Monitoring and Restoration of Ashy Storm-Petrels at Santa Cruz Island, California, in 2011

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EXECUTIVE SUMMARY

In 2011, the U.S. Fish and Wildlife Service (Arcata Fish and Wildlife Office), Channel Islands National Park (CINP), and Carter Biological Consulting were funded by the Montrose Trustee Council to continue implementation of restoration actions and continue gathering data on population size and reproductive performance of Ashy Storm-Petrels (*Oceanodroma homochroa*) at Santa Cruz Island, California. Social attraction using vocalization broadcast was redeployed at Orizaba Rock, as done in 2008-10, but artificial nest sites used in 2008-10 were either replaced with ceramic nest chambers or entrances were modified to prevent access by Common Ravens (*Corvus corax*). Continued increase in colony size at Orizaba Rock occurred with a total of 33 egg-laying pairs documented in 2011 (i.e., 26 natural and 7 artificial). Reproduction or visitation in 2011 was apparently not affected at artificial sites by ravens, which disturbed some artificial sites in 2010. Breeding success at Orizaba Rock (55% of egg-laying pairs that fledged chicks, *n* = 29) in 2011 was lower than two main reference colonies at Bat Cave (90%, *n* = 58) and Cave of the Birds' Eggs (86%, *n* = 21). Similar to 2009-10, only two active sites occurred at Cavern Point Cove Caves in 2011, following an unusual heavy predation event by island spotted skunks (*Spilogale gracilis amphiala*) in 2008 that resulted in near extirpation of this colony. In contrast, numbers of active sites in Bat Cave continued to recover following a similar unusual skunk predation event in 2005. Dry Sandy Beach Cave was not monitored for breeding success in 2011; 17 egglaying sites were documented on 30 August. At three monitored reference colonies and Orizaba Rock, a total of 110 nests were found and monitored in 2011 with a combined breeding success of 79%, relatively high compared to 1995-97. Skunk traps were redeployed in 2011 at Bat Cave, Cave of the Birds' Eggs, and Cavern Point Cove Caves to prevent possible additional predation of storm-petrels by skunks, but no skunks were detected in these sea caves in 2011. CINP and The Nature Conservancy (TNC) signs deployed in 2009-10 to reduce human disturbance were replaced as needed. As in 2010 at Orizaba Rock, video and reconnaissance cameras were deployed relative to speaker areas, as well as to assess Ashy Storm-Petrel behaviors and document raven occurrence and activities, respectively. Automated acoustic monitoring devices (songmeters) were deployed for quantifying vocal activities of Ashy Storm-Petrels at Bat Cave, Cave of the Bird's Eggs, and Cavern Point Cove Caves.

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, McIver *et al*. 2009b). Although nesting was first documented at Santa Cruz Island in 1912 (Wright and Snyder 1913), knowledge of population size and distribution of Ashy Storm-Petrels at Santa Cruz Island increased dramatically during 1991-96 surveys by Humboldt State University (HSU) (Carter *et al*. 1992, 2007, *unpubl. data*). From 1995 to 2002, HSU also implemented standardized monitoring of population size (using nest counts), breeding success, breeding phenology, and predation at five locations at Santa Cruz Island, including Orizaba Rock, Bat Cave, Cavern Point Cove Caves (comprised of two adjacent caves: Cave #4 and Cave #5), 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 (USFWS) (Ventura Fish and Wildlife Office) and Carter Biological Consulting (CBC) continued monitoring at these locations (McIver and Carter 2006; Carter *et al*. 2007).

In 2002-05, the Montrose Trustee Council identified several seabird restoration concepts for implementation with funds obtained through litigation over long-term effects of organochlorine pollutants to wildlife (including raptors and seabirds) in the Southern California Bight (Montrose Settlements Restoration Program 2005). The need for restoration of 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 bright 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 an unusual predation event by island spotted skunks (*Spilogale gracilis amphiala*) in 2005 (McIver and Carter 2006; Carter *et al*. 2008a).

In 2006-07, CBC, USFWS (Ventura and Arcata Fish and Wildlife Offices), and Channel Islands National Park (CINP) were funded by the Montrose Trustee Council to: (a) continue nest surveys and monitoring for Ashy Storm-Petrels at five locations at Santa Cruz Island to provide pre-restoration baseline data on population size, breeding success, breeding phenology, and predation for developing a long-term monitoring program for restoration assessment; and (b) develop and test restoration techniques for larger-scale implementation in 2008 (Carter *et al*. 2007; McIver *et al*. 2008). 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; Bradley 2011). Prior to 2006, long-term monitoring of Ashy Storm-Petrels was focused at Southeast Farallon Island (Ainley *et al*. 1990; Ainley 1995; Sydeman *et al*. 1998a). A long-term monitoring program for Ashy Storm-Petrels in the Channel Islands, where at least half of the world population of Ashy Storm-Petrels breeds, also is a long-term goal for Channel Islands National Park (CINP) and other state and federal agencies (Carter *et al*. 1992, 2008a).

In October 2007, the Center for Biological Diversity petitioned the Secretary of the Interior and USFWS to list the Ashy Storm-Petrel as threatened or endangered under the Endangered Species Act of 1973 (hereafter "Act"). In response to this petition, a 90-day finding was published in May 2008 (USFWS 2008) stating that listing under the Act may be warranted with initiation of a status review. The status review, published on August 19, 2009 (74 Federal Register 41832), found that listing the Ashy Storm-Petrel under the Act was not warranted at that time.

In 2008-09, USFWS (Arcata Fish and Wildlife Office), CINP, and CBC were funded by the Montrose Trustee Council to: a) continue annual monitoring work to gather data on population size, breeding success, breeding phenology, and predation of Ashy Storm-Petrels at Orizaba

Rock and four sea caves at Santa Cruz Island; b) deploy social attraction (i.e., vocalization broadcasting) and artificial nests at Orizaba Rock; c) deploy skunk traps in sea caves to prevent or reduce further predation of Ashy Storm-Petrels by island spotted skunks (2009 only); d) deploy signs at sea caves to prevent or reduce unauthorized human access (2009 only); and e) lead public outreach to educate CINP visitors and staff regarding impacts to storm-petrel colonies due to human disturbance.

In 2010, USFWS (Arcata Fish and Wildlife Office), CINP, CBC, and Simon Fraser University (SFU) were funded by the Montrose Trustee Council to continue restoration and monitoring activities as conducted in 2008-09. In addition, we: a) evaluated Ashy Storm-Petrel nocturnal behaviors in relation to social attraction techniques; b) evaluated future recruitment and visitation of Ashy Storm-Petrels by initiating a chick PIT-tag banding project; c) evaluated storm-petrel visitation to and attendance of artificial nest sites using temperature loggers; d) deployed signs at Orizaba Rock to prevent or reduce unauthorized human access; and e) gathered data on vocalization levels using acoustic monitoring devices ("songmeters").

In 2011, USFWS (Arcata Fish and Wildlife Office), CINP, and CBC were funded by the Montrose Trustee Council to continue the restoration and monitoring activities as conducted in 2008-10, with modifications as described in this report.

METHODS

Nest Monitoring

In June-November 2011, standardized methods (see McIver and Carter 1996, 2006; McIver 2002) were used during monthly field trips 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 (CBE), Cavern Point Cove Caves (CPC; comprised of two adjacent caves: Cave #4 and Cave #5), Dry Sandy Beach Cave (DSB), and Orizaba Rock (OR) (Figure 1). Nest monitoring in 2011 commenced at OR on 3 June, and at BC on 10 June; CBE and CPC were not visited in early June due to inclement weather (Table 1). All locations were visited for 1-5 hours during each monthly field trip on 29-30 June, 30-31 July, 30-31 August, 22-23 September and 18 October, with the exception of DSB, which was visited only on 30 August. BC, CBE and OR also were visited on 8 November to monitor remaining nests with late-season chicks. All field trips to and accommodations at Santa Cruz Island were provided aboard the charter boat *Miss Devin*, operated by R. Fairbanks (Lompoc, California), except for the 10 June trip, which was conducted with the assistance of the charter boat *Fuji III*, operated by F. Mize, (Ventura, California). Nesting habitats were accessed from a 14-foot (4.3 m) inflatable boat powered by a 15 or 20 horsepower outboard engine launched from the charter boat.

A storm-petrel nest was defined as a crevice, cavity, or depression containing definite evidence of egg laying (i.e., a whole egg, numerous eggshell fragments [i.e., at least one quarter of an egg which was considered sufficient to ensure that it represented a new egg and did not represent leftover fragments of an earlier egg in the same year or from previous years], or a chick). A nest was described as being used if evidence of egg laying was observed, and a nest was described as

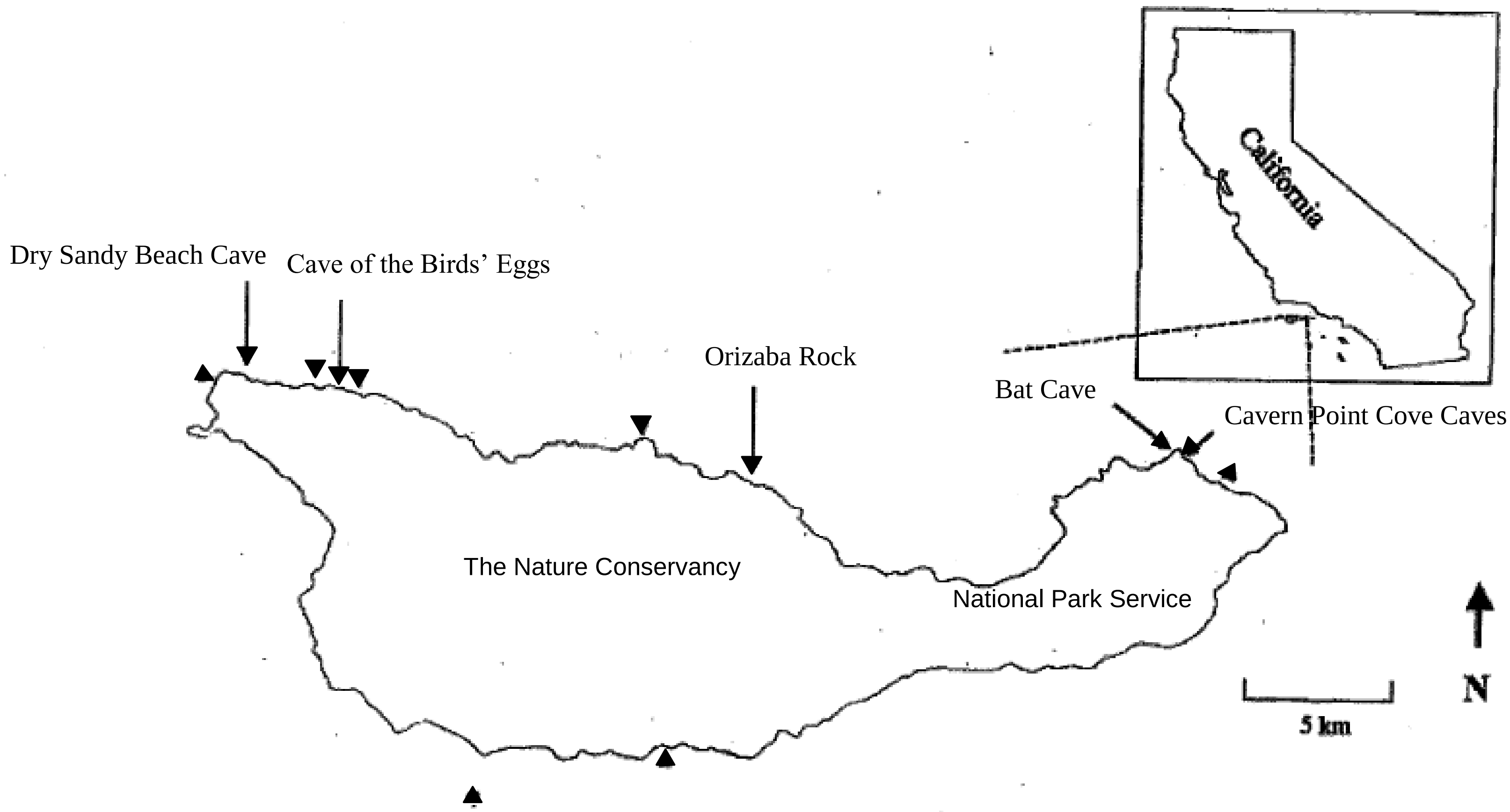


Figure 1. Breeding locations of Ashy Storm-Petrels at Santa Cruz Island, California, indicated by triangles. Monitoring and restoration locations examined in 2011 are named (see text).

