



Monitoring Western Snowy Plovers at Point Reyes National Seashore, Marin County, California

2015 Annual Report

Natural Resource Report NPS/SFAN/NRR—2017/1410



ON THE COVER

Photograph of western snowy plover chicks in scrape lined with dried *Veleva veleva* after bands were applied.
Photograph courtesy of NPS, Carolyn Campbell.

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Abstract

This report details the results of the 26th year of the western snowy plover (*Charadrius alexandrinus nivosus*) monitoring program within Point Reyes National Seashore (PORE), Marin County, California. The goal of the 2015 monitoring effort was to determine abundance, distribution, and breeding success of snowy plovers nesting on federal lands within PORE. The report provides an overview of the 2015 snowy plover monitoring program on federal lands and summarizes the results of the data collected during the field season.

In 2015, survey crews conducted 275 snowy plover surveys at PORE. There were 161 surveys conducted between Kehoe Beach and North Beach parking lot, 84 in the 2011 Dune Restoration Area, 9 from North Beach parking lot to South Beach parking lot, 1 from South Beach parking lot to the Lighthouse Beach, 19 on Limantour Spit, and 1 on Drakes Spit. A minimum estimate of 38 plovers bred in PORE. Exclosures were placed around 32 of the 49 nests located in 2015, and four of the exclosed nests failed to hatch. Thirty of the 49 nests hatched at least one egg and 80 of 131 total eggs hatched. Nineteen of 80 chicks survived for at least 28 days after hatching, for a 23.8% fledging rate. The number of fledglings per egg was 0.15, compared to 0.14 in 2014 and an average of 0.28 since exclosures were first used in 1996. The 2015 season resulted in a below average hatch rate in both nests and eggs. However, the number of fledges was above average and the highest since 2007.

The large dune restoration area created in 2011 south of Abbotts Lagoon has been diligently maintained by the PORE coastal dune restoration team. Restoration efforts continued in 2015 with minor retreatment. Since 2001, over 250 acres of plover and rare plant habitat have been restored through the removal of invasive European beach grass (*Ammophila arenaria*) and iceplant (*Carpobrotus edulis*). The 2011 Restoration Area was utilized by snowy plovers in the 2015 breeding season.

The Western Snowy Plover Docent Program remains an important tool to educate park visitors about the plight of the western snowy plover and to minimize potential negative impacts from visitors, especially those with dogs. Docents made 6,752 visitor contacts on weekends and holidays in 2015. Efforts this season focused on the Abbotts Lagoon trailhead, Abbotts Lagoon shoreline and North Beach Parking lot. Docent efforts were extended to include Kehoe beach sporadically during the summer. Park managers recommend continuation of the docent program in future breeding seasons and a full-time seasonal docent coordinator is needed to recruit, organize, and lead the volunteer docents.

To reach the US Fish and Wildlife Service recovery goal of 64 breeding birds on Point Reyes beaches, efforts to improve habitat on all current and historic breeding beaches and reduce the impacts of human recreation and natural predators on nesting plovers should be continued and expanded at PORE.

Acknowledgments

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Introduction

Western snowy plover (*Charadrius alexandrinus nivosus*) populations have declined through the species' entire range over the last century (USFWS 2007). Along the California coast, breeding and wintering populations declined significantly from the late 1970's to 2000 (Page and Stenzel 1981; USFWS 1993, 2007). The populations of snowy plovers that nest along the Pacific coast of North America from southern Washington to Baja California were declared threatened by the U.S. Fish and Wildlife Service (USFWS) in March 1993 (USFWS 1993, 2007). The reasons for decline and degree of threats vary by geographic area; however, the USFWS (1993, 2007) has identified the primary threat as habitat destruction and degradation. Habitat degradation is primarily caused by human disturbance, urban development, introduced European beach grass (*Ammophila arenaria*), and expanding predator populations.

Within Point Reyes National Seashore (PORE), the USFWS recovery plan for the Pacific coast population of the western snowy plover (USFWS 2007) sets a goal of 50 adult birds on Point Reyes Beach, 10 on Limantour Spit, and 4 on Drakes Spit (32 pairs total). Despite aggressive management actions to recover PORE snowy plover populations since 1996, the population estimate during the 2014 breeding season was still well below the goal.

Snowy plovers were initially monitored at PORE in the 1970s by the Point Reyes Bird Observatory, now Point Blue Conservation Science (PBCS). A similar monitoring protocol was implemented from 1986 to 1989, and again in 1995 by PBCS when declines were significant across the species' range and in particular at PORE beaches. In 2008, PORE, with assistance from the San Francisco Bay Area Network Inventory and Monitoring Program, took over full responsibility for monitoring plovers within PORE boundaries, consulting with PBCS as needed. At PORE, the reproductive success of this species is affected by both human disturbance and natural factors, requiring close monitoring to determine the relative importance of each factor in any given year and over the long-term. Beach visitors to PORE have also been observed approaching active nests, which has been documented as a threat to nesting snowy plovers, especially when those visitors are accompanied by a dog (Page et al. 1977).

The use of predator exclosures around snowy plover nests was initiated in 1996 on all survey areas of Point Reyes Beach and Limantour Spit as an effort to raise the percentage of clutches hatching. PORE worked with PBCS to refine the exclosure design to maximize protection but minimize set up time and the amount and weight of materials. The round exclosures consist of a fence that is 6-ft. in diameter and 5-ft. tall, with 2-inch×4-inch openings to allow passage of plovers while keeping out mammalian predators. Crow-mesh netting with 4-inch×4-inch openings is used on top to prevent access by avian predators. These exclosures have been effective at keeping predators away from nests. The percentage of clutches hatching increased from an average of 14.9% prior to exclosure use (1986–1989) to 63.8% (1996–2014).

PORE has undertaken habitat restoration to recover western snowy plovers to recovery levels. In 2001, PORE began a three-year dune restoration project focused on removing non-native European beach grass and iceplant from areas on North Beach, in particular near Abbotts Lagoon. Additional restoration funding from the SS *Cape Mohican* oil spill allowed new restoration and follow up work

to be continued through 2005. In 2003, the park found two plover nests in areas of non-native beach grass removal (Peterlein and Roth 2003). From 2006 to 2008 there were four nests each year in the restored areas (Peterlein 2009). In 2011, a large-scale mechanical removal of 90 acres of non-native European beach grass and iceplant occurred just south of Abbotts Lagoon. This large-scale restoration created a 250 acre natural dune environment. Additional efforts to remove non-natives and maintain the restored area were performed in subsequent years.

In 2011, one nest was located in the foredunes in front of the project area, and three broods were observed utilizing the restoration area on multiple occasions. In all, 46% of all the snowy plover chicks fledged within PORE in 2011 spent time in the restored dunes. In 2012, one nest was located within the 2011 restored area and one in the foredunes in front of the restoration area. Only the nest in front of the foredunes hatched, and the brood was continuously observed utilizing the restoration area. In 2013, two successful nests were located within the 2011 restored area and one in the old 2003 restored area. However, no chicks were seen utilizing the restored areas in 2013. In 2014, nine of the 14 nests located within the 2011 restored area were successful and there was one unsuccessful nest in the 2003 restored area. Six of the chicks hatched from the 2011 restoration area fledged, accounting for 40% of fledges in 2014. Continued restoration has the potential to greatly increase the coastal dune area available for snowy plover nesting, feeding, and chick rearing activities.

Current Monitoring Objective

The overall goal of the western snowy plover monitoring program is to determine trends in the estimated breeding population size, distribution, and reproductive success of snowy plovers at known breeding beaches in PORE (Adams et al. 2014).

Methods

Study Area

Snowy plovers have historically used Point Reyes Beach, Drakes Spit and Limantour Spit for nesting within PORE (Figure 1). Point Reyes Beach is separated into five beach survey sectors:

- Kehoe Beach entrance to Abbotts Lagoon (K)
- Abbotts Lagoon (including the southwest shore of the lower pond of Abbotts Lagoon) to North Beach parking lot (NP)
- The restored back dune habitat south of Abbotts Lagoon and adjacent to North Beach (RA; added as a separate survey area in 2011)
- North Beach parking lot to South Beach parking lot (NB)
- South Beach parking lot to Lighthouse Beach (SB).

Limantour Spit (L) refers to the beach area from the Limantour Beach parking lot west to the end of Limantour Spit. Although Limantour has not been used by plovers during a breeding season since 2000, it continues to be surveyed. Drakes Spit (D) refers to the beach to the west side of the mouth to Drakes Estero (Figure 1).

On Kehoe (K) and North Beach (NP) sectors, there are two areas where European beach grass was removed from 2004 to 2005. Survey data from these newly available plover habitat areas are included in the respective sectors from 2004 to the present. An additional survey sector (RA) was created during the 2011 season to acknowledge the much larger area of plover habitat restored over the spring and summer of that year (Figure 1). For more details on study area, see also Adams et al. (2014).

Heavy winter storms, particularly during El Niño-Southern Oscillation (ENSO) years, can significantly alter beach profiles at high-energy beaches such as at Point Reyes (White and Allen 1999). ENSO years may also result in more rain during the spring, at the start of the snowy plover breeding season. These combined negative impacts resulted in a 10 to 30 percent range wide decline in the western snowy plover breeding population following the ENSO winter of 1997/1998 (USFWS 2007). For this reason, annual ENSO predictions from the National Oceanic and Atmospheric Administration/National Weather Service are considered during the monitoring seasons and in reporting our annual data.



Snowy plover population survey sectors



Figure 1. Locations of monitoring sectors, including: Kehoe Beach entrance to Abbotts Lagoon (K); Abbotts Lagoon to North Beach parking lot (NP); 2011 Abbotts Lagoon Dune Restoration Project Area (RA); North Beach parking lot to South Beach parking lot (NB); South Beach parking lot to Lighthouse Beach (SB), Limantour Spit (L), and Drakes Spit (D).

Field Surveys

Breeding season surveys begin March 15th and continue until all broods have fledged in mid-September. At Kehoe Beach (K) and North Beach (NP), sites are each surveyed at least twice a week. The 2011 Restoration Area is surveyed approximately twice a week depending on the activity level in the area; for example, more frequently when broods might be utilizing the area. Limantour Beach (L) is surveyed twice a month. North Beach (NB) is surveyed approximately twice per season and increases if more activity is observed. The Drakes Beach (D) and South Beach (SB) sectors are surveyed once per season. The back-dunes along the southwest shore of Abbotts Lagoon are surveyed approximately two times per week in conjunction with the NP survey sector, though the frequency of surveys in this area may need to be adjusted based on future observations of plovers in this newly restored area.

During surveys, observers walk just below the high tide line, crossing above the line only when necessary to see the full width of the beach. Observers stop every 50 to 100 m as necessary to scan up to 100 m ahead for plovers. When a plover is located, observers may approach as close as 10 m to determine age, sex, and color band combination if bands are present, though this is rarely done unless the adult is already standing and not involved in any nest building, incubating, or brood tending activities. Date, location (GPS coordinates), and the time of sighting are recorded on datasheets. Observers then walk around the bird(s) to prevent flushing. Upon return to the office, all data is entered into a Microsoft Access database.

Nest Searching

Nests are located using three methods: 1) systematically searching microhabitats in which plovers are likely to nest; 2) watching potential breeding adults from a concealed position; and 3) following plover footprints in fine sand (Adams et al., 2014). Once a nest is located, it is exclosed with a round fence with a diameter of 6 feet as soon as possible unless it is determined that high tide will threaten the nest. The 2-inch × 4-inch fence openings allow entrance and departure of plovers while keeping out most predators. On the top of the exclosures, mesh netting is used to prevent access by avian predators. Exclosures are removed from the beach after the chicks have hatched and left the nest. The UTM coordinates of all nests are determined using GPS units and maps are produced at the end of each season (Appendix E). In 2013, an effort was made to reduce the number exclosures used (see Discussion for more detail).

Nests are checked two to four times per week to verify if they are still active. If a nest is not active during a particular visit, the cause of loss is determined using the criteria outlined in Appendix A. If a nest is abandoned by the adult plovers or has failed to hatch after 35 days, the plover biologist collects the unhatched eggs. The eggs are stored in a freezer at PORE with the collection information until they can be transferred to an appropriate facility for methyl mercury and/or fertility testing (Miles et al. 2009). If a nest remains active through its projected hatching date, checks are made more frequently at that time to determine the precise hatch day.

Adults and chicks are searched for on follow up visits. Once found, the number of chicks and location are recorded. If chicks are determined to be lost, the criteria outlined in Appendix B are used

to determine timing and cause of loss. Chicks that have survived for 28 days are considered fledged and are no longer monitored.

Chick Banding

A chick banding program for snowy plovers was initiated at PORE in 2015. Bands are applied to chicks at many other breeding sites along the Pacific Coast, allowing biologists to better track birds during the breeding season, to estimate survival of banded birds, and to better understand breeding site fidelity.

Several days before a nest is due to hatch, the eggs are checked for signs of hatching, such as cracks in the eggs, tapping, and peeping sounds. These signs of hatching help biologists better predict how soon the eggs will hatch, allowing all of the chicks to be banded at the same time and before they leave the nest cup. During banding, the chicks are placed in a knit sack, or other type of warm enclosure, to keep them contained and to aid in heat conservation. Each chick is banded with four colored plastic bands, two on each lower leg. The plastic bands are welded shut with a portable soldering iron and wrapped with the same color tape. The tape is better secured by heat sealing the ends with the soldering iron. The left leg for each chick is banded with the colors aqua over violet to designate them as banded at PORE. The right leg is banded with a unique brood or individual color combination.

