Population monitoring of Ashy Storm-Petrels and Cassin's Auklets at Santa Cruz Island, California, in 2006

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EXECUTIVE SUMMARY

In 2006, baseline population monitoring for Ashy Storm-Petrel (*Oceanodroma homochroa*) and Cassin's Auklet (*Ptychoramphus aleuticus*) was conducted at Santa Cruz Island, California, with support from the Montrose Trustee Council (U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, National Park Service, California Department of Parks and Recreation, California State Lands Commission, and California Department of Fish and Game). Additional support was provided by U.S. Geological Survey, Channel Islands National Park, and Channel Islands National Marine Sanctuary. Information from 2006 monitoring will be used by the Montrose Trustee Council and Channel Islands National Park to: a) refine and implement habitat restoration plans for Ashy Storm-Petrels and Cassin's Auklets at Orizaba Rock, Scorpion Rocks, and possibly other areas in 2007-08; and b) develop and implement long-term monitoring programs for these species at Santa Cruz Island for measuring population changes in response to restoration actions and other natural and anthropogenic factors.

In Chapter 1, Carter Biological Consulting and U.S. Fish and Wildlife Service (Ventura Fish and Wildlife Office) describe monitoring of population size, reproductive success, breeding phenology, and predation of Ashy Storm-Petrels at 5 locations at Santa Cruz Island between June and October 2006. A total of 102 nests were monitored at all 5 locations. At Orizaba Rock, 18 nests (14 active) were found, more than twice as many as in 2005 (n = 7). From 1995 to 2006, nest numbers at Orizaba Rock have declined significantly by 10.5% per annum. Most decline occurred between 1995 and 2004 when mid-summer nest numbers dropped from 18 nests to 3 nests. Decline may have resulted from high avian predation, possibly related to bright lights from squid-fishing boats. At Bat Cave, 19 nests (all active) were found in 2006, similar to numbers found in 2005 after skunk predation severely reduced this colony. Compared to July 2000–03, 37–40% of the colony remained in 2006. Compared to the peak total of 109 nests in 1996, only 19 nests (17%) were present in 2006. Numbers of nests at Cavern Point Cove Caves, Cave of the Birds' Eggs, and Dry Sandy Beach Cave have not changed significantly from 1995 to 2006 and serve as controls for measuring restoration benefits at other locations. Reproductive success of 61 active nests at 4 locations in 2006 (i.e., 84% of active sites hatched eggs, 80% of hatched chicks survived to fledging, and 67% of active sites fledged chicks) appeared to be similar to or greater than 1995-98. Analyses of breeding phenology and predation levels have not yet been conducted but typical timing of breeding and possibly lower predation were evident in 2006. Long-term monitoring should include intensive work in 2007–10 and examination of pollutant levels, with much reduced work to examine population trends after 2010. Key restoration concepts include: (a) artificial nest sites at Orizaba Rock, Scorpion Rocks, Bat Cave, and Cavern Point Cove Caves; (b) skunk trapping program for Bat Cave and possibly other locations; and (c) special protection within Channel Islands National Park for Ashy Storm-Petrel nesting colonies at Santa Cruz Island.

In Chapter 2, the U.S. Geological Survey (Western Ecological Research Center) describes monitoring of population size, reproductive success, breeding phenology, and predation of Cassin's Auklets, Ashy Storm-Petrels, and Western Gulls (*Larus occidentalis*) at Scorpion Rock, Santa Cruz Island, between March and July 2006. For Ashy Storm-Petrels, the third consecutive year catch-per-unit-effort (CPUE) and mark-recapture banding (using mistnetting) was conducted. Prince Island also was visited once in late March to assess auklet attendance and artificial nesting habitat. Among the 35 artificial auklet burrows on Scorpion Rock only 6% (2 of 33) showed signs of occupancy and no nesting attempts were recorded in 2006. In contrast, 60% (39 of 65) of overall available auklet nest sites (combination of artificial burrows, nest boxes, and natural sites) on Prince Island appeared occupied in late March. While egg laying could not be directly verified on Prince Island in 2006, observations in March 2007 indicated substantial egg abandonment and no apparent hatching in 2006. Introduced, invasive crystalline iceplant *Mesembryanthemum sp.* covered most available nesting habitat for auklets on Scorpion Rock, preventing auklets from accessing soil for digging natural burrows and blocking entrances to some artificial nest sites. Eight nights of mist-net captures were conducted for measuring and banding Ashy Storm-Petrels; 166 storm-petrels were captured, 5 of which were previously banded (3%). Standardized Catch Per Unit Effort (CPUE) per night and adult mass did not differ among years (2004, 2005, and 2006). Proportion of individuals captured with no evidence of a defeathered brood patch (*i.e*., likely nonbreeders) was relatively consistent among years (40% in 2004, 45% in 2005, and 47% in 2006). In contrast, the proportion of birds captured with fully developed brood patches (*i.e*., post-egglaying adults or likely breeders) was more variable among years (31% in 2004, 17% in 2005, and 21% in 2006). Long-term monitoring should include intensive work in 2007–10. Key restoration concepts include: (a) replacing and adding artificial auklet burrows and installing artificial petrel sites on Scorpion Rock; (b) quantification of vegetation and soil parameters that affect auklet nesting habitat on Scorpion; (c) exotic plant control and restoration of certain native plants that will improve nesting habitat for auklets and potentially Xantus's Murrelet (*Synthliboramphus hypoleucus*); and (d) development of outreach and education to inform park and sanctuary visitors of the importance of preserving and enhancing seabird habitat on Scorpion Rock and other locations at Santa Cruz Island. Comprehensive monitoring of reproductive success, adult survival, and diet of Cassin's Auklets and CPUE and mark-recapture banding for Ashy Storm-Petrels should be continued at Prince Island in order to provide a reference comparison to evaluate restoration success for Cassin's Auklets and Ashy Storm-Petrels at Scorpion Rock, Orizaba Rock, and other locations at Santa Cruz Island.

Chapter 1

Monitoring of Ashy Storm-Petrels at Orizaba Rock, Bat Cave, Cavern Point Cove Caves, Cave of the Birds' Eggs, and Dry Sandy Beach Cave

Harry R. Carter and William R. McIver

INTRODUCTION

Endemic to California and northwestern Baja California, Mexico, Ashy Storm-Petrels (*Oceanodroma homochroa*) have a small global population size (*ca*. 10,000 birds) and breed from Mendocino County (*ca*. 39° N) to Todos Santos Islands (*ca*. 32° N) (Ainley 1995; Carter *et al.*, *in press*). Largest known colonies occur at the South Farallon Islands in central California, and at Santa Barbara, Prince, and Santa Cruz Islands in southern California (Ainley *et al.* 1990; Carter *et al*. 1992, *unpubl. data*; Sydeman *et al.* 1998, McIver 2002).

Knowledge of population size, breeding biology, and conservation issues of Ashy Storm-Petrels at Santa Cruz Island have increased dramatically since 1991. Nesting at Santa Cruz Island was first documented at Painted Cave in 1912 (Wright & Synder 1913). Subsequently, nesting was discovered at Scorpion Rocks in 1928 and at Orizaba Rock in 1937 (Western Foundation of Vertebrate Zoology egg records). In 1975-77, the University of California Irvine discovered nesting on Diablo Rocks and Gull Rock (Hunt *et al*. 1979). In 1991-96, Humboldt State University discovered nesting at Bat Cave, Cave of the Birds' Eggs, Cavern Point Cove Caves, Del Mar Rock, Dry Sandy Beach Cave, Shipwreck Cave, and Willows Anchorage Rocks (Carter *et al.* 1992, *unpubl. data*). In 1995-2002, Humboldt State University also implemented standardized monitoring of population size (using nest counts), reproductive success, breeding phenology, and predation at Orizaba Rock, Bat Cave, Cavern Point Cove Caves, Cave of the Birds' Eggs, and Dry Sandy Beach Cave (McIver & Carter 1996; McIver 2002). In 1992 and 1996-97, U.S. Fish and Wildlife Service (Sacramento Fish and Wildlife Office) collected Ashy Storm-Petrel eggs at Santa Cruz Island for examining levels of eggshell thinning and organochlorine pollutants (Fry 1994; Kiff 1994; D. Welsh, *unpubl. data*). In 2003-05, U.S. Fish and Wildlife Service (Ventura Fish and Wildlife Office) and Carter Biological Consulting continued nest surveys and monitoring at 5 locations (McIver & Carter 2006; *unpubl. data*). In 2004-05, U.S. Geological Survey conducted standardized mist-net captures at Scorpion Rocks, Santa Barbara Island and Prince Island to assess population parameters and completed a radio-telemetry project to describe at-sea foraging distribution (J. Adams & J.Y. Takekawa, *unpubl. data*; see Chapter 2).