Table 1. Field trips conducted in 2011 for Ashy Storm-Petrel monitoring and restoration at Santa Cruz Island, California.

Field Trip Dates	Locations[1]	Field Crew	Main Activities
31 March-1April	CBE, OR	L. Harvey, A. Little, W. McIver, A. Yamagiwa	Deploy skunk traps at CBE; deploy social attraction, infrared cameras, & iButtons at OR; replace 13 artificial nest sites at OR.
3 June	OR	H. Carter, L. Harvey, W. McIver, A. Yamagiwa	Monitor sites; social attraction check; deploy video camera, initiate behavior filming, & swap iButtons.
10 June	BC, OR	S. Carr, A. Harvey, M-E. Jacques, D. Mazurkiewicz, S. Thomsen	Monitor sites at BC; deploy skunk traps, camera, & songmeter at BC; deploy artificial nest entrance modifiers at OR.
29-30 June	BC, CBE, CPC, OR	H. Carter, M-E. Jacques, A. Little, W. McIver	Monitor sites; deploy traps; check traps, songmeters, iButtons, cameras & social attraction
30-31 July	BC, CBE, CPC, OR	H. Carter, D. Cooper, W. McIver, J. Turner	Monitor sites; check traps, songmeters, iButtons, cameras, & social attraction
30-31 August	BC, CBE, CPC, DSB, OR	K. Barnes, H. Carter, A. Harvey, W. McIver	Monitor sites; check traps, songmeters, iButtons, & cameras; check & turn off social attraction
22-23 September	BC, CBE, CPC, OR	K. Carter, A. Harvey, A. Little, D. Mazurkiewicz, W. McIver	Monitor sites; check traps, songmeters, remove iButtons, & cameras; remove social attraction
18 October	BC, CBE, CPC, OR	S. Auer, H. Carter, I. Fox-Fernandez, W. McIver, R. Weems	Monitor sites; remove traps, & cameras
8 November	BC, CBE, OR	S. Auer, K. Barnes, A. Harvey, D. Mazurkiewicz	Monitor late sites with chicks

being visited if a bird but no evidence of egg laying was observed. At some crevices, no direct evidence of egg laying was found, although it is possible that a few eggs may have disappeared before our detection. We searched for and examined nests with the aid of headlamps, small flashlights, and maps adapted from Bunnell (1988). Each nest or suspected nest (i.e., in some cases, an adult in incubating position was present and presence of an egg could not be directly detected) was mapped and marked with an individually numbered aluminum or plastic tag. All nest contents were recorded for each marked nest on each visit. Because storm-petrels can be sensitive to disturbance at nest sites (Ainley *et al*. 1990), we did not handle adults, incubated eggs, or brooded chicks. Stages of chick plumage development (and associated approximate chick ages), as defined in McIver and Carter (1996) and McIver (2002), were recorded during nest monitoring. Evidence of predation or possible predation was recorded as carcasses, feather piles and broken eggs (possibly from predation, but possibly not); all of which were removed to facilitate detection of replacement eggs and prevent double counting.

Breeding phenology was estimated for each nest (i.e., timing of initiation [egg-laying], hatching, and fledging) using methods described in McIver and Carter (1998). Over the course of 2006-11, these methods have been updated as necessary and appropriate; revised methods will be provided in a separate report (McIver *et al*., in prep.).

Social Attraction and Artificial Nest Sites

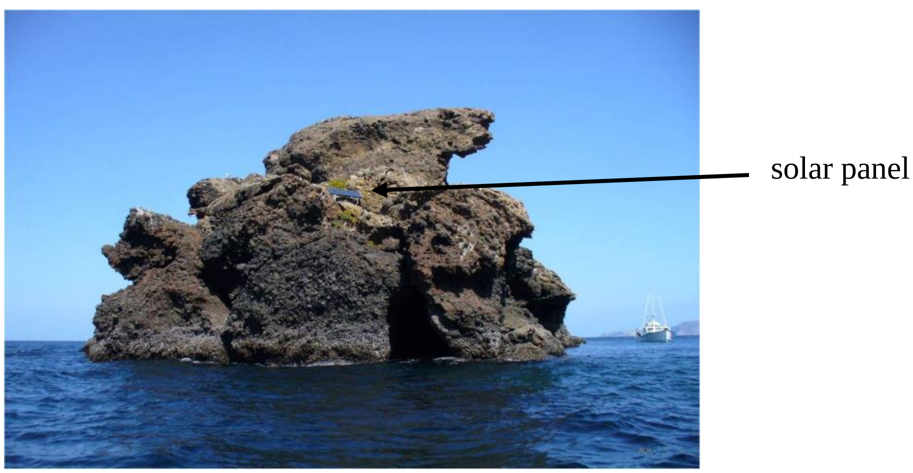
Artificial nest sites and social attraction equipment first were deployed at OR in 2008 (McIver *et al*. 2009a). A single vocalization broadcast system with two speakers was used that had been developed previously by the National Audubon Society and has been used widely for social attraction purposes (e.g., Parker *et al*. 2007). 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 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 2a). 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 2b and 2c). The vocalization broadcast equipment in the tote box was wired to two speakers, one placed in the "Upper West Cavern" and the other in the "Lower Cavern."

In response to corvid impacts to artificial nest sites in 2010 (McIver *et al*. 2011), we replaced 13 concrete roof tile sites with 13 newly-designed ceramic nests on 31 March 2011. Twelve of these ceramic nests were located on the floors of the Upper West Cavern (n = 5) and Upper East Cavern (n = 7) and one ceramic nest was located on a ledge in the northeastern portion of the Upper West Cavern. Each ceramic nest was made of clay fired at high temperatures for durability. Each ceramic nest had one entrance hole, which was large enough to allow storm-petrels to enter the front of nest chamber before turning around a small wall to reach the back of the chamber where the egg usually is incubated. This internal wall concealed nest contents from direct viewing and physical access by avian predators through the entrance opening (Figure 3a).

Due to variability in contraction rates of clay during firing, nest entrance dimensions were not standardized. However, based on advice from potters, we anticipated that clay nests would contract approximately by about 10%, post-firing. Therefore, for each artificial site we attempted to make the entrance width (post-firing) no greater than and as close as possible to 5 cm, the width of nest entrances of artificial nests built for monitoring of Ashy Storm-Petrels at Southeast Farallon Island, as described in Ainley *et al*. (1990). In this way, we attempted to exclude possible use of artificial nest sites by larger crevice-nesting Cassin's Auklets (*Ptychoramphus aleuticus*), which also nest at OR. In addition, each ceramic nest was equipped with a removable

(a)

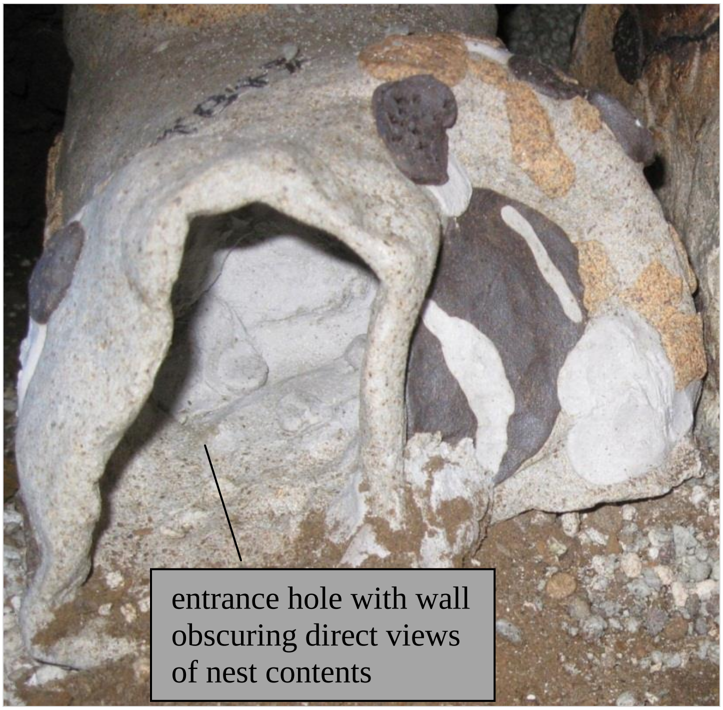
(b)



(c)

Figure 2. 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)

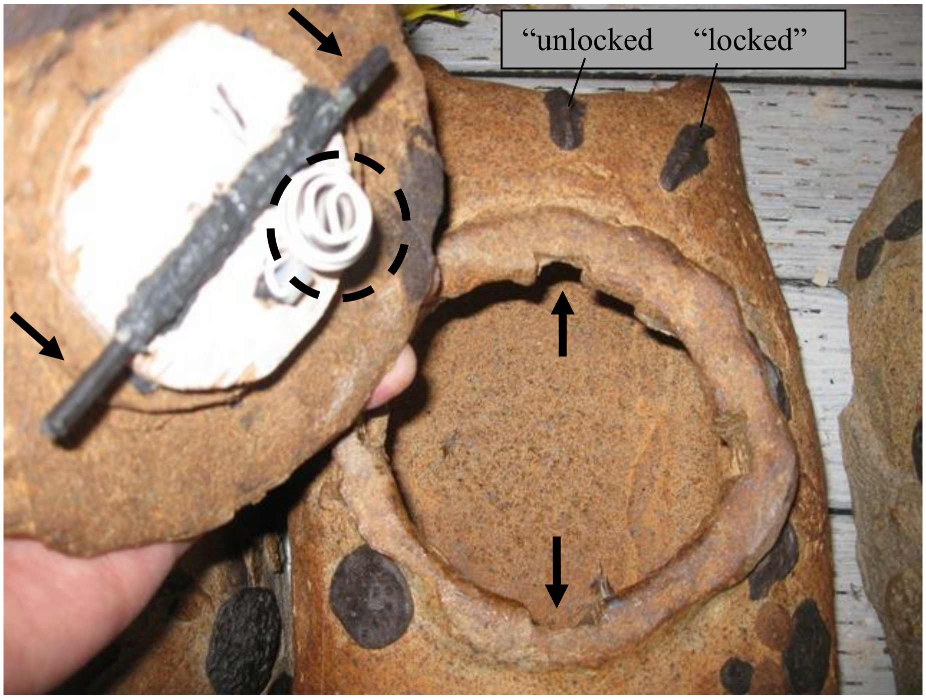


Figure 3. Ceramic nest chamber and removable lid showing (a) nest entrance; and (b) ceramic pieces indicating "locked" and "unlocked" lid positions, metal flanges on inside of removable lid (arrows), slots into which flanges fit (arrows), and wire for attaching iButton temperature loggers (dashed circle). (Photos by W. McIver)

lid for researchers to view and access nest contents. Each lid was secured to the nest chamber body by metal flanges that were glued with epoxy to the inside of each lid, and which fit into slots in the top of the nest body; the lid was then rotated slightly to either a "locked" or "unlocked" position, as necessary, and as indicated by small ceramic markers on the outside of the nest body (Figure 3b). A small piece of coiled electrical wire was attached to the inside of each removable lid, to secure iButton temperature loggers (Figure 3b; see below). A thin (~ 2 cm thick) layer of a mixture of sand and pumice was placed in each ceramic nest for nesting substrate. On 10 June, two ceramic pieces were attached (with Velcro strips) to the front of each concrete roof tile nest located on the ledge of the Upper West Cavern to reduce direct viewing of nest contents by avian predators, similar in function of the small walls in ceramic nest chambers (Figure 4).

