

Final Report: 2011 Snowy Plover Breeding in Coastal Northern California, Recovery Unit 2

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Abstract.—*The Pacific coast population segment of the Snowy Plover (Charadrius nivosus) was listed as threatened under the U.S. Endangered Species Act in 1993. Here, we report on the 11th year of monitoring the population that breeds in coastal northern California, one of six recovery units identified in the species' recovery plan. The number of breeding adults (36; 20 males and 16 females) in Recovery Unit 2 increased 16% over 2010 numbers. This increase resulted from high adult breeding site fidelity (nearly all plovers that bred in 2010 returned to breed in 2011), high natal philopatry, and immigration of marked and unmarked plovers from elsewhere along the Pacific coast. Breeding plovers occupied six locations; most (53%) plovers first bred at Clam Beach. Six philopatric yearlings (one female; five males) and one 2-year old (male) were detected, representing a high rate (60%) of survival for the ten young that fledged in 2010. Plovers initiated 32 nests and hatched 35 chicks; however, only eight young fledged from two breeding sites (Big Lagoon and Clam Beach), yielding the lowest per capita reproductive success (0.40 ± 0.82 young fledged per male) in 11 years. In part, this resulted from no plovers breeding on high quality gravel bars of the lower Eel River. Over the past three years, we have observed four cases of inbreeding. One of these inbred pairs produced inviable eggs, a circumstance that occurred significantly more often this year than in the previous 10 years combined. Analysis of breeding dispersal showed that plovers moved greater distances following nest failure, especially after they changed mates. However, most dispersal movements were not far enough (<3 km) to result in individuals leaving a breeding site, which suggests that managing predators using a combination of non-lethal and lethal methods may be required at some sites (e.g., Clam Beach, Mad River Spit). The RU2 population remains at risk because of occasional episodes of high over-winter mortality coupled with chronically low reproductive success.*

Key words.—*Charadrius nivosus, corvid activity, dispersal, inbreeding, nesting success, predation, Recovery Unit 2, reproductive success, site fidelity, Western Snowy Plover.*

Introduction

For the eleventh consecutive year, biologists from Humboldt State University (HSU) and Mad River Biologists (MRB) worked with county (Humboldt County Public Works), state (Department of Fish and Game, Department of Parks and Recreation), federal (Bureau of Land Management, National Park Service, and United States Fish and Wildlife Service) staff, as well as Mendocino Coast Audubon Society volunteers, to monitor breeding activity of the Snowy Plover (*Charadrius nivosus*; hereafter plover) in coastal northern California (Del Norte, Humboldt, and Mendocino counties; USFWS Recovery Unit 2). In this report, we summarize our findings for the 2011 breeding season and interpret results in light of the species' recovery plan (USFWS 2007), as well as management and conservation actions in coastal northern California.

Background

In 1993, the United States government listed the coastal population segment of the Snowy Plover as a threatened population under the Endangered Species Act (USFWS 1993). In 1999, the USFWS designated critical habitat, an action that was renewed in 2004 following a lawsuit over failure to analyze the economic impacts of critical habitat designation. An economic analysis of the designation of critical habitat was produced in 2005. In 2001, the USFWS produced a draft recovery plan, which was finalized in 2007 (USFWS 2007). In 2006, the USFWS denied a proposal to delist the plover based on a challenge to genetic distinctiveness of the population, despite contrary evidence (Funk et al. 2007). The USFWS did, however, propose a change to the management practices under the federal Endangered Species Act. The proposed 4(d) rule change would relax some management activities required by local jurisdictions for counties that exceeded (for 2 of 5 years) the number of breeding plovers as identified by the recovery plan (USFWS 2006).

The federal government listed the plover based on evidence of a significant population decline, as well as a reduction in the number of breeding locations along the Pacific coast of North America. The USFWS (1993, 2007) identified three factors that are thought to limit the population via negative effects on productivity or the number of young produced annually. In general, the recovery plan does not address the effects of adult and juvenile survival on population growth. The factors compromising plover productivity are: 1) increased development and human recreational activity in beach habitats favored by breeding plovers; 2) predation of eggs and young by corvids (*Corvus brachyrhynchos*, *C. corax*), gulls (*Larus* spp.), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*); and 3) degradation of nesting habitat by

introduced plants such as European beach grass (*Ammophila arenaria*). Prior to listing, Page et al. (1991) estimated the California population at 1386 plovers, down 11 percent from the 1565 estimated a decade earlier (Page and Stenzel 1981). In 2010, a coordinated, week-long survey during the breeding season indicated that 1747 plovers occurred along the U.S. Pacific coast; this estimate was slightly greater than the previous three years, when numbers varied between 1537 (2007) and 1587 (2009). This estimate remains well below the population size of 3000 birds listed as a recovery objective (USFWS 2007), although some local population sizes have approached or surpassed recovery objectives for some areas (e.g., Monterey Bay, Oregon).

