Final Report: 2009 Snowy Plover Breeding in Coastal Northern California, Recovery Unit 2

M.A. Colwell, N.S. Burrell, M.A. Hardy, K. Kayano, J.J. Muir, W.J. Pearson, S.A. Peterson, K.A. Sesser, and R.R. Thiem
Department of Wildlife, Humboldt State University, Arcata, CA 95521

Abstract.—*The Pacific coast population segment of the Western Snowy Plover (*Charadrius alexandrinus nivosus*) was listed as threatened under the U.S. Endangered Species Act in 1993. Here, we report on the ninth consecutive year of data collected to monitor the population that breeds in coastal northern California, one of six recovery units identified in the species' recovery plan. The number of adult plovers (19; 10 males and 9 females) breeding in Recovery Unit 2 was the lowest in nine years and approximately half the number recorded in 2008 (n=37). Breeding plovers occupied five locations, including the first record for Stone Lagoon in decades; most (63%) plovers bred at Clam Beach. Three philopatric yearlings (two breeding females; one non-breeding male) were detected, representing a high rate of return (survival) for the 8 young that fledged in 2008. However, the return of banded adults to breed in RU2 was markedly lower than the 9-yr average for the study area, with 33% of females and 50% of males returning to breed; observers recorded several other marked adults of both sex during the breeding season. These observations suggest that emigration may explain some of the roughly 50% population decline between 2008 and 2009. Plovers initiated 35 nests and hatched 15 chicks; nine young fledged from three breeding sites. Overall, per capita reproductive success (average number of young fledged per male) was 0.90±1.45. Males breeding on gravel bars of the lower Eel River continued to have higher fledging success (1.50±2.12) than those occupying ocean-fronting beaches (0.75+1.39), although this difference was not significant. Male cumulative reproductive success continued to be significantly lower for males on beaches than gravel bars. In 2009, plovers hatched 5 of 35 nests, a percentage (14%) identical to 2008 and the lowest since 2001. We estimated daily predation rates (DPR) for nests established over the 9-yr period of intensive monitoring and determined that there was appreciable variation among sites. DPR was lowest on the gravel bars, and at remote beaches (Centerville, Eel River Wildlife Area, South Spit, Big Lagoon, Stone Lagoon, Gold Bluff Beach) occupied by few plovers; conversely, DPR was consistently higher at Mad River Beach and Clam Beach. Using video surveillance systems on Clam Beach, we determined that Common Ravens (*Corvus corax*) caused 70% of 20 nests (with useable information) to fail during 2008 and 2009; humans caused an additional 20% of these nests to fail. Finally, management continues to be undertaken to increase the productivity of plovers by reducing the negative impacts of humans, predators, and introduced species: restrictions on human access and restoration continue to provide habitat that is attractive to nesting plovers. Unfortunately, without predator control (i.e., exclosures, lethal removal) and significant outreach to affect how humans use habitats they share with breeding plovers, negative impacts continue to compromise Snowy Plover recovery in RU2. We suggest additional ways to ameliorate these negative impacts on plovers.*

Key words.—Charadrius alexandrinus nivosus, *daily predation rates*, *habitat quality, human disturbance, nesting success, predation, Recovery Unit 2, reproductive success, site fidelity, Western Snowy Plover.*

Introduction

For the ninth year, biologists from Humboldt State University (HSU) worked with county (Humboldt County Public Works), state (Department of Fish and Game, Department of Parks and Recreation), and federal (Bureau of Land Management, National Park Service, and United States Fish and Wildlife Service) staff, biologists from Mad River Biologists (MRB), and volunteers to monitor a population of the Western Snowy Plover (*Charadrius alexandrinus 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 2009 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. We conclude with specific recommendations to improve chances for recovery of the species in Recovery Unit 2 (hereafter RU2).

Background

In 1993, the federal government listed the coastal population of the Western Snowy Plover as a threatened population segment 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 recently finalized (USFWS 2007). In 2006, the USFWS denied a proposal to de-list 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. These factors 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 plant 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 2008, a coordinated, week-long survey during the breeding season indicated that 1541 plovers occurred along the U.S. Pacific coast; this estimate was down slightly from previous years (2007, 1537; 2006, 1974; 2005, 1817). 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).

In coastal northern California, plovers have bred and wintered along ocean beaches and gravel bars of the Eel River in each of the past eight years (Colwell et al. 2008). In 2001, the USFWS designated Mendocino, Humboldt, and Del Norte counties as a discrete management unit (RU2). Surveys (Page and Stenzel 1981, Fisher 1992-94, LeValley 1999, McAllister et al. 2001, Colwell et al. 2008) 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 (1992-4) 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). The Eel River remains a unique and productive breeding habitat (Colwell et al. 2005a). 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. 2005a); this pattern, however, has changed dramatically following several years (2003, 2005, and 2006) of high river flows in late spring. Both hatching and fledging success are consistently higher for river- than beach-breeding plovers (Colwell et al. 2005a).

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 (USFWS 2007, Colwell et al. 2008). Recently, however, numbers in Humboldt County may have 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 since researchers surveyed different habitats with varying effort. Moreover, since plovers tend to disperse widely during the breeding season (Stenzel et al. 1994), 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 has declined by ~75% over the past five years, and this year represents the low point in population size (see below).

Study Area

We studied plovers from mid-March to mid-August 2009 in coastal northern California. Most intensive monitoring occurred at five locations in Humboldt County where observers detected breeding plovers (Fig. 1): Stone Lagoon, Clam Beach, Mad River Beach, Eel River Wildlife Area, and the Worswick gravel bar on the Eel River. Observers also regularly (i.e., weekly, bimonthly or window survey) monitored many other sites with suitable habitat.

Methods

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 #04/05.W.17-A) permits.

Banding. We captured and marked adult plovers with a unique combination of plastic color bands and colored tape (e.g., red, yellow, orange, green, violet, white or 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.

Surveys. Beginning in mid-March and continuing into mid-August, we surveyed for plovers, searched for nests, and monitored broods in suitable habitat. We dedicated most effort to surveying five locations where we detected breeding plovers, although we surveyed unoccupied sites a minimum of 9 times (at 7-10 day intervals) throughout the nesting season. Upon finding a nest, we 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).