Monitoring Cavern Visitation of Ravens

As in fall 2010, three reconnaissance cameras (model HC500 Hyperfire, RECONYX Inc., Holmen, WI) were redeployed in the upper caverns at OR in 2011 to capture images of any ravens visiting the caverns, depredating storm-petrels or altering artificial nest sites. The cameras were active day and night, and images were taken when cameras were motion-activated within the field of view; they were pre-programmed to take three images within three consecutive seconds before re-setting. Two cameras were deployed in the Upper West Cavern, where the majority (n = 22) of the artificial nest sites had been deployed, and one camera was deployed in the Upper East Cavern.

In the Upper West Cavern, "middle" camera was deployed on 31 March on a small boulder in the middle of the cavern; the lens of this camera was oriented in a westerly direction, with a field of view including three artificial nest sites (A-864, A-865, A-866) located on the floor of the cavern, the west entrance of the cavern, portions of both the southern and northern walls of the cavern, boulders outside of the west entrance, and the ocean between OR and the main island (Figure 5). The "west" camera was deployed on 10 June on a boulder adjacent to the west entrance of the cavern; the lens of this camera was oriented in a northeasterly direction, with a field of view including seven artificial nest sites on the north wall ledge (A-850, A-852, A-853, A-855, A-856, A861, A-863), and the northern entrance to the cavern (Figure 6). We removed both of these cameras on 8 November. In the Upper East cavern, the "east" camera was deployed on 31 March on a wall directly east of the eastern entrance of the cavern; the lens of this camera was oriented in a westerly direction, with a field of view including five artificial nest sites on the floor (A-868, A-869, A-870, A-871, A-890), an artificial site located on the ledge (A-849), and the east entrance of the cavern (Figure 7). We removed the "east" camera on 8 November. For all observations of raven and gull from reconnaissance camera images, we recorded date, time duration (to the nearest second) and number of photos taken during "visitations," specific reconnaissance camera used, numbers of birds, and behavior of the birds (Appendix A).

Recruitment Study

To better understand how the OR colony and sea cave colonies are sustaining themselves over the long term, we continued methods begun in 2010 using passive integrated transponder (PIT)

Figure 4. Ceramic pieces attached to front end of concrete roof tiles on ledge of Upper West Cavern at Orizaba Rock in 2011. These pieces allowed storm-petrels to access nest sites but reduced direct viewing of nest contents and were designed to prevent nest access by Common Ravens. (Photo by L. Harvey)

Figure 5. Typical daytime image and field of view captured from the "middle" camera, deployed to capture images of ravens entering the west entrance of the Upper West Cavern at Orizaba Rock in 2011.

Figure 6. Typical daytime image and field of view captured from the “west” camera, deployed to photogragh raven activity at artificial nest sites on the ledge in the Upper West Cavern at Orizaba Rock in 2011.

Figure 7. Typical daytime image and field of view captured from the “east” camera, deployed to photograph raven activity in the Upper East Cavern at Orizaba Rock in 2011.

technology to examine future recruitment of Ashy Storm-Petrels at artificial and natural sites at OR, and at natural sites in sea caves. PIT-tags (Model TX1400ST; Biomark, Inc., Boise, ID), are durable microchips that emit a unique identification signal (ID) and a time/date stamp when in range of an appropriate antenna. PIT-tags were incorporated into bands that were attached to chicks, with special approval from the U.S. Geological Survey's (USGS) Bird Banding Laboratory (Laurel, MD) which permitted attachment of PIT-tag bands to 250 chicks. Following methods described in Zangmeister *et al*. (2009), each tag was encased in a length of 1.6 mm diameter electrical shrink tubing that was slightly longer than the length of the tag (~1.2 cm) and attached to two plastic black bands (size XCSD Darvic; Avinet Inc., Dryden, NY) at the edge of the tubing (Figure 8). A small amount of quick-drying glue was applied to secure the PIT-tag/shrink tubing assembly to the plastic bands and to encase the shrink tubing. In 2011, PIT-tag bands were modified slightly, compared to 2010, so that both plastic bands were adjacent to each other with no intervening space between the bands (Figure 8). As in 2010, one PIT-tag band would be attached to either the left or right tarsus of each accessible chick and the unique ID number would be read with a scanner (APR350 Reader, Agrident GmbH, Barsinghausen, Germany) and recorded on the corresponding nest monitoring data form. Each handled chick (with the exception of two chicks banded with PIT-tags only, in October 2011) was also banded with a uniquely-numbered stainless steel/aluminum U.S. Geological Survey band (size 1B). We estimate that each chick was handled for less than 5 minutes; immediately after banding, each chick was returned to its nest site.

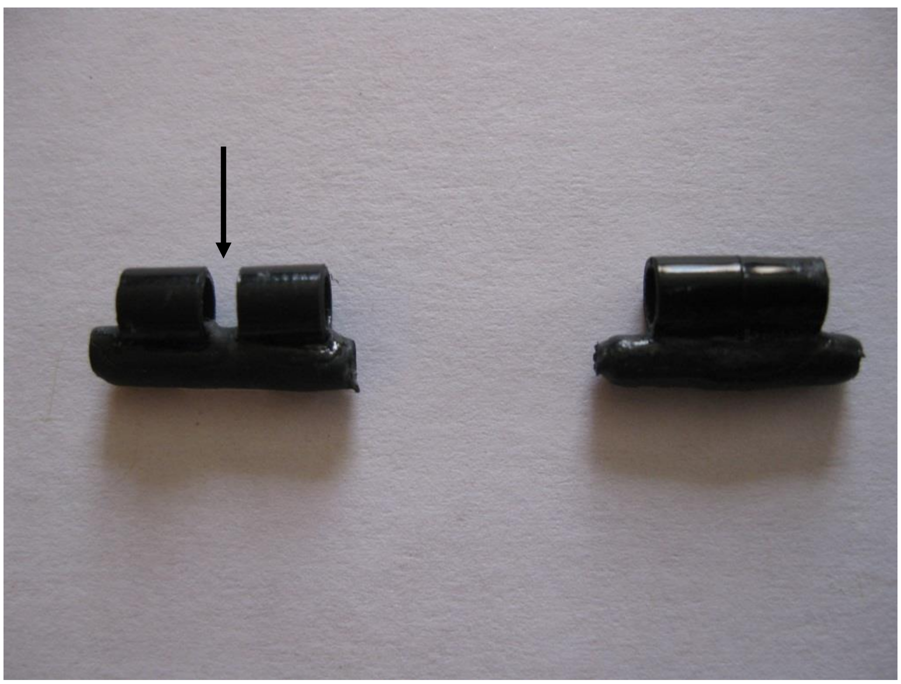


Figure 8. PIT-tag bands used in 2010 (left) and 2011 (right) on Ashy Storm-Petrel chicks at Santa Cruz Island, California. The PIT-tag band in 2011 was modified to reduce the space between the bands (arrow) on the PIT-tag band used in 2010. PIT-tag bands generally measured approximately 12-13 mm in length. (Photo by W. McIver)

In spring 2011, personnel at the U.S. Geological Survey's Bird Banding Laboratory, Laurel, MD, USA, expressed concerns about external PIT-tag attachment and possible (though not documented) negative effects of external PIT-tag bands on Ashy Storm-Petrel chicks; they recommended implementation of a sub-cutaneous implantation technique, if possible, instead of external PIT-tag attachment method. Consequently, we developed a protocol that described the implantation of PIT-tags into Ashy Storm-Petrels (Appendix B), to be attempted beginning in August 2011.

Artificial Nest Site Visitation by Storm-Petrels

In 2011, temperature loggers (iButton model #1922L, Embedded Data Systems, Lawrenceburg, KY) were placed in 27 artificial nest sites (one iButton per nest site) and in the open at four distinct locations (one iButton per location) in the upper caverns at OR to evaluate visitation and attendance of artificial nest sites by Ashy Storm-Petrels. Temperature loggers were not deployed in three artificial nest sites (A-858, A-859, A-860) because they could not be securely deployed. For concrete tile nests on the ledge of the Upper West Cavern, a small Velcro strip was glued to each iButton, which allowed the iButton to be attached to and removed from a long and thin prod, inserted into each artificial nest site. In each newly-deployed ceramic nest, an iButton was suspended within a small piece of coiled electrical wire attached to the lid (see Figure 2c). In addition, four iButtons were attached to Velcro pieces to the outside surfaces of three artificial nest sites (A-855, A-864, A-869) and a small rock (near site A-1069) to measure ambient temperatures in the caverns. Based on the chip memory capacity of iButton model #1922L and approximately month-long deployment time, each iButton was pre-programmed to take a temperature reading once every 22 minutes. Each iButton was accurate to within 0.9° F, per manufacturer specifications. Temperature loggers were initially deployed on 3 June, and on each subsequent nest-monitoring field trip (until 22 September) each previously-deployed iButton was replaced with an iButton with sufficient available memory.

Protection from Predation by Island Spotted Skunks

As in 2009 and 2010 (see McIver *et al*. 2010, 2011), lethal "body-grip" skunk traps (model 220 Conibear trap, Oneida Victor Inc. Ltd., Euclid, OH) were set inside protective custom-made wooden boxes (approximate box dimensions: 19 cm x 19 cm x 50 cm) and deployed at BC, CBE, and CPC in 2011 (Figure 9). After deployment, trap boxes were examined on each field trip in 2011 to detect any trapped skunks (or non-target entrapment), ensure proper functioning of traps and boxes, and to replace bait. Traps, protective boxes, and bait were removed from the sea caves during the October field trip.

Human Visitation

Signs prohibiting the entry of sea caves by tourists were deployed at four sea caves (BC, CPC, CBE, and DSB) in 2009 and also at OR in 2010 (McIver *et al*. 2010, 2011). These signs were refurbished, as needed, in 2011.

(a)

(b)

(c)

Figure 9 (a-c) Body-grip skunk trap (model 220 Conibear trap, used to trap island spotted skunks in sea caves at Santa Cruz Island, California, placed within protective box (photos by A.L. Harvey). Photos taken in 2009.

Video Monitoring of Nocturnal Storm-Petrel Behaviors

In 2010, a proposed 2-year study was initiated to gather information from nocturnal video footage of Ashy Storm-Petrels to assist evaluation of the efficacy of vocalization broadcasting in attracting Ashy Storm-Petrels (see Appendix A in McIver *et al*. 2011). In 2011, this study was discontinued, but infrared video cameras were again deployed at the Upper West Cavern to gather data using an experimental design with broadcast vocalizations turned off for one night during new moon periods for comparison to the following few nights with the broadcast vocalizations turned on. Frequencies and types of storm-petrel behaviors with and without broadcast vocalizations can be evaluated and compared with archived footage. Data were archived at CINP for future analysis.

