Monitoring and Restoration of Ashy Storm-Petrels at Santa Cruz Island, California, in 2008

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ABSTRACT

In 2008, U.S. Fish and Wildlife Service (Arcata Fish and Wildlife Office), Channel Islands National Park, and Carter Biological Consulting were funded by the Montrose Trustee Council to implement restoration actions and continue gathering baseline population and reproductive data on Ashy Storm-Petrels (*Oceanodroma homochroa*) at Santa Cruz Island, California. Artificial nest sites were deployed at Orizaba Rock (n = 21) and Cavern Point Cove Caves (n = 18). Social attraction using vocalization broadcast was deployed at Orizaba Rock. Initial success of restoration efforts was indicated by four new nests found in 2008 in association with artificial nest sites at Orizaba Rock, with chicks fledging from two sites. Future monitoring will determine the overall degree of success of restoration efforts on Orizaba Rock. Predation by at least two island spotted skunks (*Spilogale gracilis amphiala*) resulted in documented deaths of 32 adult Ashy Storm-Petrels, complete reproductive failure, and a lack of use of artificial sites at Cavern Point Cove Caves. A similar unusual skunk predation event at Bat Cave in 2005 also decimated that colony. Greater effort is needed: a) to understand how skunks are accessing sea caves; and b) to prevent such skunk predation events in the future. Future monitoring will determine if and how colonies at Cavern Point Cove Caves and Bat Cave recover from such major predation events. At Bat Cave, Cave of the Birds Eggs, and Orizaba Rock, a total of 83 nests were found and monitored in 2008 which had a combined reproductive success (i.e., proportion of chicks fledged per egg laid) of 70%, relatively high compared to other years.

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.*, 2008a). The largest known nesting 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.* 1998a,b; McIver 2002). Although nesting was first documented at Santa Cruz Island in 1912, knowledge of population size and distribution of Ashy Storm-Petrels at Santa Cruz Island increased dramatically during 1991-96 surveys by Humboldt State University (Wright and Snyder 1913; Carter *et al.* 1992, 2007). From 1995 to 2002, Humboldt State University also implemented standardized monitoring of population size (using nest counts), reproductive success, breeding phenology, and predation at five locations at Santa Cruz Island, including Orizaba Rock, Bat Cave, Cavern Point Cove Caves, Cave of the Birds' Eggs, and Dry Sandy Beach Cave (McIver and Carter 1996; McIver 2002; Carter *et al.* 2007). In 2003-05, the U.S. Fish and Wildlife Service (Ventura Fish and Wildlife Office) and Carter Biological Consulting continued monitoring at these locations (McIver and Carter 2006; Carter *et al.* 2007).

In 2005, the Montrose Trustee Council identified several seabird restoration concepts to be implemented with funds obtained through litigation over long-term effects of

organochlorine pollutants to wildlife (especially raptors and seabirds) in the Southern California Bight (Montrose Settlements Restoration Program 2005). The need for restoration for Ashy Storm-Petrels at Santa Cruz Island was identified based on: a) apparent loss of small colonies (i.e., no nests were found during 1991-96 surveys) at Painted Cave, Scorpion Rocks, and Gull Island where breeding had been previously documented (Carter *et al.* 1992, 2007, *unpubl. data*); b) contaminant-related eggshell thinning from eggs collected at Orizaba Rock and Cave of the Birds Eggs in 1992, 1996 and 1997 (Fry 1994; Kiff 1994; Carter *et al.* 2008b); c) reduced numbers of nest sites at Orizaba Rock after 1996 possibly due to lights from squid-fishing boats resulting in high avian predation (McIver 2002; Carter *et al.* 2008a); and d) decimation of the Bat Cave colony, the largest known colony at Santa Cruz Island, due to unusual predation by island spotted skunks (*Spilogale gracilis amphiala*) in 2005 (McIver and Carter 2006; Carter *et al.* 2008a).

In 2006, Carter Biological Consulting (CBC) and U.S. Fish and Wildlife Service (USFWS - Ventura Fish and Wildlife Office) were funded by the Montrose Trustee Council to continue nest surveys and monitoring for Ashy Storm-Petrels at five locations at Santa Cruz Island to provide continued baseline data on population size, reproductive success, breeding phenology, and predation for developing a long-term monitoring program for restoration assessments (Carter *et al.* 2007). This baseline information has assisted design of restoration actions and will be used for measuring long-term population changes in response to restoration actions and other natural and anthropogenic factors. Monitoring at Santa Cruz Island also has provided key information on the status of this rare storm-petrel which has declined at Santa Cruz Island and at the South Farallon Islands, but has increased at the Coronado Islands (Sydeman *et al.* 1998b, Carter *et al.* 2006, 2007, 2008a). Prior to 2006, long-term monitoring of Ashy Storm-Petrels was focused at the South Farallon Islands (Ainley *et al.* 1990; Ainley 1995; Sydeman *et al.* 1998a). A long-term monitoring program for Ashy Storm-Petrels in the Channel Islands also was needed as a long-term goal for Channel Islands National Park and other state and federal agencies, where at least half of the world population breeds (Carter *et al.* 1992, 2008a).

In 2007, CBC, USFWS (Arcata and Ventura Fish and Wildlife Offices), and Channel Islands National Park (CINP) were funded by the Montrose Trustee Council to continue monitoring work on Ashy Storm-Petrels at Santa Cruz Island for: a) gathering baseline data on population size, reproductive success, breeding phenology, and predation; and b) developing and testing restoration techniques for larger-scale implementation in 2008 (McIver *et al.* 2008).

In October 2007, the Center for Biological Diversity petitioned the U.S. Fish and Wildlife Service to list the Ashy Storm-Petrel as threatened or endangered under the Endangered Species Act of 1973 (hereafter "Act"). In response to this petition, on May 15, 2008, the U.S. Fish and Wildlife Service published a 90-finding (73 *Federal Register* 28080), announcing that listing under the Act may be warranted, and initiated a status review of the species (12-month finding). The U.S. Fish and Wildlife Service expects to publish results of this 12-month finding in the Federal Register in February 2009.

In 2008, USFWS (Arcata Fish and Wildlife Office), CINP, and CBC were funded by the Montrose Trustee Council to: a) continue monitoring work to gather baseline data on population size, reproductive success, breeding phenology, and predation of Ashy Storm-Petrels at Santa Cruz Island; and b) initiate larger-scale restoration actions, including deployment of artificial nests at Orizaba Rock and Cavern Point Cove Caves and deployment of social attraction equipment (i.e., vocalization broadcasting) at Orizaba Rock. In this report, we summarize the restoration and monitoring of Ashy Storm-Petrels at Santa Cruz Island in 2008.

METHODS

Nest Monitoring

In 2008, standardized methods (McIver and Carter 1996, 2006; McIver 2002) were used each month to search for and monitor all nests of Ashy Storm-Petrels found in accessible habitats at Bat Cave (BC), Cave of the Bird's Eggs (COBE), Cavern Point Cove Caves (CPCC), and Orizaba Rock (OR). We monitored nesting activities on 16-17 June, 17-18 July, 13-14 August, 8-9 September, 7 October, and 17 November (Table 1). We also visited Dry Sandy Beach Cave (DSBC) on 17 June to collect Ashy Storm-Petrel eggs for contaminants analyses, and on 18 July to conduct an annual survey of nesting activities. All trips to and accommodations at Santa Cruz Island were provided aboard the charter boat *Miss Devin*, operated by Ocean Sports Private Charters (Santa Barbara, California). Nesting habitats were accessed from an inflatable boat powered by a 15 or 20 horsepower outboard engine launched from the support vessel.