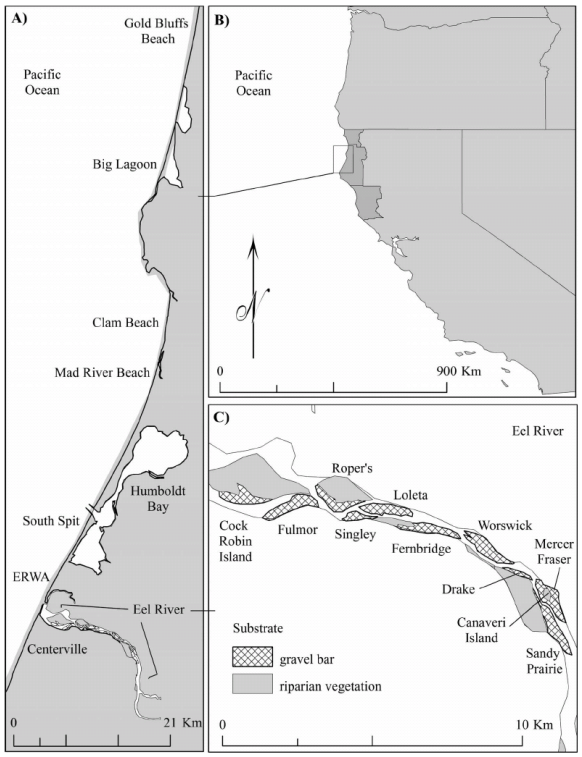

Fig. 1. Observers surveyed for breeding Snowy Plovers at multiple locations in Humboldt County, CA in 2009. Observers detected plovers at several other locations in coastal northern California (Tolowa Dunes State Beach, Del Norte County; Brush Creek, Mendocino County; Centerville Beach, Humboldt County) during surveys but found no evidence of breeding. Little River State Beach/Clam Beach is managed by California Parks and Recreation and Humboldt County, respectively; South Spit is managed by the U.S. Bureau of Land Management; Eel River Wildlife Area is managed by California Department of Fish and Game; and the gravel bars of the lower Eel River are accessed or owned mostly privately, with the exception of one county-managed site (Worswick).

Field Methods. During surveys, we 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) high tide inundation (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 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. In 2008 and 2009, we used video cameras at Clam Beach to improve our understanding of the cause of nest failures.

Management Activities. For the third consecutive year since 2001, we did not use nest exclosures to protect eggs from vertebrate nest predators. We made the decision to discontinue use of exclosures in 2006 when evidence accumulated that an avian predator at Clam Beach killed at least one adult near an exclosure, and seven other adults disappeared during incubation. On 6 March and 28 August 2009, we coordinated with Humboldt County Department of Public Works and USFWS to erect and take down, respectively, a symbolic fence for the sixth consecutive year. We erected the fence along a ~1.5 km (8 ha) stretch of beach between the north and south parking lots accessing Clam Beach County Park. In previous years, plovers used this location for nesting and rearing broods. The management objective of the fence was to minimize human activities in the vicinity of breeding plovers.

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. For each breeding location, we estimated the daily predation rates of nests using Program MARK, determining the exposure period for each nest as follows: 1) for nests that were depredated or failed due to unknown causes (most of these were likely depredated as well), we determined the number of exposure days using the Mayfield (1975) method; 2) nests that ultimately failed owing to humans, tidal overwash, or drifting sand were censored at the last active nest check and coded as successful (since they were not depredated); 3) abandoned nests were censored on the day they were determined to be abandoned and coded as successful; 4) "nests" that were located at hatch or after hatch (i.e., as a brood of chicks) were assigned 33 exposure days (5 day laying period + 28 days of incubation) and coded as successful. We excluded nests protected by predator exclosures from analyses of daily predation rate. From the number of broods hatched, we calculated brood success as the percentage of broods that had at least one chick reach 28 days age (i.e., post hatch). 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 two-tailed t-tests to compare per capita fledging success between ocean (beach) and river (gravel bar) habitats; chi-square tests to examine differences in return rates of males and females; and nonparametric correlations to evaluate changes over time (yrs) in per capita reproductive success. We present data as means (±1 SD).

Results and Discussion

Population Size. The breeding population of plovers in RU2 continues to decline dramatically (Fig. 2, Table 1). During regular monitoring, we detected 19 breeding plovers, all in Humboldt County. One yearling male was present as a non-breeder early in the breeding season. During the 17-23 May window survey, observers tallied 15 adults (seven males and eight females; three chicks). This number was down appreciably from previous years (2008=18; 2007=26; 2006=45; 2005=41). During the 2009 window survey, observers detected adult plovers at just four sites (12 at Clam Beach, three on the Worswick gravel bar, two on the North Spit of Humboldt Bay, and one at Eel River Wildlife Area). Observers detected a minimum of 68% of banded adults that bred locally, which was higher than the average of the previous eight years (63±20%; range: 27-79%). Window surveys did not detect all breeding individuals because: 1) observers occasionally failed to detect some resident breeders during the single visit to each site (e.g., Stone Lagoon), which is the protocol for the window survey; and 2) the window survey occurs during a brief interval midway through the breeding season; hence, it fails to account for individuals that either breed early and depart to breed elsewhere (e.g., Oregon) or that arrive from elsewhere to breed late in the season.

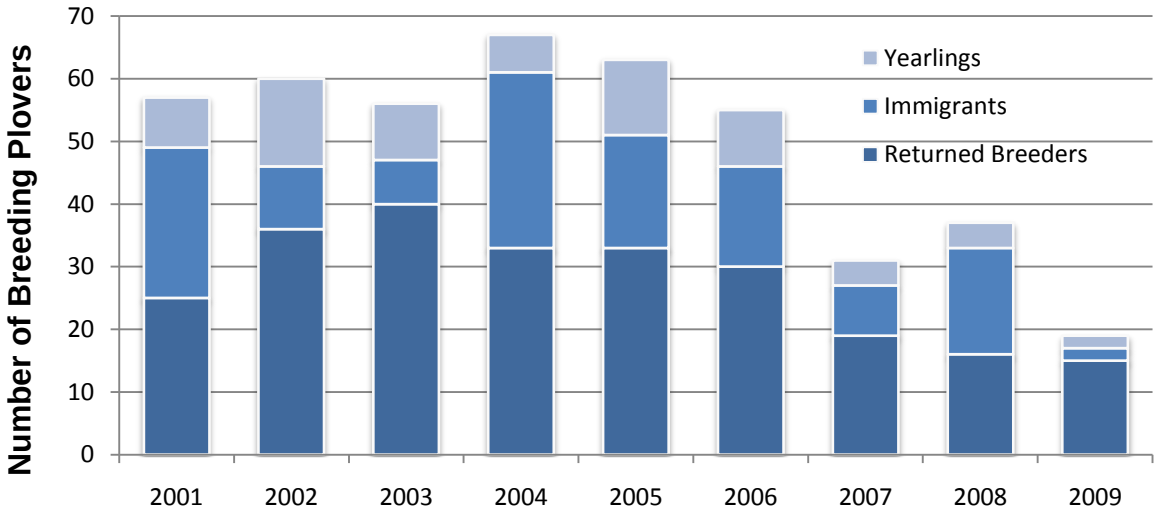

Fig. 2. Annual variation in number of breeding Snowy Plovers in Humboldt County, CA based on intensive monitoring of color-marked individuals. "Yearlings" are birds first marked as chicks in a previous year that returned to breed in Humboldt County; "Immigrants" are unmarked breeding adults, assuming we captured all marked birds the previous year, and birds with color bands and known origins outside RU2; and "Returned Breeders" are marked plovers that nested in a previous year and returned to breed.

