Beach	1	3	1	1
Bolsa Chica State Beach	7	21	15	5
Huntington State Beach	8	22	14	3
2021				
Orange				
Anaheim Bay–Seal Beach	9	18	5	3
Bolsa Chica State Beach	6	18	14	2
Huntington State Beach	13	35	22	5
Total	80	206	122	40

^aNest was abandoned, egg was brought to Wetlands and Wildlife Care Center, chick was reared in captivity and released.

and left 22 not so protected. Most unprotected nests were at Naval Weapons Station Seal Beach or the Least Tern Natural Preserve at Huntington State Beach. Of those protected by mini-enclosures, 40 nests hatched, and 18 failed (Figure 10). The hatching rate at enclosure-protected nests was 66%, whereas at unprotected nests it was 38% (Table 2). Confirmed predators at the failed unprotected nests were the American Crow, Common Raven (*Corvus corax*), Western Gull (*Larus occidentalis*), and California Ground Squirrel (*Otospermophilus beecheyi*). Mini-enclosures would have likely deterred these predators, except the squirrels that reached into the mini-enclosures and grabbed eggs. Five mini-enclosures were targets of vandalism on public beaches at Malibu Lagoon, Santa Monica, and Huntington State Beach. Two nests with mini-enclosures were abandoned for unknown reasons unrelated to the enclosures' being placed because the adults returned and incubated under them. Seasonal high tides flooded three nests at Malibu Lagoon, and

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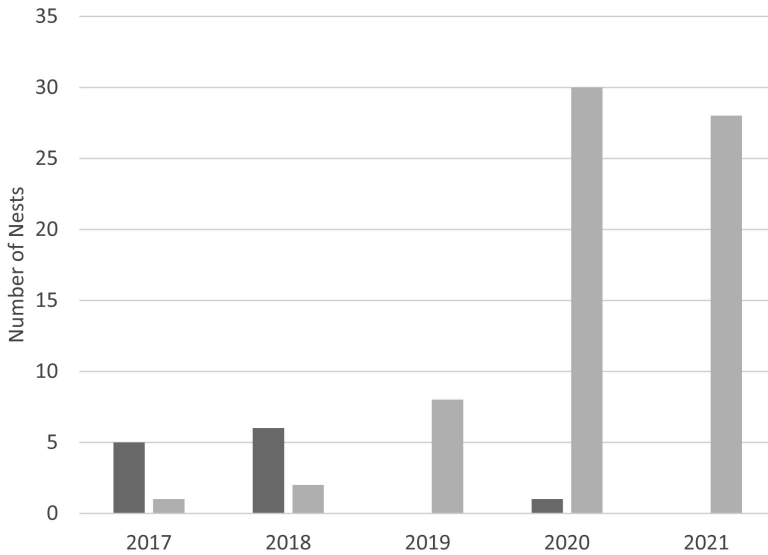


FIGURE 9. Numbers of Snowy Plover nests in Los Angeles (dark gray bars) and Orange (light gray bars) counties by year, 2017–2021.

high winds buried two nests in the sand at Malibu Lagoon and Santa Monica. No adults were known to be lost or observed depredated after mini-enclosures were installed over their nests.

Since the recolonization in 2017, nesting has continued to increase in Orange but not Los Angeles County (Figure 9). We suggest that this may be due to differences in management that amplify disturbance at Los Angeles County beaches. The sites where the increases in nesting and productivity

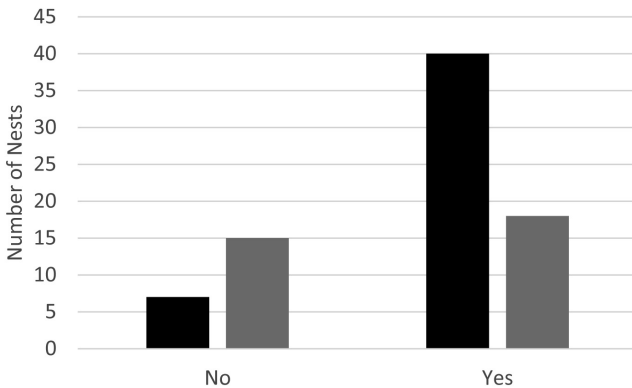


FIGURE 10. Number of Snowy Plover nests at which eggs hatched by whether the nest was protected by a mini-enclosure, Los Angeles and Orange counties, 2017–2021.