A storm-petrel nest site was defined 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. All marked nests were checked on subsequent visits, except when tags could not be relocated. All potential nesting habitat was searched at study locations until August when egg laying typically ceases (McIver 2002). After August, only marked nests were examined in September, October, and November.

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. Approximate ages of chicks were estimated based on their plumage development (McIver and 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 2008 (i.e., at least one quarter of a fresh eggshell observed). At some nest sites, no direct evidence of egg-laying was found, although eggs may have disappeared before our detection.

Approximate breeding phenology was estimated for each nest (i.e., timing of initiation, hatching, and fledging) using techniques described in McIver and Carter (1997).

Restoration

Artificial nest sites and social attraction equipment were deployed at OR. A single vocalization broadcast system was used that had been developed previously by the National Audubon Society and has been used widely for social attraction purposes (e.g., Parker *et al.* 2007). Assistance with system set up was provided by S. Schubel. This system involved use of a MP3 player for continuous play during the night of Ashy Storm-Petrel vocalizations. These vocalizations had been originally tape recorded by D.G. Ainley at Southeast Farallon Island, California, and provided to H.R. Carter in 1989 (see Carter *et al.* 1992). In 2004, vocalizations were transferred to CD by J. Adams who graciously provided this CD for this restoration project. The MP3 player, marine batteries, light sensor, and amplification system were placed in a locked plastic tote box (Figure 1a). Batteries were recharged by a 3' x 5' solar panel; the solar panel and tote box were securely placed at an inconspicuous location on the west side of OR that received adequate direct sunlight, and was not visible to most passing boats (Figures 1b and 1c). The vocalization broadcast equipment in the tote box was wired to two speakers, which were placed in nesting areas on OR. One speaker was placed in the "Upper West Cavern" (see Figure 2a), and the other speaker was placed in the "Lower Cavern."

Artificial nest sites were deployed at OR in the Upper West Cavern within 1- 7 m of the speaker to encourage storm-petrels originally attracted to vocalization broadcasts to then spend time in or near artificial site areas. Each artificial nest site was housed under a single concave cement roofing tile (A.L.L. Roofing and Building Materials Corporation, Ventura, California; Figures 2 and 3) that was 36 cm long, 20 cm wide, and 18 cm high (all inside dimensions) and provided sufficient space for a single Ashy Storm-Petrel nest. Heat-sterilized fine pumice gravel (depth 2-3 cm) was spread under each tile to form a suitable floor for each nest site (Figure 2b). Rocks were placed at tile entrances to reduce entrance sizes to generally match those of natural sites. Site entrances were made small enough (see Figure 4.1 in Ainley *et al.* [1990]) to prevent entry by other crevice-nesting seabirds such as Cassin's Auklets (*Ptychoramphus aleuticus*) and Xantus's Murrelets (*Synthliboramphus hypoleucus*) which also nest at OR. One end of each tile was blocked completely by rocks or pieces of cement tile backer boards to provide an enclosed site mimicking a natural nest crevice and protecting the interior of the site from wind. Small mirrors (13 cm wide x 6 cm high; Educational Innovations, Inc., Norwalk, Connecticut) were taped to the inward-facing side of all artificial nests to provide additional encouragement to prospecting storm-petrels standing outside the artificial site to stay in the vicinity of the artificial nest site where they might meet other prospecting storm-petrels and/or enter the artificial site (see Figures 3a, 3b, 4a, and 4b). Small sachets (or bags) filled with Ashy Storm-Petrel feathers gathered during monitoring in past years were placed inside each site to provide an olfactory cue of nest site suitability to further encourage storm-petrel prospecting of the interior of the site. Fine sand was placed around artificial nest sites to detect storm-petrel footprints that would indicate site

visitation by storm-petrels. At some artificial sites, additional sand was placed at the bottom edges of tiles to prevent or reduce wind inside sites (see Figure 3b).

Artificial nest sites also were deployed at CPCC #4 and CPCC #5. Vocalization broadcast systems were not deployed at these locations because: a) these locations are constantly in shade and solar panels would not be adequate to charge batteries; and b) we wished to compare use of artificial sites at CPCC to those at OR (with vocalization broadcasting).

Data Handling and Statistical Analyses

When another egg was found in the same nest site where a previous (i.e., “first”) egg had been laid but failed, we defined this egg as a “replacement” egg by the same breeding pair. Due to monthly nest checks and inexact information on when the first egg failed, we could not determine how much time had elapsed after failure of the first egg to ensure sufficient time for formation of the second egg. When only one egg was laid in a nest site, we refer to these as "single” eggs. If another egg was found in the same nest site where a previous single egg had been laid and successfully fledged a chick, we defined this egg as a “second” egg from a different breeding pair. First, single, replacement, and second eggs were collectively referred to as “all” eggs. Except for sites with second eggs, the latest egg laid at a nest site within a breeding season (either single or replacement) was referred to as the “last” egg. Hatching success was defined as the percentage of first, single, or second eggs hatched per egg laid for all sites where egg fate was known. Fledging success was defined as the percentage of chicks fledged (from single, replacement, or second eggs) per chick hatched for all sites where chick fate was determined. Reproductive success was defined as the percentage of active nest sites which fledged a chick from single or replacement eggs, with second eggs treated as another nest site for analysis purposes. Since it is based upon chicks hatched, fledging success is inherently based upon the smallest subset of nests. For hatching, fledging, and reproductive success, we excluded nests for which egg or chick fates were not known.

One-way analysis of variance (Hintze 2001) was used to compare mean (± SE) dates of egg laying (or “nest initiation”), hatching, and fledging between study locations. Plots of initiation dates were checked for normality, and tested for equality of variances with Modified-Levene Equal-Variance Test (Hintze 2001). Differences were considered statistically significant if $p < 0.05$. Descriptive statistics are presented for initiation, hatching, and fledging dates of first, single, and replacement eggs. For hatching success, chi-square contingency and heterogeneity tests (Hintze 2001) were used.

RESULTS

Bat Cave

Ashy Storm-Petrel: Thirty-five nests were documented in BC in 2008. Nests occurred in the “main room” and in crevices under boulders outside the entrance of the main room. However, one nest was found in the “slope room,” a portion of BC where storm-petrels

nested prior to skunk predation in 2005. Hatching success of first and single eggs was 83% (*n* = 35), fledging success of chicks from all eggs was 97% (*n* = 29), and reproductive success of last eggs was 85% (*n* = 33; Table 2). Storm-petrel footprints were observed in fine sand at the top of the slope in the main room, and at the top of the slope in the slope room. Two unusual nesting behaviors were observed: 1) one site had three adults with no evidence of egg-laying; and 2) a second egg (that subsequently fledged a chick) was presumably laid by another breeding pair in a site where a single egg had already fledged a chick earlier in the season.

Predation: No evidence of avian, deer mouse (*Peromyscus maniculatus santacruzae*), or skunk predation was found. In July, three Common Ravens (*Corvus corax*) were observed circling over the cove adjacent to the cave, before continuing their flight along the coastline.

Xantus's Murrelet: No nests were found in 2008.

California sea lion (*Zalophus californianus*): On 9 September, we found packed dirt behind a driftwood berm and odor of urine and excrement, evidence that sea lions had hauled out at the entrance of the cave since our August field trip. However, no nest sites appeared to be altered during sea lion visitation.