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 nine 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 eight years (2002-09; when we were confident that we had marked virtually all breeding plovers in the previous year), population size tended to increase with the percentage of immigrants in the population. In 2009, the population included just two immigrants (one unmarked male and one previously marked female), which represents the lowest total and percentage (11%) of immigrants since 2002 (30±13%). These data, coupled with analyses of survival and population growth (Mullin et al. in revision), attest to the importance of immigrants to the local population. The local population cannot sustain itself owing to poor productivity; it is maintained by immigration.

Table 1. Annual variation in composition of the Snowy Plover population in Recovery Unit 2. Totals do not include non-breeding birds.

	Males					Females				
Year	Returning (marked) Adults	Returning (marked) Yearlings	Immigrants Banded Elsewhere	Unbanded Immigrants		Returning (marked) Adults	Returning (marked) Yearlings	Immigrants Banded Elsewhere	Unbanded Immigrants	Total
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

Philopatry and Site Fidelity. In 2009, 9 males and 8 females returned to breed in RU2, either as yearlings or older birds (Tables 1 and 2). We confirmed that most (94%) of these plovers bred locally; one yearling male was present for approximately two months early in the breeding season on Clam Beach and associated with females but never bred. With a ninth year of data, the overall return rate of chicks to the population remained slightly, but not significantly, male-biased (X^2 = 1.58, df = 1, P = 0.21). In total, 11.5% of females and 15.6% of males marked as chicks were philopatric (i.e., returned to breed in RU2).

For adults, a greater percentage of males (50%) returned to breed in RU2 compared to females (33%) (Table 2), although this difference was not significant (X^2 = 0.41, df = 1, P = 0.52). These return rates are lower than earlier years (2001-04), when >60% of males and >50% of females returned annually. The lower return rates may stem from birds emigrating, especially given the low reproductive success of most individuals. Conversely, higher site fidelity in early years may be related to the use of exclosures and the tendency for individuals to return based on improved hatching success. In support of this, it is noteworthy that since we stopped using exclosures in mid-2006, adult site fidelity has decreased to 34-63% and 33-40% for males and females, respectively. Moreover, at Clam Beach, where most exclosures were erected, several adults that formerly bred there have apparently emigrated (i.e., outside of RU2). We base this conclusion on the observation of three females and one male observed at various times before, during and after the 2009 breeding season on Clam Beach but did not breed there. A final anecdote offers additional insights into the relationship between exclosures, reproductive success, and site fidelity. The oldest male in the RU2 population (OR:YR) started his eighth year breeding on Clam Beach this year; during this time, he cared for >90 eggs but fledged only four chicks. From 2002-06, he incubated with various females in 12 exclosures. This year, OR:YR nested early in the season on Clam Beach, producing five nests with the same female (OR:RR). In early May, they disappeared from Clam Beach and were later observed with a brood of 10-d old chicks at Stone Lagoon, representing the first breeding record there in decades. OR:YR fledged these three chicks in mid-July. This observation suggests several things. First, it attests to the poor quality of breeding habitat at Clam Beach. Specifically, this male contributed nearly as many young to his cumulative reproductive success in one attempt at Stone Lagoon compared with a monumental effort over eight years at Clam Beach. Second, it indicates the strong effect that hatching success (but poor fledging success) has on individual decisions to remain at a site or disperse. And, it attests to the unintended consequences of a management practice (exclosures) on individual behavior and population growth.

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

		Females			Males	
	Year	Number Banded	Percentage Returned (n)		Number Banded	Percentage Returned (n)
Philopatry[a]	2009	7.5	50 (2)		7.5	25 (1)
	2008	21	19 (2)		21	19 (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	270.5	11.5 (31)		270.5	15.5 (42)
Adult Site Fidelity[b]	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.

Patch Occupancy. Since 2001, plovers have bred at 19 sites (8 beaches, 11 gravel bars on the Eel River) within Humboldt County; plovers have bred sporadically at several sites in Mendocino County; there are no recent records of plovers breeding in Del Norte County. Over the past nine years, occupancy and density have varied markedly among the 19 breeding sites in Humboldt County (Table 3). 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; by contrast, the percentage of the population occupying beach sites has increased gradually. In 2009, breeding plovers occupied five locations (four beaches, one gravel bar) in RU2, all located in Humboldt County. In 2009, occupied sites were similar to those in 2007 and 2008, with one exception. A pair of plovers successfully bred at Stone Lagoon for the first time in decades. A total of 14 individually-marked adults (eight males and six females) returned to nest at the site they occupied in 2008. The persistence of plovers at these sites is due to site fidelity of breeders, social attraction (Nelson 2007), and recruitment. Since the discontinued use of nest exclosures, the number of breeding plovers at Clam Beach has declined by 61.3% from 31 adults (2006) to 12 (2009) adults.

Patch Productivity. In 2009, productivity of plovers in RU2, as measured by per capita fledging success of breeding adults (i.e., not including one non-breeding yearling male) was the second lowest recorded since intensive monitoring began in 2001. Overall, plovers initiated 35 nests, hatched 15 chicks, and fledged nine young. Over the past nine years, two breeding sites, Worswick gravel bar and Clam Beach, have consistently had the highest numbers of breeding plovers for river and beach sites, respectively; these two sites are the only ones to host breeding plovers each year since 2001. From 2001-09, annual per capita reproductive success (fledglings male^{-1}) at Worswick gravel bar (1.70±0.40) has been significantly higher (P=0.0005) than that of Clam Beach (0.50±0.49). This is consistent with a pattern of higher reproductive success of river- versus beach-breeding plovers in previous years (Colwell et al. 2005a). In 2009, this pattern continued with plovers at Clam Beach (n=12) producing at least 56 eggs in 25 nests; two of these nest hatched three chicks each, but neither brood fledged young. Consequently, per capita reproductive success was 0.00 for plovers breeding on Clam Beach. By contrast, four breeding plovers on the Worswick gravel bar produced nine eggs in three nests, and fledged three juveniles; per capita reproductive success was 1.50 juveniles male^{-1}.

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

	Year									Average
	2001	2002	2003	2004	2005	2006	2007	2008	2009	±SD
Del Norte County	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Humboldt County										
Gold Bluffs Beach	0.0	0.0	0.0	2.4	3.0	0.0	0.0	0.0	0.0	0.6±1.2
Stone Lagoon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0[a]	0.0±0.0
Big Lagoon	0.0	0.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.7±2.0
Clam Beach	16.4	28.6	37.7	40.2	48.5	52.5	56.3	67.6	63.2	45.7±16.6
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]	1.0±3.1
Elk River	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	3.9±4.4
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]	8.4±7.6
Centerville Beach	0.0	0.0	0.0	2.4	0.0	3.4	0.0	0.0	0.0	0.6±1.3
Eel River gravel bars	65.6	54.0	50.8	39.0	27.3	28.8	25.0	13.5	21.0	36.0±17.3
Mendocino County										
Brush Creek	0.0	0.0	0.0	4.9	3.0	3.4	0.0	0.0	0.0	1.3±1.9
Ten-mile Creek	0.0	0.0	3.3	7.3	3.0	0.0	0.0	0.0	0.0	1.5±2.6
Virgin Creek	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.3±1.0
Total Banded Plovers	61	63	61	82	66	59	32	37	19	

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

Reproductive Success. In 2009, productivity was the second lowest recorded in nine years in RU2 (Tables 4 and 5). Overall, plovers initiated 35 nests, hatched 15 chicks, and fledged nine young. The comparatively low productivity of the local population has resulted from a disproportionate number of breeding plovers at Clam Beach, where reproductive success has been consistently low, especially after 2006, when we discontinued using nest exclosures to manage the effects of egg predation. In total, 71% (25/35) of nests in RU2 occurred at Clam Beach; only two of these 35 nests hatched chicks, and none survived longer than one week. The number of plovers breeding in gravel bar habitats of the Eel River continues to be low.