In 2001, the USFWS designated Mendocino, Humboldt, and Del Norte counties as a discrete management or recovery unit (RU2), one of six within the range of the listed population segment. In RU2, plovers have bred and wintered along ocean beaches and gravel bars of the Eel River in nearly all of the past 11 years (Colwell et al. 2010). Surveys indicate that most observations of breeding plovers occur in Humboldt County. In 1977, Page and Stenzel (1981) observed 64 birds (18 nests) at seven Humboldt County locations and estimated that this represented 6% of plovers breeding in coastal California. At this time, Humboldt County had more plovers than any location north of Monterey. During the early 1990s, Fisher (1992-94) surveyed Humboldt County beaches and recorded 22-32 plovers and 17-26 nests annually. In 1999, LeValley (1999) recorded 49 birds and 23 nests at four locations. In 2000, this same area supported about 40 adults and 42 nests (McAllister et al. 2001). Until recently, plovers had not been observed nesting in habitats other than along coastal beaches of northern California. However, in 1996 plovers were first recorded nesting on gravel bars of the lower Eel River (Tuttle et al. 1997). Until 2011, the Eel River remained a unique and productive breeding habitat. With the onset of intensive monitoring in 2001, we showed that most plovers in Humboldt County nested on Eel River gravel bars (Colwell et al. 2005, 2010); this pattern, however, has been reversed in recent years. Both hatching and fledging success are consistently higher for river- than beach-breeding plovers (Colwell et al. 2005a, 2010).

In summary, over the past several decades the total number of breeding sites and breeding population in Humboldt, Mendocino, and Del Norte counties has decreased. Recently, however, numbers in Humboldt County increased slightly with the discovery of plovers nesting on Eel River gravel bars (Tuttle et al. 1997). It is difficult, however, to address local population trends prior to 2001 since researchers surveyed different habitats with varying effort. Moreover, since plovers tend to disperse widely during the breeding season (Stenzel et al. 1994, Pearson 2011), it is likely that some individuals may be recorded as breeding in more than one location. Nevertheless, the population of Snowy Plovers breeding in RU2 remains at a low level compared to 5-10 years ago, despite the population increase in 2011 (see below).

Study Area

Observers monitored plovers in coastal northern California. Most intensive monitoring occurred at seven locations in Humboldt County where observers detected most breeding activity by plovers. These locations included: Stone Lagoon, Big Lagoon, Clam Beach, Mad River Beach, South Spit, Eel River Wildlife Area, and Centerville Beach. Observers also regularly (i.e., weekly, bimonthly or window survey) monitored many other sites with suitable habitat.

Methods

Surveys. Observers surveyed suitable habitats for breeding activity beginning in mid-March and continuing until 5 September, when the last chicks fledged on Clam Beach. Most surveys occurred at locations where observers detected breeding plovers, although observers visited unoccupied sites a minimum of 7-10 day intervals. For example, observers surveyed the gravel bars of the lower Eel River on 125 occasions (range: 10 to 19 visits per site) between 16 April and 28 August despite finding no breeding activity. Upon finding a nest, observers noted the number of eggs in the clutch. For complete clutches, we floated eggs to determine stage of development and estimate hatching dates (Liebezeit et al. 2007). We recorded the location of each nest using a global positioning system (GPS). We monitored broods during regular surveys and confirmed that chicks had fledged by noting their presence at a site 28 days after they had hatched (Page et al. 1995). Observers also used adult behaviors to confirm that chicks had failed to survive, such as when we observed males (which usually tend chicks for 28 days after hatch) courting females before their chicks would have fledged.

Banding. We captured and marked adult plovers with a unique combination of colored leg bands and colored tape (e.g., red, yellow, orange, green, violet, white and blue) wrapped around a USFWS metal band. At hatch, we marked chicks on the right leg with a single metal band wrapped with brood-specific colored tape to enhance knowledge of brood survival (Colwell et al. 2007a). When the hatching sequence of chicks was evident, we marked the colored tape attached to the metal band with the number 1, 2 or 3 denoting the order of hatch (and hence age) of chicks. Details of banding effort for 2011 are shown in Appendix 1.

Field Methods. During surveys, observers collected data on the identity of marked adults incubating eggs or tending young (e.g., brooding, performing a distraction display), and we used this information to determine clutch ownership and reproductive success. We regularly monitored the status of nests, noting whether a clutch had failed or not. In the event of clutch failure, we determined probable cause to be: 1) predation (eggs disappeared prior to predicted hatch date, predator footprints occurred at a nest or egg shell fragments/yolk at nest); 2) drifting sand (coincident with strong winds, eggs partially or completely buried by sand); 3) over wash by high tide (eggs displaced or absent from nest and recent high tide line situated above nest elevation); 4) human-caused (vehicle tracks or footprints pass directly over nest and eggs gone or egg remnants in nest cup); 5) dog-caused (tracks leading to nest cup and eggs gone); 6) abandoned (eggs untended as evidenced by absence of plover tracks over multiple days); or 7) unknown (eggs disappear from nest with no sign of causes listed above or we were unable to conclude the cause of failure because more than a day had elapsed since the last nest check). In the case of drifting sand, we could not easily discern when a clutch failed nor could we be certain that drifting sand caused failure. Moreover, in the case of incomplete clutches (i.e., found during the laying stage with one or two eggs), the general absence from the nest site of tending adults until the last egg was laid made eggs vulnerable to being covered by drifting sand. By contrast, during incubation, sand may drift over clutches when humans, dogs or vehicles disturb tending adults for long intervals. We conducted research under federal (USFWS permit TE-823807-3; USFWS banding permits #22971 and #10457), state (Department of Fish and Game collecting permit #SC0496; Department of Parks and Recreation permit #08-635-011), and university (Humboldt State University IACUC #08/09.W.23.A) permits.