The condition of each chick is assessed before bands are applied to insure that only strong, healthy chicks are banded. To estimate the amount of time the chick has been out of the egg, the percentage of dry feathers on the chick and the presence of an egg tooth or yolk sac are noted. The weight of each individual chick is measured by placing the chick in a nylon sack and using a Pesola scale. Chicks cannot be weighed if it is too windy due to inaccurate readings on the scale.

Predator Counts

Frequent predator population surveys are conducted to monitor changes in local predator populations and distributions near plover habitat. Predator surveys are conducted in conjunction with daily plover surveys. All predators are recorded as they pass observers at a 90° angle on the beach or up to 75 meters into the dunes. Predators that flush in any direction from a stationary position in response to observers are also counted. However, predators that pass the observer and then immediately reverse direction are not counted. A GPS unit is used to record location of the observer when he/she is adjacent to the location of the predator at first sighting. Results are entered in a Microsoft Access database.

Minimum Population Estimate

Due to the small size of the plover population at PORE, it is possible to obtain an accurate estimate of the minimum population size without banding. A minimum population estimate is determined using the steps outlined in Appendix D and corroborated with the results of the annual Snowy Plover Breeding Bird Window Survey, which is coordinated by the USFWS. The window survey involves surveying all current and historic PORE breeding sites during a pre-defined time period that includes the typical peak of nesting season. Since past monitoring data shows that the peak nesting period of

the PORE plover population is typically outside this time period, the criteria listed Appendix D are used to determine a more accurate minimum estimate.

Western Snowy Plover Docent Program

To educate park visitors about the plight of the western snowy plover and to minimize potential negative impacts from visitors, especially those with dogs, the Western Snowy Plover Docent Program was established in 2003. Volunteer docents are stationed at trailheads leading to snowy plover habitat on all weekends and holidays between Memorial Day and Labor Day. Docents educate visitors about snowy plovers and the entire coastal dune ecosystem through one-on-one contacts, educational flyers, and guided observations of snowy plovers on the beach. Docents also serve an important role in addressing and reporting law enforcement violations conducted in and near snowy plover habitat, particularly visitors in closed areas.

Results

Number of Surveys

During the 2015 snowy plover breeding season (March 2nd-September 2nd), monitoring staff conducted 161 surveys between Kehoe Beach and North Beach parking lot (K, NP), 84 in the 2011 Dune Restoration Area (RA), 9 from North Beach parking lot to South Beach parking lot (NB), 1 from South Beach parking lot to Lighthouse Beach (SB), 19 on Limantour Spit (L), and 1 survey on Drakes Spit (D).

Number of Nesting Plovers and Nests

A minimum estimate of 38 plovers bred at PORE in 2015 (22 males, 16 females; see Appendix D for estimation criteria). The USFWS Breeding Bird Window Survey resulted in an estimate of 40 adults (17 males, 23 females), higher than the minimum estimate calculation for PORE. In 2014, there were 29 breeding plovers at PORE, compared to a total of 18 and 9 plovers that bred at PORE in 2013 and 2012 respectively (Table 1, Figure 2).

Maximum numbers have not been reported since 2009 due to variability in observer detection and the adoption of a new methodology to determine the number of nesting plovers at PORE (Appendix D). See Adams et al. (2014) for an explanation of methodology used to determine minimum and maximum numbers before 2009.

Of the 49 nests located in 2015, 22 were between Abbotts Lagoon and North Beach parking lot, 8 were between the Kehoe Beach entrance and Abbotts Lagoon, and 16 were in the 2011 Restoration Area (Appendix E). For the first time in 14 years nesting occurred on Limantour Spit, with two nests located there in 2015 (Table 2, Figure 3). Additionally, for the first time since 1995 a nest was located between North Beach parking lot and South Beach parking lot. For the third year in a row, one nest was located in the hardpan area immediately north of the North Beach parking lot. This area was not utilized in 2012 but had been used the three preceding years.

Nest Success

Exclosures were placed around 32 of the 49 nests in 2015. Overall, 30 of the 49 nests hatched at least one egg and 80 of 131 eggs hatched (Table 3, Figure 4). Of the 19 nests that failed to hatch, four were exclosed. The cause of loss for the 19 failed nests was determined to be: 11 by depredation, 2 by abandonment, 3 unknown causes, and 3 by environment (Table 4, Figure 5). Of the depredated nests, four were determined to be by ravens and seven were unknown (Table 4, Figure 5). See Appendix A for an explanation of criteria used to determine nest loss and Appendix C for details on the fate of all nests found in 2015.

Table 1. Number of western snowy plovers nesting at PORE, 1986–1989 and 1995–2015.

Year	Females	Males	Total ¹	ENSO Events (June – Nov)
1986	22-23	19-21	41-44	
1987	25-26	25-28	50-54	Yes
1988	21-22	19-20	40-42	
1989	18-20	16-17	34-37	
NO DATA	–	–	–	
1995	6	6	12	
1996	5-6	5	10-11	
1997	12	13	25	Yes
1998	7	9	16	
1999	9	11	20	
2000	17-18	14-19	31-37	
2001	13-19	14-17	27-36	
2002	17-19	17-18	34-37	Yes
2003	11-12	12-13	23-25	
2004	17-18	17-18	34-36	Yes
2005	9-10	10-11	19-21	
2006	14-15	16-17	30-32	Yes
2007	14-15	16-17	30-32	
2008	11-12	12-13	23-24	
2009 ¹	11	13	24	Yes
2010	6	8	14	
2011	5	9	14	
2012	4	5	9	
2013	9	9	18	
2014	13	16	29	
2015	16	22	38	

¹In 2009, alternative methodology was developed to determine the number of nesting plovers at PORE. See Appendix D for further explanation.

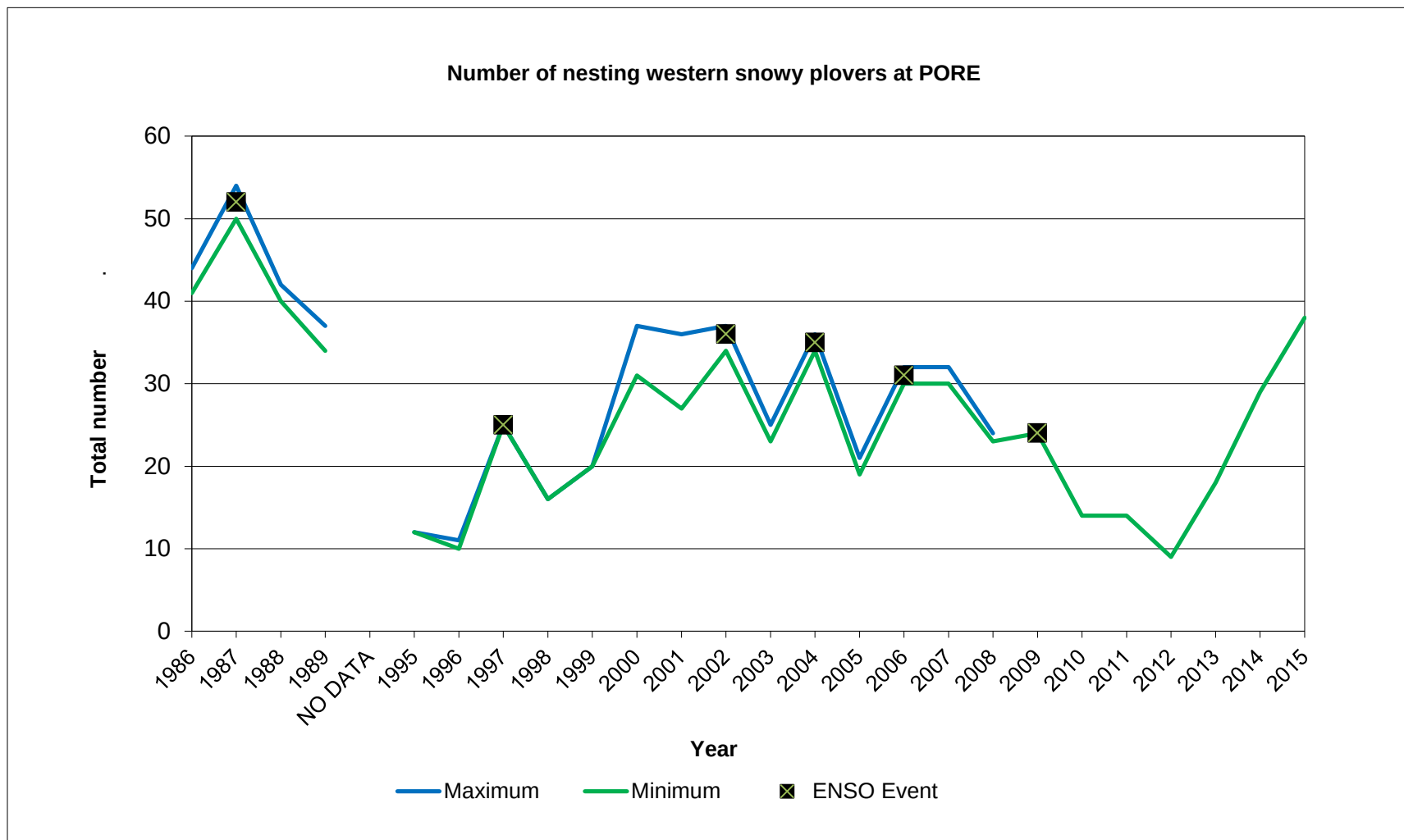


Figure 2. Number of nesting western snowy plovers and occurrence of El Niño (ENSO) events, 1986–1989 and 1995–2015. Square data points indicate ENSO events occurred between June and November of specified year.

Table 2. Number of western snowy plover nests, by survey sector, 1986–1989 and 1995–2015.

Year	Number of nests by beach survey sector ¹						
	K	NP	RA ²	NB	SB	L	Total
1986	5	29	NA	1	2	4	41
1987	9	48	NA	6	11	1	75
1988	5	41	NA	7	12	0	65
1989	6	42	NA	7	6	0	61
NO DATA	–	–	–	–	–	–	–
1995	4	11	NA	5	0	0	20
1996	0	8	NA	0	0	1	9
1997	0	18	NA	0	0	7	25
1998	2	10	NA	0	0	2	14
1999	0	16	NA	0	0	5	21
2000	10	15	NA	0	0	3	28
2001	8	26	NA	0	0	0	34
2002	6	24	NA	0	0	0	30
2003	6	16	NA	0	0	0	22
2004	21	16	NA	0	0	0	37
2005	4	15	NA	0	0	0	19
2006	11	13	NA	0	0	0	24
2007	14	14	NA	0	0	0	28
2008	11	10	NA	0	0	0	21
2009	9	12	NA	0	0	0	21
2010	7	8	NA	0	0	0	15
2011	3	12	0	0	0	0	15
2012	2	4	1	0	0	0	7
2013	6	13	2	0	0	0	21
2014	6	25	14	0	0	0	45
2015	8	22	16	1	0	2	49
Mean ³	7	15	8	0	0	1	24

¹K = Kehoe Beach to Abbotts Lagoon, NP = Abbotts Lagoon to North Beach parking lot, NB = North Beach parking lot to South Beach parking lot, SB = South Beach parking lot to Lighthouse Beach, L = Limantour Spit

² RA sector created in 2011, no previous data

³ Mean is from years with exclosures (1996-2015)