Table 4. Summary of Snowy Plover breeding in Recovery Unit 2 in 2009 with comparison to 2000-08.

Location		Females[a]	Males[a]	Number of Nests	Number Exclosed	% Nests Hatched[b]	# Chicks Hatched	# Chicks Fledged[c]
Del Norte County		0	0	0	-	-	-	-
Humboldt County		9	10	35	0	14	15	9
Gold Bluffs Beach		0	0	0	-	-	-	-
Stone Lagoon		1	1	1	0	100	3	3
Big Lagoon		0	0	0	-	-	-	-
North Clam Beach and LRSB		5	4	12	0	8	3	0
South Clam Beach		5	5	13	0	8	3	0
Mad River Beach		2	3	3	0	0	0	0
South Spit Beach		0	0	0	-	-	-	-
ERWA		1	2	3	0	33	3	3
Centerville Beach		0	0	0	-	-	-	-
Eel River Gravel Bars								
Cock Robin Island		0	0	0	-	-	-	-
Fulmor		0	0	0	-	-	-	-
Roper's		0	0	0	-	-	-	-
Singley		0	0	0	-	-	-	-
Loleta		0	0	0	-	-	-	-
Fernbridge		0	0	0	-	-	-	-
Worswick		2	2	3	0	33	3	3
Drake		0	0	0	-	-	-	-
Canaveri Island		0	0	0	-	-	-	-
Mercer-Fraser		0	0	0	-	-	-	-
Sandy Prairie		0	0	0	-	-	-	-
Hauk-Hansen		-	-	-	-	-	-	-
Leland		-	-	-	-	-	-	-
Mendocino County		0	0	0	-	-	-	-
Brush Creek		0	0	0	-	-	-	-
Tenmile River		0	0	0	-	-	-	-
Virgin Creek		0	0	0	-	-	-	-
RU2 Total	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 (8) individuals are assigned to multiple sites (e.g., Worswick, Eel River Wildlife Area, Mad River, Clam Beach, Stone Lagoon).

[b] Apparent nest success = number of nests that hatched at least 1 chick / total nests.

[c] Not surveyed in 2006, 2007, 2008, or 2009.

Apparent nesting success of plovers in RU2 has varied substantially over the nine years of intensive monitoring (Table 5). Overall, 37% of 517 nests hatched at least one chick. Hatching success has varied annually from 14-68%, with the lowest success in 2008 and 2009. A decline in hatching success since 2001 (r_s=-0.85, P=0.004) parallels a shift in distribution of breeding plovers away from highly productive habitats along the Eel River to ocean-fronting beaches. High nesting success of plovers breeding along the Eel River is attributable to natural crypsis afforded eggs by coarse substrates (Meyer 2005, Colwell et al. in prep.). Conversely, the low hatching success of recent years coincides with cessation of active predator control when many nests on Clam Beach were protected by exclosures. Predation was the leading cause of nest failure and video camera evidence (see below) at Clam Beach continues to show that Common Ravens are the main egg predator. As in years past, our estimate of the contribution of predation to nest failure is conservative because the "unknown" category (31% of nests) includes many nests from which eggs disappeared and there was no clear evidence of the cause of failure (e.g., corvid tracks at the nest). It is reasonable to conclude, however, that most of the nests failed owing to predation.

Table 5. Annual variation in Snowy Plover nesting success[a] and causes of clutch failure in Recovery Unit 2.

	2001		2002		2003		2004		2005		2006		2007		2008		2009	
Clutch Fate	**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
Failed and cause																		
Predation	4	7	12	16	17	23	18	26	7	12	11	19	11	27	14	28	11	31
Abandoned	2	4	4	5	5	7	9	13	4	7	8	14	1	2	2	4	0	0
Sand covered	1	2	7	9	6	8	4	6	4	7	0	0	2	5	2	4	2	6
Tidal overwash	0	0	2	3	4	5	1	1	2	4	0	0	0	0	0	0	2	6
Human	0	0	7	9	5	7	3	4	0	0	3	5	2	5	3	6	4[b]	11
River flood	0	0	0	0	5	7	0	0	4	7	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
Total Nests	57		75		74		70		57		58		41		50		35	

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

[b] Includes: 1) a nest on Clam Beach in which humans took 3 eggs; 2) two additional Clam Beach nests destroyed by unleashed dogs; and 3) a nest on Worswick that was crushed by a vehicle.

Overall, males in RU2 fledged 0.90±1.45 chicks, which is below the level necessary to maintain the population (USFWS 2007). It also represents a pattern of low and declining productivity over the past nine years (1.7, 0.8, 1.1, 1.2, 0.9, 0.7, 0.7 and 0.5 fledged chicks per male for 2001-08, respectively). Plovers breeding on ocean beaches continued to exhibit low fledging success (0.75±1.39 fledglings per male) compared to those breeding on gravel bars of the Eel River (1.50±2.12). In each of the preceding eight years, plovers on the Eel River have fledged significantly more young than those breeding on ocean-fronting beaches (Colwell et al. 2005a). In 2009, this difference was not significant (P = 0.54), probably because of small sample size.

Daily Predation Rates. As predation is the leading known cause of nest failure in RU2 (Table 5), we calculated daily predation rates (hereafter DPR) in order to better compare the relative impact of predation on nest survival among sites and between years. We treated nests that failed due to unknown causes the same as known predation events, since the majority of these nests were probably depredated (see *Video Monitoring of Nests*, below). We also included nests that ultimately failed due to other known causes, although these nests were coded as successful (see Methods, above); we felt that these nests should be included (since they were exposed to the threat of predation while active), but not treated as failures (since they were not depredated). In order to avoid biasing our DPR estimates low, we only considered unexclosed nests. Note, however, that we made a concerted effort to exclose as many beach nests as possible during the first five years of the study and many unexclosed beach nests were only unexclosed because they failed quickly, before biologists could protect them. Thus, beach DPR estimates from 2001-2005 may actually be biased high, particularly at Clam Beach. Beach estimates from 2006-2009 (and all river estimates, as river nests were never exclosed) should not suffer from this same bias.