Data Summary and Analysis. Since the locations at which plovers bred differed in habitat and management issues, we collated data separately by location. We defined apparent nest success as the number of nests that successfully hatched at least one chick divided by the total number of nests. We calculated the number of fledged chicks per male to facilitate comparisons with population viability analyses published in the recovery plan (USFWS 2007). We used nest location coordinates obtained from 2001-2010 to analyze breeding dispersal distance of male and female plovers within and between breeding seasons. We quantified dispersal using a GIS and Hawth's Analysis Tools (Beyer 2004), measuring the straight-line distance (m) (Colwell et al. 2007) between a) successive nests of an individual within a year and b) the last nest of a year and first nest of the subsequent year (Colwell et al. 2007b). To improve normality of residuals, we transformed (ln) all distances. We developed an *a priori* candidate set of models for testing using linear mixed effects models in R statistical software (Pinheiro et al. 2011). We considered individual plovers as a random effect to account for repeated measurements of the same individual; we analyzed males and females separately.

Management. We did not actively manage the effects of egg predators using nest exclosures. And, for the first time in seven years (2004-10), we did not erect a "symbolic" fence on Humboldt County park lands at Clam Beach to minimize the impact of human disturbance on breeding plovers. However, State Parks personnel maintained "plover protection areas" (i.e., symbolic fencing) around nests on Big Lagoon and Stone Lagoon.

Results and Discussion

Population Size. Numbers of breeding plovers increased 16% to 36 adults compared to 2010. This increase followed several years (2008-09) of low population size, when the number of breeding adults decreased to 19 (Table 1). During the mid-May RU2 "window survey", observers tallied 28 adult plovers, most of which (96%) were detected in Humboldt County. This number was slightly higher than the 26 adults detected in 2010. During the 2011 window survey, observers detected adult plovers at nine sites. These surveys represent a smaller number of the total population because: 1) observers occasionally failed to detect some resident plovers during the single visit to each site, which is the protocol for the window survey; and 2) the survey occurs during a brief interval midway through the breeding season. As a result, it fails to account for birds that bred early and departed to breed elsewhere along the Pacific coast or those that arrived late in the season.

In 2000, prior to intensive monitoring, we began capturing plovers with the goal of marking all breeding individuals in RU2 by the end of each breeding season. Table 1 shows annual variation in the composition of the breeding population over the past 11 years, broken down into: a) marked yearlings recruited from the local population; b) site-faithful adults marked in RU2 in a previous year; c) marked immigrants from elsewhere along the Pacific coast; and d) unmarked birds, which are presumed to be immigrants from outside RU2. Over the past 10 years (2002-11; when we are confident that we had marked nearly all breeding plovers in the previous year), population size tended to increase with the percentage of immigrants in the population. In 2011, the population included 11 immigrants (including one unmarked male), which is comparable to the proportion (roughly one third) of immigrants in the population in previous years. These data, coupled with analyses of survival and population growth (Mullin et al. 2010), continue to emphasize the importance of immigration in maintaining the RU2 population.

Table 1. Annual variation in composition of the Snowy Plover population in Recovery Unit 2.

Year	Males				Females				Total
	Returning (marked) Adults	Returning (marked) Yearlings	Immigrants Banded Elsewhere	Unbanded Immigrants	Returning (marked) Adults	Returning (marked) Yearlings	Immigrants Banded Elsewhere	Unbanded Immigrants	
2011	11 ^a	6 ^b	2	1	7	1	8	0	36
2010	9	2	4	1	9	1	4	1	31
2009	9	0	0	1	6	2	1	0	19
2008	10	2	3	3	6	2	6	5	37
2007	10	2	2	2	8	2	2	2	30
2006	16	6	4	3	13	4	4	7	57
2005	16	8	2	5	17	4	4	7	63
2004	17	5	4	11	16	4	6	11	74
2003	23	4	0	1	18	5	1	5	57
2002	17	8	0	5	19	6	1	4	60
2001	14	6	0	8	11	2	1	15	57

^a Includes two adult males resident for 2+ months on gravel bars of the Eel River.