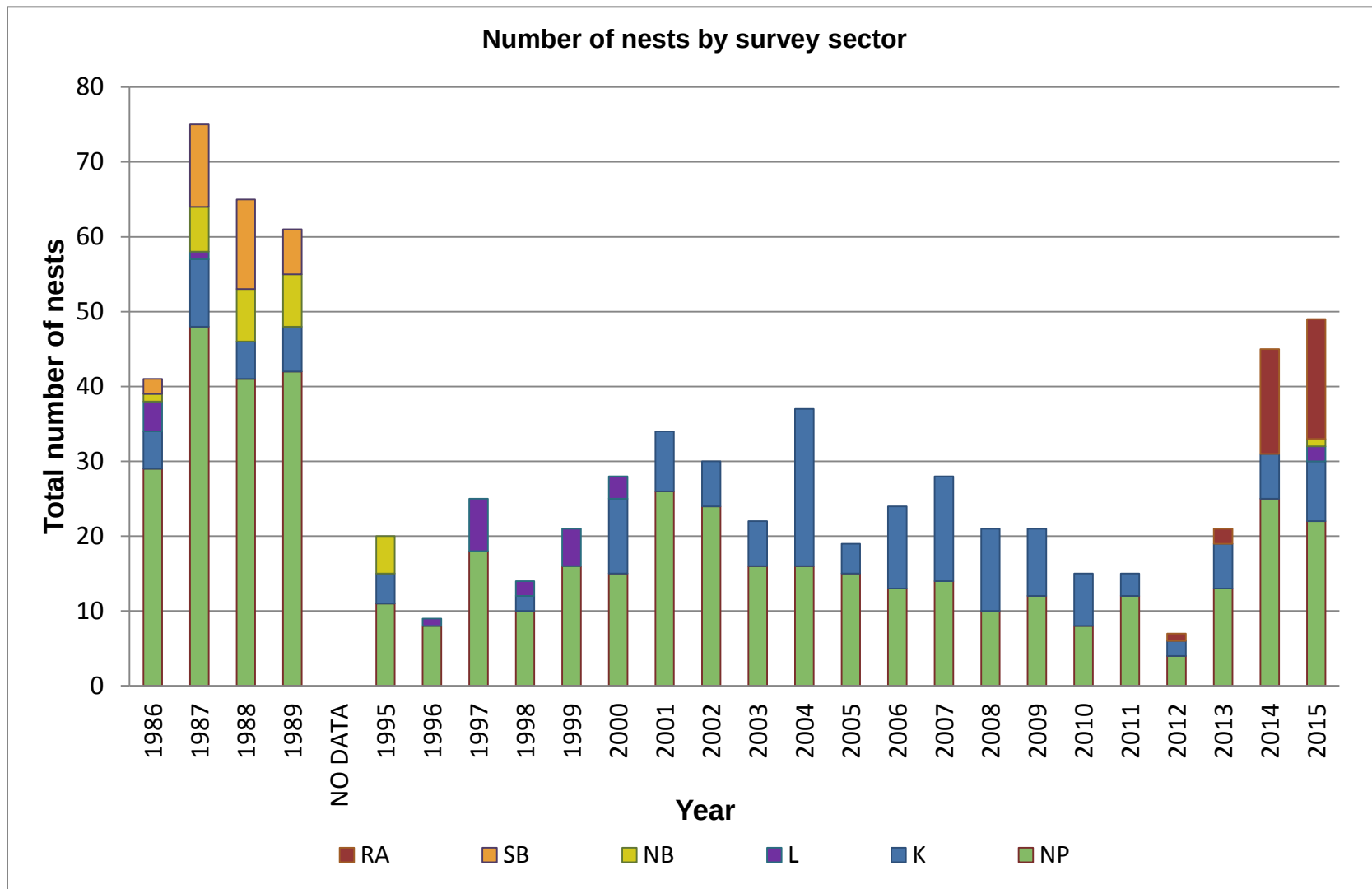


Figure 3. Number of western snowy plover nests at all surveyed beaches, 1986–1989 and 1995–2015. RA = 2011 Restoration Area, SB = South Beach parking lot to Lighthouse Beach, NB = North Beach parking lot to South Beach parking lot, L = Limantour Spit, K = Kehoe Beach to Abbotts Lagoon, NP = Abbotts Lagoon to North Beach parking lot.

Table 3. Western snowy plover nest success on Point Reyes beaches, 1986–1989 and 1995–2015.

Year	Nests		Eggs			Chicks		
	Number	% Hatched	Number	Number Hatched	% Hatched	Number Fledged	% Fledged	Fledged Per Egg
1986	38 ¹	26.3	108	28	25.9	5	17.9	0.04
1987	75	18.6	201	35	17.4	15	42.9	0.07
1988	65	7.7	161	11	6.8	5	45.5	0.03
1989	61	1.6	146	3	2.1	1	33.3	0.01
NO DATA	–	–	–	–	–	–	–	–
1995	20	10.0	55	5	9.1	4	80.0	0.07
1996	9	77.8	27	19	70.4	15	78.9	0.56
1997	25	64	62	41	66.1	25	61	0.4
1998	14	92.9	42	37	88.1	23	62.2	0.55
1999	21	76.2	61	44	72.1	24	54.5	0.39
2000	28	50	81 ³	41	50.6	14	34.1	0.17
2001	34	26.5	86 ⁴	25	29.1	10	40.0	0.12
2002	30	50.0	76	41	53.9	17	41.5	0.22
2003	22	77.2	63	43	68.3	19	44.2	0.30
2004	37	78.3	107	86	80.4	19	22.1	0.18
2005	19	63.1	53	33	62.3	17	51.5	0.32
2006	24	79.2	69	51	73.9	23	45.0	0.33
2007	28	82.1	83	64	77.1	24	37.5	0.29
2008	21	52.3	55	30	54.5	5	16.1	0.09
2009	21	66.7	60	38	63.3	8	21.0	0.13
2010	15	60.0	42	21	50.0	7	33.3	0.17
2011	15	86.7	45	36	80.0	11	30.5	0.24
2012	7	71.4	21	15	71.4	9	60.0	0.43
2013	21	52.4	58	30	51.7	15	50.0	0.26
2014	45	44.4	108	54	50.0	15	27.8	0.14
2015	49	61.2	131	80	61.1	19	23.8	0.15
Mean ⁵	24.3	65.6	66.5	41.5	63.7	16.0	41.8	0.30

¹ 41 nests were located in 1986 but only 38 were monitored for success.

² 38-40 eggs hatched

³ 80-81 eggs laid

⁴ 85-87 eggs laid

⁵ Mean includes data from first year exclosures were used in 1996 through 2015.

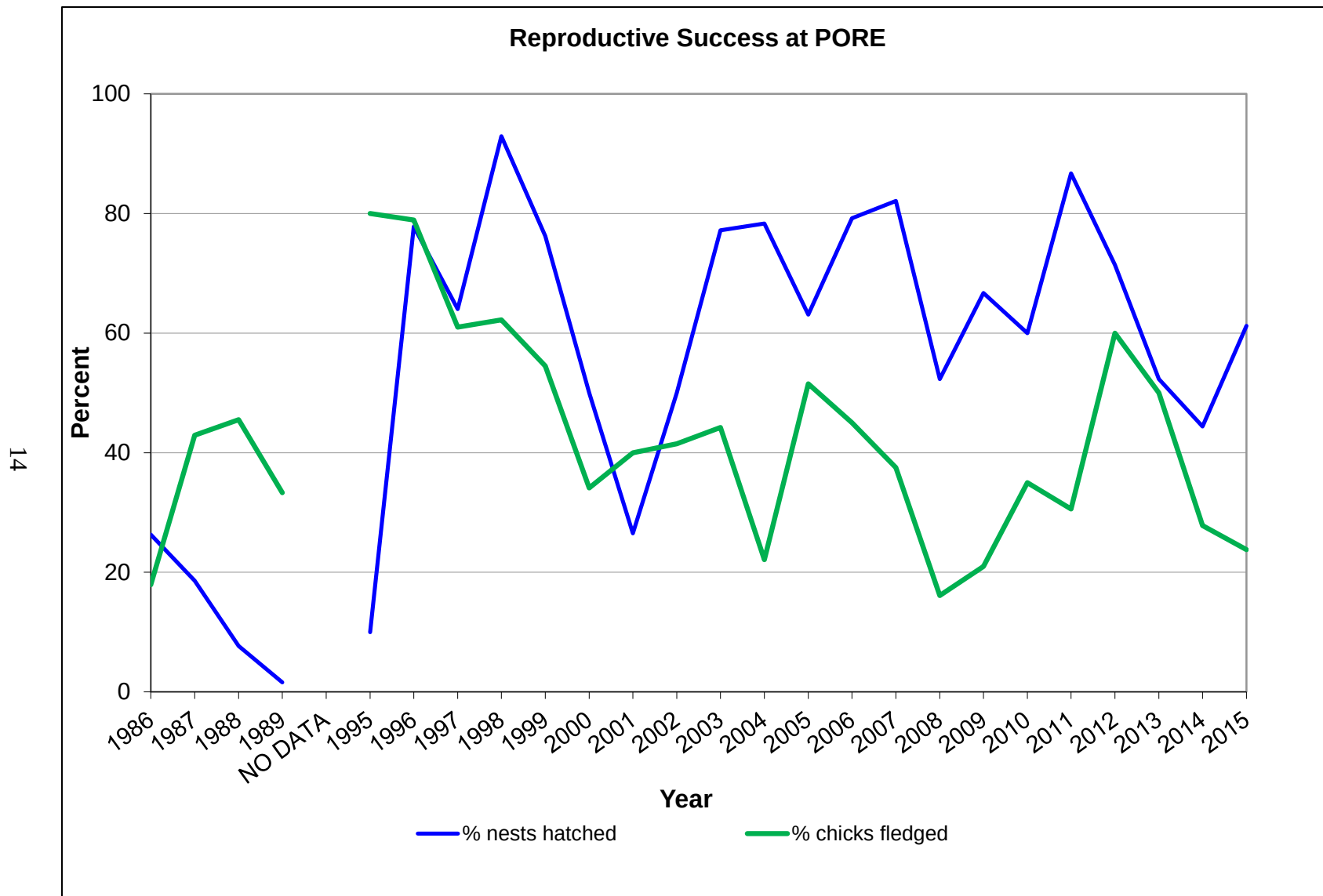


Figure 4. Comparison of reproductive success parameters at Point Reyes, 1986–1989 and 1995–2015.

Table 4. Causes of western snowy plover complete nest loss on Point Reyes beaches, 1996–2015.

Year	Total Nests	Nests Exclosed	Raven		Wild Canid ¹		Bob-cat		Other Predator ²		Unidentified Predator		Unknown		Abandonment		Environmental ³		Unhatched Eggs	
			N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
1996	9	8	1												1					
1997	25	19	3										2				1	3		
1998	14	14															1			
1999	21	20						1					1		2	1	1			
2000	28	28											1		7		2			4
2001	34	16	11		2					1			2		8	1				
2002	30	20	5		1					1	2				3	2	1			
2003	22	22													2		3			
2004	37	32			1										1	1		5		
2005	19	16			2	1									2	2				
2006	24	23				1									2					2
2007	28	22	1										3					1		
2008	21	18	2										3					5		
2009	21	19	1							1			1	1				3		
2010	15	15										2				3				1
2011	15	13											1			1				
2012	7	5														1		1		
2013	21	11			3						2					2		2		1
2014	45	25	6						1		8		2			5		1		2
2015	49	32	4								7		3		1	1		3		

N = Nest was not exclosed, E = Nest was exclosed

¹ "Wild Canid" includes coyotes and foxes

² "Other Predator" includes other avian species, rodents, mustelids, etc.

³ "Environmental" includes wind and tides

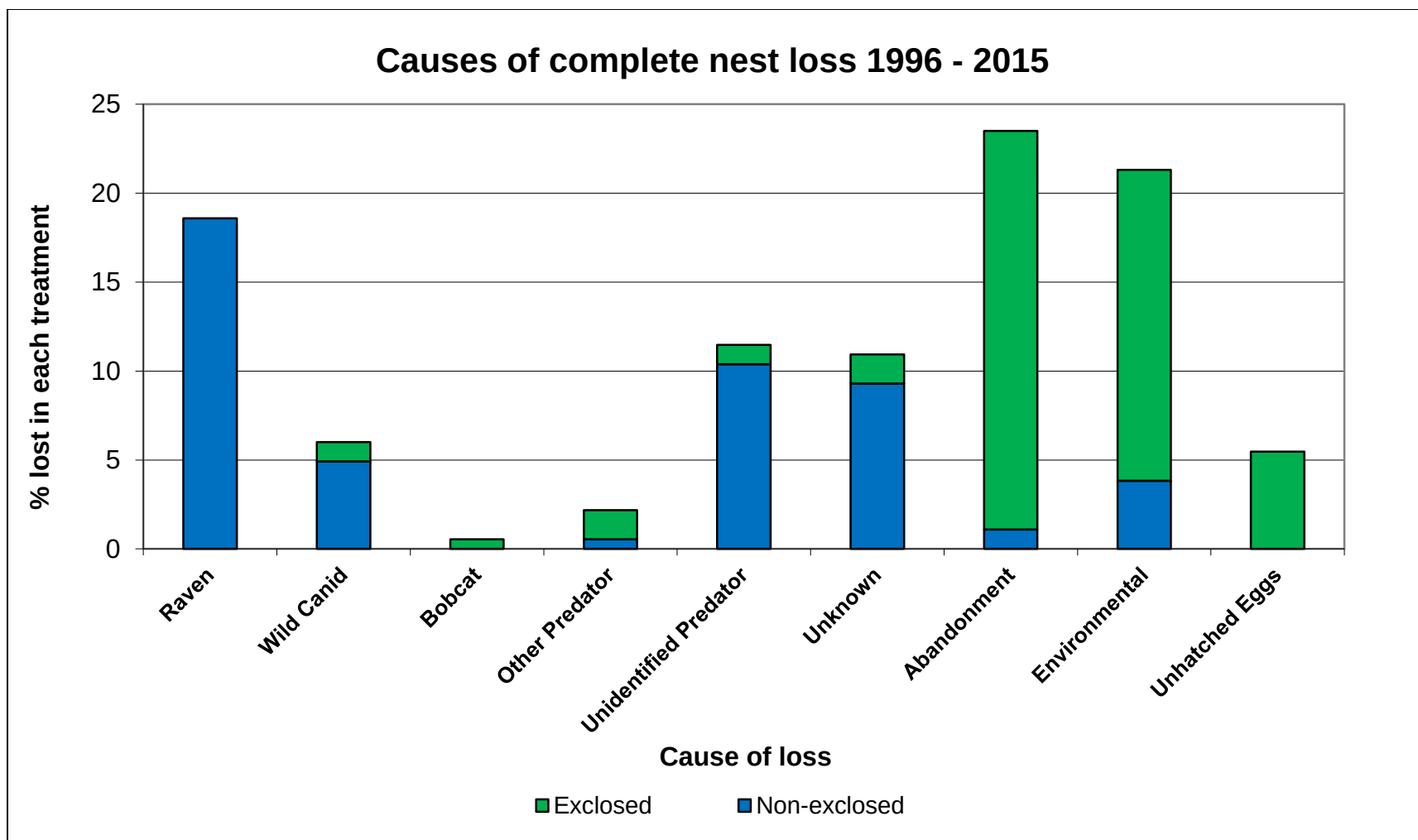


Figure 5. Percent of total nests lost for exclosed nests and non-excused nests from 1996–2015.