Overall, nests on riverine gravel bars experienced lower DPR than beach nests, although there were some exceptions (Table 6). DPR was particularly high at Clam Beach (0.065-0.390) and Mad River Beach (0.051-0.157), but nests at more remote beach sites (e.g., Stone Lagoon, Big Lagoon, South Spit, and Centerville Beach) or beaches with greater amounts of cryptic nesting habitat (e.g., Eel River Wildlife Area) generally experienced lower predation rates similar to those found on gravel bars. Worswick, the only gravel bar occupied during each of the past nine years, had consistently low DPR (0.000-0.027); in contrast, the Fulmor gravel bar had DPR comparable to, or higher than, that found at Clam and Mad River Beaches (0.137-0.905) in the years when plovers nested there. It is worth noting that observers regularly detected large aggregations of foraging and roosting corvids while surveying the Fulmor gravel bar; DPR suggests that corvid predation may overwhelm the beneficial effects of cryptic, high-quality nesting habitat (Meyer 2005). Finally, DPR at the Loleta gravel bar may offer additional insight into plover nest site selection and site fidelity: Plovers nested on Loleta for each of the first six years of intensive monitoring, but following a season of exceptionally high DPR in 2006 (0.218), plovers ceased nesting at this site and Loleta has remained unoccupied ever since.

Table 6. A summary of daily predation rates[a] at breeding sites in RU2, 2001-09.

	Year								
	2001	2002	2003	2004	2005	2006	2007	2008	2009
Del Norte County	-	-	-	-	-	-	-	-	-
Humboldt County									
Gold Bluffs Beach	-	-	-	-	0.080	-	-	-	-
Stone Lagoon	-	-	-	-	-	-	-	-	0.000
Big Lagoon	-	-	-	-	0.000	-	-	-	-
Clam Beach[a]	0.065	0.390	0.184	0.264	0.125	0.080	0.094	0.098	0.082
Mad River Beach	-	-	-	-	-	0.157	0.051	0.146	0.110
South Spit[a]	-	-	-	-	-	0.000	0.000	0.029	-
Eel River Wildlife Area[a]	0.905	0.038	0.000	-	-	-	0.000	0.031	0.031
Centerville Beach	-	-	-	0.000	-	0.000	-	-	-
Eel River gravel bars									
Sandy Prairie	-	0.000	0.000	-	-	-	-	-	-
Mercer Fraser	-	-	-	0.020	-	-	-	-	-
Canaveri Island	0.937	0.000	0.094	-	-	-	-	-	-
Drake	0.000	-	-	-	-	-	-	-	-
Worswick	0.019	0.014	0.018	0.027	0.014	0.018	0.011	0.000	0.018
Fernbridge	-	0.000	0.000	-	-	0.000	-	-	-
Loleta	0.031	0.095	0.045	0.017	0.024	0.218	-	-	-
Singley	0.000	0.077	0.000	-	-	-	-	-	-
Roper's	0.000	0.000	0.000	0.060	-	-	-	-	-
Fulmor	0.905	-	-	0.137	-	-	-	-	-
Cock Robin Island	-	-	0.000	0.035	-	-	-	-	-
Mendocino County	-	-	-	*1.000*	-	*0.000*	-	-	-

[a] Daily predation rates calculated using the Mayfield (1975) method, including exposure days for nests that failed owing to human causes, tidal overwash and drifting sand.

In summary, patterns of DPR indicate that: 1) remote beaches and most Eel River gravel bars experience a lower incidence of nest predation relative to Clam and Mad River beaches; 2) concentrated corvid activity can render otherwise high-quality nesting sites unsuitable; and 3) high levels of nest predation may influence nesting behavior (i.e., prompt plovers to nest elsewhere). Nevertheless, there has been a gradual but steady shift of plover reproductive effort from the Eel River to Clam and Mad River beaches over the past nine years. Given the strong negative impact of corvid predation on plover eggs and chicks, this trend is cause for concern. Taken together, these data suggest two alternative (but not mutually exclusive) strategies to aid recovery of the RU2 population: 1) encourage plovers to settle at sites with lower DPR, by allowing high nest predation rates to gradually "push" breeding birds into higher-quality sites and/or modifying those sites to make them more attractive; and 2) reducing DPR at sites with aggregations of breeding plovers (specifically, Clam and Mad River beaches) through active predator management.

Video Monitoring of Nests. For a second year, we monitored nests on Clam Beach using infrared video surveillance systems, with three objectives. First, we sought to document with strong evidence the causes of nest failure for a sample of nests. Specifically, in most years, we have concluded that many (5-44% annually) nests failed for "unknown" reasons (Table 7). Although predators probably consumed eggs in many of these nests (i.e., eggs were absent from the nest cup), we lacked evidence to accurately assess the cause of failure. This shortcoming in determining clutch fate arose because of long intervals (often several days) between consecutive visits to nests, which resulted in limited evidence (e.g., predator tracks) to ascertain the cause of failure. Additionally, plovers sometimes nested in habitats (e.g., coarse sediments and debris fields) where predator sign was difficult to read. Second, we hoped to improve understanding of the role that corvids play in egg predation. This interest was sparked by the common field observation that corvid tracks were present at failed nests. Finally, we wanted to measure the accuracy with which surveyors determined causes of nest failure, and suggest an interval of time (i.e., survey frequency or nest visitation rate) necessary to accurately assess the cause of nest failure; this latter analysis is incomplete and will be finalized next month.

Table 7. Summary of video-monitored Snowy Plover nests at Clam Beach/Little River State Beach

Year	Nest I.D.	Male	Female	Date			Fate & Determined Outcome of Nest Attempt	
				Clutch Initiated	Camera Installed	Date Done	Field Observation	Video Camera
2008	08CN06	GV:GB	VW:GW	25-Apr	26-Apr	1-May	Unknown	Common Raven
2008	08CS07	OR:RY	VW:YY	28-Apr	2-May	2-May	Unknown	Common Raven
2008	08CS13	GV:GB	BP:OG	9-May	22-May	29-May	Unknown	Common Raven
2008	08CS18	VW:OW	GL:WO	25-May	7-Jun	23-Jun	Unknown	Common Raven
2008	08CS19	OR:YR	WW:YG	26-May	30-May	1-Jun	Unknown	Common Raven
2008	08CS26	OR:YR	RY:YW	27-Jun	30-Jun	20 & 29 Jul	Truck crushed 2 eggs; 3rd egg hatched	Truck crushed 2 eggs; 3rd egg hatched
2008	08CS27	VW:OW	GL:WO	30-Jun	30-Jun	21-Jul	Unknown	Common Raven
2009	09CN02	OR:YR	OR:RR	17-Mar	21-Mar	20-Mar	Unknown	Dog
2009	09CN03	unkn	unkn	20-Mar	24-Mar	24-Mar	Common Raven	Common Raven
2009	09CN04	VW:BR	VW:GW	23-Mar	25-Mar	24-Mar	Unknown	Common Raven
2009	09CN09	WW:YB	BP:OG	29-May	29-May	30-May	Common Raven	Dog
2009	09CN10	WW:YB	BP:OG	6-Jun	12-Jun	26-Jun	Tidal overwash	Tidal overwash
2009	09CN11	WW:YB	BP:OG	5-Jul	8-Jul	15-Jul	Common Raven	Common Raven
2009	09CN12	VW:BR	VW:YY	11-Jul	16-Jul	1-Aug	Unknown	Common Raven
2009	09CS04	OR:YR	OR:RR	17-Apr	19-Apr	3-May	Unknown	Common Raven
2009	09CS05	VW:OW	VW:YY	25-Apr	2-May	29-May	Hatched	Hatched
2009	09CS07	VW:BR	VW:GW	2-May	8-May	9-May	Unknown	Human
2009	09CS08	WW:YB	BP:OG	12-May	15-May	17-May	Common Raven	Common Raven
2009	09CS10	GV:GB	X:R	17-May	18-May	20-May	Unknown	Sand blown - buried
2009	09CS11	VW:BR	VW:YY	5-Jun	8-Jun	9-Jun	Common Raven	Common Raven
2009	09CS12	VW:BR	VW:YY	13-Jun	16-Jun	2-Jul	Unknown	Common Raven