In 2005, the Montrose Trustee Council completed development of seabird restoration concepts related to funds obtained through litigation over long-term effects from organochlorine pollutants in the Southern California Bight (MSRP 2005). The need for restoration for Ashy Storm-Petrels at Orizaba Rock, Scorpion Rocks, and possibly other locations at Santa Cruz Island was identified. Evidence of impacts to Ashy Storm-Petrels from eggshell thinning and organochlorine pollutants have been found at Santa Cruz Island (Fry 1994, Kiff 1994; D. Welsh, *unpubl. data*) and evidence of reduced numbers of nest sites at accessible nesting areas at Santa Cruz Island was available. In 1991-96, no Ashy Storm-Petrel nests were found at Painted Cave, Scorpion Rocks, and Gull Island where past breeding had been documented (Carter *et al.* 1992, *unpubl. data*). Numbers of nests at Orizaba Rock had declined since 1995, possibly due to lights from squid-fishing boats resulting in high avian predation (Carter *et al.*, *in press*). Predation by island spotted skunks (*Spilogale gracilis amphiala*) in 2005 also resulted in decimation of the Bat Cave colony, the largest known colony at Santa Cruz Island (McIver & Carter 2006).

In 2006, Carter Biological Consulting and U.S. Fish and Wildlife Service (Ventura Fish and Wildlife Office) were contracted with funds from the Montrose Trustee Council to continue nest surveys and monitoring for Ashy Storm-Petrels at 5 locations at Santa Cruz Island to provide continued baseline data on population size, reproductive success, breeding phenology, and predation. This baseline information will assist design of restoration actions and long-term monitoring will allow measurement of population changes in response to restoration actions and other natural and anthropogenic factors. Monitoring at Santa Cruz Island also provides key information on the status of this rare species which has declined at Santa Cruz Island, has declined at the South Farallon Islands, but has increased at the Coronado Islands (Sydeman *et al.* 1998b, Carter *et al.* 2006). To date, long-term monitoring has been focused at the South Farallon Islands (Ainley *et al.* 1990; Ainley 1995; Sydeman *et al.* 1998a,b). However, breeding and feeding conditions in the Channel Islands and Southern California Bight are very different than at the South Farallon Islands in central California. A long-term monitoring program in the Channel Islands is desirable, where at least half of the world population breeds (Carter *et al.* 1992, *in press*). Work conducted on Ashy Storm-Petrels at Santa Cruz Island since 1991 has set the stage for a long-term restoration and monitoring program in the Channel Islands.

METHODS

In 2006, we used standardized methods (McIver & Carter 1996, 2006; McIver 2002) to search for and monitor all nests of Ashy Storm-Petrels in accessible habitats at Bat Cave, Cave of the Bird's Eggs, Cavern Point Cove Caves, Dry Sandy Beach Cave, and Orizaba Rock. We visited 4 locations (all except Dry Sandy Beach Cave) on 14-16 June, 28-29 July, 19-20 September, and 20-21 October (Table 1-1). Bat Cave also was visited on 25 and 29 March for skunk trapping purposes. Dry Sandy Beach Cave was visited only on 28-29 July. Trips in March and June were conducted from the R/V *Shearwater*, operated by the Channel Islands National Marine Sanctuary. Trips in July, September, and October were conducted from the charter boat *Miss Devin*, operated by Santa Barbara Ocean Charters.

We defined a storm-petrel nest site as a crevice, cavity, or depression containing an adult storm-petrel(s), chick, egg, or numerous eggshell fragments (that together constituted at least one quarter of an egg). We searched for and examined nests with the aid of headlamps, small flashlights, and maps adapted from Bunnell (1988). Each nest was mapped and marked with an individually numbered aluminum tag. We monitored all marked nests on subsequent visits, except when tags could not be relocated. All potential nesting habitat was searched in caves and on the offshore rock until October, after which only marked nests were examined.

Observed numbers of birds, eggs and chicks were recorded for each nest site. Because storm-petrels are sensitive to disturbance at nest sites (Ainley *et al.* 1990), we did not handle adults, incubated eggs, or brooded chicks. We estimated ages of chicks based on their plumage development (McIver & Carter 1996; McIver 2002). Evidence of predation was recorded and broken eggs, carcasses, and feather piles were removed to prevent double-counting. Active nests were defined as having evidence of an egg laid in 2006 (i.e., at least one quarter of a fresh eggshell). At some nests, no direct evidence of egg laying was found, although eggs may have disappeared before potential detection.

Numbers of nests found during the July check were used as an index of population size. Most egg laying is completed by July in most years (McIver 2002). However, we verified this assumption in 2006 by comparing July counts with total counts over the season. By examining nest stages of July nests and determining numbers of eggs laid after July, we evaluated the use of total July nests as an indicator of the total number of nest sites at each location in 2006. To determine trends in numbers of nests at each location, we compared 2006 with 1995-2005 July nest totals, using linear regression analysis and direct comparisons.

Hatching success was defined as the percentage of eggs hatched per eggs laid for all sites where egg fate was known. Fledging success was defined as the percentage of chicks fledged per chicks hatched for all sites where chick fate was determined. Reproductive success was defined as the percentage of active nest sites which fledged a chick. For preliminary analyses in this report, we considered chicks to have fledged if they were greater than 30 days of age when last seen in the nest. In future analyses, fledging and reproductive success will be better confirmed using breeding phenology data. If a replacement egg was laid at a nest site after the first egg had failed, we calculated reproductive success for these sites based on the replacement egg only.

Although we gathered data for determining breeding phenology and predation levels in 2006, insufficient funds were available to analyze these data for this report. Such analyses will be conducted in future reports.

RESULTS

Orizaba Rock

Eighteen nests were documented in June-October 2006, although only 14 nests were considered active; 10 nests (53%) nests were noted in July. We also found: a) 1 nest and 1 scrape of Black Oystercatchers (*Haematopus bachmani*); and b) 2 nests of Western Gulls (*Larus occidentalis*). No Cassin's Auklets (*Ptychoramphus aleuticus*) nests were found. On 28 July, we observed several large guano droppings, possibly Barn Owl (*Tyto alba*), on the west side of the rock near a cavern entrance. On 20 September, 2 Common Ravens (*Corvus corax*) were seen roosting on the top of the rock.

Numbers of July nests in 2006 increased from numbers in 2002-05 and were similar to the 1997-2001 period (Figure 1-1). However, 2006 numbers were still relatively low compared to the 1995-96 period. The log-transformed regression from 1995 through 2006 was significant ($r^2 = 0.49$, $p = 0.02$), declining at -1.11 nests per year (95% CI -0.99 to -1.22) or about -10.5% per annum. Fairly constant decline was noted from 1995 to 2004 but 2005-06 may signal partial recovery from this earlier decline. Between 1995 and 2004, numbers of July nests fell from 18 to 3 (17%). However, the total number of nests in 2006 (18) was similar to 1995-97 totals (range = 14-29).

At 14 active nests, 12 (86%) hatched eggs and 9 (64%) fledged chicks (Table 1-2).

Bat Cave

In 2005, at least two island spotted skunks were detected in this cave and one was removed with a trap (McIver & Carter 2006). On 25 March 2006, we visited Bat Cave prior to egg laying to trap any skunks that may have accessed the cave over the winter. Trained trappers Mitch Dennis and Kara Randall from Channel Islands National Park (CINP) placed two live traps in the main room and one in the slope room. HRC guided them to areas without storm-petrel nest sites to prevent damage to nesting habitats during trapping work. Traps were baited with opened cans of cat food and paper was placed in traps to help skunks stay warm in the trap until later removal. No skunk smell and no dead storm-petrels were noted. On 29 March, CINP staff (Dan Richards) returned to Bat Cave and found no skunk smell and no skunks in traps. Two traps in the main room were removed. The trap in the slope room was removed in June during nest monitoring.

Nineteen nests (all active) were documented in June-October 2006 and 18 (95%) were noted in July 2006. No evidence of avian, deer mouse (*Peromyscus maniculatus*), or skunk predation was found. One Xantus's Murrelet (*Synthliboramphus hypoleucus*) egg was found on 28 July in the upper slope area of the main room and had apparently rolled out of an unspecified nest site. Human visitation was indicated by 2 metal tops from pudding containers found on 28 July, one inside a passageway in the slope room and the other outside the entrance to the pool room. On 16 October, we observed 12 bats in the pool room. These bats had very long ears and may have been Townsend's big-eared bats (*Plecotus townsendii*) but we could not confirm this species identification.