Fledging Success

Nineteen of 80 chicks survived to fledging (for at least 28 days) after hatching, a 23.8% fledging rate (Table 3). Only 13 of the 30 successful nests fledged at least one chick (43%), compared to 45% in 2014, 72.7% in 2013, and 80% in 2012. Two chicks fledged from the hardpan area immediately north of the North Beach parking lot (Appendix E), however, the brood moved north out of the hardpan area a day after all the chicks had hatched. One chick fledged from this area in 2011 and 2010, and two chicks in 2009, which was the first year snowy plovers were recorded using this area for nesting. Overall, the 2015 fledging rate was 0.86 chicks per male, the second year in a row since 2010 that the rate was below 1.0 (Figure 6). The USFWS has set a recovery goal of maintaining fledge rates of at least one chick per male to attain a sustainable population (USFWS 2007).

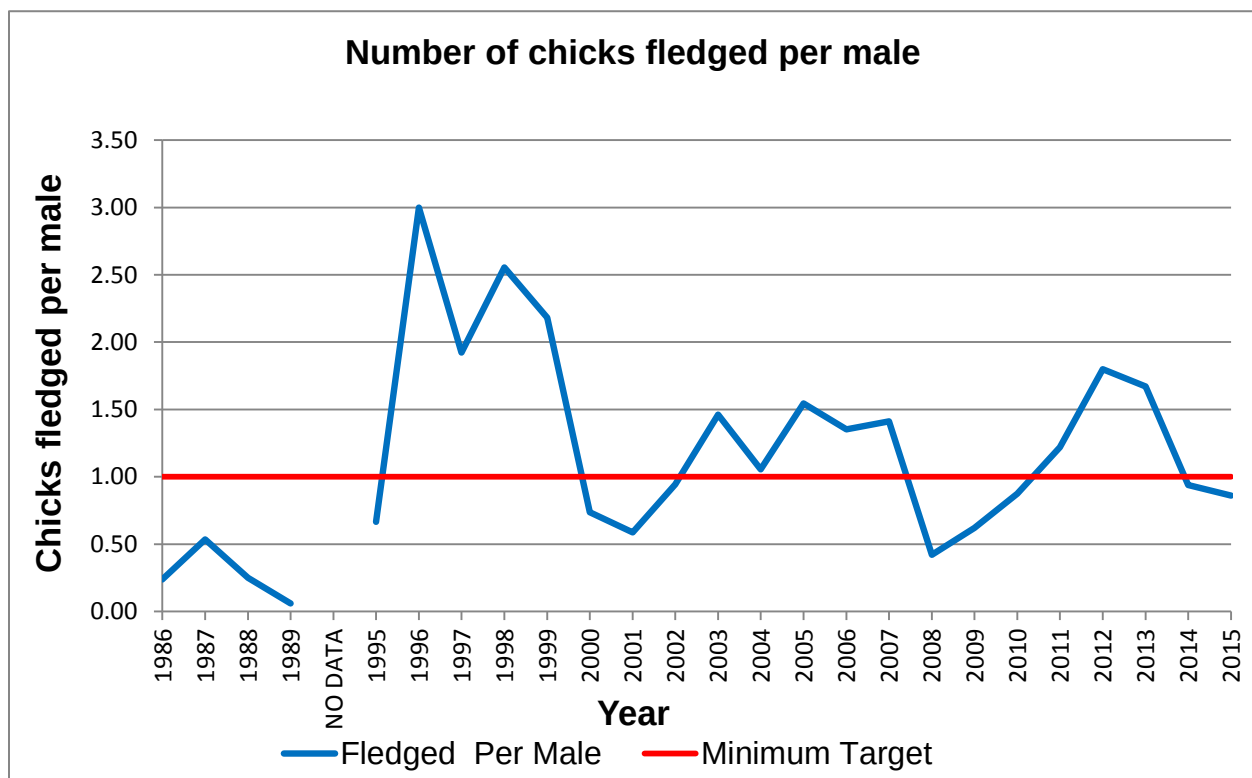


Figure 6. Total number of chicks fledged per male, 1986–1989 and 1995–2015.

Timing of Chick Loss

The timing of chick loss was determined for all 61 chicks lost in 2015 (using criteria in Appendix B). Of the 22 chicks that failed to fledge on North Beach, six were lost on a weekend/holiday, and 16 on weekdays. On Kehoe Beach, of the eight chicks that failed to fledge, six were lost on a weekend/holiday and two on weekdays. Of the 29 chicks that failed to fledge in the RA, 11 were on a weekend/holiday, and 18 on weekdays. Of the ten chicks on the beach during the busy weekend of July 4th holiday, nine survived. All eight chicks on North Beach survived, one on Kehoe survived and one was lost on Kehoe. Overall, 37.7% of chicks lost were lost on weekends/holidays, which

constituted 30.2% of all days that chicks were on the beach. The weekend/holiday chick loss of 37.7% was a higher percentage of chicks lost on weekends and holidays than 2014 at 25.6% (Figure 7). In 2015, 74% of chicks that failed to fledge disappeared by the age of 10 days, 15% from ages 11-20 days, and 10% from ages 21-28 days (Figure 8).

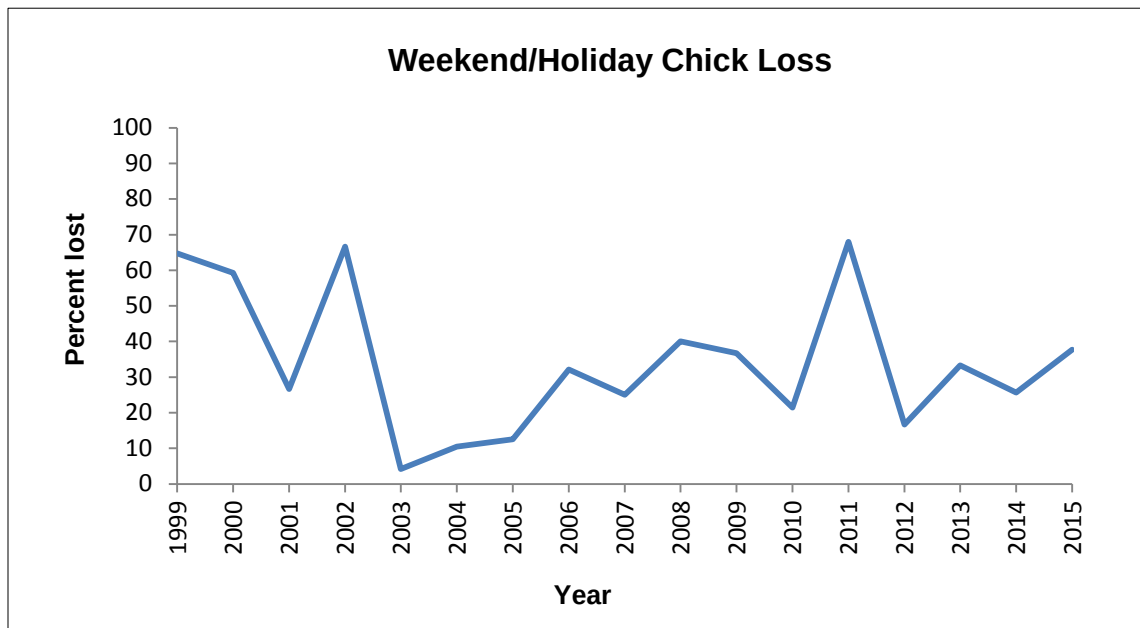


Figure 7. Percent of pre-fledge chicks lost on weekends/holidays from 1999 to 2015.

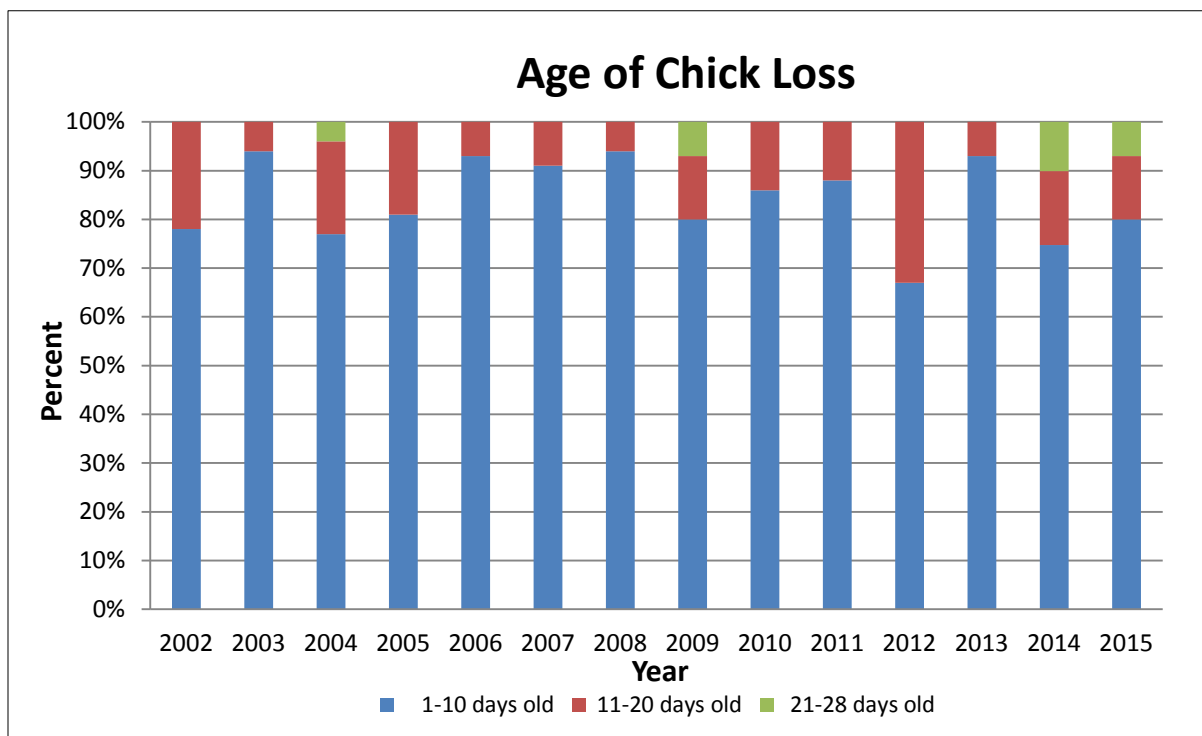


Figure 8. Percent of chicks lost in each age category from 2002 to 2015.

Plover Use of Restored Habitat

Between 2011 and 2012, approximately 250 acres of dune habitat has been restored to native plant communities. European beach grass and iceplant has been removed through a combination of mechanical treatment, herbicide, and hand-pulling, creating the RA sector along the boundary of the NP sector (Figure 1). It should be noted that excavation of beach grass was occurring in this area through July 2011, so nesting during the 2011 season may have been discouraged by restoration activity. Beach grass was also removed from two areas on NP and K sectors in 2004 and 2005, although only the restored area on Kehoe (K) has been maintained over time. Thus, beach grass on North Beach (NP) has returned to pre-restoration levels, making assessment of use of this “restored” habitat of limited value. Therefore, we only report data for the area restored in 2004 and 2005 for the Kehoe sector.

Sixteen nests in the 2015 season were located in the 2011 dune restoration area (RA sector). Of the 22 nests on North Beach, one was located adjacent to the RA sector. Of the eight nests on Kehoe Beach, none were on the beach near the 2004 and 2005 restored area.

Of the 35 chicks hatched in the RA, six reached fledging age, accounting for 32% of fledges in 2015. None of the six fledges stayed in the RA longer than two weeks, instead moving south to the NP sector. In 2014, six of the chicks hatched from the 2011 restoration area fledged, accounting for 40% of fledges. No chicks fledged from or utilized the RA sector in 2013. In 2012, two chicks regularly utilized the RA sector and fledged.

Chick Banding

Chicks were banded for the first time at PORE in 2015. Of the 30 nests that hatched at least one chick, bands were applied to 13 of the broods and a total of 34 chicks (Appendix F). Seven broods (18 chicks) hatched from the RA sector, two broods (6 chicks) were from the Kehoe sector, and four broods (10 chicks) were from the NP sector. Nine banded chicks from five different broods survived to fledging.

Eleven of the 13 broods banded were banded with brood combinations, all of the chicks receiving the same color bands. Two broods were banded with individual combinations, a unique color combination for each chick. Two of the eleven broods banded with brood combinations fledged two chicks each, resulting in two sets of duplicate band combinations. Of the two broods banded with individual combinations, one fledged all three chicks and one fledged one chick. In total, seven different band combinations on nine individual fledges were contributed to the western snowy plover population from PORE (Appendix F).

Raven Occurrence

Common ravens have been a constant presence on PORE beaches since predator monitoring began in 2002. Raven activity on Kehoe Beach in 2015 was higher than in any other survey area (Figure 9, Table 5). Ravens were seen on Kehoe Beach on 95.1% of surveys and the average number of ravens observed per survey was 37.9, far exceeding the next highest survey area at North Beach where 4.1 ravens per survey were observed on average. Ravens averaged 12.32 birds per survey hour on Kehoe Beach in 2015, nearly nine times higher than the Restoration Area where ravens averaged 1.4 birds

per survey hour. Ravens were least active on Limantour Beach where ravens averaged 1.8 per survey and averaged 0.64 birds per survey hour (Figure 9, Table 5).