^b Includes one 2-yr old bird breeding for the first time in RU2.

Philopatry and Site Fidelity. In 2011, 11 adult males (67% of 2010 breeders) and 7 adult females (47% of 2010 breeders) returned during the breeding season; seven young birds (6 yearlings and 1 two year old) also returned (Tables 1 and 2). Most (94%) of these adults bred locally; however, two of the males were present continuously on Eel River gravel bars through much of the breeding season but did not acquire mates. On average, male breeding site fidelity ($61.9 \pm 15.4\%$) has exceeded female fidelity ($52.2 \pm 18.9\%$) in 8 of 11 years. These differences in return rates between the sexes are related to differential mortality of males and females (Stenzel et al. 2011) and/or differences in breeding dispersal associated with the species' mating system and greater competition among females for mates (Stenzel et al. 2007, Pearson 2011). The annual variation in return rates also suggests that adult mortality is higher in some years (e.g., 2006-07) than others.

Patch Occupancy. Since 2001, plovers have bred at 19 sites (8 beaches, 11 gravel bars on the Eel River) within Humboldt County (Table 3); plovers have bred sporadically at several sites in Mendocino County, and there are no recent breeding records from Del Norte County. Over the past 11 years, occupancy and density have varied markedly among the 19 breeding sites in Humboldt County (Burrell 2010). There has been a decline in both the percentage of the RU2 population and the number of occupied breeding sites along the gravel bars of the Eel River. This year marked the first season during which no pairs initiated nests on the gravel bars. The percentage of the population occupying beach sites has increased gradually (Colwell et al. 2010). In 2011, plovers nested at six sites in RU2, all in Humboldt County (Table 3).

Dispersal. Dispersal varied greatly (Fig. 1), but within- and between-season patterns were similar for both male and female plovers. The top models indicated that plovers that retained mates and were successful (i.e., hatched chicks) moved shorter distances than did those that changed mates or were not as successful (Table 4). Both within and between seasons, most plovers (within=92%, between=85%) dispersed less than 10 km (Fig. 1). Most plovers dispersed comparatively short distances (male_{within}=0.9 km [0.2-2.0], male_{between}=0.5 km [0.1-2.5], female_{within}=1.0 km [0.2-2.7], female_{between}=1.0 km [0.3-5.1]). In 2010, we suggested that plovers be allowed to fail at sites where high corvid activity results in low reproductive success, particularly at Clam Beach and Mad River (Colwell et al. 2010). However, only 22% of males and 33% of females dispersed >3 km, suggesting that most movements are of insufficient distance for plovers to leave these two principal breeding sites.

Productivity. In 2011, plovers breeding in RU2 initiated 32 nests, hatched 35 chicks, and fledged 8 young. Apparent nesting success of plovers in RU2 has varied substantially over the 11 years of intensive monitoring (Tables 5 and 6). In 2011, 44% of nests hatched at least one chick, which was comparable to the highest value (47%) in the last full year (2005) when exclosures were used to reduce predation on many nests at Clam Beach. Predation (including the "unknown" category) was the leading cause of nest failure, accounting for a total of 78% of failed nests. Per capita reproductive success (fledged young per adult male) was 0.40 ± 0.82 , which was the lowest rate in the 11 years that plovers have been intensively monitored in RU2. The low productivity of plovers in RU2 was driven, in part, by the absence of plovers breeding on high quality gravel bars. The 2011 productivity (0.40) represents a pattern of chronic low productivity (0.90, 1.7, 0.8, 1.1, 1.2, 0.9, 0.7, 0.7, 0.5, and 0.8 fledged chicks per male for 2001-10, respectively).

Table 2. Annual variation in philopatry and site fidelity of Snowy Plovers in Recovery Unit 2.

	Year	Females		Males	
		Number Banded	Percentage Returned (n)	Number Banded	Percentage Returned (n)
<i>Philopatry^a</i>	2011	10.5	10 (1)	10.5	57 (6)
	2010	7.5	13 (1)	7.5	27 (2)
	2009	7.5	27 (2)	7.5	13 (1)
	2008	21	9 (2)	21	9 (2)
	2007	27.5	7 (2)	27.5	7 (2)
	2006	35.5	11 (4)	35.5	17 (6)
	2005	38	11 (4)	38	16 (6)
	2004	30.5	13 (4)	30.5	20 (6)
	2003	34.5	14 (5)	34.5	12 (4)
	2002	46.5	13 (6)	46.5	17 (8)
	2001	29	7 (2)	29	24 (7)
	Total	288	11.5 (33)	288	17.4 (50)
<i>Adult Site Fidelity^b</i>	2011	15	47 (7)	15	67 (11) ^c
	2010	9	100 (9)	10	90 (9)
	2009	18	33 (6)	16	50 (8)
	2008	15	40 (6)	16	63 (10)
	2007	25	36 (9)	29	34 (10)
	2006	31	42 (13)	32	50 (16)
	2005	35	40 (14)	33	52 (17)
	2004	28	54 (15)	27	63 (17)
	2003	29	59 (17)	30	73 (22)
	2002	29	62 (18)	28	61 (17)
	2001	18	61 (11)	18	78 (14)

^a Return of a locally-banded chick to breed in RU2; assumes an equal sex ratio at hatch (i.e., an odd number of chicks hatched in a previous year produces a non-integer value for the number of young of both sexes).