From June to October 2011, two automated infrared video camera systems (different than the reconnaissance cameras) were deployed in separate caverns at OR (Upper West Cavern and "Lower Cavern"), and one camera was deployed at BC. Each camera system consisted of a main housing unit built into a large Pelican case containing a digital video recorder (MDVR25; Supercircuits, Austin, TX), a 12v lead acid battery and a power supply timer unit (see Appendix A in McIver *et al*. 2011 for details). The housing units contained the bulk of the recording equipment. A small infrared security camera (Supercircuits PC168 IR Camera) and a weatherproof microphone (Supercircuits ETS SM1-W) were attached to concealed cables leading back to the unit. By storing the bulk of the recording equipment away from filming areas used frequently by storm-petrels, minimal disturbance to storm-petrels occurred. Cameras were mounted on wooden blocks and attached to the walls of the lower cavern and upper west cavern at OR. At BC a camera was mounted to a tripod and secured firmly in place for the duration of the breeding season. Each camera was pre-programmed to record for 4 hours each night between 22:30 h to 02:30 h, within a few days of the new moon each month. Data were collected for several days before the battery power became too low for operation. Cameras recorded the same area at each colony for each deployment from April through August 2010.

Vocalization Study

In collaboration with the University of California Santa Cruz (UCSC), we deployed automated acoustic monitoring devices (Songmeter-2, Wildlife Acoustics Inc., Concord, MA) in BC, CBE and CPC from April through October 2011 to record Ashy Storm-Petrel vocal activity levels each night. For later analyses, the number of nests with incubated eggs or chicks at BC, CBE, and CPC will be estimated for each ten day block from April through November.

Data Handling and Descriptive Statistics

Like other procellariids, Ashy Storm-Petrels are highly philopatric and typically each pair only lays one egg per year, and replacement eggs are uncommon (Ainley 1995). Therefore, to account for various possible egg-laying scenarios within the same breeding season, we categorized egg-laying attempts in the following manner. Within a nesting season, if only one egg was laid in a nest site, it was categorized as a "single" egg. When a second egg was found in the same nest site where a previous egg (i.e., "first") had been laid earlier but failed, we considered it to be a replacement egg by the same breeding pair. In the rare event that another egg was found in the same nest site where an egg had been laid and successfully fledged a chick, we considered this egg as a single egg laid by a second breeding pair.

Hatching success was defined as the percentage of single/first eggs hatched per egg laid for each breeding pair where egg fate was known. For fledging success and breeding success, we quantified the final breeding effort for each breeding pair, using single and replacement eggs (also referred to as "last eggs"). Fledging success was defined as the percentage of last chicks fledged per last chick hatched for each breeding pair where last chick fate was determined. Breeding success was defined as the percentage of last chicks that fledged per last egg laid. Since it is based upon hatched chicks only, fledging success has the smallest sample size of breeding pairs. For hatching, fledging, and breeding success, we excluded a few breeding pairs for which egg or chick fates were not known.

Descriptive statistics for breeding phenology (i.e., timing) for laying, hatching and fledging are presented separately for single/first eggs versus replacement eggs. Methods for estimating breeding phenology and hatching, fledging, and breeding success of Ashy Storm-Petrels from monthly data are described in McIver and Carter (1996, 1998) and McIver *et al*. (2010, in prep.). Numbers of active nests containing chicks and observed chick stages (as described in McIver and Carter [1996, 1998]) during the 30-31 August fieldtrip are described for each location, for evaluation of timing of breeding at DSB.

RESULTS

Breeding Phenology

Mean dates of egg laying, chick hatching and chick fledging in natural and artificial nest sites at each monitored location at Santa Cruz Island are summarized in Table 2. In 2011, estimated average laying dates in natural crevices (all locations [except DSB] combined) ranged from 21 April to 31 August for single/first eggs (*n* = 107) versus 12 July to 24 August for replacement eggs (*n* = 7). Laying dates for artificial nest sites at OR ranged from 31 May to 15 July (*n* = 7 single eggs). Hatch dates in natural crevices (all locations [except DSB] combined) ranged from 4 June to 15 October for single/first eggs (*n* = 89) versus 25 August to 7 October for replacement eggs (*n* = 4). Hatch dates in artificial nest sites at OR ranged from 14 July to 19 August (*n* = 6 single eggs). Fledging dates for natural crevices (all locations [except DSB] combined) ranged from 23 August to 18 December for chicks from single/first eggs (*n* = 80), versus 13 November to 6 December for chicks from replacement eggs (*n* = 3). Fledging dates for artificial sites at OR ranged from 3 October to 7 November for chicks from single eggs (*n* = 4). At DSB, we had only one visit in August and used 12 nests with chicks for estimating lay and hatch dates from estimated chick ages. Lay dates ranged from 10 May to 22 June. Hatch dates ranged from 23 June to 5 August. The 12 chicks observed in DSB on 30 August ranged from "small gawky" to "mostly feathered"; average projected date of fledge for these chicks, assuming all survived, was 10 October ± 4 d (chick descriptions, estimated ages and value for fledge as described in McIver and Carter [1998]).

Bat Cave

Ashy Storm-Petrel: Sixty-one nests were documented at BC in 2011. Fifty-eight active nests were observed on 31 August; 53 of these nests (91%) contained chicks, ranging from "large downy" to "fully-feathered" for plumage development. Hatching, fledging and breeding success were 85% (*n* = 61), 100% (*n* = 55), and 90% (*n* = 58), respectively (Table 3). As in 2010, storm-petrel footprints were observed in fine sand at: a) the top of the front slope in the main room; b) at the top of the large slope in the slope room; and c) at the top of the slope outside the cave (near tag #746).

Evaluation of Storm-Petrel Nocturnal Behaviors: On 10 June, an infrared video camera was deployed in the main room near storm-petrel nests among driftwood. Data from the camera were downloaded monthly until October, when we removed the camera. Video data have been archived at CINP.

Evaluation of Storm-Petrel Vocalizations: On June 10, a songmeter was deployed in the main room near storm-petrel nests occurring among driftwood. Data from the songmeter were down loaded every 1-2 months and the songmeter was removed in November. Acoustic data have been archived at CINP.

Brandt's Cormorant (*Phalacrocorax penicillatus*): On 31 July, two adults were observed on a cliff ledge adjacent to and about 50 m northwest of the cave entrance.

Table 2. Average timing of breeding (mean date ± standard error in days) for Ashy Storm-Petrels at five locations at Santa Cruz Island, California, in 2011[a]. Sample sizes of eggs used for phenology calculations are shown in parentheses. Location abbreviations are in Table 1. Clutch codes: 1, single and first eggs combined; 2, replacement eggs.

Location	Clutch	Initiation	Hatch	Fledging
BC	1	7 June ± 3 (60)	20 July ± 3 (52)	6 October ± 3 (49)
BC	2	20 July ± 8 (3)	2 September ± 8 (3)	21 November ± 8 (3)
CBE	1	15 June ± 7 (22)	30 July ± 7 (19)	13 October ± 6 (18)
CBE	2	19 August (1)	-	-
CPC	1	2 July (1)	16 August (1)	3 November (1)
DSB[b]	1	8 June ± 4 (12)	22 July ± 4 (12)	-
OR[c]	1	29 June ± 7 (24)	8 August ± 8 (17)	17 October ± 9 (12)
OR[c]	2	4 August ± 20 (2)	7 October (1)	-
OR[d]	1	15 June ± 7 (7)	24 July ± 7 (6)	18 October ± 10 (4)
All[e,f]	1	14 June ± 3 (114)	25 July ± 3 (95)	9 October ± 3 (84)
	2	30 July ± 8 (6)	11 September ± 10 (4)	21 November ± 8 (3)

[a] Sample sizes at locations in Table 2 may differ from sample sizes at the same locations in Table 3, primarily because nests with a wide range of possible egg laying dates (> 30d) were excluded from Table 2, but included in Table 3.
[b] Using nests with chicks only, but fledging dates not estimated.
[c] Natural crevices only.
[d] Artificial sites only.
[e] DSB not included.
[f] MHD of all natural sites at Santa Cruz Island (n = 89) was also 25 July ± 3 d.

Table 3. Percent hatching, fledging, and breeding success[a] of Ashy Storm-Petrel nests monitored at Santa Cruz Island, California, in 2011. Location abbreviations are in Table 1[b]. Clutch codes/descriptions: 1 = first and single eggs; 2 = replacement eggs; and Last = all single and replacement eggs. Sample sizes in parentheses.

		Location							
	Clutch	BC	CBE	CPC	DSB[c]	OR[d]	OR[e]	All[d,f]	All[e,f]
Hatching Success (%)	1	85.2 (61)	87.5 (24)	50.0 (2)	70.6 (17)	65.4 (26)	69.7 (33)	80.5 (113)	80.8 (120)
	2	100.0 (3)	0 (1)	-	-	50.0 (2)	50.0 (2)	66.7 (6)	66.7 (6)
Fledging Success (%)	Last	100.0 (55)	94.7 (19)	100.0 (1)	-	85.7 (14)	80.0 (20)	96.6 (89)	94.7 (95)
Breeding Success (%)	Last	89.7 (58)	85.7 (21)	50.0 (2)	-	54.5 (22)	55.2 (29)	80.6 (103)	79.1 (110)

Footnotes -

[a] Hatching success defined as the percentage of single/first eggs hatched per egg laid for each breeding pair where egg fate was known; fledging success defined as the percentage of last chicks fledged per last chick hatched for each breeding pair where chick fate was determined; and breeding success defined as the percentage of last chicks that fledged per last egg laid, where egg and chick fates were known.

[b] Sample sizes at locations in Table 2 may differ from sample sizes at the same locations in Table 3, primarily because nests with a wide range of possible egg laying dates (> 30d) were excluded from Table 2, but included in Table 3.

[c] DSB visited only once in 2011, so only hatching success was estimated.

[d] Natural crevices only.

[e] Natural and artificial sites.

[f] DSB not included.

Scripps's Murrelet (Synthliboramphus scrippsi): No nests were found in 2011.

Predation: Three skunk traps were deployed on 10 June and removed on 18 October. No evidence that skunks (or any other mammal or bird) entered trap boxes was found. No smell of skunk presence or other evidence of skunk predation was found in 2011. Small numbers of Ashy Storm-Petrel eggshell fragments were found away from suitable nest sites, as follows: 30 June — 2 broken eggs, 1 partial eggshell fragment; 31 July — 1 broken egg, 4 partial eggshell fragments; and 31 August — 3 partial eggshell fragments. These eggshells indicated either: (a) scavenging or predation by deer mouse (*Peromyscus maniculatus santacruzae*) inside nest sites with mice removing some eggshells from nest sites; (b) scavenging by mice of eggshells found outside nest sites; or (c) removal of eggshells from nest sites by some adult storm-petrels after eggs hatch or fail.

Human Disturbance: CINP signs prohibiting cave entry by tourists were deployed inside both the main room and slope room in 2009. In 2011, these signs were intact and in their original locations (i.e., unaffected by ocean wave action or human vandalism). No evidence of human disturbance or non-researcher human visitation was detected in 2011.

Cave of the Birds' Eggs

Ashy Storm-Petrel: Twenty-four nests were documented at CBE in 2011. Twenty-two active nests were observed on 30 August; 17 of these nests (77%) contained chicks, ranging from "large downy" to "fully-feathered" for plumage development. Hatching, fledging, and breeding success were 87% (n = 24), 95% (n = 19), and 86% (n = 21), respectively (Table 3).

Evaluation of Storm-Petrel Vocalizations: On 29 June, a songmeter was deployed in the main room near storm-petrel nests, but a bit further inside the cave than placed in 2010. Data from the songmeter were down loaded every 1-2 months and the songmeter was removed in October. Acoustic data have been archived at CINP.

Black Oystercatcher (*Haematopus bachmani*): One adult attended a potential nest site on cliffs outside of and adjacent to the cave on 29 June.

Western Gull (*Larus occidentalis*): Six nest sites were observed on cliffs outside of and adjacent to the cave on 29 June.