Numbers of July nests in 2006 were slightly higher than 14 nests recorded in July 2005. However, earlier egglaying in 2005 was obscured by heavy skunk predation (prior to trapping removal of one skunk in June) and all July nests failed due to later skunk predation (McIver & Carter 2006). With at least 70 dead adult storm-petrels found in 2005, we were concerned that this colony might have been lost. This colony had contained the largest number of Ashy Storm-Petrel nests ever found and monitored (highest total of 109 nests in 1996), more than all other areas at Santa Cruz Island combined and more than any year at Southeast Farallon Island (Ainley *et al.* 1990, McIver 2002). While we are relieved that colony loss did not occur, only 37-40% (compared to 2000, 2001, and 2003 July totals) survived. Compared to the peak July 1996 count of 64 nests, only 30% (n = 18) were present in 2006. Compared to the peak total count of 109 nests in 1996, only 17% (n = 19) were present in 2006. Prior to skunk predation, this colony had relatively stable numbers. The log-transformed regression from 1995 through 2003 was not significant. July data from 2004 were excluded due to possible late egglaying (see below) and 2005-06 July data were excluded due to impacts from skunk predation. Data in 2006 serve as valuable baseline data for measuring future changes at this colony.

At 19 active nests, 17 (90%) hatched eggs and 13 (68%) fledged chicks (Table 1-2).

Cavern Point Cove Caves

Twelve nests were documented in June-October 2006 (6 nests in Cavern Point Cave #4 and 6 nests in Cavern Point Cove Cave #5), although only eight nests were considered active; on the July trip, 5 nests (42%) were detected. No evidence of predation by deer mice on storm-petrel eggs was noted. No petrel feather piles were noted. No Xantus's Murrelet nests were found. On 16 October, 2 unidentified bats were heard grunting in the dark in Cavern Point Cave #4.

Similar numbers of nests (n = 13) were found in 2005 and 1995-97 (range = 13-19). The log-transformed regression over the 1995-2003 period was not significant.

At eight active nests, all hatched eggs and all fledged chicks (Table 1-2).

Cave of the Birds' Eggs

Twenty-four nests were documented in June-October 2006, although only 20 nests were considered active; 12 (50%) were detected in July. A total of 7 Pigeon Guillemot (*Cepphus columba*) nests were found. We also found 1 petrel feather pile on 14 June, 1 guillemot feather pile on 29 July, and 1 petrel feather pile on 20 September. In the past, we have assumed that guillemot predation resulted from Peregrine Falcons (*Falco peregrinus*) because sternums and other bones often were picked clean without bite marks. On 29 July, guano (possibly owl) was noted on rocks at the front of the cave and many unattended guillemot eggs may have reflected presence of predators. On 20

September, 1 dead regurgitated petrel chick was found in the front area of the cave, apparently deposited by an avian predator.

Similar numbers of nests (n = 20) were found in 2005; 2005-06 totals were somewhat higher than in 1995-97 (range = 11-13). The log-transformed regression over the 1995-2003 period was not significant.

At 20 active nests, 14 (70%) hatched eggs and 11 (55%) fledged chicks (Table 1-2).

Dry Sandy Beach Cave

We did not monitor this colony on each trip in 2006 but 29 active nests were documented on 29 July, similar to other July surveys between 1995 and 2005. The log-transformed regression over the 1995-2003 period was not significant. No petrel feather piles or evidence of predation of deer mice on eggs were noted. However, 1 feather pile from a dead Western Gull and 1 Pigeon Guillemot nest were found. Reproductive success was not determined at this location in 2006.

DISCUSSION

Monitoring reproductive success and breeding phenology

Reproductive success is a key demographic variable needed for assessing population growth conditions and modeling population changes over time, although variation between years clearly needs to be measured and reasons for variation assessed (Ainley *et al.* 1990, Sydeman *et al.* 1998b, McIver 2002). Breeding phenology also is important for assessing natural factors affecting prey availability and adequacy of survey techniques. We found that a minimum of 4 trips between June and November were adequate for monitoring reproductive success of Ashy Storm-Petrels at Santa Cruz Island in 2006, although we recommend 5 trips per year for future monitoring. Reproductive success at 4 monitored locations in 2006 (i.e., 84% of active sites hatched eggs, 80% of hatched chicks survived to fledging, and 67% of active sites fledged chicks; see Table 1-2) appeared to be similar to or greater than 1995-98 (McIver 2002). Breeding phenology at 4 locations in 2006 also was protracted, similar to other years monitored in 1995-2005 (McIver 2002; Figure 1-3). Most eggs were laid in June, most hatching occurred in late July and early August, and most fledging occurred in mid October.

In 1995-97, we conducted 8-10 trips per year between April and November to monitor reproductive success of Ashy Storm-Petrels at 5 locations at Santa Cruz Island (McIver 2002). In 1998, we monitored only 2 locations on 6 trips between July and November to document the effects of severe 1998 El Niño conditions (McIver 2002). In past work, reproductive success was moderate with relatively high hatching failure, compared with published values from the South Farallon Islands from 1971 to 1995 (Ainley *et al.* 1990; Sydeman *et al.* 1998b). Timing of breeding in 1995-98 also did not vary to a great degree between years, including the severe 1998 El Niño (McIver 2002). With additional data in

2007 and further analysis of 2005-07 data, we will compare reproductive success and breeding phenology in 2005-07 versus 1995-98 in future reports.

Reproductive success was not monitored in 1999-2004 but July surveys were conducted at all 5 locations, except 1999 (Dry Sandy Beach Cave and Cave of the Birds' Eggs only), 2003 (Bat Cave only), and 2004 (Bat Cave, Cavern Point Cove Caves, Cave of the Birds' Eggs, and Orizaba Rock only). Status of nests during July surveys were similar in most years (Figure 1-3), indicating similar timing of breeding between most years. One major exception was Bat Cave in 2004 when only 21 nests were found on the July survey, apparently indicating delayed or reduced egg laying. In July in most years, most nests held small chicks or eggs, with a few nest failures and no large chicks near fledging.

In 2005, we conducted 6 trips to 4 locations between June and November, plus one skunk trapping trip in June and one trip to Dry Sandy Beach Cave in July (McIver and Carter 2006). In 2006, we conducted 4 trips to 4 locations between June and October, plus skunk trapping trips in March and one trip to Dry Sandy Beach Cave in July (Table 1-1). The planned November 2006 trip was cancelled because of few remaining nests and insufficient funds related to unbudgeted costs from using a charter boat for July, September and October trips.

Monitoring trends in population size

Standardized counts of nests (or birds attending nests) in sample plots or for entire breeding colonies are primary data used to measure trends in seabird breeding population size over time. For Ashy Storm-Petrels, reliable nest counts with adequate sample sizes have not been possible at most colonies (except Santa Cruz Island and Middle Coronado Rock) and mist-net captures have been used instead to monitor trends. Despite analysis difficulties using capture per unit effort and mark-recapture techniques (Ainley *et al.* 1974, Carter *et al.* 1992, Sydeman *et al.* 1998a), successful implementation of these techniques in the Channel Islands allows for direct comparison with similar data collected at the South Farallon Islands off central California. At Santa Cruz Island, sufficient numbers of nests fortunately were found at several locations in 1991-94 for development of nest monitoring in 1995 that allowed measurement of trends in nest numbers. July nest counts are most cost-effective for long-term monitoring of numbers of nests of Ashy Storm-Petrels at 5 locations at Santa Cruz Island. By July, more than half of eggs usually have been laid and can be counted using standardized techniques at 5 locations. In 1995-97, July counts represented 57-67% of all nests at Bat Cave and 55-82% of all nests at Orizaba Rock in each year (W.R. McIver & H.R. Carter, unpubl. data). In 2006, July counts represented 95%, 53%, 50% and 42% of all nests at Bat Cave, Orizaba Rock, Cave of the Birds' Eggs, and Cavern Point Cove Caves, respectively. July counts serve as an index of total nest numbers over the entire breeding season. This index can be obtained with relatively low effort for long-term monitoring of population size but does contain an unmeasured degree of variation due to protracted breeding in each year with limited variation in timing of breeding between years. While August surveys are a future option and would occur when a greater proportion of eggs have been laid and before any fledging, egg disappearances after nest failure also cause lack of detection of some nests at this time. Such variation in this July index will lead to the inability to statistically detect small-scale trends. However, major changes in numbers of nests can be detected. Work over the next few years should focus on refining analysis techniques for measuring trends and assessing the degree of change that can be detected using power analyses.