During 2008 and 2009, we monitored 25 nests with cameras (Table 7). At 20 nests, cameras provided firm evidence of the cause of clutch failure; camera systems failed at four additional nests during the interval when the clutch failed; and one nest hatched. Cameras did not influence the nesting success of plovers, as there was no difference in the daily survival rates of nests with (0.915; 95% CI: 0.875-0.944) and without (0.862; 95% CI: 0.813-0.899) video cameras. There were two main causes of clutch failure for the 20 failed nests monitored by cameras. Common Ravens depredated eggs at 70% (n=14) of nests, and humans (or dogs) destroyed 20% (n=4) of clutches; two additional nests failed owing to tidal overwash and wind-driven sand burying eggs. Observers successfully classified the one nest destroyed by tide; by contrast, observers failed to correctly categorize 71% (n=10) of nests depredated by Common Ravens and 75% (n=3) of human induced nest failures. In these cases, observers categorized the cause of failure as "unknown." Several factors may be responsible for this discrepancy. First, in many cases it appeared as if ravens detected nests from the air after observing the incubating adult plover leave the nest. We concluded this because ravens frequently landed directly at the nest cup a short time after the adult plover ceased incubation. These circumstances probably lead to few if any raven tracks present at the nest cup (sometimes only a single set). Second, as time passed since clutch failure (as determined by video system date/time recorder), observers were increasingly unable to accurately categorize the cause of clutch failure (i.e., the longer the interval between successive visits to a nest; Fig. 3). This may be due to the fact that after several days and varying weather conditions (i.e., drifting sand), the substrate around the nest cup had been altered so that observers could not detect tracks. Finally, two depredated nests were initiated on coarse substrates of sand and pebbles, which obscured tracks. The difficulty with which field observers correctly categorized egg predation by ravens and the high percentage of cases in which “unknown” nest fates were actually caused by ravens suggest that in previous years ravens caused most nest failures. Therefore, we conclude that predation of eggs (and probably chicks) by corvids is overwhelmingly responsible for low and declining reproductive success of plovers on Clam Beach.

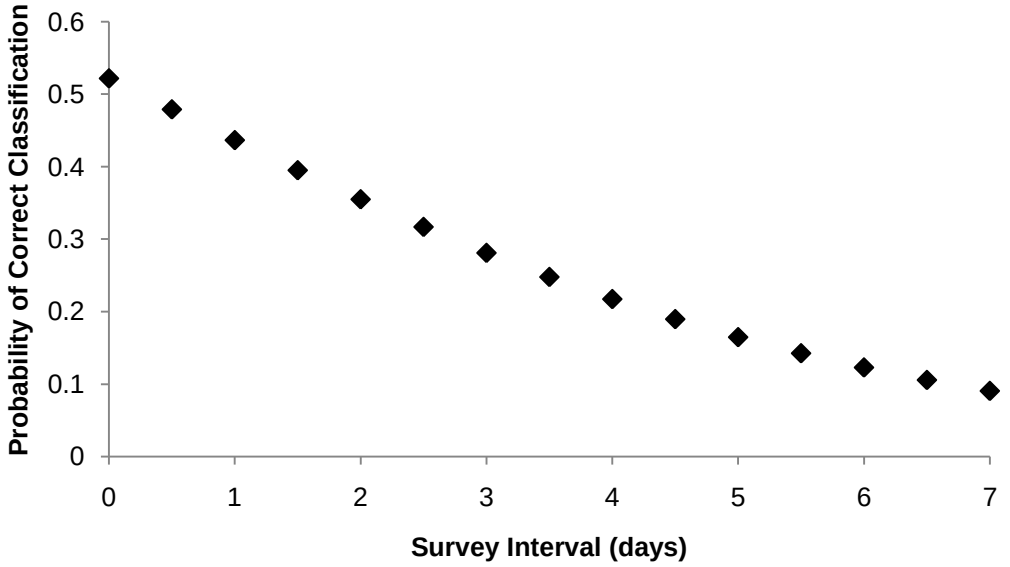

Fig. 3. The probability that a field observer correctly classified the fate of a Snowy Plover nest monitored by a video surveillance system declined as the interval lengthened between successive nest visits.

Humans were the second leading cause of clutch failure on Clam Beach. Humans directly (i.e., vehicle crushed eggs; humans took eggs) or indirectly (i.e., unleashed dogs) caused five nests to fail. In 2009, unleashed dogs (i.e., in violation of county ordinance) destroyed two incomplete clutches when they ran through a nest. In a unique circumstance, two young girls beachcombing south of Strawberry Creek took a clutch of three eggs from a nest on 5 June 2009. Shortly thereafter, the USFWS office in Arcata issued a news release, which prompted these individuals to return two of the three eggs; embryos were later determined to be unviable. At a fourth nest, a woman repeatedly flushed the incubating adult to handle and photograph the eggs and nest. Cameras also documented frequent illegal vehicle play and off-waveslope driving, firewood collecting, and leash law violations near nests. Illegal vehicle play and unleashed dogs on foredunes frequently flushed incubating birds, kept them from nests in adverse weather conditions, and threatened nests themselves. Finally, it is important to note the unexpectedly high occurrence of human-caused clutch failure, especially because these instances would likely have been categorized as "unknown" by field observers. This latter observation calls into question the assumption that eggs that disappear from nests have been depredated, at least on beaches valued and used by the public for recreation. The difficulty with which field observers detected human-caused clutch loss, and frequency with which cameras documented human disturbance at nests, suggest that the deleterious effects of humans on plover hatching success have been underestimated. Our observations emphasize the importance of redoubling efforts to manage the negative human impacts via increased outreach. For instance, none of the signs posted at the main access points to Clam Beach inform the public that disturbing plover nests or taking eggs is a violation of federal law.