^b Return of a breeding adult (with a known nest) to nest the next year. Individuals may be represented in multiple years; includes philopatric yearlings.

^c Includes two nonbreeding males resident for several months on gravel bars of the lower Eel River.

Table 3. A summary of distribution of breeding Snowy Plovers (percentage of adults) at locations in RU2.

	Year											Average ±SD
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
<i>Del Norte County</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Humboldt County</i>												
Gold Bluffs Beach	0.0	0.0	0.0	2.4	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5±1.1
Stone Lagoon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 ^a	3.2	0.0 ^a	0.30±1.0
Big Lagoon	0.0	0.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	11.7	1.6±3.8
Clam Beach	16.4	28.6	37.7	40.2	48.5	52.5	56.3	67.6	63.2	51.6	55.9	47.1±15.2
Mad River Beach	0.0	0.0	0.0	0.0	0.0	0.0 ^a	9.4 ^a	0.0 ^a	0.0 ^a	6.5	8.8	2.2±3.8
Elk River	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0±0.0
South Spit	0.0	0.0	6.6	2.4	6.1	11.9 ^a	0.0 ^a	8.1 ^a	0.0	0.0	0.0	1.9±2.9
Eel River Wildlife Area	18.0	17.5	1.6 ^a	2.4	0.0	0.0	9.4 ^a	10.8	15.7 ^a	16.1	14.7	9.9±7.9
Centerville Beach	0.0	0.0	0.0	2.4	0.0	3.4	0.0	0.0	0.0	6.5	11.7	1.2±2.2
Eel River gravel bars	65.6	54.0	50.8	39.0	27.3	28.8	25.0	13.5	21.0	16.1	0.0	31.0±19.6
<i>Mendocino County</i>												
Brush Creek	0.0	0.0	0.0	4.9	3.0	3.4	0.0	0.0	0.0	0.0	0.0	1.1±1.9
Ten-mile Creek	0.0	0.0	3.3	7.3	3.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4±2.5
Virgin Creek	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3±0.9
Total Breeding Plovers	61	63	61	82	66	59	32	37	19	31	34	

^a Individuals were counted only once per year (at their first breeding site), despite nesting at up to three locations within a year.

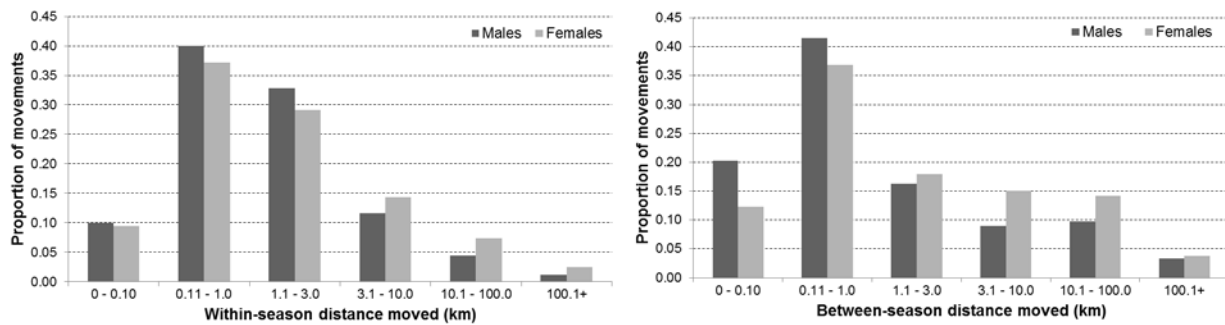


Figure 1. Frequency distribution of distance moved between nesting attempts within a single breeding season (left) and between the last and first nests of consecutive breeding seasons (right) for male and female Snowy Plovers breeding in Humboldt County, CA, 2001-10.

Table 4. Model averaged coefficient estimates and 95% confidence intervals from models receiving up to 90% of the total weight for within- and between-season breeding dispersal of Snowy Plovers nesting in Humboldt County, California between 2001-10.

Parameter	Within-season		Between-season	
	Male	Female	Male	Female
Intercept	6.85 (6.21 - 7.49)	6.79 (6.14 - 7.43)	6.82 (6.14 - 9.00)	7.30 (8.10 - 9.89)
Mate Change (Yes)	0.88 (0.23 - 1.54)	1.20 (0.51 - 1.88)	1.09 (0.25 - 1.92)	1.70 (0.83 - 2.56)
Success (Yes) ^a	-0.25 (-0.45 - -0.05)	-0.20 (-0.44 - 0.04)	-1.12 (-2.21 - -0.03)	-1.67 (-2.64 - -0.71)
Habitat (Gravel)			-1.01 (-1.87 - -0.14)	

^a Success within-season is a continuous variable indicating the number of successful nests while between-season the variable is categorical indicating that the individual hatched at least one nest in the prior year.