Pigeon Guillemot (*Cepphus columba*): Birds were recorded sitting on the water within the cove adjacent to the cave entrance, as follows: a) 29 June — 15-20 adults; b) 30 July — 12 adults; c) 30 August — no information recorded; and d) 22 September — 0 adults observed. Twelve nests (*i.e.*, evidence of egg laying) were documented in 2011; 6 nests hatched at least one egg and 2 nests appeared to fledge at least one chick (i.e., ≥ "small gawky chick" and no carcass found; Table 4).

Predation: One skunk trap was deployed on 31 March and removed 18 October, and no evidence that skunks (or seabirds) entered trap boxes was found. No evidence of skunk predation nor

Table 4. Nesting activities[a,b] of Pigeon Guillemots at Cave of the Birds' Eggs in 2011.

Nest Number	29 Jun	30 Jul	30 Aug	22 Sep	Clutch Size	Hatch	Fledge
"B"	FFC	0	0	0	1 or 2	1 or 2	1 or 2
"E"	MGCdd+2 EF	0	0	0	2	1 or 2	0
"G"	1 Ero-c	0	0	0	1 or 2	0	0
"K"	1 EF	0	0	0	1 or 2	0	0
"BB"	SGCdd	0	0	0	1 or 2	1 or 2	0
"CC"	1 E	0	0	0	1 or 2	0	0
"DD"	1 E	0	0	0	1 or 2	0	0
"EE"	MFCdd	0	0	0	1 or 2	1 or 2	0
"FF"	LDCdd+MFC	0	0	0	2	2	1 or 2
"HH"	DCdd+1 E	0	0	0	2	1	0
tag #737A	0	1 Eab	1 Eab	0	1 or 2	0	0
tag #821	1 EF	0	0	0	1 or 2	0	0

Footnotes -

[a] Data on nesting activities of Pigeon Guillemots are collected opportunistically in conjunction with Ashy Storm-Petrel nest monitoring, and are not always collected in standardized fashion.

[b] Abbreviations: -c = collected, DC = downy chick, dd = dead, E = egg only, Ero = egg rolled out of nest, EF = eggshell fragment, FFC = fully-feathered chick, LDC = large downy chick, MFC = mostly feathered chick, SGC = small gawky chick, 0 = empty nest.

mouse scavenging/predation was found in 2011. Evidence of avian predation (likely by Western Gull or Common Raven) was detected. Pigeon Guillemot adult and chick carcasses, eggs, and feather piles were found away from nest sites on 29 June only; 8 distinct predation events (5 adults, 2 chicks, 1 egg) were recorded.

Human Disturbance: No evidence of human disturbance or non-researcher human visitation was detected in 2011. TNC no-entry signs were deployed here in 2009-11.

Wave Wash Events: On our first visit on 29 June, the TNC sign prohibiting cave entry by tourists, was found away from its redeployed position within the cave, likely moved by winter wave action in 2011. This sign had been originally deployed in 2009, and had been moved by winter wave action in 2010, before being redeployed in 2010. The sign was battered but still legible, and was redeployed near its original location.

Cavern Point Cove Caves

Ashy Storm-Petrel: Two nests were documented Cave #5 in 2011, and an adult bird visited an additional site in Cave #5. One active nest was observed on 31 August, containing a “large downy” chick. Hatching, fledging, and breeding success were 50% (n = 2), 100% (n = 1), and 50% (n = 2), respectively (Table 3), although small sample sizes make percent success incomparable to other locations. Ashy Storm-Petrel nesting activity was not detected in Cave #4.

Evaluation of Storm-Petrel Vocalizations: On 30 June, a songmeter was deployed in Cave #4 near remaining storm-petrel nests. Data from the songmeter were down loaded every 1-2 months and the songmeter was removed in October. Acoustic data have been archived at CINP.

Scripps's Murrelet: No nests were found in 2011.

Predation: Three skunk traps were deployed on 30 June and removed on 18 October, and no evidence that skunks (or other species) entered trap boxes was found. No evidence of avian or skunk predation nor mouse scavenging/predation was found in 2011.

Human Disturbance: No evidence of human disturbance or non-researcher human visitation was detected. CINP signs originally installed in 2009 remained intact.

Dry Sandy Beach Cave

Ashy Storm-Petrel: Seventeen nests were documented on 30 August 2011; 12 of these nests (70%) contained “small gawky” to “mostly-feathered” chicks. Hatching success was 71% (n = 17). Fledging and breeding success were not determined, because we visited this location only once in 2011 and fates of observed chicks were not determined (Table 3). Two Ashy Storm-Petrel eggs and 6 partial eggshell fragments were found away from suitable nest sites, indicating either: (a) extensive wave wash of nesting habitats after egg laying had begun; (b) scavenging/predation by deer mouse; or (c) removal of eggshells from nest sites by adults. We attempted to implant PIT-tags into the napes of two Ashy Storm-Petrel chicks (mostly-feathered chick from #806 and medium gawky chick from #1107). However, due to the small size of these chicks (i.e., inability to grasp a large enough fold of nape skin), PIT-tags were not implanted.

Pigeon Guillemot: No nests were found on 30 August. One Pigeon Guillemot eggshell fragment was found in the open and away from suitable nesting habitat, indicating at least some earlier breeding with little evidence remaining by the end of August.

California sea lion (*Zalophus californianus*): One live and two dead sea lions were observed at the main beach of the cave on 30 August.

Predation: No evidence of avian or skunk predation was found in 2011.

Human Disturbance: No evidence of human disturbance or visitation was observed. McIver *et* al. (2011) reported that the TNC sign deployed on the beach in 2009 was missing and not replaced in 2010. However, based on a review of notes from 2010, the sign was observed as dislodged on 12 August 2010 (likely dislodged by waves during the 2010 winter), and was replaced on 2 December 2010. In 2011, the sign remained intact and undisturbed.

Orizaba Rock

Ashy Storm-Petrel Restoration: On 31 March, the vocalization broadcast system was redeployed and activated, and 13 artificial (cement tile) nest sites were replaced with newly-designed ceramic nest chambers. These new artificial nest sites were installed on the floors of the Upper West (*n* = 5) and Upper East (*n* = 7) caverns, and northeastern portion of the ledge in the Upper West Cavern (*n* = 1). Data from the infrared video cameras were downloaded monthly until October, when both cameras were removed from OR.

During each field trip from June to August 2011, vocalization broadcast equipment was tested and found to be functioning properly. We are confident that Ashy Storm-Petrel vocalizations were broadcasted nightly from 31 April to 30 August. On 30 August, we turned off the broadcast equipment. The solar panel and broadcast equipment were removed on 22 September, but the speaker in the Upper Cavern was left in place. Similarly, all artificial nest sites were left in place.

Ashy Storm-Petrel Nest Monitoring: Including 26 natural and 7 artificial sites, 33 nests were documented at OR in 2011 (Table 3). Twenty-five active nests (natural and artificial) were observed on 30 August 2011; 14 of these nests (56%) contained chicks, ranging from "large downy" to "mostly-feathered" for plumage development. For natural sites, hatching, fledging, and breeding success were 65% (*n* = 26), 86% (*n* = 14), and 55% (*n* = 22), respectively (Table 3). For artificial nest sites, hatching, fledging, and breeding success were 86% (*n* = 7), 67% (*n* = 6), and 57% (*n* = 7), respectively. For all sites (natural and artificial sites combined), hatching, fledging, and reproductive were 70% (*n* = 33), 80% (*n* = 20), and 55% (*n* = 29), respectively (Table 3).

On 30 July, two Ashy Storm-Petrels were observed tumbling from the ledge to the floor in the Upper West Cavern, with bills locked. We were able to grab one of these birds and place it into an unoccupied artificial nest site (tag #A-855) while the other bird flew away. This type of agonistic behavior was described by L. Halpin (see Appendix A in McIver *et al*. [2011]) as "Lock and Tumble – one bird begins to peck at a conspecific, after which both individuals lock bills and tumble to a lower surface, off a rock or down a ledge."

iButton Data for Evaluating Artificial Nest Site Visitation: Data from iButton temperature loggers deployed in 2011 has not been fully analyzed. However, based upon a cursory examination of temperature data from deployed iButtons and some apparent inconsistent readings, we are evaluating the efficacy of the use of iButton temperature loggers as a reliable method of gauging storm-petrel visitation in artificial nest sites. Data from the temperature loggers will be archived at CINP for future analysis.

Ashy Storm-Petrel Use of Artificial Nest Sites: Based on direct observations of birds in sites, four of six nesting attempts associated with artificial nest sites in 2011 occurred at sites that had been used or visited in 2010 (#A-847B, #A-860, #A-863, #A-869). Only one of these sites (#A-869) was in a ceramic nest chamber that fledged a chick in 2011 (see Figure 8). However, the previous artificial nest site (a concrete roof tile site) at this location had been used or visited in every year since 2008. In two instances (#A-847B, #A-848B) in 2011, Ashy Storm-Petrel nesting activity was observed in association with, but not directly inside, two other ceramic nest chambers; in other words, the presence of the artificial sites appeared to facilitate egg laying in locations where egg laying likely would not have otherwise occurred. Site #A-847B was located in a natural depression or cavity directly beneath ceramic nest chamber #A-847, the latter which formed the roof for the natural cavity. In 2011, this site contained a chick in the same depression or cavity used by a chick in 2010. Site #A-848B contained an egg adjacent to and outside of ceramic nest chamber #A-848. Based on direct observations during our nest checks, no visiting birds were observed in artificial (or natural) nest sites. However, based on indirect evidence of visitation (i.e., nest bowls in gravel, presence of contour feathers), seven artificial nest sites (#A-857, #A-864, #A-866, #A-867, #A-868, #A-870, #A-871) were likely visited in 2011; all sites except #A-857 were ceramic nest chambers.

Evaluation of Storm-Petrel Nocturnal Behaviors: On 3 June, video cameras were deployed in the Upper West Cavern and Lower Cavern (one camera each location). Due to malfunctions with equipment (i.e., battery not charged; sea-spray on lenses), data were gathered on an estimated two nights in July and August only. Data were downloaded the following month and the video camera was removed in October. Video data have been archived at CINP.

Brown Pelican (*Pelecanus occidentalis*): Adults and immatures (ages combined) were recorded roosting as follows: a) 29 June — 15 birds; b) 30 July — 40 birds; and c) 30 August — 225 birds.

Brandt's Cormorant: Adults and immatures (ages combined) were recorded roosting as follows: a) 30 July — 1 bird; and b) 30 August — 10 birds.

Black Oystercatcher: Adults were observed regularly at OR as follows: 3 June — six birds; 29 June — two birds; 30 July — six birds; and 30 August — one bird. One oystercatcher nest with two eggs was observed during a complete survey on 3 June.

Figure 8. Mostly-feathered chick inside ceramic nest chamber #A-869 at Orizaba Rock on 22 September 2011 (photo by K. Carter).

Heermann's Gull (*Larus heermanni*): Adults and immatures (ages combined) were recorded roosting as follows: a) 14 June — 15 birds; b) 30 August — 75 birds; c) 15 September — 100 birds; and d) 12 October — 1 bird.

Western Gull: Five nests were observed on 3 June; three of which contained three eggs, one nest contained two eggs and one nest contained zero eggs.

Elegant and Royal Terns (*Sterna elegans* and *S. maxima)*: Adults and immatures (species and ages combined) were observed roosting as follows: 30 August — 50 birds.

Cassin's Auklet: Two occupied nest sites were documented in 2011. Auklets (adults or fully-feathered chicks – difficult to determine in deep crevices) were detected only once per year in each site (Table 5), but most nesting activities likely occurred before 3 June when our first check occurred.