Numbers of July nests declined at Orizaba Rock between 1995 and 2006. Numbers of July nests also have declined to a great degree at Bat Cave after 2003, especially after skunk predation events in 2005. At Cavern Point Cove Caves, Cave of the Birds' Eggs and Dry Sandy Beach Caves, numbers of July nests did not decline significantly between 1995 and 2006. Monitoring of several locations is valuable for identifying factors affecting specific sites. Decline in numbers at Orizaba Rock appears to reflect greater relative levels of predation by avian predators, possibly related to colony illumination from lights (Carter *et al., in press*). Progressively greater numbers of nests at Orizaba Rock from 2004 to 2006 may indicate some colony recovery, possibly related to lower levels of illumination or predators in recent years. Relatively low levels of predation (i.e., few carcasses or feather piles) also appeared to occur in 2006 but lesser numbers of breeding birds also occurred at Bat Cave and Orizaba Rock and more work is needed to summarize and assess past predation data for comparison to 2006 data. Lack of increase of nest numbers or possible slow decline at Cavern Point Cove Caves, Cave of the Birds' Eggs and Dry Sandy Beach Cave may partly reflect moderate breeding success, likely related to substantial avian predation levels and low hatching success related to pollutants (McIver 2002; W.R. McIver & H.R. Carter, *unpubl. data*; D. Welsh, *unpubl. data*).

In 1991-96, numbers of nests and breeding adults found at these 5 monitored locations accounted for more than three-quarters of Ashy Storm-Petrel nests found at Santa Cruz Island (Carter *et al.* 1992, *unpubl. data*). We believe that trends found in these 5 locations are reasonably indicative of trends for all Ashy Storm-Petrels breeding at Santa Cruz Island. Although some storm-petrels likely breed in inaccessible cliffs that were not surveyed, we believe that nesting conditions for Ashy Storm-Petrels nesting in sea caves are comparable to those nesting in adjacent cliff habitats. Foraging areas used by storm-petrels from different breeding locations on Santa Cruz Island are likely similar, given most foraging in offshore waters occurs far from colonies (Mason *et al.* 2004; J. Adams & J.Y. Takekawa, *unpubl. data*). Skunk predation in Bat Cave in 2005 appears to be an anomaly which occurs very infrequently; similar anomalies also may occur on occasion in some cliff nesting areas. Otherwise, relatively low levels of avian and mammalian predation probably occur at colonies, in the absence of human impacts. However, this unusual natural event in Bat Cave has provided an excellent opportunity to assist and examine recovery of this colony over time. Ashy Storm-Petrels breeding on offshore rocks at Santa Cruz Island (*i.e.*, Orizaba Rock, Scorpion Rocks, Willows Anchorage Rocks, Diablo Rocks, Del Mar Rock, and Gull Island) likely have greater exposure to avian predators, especially when Western Gulls nest on the same rock. A portion of nesting habitats in sea caves (*i.e.*, open surfaces, driftwood, and loose boulders) are more fragile and can be easily damaged by human trampling; nesting habitats on offshore rocks tend to be more stable and much less easily trampled. Sea caves are tourist attractions for kayakers and other boaters at Santa Cruz Island (Bunnell 1988) and sea cave entrances with beaches (*i.e.*, Bat Cave, Cavern Point Cove Caves) are more easily accessible by sea kayak for landings than offshore rocks. In addition, birds nest in more shallow crevices and other habitats in sea caves, making them more prone to human disturbance. Thus, sea caves are more susceptible to certain human impacts but, to date, human impacts appear to be relatively low at sea caves. Light pollution may affect sea caves, offshore rocks, and cliffs in differing ways but more work is needed to examine this issue. Decline at Orizaba Rock and loss of nesting on the main rock of Scorpion Rocks and Gull Island may suggest that light pollution has greater impact on offshore rocks than in sea caves. Variation in trends in numbers of nests, reproductive success, breeding phenology, and predation is expected between breeding locations. Our monitoring of Ashy Storm-Petrels at Santa Cruz Island has several abilities: (a) to measure trends that are generally representative all nesting areas on Santa Cruz Island; (b) to identify different factors responsible for variation between locations; and (c) to provide reference sites or controls for measuring restoration benefits at certain locations.

We have not focused on monitoring trends in reproductive success of Ashy Storm-Petrels because we do not expect to find significant trends in this parameter and monitoring reproductive success requires more time and cost than a once a year nest count. In 1995-98, little difference in reproductive success or breeding phenology occurred between years, including the severe El Niño year of 1998 (McIver 2002). Similarily, Ashy Storm-Petrels at the South Farallon Islands in 1971-83 did not show significant differences in reproductive success, breeding phenology, or mean fledging weight between years, including the severe El Niño of 1983 (Ainley *et al.* 1990). However, reproductive success may gradually improve over time as levels of organochlorine pollution continue to slowly decline in the Southern California Bight and older adults with higher contamination levels die out of the population. Climate change also may result in either improved or reduced prey resources for storm-petrels in the Southern California Bight over time, leading to long-term population changes. At a minimum, periodic assessments of reproductive success are needed to assess possible changes in this important parameter.

Long-term monitoring concepts

Pre-restoration baseline data for July nest counts of Ashy Storm-Petrels at Santa Cruz Island has been gathered almost annually at all 5 locations from 1995 to 2006. However, total annual nest numbers, reproductive success, and breeding phenology have been gathered only in 1995-98 and 2005-06. Implementation of most or all restoration actions is anticipated in 2008. Annual monitoring of nest counts (total and July), reproductive success, breeding phenology, and predation should be conducted in 2007 to complete 3 years of baseline data immediately prior to restoration actions. Similar monitoring also should be conducted in 2008-10 to gather 3 years of post-restoration data for assessing immediate responses to restoration actions and to check and modify restoration actions as needed. A sample of eggs also should be collected between 2007 and 2010 to examine eggshell thinning and pollutant levels for comparison to samples collected in 1992-97. In 2011, annual monitoring could be reduced to July surveys only for cost-effective long-term assessment of population trends and to continue to check on restoration actions with reduced effort.

Restoration concepts

A detailed plan for seabird restoration at Santa Cruz Island will be developed by the Channel Islands National Park and the Montrose Trustee Council in 2007. Carter *et al.* (*in press*) identified several restoration actions for Ashy Storm-Petrels. At least 5 actions could be implemented at Santa Cruz Island:

(1) *Design and install artificial nest structures at Orizaba Rock, Scorpion Rocks, Bat Cave, and Cavern Point Cove Caves.* At Orizaba Rock, artificial nests could reduce avian predation of storm-petrels at exposed nest site locations where nests and visiting adults are most susceptible to potential predation and colony illumination. Declining nest numbers at Orizaba Rock also prompt urgent action, although 2006 nest numbers showed some increase. This rock is located beside a heavily used anchorage, is easily accessible with a small boat, and is potentially susceptible to human disturbance (although nesting areas are partly protected within a rock labyrinth formed by a pile of eroding boulders. While many visitors will avoid this labyrinth, certain visitors may be attracted to explore them. The rock is also located on the western end of the north side of Santa Cruz Island, near squid fishing areas off the west end of the island. At Bat Cave and Cavern Point Cave Caves, artificial nests could reduce or prevent effects from habitat destruction and human disturbance from uninformed people landing by boat and from trained seabird biologists during monitoring work. At Scorpion Rocks, Ashy Storm-Petrels nests have not been found on the main rock since 1976-77, but storm-petrels continue to visit the main rock and can be captured in mist nets (Hunt *et al.* 1979; Carter *et al.* 1992, *unpubl. data*; see Chapter 2). Reasons for a lack of current nesting are not clear. We presume that birds visiting the main rock still breed on the more inaccessible smaller rock or in adjacent areas on Santa Cruz Island proper, possibly Cavern Point Cove Caves and Bat Cave. Installing artificial nest sites (possibly aided by social facilitation techniques) on the main rock may permit recolonization of the main rock, although limited natural nesting habitats and predation likely will prevent development of a large colony on the main rock. Much reduced numbers at Bat Cave also prompt urgent action to reduce any impacts which might slow or prevent colony regrowth. Both Bat Cave and Cavern Point Cove Caves occur very near the east end of Santa Cruz Island where extensive tourism, especially camping and kayaking, increases potential human visitation of storm-petrel nesting areas. At these locations, landing beaches exist, park visitors have been noted landing on occasion, and relatively large numbers of kayaks and other boats occur in the vicinity;

(2) *Establish a skunk trapping program for Bat Cave and possibly other locations*: This program would ensure that no skunks are present at the start of each breeding season. Alternatively, a program could respond mid-season to remove skunks, if skunks are detected during monitoring;

(3) *Establish special protection within Channel Islands National Park for Ashy Storm-Petrel nesting colonies at Santa Cruz Island*: This protection would only allow permitted people to access nesting areas at all times of the year. Place inconspicuous signs at

nesting areas that inform trespassers that they are violating this special protected area and should leave immediately to avoid impacting petrels and potential prosecution;

(4) *Continue efforts to reduce or prevent bright lights near breeding habitats*: Reduce or prevent lights on all boats or other structures at night within 2 km of breeding locations at Santa Cruz Island, especially squid fishing boats and anchored vessels near shore; and

(5) *Educate park visitors*: Educate to prevent landings on areas of special protection in Channel Islands National Park, including Ashy Storm-Petrel nesting areas at Santa Cruz Island.