Inbreeding. Over the past three years, we documented four cases of inbreeding in RU2 (Colwell and Pearson in review). These inbred pairs represented 4-10% of pairs annually compared to 1% of the 200 pairs observed in the previous years (2001-08 combined). The cases of inbreeding occurred at isolated sites and coincided with the period when the population was at its lowest level, which are the conditions predicted by theory to increase the likelihood of inbreeding (Frankham et al. 2002). In 2011, one case of inbreeding between a mother and her yearling son produced a clutch of three eggs that failed to hatch after 42 days of incubation. The observation that these eggs showed no sign of embryo development suggests that inbreeding depression may be affecting productivity of plovers in RU2.

Conclusions

In 2011, the population size of Snowy Plovers in RU2 (36 adults) increased by 16% over 2010 (31). The population has increased from a low of 19 adults in 2009. This year, plovers bred at six locations in RU2, all in Humboldt County. The population has grown owing to: 1) continued immigration of plovers from elsewhere along the Pacific coast, especially Oregon; 2) high over-winter survival of adults and juveniles during the past few years, as evidenced by the high return rates of both age groups to breed locally. However, RU2 continues to be a sink population because of chronic, low reproductive success. The total number of fledged chicks (8) is the lowest number produced since 2008. Active management to improve conditions (e.g., reduce predation, human disturbance, and restore high quality habitats) at sites occupied by breeding plovers was limited to just a few locations (e.g., Stone Lagoon, Big Lagoon).

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Table 5. Summary of Snowy Plover breeding in Recovery Unit 2 in 2011 with comparison to 2000-10.

Location	Females ^a	Males ^a	Number of Nests	Number Exclosed	% Nests Hatched ^b	# Chicks Hatched	# Chicks Fledged
Del Norte County	0	0	0	0	0	0	0
Humboldt County							
Gold Bluffs Beach	0	0	0	0	0	0	0
Stone Lagoon	1	1	1	0	100	2	0
Big Lagoon	2	2	3	0	67	6	4
North Clam Beach and LRSB	5	6	9	0	33	6	1
South Clam Beach	5	5	9	0	44	11	3
Mad River Beach	1	1	3	0	33	3	0
South Spit Beach	0	0	0	0	0	0	0
ERWA	2	3	4	0	25	3	0
Centerville Beach	2	2	3	0	67	5	0
Eel River Gravel Bars	0	0	0	0	0	0	0
Cock Robin Island	0	0	0	0	0	0	0
Fulmor	0	0	0	0	0	0	0
Roper's	0	0	0	0	0	0	0
Singley	0	0	0	0	0	0	0
Loleta	0	0	0	0	0	0	0
Fernbridge	0	0	0	0	0	0	0
Worswick	0	0	0	0	0	0	0
Drake	0	0	0	0	0	0	0
Canaveri Island	0	0	0	0	0	0	0
Mercer-Fraser	0	0	0	0	0	0	0
Sandy Prairie	0	0	0	0	0	0	0
Mendocino County	0	0	0	0	0	0	0
Brush Creek	0	0	0	0	0	0	0
Tenmile River	0	0	0	0	0	0	0
Virgin Creek	0	0	0	0	0	0	0
RU2 Total							
2011	16	20	32	0	44	35	8
2010	15	16	42	2	21	24	13
2009	9	10	35	0	14	15	9
2008	14	16	50	0	14	15	8
2007	14	16	41	0	22	21	11
2006	28	29	58	19	34	55	20
2005	31	32	57	27	47	71	28
2004	37	35	70	28	43	76	39
2003	27	27	74	23	38	64	32
2002	30	33	75	25	40	76	23
2001	31	29	57	13	68	97	46
2000	--	--	42	18	64	58	--

^a Based on histories of marked birds with known nests. Some individuals are assigned to multiple sites (e.g., Stone Lagoon, Clam Beach, Mad River Beach).

^b Apparent nest success = number of nests that hatched at least 1 chick / total nests(100).

Table 6. Annual variation in Snowy Plover nesting success^a and causes of clutch failure in Recovery Unit 2.