Common Raven: Reconnaissance cameras documented ravens in the upper caverns at OR on a total of 48 days, from 12 April through 7 November, as follows: 7 days in April; 16 days in May; 18 days in June; 4 days in July; 1 day in August; 1 day in September; 0 days in October; and 1 day in November (Appendix A). The majority of reconnaissance camera images comprised a single raven only, mostly in the Upper West Cavern, which was visited on 46 different days (Appendix A). No more than two ravens were observed in any image, and visitation by two ravens at the same time was only observed on 3 days. In the Upper West Cavern, raven behaviors included apparent investigations of natural crevices in the floor, artificial concrete tile nests on the ledge, and the reconnaissance camera (Figure 9a-d). On 12 June, a raven was observed (from "west" camera) on the Upper West Cavern ledge, and all ceramic nest entrance modifiers were intact (Figure 10a). On 14 June, a raven was observed on the same ledge, with ceramic nest entrance modifiers from "A-856" and "A-861" dis-lodged (Figure 10b). On both 12 and 14 June, a raven in these images is perched near these nest sites. On 29 June, during our nest monitoring trip, one of the ceramic pieces for "A-853" was observed on the floor of the cavern, but removal of this piece by ravens was not detected by the reconnaissance cameras. On the same date, a pile of Ashy Storm-Petrel feathers was observed near the speaker on the ledge in the Upper West Cavern. On 29 June, we re-secured the ceramic pieces to the concrete tile sites with wider, more durable pieces of Velcro.

Ravens also were commonly observed on or near the rock during our nest checks in 2011, as follows: one bird on bluff opposite OR on 3 June; two birds on bluff opposite OR on 29 June; and two birds on OR, one bird fly over water nearby and five birds roosting on main island near anchored *Miss Devin* on 30 August. One unidentified large black flight feather, possibly from a raven, was found in the lower cavern at OR on 22 September.

Table 5. Nesting activities[1] of Cassin's Auklets recorded at Orizaba Rock in 2011.

Nest Number	3 June	29 June	30 July	30 August	Egg Number	Hatch	Fledge
tag #49[2]	1B or FFC	0	0	0	0	0	0
Tag #821[2]	0	0	1B or FFC	fthrs[3]	0	0	0

Footnotes -
[1]Abbreviations: B = adult bird, FFC = fully-feathered chick, fthrs = feathers, 0 = empty nest.
[2]Nest site difficult to view, so "0" activity may not indicate absence, and presence of bird or chick may have been missed.
[3]Small pile of feathers in nest site; possibly, avian predation.

Hatching, Fledging, and Reproductive Success

Hatching, fledging, and breeding success are summarized in Table 3. Overall breeding success at natural and artificial combined at all monitored locations (except DSB, which was only visited once by researchers) at Santa Cruz Island was 79% (*n* = 110) (Table 3).

Recruitment Study

A total of 28 Ashy Storm-Petrel chicks were fitted with PIT-tag bands at Santa Cruz Island in 2011, including three chicks that fledged from artificial nest sites (#A-858, #A-869 and #A-1067), as follows: BC (*n* = 12); CBE (*n* = 8); and OR (*n* = 8) (see Figure 11, Appendix C).

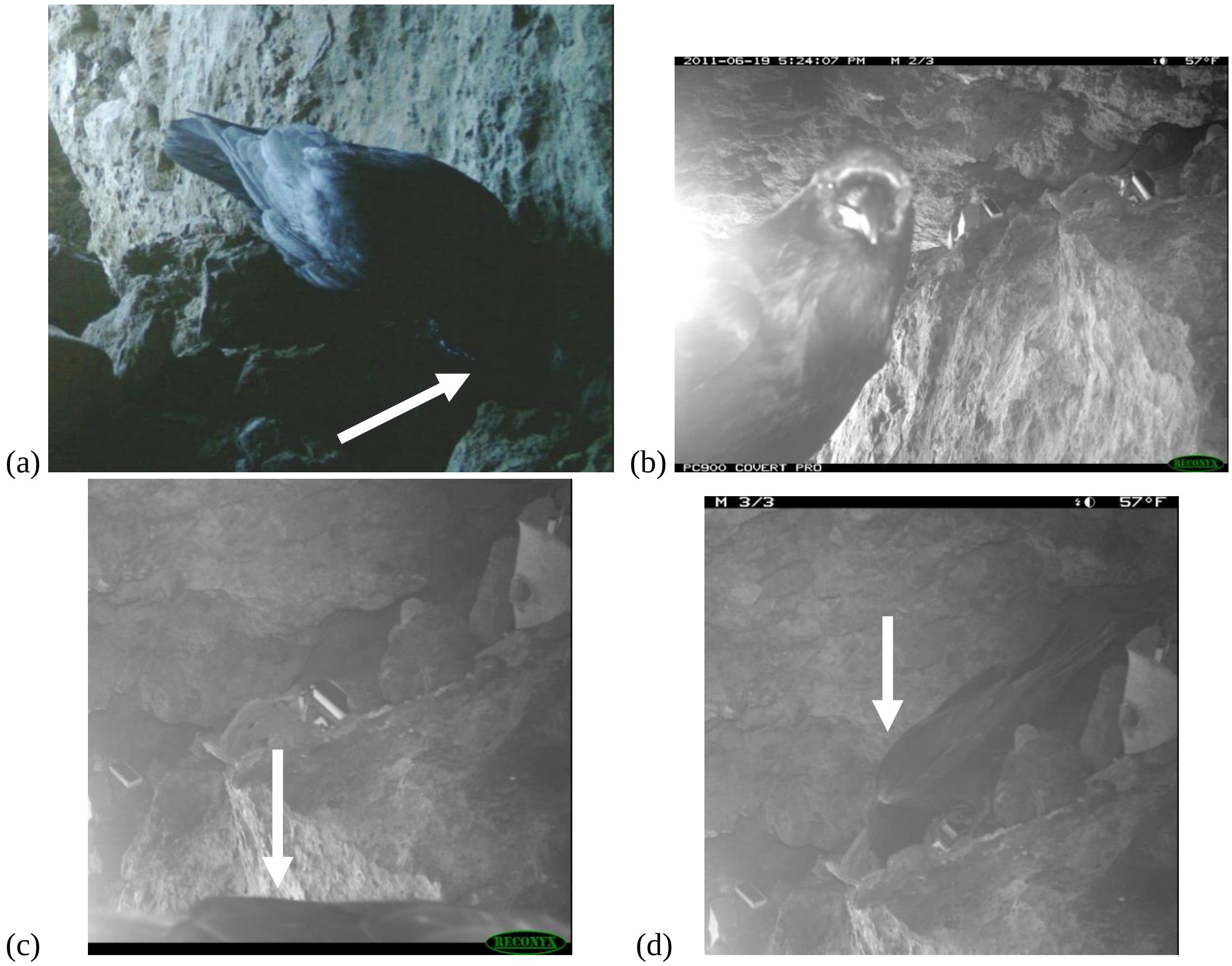
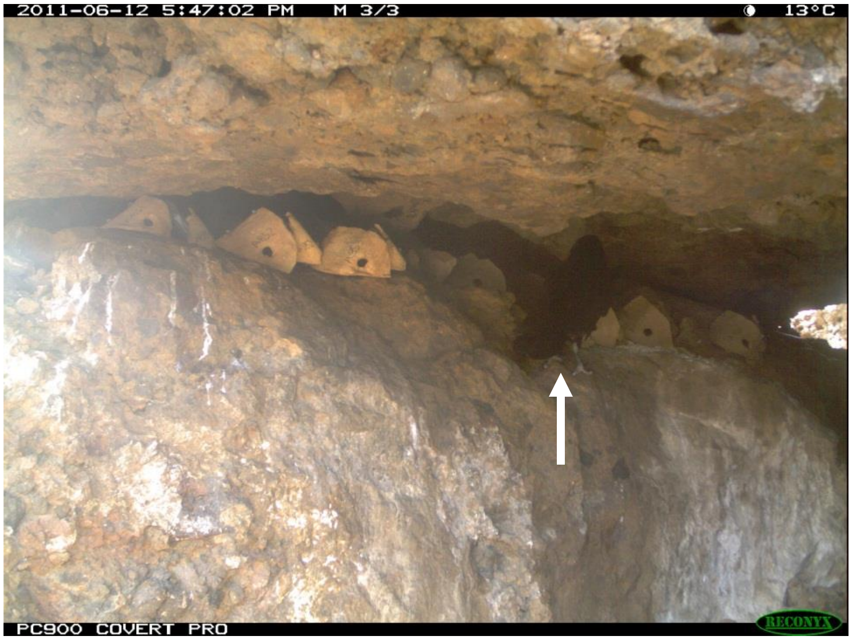
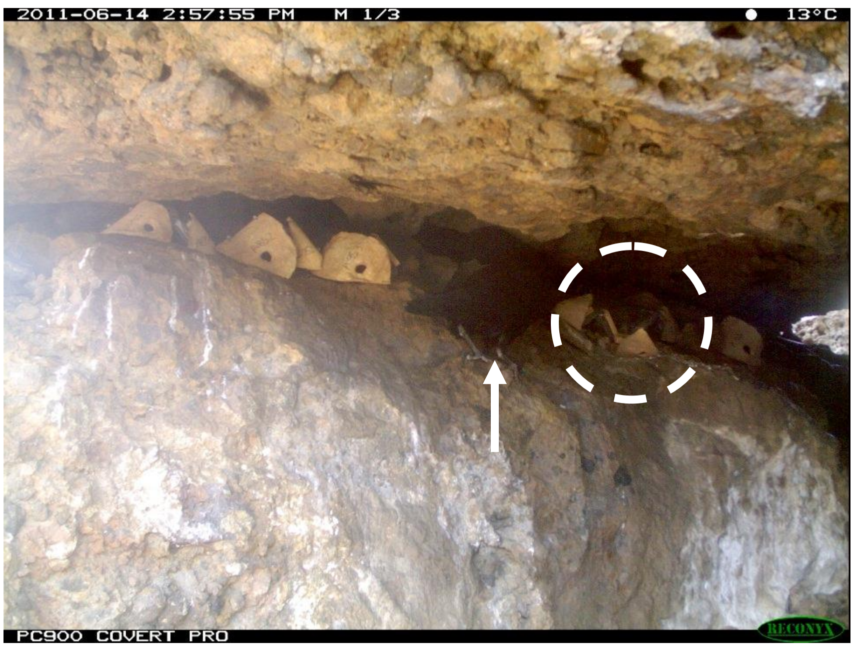


Figure 9. Middle camera images from Upper West Cavern, Orizaba Rock: (a) 11:22:09 h on 29 April 2011 – shows raven investigating top-entrance natural crevice Ashy Storm-Petrel nest site [arrow]; (b) 17:24:07 h on 19 June 2011 – shows raven looking directly toward camera; (c) 13:20:02 h on 24 June 2011 – shows raven in front of camera [arrow] and artificial nest site [likely, #A-861] without protective ceramic pieces [dashed circle]; and (d) 13:24:34 h on 24 June 2011 – shows raven (arrow) peering into artificial site [likely, #A-861].



(a)



(b)

Figure 10. West camera images of Common Raven (arrow below) at artificial nest sites on the ledge in the “Upper West Cavern” at Orizaba Rock: (a) 15:47:02 h on 12 June 2011 - shows ceramic protective pieces attached to concrete tile nests; (b) 14:57:55 h 14 June 2011 - shows ceramic protective pieces not attached to at least two concrete tile artificial sites (dashed circle added).

Figure 11. Ashy Storm-Petrel fully-feathered chick (nest tag #483A) with PIT-tag band on left leg (arrow) and USGS band on the right leg at Orizaba Rock on 22 September 2011 (Photo by K. Carter).