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Table 1-1. Field trips conducted in 2006 for Ashy Storm-Petrel nest monitoring at Santa Cruz Island, California.

Trip Number	Field Dates	Locations[1]	Field Staff	Support Vessel
Trip 2006-01a	25 March	BC	B. McIver H. Carter D. Richards M. Dennis K. Randall A. Little J. Boyce	*Shearwater*
Trip 2006-01b	29 March	BC	D. Richards	*Shearwater*
Trip 2005-02a	14 June	CPCC, OR, COBE, DSBC	B. McIver H. Carter D. Lipski D. Williams	*Shearwater*
Trip 2005-02b	16 June	BC	H. Carter D. Lipski	*Shearwater*
Trip 2005-03	28-29 July	CPCC, BC, OR, COBE, DSBC	B. McIver H. Carter G. McChesney D. Cooper J. Turner	*Miss Devin*
Trip 2005-04	19-20 September	CPCC, BC, OR, COBE	B. McIver H. Carter C. Hamilton J. Koepke	*Miss Devin*
Trip 2005-05	21-22 October	CPCC, BC, OR, COBE	B. McIver H. Carter C. Hamilton A. Little	*Miss Devin*

[1] Abbreviations: CPCC (Cavern Point Cove Caves); BC (Bat Cave); OR (Orizaba Rock); COBE (Cave of the Birds' Eggs); and DSBC (Dry Sandy Beach Cave).

Table 1-2. Hatching, fledging, and reproductive success of 61Ashy Storm-Petrel nests monitored at Santa Cruz Island, California, in 2006. Locations are coded: Bat Cave (BATC); Cave of the Bird's Eggs (COBE); Cavern Point Cove Caves (CPCC), and Orizaba Rock (ORIZ). Sample sizes are in parentheses.

	Location				
	BATC	COBE	CPCC	ORIZ	Total
Hatching Success	90% (19)	70% (20)	100% (8)	86% (14)	84% (61)
Fledging Success	77% (17)	79% (14)	100% (8)	75% (12)	80% (51)
Reproductive Success	68% (19)	55% (20)	100% (8)	64% (14)	67% (61)

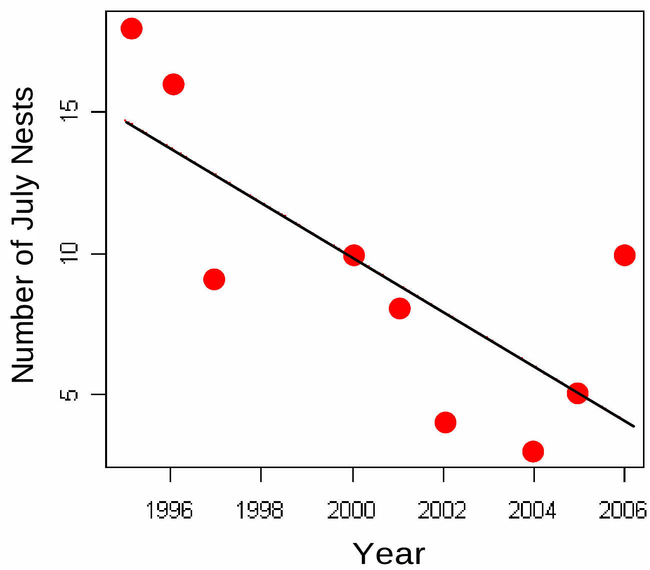

Figure 1-1. Numbers of Ashy Storm-Petrel nests in Orizaba Rock, Santa Cruz Island, counted during July surveys in 1995-2006.

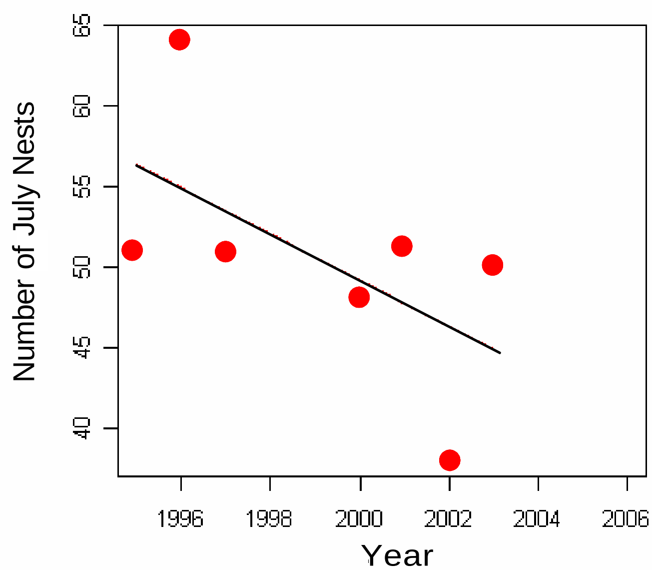

Figure 1-2. Numbers of Ashy Storm-Petrel nests in Bat Cave, Santa Cruz Island, counted during July surveys in 1995-2003. Data for 2004-06 were excluded (see text).

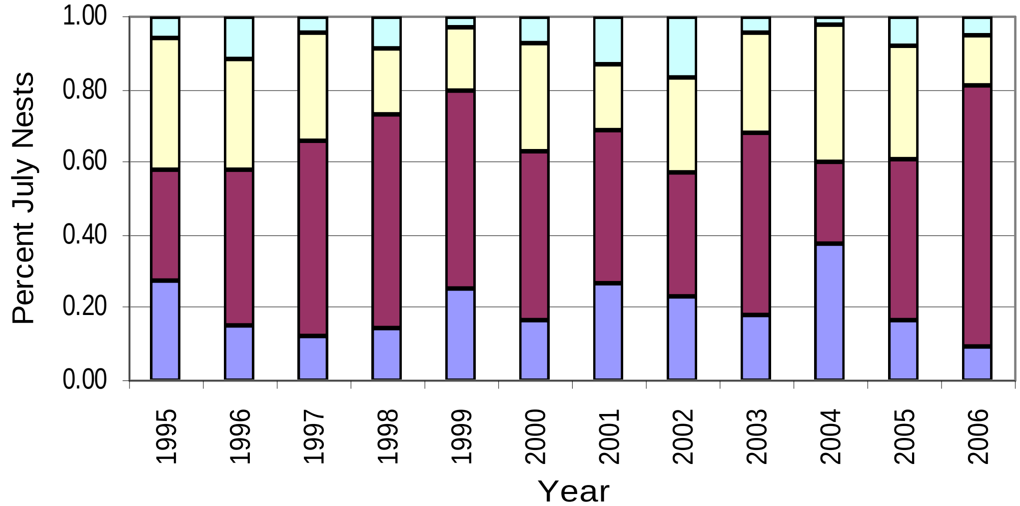

Figure 1-3. Status of Ashy Storm-Petrel nests during July surveys at Santa Cruz Island in 1995-2006. Bar colors reflect adult in nest (blue), chick in nest (purple), egg in nest (yellow), and failed nest (green). Available data for all 5 monitored locations are included (see text).

Chapter 2

Monitoring of Cassin's Auklets and Ashy Storm-Petrels at Scorpion Rock

Josh Adams and John Y. Takekawa

INTRODUCTION

Islands within Channel Islands National Park (CINP) provide essential nesting habitat for seabirds including Ashy Storm-Petrel (*Oceanodroma homochroa*), Cassin's Auklet (*Ptychoramphus a. aleuticus*), and Xantus's Murrelet (*Synthliboramphus hypoleucus*). These species also depend upon marine prey resources throughout surrounding waters of the southern California Current System (CCS) including several west coast National Marine Sanctuaries. For example, off southern California, several studies indicate that Cassin's Auklet has declined 50–60% (Carter *et al.* 1992, Hyrenbach & Veit 2003, Mason *et al*. 2004), coincident with changes in zooplankton community structure (McGowan *et al.* 1998, Peterson & Schwing 2003). With the onset of strong and prolonged La Niña ocean conditions in 1999, prey (*e.g.*, rockfish, euphausiids; Peterson & Schwing 2003) and predator populations responded rapidly to enhanced productivity in the southern CCS (Adams 2004b). In contrast, conditions during 2004 through 2006 in have been characterized by anomalously warm ocean waters, low productivity, and delayed upwelling; these conditions are thought to be partly responsible for several seabird mortality events and dramatic breeding failure in some species (*e.g.*, Cassin's Auklets from California to British Columbia). The vast majority of the statewide population in 1989-91 occurred at three colonies: South Farallon Islands (Farallon NWR, San Francisco County; 68%), Prince Island and Castle Rock (Channel Islands National Park, Santa Barbara County; 16%), and Castle Rock (Castle Rock NWR, Del Norte County; 10%; Carter *et al.* 1992; Adams, *in press*).