Cave of the Birds' Eggs

Ashy Storm-Petrel: Twenty-eight nests were documented in COBE in 2008. Hatching success of first and single eggs was 82% (*n* = 28), fledging success of chicks from all eggs was 88% (*n* = 25), and reproductive success of last eggs was 79% (*n* = 28; Table 2).

Predation: Evidence of avian predation of storm-petrels included three storm-petrel feather piles (one each found in June, July and September) plus one broken storm-petrel egg found away from a nest site in July. We suspect that this predation was caused by Barn Owls (*Tyto alba*) or Common Ravens. None of these avian predators were seen inside the cave but some white guano was noted on rocks inside the cave entrance.

Flooding: In November, we observed water on the floor near the cave entrance, missing nest tags, and a wet and dead storm-petrel chick near the cave entrance, indicating that at least the front portion of the cave had been washed by wave action since the October field trip.

Pigeon Guillemot (*Cepphus columba*): Seven nests were documented in 2008, with the following descriptions: two intact eggs only (*n* = 4); one adult in incubation position but no egg(s) observed (*n* = 1); one dead small downy chick (*n* = 1); and one medium gawky chick (*n* = 1). Much evidence of avian predation of guillemots also was found, including: a) on 17 June, five guillemot adult carcasses, a guillemot head and feather pile, two guillemot nests with dead chicks, and a guillemot chick carcass away from suitable

nesting habitat; and b) on 18 July, one guillemot adult carcass. We suspect that this predation was caused by Barn Owls or Common Ravens (see above).

Cavern Point Cove Caves

Ashy Storm-Petrel Restoration and Monitoring: Eighteen artificial nests were deployed in CPCC # 4 (n = 10) and CPCC #5 (n = 8) on 25 April (see Figure 4a). Complete reproductive failure was documented at CPCC #4 and CPCC #5 in 2008 due to skunk predation (see below). No evidence of egglaying was found in artificial sites at CPCC #4 or CPCC #5, and only one egg (depredated) was found in a natural site in CPCC #4.

Predation: Over the course of the survey period, at least two island spotted skunks (*Spilogole gracilis amphiala*) were documented in these caves, along with carcasses of at least 32 adult storm-petrels. Eighteen carcasses were found on 16 June, 9 carcasses on 19-20 June [a skunk-trapping field trip], and 5 carcasses in July. One depredated storm-petrel egg also was found away from a nest site in CPCC #4 in July. Fourteen (44%, n = 32) storm-petrel carcasses were found in CPCC #4, and 18 (56%) were found in CPCC #5. In June, two storm-petrel carcasses were found immediately adjacent to and outside entrances of two artificial nest sites in CPCC #4, indicating that storm-petrels may have been visiting artificial sites, although they also may have been moved there by skunks.

The distinct odor of skunk was evident in both caves on the June field trip, and in CPCC #5 on July, August, and September field trips. Obvious signs of digging were observed within both caves, and a skunk “latrine” (i.e., small area near small inner caves where skunks defecated and may have slept, containing approximately 50 scats) was found in June, indicating longer-term presence of a skunk in this cave. Traps (Havahart® live traps) were deployed on 19 June at both caves (three traps per cave) and checked regularly (20, 22, 24, 28 June; 3 July) by CINP personnel (L. Harvey, D. Black, K. Faulkner, M. Hornfeck) and volunteers (J. Dresser, J. Koepke, D. Mazurkiewicz). On 3 July, one live skunk was removed from CPCC #5, marked (with paint), and released near Smugglers Cove on Santa Cruz Island (Figure 4b). Traps were re-baited with cat food on subsequent visits, and one dead skunk was removed from CPCC #5 on 9 September. Traps were removed from CPCC #4 and CPCC #5 on 7 October. No evidence of predation by deer mice on storm-petrel eggs was noted.

Four Barn Owl pellets and much white guano were found in CPCC #5 in June. One pellet contained a storm-petrel band (#1401-56368), which was subsequently determined to have been from an Ashy Storm-Petrel captured in a mist net, banded, and released at Vandenberg Air Force Base in July 2003 (see Brown *et al.* 2003).

Human Disturbance: On 22 June, CINP personnel observed a red kayak on the beach at CPCC. On 17 July, we found two artificial nest sites outside the entrance of CPCC #5. They had apparently been removed from the cave by a person(s) exploring the cave. In August, we found a nest tag placed on a large rock at the cave entrance. This tag also apparently had been found and moved from its original location by a person(s) exploring the cave.

Xantus's Murrelet: No nests were found in 2008.

Dry Sandy Beach Cave

Ashy Storm-Petrel: On 17 June, we collected 10 whole eggs (9 being incubated by adults and one not being incubated by an adult) from DSBC for contaminants analyses (see Carter *et al.* 2008b). Eggs were collected from 8 sites that had been marked as storm-petrel nest sites in previous years and 2 sites without past nesting. As in 2006-07, DSBC was not monitored on each trip in 2008. Evidence of egg laying (i.e., 9 adults, 11 chicks, 11 eggs, and 3 broken eggshells) was observed in 34 nests on 17 June (n = 10 nests with collected eggs) and 18 July (n = 24 other nests), similar to other July and August surveys between 1995 and 2007 (McIver 2002; Carter *et al.* 2007; McIver *et al.* 2008). One nest site from which an egg was collected in June showed behavior indicative of relaying (i.e., adult in incubation posture in the tagged nest site but egg not observed) on 18 July. All other sites from which eggs were collected on 17 June were empty on 18 July. Reproductive success was not determined at DSBC in 2008.

Predation: No storm-petrel feather piles were found. In addition to three broken eggshells in nest sites, two broken storm-petrel eggs were found not associated with nest sites, one with mouse bite marks from either predation or scavenging.

Pigeon Guillemot: Much evidence of guillemot nesting was found in DSBC in 2008. In June, three adults flew out of the cave upon our arrival and we found two nests with chicks and two eggs not associated with nest sites (likely depredated or scavenged by deer mice based on bite marks). In July, three adults were perched on a large rock at the cave entrance upon our arrival and we found one nest and one egg not associated with a nest site, with an apparent puncture hole (about 2 cm^2).

Brandt's Cormorant (Phalacrocorax penicillatus): In June, one adult flew out of the cave upon our arrival which had apparently been roosting on the beach in the cave.

California sea lion: In June, about 150-200 sea lions were on the beach by the tide pool upon our arrival, and left the cave as we entered. However, none were present in July.

Orizaba Rock

Ashy Storm-Petrel Restoration: On 1 April, 21 artificial nests and a vocalization broadcast system was deployed on OR. Artificial sites were not deployed in the Lower Cavern because of the unevenness and rocky substrate of the cavern floor, lack of flat spaces on which to place the pumice gravel pads and roof tiles, and possible washing of this cavern by waves during storm events. Artificial sites were installed in three areas on OR: a) 13 on a ledge (about 5 m long and 2 m deep) in the Upper West Cavern; b) 3 on the floor of the Upper West Cavern; and c) 5 on the floor of the "Upper East Cavern" (Figures 3a and 3b). In the Upper West Cavern, artificial sites were generally installed adjacent to each other in a row, but some were placed behind others. Each site entrance

was not obstructed by other sites. No natural nest sites had been previously observed on this ledge in 1995-2007, although some natural crevices inaccessible to researchers might have occurred (and may still occur) in the wall behind this ledge. Six natural sites had been previously monitored in these upper caverns within about 1-5 m of artificial nest sites.