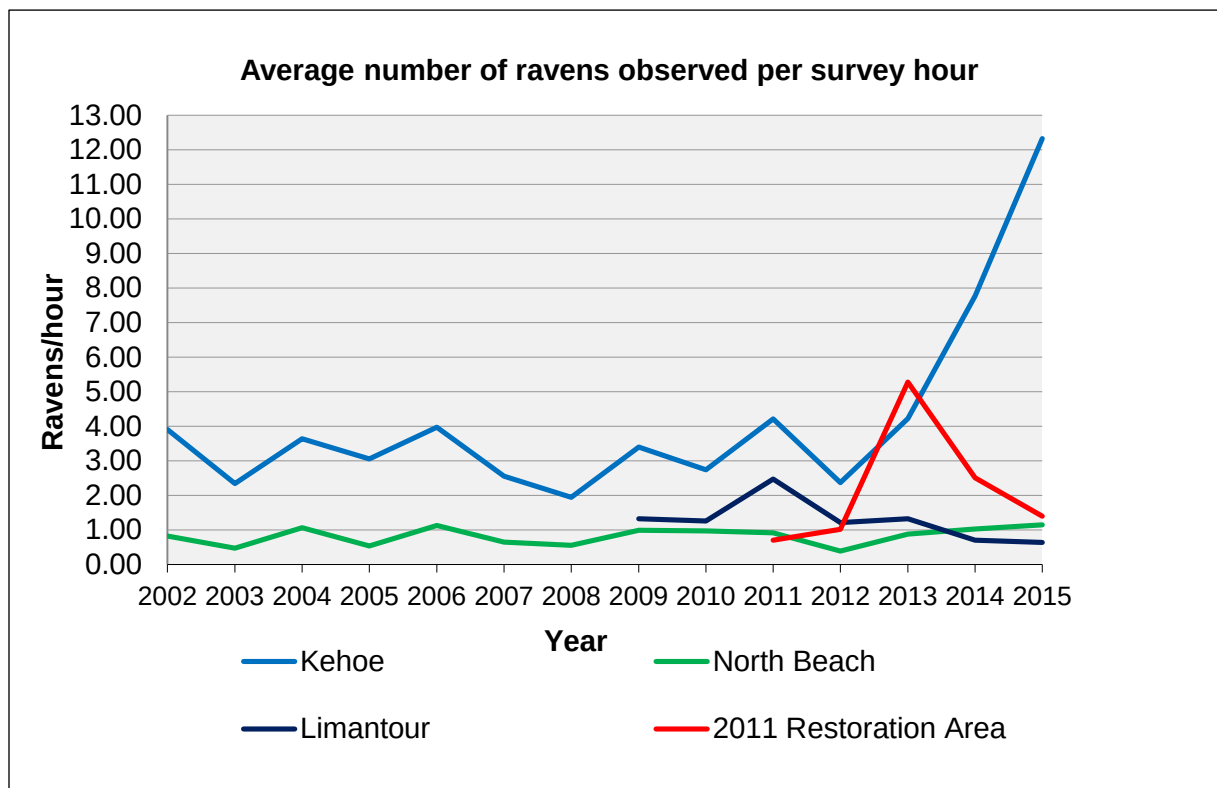


Figure 9. Average number of ravens observed per survey hour from 2002 to 2015. Data not available for Limantour from 2002-2008 and the Restoration Area wasn't established until 2011.

Table 5. Occurrence of common ravens on surveys from 2002 to 2015. Data not available for Limantour from 2002-2008 and the Restoration Area wasn't established until 2011.

Site	Year	No. of Surveys	Total Survey Hours	Surveys with Ravens	Total Raven Sightings	% Surveys with Ravens	Average Ravens per Survey	Average Ravens per Survey per Hour
Kehoe Beach	2002	47	120	39	470	83	10.0	3.91
	2003	41	128	22	300	54	7.3	2.34
	2004	72	292	66	1062	92	14.8	3.64
	2005	40	95	34	291	85	7.3	3.05
	2006	76	211	68	836	89	11.0	3.97
	2007	78	312	71	795	91	10.2	2.55
	2008	86	344	64	666	74	7.7	1.94
	2009	59	164.8	53	561	89.8	9.51	3.40
	2010	68	161.9	55	444	80.9	6.53	2.74
	2011	59	116.5	45	491	76.3	8.32	4.21
	2012	60	97.5	28	231	46.7	3.85	2.37
	2013	50	82.1	31	347	62	6.94	4.22
	2014	49	106.7	39	829	79.6	16.92	7.77
	2015	41	126.2	39	1555	95.1	37.93	12.32
	Average	59	168.4	47	634	78.5	11.31	4.17
North Beach	2002	57	172	31	141	54	2.5	0.82
	2003	72	231	20	108	28	1.5	0.47
	2004	62	150	25	158	40	2.6	1.06
	2005	68	121	18	65	27	1.0	0.54
	2006	76	204	48	230	63	3.0	1.13
	2007	70	350	68	228	97	3.3	0.65
	2008	61	305	45	169	74	2.8	0.55
	2009	66	207.8	33	206	50.0	3.12	0.99
	2010	60	167.7	38	163	63.3	2.72	0.97
	2011	99	200.1	39	184	39.4	1.86	0.92
	2012	75	160.7	22	63	29.3	0.84	0.39
	2013	49	100.1	22	88	44.9	1.79	0.88
	2014	86	246.2	48	255	55.8	2.96	1.03
	2015	83	299.7	59	346	71.1	4.14	1.15
	Average	70	208.2	37	172	52.6	2.43	0.83
Restoration Area	2011	12	7.2	4	5	33.3	0.42	0.7
	2012	13	12.7	4	13	30.8	1	1.02
	2013	16	16.1	9	85	56.3	5.31	5.28
	2014	47	78.3	27	197	57.4	4.19	2.51
	2015	51	88.2	29	124	56.9	2.43	1.4
	Average	28	40.5	15	85	46.9	2.67	2.18

Table 5 (continued). Occurrence of common ravens on surveys from 2002 to 2015. Data not available for Limantour from 2002-2008 and the Restoration Area wasn't established until 2011.

Site	Year	No. of Surveys	Total Survey Hours	Surveys with Ravens	Total Raven Sightings	% Surveys with Ravens	Average Ravens per Survey	Average Ravens per Survey per Hour
Limantour Beach	2009	3	5.3	3	7	100	2.33	1.32
	2010	8	13.5	6	17	75	2.12	1.26
	2011	20	54.5	17	135	85	6.75	2.47
	2012	7	11.6	6	14	85.7	2	1.21
	2013	8	10.6	7	14	87.5	1.75	1.32
	2014	6	11.4	3	8	50	1.33	0.7
	2015	17	46.8	11	30	64.7	1.76	0.64
	Average	10	22.0	8	32	78.3	2.58	1.27

Discussion

Number of Nesting Plovers

The minimum estimate of 38 nesting snowy plovers at PORE in 2015 was higher than the mean estimate of 22.6 (SD = 7.8) individuals in the 19-year period from 1996 to 2014, during which exclosures have been used to protect nests. Thirty-eight nesting snowy plovers was one of the highest estimated minimum numbers of nesting plovers since 1995 (Table 1). Additionally, 2015 was the third year in a row the number of breeding adults has increased after hitting the lowest on record in the 2012 breeding season. The reason for the increase is uncertain, but follows a trend seen across the range of the western snowy plover. Following a count of 1,834 birds along the Pacific Coast in 2013, the number of breeding birds counted during the USFWS Breeding Bird Window Survey has increased by 23% to 2,260 birds in 2015 (USFWS 2015). The rangewide increase in the western snowy plover population may in part be due to mild winter conditions in the western United States and subsequent higher overwinter survival of plovers during this time period.

The minimum estimate of 38 nesting adults was lower than the USFWS Breeding Bird Window Survey's estimate of 40 adults. High nest loss can cause a discrepancy between the minimum estimate and that of the breeding window survey. The minimum estimate is based off the peak number of nests and broods on the beach at one time, plus any banded birds that may breed outside that peak. With high nest loss, some adults may be between nesting attempts when the peak occurs and therefore are not included in the minimum estimate. The USFWS Breeding Bird Window Survey included some of these adults in the count.

Nest Hatching Rate

The 61.2% clutch hatching rate in 2015 was slightly lower than the mean of 65.8% (SD = 16.8) from 1996 to 2014. Post-management hatch rates (1996-2015) have increased compared to pre-management hatch rates (Figure 4). This is likely due to the success of predator exclosures at protecting nests until their hatch date.

Nest abandonment was the cause of two nest losses in 2015. One was located on NP and one on K. Predation was ruled out for both nests because the eggs remained in the scrape. The nest on NP was abandoned at one egg before an exclosure was established and before incubation had started. On the day of discovery, two adults were observed in the area but project biologists could not confirm if the adults were associated with the nest. There were several visitor disturbances in a short amount of time after the nest was discovered but before the closure around the nest could be established. High disturbance at the beginning of nesting can lead to abandonment. Predation of adults on one egg nests is unlikely because incubation has not yet begun.

The nest on K was abandoned after incubation had begun and after the exclosure was established. The eggs were found buried by sand after a period of high, sustained winds. Two out of three eggs were subsequently found and unburied by the project biologist, and an adult plover was observed back at the nest incubating the eggs again. The eggs were found buried a second time, but this time no plovers returned to the nest after the eggs were unburied. Neither adult was banded, therefore the

plovers could not be confirmed as still alive and predation remains a possibility. Wind was eliminated as the primary cause of nest loss because nests in adjacent areas were not buried.

Abandonment was the cause of five nest losses in 2014, two nest losses in 2013, one nest loss in both 2012 and 2011, and was the primary cause of nest loss in 2010 (20% abandonment). The reasons for most of the recorded abandonment events at PORE are unknown, but the relationship between prolonged exclosure use and increased snowy plover adult mortality rates has been documented in Monterey Bay (Neumann et al. 2004). Abandonment of exclosed nests in Monterey Bay was often linked with the disappearance and presumed death of a banded adult, suggesting that the abandonment was caused by adult mortality associated with the exclosure (Neumann et al. 2004).

Annually, the PORE plover management team evaluates the use of exclosures at PORE, and for the third year in a row it was decided to reduce the number of exclosures used to help lower abandonment rates. Prior to 2013, it was concluded that predation pressures on unprotected nests at PORE remained too high to warrant a reduction in exclosure use. In the 2012 breeding season, however, two nests were not exclosed at PORE and both hatched three eggs successfully. The PORE plover management team decided to treat each nest individually in 2013 to determine whether or not it should be exclosed. The factors considered for each nest was: predator presence observed in that location, fate of other adjacent nests, distance from dunes, location relative to public access, and whether the plover pair had nested successfully earlier in the season.

The success rates between exclosed and non-exclosed nests were very similar in 2013. Six of the eleven nests exclosed in 2013 successfully hatched (54.5%) and five of the ten non-exclosed nests hatched (50%). In 2014, exclosed nests were more successful with 17 of the 25 exclosed nests hatching (68%), while only three of the twenty unexclosed nests hatched (15%). In 2015, results were similar to 2014 with exclosed nests being more successful than unexclosed nests. Of 32 nests that were exclosed, 27 hatched (84%), while only two out of 17 unexclosed nests hatched (12%).

Despite clearly higher success rates of exclosed nests over unexclosed nests in 2014 and 2015, the PORE plover management team will continue to strive to reduce the use of exclosures to protect plovers at PORE. Exclosures expose adult plovers to a greater risk of predation, and losing an adult plover, as opposed to a nest, has a more lasting effect on the plover population. When a nest is lost, plovers can and will re-nest, but when a breeding adult is lost, that individual's ability to nest and contribute new plovers to the population is lost forever. Besides considering the use of exclosures on a case by case (nest by nest) basis, other strategies include letting nests remain unexclosed until just prior to hatch and using exclosures more exclusively in the latter part of the season.

Chick Fledging Rate

In 2015, the 23.8% fledging rate at PORE was lower than the 42.8% (SD=16.2) average of the previous 19 years, 1996-2014 (Table 3) and the lowest since 2009. The rate has climbed steadily since falling to an all-time low in 2008 (16.1%). The low fledgling rate may have been a result of high raven use of the K and NP sectors, where the raven detection rates were above average (see Raven Occurrence section below). Additionally, similar to 2014, more chicks were lost at an older age than previously seen (see Timing of Chick Loss section below). Older chicks are less vulnerable

to environmental conditions, so increased predator pressure may have been the cause of the higher loss rate in older chicks.

Reducing exclosure use may aid chick fledging success. Of the 80 chicks that hatched, 74 were from exclosed nests and six were from unexclosed nests. Of those 74 from exclosed nests, 17 fledged (23.0%) and of the six from unexclosed, two fledged (33.3%). In 2014, the fledge success of exclosed nests was 26% and unexclosed was 38%. In 2013, the fledge success of exclosed nests was 38%, but was 64% from unexclosed nests. The exclosures may draw the attention of predators, resulting in lower survival of chicks from exclosed nests. In 2015, raven tracks were seen circling several exclosed nests, particularly in the RA, and the chicks from those nests were lost soon after hatching.