DISCUSSION

Reproductive Performance

Reproductive performance is one key demographic variable that should be measured for assessing population growth conditions and population changes over time and can be influenced by extrinsic (e.g., food availability, pollutants) and intrinsic (e.g., predation) factors (Schreiber and Kissling 2005, Lewis et al. 2009). Factors at breeding colonies that influence reproductive performance in storm-petrels include predation by native and non-native predators, habitat quality and various forms of disturbance (Warham 1990, Stenhouse and Montevecchi 2000, De León and Mínguez 2003). At Santa Cruz Island, spatial and temporal variation in breeding success of Ashy Storm-Petrels has been observed in the 11 years during which reproductive studies have been conducted (McIver 2002, McIver *et al*. 2009b, this study). Thus, to evaluate the success of management actions such as colony restoration actions, breeding success should be measured annually at several locations and reasons for variation assessed.

At Santa Cruz Island, breeding success has been shown to be affected primarily by success or failure during the incubation stage (McIver 2002, McIver *et al*. 2009). In the absence of skunk predation, improved breeding success at Santa Cruz Island in 2005-11, compared to 1995-98, mainly reflects higher hatching success and is consistent with: a) reduced levels of organochlorine contaminants which may no longer reduce breeding success of Ashy Storm-Petrels on a population level (Carter *et al*. 2008b); and b) reduced avian predation in 2005-11 compared to 1995-97 (McIver 2002). However, higher success rates do not account for major impacts from skunk predation events at BC in 2005 and CPC in 2008. Relationships between organochlorine levels and eggshell thickness from eggs collected and salvaged in 1992-2011 are being examined to better evaluate potential past and present effects from these contaminants (Carter *et al*., *in prep*.).

In 2011, hatching success (81%; *n* = 120), fledging success (95%; *n* = 95), and breeding success (79%; *n* = 110) at Santa Cruz Island (i.e., BC, CBE, CPC and OR combined) was generally greater than in 1995-98, but similar to 2005-10. As in 1995-98 and 2005, relatively high breeding success values in 2011 occurred at CBE. In contrast to 1995-97 but as observed in 2006-10, breeding success values at BC in 2011 were relatively high, in spite of a major reduction in colony size due to the skunk predation event in 2005. Two pairs of Ashy Storm-Petrels bred at CPC (Cave #5) in 2011 (no breeding occurred at CPC in 2010), indicating much greater colony impacts at CPC from the skunk predation event in 2008, compared to a similar event at BC in 2005. Future monitoring will determine the full extent of long-term impacts at the CPC colony from 2008 skunk predation. Low numbers of nests in 2009 (one nest) and 2011 (two nests) and no nests in 2010 indicate that major long-term impacts have occurred and that new ways to assist recovery of this colony should be considered (discussed further below).

Breeding success at OR (natural and artificial sites combined) in 2011 (55%, *n* = 29) was similar to 2010 (56%, *n* = 27), and hatching success in 2011 (70%, *n* = 33) appeared to be higher than in 2010 (57%, *n* = 28). Fledging success in 2011 (80%, *n* = 20) was similar to and perhaps slightly lower than 2010 (83%, *n* = 18). Similar to 2010, breeding success at OR (natural and artificial sites combined) in 2011 appeared to be: (1) higher than in 1995-98, and (2) lower than other locations monitored at Santa Cruz Island in 2011 (as also noted in 1995-98).

Although sample sizes were low, hatching and fledging success in artificial sites (including nesting attempts associated with [i.e., adjacent to but outside]) at OR appeared to be higher in 2011 (86% [*n* = 7], 57% [*n* = 6], respectively) than in 2010 (67% [*n* = 6], 50% [*n* = 4], respectively). The apparent increase in hatching success in artificial sites may have resulted from replacement of concrete roof tile nests with ceramic nests (*n* = 13). Modification of entrances of concrete roof tile nests using ceramic pieces (*n* = 16) may have reduced disturbance to incubating adults in artificial sites at OR by Common Ravens in 2011, possibly because nest contents in artificial sites were more difficult to see and access by ravens. Fledging success in 2011 appeared to be lower at artificial sites than at natural sites at OR and other colonies in 2011, but we could not explain this difference. Ravens primarily visited the upper caverns at OR (where the artificial sites are located) before and during the Ashy Storm-Petrel egg laying period, before most chicks hatched. Ravens did not appear to be responsible for reduced fledging success of Ashy Storm-Petrels in artificial sites. Numbers of nesting birds at DSB in 2011 (*n* = 17) were the second-lowest observed in mid-summer since 1995; the lowest counts occurred in 2010 (12 nests) (Carter et al. 2007; McIver and Carter, unpubl. data).

Breeding Phenology

In 2011, breeding phenology at all locations at Santa Cruz Island was protracted, as also found in 1995-98 and in 2005-10 (McIver 2002, McIver et al. 2009b, 2011). Most eggs were laid in June, most hatching occurred in late July and early August, and most fledging occurred in early- to mid-October. Including natural and artificial sites, eggs were laid at Santa Cruz Island over a similar length of time in 2011 (mean egg laying range = 125 d) as observed in 2005-09 (range 101-144 d), and approximately 77 d less than what was observed in 2010 (mean egg laying range = 202 d). In seabirds, older birds typically reproduce earlier in the season than younger ones (Coulson and White 1958, DeForest and Gaston 1996). In two different storm-petrel studies that utilized social attraction and artificial nest sites, Bolton et al. (2004) (Madeiran Storm-Petrels [*Oceanodroma castro*] at Azores Archipelago, Portugal) and Libois et al. (2012) (Mediterranean Storm-Petrel (*Hydrobates pelagicus melitensis*) at Benidorm Island, Spain) speculated that pairs of birds that bred in artificial nest boxes were likely younger, inexperienced individuals, based primarily upon observations that birds did not leave nearby natural sites to occupy artificial sites. At OR, due to low sample sizes at artificial nests during each year in 2008-11 (Table 6), within-year timing of breeding comparisons between natural and artificial nest sites was statistically problematic. When 2008-11 data are combined to increase sample sizes of artificial sites at OR, we did not find a significant difference between the two nest types (McIver et al., *in prep*). At Santa Cruz Island, to minimize disturbance to incubating birds, we did not band adult birds in nest sites; consequently, we do not know the individual identities of the birds occupying natural and artificial sites at OR. In addition, we could not determine if adults using artificial sites were older or younger than adults using natural sites. However, because of the increase in numbers of active natural nest sites used at OR since 2006 (McIver et al. *in prep*.) and the occupation of artificial sites in every year since restoration efforts began 2008, we believe that Ashy Storm-Petrels did not leave natural sites at OR to occupy artificial sites. In 2009-11, initiation of vocalization broadcasting as early as late March (2009 and 2011) and as late as mid-April (2010) also may have facilitated early courtship and copulation, leading to slightly earlier egg laying in artificial sites in these years. Early egg laying in February and March occurred at OR in 2010 but, while birds were observed occupying nest sites during our 31 March-1 April 2011 deployment trip, early egg-laying was not found in 2011.

Many factors can influence timing of breeding in seabirds, including age (and age-related factors) of breeding adults, environmental conditions, prey availability and population size (De Forest and Gaston 1996, Payne and Prince 1979, Bertram et al. 2001, Votier et al. 2009, Goutte et al. 2010). Low numbers of nests were detected at DSB in August 2011 ($n = 17$), compared to mid-summer nest counts since 1995 (McIver et al., *in prep*.). Similar low numbers of nests ($n = 12$) were observed at DSB in August 2010, along with delayed breeding; another 17 nests were documented after August 2010(McIver et al. 2011). In 2011, proportions of active nests containing chicks, and estimated chick ages during the 30-31 August fieldtrip were comparable between locations at Santa Cruz Island. In addition, delayed egg-laying did not occur at other Santa Cruz Island storm-petrel colonies in 2011, and the latest estimated mean laying date was 19 August for one replacement egg at CBE. Based on these aspects of breeding phenology, little if any additional egg-laying likely occurred at DSB after our 30 August visit. Causes for low numbers of nests at DSB in August 2011 are not clear, but may have resulted from lingering effects of a possible high water event in 2010; another high water event is unlikely to have occurred during pre-breeding or early egg laying in 2011, because the deployed sign was not disturbed, and likely would have been moved by a high water event.

Restoration at Orizaba Rock

Background. Artificial nest sites have been used widely for colony and habitat restoration in storm-petrels and other procellariiforms (Priddle and Carlile 1995, Bolton 1996, De León and Mínguez 2003, Praia *et al*. 2009). Major benefits of artificial habitat include increased available habitat, increased population size, greater protection from avian predators, greater ease of monitoring, and lower impact of monitoring. Social attraction, consisting of playback of recorded calls, which mimics the sounds of conspecifics, also has been used in some studies to speed occupation of artificial nest sites or improve reproductive success for storm-petrels and other procellariiforms (Podolsky and Kress 1989, Cruz and Cruz 1996, Bolton *et al*. 2004, Libois *et al*. 2012, Buxton and Jones 2012).

<u>*Historical Colony Size*</u>: Between 1995 and 2012, the highest recorded number of Ashy Storm-Petrel nests at OR was documented in 1996: 27 nests in natural sites (McIver 2002). Lower numbers were found at OR on single day visits in July 1976 and July 1994 (Hunt et al. 1979; HRC, unpubl. data). Carter et al. (2008a) suggested that lower breeding success and population size of Ashy Storm-Petrels may have occurred in the Channel Islands from the 1950s to 1970s, when organochlorine contaminant levels were much higher and greatly affected Brown Pelicans (*Pelecanus occidentalis californicus*) and Double-crested Cormorants (*Phalacrocorax auritus*) (Gress et al. 1973, Gress 1995). Given documented eggshell thinning and hatching failures of Ashy Storm-Petrels at Santa Cruz Island in 1992-97 (McIver 2002, Carter et al. 2008b), higher numbers of Ashy Storm-Petrels may have historically bred at OR than documented in 1996. As many as 48 different natural crevices were used for nest sites during at least one year from 1995 through 2011 (McIver et al., in prep.), although these sites likely vary in terms of their suitability

for successful chick fledging, and some crevices are periodically added or removed from small rock slides. Without detailed monitoring of all potential natural crevices and their use by Ashy Storm-Petrels in the past, we cannot measure if greater, similar or lower availability or suitability of natural crevices occurred in the past compared to 1995-2011.

Unlike many other storm-petrels, Ashy Storm-Petrels do not excavate burrows, and instead rely upon suitable available nesting cavities formed in rock and driftwood (James-Veitch 1970, Ainley et al. 1990, McIver 2002). In the sea caves at SCI, much of this habitat occurs among boulders and in rock piles that occur on relatively dry floors (i.e., generally free from wave-wash and tidal flooding during the breeding season) (McIver 2002). Rock falls from sea cave walls and ceilings has been observed to both create and destroy small numbers of Ashy Storm-Petrel nest sites at BC and DSB and a high water event removed some floor crevice habitats in CBE (McIver et al. 2011; McIver and Carter, unpublished notes). At OR, Ashy Storm-Petrels nest in crevices formed by rock fall, with the majority of natural nest sites in crevices or fissures that occur in cavern walls, floors and boulders. OR habitats are more exposed to ocean waves, highly erodible, involve different rock types, and may be structurally less stable than the sea caves. Thus, over time crevice habitat is likely replenished less at OR, whereas both rock crevices and driftwood are replenished or increased periodically in the sea caves.