During each field trip to OR in June through September 2008, vocalization broadcast equipment was tested and determined to be functioning properly. Thus, we are confident that Ashy Storm-Petrel vocalizations were broadcasted nightly from 1 April through 7-8 September. On 8 September, the solar panel, broadcast equipment, and the speaker from the Lower Cavern were removed, but we left the speaker in the Upper Cavern in place. Similarly, all artificial nest sites were left in place.

Ashy Storm-Petrel Monitoring: Including natural and artificial sites, 24 nests were documented in 2008. For natural sites, hatching success of first and single eggs was 70% (n = 20), fledging success of chicks from all eggs was 43% (n = 14) and reproductive success of last eggs was 32% (n = 19; Table 2). Ashy Storm-Petrels laid eggs in association with four artificial sites. Eggs were laid inside two artificial sites, and behind and outside of two other sites. At the latter locations, nearby artificial sites likely afforded protective cover for nesting storm-petrels, allowing nesting in open locations where egg laying had not previously been observed and would not be likely without the presence of artificial sites. Successful egg laying in association with artificial sites at OR was first observed on 16 June at two artificial sites ("A-868" and "A-1000") (see Figure 5a). The first chick (large downy) associated with an artificial nest site ("A-686") was observed on 12 August (see Figure 5b). For artificial sites, hatching success was 50% (n = 4), fledging success was 100% (n = 2), and reproductive success was 50% (n = 4). Ashy Storm-Petrel footprints were not detected in sand placed around artificial nests. However, on 16 June, dusty mirrors on all artificial sites in the Upper East Cavern had markings caused by storm-petrel toenails or wing edgings. On 17 July, four empty artificial sites on the ledge in the Upper West Cavern also showed signs of probable excavation of a potential nest bowl, with some gravel and sand displaced outside nest site entrances.

Feather Bags: At one artificial nest site where the egg did not hatch ("A-869"), an adult was observed incubating an egg on 17 July but the feather bag was found directly in front of the egg on 12 August. We later suspected that this feather bag may have obstructed or otherwise interfered with incubation by preventing access to the egg. When deployed, feather bags were pushed far to the back of each artificial site, but this feather bag may have been subsequently moved by wind or storm-petrels into an obstructing position. In November, we removed all feather bags from artificial sites at OR to ensure that: a) sites were not obstructed during any visitation the non-breeding season; and b) feather bags were not soaked or damaged by winter storms.

Unusual Observations: Some unusual observations of Ashy Storm-Petrels were noted in 2008 which may have partly reflected responses to vocalization broadcasting or nearby artificial sites:

1) Two eggs were found in open areas not associated with natural or artificial nest sites on 17 July that likely had rolled out or been ejected from inaccessible natural nest sites. No rolled-out or ejected eggs were observed in association with artificial sites or any monitored natural nest sites.
2) One adult was observed in the Lower Cavern on 8 September, perched on an open ledge not suitable as a nesting crevice.
3) Two adults were observed sitting together in a nest site (#744) without an egg on 8 September – such behavior typically occurs on occasion during courtship prior to egg-laying in the early part of the breeding season.

Predation: Little evidence of predation of storm-petrels was found at OR in 2008, with only one feather pile found on 12 August, approximately 5 m outside of the Upper West Cavern. Increased levels of storm-petrel nesting activity at OR apparently did not result in increased levels of avian predation.

Cassin's Auklet: One nest (#999) was detected on 16 June which contained a dead small downy chick.

Black Oystercatcher (*Haemotopus bachmani*): Three nests (each with one egg; in one case, the egg had rolled out of the nest), two empty scrapes, and one dead small downy chick were found on 16 June.

Hatching, Fledging, and Reproductive Success

For natural sites only, hatching success of first and single eggs did not differ significantly between Bat Cave, Orizaba Rock, and Cave of the Birds Eggs in 2008 ($F = 0.72$, $p = 0.49$, $df = 2$). Fledging success of chicks from all eggs (natural sites only) differed significantly between locations, being highest at BC and lowest at OR ($F = 13.2$, $p < 0.001$, $df = 2$) (Kruskal-Wallis Z-values 1.7 and -2.9, respectively). Reproductive success of last eggs (natural sites only) also differed significantly between locations, being highest at BC and lowest at OR ($F = 11.0$, $p < 0.001$, $df = 2$) (Kruskal-Wallis Z-values 1.9 and -3.3, respectively).

Breeding Phenology

Mean initiation dates (± SE) for Santa Cruz Island in 2008 (i.e., 310 first and single eggs at Bat Cave, Orizaba Rock, and Cave of the Birds Eggs, natural sites only) were not significantly different than in 2005-07 (i.e., at these caves plus Cavern Point Cove Caves) ($F = 2.05$, $p = 0.11$, $df = 3$) (Table 3). In 2008, initiation dates ranged from 18 April to 9 September for first and single eggs versus 2 July to 6 September for replacement eggs. Mean hatch dates for chicks from first and single eggs differed significantly among years, being earlier in 2007 than 2005 ($F = 3.2$, $p = 0.02$, $df = 3$) (Kruskal-Wallis Z-values 1.8 and 2.9, respectively) (Table 3). In 2008, hatch dates ranged from 1 June to 22 October for first and single eggs versus 28 August to 28 October for replacement eggs. Mean fledging dates also differed significantly among years, being earlier in 2008 than 2005 and 2006 ($F = 6.9$, $p < 0.001$, $df = 3$) (Kruskal-

Wallis Z-values -3.9, 2.4, and 2.8, respectively) (Table 3). In 2008, fledging dates ranged from 20 August to 20 December for first and single eggs versus 16 November to 20 December for replacement eggs. For artificial sites at OR in 2008: a) initiation dates were 8 June, 13 June, 9 July, and 27 July; b) hatch dates were 26 July and 9 September; and c) fledging dates were 14 October and 28 November.

DISCUSSION

Monitoring Reproductive Success and Breeding Phenology

Seabird restoration has focused primarily on improving habitat at breeding colonies to increase numbers of breeding birds and reproductive success (e.g., Parker *et al.* 2007). Reproductive success is a key demographic variable needed for assessing population growth conditions and modeling population changes over time. In Ashy Storm-Petrels, variation between locations and 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. In 2007, we found that a minimum of five monthly trips between June and October were adequate for monitoring reproductive success of Ashy Storm-Petrels at Santa Cruz Island (see McIver *et al.* 2008). However, in 2008, an additional trip in November was necessary to determine fledging and reproductive success for several late nests. Breeding phenology in each year (2005-08) was protracted, as also found in 1995-98 (McIver 2002). Most eggs were laid in June, most hatching occurred in late July and early August, and most fledging occurred in early October. Peak fledging appeared to occur earlier in 2008, but eggs were laid over a greater period (i.e., 144 d) than in 2005, 2006, and 2007 (i.e., 105 d, 132 d, and 126 d, respectively). Reproductive success at three monitored locations combined in 2008 (i.e., 80% hatching success, 82% fledging success, and 70% of active sites fledging chicks; see Table 2) appeared to be similar to or greater than in 1995-98 (McIver 2002). As in 1995-98, high reproductive success values occurred at COBE and lower values occurred at OR. In contrast to 1995-97, but as also observed in 2006 and 2007, reproductive success values at BC were high (McIver et al. *in preparation*). This improved reproductive success (mainly reflecting higher hatching success) is consistent with: a) reduced levels of organochlorine contaminants may no longer reduce reproductive success of Ashy Storm-Petrels on a population level (Carter *et al.* 2008b); and b) reduced avian predation in 2005-08. However, these reproductive success rates do not include major impacts from unusual skunk predation events at BC in 2005 and CPCC in 2008. Relationships between organochlorine levels and eggshell thickness from eggs collected in 1992-2008 also require further analysis to better evaluate potential past and present effects from these contaminants. While generally higher than observed in 1995-98 (McIver 2002), reproductive success in 2008 was still lowest at OR as also noted in 1995-98. However, nesting conditions at OR are different than at sea caves, potentially affecting the nature and amount of predation, nesting habitat, and human disturbance.