The USFWS uses the chick fledgling rate to gauge progress towards a sustainable coastal population of western snowy plovers, and aims to have at least one chick fledged per male in order to achieve this goal (USFWS 2007). From 1996 to 2007, Point Reyes beaches surpassed that goal by producing an average of 1.56 chicks per male. However, in 2008, only 0.42 chicks were fledged per male. After 2008, the number of chicks per male steadily increased and was higher than the one chick per male goal for three years in a row (2011-2013). Unfortunately, the 2014 rate fell to 0.94 chicks per male and decreased again in 2015 to 0.86 chicks per male, below the average of 1.38 from 1996-2014 (Figure 6).

Timing of Chick Loss

As in the past 13 years, most chick losses occurred during the first third (1-10 days) of the fledging period in 2015 (80%; Figure 8). Once the chick reached the second third (11-20 days) the loss rate decreased (13%). The rate decreased again once the chicks reach 21-28 days old (7%). The 2015 season was the fourth season in which chicks were lost in the oldest age group since the metric was first recorded in 2002. The 2014 season had the highest rate of loss (10%) in the oldest age group, compared with 7% in 2015 and 2009, and 4% in 2004 (Figure 8).

Chick survival rates may decrease over weekends and holidays when human activity is higher on the beaches (Ruhlen et al 2003). Disturbances to broods cause changes in behavior from foraging or roosting to running and being vigilant. This change in behavior can result in less foraging time, reduced parental care, increased exposure to predators and environmental hazards for the chicks (Ruhlen et al 2003). In the 2015 season, 37.7% of the chicks were lost on weekends and holidays. This rate was above the average (34.0%) of the years the metric has been recorded since 1999 (Figure 7).

Use of Restored Dune Habitat

The restored dune area of Kehoe was not utilized in 2015 after being used in both 2014 and 2013. Before 2013, the area had not been used since 2005. The nest in 2014 was unsuccessful with an unknown cause of failure. Located in front of the most southern restored dune, this nest was near a public access point and experienced near-continuous human presence. The 2013 nest was located in a break in the dunes, further back on the beach and successfully hatched. Wintering groups of plovers are frequently sighted feeding and roosting in this area during early and late nesting season.

The lack of nesting between 2005 and 2013 in the portion of restored habitat nearest to sector K may have been due to the consistent presence of large groups of ravens that roost on a hill adjacent to this site. Previous attempts to deter ravens from this area have included the use of bald eagle decoys, hazing, and lethal removal of territorial pairs. While bald eagle decoys and hazing were not used this year, lethal removal was employed to reduce corvid impacts to plovers in this area.

Of the 22 nests on North Beach (NP) in 2015, one was located adjacent to the RA dunes and the nest was successful, it may have benefitted from the restored dunes. In 2014, four nests were located adjacent to the RA but only one hatched successfully. The chicks were observed utilizing the restored area but did not fledge. In 2013, no NP nests were located adjacent to the RA. In 2012, one nest was located in front of the RA sector and successfully fledged two out of three chicks. The chicks were observed utilizing the restored foredunes frequently and accounted for 22% of the fledglings in 2012.

In the 2015 season, 16 nests were located in the RA sector. Fourteen of the 16 nests hatched (87.5%) but only six of the 35 hatched chicks fledged (17.1%). By comparison, only 12 of the 22 nests in the NP sector hatched, but 11 of the 33 hatched chicks fledged (33.3%). Although the six fledges from the RA sector accounted for 31.6% of the fledglings in 2015, all of the fledges from the RA sector spent the majority of the 28 days before fledging on the NP sector south of the RA sector. Nest success in the RA was lower in 2014 than 2015 at 64.3%, but the fledge rate was higher with 6 of the 23 hatched chicks reaching fledgling age (26.1%). In 2015, extensive use of exclosures allowed most nests to hatch in the RA, but raven activity in the area helped explain the low reproductive output of the RA.

Raven Occurrence

Forty one predator surveys were conducted in conjunction with the plover surveys on Kehoe Beach in 2015 and ravens were present on 95.1% of those surveys. In the past few years, raven activity has increased dramatically on Kehoe Beach, rising from an average of 3.8 ravens per survey and 2.37 ravens per survey hour in 2012 to 37.9 ravens per survey and 12.3 ravens per survey hour in 2015. Raven presence may be suppressing plover activity and nesting on Kehoe Beach. Of the only eight nests that occurred on Kehoe Beach, three succeeded in hatching. Of the nests that hatched, only one of the nine chicks survived to fledgling age.

As noted in the previous section, fledging success was lower in the Restoration Area than on North Beach as attributed to raven activity. However, the actual recorded raven activity in the Restoration Area was lower than on North Beach (Table 5, Figure 9). The data may suggest that a small number of ravens were repeatedly targeting the Restoration Area as opposed to North Beach where more ravens may be traveling up and down the beach.

Lethal removal was used as a predator management strategy for corvids for the eleventh consecutive year at PORE. When used in combination with non-lethal predator control strategies, targeted removal of territorial pairs has been shown to have a large, positive effect on hatching success of the target bird species (Côté et al. 1997). Lethal removal at PORE was used only for corvids that were either identified as responsible for depredation of snowy plovers or observed actively hunting in

snowy plover nesting areas. Non-lethal raven deterrent measures were also put in place in 2015. Effigies were hung in the RA sector a week at a time to assist during nest hatching.

Vandalism

Since 2008, occurrences of vandalism have remained relatively infrequent. There have been up to three instances of vandalism per year since 2008. The 2015 season was similar to the 2014 and 2012 season in that there were no major instances of vandalism and no valuable property lost or damaged, other than paper signs removed and fences moved. There were no occurrences of vandalism in 2013. This compares to 19 instances of vandalism in 2007 and 24 in 2006. The high rate of vandalism in these two years may be suggestive of a single perpetrator. However, the decrease in vandalism since 2007 may also be attributed to better placement of permanent "No Dogs" signs along Kehoe Trail and at the entrance to the beach from North Beach parking lot. This signage has likely communicated a more official message than the temporary signage used in the past and is likely more difficult to vandalize than laminated signs on wooden posts that are easily removed and vandalized.

Although staff and docents were present on the beaches during busy weekend times, people were still observed entering closed, fenced areas on several occasions in the higher visitation areas at Abbotts Lagoon and near the North Beach parking lot. The most severe violation was when two people entered the closed area protecting the RA sector to build a structure on top of one of the restored dunes out of beach debris collected from the area. A plover nest was located behind the dune they built upon, and the adult was flushed off the nest several times. The people were contacted and left the closure reluctantly. Several violations occurred in which people walked past the boundary marking the weekend beach closure between Abbotts Lagoon and North Beach parking lot. Of the violations that were observed, they were minor and infrequent with limited disturbance.

Research and Management Recommendations

Continue Current Monitoring

The recovery plan (USFWS 2007) sets a goal of 50 adult birds on Point Reyes Beach (there were 34 in 2015), ten on Limantour Spit (there were four in 2015), and four on Drakes Spit (there were zero in 2015). The plan also recommends that a reproductive rate of one fledged chick per male is the minimum required to sustain the population (2015 rate was 0.86 chicks per male, Figure 6).

Continued monitoring is critical to determine if these population goals are being met and to allow managers to respond to new and increasing threats in a timely manner. The banding program initiated in 2015 will assist in achieving these goals by offering insight into survivorship rates, site fidelity and improving the quality of data collected at PORE. Multiple years of banding are required to obtain sufficient data for these analyses.

Further analysis of reducing exclosure use and its effects on hatch rates and fledging success is also important. Recent reports from Oregon suggest that exclosure use may increase hatch and fledge success up to the first several years of use, but that over time, increasing adult and chick depredation events near exclosures may actually decrease fledge success (Lauten et al. 2010). The banding program will assist in determining if exclosures are associated with adult depredation in PORE.

Ideal staffing for the snowy plover program at Point Reyes is one full time biologist from approximately March to October and one full time biologist from approximately April to September. Since monitoring plovers requires a significant amount of training to become familiar with field techniques, the program would greatly benefit from retaining the same field technicians from year to year. As the plover population increases and more habitat is restored, additional staff may be needed to adequately monitor and protect plovers at Point Reyes. All project staff must be added to the park's USFWS recovery permit in order to conduct snowy plover monitoring and protection activities at Point Reyes.

Predator Data Collection and Analysis

Improved methods for predator data collection were tested in 2011 and continued through 2015 in response to peer review comments on the draft monitoring protocol (Adams et al., 2014). The previous methods were not considered adequately systematic or standardized to assess how fluctuations in predator abundance, especially common ravens, relate to snowy plover nest success and productivity. The new, draft methods better quantify the time spent searching for predators and utilize a line transect method for collecting predator data. Using distance sampling techniques (Buckland et al. 1993), the data should allow for calculations of predator abundance and density that can be assessed in regards to the recovery of snowy plovers at PORE. These methods are being further refined, require peer-review, and will be formally incorporated into the snowy plover monitoring protocol.

In the future, predator monitoring data should be assessed for correlations with land management practices at the local and regional scale. For example, any seasonal trends across the plover breeding season that correlate with nearby agricultural activities are important to document. Subsidized

feeding from dairy operations is a likely cause of raven increases in the PORE area in the past decade (Kelly et al. 2002).

Peregrine falcons may also be an important plover predator, and a pair was first observed nesting and feeding in the historic plover nesting area around Abbotts Lagoon in 2009. In 2012 through 2015 a peregrine nest was located on the Kehoe cliffs north of the beach trailhead. Peregrines were observed on 13.6% of the plover surveys between Kehoe and North Beach parking lot in 2015. The highest percentage was in 2011 with peregrines observed on approximately 16% of the surveys. Previous years the percentage of peregrines observed was lower at approximately 5% in both 2009 and 2010, 7% in 2012, and 8% in both 2013 and 2014. No instances of depredation of snowy plovers by peregrines at PORE have been recorded, but the likelihood of detecting such an event is low. During one survey, however, a peregrine falcon was observed attempting to depredate an adult plover on North Beach sector. Thus, further monitoring of peregrines is warranted to monitor and mitigate impacts to nesting plovers in this area.

Habitat Restoration

The positive effect of dune restoration activities is illustrated by the 2014 and 2015 seasons during which over a third of all Point Reyes nests were established in the 2011 Restoration Area adjacent to Abbotts Lagoon. However, as beach grass and iceplant removal continues at Point Reyes into the future, past restoration efforts have provided useful insights. First, considerable follow-up efforts are required in order to keep restored areas from being re-invaded by non-native plants. Second, barren sand dunes may provide good nesting habitat, but without native dune vegetation, there is little cover available for plover chicks and foraging opportunities are reduced without plants to attract insect prey. If restored dunes do not naturally re-vegetate, further efforts should be made to re-seed or out-plant restored dunes with native dune vegetation. Finally, restored dune habitats provide additional foraging habitat for ravens. In order for snowy plovers to successfully nest in restored dune habitats, significant predator management actions may be required.

Predator Management

To attain a sustainable plover population, predator management recommendations are outlined below. Where feasible, the effectiveness of all implemented management actions should be assessed through monitoring.

- implementation of agricultural operation Best Management Practices (covering feeding troughs)
- implement projects to prevent ranch barns and other structures from being overnight roosts for ravens
- enforce current restrictions on dairy ranch permittees concerning disposal of cow carcasses and afterbirths, thus reducing food subsidization of corvids
- increase understanding of how silage harvesting in fields adjacent to plover breeding areas may impact raven activity and thereby indirectly impact plovers

- manage “problem” ravens (i.e., ravens seen attacking plovers or nests, or perching regularly near nests or broods) throughout the breeding season, but especially within the first month of the season (April)
- focus avian predator management efforts in dune restoration areas
- continue testing use of bald eagle decoys and, where appropriate, raven effigies, in strategic locations along the dunes, to deter patrolling by avian predators
- continue to reduce European beach grass coverage through dune restoration within plover breeding habitat to reduce cover for terrestrial predators.

Visitor Education and Outreach

The Snowy Plover Docent Program continues to be a key element for successful protection of breeding plovers. The educational and informational contacts made by the docents on weekends and holidays increase the understanding and compliance of habitat closures by park visitors. One measure of success is the 20% decrease in average percent chick loss over weekends and holidays that has been observed since the docent program started in 2003 (Figure 7). However, weekend/holiday chick loss has been variable over the last six years, with a 21% loss in 2010, a 68% loss in 2011, a 17% loss in 2012, a 33% loss in 2013, a 26% loss in 2014 and a 38% loss in 2015. Therefore, increased law enforcement beach patrols, clear and durable signage, public outreach, and a strong docent presence at trailheads and on beaches are continued priorities for the plover management program.

In addition to continuing the program, the park should consider extending the docent season to include several weeks prior to Memorial Day weekend and until all chicks have fledged, which could extend past Labor Day weekend. It is also highly recommended that a coordinator be hired and assigned to the program in order to recruit, organize, and lead the volunteer docents. Over the last several years, docent program coordination has been a collateral duty of the project biologists, who must make the plover surveys and protections first priority. As in recent years, the docent program was comprised of a small group of motivated, self-led volunteers who were able to make a presence each weekend and holiday during the summer of 2015. An additional volunteer from the park’s Law Enforcement Division assisted with staffing the weekend beach closures. Staffing the beach closure at the North Beach parking lot is vital to the success of the closure and adds to the number of visitor contacts.