Scientists and resource managers lack basic information regarding important CINP seabird species, including current population sizes, diet, and quantitative information necessary to identify important oceanographic habitats. Such information, however, is required for effective monitoring and management and has been strongly recommended as an urgent priority for future research (Ainley 1995; Adams, *in press*; Carter *et al., in press*). Furthermore, Ashy Storm-Petrel, Xantus's Murrelet, and Cassin's Auklet all have been identified as preferred species for restoration to mitigate negative effects suffered from exposure to DDT/DDE in the Southern California Bight ecosystem (MSRP 2005).

In 2006, the U.S. Geological Survey (Western Ecological Research Center; USGS) continued efforts to maintain long-term studies regarding the status of Cassin's Auklet and Ashy Storm-Petrel. Efforts in 2006 were concentrated at Scorpion Rock; several planned visits to Prince Island were cancelled due to strong winds that occurred during pre-scheduled trips. In this chapter, we summarize activities and visits to Scorpion Rock

(9 days) and Prince Island (1 day only) during spring to summer 2006. Specifically, we report on: (1) condition and occupancy of artificial Cassin's Auklet burrows on Scorpion Rock and Prince Island; (2) breeding and depredation of Western Gull (*Larus occidentalis*) on Scorpion Rock; and (3) ongoing efforts to establish trends in standardized catch per unit effort (CPUE) and mark-recapture population assessment for Ashy Storm-Petrel. We also present some comparative information from previous research and monitoring efforts.

BACKGROUND

Cassin's Auklet— Cassin's Auklet ranges from Alaska to northern Baja California, Mexico. Although the species is abundant in portions of its overall range (i.e., British Columbia) it is recognized by the California Department of Fish & Game as a Bird Species of Special Concern (BSSC; Adams, *in press*). Within the CINP, the largest colonies occur on Prince Island (8922 birds in 1991) and Castle Rock (2614 birds in 1991), both off San Miguel Island (Carter *et al.* 1992). Cassin's Auklets nest on other small islands scattered throughout the northern Channel Islands (unless noted otherwise, numbers of birds from Carter *et al.* 1992, Table 35): Point Bennett (20) and Harris Point to Cuyler Harbor ("Hare Rock," 28) in San Miguel Island area; Diablo Rocks (28), Sppit or Orizaba Rock (10 estimated by Hunt *et al.* 1979 in June 1977, 0 found in May 1991 by Carter *et al.* 1992), Scorpion Rocks (546), Willows Anchorage Rocks (10), and Gull Island (132) in Santa Cruz Island area; and Santa Barbara Island (132), Shag Rock (2), and Sutil Island (122) in Santa Barbara Island area. A maximum estimate of 120 (probably fewer) birds nested on Scorpion Rocks in 2000 (J. Adams, *unpubl. data*). Cassin's Auklet has been monitored on Prince Island, off San Miguel Island, and Scorpion Rock, off Santa Cruz Island, intermittently from 1975 to 1999. In 1975–76, University of California Irvine studied population size, reproductive success, and diet at Prince Island (Hunt *et al.* 1979, 1980). Since 1985, the CINP seabird monitoring program has monitored reproductive success, breeding phenology, and adult survival at Prince Island (Lewis *et al.* 1988; Ingram 1992; Ingram & Jory-Carter 1997; CINP, *unpubl. data*). In 1991, Humboldt State University estimated population size at Prince Island and Scorpion Rocks (Carter *et al.* 1992). In 1998–99, Point Reyes Bird Observatory studied reproductive success and diet at Prince Island (W.J. Sydeman, *unpubl. data*). From 1999 to 2001, more extensive and consistent monitoring and research efforts were conducted annually by USGS and Humboldt State University. Research and monitoring during 1999–2001 were greatly enhanced through the addition of 84 new artificial burrows (Adams *et al*. 2000, Ackerman *et al*. 2004, Adams *et al*. 2004a, 2004b). Lower-level monitoring efforts by USGS also continued annually from 2002–05.

Ashy Storm-Petrel— The Ashy Storm-Petrel is a vulnerable species endemic to southern CCS and breeds on islands in California, NW Mexico, and a few adjacent mainland sites, with a global population estimated at <10,000 birds (Carter *et al.* 1992, *in press*; Ainley 1995; Brown *et al*. 2003). Research at the largest Ashy Storm-Petrel colony at the South Farallon Islands in central California indicates the species has undergone a 30-year decline (Sydeman *et al*. 1998). Currently, southern California hosts approximately 50%

of the world's breeding population (Carter *et al., in press*). The Ashy Storm-Petrel is listed by the IUCN as "near threatened" (Bird Life International 2000) and is a species of concern for the U.S. Fish and Wildlife Service and the California Department of Fish and Game (Carter *et al., in press*). Prior to 1991, work on Ashy Storm-Petrels in the Channel Islands was limited to detecting some colony locations and estimating population size (Hunt *et al.* 1979, 1980). In 1991–96, extensive surveys were conducted by Humboldt State University to detect all breeding colonies in the Channel Islands and estimate population size, including Prince Island and Scorpion Rocks (Carter *et al.* 1992, *unpubl. data*). Trends of nest numbers, reproductive success, breeding phenology, and predation were studied by Humboldt State University, U.S. Fish and Wildlife Service and Carter Biological Consulting at Santa Cruz Island from 1995 to 2006 (see Chapter 1). In 2004–05, USGS studied at-sea foraging patterns with radio-marked birds, intercolony exchange, and catch per unit effort (CPUE) trends based on mist-net captures at Scorpion Rock, Prince Island, and Santa Barbara Island (J. Adams, *unpubl. data*; see below). Most of the breeding birds in the Southern California Bight are found on islands managed by CINP. Given its extreme life history traits, poorly understood population status, and threats both at colonies and at sea, a better understanding of population size, food resources, and critical habitats at sea will be essential background for CINP management actions designed to protect or enhance their populations. Currently, information is required to maintain, enhance, and standardize monitoring to facilitate and evaluate proposed restoration efforts in the Channel Islands National Park.

METHODS

Cassin's Auklet— In addition to detailed foraging ecology studies, USGS continued CINP seabird monitoring efforts by collecting reproductive success, chick growth, and mark-recapture banding studies for chick and adult Cassin's Auklets captured at Scorpion Rock and Prince Island colonies. Generally, we visit nest sites periodically throughout each nesting season (January through July). Although frequent visits to these colonies are desirable, logistic constraints limit the number of repeat visits to colonies. Colonies are generally visited approximately monthly, but two week intervals are desirable. In 2000 and 2001, we added 48 new artificial burrows at Prince Island and 35 artificial burrows at Scorpion Rock (described in Adams *et al*. 2000). Thus, we use a combination of natural sites, artificial nest-boxes, and artificial burrows for monitoring auklet reproduction and chick growth following methods detailed in Adams *et al*. (2004b). The use and evaluation of artificial nesting habitat for auklets provides the necessary background for the evaluation, implementation, and monitoring of such structures during future Montrose restoration actions.

Ashy Storm-Petrel—From 2004 to 2006, we visited storm-petrel colony areas (Scorpion Rock, Santa Barbara Island, and Prince Island) and employed standardized capture-recapture techniques (Carter *et al.* 1992; Ainley 1995; Sydeman *et al.* 1998). Pre-established netting locations (Carter *et al.* 1992; CINP, *unpubl. data*) were visited approximately monthly during April through August 2004, 2005, and 2006 during dark nights near the new moon. We captured storm-petrels at night using broadcast recorded vocalizations (recordings from

Farallon Islands provided by D. Ainley and Point Reyes Bird Observatory). Broadcasts were continuous (Lohman Predator Master 2560 15-W CD player) and birds were captured using polyester mist-nets (12 meters wide, 2.6 meters high, 4 shelves, 75/2, 38-mm mesh). We identified captured storm-petrels to species (Ashy, Leach's, Black) and conducted standard morphometrics including, bill length, head-bill length, skull width, tarsus length, wing chord, and mass. To classify probable breeders, we determined brood-patch development; birds with downy brood patches were classified as "likely nonbreeding" and birds with completely bare or bare and vascularized brood patches (*i.e.*, post-egglaying adults) were classified as "likely breeders". All birds captured were marked with unique, stainless-steel leg-bands. To determine sex among a representative sample, we collected one drop of blood by aseptic venipuncture from the medial tarsal vein using a 26-gauge needle and FTA paper. Sex was determined by molecular techniques (C. Baduini, Keck Science Center, Claremont College, California).