Several eggshells not associated with nest sites were curiously found in the lower cavern at OR in 2008, as also observed in 2006 and 2007. These eggshells apparently came from nest sites above this cavern floor which were hidden from view and not monitored. Such eggshells may have reflected: a) whole eggs accidentally rolling out of nest sites and breaking on lower rocks; b) abandoned whole eggs intentionally ejected from nest sites by adults before laying; or c) hatched eggshells ejected from nest sites by adults after hatch. Causes for these eggshells also may include loss of whole or broken eggs after disturbance during incubation by avian predators or humans. Fragile and limited nesting substrates at OR also may facilitate such eggshells away from nest sites. For example, use of small unmonitorable crevices may reflect predation pressure or limited nesting space, and encourage adults to remove eggshells after hatch to make room for a brooding adult and a growing chick. Or strong winds may blow hatched eggshells out of certain monitored nest sites, with eggshells collecting in the lower cavern area away from monitored sites. In any case, these eggshells were not directly included in our measurement of reproductive success.

Restoration at Orizaba Rock

Vocalization broadcast systems with or without other social attractants (e.g., decoys, artificial nest sites) have been successfully used to attract seabirds and restore colonies of Common Murres (*Uria aalge*), Atlantic Puffins (*Fratercula arctica*), Dark-rumped Petrels (*Pterodroma phaeopygia*), Band-rumped Storm-Petrels (*O. castro*), Common terns (*Sterna hirundo*), and Arctic terns (*Sterna paradisaea*) (Kress 1983; Kress and Nettleship 1988; Podolsky and Kress 1989, 1992; Bolton *et al.* 2004; Parker *et al.* 2007). In 2008, we had several signs of initial success with both attracting Ashy Storm-Petrels and initiating breeding at artificial sites at OR. Visitation by Ashy Storm-Petrels was observed at 52% of 21 artificial sites, eggs were laid in association with four artificial sites, and two chicks successfully hatched and then fledged from these four sites. By monitoring all natural nest sites found at OR, we documented a 58% increase in numbers of active nests (i.e., with eggs laid in them) at OR from 14 sites (all natural) in 2007 to 24 sites (20 natural and 4 artificial) in 2008. Similar higher levels of nesting were found in 1995-97, with a peak of 27 nests documented in 1996 (McIver 2002). Numbers have increased since 2005 and now recovered to 1995-97 levels due to both natural recovery and restoration actions. In the future, numbers may increase to even higher levels due to enlarging the number of suitable nest sites on OR. If so, a larger OR colony with a greater proportion of protected nest sites would have a greater buffer against certain anthropogenic impacts (e.g., increased predation related to bright lights).

Twenty natural sites occurred at OR in 2008, compared to 14 natural sites in 2007. Five of six additional sites occurred in crevices in which Ashy Storm-Petrels had nested prior to 2008 which were distributed widely around the rock. At one other site, the crevice had been previously occupied by Cassin's Auklets. Five other natural sites (that had been occupied prior to 2008) also occurred in caverns where artificial sites had been placed. These five sites also were occupied in 2008. Therefore, we could exclude possibilities that: a) pairs nesting in association with artificial nest sites had simply moved from nearby natural nest sites; and b) birds would recruit only to artificial site areas and not

more widely on the rock. However, without banded birds, we could not ascertain the source of nesting pairs using artificial sites or other newly occupied sites. Possible sources for these birds include: a) recruitment of subadults raised at OR; b) enhanced recruitment of subadults or adults from other colonies; and c) return of adults that previously bred at OR but had temporarily not bred at this colony, possibly due to past impacts from bright lights. Procellariiformes typically exhibit a high degree of philopatry and experienced breeders generally have higher breeding success than first-time breeders (Warham 1990). Established storm-petrel pairs breeding in natural sites at OR or other colonies probably would not jeopardize their breeding success by moving to artificial sites at OR, unless they had some previous experience at OR or natal colony abandonment was necessary (e.g., due to loss of nesting habitat). In addition, pairing, nest site selection, and egg laying often takes more than one year and can depend on various factors. Given the rapid response of these birds to the newly-deployed vocalization broadcast system and artificial sites plus similar timing of breeding at artificial and natural sites, we suspect that these birds likely had not yet selected nest sites prior to 2008 but had already been attending OR since 2007 or earlier. We consider that it is most likely that subadults from the OR colony recruited at newly-available sites near the speaker. Hatching failure at two of these sites may reflect inexperienced first-time breeders. Vocalization broadcast also may have encouraged some subadults from OR to recruit at an earlier age or earlier in the season. However, we also could not exclude the possibility that a few experienced breeders from decimated colonies at CPCC in early 2008 might have moved to and bred at the OR colony in 2008. Future patterns of breeding in artificial and natural sites at OR, CPCC, and other colonies will further assist eventual final interpretation of 2008 data.

Skunk Predation at Cavern Point Cove Caves

At least two island spotted skunks somehow gained access to CPCC in 2008, killing at least 32 adult Ashy Storm-Petrels and causing complete reproductive failure of this colony. In 2005, we also documented a similar skunk predation event at BC where at least 72 adult Ashy Storm-Petrels were killed (McIver and Carter 2006). While the BC colony has continued to exist at lower numbers (likely composed mainly of escaped adults from this relatively large colony), we suspect that few adult storm-petrels escaped skunk predation at CPCC in 2008 because: a) low cave ceilings and narrow entrances may have allowed few if any storm-petrels to exit by flying; and b) CPCC caves are much smaller in area than BC, and skunks were likely more able to rapidly search caves and find and kill storm-petrels. Future monitoring will determine if a reduced colony still exists or if the colony was extirpated in 2008.

Prior to these events in 2005 and 2008, skunk predation of Ashy Storm-Petrels was not known to occur and had not been documented during monitoring in 1995-2004 (McIver 2002). Recent research has shown that island spotted skunk population numbers at Santa Cruz Island have increased dramatically, possibly in response to reduced numbers of island foxes (*Urocyon littoralis santacruzae*), changes in island vegetation, or a combination of these and other factors (Jones *et al.* 2008). Much additional field work was needed on 19-20, 22, 24, 28 June, and 3 July to trap island spotted skunks and

monitor predation on Ashy Storm-Petrels at CPCC. Much assistance was provided by CINP and other personnel. Future skunk management plans for sea caves at Santa Cruz Island are needed as soon as possible. Given skunk predation incidents in 2005 and 2008, and because Ashy Storm-Petrels are long-lived, highly philopatric, and exhibit low annual reproductive output, Ashy Storm-Petrels nesting in all sea caves on Santa Cruz Island likely are vulnerable to sporadic predation by skunks.