Clutch Fate	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
	N	%	N	%	N	%	n	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Hatched	39	68	29	39	28	38	30	43	27	47	20	34	9	22	7 ^b	14	5	14	9	21	14	44
Failed and cause																						
Predation	4	7	12	16	17	23	18	26	7	12	11	19	11	27	14	28	11	31	8	19	4	13
Abandoned	2	4	4	5	5	7	9	13	4	7	8	14	1	2	2	4	0	0	1	2	1 ^b	3
Sand covered	1	2	7	9	6	8	4	6	4	7	0	0	2	5	2	4	2	6	0	0	1 ^c	3
Tidal overwash	0	0	2	3	4	5	1	1	2	4	0	0	0	0	0	0	2	6	2	5	1	3
Human	0	0	7	9	5	7	3	4	0	0	3	5	2	5	3	6	4 ^c	11	0	0	0	0
River flood	0	0	0	0	5	7	0	0	4	7	0	0	0	0	0	0	0	0	0	0	0	0
Unknown	11	19	14	19	4	5	5	7	9	16	16	28	16	39	22	44	11	31	22	52	11	34
Total Nests	57		75		74		70		57		58		41		50		35		42		32	

^a Apparent nesting success = 100[number of nests hatching at least one chick / total number of nests].

^b Nest failed to hatch after eggs incubated from ~42 days.

^c Nest never held more than 1 egg but it was partially sand covered during the laying period.

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Appendix 1. Details of 2011 banding effort in Recovery Unit 2.

Band Number (USFWS)	Location	Color Band	Sex	Age	Date Banded	Nest Code	Notes
8021-23442	Centerville	GY:WG	Female	AHY	14 May 2011	11CV01	
8021-23443	Centerville	X:B	Unknown	HY	25 May 2011	11CV01	
8021-23444	Centerville	X:B	Unknown	HY	26 May 2011	11CV01	
8021-23445	Centerville	X:B	Unknown	HY	26 May 2011	11CV01	
8021-23446	Stone Lagoon	X:G	Unknown	HY	9 June 2011	11SL01	
8021-23447	Stone Lagoon	X:G	Unknown	HY	9 June 2011	11SL01	
8021-23448	Big Lagoon	GY:GB	Male	AHY	27 July 2011	11BL03	
8021-23449	Eel River WA	X:W	Unknown	HY	16 June 2011	11ES02	
8021-23450	Eel River WA	X:W	Unknown	HY	16 June 2011	11ES02	
8021-23451	Eel River WA	X:W	Unknown	HY	17 June 2011	11ES02	
8021-23452	Clam Beach	X:Y	Unknown	HY	18 June 2011	11CS04	
8021-23453	Clam Beach	X:Y	Unknown	HY	18 June 2011	11CS04	
8021-23454	Clam Beach	X:Y	Unknown	HY	18 June 2011	11CS04	
8021-23455	Big Lagoon	X:W	Unknown	HY	19 July 2011	11BL03	
8021-23456	Big Lagoon	X:W	Unknown	HY	19 July 2011	11BL03	
8021-23457	Big Lagoon	X:W	Unknown	HY	19 July 2011	11BL03	
8021-23460	Mad River	X:R	Unknown	HY	26 June 2011	11MR02	
8021-23461	Mad River	X:R	Unknown	HY	26 June 2011	11MR02	
8021-23463	Clam Beach	X:Y	Unknown	HY	8 August 2011	11CS08	
8021-23464	Clam Beach	X:Y	Unknown	HY	8 August 2011	11CS08	
8021-23465	Clam Beach	X:Y	Unknown	HY	9 August 2011	11CS08	
8021-24039	Eel River WA	WW:RB	Male	TY	11 June 2011	11ES03	Formerly banded X:R
8021-24043	Clam Beach	X:W	Unknown	HY	8 May 2011	11CS01	
8021-24044	Clam Beach	X:W	Unknown	HY	8 May 2011	11CS01	
8021-24045	Centerville	X:W	Unknown	HY	15 July 2011	11CV03	
8021-24055	Centerville	WW:GB	Male	SY	15 May 2011	-	Formerly banded X:B
8021-24058	Eel River WA	OR:BB	Male	SY	15 June 2011	11ES02	Formerly banded X:G
8021-24066	Big Lagoon	OR:BY	Male	SY	29 May 2011	11BL02	Formerly banded X:R
8021-24068	Clam Beach	OR:WG	Female	AHY	18 April 2011	11CS02	
8021-24069	Clam Beach	X:G	Unknown	HY	16 May 2011	11CN02	
8021-24070	Clam Beach	X:G	Unknown	HY	16 May 2011	11CN02	
8021-24071	Centerville	X:G	Unknown	HY	15 July 2011	11CV03	
8021-24072	Clam Beach	X:R	Unknown	HY	10 July 2011	11CN07	
8021-24075	Big Lagoon	X:Y	Unknown	HY	23 June 2011	11BL02	
8021-24076	Big Lagoon	X:Y	Unknown	HY	23 June 2011	11BL02	
8021-24077	Big Lagoon	X:Y	Unknown	HY	23 June 2011	11BL02	
8021-24078	Clam Beach	X:Y	Unknown	HY	16 May 2011	11CS02	
8021-24079	Clam Beach	X:Y	Unknown	HY	16 May 2011	11CS02	
8021-24080	Clam Beach	X:Y	Unknown	HY	16 May 2011	11CS02	
8021-24081	Clam Beach	X:G	Unknown	HY	26 May 2011	11CN04	
8021-24082	Clam Beach	X:G	Unknown	HY	26 May 2011	11CN04	
8021-24083	Big Lagoon	OR:RW	Female	AHY	29 May 2011	11BL01	
8021-24084	Clam Beach	GY:GR	Male	SY	22 July 2011	11CS08	Formerly banded X:R; 8021-24053
2381-00941	Centerville	WW:WB	Female	AHY	14 May 2011	11CV01	Formerly banded R/L/R:W
2381-01042	Clam Beach	GY:GW	Male	AHY	26 May 2011	11CN04	Formerly banded G/Y:W

Appendix 2. List of papers, oral presentations at professional meetings, graduate and undergraduate theses, workshops and opinion pieces produced 2010-11.