In 2006, we continued to monitor Ashy Storm-Petrel mist net capture rates and continued efforts toward long-term mark/recapture analyses at Scorpion Rock. Additionally, we assessed nesting activity for Cassin's Auklet among artificial nest boxes and artificial burrows on Prince Island (only one visit in 2006) and among artificial burrows on Scorpion Rock. We also collected observations of Western Gull nesting effort and predation, noted presence and absence of Xantus's Murrelet vocalizations at night, and made general observations about the vegetation on Scorpion Rocks.

RESULTS

Cassin's Auklet and Western Gull on Scorpion Rock in 2006

25 March 2006, Scorpion Rock— We checked 35 artificial nest sites, all were empty, only 2 sites (AB26 & AB36) appeared to have been recently visited by auklets. All sites were cleared and 6 of 35 sites were reset; 2 nest chamber lids that had been lost were replaced. Site AB21 had an abandoned egg from 9 July 2005 that contained an approximately 75% developed embryo. Two nest sites (AB21 & AB28) contained fresh auklet heads that had been scavenged either by deer mice (*Peromyscus maniculatus*) or unidentified invertebrates. In addition, we found 5–6 natural burrows that bore sign of recent excavation. Vegetation observations include the following: *Mesembryanthemum sp*. was most dense near the top and throughout the middle of the island (vegetative and ~20 cm high); *Chenopodium sp*. was flowering and had developed seed heads; no extensive *Malva parviflora* growth noted, but dead stems were present; *Hordeum sp*. grass was in flower with seed heads and appeared to be spreading compared with 2005; invasive kikuyu grass (*Pennisetum clandestinum*) remained confined to the upper southwest side of the island, but appeared to be expanding; a lone *Coreopsis gigantea* (>1 yr old) was vegetative and appeared healthy. Gull carcasses: We counted and removed from Scorpion Rock a minimum of 10 scavenged Western Gull carcasses: minimum 4 adults, 4 sub-adults, and 2 juveniles. Personnel: Josh Adams, Jen Boyce, Annie Little, Jim Lovvorn, Bill McIver, and Harry Carter.

26 March 2006, Prince Island— We checked 25 nest boxes (CINP – south), 42 of 48 artificial burrows (6 sites were lost to erosion), and 6 previously marked natural burrows. Of 25 nest boxes, 9 appeared active/occupied, and 2 had nest chamber lids that were ajar (replaced). Of 42 artificial burrows, 25 appeared active/occupied, and 6 had nest chamber lids that were blown off or ajar (all replaced). Of the 6 natural burrows, 5 appeared active/occupied. Logistic constraints prevented assessment of the 24 nest boxes (CINP – north) located on the northeast side of Prince Island. Throughout the colony on the southeast side, there was much fresh digging by attending auklets, but we detected no sign that nesting had been initiated. Personnel: Josh Adams and Jim Lovvorn.

29–30 April 2006, Scorpion Rock— We relocated and checked 27 of 35 artificial burrows. Of these 27, only 1 appeared active/occupied. 8 burrows could not be located because they were completely overgrown by impenetrable *Mesembryanthemum*. Of the 27 burrows located, 3 entrances were completely blocked by *Mesembryanthemum*, and 8 contained seed cashes (primarily *Hordeum sp.* grass and *Chenopodium*) likely from mice or invertebrates. Many new *Coreopsis* sprouts were scattered about the dense *Mesembryanthemum* carpet toward the lower, western portion of the plateau. *Coreopsis* was in full bloom on Little Scorpion Rock. Gull carcasses: 2 adult and 1 juvenile. No Xantus's Murrelets seen or heard at night. Personnel: Josh Adams and Joelle Sweeney.

2–3 June 2006, Scorpion Rock— We relocated and checked 27 of 35 artificial burrows. Of these 27, none appeared active/occupied. 8 burrows could not be located because they remained completely covered by impenetrable *Mesembryanthemum*. By 3 June, Western Gull nests had just begun to hatch indicating that laying had been initiated on approximately 8 May. We counted 31 nest sites, including: 4 empty scrapes, 21 with three eggs, 5 with two eggs, and one with 1 egg. We recorded pipping and or hatching in 4 nests (2 pipped eggs, 3 new hatchlings). We counted and removed two old scavenged adult gull carcasses. We heard many Xantus's Murrelets calling throughout the night from the water near Scorpion Rocks, and observed several pairs on the water during our return to Scorpion Ranch (0330). Personnel: Josh Adams and Hannah Nevins.

28–29 June, Scorpion Rock— We relocated and checked 29 of 35 artificial burrows. Of these 29, none appeared active/occupied. 6 burrows could not be located because they remained completely covered by impenetrable *Mesembryanthemum*. One nest had its lid dislodged, and 7 nest chambers either contained grass and/or appeared occupied by mice. On 29 June we counted 36 gull chicks (including 5 dead), and 2 eggs. We found no new subadult or adult gull carcasses. No Xantus's Murrelets were heard calling on either night. Personnel: Josh Adams and Elizabeth Phillips.

26–27 July, Scorpion Rock— We relocated and checked 32 of 35 artificial burrows. Of these 32, none appeared active/occupied. 3 burrows could not be located because they remained completely covered by impenetrable *Mesembryanthemum*. One nest had its lid dislodged. On 26 June we counted 16 volant gull chicks on Scorpion Rock or rafting near the island. No Xantus's Murrelets were heard calling on either night. Personnel: Josh Adams and Joelle Sweeney.

Ashy Storm-Petrel monitoring on Scorpion Rock in 2006

Only sporadic efforts to capture Ashy Storm-Petrels in mist nets for mark-recapture analyses have been conducted in the Channel Islands, focused mainly on mistnetting for storm-petrel species presence or absence and as a means for estimating colony sizes (Hunt *et al.* 1979, Carter *et al.* 1992, *unpubl. data*; CINP, *unpubl. data*). Researchers have used varying techniques (*i.e.*, mist-netting with and without broadcast vocalizations), but covariates (*e.g.*, netting effort, net size, moon phase, wind speed, *etc*.) are not readily available for past studies, making comparisons with past monitoring difficult. In addition to continued efforts to collate historical mist-net data for comparison, we currently are evaluating the utility of consistent, standardized effort mistnetting to improve monitoring for Ashy Storm-Petrel at certain colonies in the CINP.

In 2006, we successfully completed the third year of our ongoing population studies of Ashy Storm-Petrel in the CINP. In 2004 and 2005, mistnetting efforts and radiotelemetry were supported by USGS Park Oriented Biological Support program and results currently are in review and not extensively detailed herein. Efforts supported by USGS and Montrose Trustee Council in 2006 were focused at Scorpion Rock. We conducted 8 nights capturing, measuring, and banding. We captured 166 storm-petrels; 5 of which were previously banded (3%). Standardized Catch Per Unit Effort (CPUE ± SD) per night at Scorpion Rock did not differ among years (2004, 2005, and 2006; ANOVA $F_{2,22\ (0.05)}$ = 0.921, P = 0.413) and was 0.074 ± 0.040 birds min^{-1} in 2006 (35.3 net hours), compared with 0.118 ± 0.067 birds min^{-1} in 2004 (36.1 net hours), and 0.101 ± 0.045 birds min^{-1} in 2005 (40.4 net hours). Mean adult mass (± SD) at Scorpion Rock was 35.6 ± 2.4 g (CV = 0.07) and also did not differ by year (ANOVA $F_{2,602\ (0.05)}$ = 0.186, P = 0.831). Proportion of individuals captured with no evidence of a defeathered brood-patch (*i.e.*, likely nonbreeders) was relatively consistent: 40% in 2004, 45% in 2005, and 47% in 2006). In contrast, the proportion of birds captured with fully developed brood patches (*i.e.*, more likely breeding individuals) was more variable: 31% in 2004, 17% in 2005, and 21% in 2006.

During mistnetting for storm-petrels in 2006, we captured two Cassin’s Auklets on 2 June (compared with 19 individuals in 2005 and none in 2004).

Results from our 2004–05 radio telemetry study (USGS POBS) have been submitted for USGS peer review and are forthcoming. Briefly, storm-petrels in 2004 and 2005 (215 valid locations from 57 individuals) were aggregated over the continental shelf-break from Pt. Conception to Pt. Buchon, within the western Santa Barbara Channel, and over the Santa Cruz Basin separating Santa Cruz, San Nicolas, and Santa Barbara Islands. Individuals ranged as far north as Gulf of the Farallones National Marine Sanctuary (J. Adams & J. Y. Takekawa, *unpubl. data*).