Avian Predators

During 1995-98 monitoring, Barn Owls were well documented as predators of Ashy Storm-Petrels at Santa Cruz Island, especially at BC, CPCC, COBE, and OR (McIver 2002). Common Ravens are commonly observed near cave entrances, have been documented in sea caves (e.g., COBE in 1997; McIver 2002), and may prey on storm-petrels. Only one apparent raven predation of a Pigeon Guillemot chick in COBE was noted in July 1997 although many instances of predation of Pigeon Guillemots occurred, possibly by Barn Owls (McIver 2002). For instance, in COBE, four Pigeon Guillemot carcasses or feather piles were found in 1996, seven Pigeon Guillemot carcasses or feather piles were found in 1997, and one Xantus's Murrelet carcass was found in 1997 (W.R. McIver and H.R. Carter, unpubl. data). In addition, Pigeon Guillemot eggs or eggshell fragments with apparent peck marks have commonly been found away from suitable nest sites (e.g., seven eggs or eggshell fragments in COBE in 1996, and seven eggs or eggshell fragments in COBE in 1997; W.R. McIver and H.R. Carter, unpubl. data), likely from predation or scavenging by Common Ravens. In 2008, limited Ashy Storm-Petrel predation and extensive Pigeon Guillemot predation at COBE indicated either Common Raven or Barn Owl predation. Pigeon Guillemot adults at COBE may also be depredated by Peregrine Falcons (*Falco peregrinus*), which have been observed flying above and roosting on cliffs near the entrance to COBE. As in 1996-97 and 2005-07, Pigeon Guillemots may be targeted more frequently than storm-petrels at COBE because they are active at this location during the day (i.e., standing and vocalizing on the surface of the nesting area, sitting on the water in front of the cave, and flying in and out of the cave) and each individual guillemot provides a large amount of food for a predator. In addition, ravens might obtain fish from guillemots when they return to the colony. Northwestern Crows (*Corvus caurinus*) are known to intercept Pigeon Guillemots as they fly to nests with fish to feed their young (Emms and Verbeek 1991). Ashy Storm-Petrels are less easy for avian predators to detect, being nocturnal in their arrival to and departure from nest sites, and incubating adults and chicks before fledging age (~80 d) are generally non-vocal and inactive within their nesting crevices during the day. Near fledging age, older chicks can move outside of nest sites but are still non vocal. A few smaller non-handled chicks also make peeping or begging sounds while we are checking nests but this may reflect minor disturbance to chicks from our activities (e.g., use of flashlights) and not occur regularly.

Compared to 1995-98, relatively low levels of storm-petrel predation by avian predators (i.e., few carcasses or feather piles) appeared to occur in 2008, as also noted in 2006-07 (Carter *et al.* 2007; McIver *et al.* 2008). However, lower numbers of breeding birds also occurred at BC and CPCC in 2005-07. More work is needed to summarize and assess past predation data for comparison to 2005-07 data. At BC, Barn Owls may have

switched to hunting elsewhere, due to the reduction in population size of storm-petrels after the skunk predation event in 2005. Further monitoring of predation will assist in determining trends in the frequency and type of predation upon storm-petrels.

Western Gulls (*Larus occidentalis*) are known predators of Ashy Storm-Petrels at Southeast Farallon Island where both breed together (Ainley *et al.* 1990, Sydeman *et al.* 1998a). At Santa Cruz Island, Western Gulls have not been observed to occur inside sea caves during nest monitoring; however, a few pairs nest on OR but little evidence of gull predation on seabirds has been found there (McIver 2002).

Human Visitation

Evidence of human visitation (unrelated to researcher visitation) was found at CPCC on 22 June, 17 July, and 12 August. These documented events likely indicate more frequent visitation of CPCC by tourists without such evidence of entry during most of our visits. Since complete reproductive failure occurred at CPCC in 2008, effects of human visitation on storm-petrel nests did not occur. Signs prohibiting cave entry and education of tourists visiting Santa Cruz Island are needed to prevent visitations of specific caves with relatively large numbers of nesting Ashy Storm-Petrels. Natural and artificial nesting habitats within sea caves and on OR are fragile and prone to movement or collapse if carelessly stepped upon. During the breeding season (April-November), storm-petrel adults, chicks, and eggs within nest sites also are vulnerable to being crushed or disturbed by unaware human visitors.

Restoration Recommendations

Based on the nest monitoring and restoration activities described above, we recommend implementation of the following procedures during restoration work proposed for 2009 and 2010:

Artificial Nest Sites

- Deploy an additional 5-10 artificial nest sites at OR in March 2009. Deploy these sites in available areas in the upper cavern area near speakers. Once deployed, all high-quality available space for artificial sites will be used up on OR.
- Do not redeploy feather bags to artificial nests at OR in 2009-11 to prevent possible obstruction of incubating adults. Instead, place 4-5 loose feathers in sites to provide storm-petrel odor and encourage attendance by storm-petrels. In March 2009, remove feather bags from artificial nest sites at CPCC.

Vocalization Broadcast

- At OR, deploy and operate the vocalization broadcast system from late March through mid-August 2009-11. Shut down and remove part of the system during the August field trip to prevent attraction of non-breeding birds to OR after the egglaying period which may lead to increased predation of inexperienced birds at OR in fall.

Skunk Management

- Develop and implement a skunk management plan to prevent skunk predation of storm-petrels at CPCC, BC, COBE and DSBC in 2009-11. If a skunk management plan cannot be implemented at CPCC, remove artificial nest sites from CPCC #4 and CPCC#5. Artificial sites may encourage some Ashy Storm-Petrels to nest in these caves that otherwise might nest elsewhere.
- Coordinate with other researchers to gather information and develop further studies on population size, distribution, and behavior of island spotted skunks at Santa Cruz Island.
- Coordinate with other researchers to determine routes and methods that island spotted skunks utilize to gain access to sea caves at Santa Cruz Island.

Signs

- Deploy signs at CPCC, BC, COBE, DSBC, and OR in 2009-11 which state that: a) Ashy Storm-Petrels and other sensitive species breed in dry portions of five major sea caves at Santa Cruz Island; b) human visitation of dry portions of these sea caves can cause breakage of eggs, killing of adults and chicks, and damage to fragile nesting habitats in rock crevices, rock rubble, and under driftwood; and c) human visitation of these caves without a permit is not permitted. Signs should be deployed in inconspicuous locations (i.e., on cave walls) within caves and should not be viewable from boats which might attract people. However, if people begin to enter caves, signs should be visible to encourage them to leave immediately before impacting storm-petrels or their nesting habitat.

Long-term Restoration and Monitoring

At OR, the Montrose Trustee Council has agreed to fund deployment of a vocalization broadcast system, artificial nest sites, and monitoring in 2009-11, prior to evaluating whether continued efforts are desirable or necessary. Artificial sites should remain on OR after initial project completion, although periodic maintenance is desirable to ensure they remain suitable for nesting. Artificial sites provide additional suitable nest sites to increase population size as well as increase reproductive success by preventing or reducing impacts from avian predation or human disturbance. Continued monitoring is desirable to document restoration success over the long term, to track population status of this rare species, and to address various conservation issues.