Conclusions and Management Recommendations

The population size of Snowy Plovers in RU2 is the lowest since intensive monitoring began in 2001; this year 19 adult plovers (including one male who was present early in the season but did not obtain a mate) bred at just five locations, all in Humboldt County. Low productivity in 2008, comparatively low returns of adults to RU2, and the near absence of immigrants from outside RU2 contributed to this decline. Plovers continue to be concentrated at Clam Beach/Mad River Beach where no chicks fledged in 2008 or 2009; by contrast, the few plovers breeding at the three other sites in RU2 (Stone Lagoon, Eel River Wildlife Area, and Worswick gravel bar) experienced higher per capita fledging success (1.5-3.0 fledglings per male). These observations indicate the need for renewed efforts to effectively manage the factors that limit productivity of the population.

The USFWS (1993, 2007) identified three factors (predation of eggs and chicks, human activity, and introduced plants) that are thought to have contributed to the low productivity and population decline of plovers along the Pacific coast. The factors affecting survival of adults and juveniles are unknown but it is important to recognize that apparent survival of plovers in RU2 is lower than that reported for a population in central

California (Stenzel et al. 2007, Mullin et al. in revision). Here, we summarize information on factors limiting breeding productivity of plovers in RU2. Our objective is to draw attention to management issues at different breeding sites with the goal of initiating changes to management that will reverse the population decline by ameliorating the negative effects of the limiting factors. These objectives are long-term and incorporate the spatial scale of the entire listed population segment, not merely RU2.

Managing Predators. In RU2, predation of eggs and chicks is the most significant factor limiting productivity. Evidence to support this includes the following. First, predation is the principal cause of reproductive failure. Second, video cameras have shown that most nests on Clam Beach (where the greatest percentage of the RU2 population has bred over the past three years of a steep population decline) are depredated by corvids, especially Common Ravens. Third, at Clam Beach, daily nest predation rates and apparent nesting success over nine years indicate that very few nests successfully hatch chicks; those that do hatch commonly fail to fledge young. Moreover, no young have fledged from this site in the past two years despite high reproductive effort; daily predation rate at Mad River Beach is higher still. Finally, both the total number of young fledged and per capita reproductive success of males breeding on Clam Beach (and RU2) have declined since 2006, when we stopped using predator exclosures to reduce egg predation.

Currently, very little is being done to control predators in RU2. Therefore, we suggest that there are two alternative actions that can be taken to ameliorate the negative impacts of corvids and that these approaches be focused at Clam Beach and capitalize on the biology of plovers and their natural response to reproductive failure in dynamic breeding habitats. We propose a 5-yr interval, beginning in 2010, during which management continues as it has for the past three years. In other words, no specific methods (i.e., nest exclosures) are used to reduce nest predation at Clam Beach. The continued high failure rate of breeding plovers at Clam Beach will result in dispersal of adults to breed elsewhere. This appears to be happening already, as evidenced by the few birds that returned to breed in 2009, breeding dispersal of the oldest male in RU2 to Stone Lagoon (where he fledged three young this summer), and the observation of several adults who left Clam Beach to breed elsewhere (i.e., probably outside RU2) and later returned to the post-breeding flock. To encourage establishment and maintenance of breeding plovers at other sites where management of people, predators, and humans is more easily accomplished, we propose that exclosures be used at these other sites (albeit with low daily predation rates) to increase hatching success, local productivity and, importantly, the retention of adult plovers at these sites. As was the case at Clam Beach in 2006, adults incubating in exclosures should be monitored closely to ensure that survival is not compromised by this management practice. If, after five years, evidence shows that this strategy has failed to move breeding plovers away from poor quality breeding habitats at Clam Beach and Mad River Beach to alternative sites, then we suggest that a lethal control program be used to reduce the local population of corvids to a level comparable to other locations in RU2, where indices of corvid activity and daily predation rates are considerably lower and per capita fledging success is higher.

Managing Humans. Humans continue to compromise the breeding productivity and recovery of plovers in RU2. In 2009, four nests failed owing to human activity. On Clam Beach, a video camera recorded humans taking eggs from a plover nest; two other nests failed when unleashed dogs trampled them. On the Eel River, a vehicle crushed one of three nests on the Worswick gravel bar. Finally, during late winter, a vehicle ran over and killed a plover wintering on Centerville Beach (Brindock 2009).

These observations suggest several opportunities to reduce the negative impacts of humans on plovers. First, we suggest that increased outreach be conducted on all beaches and gravel bars where plovers are known to breed and winter, so as to increase the awareness and decrease the detrimental activities of humans. The circumstances surrounding the May 2009 “egg incident” on Clam Beach are especially illuminating. The two individuals who took the plover eggs indicated that they thought that the nest was abandoned owing to the presence of a dead bird (of unknown species) nearby. In hindsight, it became apparent that educational signage at main access points to Clam Beach is inadequate to protect plovers from these seemingly “honest mistakes.” Specifically, nowhere on these signs at access points does it indicate that visitors to the beach may encounter nests on the ground and that disturbing eggs and adults is a violation of federal law (Migratory Bird Treaty Act; Endangered Species Act). Even well-intentioned and knowledgeable visitors to Clam Beach appear to be ignorant of this, as evidenced by a woman who was recorded on video tape manipulating eggs in a plover nest so as to improve the quality of photographs she was taking. Ironically, this individual reported the presence of the nest that she disturbed to county personnel. Two other nests on Clam Beach were destroyed by off-leash dogs (not in compliance with county ordinance). Video cameras recorded numerous other instances in which off-leash dogs posed a threat to plover nests. Lastly, illegal vehicle use of beaches continues to be a problem year-round. The death of a wintering plover on Centerville Beach (Brindock 2009) occurred at a location used predictably by a wintering flock in that area; no signage at the access point to Centerville Beach indicates that vehicles are prohibited in this habitat. Finally, although there is some evidence that the placement of the

symbolic fence between the two main access points to Clam Beach has resulted in higher fledging success (Wilson and Colwell, in revision), at present this fence is ineffective because predators caused most reproductive failures before chicks could take advantage of this refuge.

In light of these observations, we suggest that increased outreach, and, where necessary, heightened enforcement be effected at all beaches to further minimize negative impacts of humans. We note that some progress has been made at Clam Beach with repair of the Hammond Trail fence north of the Vista Point restricting access to the south end of Clam Beach. In addition, county personnel posted signs on the Worswick gravel bar alerting drivers of off-road vehicles to the presence of breeding plovers. Despite these efforts, human caused nest failure was the highest in the nine years we have monitored the population. Therefore, we reiterate our call for the county to further restrict vehicle use by following through on its management plan (Humboldt County Department of Public Works 2006), which calls for a beach closure to vehicles from 1 March into September. We also reiterate our suggestion, first posed four years ago (Colwell et al. 2005b), that the county use carsonite signs or roping at the Strawberry Creek access to direct vehicles onto the beach via a prescribed corridor. Finally, given the predictable locations at which plovers occur in winter flocks (Brindock 2009) during daylight hours when humans access beaches with vehicles, we strongly urge county, state, and federal agencies to protect plovers at these wintering locations using symbolic fencing. A single vehicle speeding through a wintering flock of plovers is sufficient to pose a serious setback to recovery goals by increasing over-winter mortality.