Scientific Papers

- Brindock, K.M., and M.A. Colwell. 2011. Habitat selection by Western Snowy Plovers during the nonbreeding season. *J. Wildlife Management* 75:786-793.
- Burrell, N.S., and M.A. Colwell. Productivity of Snowy Plovers varies with activity of a nest predator. *Auk*. In review.
- Colwell, M.A., N.S. Burrell, M.A. Hardy, K. Kayano, J.J. Muir, W.J. Pearson, S.A. Peterson, and K.A. Sesser. 2010. Arrival times, laying dates, and reproductive success of Snowy Plovers in two habitats in coastal northern California. *J. Field Ornithology* 81:349-360.
- Colwell, M.A., L.J. Eberhart-Phillips, W.J. Pearson, and S.J. Dinsmore. Apparent survival of Snowy Plovers varies annually but not with reproductive effort. In prep.
- Colwell, M.A., and W.J. Pearson. Four cases of inbreeding in a population of Snowy Plovers. *Wader Study Group Bulletin*. In review.
- Colwell, M.A., J.J. Meyer, M.A. Hardy, S.E. McAllister, A.N. Transou, R.R. LeValley, and S.J. Dinsmore. 2011. Western Snowy Plovers *Charadrius alexandrinus nivosus* select nesting substrates that enhance egg crypsis and improve nest survival. *Ibis* 153:303-311.
- Hardy, M.A., and M.A. Colwell. Snowy Plover nest survival is not related to habitat characteristics or the activity of predators or humans at the nest. *Waterbirds*. In review.
- Mullin, S.M., M.A. Colwell, S.E. McAllister, and S.J. Dinsmore. 2010. Apparent survival and population growth of Snowy Plovers in coastal northern California. *J. Wildlife Management* 74:1792-1798.
- Nelson, Z.J., and M.A. Colwell. Social attraction in breeding Snowy Plovers. *Wilson J. Ornithology*. In revision.
- Watts, C.M., Cao, J., Panza, C., Dugaw, C., Colwell, M., and E.A. Burroughs. Modeling the effects of predator exclosures on a Western Snowy Plover population. *Natural Resource Modeling*. In review.

Professional Presentations

- Colwell, M.A. Recovery Unit 2: Mendocino, Humboldt and Del Norte counties. Jan 2011. Annual Snowy Plover Recovery meeting, Monterey Natural History Museum, Pacific Grove, CA
- Colwell, M.A. Factors limiting recovery of Snowy Plovers. Jan 2011. Annual Snowy Plover Recovery meeting, Monterey Natural History Museum, Pacific Grove, CA.
- Colwell, M.A. The value of studying lifetime reproductive success. Feb 2011. Ecology Seminar Series, Wildlife Department, HSU.
- Colwell, M.A., L.J. Eberhart-Phillips, W.J. Pearson, and S.J. Dinsmore. Apparent survival of Snowy Plovers varies annually but not with reproductive effort. Aug 2011. Western Hemisphere Shorebird Group meeting, Simon Fraser University, Burnaby, BC.
- Pearson, W.J. Effects of nest success and mate fidelity on breeding dispersal in a population of Snowy Plovers (*Charadrius nivosus*). Oct 2011. Thesis defense, Humboldt State University, Arcata, CA.
- Pearson, W.J., and M.A. Colwell. Effects of nest success and mate fidelity on breeding dispersal in a population of Snowy Plovers (*Charadrius alexandrinus nivosus*). Aug 2011. Western Hemisphere Shorebird Group meeting, Simon Fraser University, Burnaby, BC.

Graduate Theses

- Hardy, M.A. 2010. Western Snowy Plover nest survival on ocean-fronting beaches in coastal northern California. M.Sc. thesis, Humboldt State University, Arcata, CA.
- Pearson, W.J. 2011. Effects of nest success and mate fidelity on breeding dispersal in a population of Snowy Plovers (*Charadrius nivosus*). M.Sc. thesis, Humboldt State University, Arcata, CA.

Workshops

- LeValley, R.R. Snowy Plover and shorebird training. May 2011. Russian Gulch State Park, CA.

Opinion Piece

- Colwell, M.A., and M.D. Johnson. The real plight of the Snowy Plover. December 2010. Eureka Times-Standard.