Earlier, we recommended that social attraction techniques also should be employed at BC in 2009 (McIver *et al.* 2008). However, the skunk predation event at CPCC in 2008 has demonstrated that the skunk predation event at BC in 2005 was not an isolated and unusual event. We now consider that Ashy Storm-Petrels nesting in sea caves at Santa Cruz Island are susceptible to further depredation by island spotted skunks without human intervention. Social attraction techniques for Ashy Storm-Petrels should not be implemented at sea caves at Santa Cruz Island, unless a long-term skunk management plan has been implemented.

Given skunk predation events, we now have much greater concern about the long-term viability of Ashy Storm-Petrel populations at Santa Cruz Island. In addition to continued restoration and conservation efforts at Santa Cruz Island (even more necessary than previously thought), we recommend that social attraction techniques should be implemented in sea caves at nearby Anacapa Island to speed recovery of Ashy Storm-Petrels at this colony where skunks do not occur. While Ashy Storm-Petrels attend and likely already nest at Anacapa Island (Carter *et al.* 2008a), they appear to be restricted to cliff habitats that were inaccessible to Black Rats (*Rattus rattus*) prior to rat eradication in 2002, similar to Xantus's Murrelets (Howald *et al.* 2005, Whitworth *et al.* 2005). However, Ashy Storm-Petrels are even more susceptible to rat depredation than Xantus's Murrelets because of their much longer nesting season and smaller body size. Currently, Ashy Storm-Petrels do not nest in sea caves at Anacapa Island even though much suitable habitat exists there. By attracting Ashy Storm-Petrels to breed in Anacapa sea caves, we can: a) speed recolonization of suitable but unoccupied nesting habitats and thus speed increase in overall population size at Anacapa Island; b) better determine breeding status and population trends at Anacapa Island; and c) by assisting recovery of the predator-free Anacapa Island colony, ensure a nearby source of Ashy Storm-Petrels to eventually recolonize any colonies lost to skunk predation at Santa Cruz Island, unless skunks somehow regularly inhabit these habitats in the future.

Baseline data on population size, reproductive success and breeding phenology at Santa Cruz Island colonies should continue to be gathered as part of a long-term monitoring program for this species in southern California. To date, baseline data have been gathered primarily in 1995-98 and 2005-08. Implementation of most restoration actions is anticipated in 2008-09. Continued monitoring should be conducted in 2009-11 at a minimum to gather 3 years of post-restoration data for assessing immediate responses to restoration actions and to check and modify restoration actions as needed. However, longer-term monitoring is needed to fully measure all population changes related to restoration and other conservation issues over time. We recommend that CINP coordinate with the Nature Conservancy and others to include monitoring of Ashy Storm-Petrels at Santa Cruz Island in the CINP seabird monitoring program and search for additional funds necessary to implement this monitoring in the future.

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Table 1. Field trips conducted in 2008 for Ashy Storm-Petrel nest monitoring and restoration, and skunk trapping activities at Santa Cruz Island, California.

Trip Number	**Field Dates**	**Locations**[1]	**Field Staff**	**Support Vessel**	**Main Activities**
2008-01	1 April	OR	B. McIver, L. Harvey, R. McMorran, J. Howard	*Miss Devin*	Deploy artificial sites and vocalization broadcast system
2008-02	25-26 April	CPCC, OR	L. Harvey, K. Moore, L. Morlock	*Miss Devin*	Deploy artificial sites
2008-03	16-17 June	BC, COBE, DSBC, CPCC, OR	B. McIver, H. Carter, A. Harvey, M. Hornfeck	*Miss Devin*	Nest Monitoring, Egg Collection, & Restoration Check
2008-04	19-20 June	CPCC	L. Harvey, K. Faulkner, J. Koepke, D. Mazurkiewicz	*Ocean Ranger*	Skunk Trapping
2008-05	22 June	CPCC	D. Black	CINP boat	Skunk Trapping
2008-06	24 June	CPCC	D. Black	CINP boat	Skunk Trapping
2008-07	28 June	CPCC	J. Dresser	IP boat	Skunk Trapping
2008-08	3 July	CPCC	L. Harvey	IP boat	Skunk Trapping
2008-09	17-18 July	BC, COBE, CPCC, DSBC, OR	B. McIver, L. Harvey, H. Carter, M. Hornfeck	*Miss Devin*	Nest Monitoring & Restoration Check
2008-10	12-13 August	BC, COBE, CPCC, DSBC, OR	B. McIver, L. Harvey, L. Koczur, M. Carter	*Miss Devin*	Nest Monitoring & Restoration Check
2008-11	8-9 September	BC, COBE, CPCC, OR	B. McIver, L. Harvey, M. Hornfeck, J. Turner	*Miss Devin*	Nest Monitoring & Restoration Check
2008-12	7 October	BC, COBE, OR	B. McIver, L. Harvey, H. Carter, D. Mazurkiewicz	*Miss Devin*	Nest Monitoring
2008-13	17 November	BC, COBE, OR	B. McIver, L. Harvey, C. Hand	*Miss Devin*	Nest Monitoring

[1] Abbreviations: BC (Bat Cave), COBE (Cave of the Birds' Eggs), CPCC (Cavern Point Cove Caves), DSBC (Dry Sandy Beach Cave), and OR (Orizaba Rock); CINP (Channel Islands National Park) and Islands Packers (IP).

Table 2. Hatching, fledging, and reproductive success of Ashy Storm-Petrel nests monitored at Santa Cruz Island, California, in 2008. Locations are coded: Bat Cave (BC); Cave of the Bird's Eggs (COBE); and Orizaba Rock (OR). Clutches are coded: 1, first and single; and 2, replacement. Sample sizes in parentheses.

		Location					
	Clutch	BC	COBE	OR[1]	OR[2]	Total[1]	Total[2]
Hatching Success	1	82.9% (35)	82.1% (28)	70.0% (20)	66.7% (24)	79.5% (83)	78.2% (87)
	2	100% (2)	100% (2)	33.3% (3)	33.3% (3)	71.4% (7)	71.4% (7)
Fledging Success	All	96.6% (29)	88.0% (25)	42.9% (14)	50% (16)	82.4% (68)	82.9% (70)
Reproductive Success	Last	84.8% (33)	78.6% (28)	31.6% (19)	34.8% (23)	70.0% (80)	69.0% (84)

[1] Natural nest sites only; [2] Natural and artificial nest sites.

Table 3. Timing of breeding (mean ± standard error in days) for Ashy Storm-Petrels at Santa Cruz Island, California, in 2005-08. Sample sizes of nests used for phenology calculations are shown in parentheses. Codes: Clutch 1 includes single and first eggs; clutch 2 includes replacement eggs.