have been greatest, the mouth of Anaheim Bay, Bolsa Chica State Beach, and Huntington State Beach, have three elements of management in common: (1) kelp wrack and driftwood are not groomed but remain on the beach to be occupied by arthropods, (2) dog walking and letting dogs run off leash are restricted and the restrictions are enforced on these beaches, and (3) while regularly patrolled, both Bolsa Chica and Huntington state beaches are broad, and vehicles attempt to avoid known plover roosts. On Los Angeles County beaches, dogs are present both on and off leash despite regulations prohibiting them, and enforcement of dog regulations appears to be limited. Volunteers' counts of off-leash dogs have increased (Figure 8). Except at Malibu Lagoon and in enclosed areas at Santa Monica and Dockweiler State Beach, beaches are groomed daily. Los Angeles County's beaches are regularly driven by lifeguards, law enforcement, and maintenance vehicles, with vehicle tracks regularly observed in front of areas established to protect the plovers. Volunteers' reports on beach-wide surveys show that vehicle use is generally heavier in Los Angeles County. At Santa Monica Beach, youth surf camps take place adjacent to the enclosures between May and August annually. Adherence to USFWS (2016) recommendations would likely promote Snowy Plover nesting in Los Angeles County.

CONCLUSIONS

Los Angeles and Orange counties host approximately 11% of the Snowy Plovers spending their nonbreeding season along the Pacific coast of the U.S. (USFWS unpubl. data). In both our study area and elsewhere along the Pacific coast counts at nonbreeding roosts vary cyclically, but the trend in Los Angeles County is a decline (Figures 3, 4). The causes of this pattern require further investigation. In our study area, the largest roosts, at Zuma Beach and Balboa Beach, have had the largest declines (Figures 5, 6). Roosting areas at both sites are regularly driven through by lifeguards and beach-maintenance vehicles and run through by off-leash dogs. Zuma Beach has no protective enclosure. Balboa's nominally protected area is farther up the beach than plovers typically roost, the enclosure has deteriorated, and a walkway has been constructed through it.

Migratory Snowy Plovers begin returning to southern California in July, and numbers stabilize by September (Table 1, Figure 2). Roosts begin to disperse in March, and most plovers depart their roosts for breeding sites elsewhere by May (Table 1, Figure 2). Because migrants return in July, protective measures should be considered even during the busy summer tourist season when recreational use, beach driving, and beach grooming are at their peak. The plovers continue to use their traditional roosting areas in both counties, with 95–98% of them roosting at these main sites. In addition, new roosts have appeared at Venice Beach and near Dockweiler lifeguard tower 50 but have become occasional at Dockweiler lifeguard tower 58.

This study identified numerous challenges the plovers face at their roost sites. Frequent beach driving, beach grooming, dogs, surf camps, and other large-scale events near roosts are sources of disturbance and direct mortality. Disturbance contributes to increased use of energy, susceptibility to predation, and roost displacement. Daily flushing of plovers by beach drivers and

removal of foraging resources continues. Of particular concern as causing direct mortality are off-leash dogs and motorized vehicles, especially those exceeding 16 km/hr. During the study, we documented three confirmed and two probable vehicle strikes, all of which killed the plover. We also observed a dog's capture of a plover that required the bird's rehabilitation. We suggest that unless these activities are consistently curtailed near roosts, the number of plovers at them is likely to continue to decline.

In Orange County, in contrast, the number of nesting plovers has increased within areas managed by the U.S. Navy and California State Parks at Anaheim Bay, Bolsa Chica State Beach, and Huntington State Beach. Both agencies actively protect nests by establishing buffers and, in some cases, installing mini-enclosures at nests. These state parks have modified their management to reduce the disturbance of the roosting plovers as recommended by the USFWS (2016). At the three Los Angeles beaches where the plover has nested, off-leash dogs have increased, and tracks are regularly observed inside supposedly protective enclosures. There has been little change in beach driving at any beach except Malibu Lagoon State Beach: speeds >16 km/hr continue, and driving in front of protective enclosures at Santa Monica and Dockweiler State Beach North remains regular. There have been no changes in beach-grooming practices. The wood-slat enclosure at Dockweiler State Beach North has been vandalized in combination with illegal fires adjacent to the enclosure. These recurring disturbances and removal of foraging resources may inhibit continued nesting in Los Angeles County.