Beach Closures

Summer weekends, particularly holiday weekends, are some of the highest visitation times at Point Reyes beaches. High visitation poses a potential impact to incubating nests and newly hatched chicks. Visitors may inadvertently flush incubating adults from the nests and separate chicks from adults, leaving the chicks less able to forage efficiently, thermoregulate properly, and escape predation. In 2013, four nests hatched in the NP sector within a week leading up to the July 4th weekend. Of the 11 chicks hatched, only three survived past the weekend. As a management response, in 2014, a temporary beach closure was established for the July 4th weekend along a two mile stretch of beach in the NP sector. One nest had hatched the week before July 4th weekend and

one hatched on July 5th. All chicks survived the weekend. Visitors abided by the temporary closure, and comments from visitors to docents were all positive and even thankful.

The successful beach closure in 2014 supported the decision in 2015 to close the beach to all visitor access between Abbotts Lagoon and North Beach parking lot on multiple weekends in order to protect snowy plovers. The first temporary beach closure occurred over Memorial Day weekend. Then, starting with the weekend of June 20th, the beach was closed on every weekend during the remainder of the summer and through the Labor Day weekend. All total of 13 temporary weekend beach closures were implemented during the 2015 season.

Dogs are not allowed during the plover breeding season of March through September between the Kehoe Beach trailhead and the North Beach parking lot. An additional temporary dog closure was put in place on Point Reyes Beach in 2015 between North Beach parking lot and South Beach parking lot. This closure was put in place after a nest on the NB sector was discovered, the first since 1995. The closure was only a half mile in either direction from the nest and was only in place while the nest was incubating. No violations of this closure were observed, although it was not monitored as frequently as the other beaches. The nest successfully hatched after which the brood moved to the NP sector where one chick was fledged.

Wilderness Awareness

Limantour Spit and much of Point Reyes Beach lie within federally designated wilderness as set forth in the Point Reyes Wilderness Act of 1976. Efforts were made for the fourth year to minimize motorized vehicle use associated with the plover project in compliance with the Wilderness Act. In the past, a utility terrain vehicle was used to distribute and collect the fencing and exclosure gear throughout the beach. Since 2012, at the start of the season, all fencing and exclosure gear was distributed by foot through the wilderness areas, thus reducing the impact the monitoring activities have on snowy plovers and on Wilderness values. All temporary fencing established in Wilderness areas was recorded by GPS to document the monitoring team's presence on Wilderness beaches. At the peak of the season, approximately three and a half miles of fencing was present.

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Appendix A. Criteria and evidence for determining fate of snowy plover clutches.

Hatched

- Tapping or cracks observed in eggs one to two days before eggs disappeared (not fail safe)
- Eggs disappear close to estimated hatch date with no signs of predation
- Indication of a newly hatched brood in the immediate vicinity (direct observation, broody behavior exhibited by nearby adult)
- Flattened scrape with tiny egg shell fragments located in scrape

Not hatched

Depredated - Unknown Predator:

- Direct evidence that eggs were destroyed, including:
 - Substrate cemented together by egg contents, or
 - Egg shell fragments intact but damaged eggs found well before estimated hatch date.
- Eggs gone well before estimated hatch date, no predator tracks to nest, but wind or tide would not have destroyed nest. Evidence may include:
 - Scrape intact or still discernible, or substrate stable or level enough such that wind would not cause clutch to be buried or eggs to roll out of scrape, or
 - Substrate too firm for imprint of predator tracks.
- Unidentified potential predator tracks directly to and at nest site (if potential predator tracks are observed leading towards nest site but gait is unchanging directly past nest site, that predator is not associated with clutch loss).

Depredated - Known Predator:

- Identified predator tracks directly to the nest site.
- Timing of lain predator tracks coincides with nest loss, as indicated by substrate conditions.

Tide:

- Tide has washed over the original nest location, leaving no evidence of the eggs or nest scrape, and there is no indication of a newly hatched brood in the vicinity
- Eggs are located near original location or nest washed over by the tide but no indication eggs are being incubated.

- Tide has washed over nest location, eggs are located near original nest location and are being incubated well past estimated hatch date.

****Non-viable Eggs:***

- Intact eggs of full clutch remain well after estimated hatch date along with evidence that there is consistent adult activity at nest location. Adult activity can be determined by presence of adult on nest, egg position changing from survey to survey. Nests should be monitored until adult activity ceases.

****Abandoned:***

- Intact eggs of clutch remain but evidence of adult activity at nest ceased well before the estimated hatching date. No evidence nest was washed over by tides or ever buried by wind blown sand or other debris.

****Wind:***

- Eggs not being incubated and one of the following:
 - Intact eggs located outside of scrape, eggs not being incubated, and no indication that any other species may have moved eggs, or
 - Eggs in scrape and covered by wind-blown sand or other debris.

*Note: Distinction between the above three categories (non-viable eggs, abandoned, and wind) can be difficult and may require additional information.

Trampled:

- Eggs found destroyed (not depredated) and tracks of a larger species directly through nest location.

Destroyed – Human:

- Human footprints directly next to or on the nest location and:
 - one or more eggs missing from the clutch, or
 - evidence that eggs were destroyed including shell fragments or contents.
- Human footprints near nest with evidence that something was dragged over, dropped or placed on nest.

Failed Unknown:

- Eggs gone well before estimated hatch date, but absence of clear evidence of depredation, wind loss, tide, or trampling.

Unknown:

- Eggs gone close to estimated hatch date, but evidence of hatch would have been obscured by weather conditions or other factors.

Appendix B. Criteria for determining snowy plover brood fate.

Determining hatch date:

- Make notes of when bird activity first started.
- When was the first egg laid?
- When was the clutch complete (usually 3-5 days)?
- Nests should be checked daily at 25 days past known clutch completion.
- If exact clutch completion date cannot be determined, nest checks should be made more frequently at 20 days past estimated completion. Your field notebook should provide good clues to bird activity around the nest site making it possible to closely estimate hatch dates.

Monitoring broods:

- Once a nest has hatched, chicks should be checked daily to determine timing of any loss that may occur.
- Approach the area where the brood was last seen slowly and cautiously.
- Are there adults present? And if so, are they displaying broody behavior (flying, vocalizing or feigning injury)?
- Can you easily see the chicks? Often, chicks are within a few meters of the adult.
- If a brood is located immediately, count the number of chicks present, location, and behavior. Record this information in your field notebook. Leave the area quickly, particularly if the tending adult is agitated.
- If the brood is not immediately located, move away to a concealed position and wait for the birds to resume undisturbed behavior. Again, count the number of chicks present, location, and behavior in your notebook.
- Once the brood is located and counted, leave the area. Any additional notes should be written well away from the site.
- If additional data collection is required (disturbance study or better aging) do so from a concealed area where your presence is not a factor and the birds are not disturbed further.
- First, determine what information is needed. For example, is it important to know the exact time of loss? Or, does general knowledge of loss suffice for your study area?
- When determining the difference between weekday and weekend loss, all broods should be checked on Friday afternoon and again on Monday morning. If chicks are present on Friday but not on Monday morning, this is considered a weekend loss and should be recorded in your field notebook and data sheets as such.

- When trying to determine whether chick loss occurs in the day, at night, or at dusk or dawn, checks must be made within each of those time periods. For example, if chicks are present at 7 pm and at again at 9 pm, but not present at 5 am, the loss event would be recorded as occurring at night (take into consideration changing hours of sunrise and sunset).
- Determining the timing of chick loss events can be time consuming and somewhat difficult. Remember that most brood checks cause some disturbance to the birds and should only be done at a minimum frequency required to answer your research questions.
- If exact date of chick loss cannot be determined, the midpoint between 2 brood checks when a reduction in brood size is determined should be used as the date of loss.

Appendix C. Fate of snowy plover nests at PORE in 2015.

Nest & Location1	Date Found	Exc.2 Yes/No	Female ID3	Male ID3	Eggs Laid	Eggs Hatched	Clutch Fate	Final Status
NP01	3/30/2015	YES	U	U	3	0	FAIL	TIDE
NP02	4/6/2015	YES	U	U	3	0	FAIL	TIDE
NP03	4/6/2015	NO	U	U	1	0	FAIL	DEPREDATED
NP04	4/14/2015	NO	UNK	UNK	2	0	FAIL	DEPREDATED
NP05	4/20/2015	YES	l:v	U	3	2	HATCH	FLEDGE 0
NP06	4/28/2015	NO	UNK	UNK	1	0	FAIL	DEPREDATED
NP07	5/4/2015	NO	U	UNK	3	0	FAIL	UNKNOWN
NP08	5/8/2015	NO	UNK	UNK	1	0	FAIL	ABANDONED
NP09	5/15/2015	YES	U	U	3	2	HATCH	FLEDGE 0
NP10	5/15/2015	YES	U	U	3	3	HATCH	FLEDGE 1
NP11	5/17/2015	YES	U	U	3	3	HATCH	FLEDGE 2
NP12	5/20/2015	YES	U	U	3	3	HATCH	FLEDGE 0
NP13	6/11/2015	NO	:s	ly:yo	2	0	FAIL	DEPREDATED
NP14	6/12/2015	NO	UNK	U	3	0	FAIL	DEPREDATED
NP15	6/13/2015	YES	U	U	3	3	HATCH	FLEDGE 1
NP16	6/25/2015	YES	U	ow:wg	3	3	HATCH	FLEDGE 3
NP17	7/2/2015	YES	U	U	3	2	HATCH	FLEDGE 2
NP18	7/2/2015	YES	U	U	3	3	HATCH	FLEDGE 0
NP19	7/2/2015	YES	:s	U	3	3	HATCH	FLEDGE 0
NP20	7/3/2015	YES	U	U	3	3	HATCH	FLEDGE 0
NP21	7/10/2015	NO	UNK	U	3	0	FAIL	DEPREDATED
NP22	7/13/2015	NO	ao:by	U	3	3	HATCH	FLEDGE 2
RA01	3/30/2015	YES	ga:gg	U	3	3	HATCH	FLEDGE 0
RA02	3/30/2015	YES	U	ly:yo	3	2	HATCH	FLEDGE 0
RA03	4/8/2015	YES	U	b/r/b:y	3	3	HATCH	FLEDGE 0
RA04	4/15/2015	YES	U	U	3	2	HATCH	FLEDGE 0
RA05	4/22/2015	YES	U	ow:wg	3	3	HATCH	FLEDGE 0
RA06	4/23/2015	YES	:s	U	3	2	HATCH	FLEDGE 0
RA07	4/30/2015	NO	U	UNK	1	0	FAIL	DEPREDATED
RA08	5/1/2015	NO	UNK	UNK	1	0	FAIL	DEPREDATED
RA09	5/17/2015	YES	U	s:y	3	2	HATCH	FLEDGE 0
RA10	5/21/2015	YES	U	w/o/w:v	2	2	HATCH	FLEDGE 1
RA11	6/1/2015	YES	U	U	3	2	HATCH	FLEDGE 1
RA12	6/8/2015	YES	ao:by	U	2	2	HATCH	FLEDGE 2

RA13	6/24/2015	YES	U	U	3	3	HATCH	FLEDGE 1
RA14	6/29/2015	YES	U	s:y	3	3	HATCH	FLEDGE 0
RA15	7/6/2015	YES	:s	ly:yo	3	3	HATCH	FLEDGE 1
RA16	7/12/2015	NO	U	U	3	3	HATCH	FLEDGE 0
K01	4/3/2015	YES	U	U	3	0	FAIL	WIND
K02	4/10/2015	NO	:s	UNK	1	0	FAIL	DEPREDATED
K03	4/21/2015	YES	U	U	3	0	FAIL	ABANDONED
K04	4/29/2015	YES	:s	U	3	3	HATCH	FLEDGE 0
K05	5/3/2015	NO	U	UKN	3	0	FAIL	DEPREDATED
K06	5/18/2015	YES	aw:yl	U	3	3	HATCH	FLEDGE 0
K07	5/27/2015	YES	ga:gg	U	3	3	HATCH	FLEDGE 1
K08	7/15/2015	NO	aw:yl	U	3	0	FAIL	DEPREDATED
L01	4/24/2015	NO	U	bg:bb	3	0	UNK	FATE UNK
L02	7/21/2015	NO	og:yr	U	3	0	UNK	FATE UNK
NB01	5/25/2015	YES	U	U	3	3	HATCH	FLEDGE 1

¹K = Kehoe Beach to Abbotts Lagoon; NP = Abbotts Lagoon to North Beach parking lot (including shore of the lagoon); RA = 2011 Restoration Area, L = Limantour and NB= North Beach parking lot to South Beach parking lot.

²Exc.=exclosure.