Year	Clutch	Initiation	Hatch	Fledging
2005	1	14 June ± 2.6 d (81)	26 July ± 2.6 d (55)	8 Oct. ± 2.8 d (43)
	2	5 Aug. ± 10.6 d (3)	22 Sep. ± 13.5 d (2)	23 Nov. (1)
2006	1	11 June ± 3.0 d (61)	22 July ± 2.8 d (50)	8 Oct. ± 3.4 d (39)
	2	14 July (1)	--	--
2007	1	7 June ± 2.6 d (85)	14 July ± 2.6 d (59)	29 Sep. ± 1.5 d (52)
	2	17 Aug. ± 7.5 d (6)	17 Sep. (1)	--
2008	1	5 June ± 3.4 d (83)	12 July ± 3.5 d (66)	24 Sept. ± 3.1 d (52)
	2	3 Aug. ± 9.3 d (7)	20 Sept. ± 11.4 d (5)	30 Nov. ± 8.1 d (4)
2005-08	1	9 June ± 1.5 d (310)	18 July ± 1.5 d (230)	2 Oct. ± 1.4 d (186)
	2	7 Aug. ± 5.2 d (17)	20 Sep. ± 7.3 d (8)	28 Nov. ± 6.4 d (5)

(a)

(b)

(c)

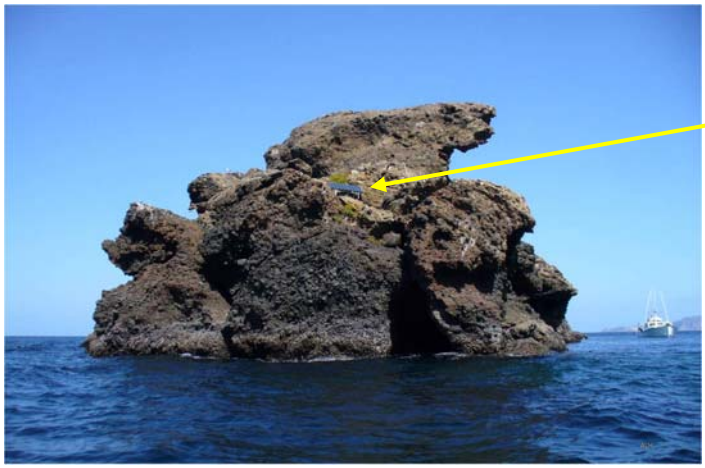

Figure 1. Vocalization broadcast system on Orizaba Rock, California: (a) tote box containing MP3 player and other equipment (photo by A.L. Harvey); (b) close-up of solar panel and tote box (photo by W.R. McIver); and (c) location of solar panel and tote box on west end of the rock (photo by A.L. Harvey).

(a)

(b)

Figure 2. Artificial nest sites on Orizaba Rock on 1 April 2008 (photos by W.R. McIver): (a) showing close proximity of artificial nest sites and audio speaker in the upper western cavern; and (b) showing pumice gravel pad of artificial nest site before the cement tile is placed over the pad.

(a)

(b)

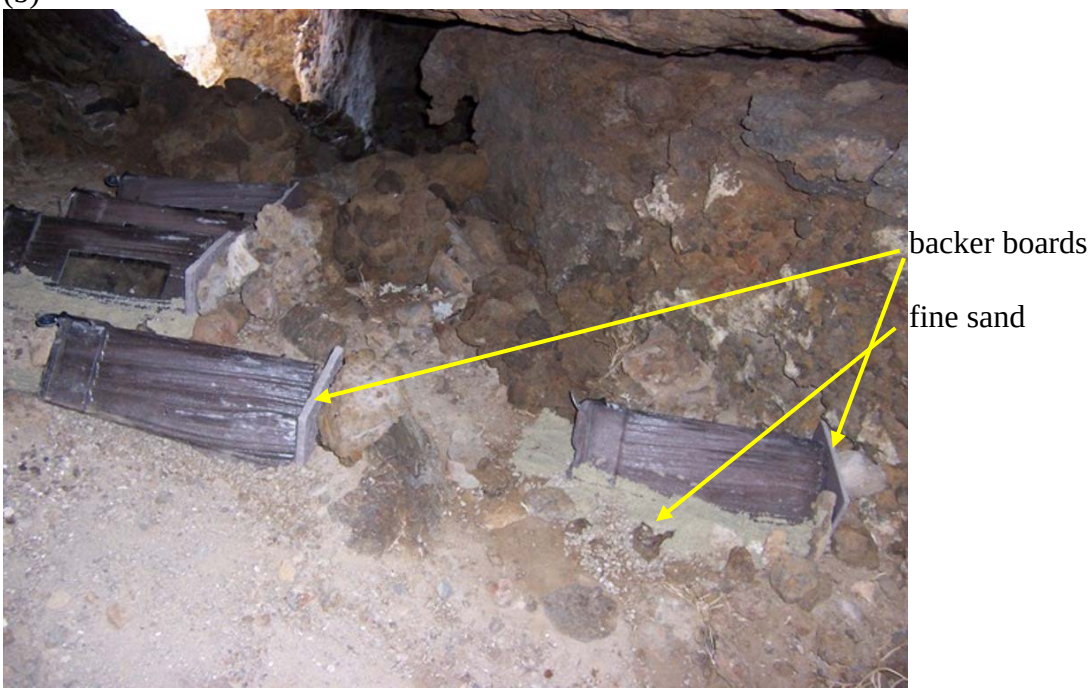

Figure 3. Artificial nest sites at Orizaba Rock (photos by W.R. McIver): (a) “Upper West Cavern” showing mirrors on the inward facing side of the site; and (b) “Upper East Cavern” showing backer boards and fine sand around site sides.

(a)

(b)

Figure 4. Photographs from Cavern Point Cove Caves (photos by A.L. Harvey): (a) six artificial nest sites in Cavern Point Cove Cave #4; and (b) one island spotted skunk captured on 3 July 2008 in live trap deployed in Cavern Point Cove Cave #5.

(a)

(b)

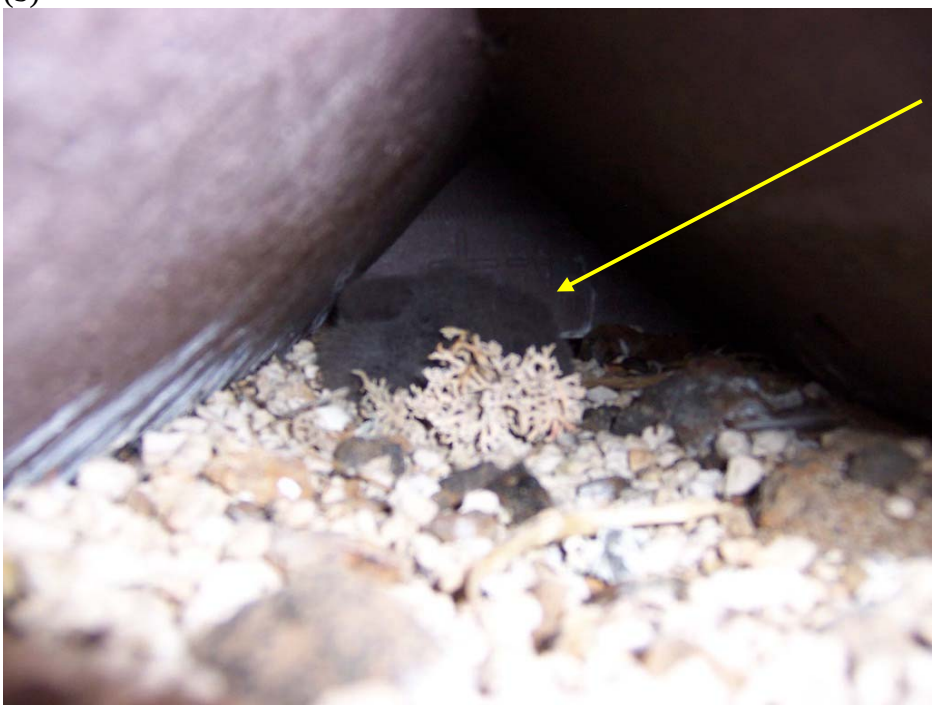

Figure 5. Artificial nest site “A-868” at Orizaba Rock (photos by W.R. McIver): a) 16 June 2008 - adult Ashy Storm-Petrel incubating an egg; and b) 13 August - large downy chick.