The number of nests in our study area increased from 6 in 2017 to 28 in 2021 (Table 2, Figure 9). Since 2018, however, all nests but one have been in Orange County (Table 2). The increased protective measures at northern Orange County beaches may be attractive to nesting plovers. The hatching rates of 59–61% in our study area are higher than the 34% reported from a similarly sized population in Humboldt County, California (Colwell et al. 2018), but lower than hatching rates found at Marine Corps Base Camp Pendleton (74%) and Naval Base Coronado (85%), where nests are also protected by mini-enclosures and predators are controlled (San Diego Zoo unpubl. data). The breeding efficiencies of 0.27 in Los Angeles County and 0.18 in Orange County are similar to the average of 0.19 reported from 126 nests in Humboldt County by Colwell et al. (2018), who found that an efficiency ≥ 0.20 was positively correlated with a per capita fledging success ≥ 1.0 , among the criteria for success in the recovery plan (USFWS 2007). Colwell et al. (2017, 2018) found the breeding efficiency at 126 Snowy Plover nests in Humboldt County to average 0.19 (± 0.25).

Because of so low a hatching rate, Colwell et al. (2018) considered Humboldt County a population sink. Orange County is also a population sink under this criterion. We suggest that increased protection of chicks until fledging could improve this.

Hatching rates at nests protected by mini-enclosures are higher than at those not so protected. Nest failures were due mostly to predation, much of which could have been prevented with mini-enclosures. This suggests that the enclosures should be placed on as many nests as possible to increase reproductive output. On southern California's beaches, predators are numerous, with corvids attracted to human food and trash, dogs common during

the day, and coyotes and other mesopredators present at night. During our study, no adult plovers whose nest was equipped with a mini-enclosure were depredated. Our data support mini-enclosures' and protective buffers' continued use and expansion.

Human disturbance and interference with plover nests and chicks are problems at public beaches, especially popular beaches. Plover nests can go undetected by monitors for several days and accidentally be found by beachgoers. Once chicks hatch, they can move into more crowded beach areas. From 2019 to 2021, beachgoers collected two eggs and six chicks. Unfortunately, two of the chicks were likely already distressed and died in captivity.

Additionally, five mini-enclosures have been vandalized, with seven eggs destroyed. The year 2020 was particularly problematic, with three enclosures vandalized and four chicks picked up. As a result, we altered our public outreach and increased our efforts at Bolsa Chica and Huntington state beaches. In 2021, no mini-enclosures were vandalized; two chicks were picked up, and both were immediately returned to their broods. Public outreach and education are essential to plover conservation on public beaches.

The conservation of the Snowy Plover on popular public beaches in southern California is exceptionally challenging. Nevertheless, we have successfully brought nesting plovers back to these beaches and protected them. Success has been greater at sites where monitors search for nests and protect them with mini-enclosures, establish buffers, and educate the public. However, it has been greatest at sites where (1) beach wrack is allowed to remain, (2) regulations against dogs are enforced, reducing their numbers, (3) beach drivers are educated about the value of reducing speed and avoiding plovers, and (4) plover roosts and nesting areas are marked for avoidance.

The recommendations made by the USFWS (2016) were issued before nesting plovers recolonized Los Angeles and Orange counties in 2017. These recommendations should be followed and expanded to take nesting into account, with special protection zones established in known roosting and nesting areas. Within these zones, we recommend that beach grooming/raking be stopped to reduce flushing and removal of kelp wrack. Beach driving, heavy equipment, and all-terrain vehicle use should be reduced to the minimum necessary. Existing dog regulations should be enforced through outreach and citations. Large-scale recreational activities, events, and summer camps should be moved to other areas of the beach away from the zones. During the nesting season, all essential activities in special protection zones should account for the possibility of nesting, and nest surveys should precede any work. Outreach and educational programs should be expanded and evaluated to better align beachgoers' behaviors with plover conservation. The effects of beach erosion and trophic changes due to climate change should also be studied. We believe that these measures should further the recovery of the Snowy Plover.

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