³U= Unbanded

⁴UNK = Unknown

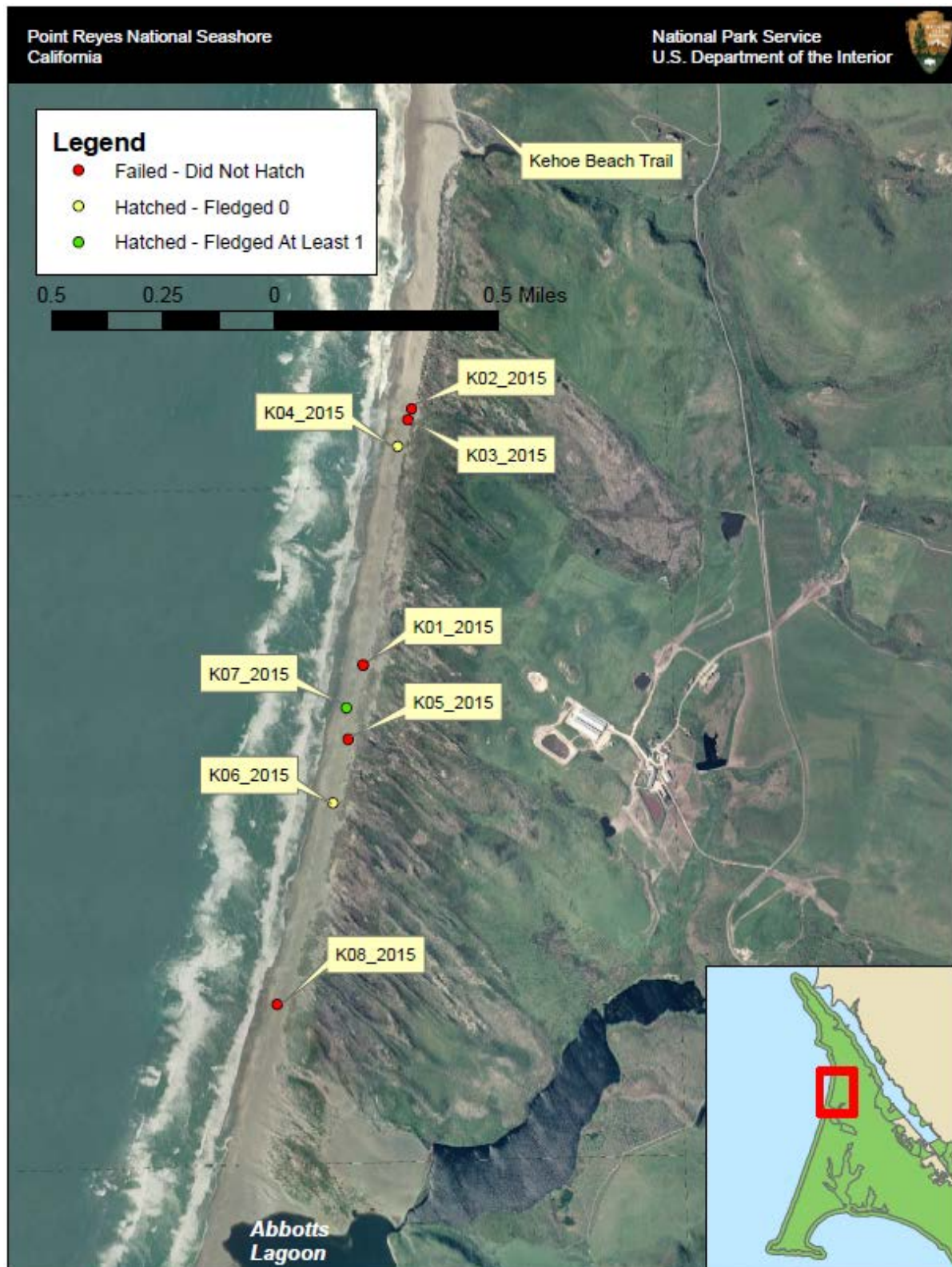
Appendix D. Criteria for determining minimum numbers of western snowy plovers breeding at PORE.

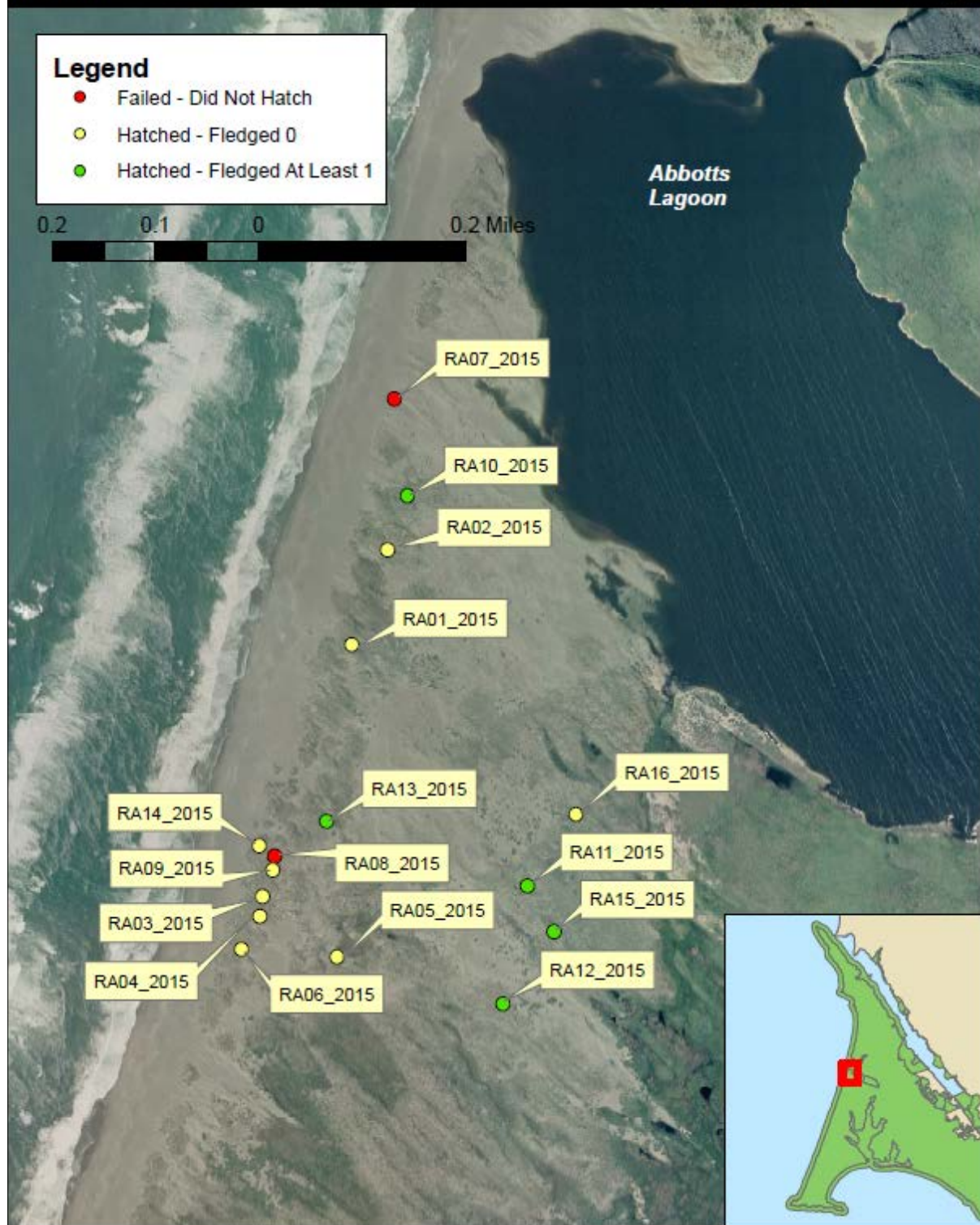
In 2009, it was determined that maximum estimates would no longer be appropriate due to the subjectivity involved in analyzing behavioral characteristics, as was required by the original methodology (Adams et al., 2014). The advent of seasonally changing staff and a need for objective, repeatable methodology resulted in adoption of the following method for determining a minimum estimate:

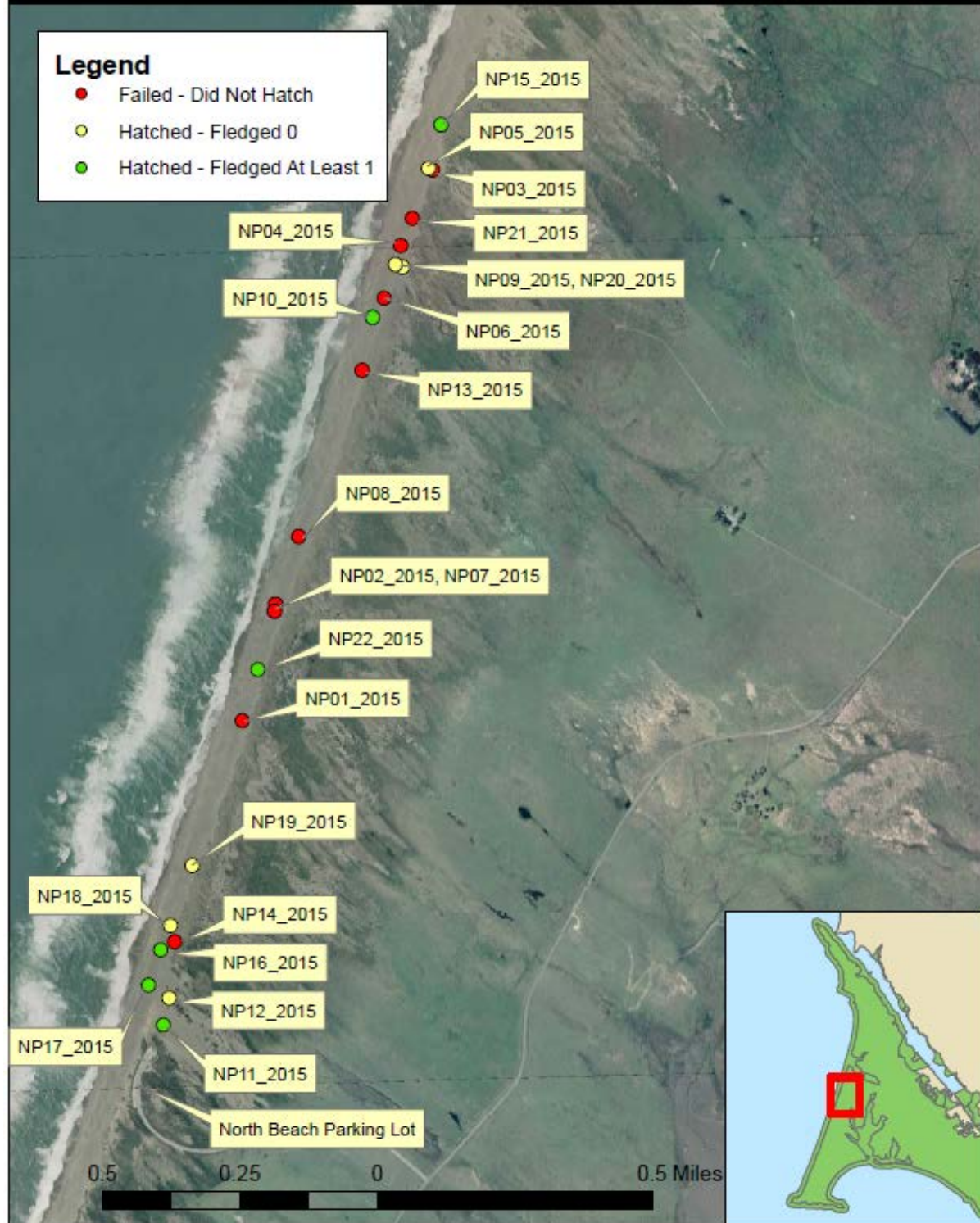
1. Determine the time period when the maximum number of simultaneously active nests and broods were present on the beach during the breeding season and use data from this period to calculate the minimum number of breeders using the methods below:
 - a. An active nest represents the presence of 1 male and 1 female (count = 1 male, 1 female).
 - b. If one or more chicks of a brood are known to be alive and less than 3 weeks old, one male is inferred (count = 1 male).
 - c. If a male is present with a brood greater than 3 weeks old, that male is probably with a new mate who may have initiated a new nest. This nest, if found, would result in counting of 1 male and 1 female. Therefore, males with broods of over 3 weeks are not counted (count = 0 male)
 - i. However, if it is possible to determine that there are no available (unpaired) females within the vicinity, one male may be counted (count=1 male).
 - d. One day prior to the estimated initiation date of a nest represents the presence of one male and one female which are about to nest (count=1 male, 1 female).
 - i. This step is only relevant if a pair initiates a nest one day after the last day of the peak number of nests present on the beach.
 - e. If any banded birds had confirmed nests outside of the peak window, add 1 male and 1 female (count = 1 male, 1 female).

Given the relatively small number of birds and few banded ones at PORE, this method has been determined to be the best possible *minimum* estimate. However, years with a high rate of nest loss could result in inaccurate estimates since all of the birds won't have active nests. Therefore, results of the window survey for that year should also be reported as further corroboration of minimum numbers.

Appendix E. Western snowy plover nest locations at PORE, April 2015 – August 2015.









Legend

- Failed - Did Not Hatch
- Hatched - Fledged 0
- Hatched - Fledged At Least 1





Legend

- Failed - Did Not Hatch
- Hatched - Fledged 0
- Hatched - Fledged At Least 1



Appendix F. Western snowy plover chicks banded at PORE, 2015.

Nest ID	Date Banded	Band Combination	Number Banded	Notes
RA03_2015	4/30/2015	av:ar	3	0 Fledge
RA01_2015	5/2/2015	av:aw	3	0 Fledge
RA06_2015	5/28/2015	av:yg	2	0 Fledge
K04_2015	5/29/2015	av:ry	3	0 Fledge
RA04_2015	5/29/2015	av:og	2	0 Fledge
RA11_2015	6/11/2015	av:br	2	1 Fledge
NP12_2015	6/15/2015	av:wb	3	0 Fledge
K06_2015	6/19/2015	av:gr	3	0 Fledge
NP11_2015	6/20/2015	av:ow	2	2 Fledge
NP16_2015	7/22/2015	av:wb, av:wy, av:ry	3	3 Fledge
RA15_2015	7/24/2015	av:ar, av:aw, av:yg	3	1 Fledge, av:ar
NP17_2015	7/27/2015	av:bb	2	2 Fledge
RA16_2015	7/27/2015	av:yy	3	0 Fledge

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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