Managing Habitat. The recovery plan for the Pacific coast population segment of the Western Snowy Plover (USFWS 2007) identifies loss and degradation of habitat as one of three factors limiting the population. Although plovers clearly select open habitats in which to court and nest (Muir and Colwell, in revision) and they occasionally settle disproportionately in newly restored habitats (e.g., Caltrans restoration below Vista Point at Clam Beach; Colwell et al. 2008), little evidence exists to support the notion that the extent of sparsely vegetated habitat currently available to plovers in RU2 limits their productivity. It is important to note that the center of the species' range, and, hence, areas of highest density, occur well south of RU2. For the past nine years, plovers have bred at low densities at most sites in RU2; moreover, the number of breeding adults has declined to just a quarter of the population that bred locally just five years ago. To our knowledge, the amount of suitable breeding habitat has not declined appreciably commensurate with this population decline. In fact, restoration efforts at many locations (e.g., Tolowa Dunes, Gold Bluff Beach, Stone Lagoon, Big Lagoon, Little River State Beach, Clam Beach vista point, and South Spit) have increased the area of suitable breeding habitat; and, natural dynamics of the Eel River have further increased the amount and quality of breeding habitat at the Eel River Wildlife Area. Furthermore, there is no strong relationship between breeding density and nest survival (Hardy, M.A., and M.A. Colwell, unpubl. data). These observations indicate that habitat restoration aimed solely at recovering the population is likely to fail because other factors, especially predation, exert overwhelmingly stronger impacts on plover productivity. Despite this, we suggest that other forms of habitat management, specifically those addressing nest survival by increasing the crypsis of substrates for eggs and chicks, as well as the use of symbolic fencing to minimize human impacts may be productive, one-time management practices that could increase productivity when coupled with other forms of predator management.

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Appendix. List of papers, presentations of oral papers at professional meetings, graduate and undergraduate theses, 2008-09.

Scientific Papers

Brindock, K.M., and M.A. Colwell. Habitat selection by wintering Snowy Plovers in coastal northern California. In review. Auk.

Mullin, S., M.A. Colwell, S.E. McAllister, and S.J. Dinsmore. Apparent survival of adult and juvenile Snowy Plovers in coastal northern California. Journal of Wildlife Management. In revision.

Muir, J. J., and M. A. Colwell. Effects of European beachgrass on Snowy Plover nest site selection. Condor. In revision.

Nelson, Z.J., and M.A. Colwell. Social attraction in breeding Snowy Plovers. Wilson Journal of Ornithology. In revision.

Panza, C.S., C.J. Dugaw, M.A. Colwell, and E.A. Burroughs. A model to assess the use of nest exclosures for local population recovery of the Western Snowy Plover (Charadrius alexandrinus nivosus). Natural Resource Modeling. Submitted August 2009.

Wilson, C.A., and M.A. Colwell. Age-related changes in space use and movements of male Snowy Plovers tending chicks. Waterbirds. In revision.

Colwell, M.A., N.S. Burrell, M.A. Hardy, K. Kayano, J.J. Muir, W.J. Pearson, S.A. Peterson, and K.A. Sesser. Arrival dates, clutch initiation dates, and reproductive success of Snowy Plovers breeding on riverine gravel bars and ocean-fronting beaches. In prep.

Presentations

Peterson, S.A. Cumulative reproductive success of male Snowy Plovers breeding in two habitats of different quality. Eco Series seminar. December 2008, HSU.

Colwell, M.A. Annual summary for Recovery Unit 2. Western Snowy Plover recovery meeting. January 2009. Sacramento, CA.

Muir, J.J. Use of video cameras to monitor plover nests. Western Snowy Plover recovery meeting. January 2009. Sacramento, CA.

Peterson, S.A., and M. A. Colwell. Cumulative reproductive success of male Snowy Plovers breeding in two habitats of different quality. Annual meeting of the Western Section of The Wildlife Society. January 2009, Sacramento, CA.

Brindock, K.M., and M. A. Colwell. Habitat selection by nonbreeding Snowy Plovers in coastal northern California. Annual meeting of the Western Section of The Wildlife Society. January 2009, Sacramento, CA.

Colwell, M.A. et al. Snowy Plover population dynamics in coastal northern California. Annual meeting of the Western Section of The Wildlife Society. January 2009, Sacramento, CA.

Brindock, K.M., and M. A. Colwell. Habitat selection by nonbreeding Snowy Plovers in coastal northern California. Western Hemisphere Shorebird Research Group. March 2009, Mazatlan, MX.

Burrell, N.S., and M.A. Colwell. Occupancy, density and productivity of Snowy Plovers. Western Hemisphere Shorebird Research Group. March 2009, Mazatlan, MX.

Colwell, M.A., S. M. Mullin, S.E. McAllister, and S.J. Dinsmore. Snowy Plover population dynamics in coastal northern California. Western Hemisphere Shorebird Research Group. March 2009, Mazatlan, MX.

Brindock, K., and M. A. Colwell. Habitat selection by nonbreeding Snowy Plovers in coastal northern California. Spring conference of the North Coast Chapter of The Wildlife Society. April 2009, Arcata, CA

Peterson, S.A., and M.A. Colwell. Cumulative reproductive success of male Snowy Plovers breeding in two habitats of different quality. Spring conference of the North Coast Chapter of The Wildlife Society. April 2009, Arcata, CA

Hardy, M.A. Effects of nest density on Western Snowy Plover Nest Survival. Spring conference of the North Coast Chapter of The Wildlife Society. April 2009, Arcata, CA

Brindock, K. Habitat selection by nonbreeding Snowy Plovers in coastal northern California. Thesis defense. July 2009. Humboldt State University, Arcata, CA.

Kayano, K. A comparison of female Snowy Plover reproductive effort in two habitats. NSF/REU seminar. July 2009. Humboldt State University, Arcata, CA.

Kayano, K., and M.A. Colwell. A comparison of female Snowy Plover reproductive effort in two habitats. September 2009. National meeting of SACNAS, Dallas, TX.

Graduate Thesis

Brindock, K.M. 2009. Habitat selection by wintering Snowy Plovers in coastal northern California. M.Sc. thesis, Humboldt State University, Arcata, CA.

Undergraduate Honor's Theses

Peterson, S.A. 2009. Cumulative reproductive success of male Snowy Plovers breeding in two habitats of different quality. Wildlife Department, Humboldt State University, Arcata, CA.

Thiem, R.R. In progress. Determining how Common Ravens find Snowy Plover nests using video cameras. Wildlife Department, Humboldt State University, Arcata, CA.

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