DISCUSSION

Cassin's Auklet on Scorpion Rock— In March 2006, 2 of 35 sites appeared visited on Scorpion Rock compared with 34 of 67 sites on Prince Island. Logistic constraints prevented assessment of continued breeding effort after March 2006 at Prince Island. Recent observations on 15 March 2007, however documented substantial egg abandonment occurred on Prince Island during 2006. Furthermore, evaluation of nest sites on Prince Island revealed no evidence that nesting Cassin's Auklets hatched chicks during 2006 (Adams *unpubl. data*). Early differences in proportion of occupied nest sites in 2006 is consistent with past observations that reveal differences in foraging area, diet, and reproductive success between these two colonies. Although auklets visited nest sites on Scorpion Rock early in the breeding season (March 2006), as evidenced by fresh digging, we documented no nest initiations resulting in zero reproductive output for the year. In contrast, during 2005 at Scorpion Rock, we documented nest initiation in 13 of 35 (37%) of artificial burrows (a minimum 9 of these 13 failed during incubation or early chick rearing; fledging in the remaining 4 sites with chicks could not be confirmed due to infrequent island visits (J. Adams, *unpubl. data*).

Auklet nesting habitat disturbance on Scorpion Rock from non-native, invasive crystalline iceplant (*Mesembryanthemum sp.*) continues to pose a significant threat to prospecting and breeding adult auklets. During the past several years, thick vegetative growth of this weed has completely overtopped burrows and appears to prevent auklets from accessing the soil surface, existing natural burrows, and entrances to artificial burrows. Evidence of depredation in March 2006 (auklet heads) may have resulted from Barn Owls (*Tyto alba*) or Western Gulls taking individuals that attended the colony at night. Auklets can seek refuge from such predators if they can rapidly access non-obstructed burrow entrances.

Evaluation of adaptive management actions and restoration success for auklets at Scorpion Rock (and at other sites in the CINP) will require a comprehensive assessment of the inherent variability in reproductive effort and subsequent success among Cassin's Auklet at Scorpion Rock and Prince Island colonies. Prince Island, the largest auklet colony in southern California, serves as a reference (*i.e.*, control-comparison) to evaluate interannual trends in population response to variable oceanographically linked prey availability. Differences in reproductive effort and ultimately, chick growth and reproductive success among auklets nesting at Prince Island and Scorpion Rock likely reflect differences in foraging conditions experienced by provisioning adults at each colony (Adams *et al*. 2004a). For example, diet collections at both colonies during May 2001 indicate that auklets at Scorpion Rock were provisioning chicks with hyperiid amphipods (33–47% by number) and fishes (53–56% by number), whereas parents at Prince brought chicks euphausiids (85–93% by number; Adams *et al*., *unpubl. data*). A switch in the diet at Scorpion Rock in April 2001 from euphausiids to amphipods and fishes in May 2001 coincided with rapid warming of the eastern Santa Barbara Channel waters and early and rapid dispersal of adults away from Scorpion Rock (Adams *et al*. 2004a; *unpubl. data*). Because auklet reproduction can respond rapidly to enhanced prey availability (*e.g.*, euphausiid swarms in Santa Barbara Channel), evaluation of restoration success in future years should include the continued collection and analysis of diet samples.

Although still used by auklets during the past two years (2005 and 2006), artificial burrows installed in 2000 and 2001 are due for replacement and improvement. Because these originally were constructed to assist efforts during foraging ecology and breeding ecology studies (Adams 2004; Adams *et al.* 2004a,b) by augmenting inaccessible natural burrows, the original design was for a temporary nesting site that could be removed at CINP's discretion. However, as the invasive non-native vegetation (*Mesembryanthemum sp.*, *Hordeum sp.*, and *Pennisetum clandestinum*) appears to be worsening, the artificial burrows provide critical nesting habitat for auklets that may now experience hindered access to soil in which to excavate natural burrows and evade predators.

Long-term monitoring of individual nest sites is rare; both time series analyses and before-after impact/restoration analyses greatly benefit from continuous data without gaps. Continuing information regarding breeding effort, occupancy, nesting success, diet, predation, adult survival, sub-adult recruitment, and nesting habitat modification are important management priorities for CINP. Continued research in 2007 and beyond is essential because such efforts precede planned restoration actions on Scorpion Rock and Santa Barbara Island to enhance nesting habitat for auklets and murrelets (*e.g.*, provide improved nesting habitat, control and eradicate invasive plants, and restore native and endemic vegetation) with the ultimate goal of recovering damages to seabirds brought on by the dumping of DDT within Southern California Bight waters (MSRP 2005).

Successful restoration of seabirds by resource managers (*i.e.*, CINP and Montrose Trustees) can be achieved by improving nesting habitat and increasing reproductive output and survival. These actions also will benefit the Scorpion Rock nesting-island ecosystem. Previous USGS data and renewed 2007 cooperative studies will provide ability to document, monitor, and evaluate continuing restoration actions and overall success.

Adams (*in press*) identified several conservation and restoration actions for Cassin's Auklets in California. Future efforts (2007–2011) to restore and evaluate auklet habitat and native plant community structure on Scorpion Rock likely will benefit from:

(1) Maintain current efforts to quantify breeding biology parameters for Cassin's Auklets at Prince Island and Scorpion Rock with visits throughout the breeding season spaced no greater than 2-weeks apart. Parameters include: breeding phenology, site occupancy, hatching success, fledging success, chick growth and diet, and adult condition, survival, and breeding histories (from banding and morphometrics);

(2) Replace all existing sites and increase number of artificial Cassin's Auklet burrows with more permanent structures that will reduce the likelihood of lid disruptions (wind, roosting pelicans, and unauthorized visitors) and reduce time required for pre-nesting maintenance. Permanently mark and map all artificial and natural burrow sites;

(3) Design and implement methods to collect quantifiable baseline information regarding vegetative cover, species assemblage, and soil parameters (*e.g.*, salinity, pH, moisture content, and compaction, *etc*.) prior to directed restoration actions;

(4) Evaluate thermal (Parish 1990) and/or chemical weed control as an inexpensive, non-labor-intensive method to prevent rapid, extensive vegetative growth of *Mesembryanthemum* during the late winter–early spring before auklets arrive to initiate nesting. Thermal techniques are ideally suited for Scorpion Rock. Native vegetation can be marked in advance and therefore protected during treatment. Thermal techniques deplete the seed bank without disrupting the fragile soil layer witch could easily be disturbed by manual pulling of weeds and subsequently facilitate rapid loss of top soil by eolian or hydrologic erosion;

(5) Supplement Scorpion Rock with native vegetation (propagated locally from local seeds collected on adjacent rocks or mainland Santa Cruz Island) and consider use of sterile cover vegetation or material to facilitate native recovery, prevent erosion, and improve soil condition (*i.e.*, moisture retention) to benefit burrowing alcids;

(6) Develop outreach and education to inform CINP, CINMS, and recreational concession personnel (*e.g.*, Island Packers, kayak companies) of the importance of preserving and enhancing seabird habitat on Scorpion Rock. These people can then better inform the tens of thousands of visiting public who come to Santa Cruz Island each summer about unique and important seabirds and habitats within CINP and CINMS; and

(7) Develop methods to prevent the reintroduction of additional weeds to Scorpion Rock by researchers, restoration personnel, and resource managers.

Ashy Storm-Petrel on Scorpion Rock— Ashy Storm-Petrel is a difficult species to monitor. Although thought to nest throughout the Channel Islands primarily in inaccessible cliff areas, talus slopes, and sea caves, current monitoring of reproductive success is restricted to several accessible sea caves along the northern side of Santa Cruz Island (see Chapter 1). Whereas continued monitoring of nests at Orizaba Rock and in sea caves is important (see Chapter 1), maintaining mistnet and mark-recapture studies will provide additional independent information related to the status of the species within the CINP. Mist-netting efforts should continue within the Channel Islands for many reasons: (1) at most colonies, nests are difficult to find or access and mist-net capture-recapture is one of the only effective methods for assessing population size and trends over time (Carter *et al*. 1992; Sydeman *et al*. 1998); (2) at present, no nests are accessible at Scorpion Rocks to monitor and mist-net monitoring is the only method available for measuring population fluctuations (*i.e.*, changes from restoration actions); (3) mist netting data are directly comparable to similar, continuous and long-term studies at Farallon Islands, and thereby provide insight to potentially contrasting trends across the species' range; (4) CPUE provides an independent, robust metric related to colony area attendance patterns both within seasons and across multiple years, and therefore may be useful for future trend analyses and as a covariate to explain variability in nesting success; (5) capture of individuals provides the opportunity to assess individual's body condition (*i.e.*, mass scaled to body size, feather condition, proportion of non-breeders, *etc*.); (6) information to inform and assess social attraction (*i.e.,* sex-specific attraction to broadcast vocalizations); and (7) mark-recapture analyses eventually can be used to estimate sub-adult/adult survival—the most important demographic parameter influencing population growth (lambda) among long-lived, slowly maturing, and low-fecundity seabirds.

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