Success of Restoration Actions: In 2011 at OR, two primary signs of continued success with restoration efforts included: (1) continued breeding at most artificial sites used in 2008-10, despite replacement or modification of artificial habitats; and (2) relatively high numbers of natural sites comparable to peak numbers observed in 1996. In addition, 8 (62%) of the 13 newly-designed and deployed ceramic nest sites showed direct evidence of use (including one egglaying site) and indirect evidence of visitation (seven sites in which gravel was observed to have been excavated). Common Ravens, which disturbed artificial nest sites at OR during the summer of 2010, were present near artificial nest sites throughout the 2011 breeding season and disturbed artificial nesting habitat (two artificial sites) only in June. In 2012, we plan to replace all concrete roof tile artificial nest sites located on the ledge in the Upper West Cavern with newly-designed ceramic nest sites. These sites will be similar in design and concept to the ceramic nests deployed on the cavern floors in 2011, but without a top hatch and with a removable front for researchers to access nest contents (Figure 12).

Increase in Colony Size: Numbers of active nests of Ashy Storm-Petrels at OR increased between 2006 and 2011 (Figure 13). Before restoration actions (2005-07), only 7-14 nest sites were documented at OR; during restoration actions (2008-11), higher numbers (24-33) have occurred, similar to or greater than 1995-97 (8-27 sites). However, an increase in the number of nests also had occurred from 2005 to 2007, likely indicating some natural increase in this colony prior to restoration actions. We consider that a portion of the increase in total sites between 2007 (14) and 2011 (33) likely is accounted for by continued natural increase in 2008-11, which may have been facilitated because of restoration actions. The gradual increase in total sites from 2005 to 2011 was consistent with natural recovery that could have occurred without restoration actions. However, this increase may not have been sustained between 2008 and 2011 without restoration actions. It is difficult to ascertain how much of the increase in nests from 2005 to 2011 was due to natural recovery and how much was due to restoration actions.

(a)

(b)

Figure 12. Prototype for re-designed ceramic artificial nest sites for use in 2012 on ledge at "Upper West Cavern," Orizaba Rock: (a) shows a non-direct nest entrance that precludes ravens from direct viewing of nest contents and a small viewing hole for researchers; and (b) shows plastic-coated electrical wires for attaching or removing the nest front.

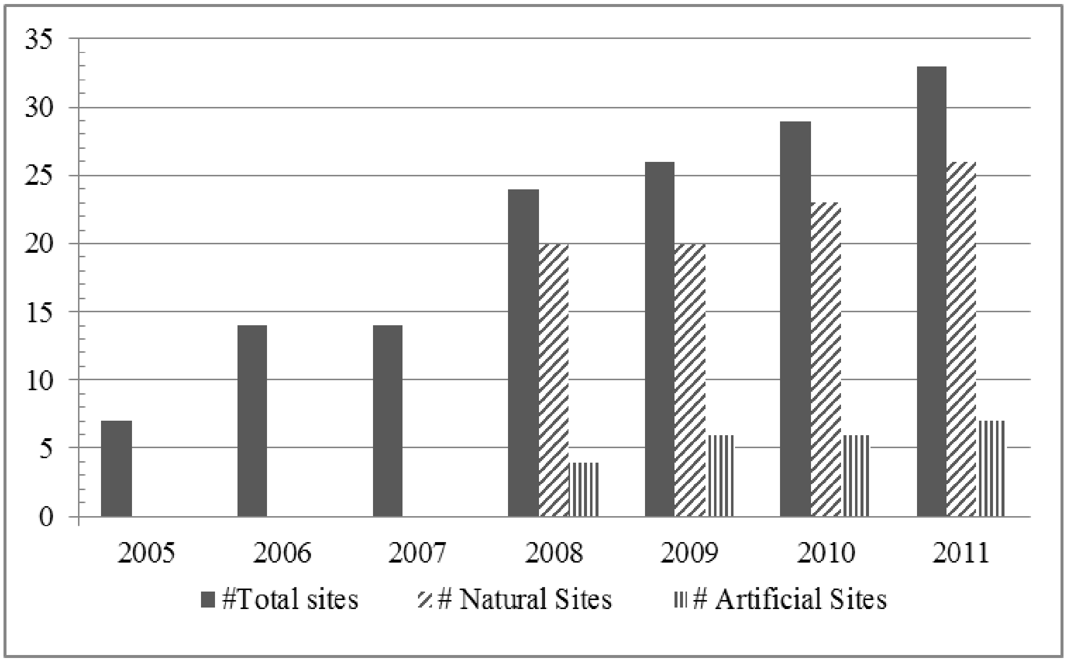


Figure 13. Numbers of active nests at Orizaba Rock in 2005-11. Artificial nest sites were deployed beginning in 2008, as part of restoration work.

Use of Artificial Sites: Nesting in artificial sites provided clear evidence of effects of restoration actions. By deploying artificial sites, we increased the number of suitable nest sites on OR and by placing them near speakers in areas with few natural sites, we increased the overall amount of nesting habitat. The majority of artificial sites occupied from 2008 through 2011 occurred within approximately 3 m of the speaker in the Upper West Cavern, and the availability of these suitable cavities in proximity to the speaker likely facilitated their use. If artificial habitats were left on OR in the long term, we would expect greater use by Ashy Storm-Petrels which would: (1) better protect a portion of the colony from predation and human disturbance (especially bright lights from squid fishing boats); (2) allow the colony to increase in population size beyond its current natural maximum; and (3) increase numbers of recruiting birds to replace any adults killed by predators or other factors. Long-term benefits from long-term artificial habitats would help this small colony to continue to exist in the future in a human-modified environment which likely contributed to the reduction in numbers of active nests at this colony in the late 1990s to mid-2000s.

Breeding Success. Higher breeding success at OR in 2005-11 has been accompanied by lower pollutant levels, lower avian predation and reduced squid fishing in southern California and possibly off the north side of Santa Cruz Island (however, this is based on tonnage, not location) (Carter *et al*. 2008b, McIver *et al*. 2009b, California Department of Fish and Game 2012). However, breeding success at OR has remained lower than at Santa Cruz Island sea caves locations in 1995-2011, which may reflect differences in breeding habitats (e.g., more egg loss at OR from eggs rolling out of nest sites), or predation (e.g., higher predation at OR due to greater exposure of nest sites to predators).

Philopatric and New Residents: By protocol, Ashy Storm-Petrels at Santa Cruz Island are not handled and banded from nests (McIver and Carter 1996); consequently, we do not know the identity of nesting storm-petrels. However, because Ashy Storm-Petrels are highly philopatric, we believe that most birds that used artificial sites likely had been hatched at OR (i.e., they were "philopatric residents"), they had returned to attend the natal colony prior to breeding, and they would have attempted to breed in a natural site at OR in the same year or a subsequent year if they had not used an artificial site. Only a small portion of birds or perhaps none that used artificial sites may have hatched at other colonies (i.e., they were "new residents") and they were attracted to attend and breed at OR by the vocalization broadcasting used for this project that was primarily aimed at retaining birds already attending the colony. Use of artificial sites in proximity to the speakers likely facilitated nesting by both philopatric or new residents in artificial habitats.

Skunk Predation at Sea Caves

Bat Cave: Skunks were not detected during monitoring at OR and sea caves in 1995-2004. At least two island spotted skunks somehow gained access to BC in 2005 and at least 70 adult Ashy Storm-Petrels were killed, accompanied by complete reproductive failure (McIver and Carter 2006). Numbers of active nests were greatly reduced to only 19 active nests in 2006 but have increased rapidly since then (Table 6). BC appears to be experiencing a rapid natural recovery, likely facilitated by: (1) the relatively large floor area and high roof of the cave, which allowed many adults to escape during the 2005 predation events; (2) relatively large population size and high breeding success providing relatively high recruitment; and (3) relatively low avian predation. If skunks do not gain access to this cave again, we expect that this colony will eventually recover. No evidence of skunk access has been noted in 2006-11.

Table 6. Numbers of egg-laying sites at Bat Cave in 2006-11, following the skunk predation event in 2005.

	Year					
	2006	2007	2008	2009	2010	2011
No. active nests	19	28	35	48	60	61

Cavern Point Cove Caves: Skunks were not detected during monitoring in 1995-2007, but at least two island spotted skunks gained access to CPC in 2008 (McIver et al. 2009). At least 32 adult Ashy Storm-Petrels were killed before or after laying eggs and complete reproductive failure occurred. Only 14 nests were documented at this small colony in 2007; the loss of 32 adults or subadults therefore appeared to represent most breeders and some future breeders. In 2009, only two active nests (#54 and #1040 in Cave #5) were found. In 2010, no active nests were found. In 2011, the same two nests were active as in 2009; in addition, a bird was observed but no evidence of egglaying was found at a new tagged site (#1111) in Cave #5. We suspect that few adult storm-petrels escaped skunk predation at CPC in 2008, due to the small cavern floor areas and low ceilings of these two caves that allowed fewer adults to escape (compared to BC); skunks that entered CPC were likely more able to quickly investigate available nesting habitats and potentially prey upon both adults of each nesting pair at CPC, compared to BC where one or both adults escaped. Future monitoring is needed to determine if and when this colony fully recovers.

General: Prior to the events described above, skunk predation of Ashy Storm-Petrels at Santa Cruz Island was not known to occur and had not been documented during monitoring in 1995-2004 (McIver 2002; W.R. McIver and H.R. Carter, unpubl. data). In recent years, island spotted skunk population numbers at the 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 (Bakker *et al*. 2005, Jones *et al*. 2008). Given major impacts to Ashy Storm-Petrels at BC and CPC, it is highly unlikely that such impacts have occurred at least since the 1980s, if not much earlier or perhaps never before. Future monitoring will allow evaluation of the ability of Ashy Storm-Petrel colonies to recover from such events. Although recent population estimates are not available, Jones *et al*. (2008) reported that island skunk populations were at unnaturally high densities on Santa Cruz Island as late as 2004. We are not aware of any recent estimates of population size of island spotted skunks at Santa Cruz Island, but based on a review of recent information (Coonan 2011, Friends of the Island Fox 2011), densities or population numbers of spotted skunks at Santa Cruz Island still appear to be elevated, compared to the 1990s (i.e., prior to the decrease in island fox numbers, when island spotted skunk population numbers were lower). In 2010, island fox population numbers at Santa Cruz Island were estimated at about 1,300 total individuals (about 800 adults), compared to historical estimates of 1,465 individuals (Coonan 2011, Friends of the Island Fox 2011). As the fox population at Santa Cruz Island recovers, island spotted skunks numbers may decrease, but this interaction will need to be tracked with future monitoring (Coonan and Guglielmino 2012). In 2011, no island spotted skunks were detected or captured in any of the Ashy Storm-Petrel colonies, but continued preventative efforts (i.e., trapping and protective nesting crevices) and monitoring will be necessary to ensure that these caves remain free of skunks to allow recovery of BC and CPC colonies and provide long-term skunk-free habitats for Ashy Storm-Petrels at Santa Cruz Island.

Avian Predators

During monitoring in 1995-98, Barn Owls (*Tyto alba*) were well documented as predators of Ashy Storm-Petrels at Santa Cruz Island, specifically at BC, CPC, CBE, and OR (McIver 2002). However, during monitoring in 2005-11, predation by Barn Owls was much reduced. Western Gulls are known predators of Ashy Storm-Petrels at Southeast Farallon Island when both breed in the same parts of the island (Ainley *et al*. 1990, Sydeman *et al*. 1998a). At Santa Cruz Island, single Western Gulls have been rarely observed to fly inside sea caves during nest monitoring and only a few pairs of gulls nest on OR, with little evidence of gull predation on seabirds there (McIver 2002). Peregrine Falcons (*Falco peregrinus*) are commonly observed near Ashy Storm-Petrel breeding locations at the bases of steep cliffs at Santa Cruz Island (McIver 2002; W. R. McIver, H.R. Carter, and A.L. Harvey, *unpublished notes*). Falcon predation of storm-petrels by falcons at or near breeding colonies may occur at first light on late-departing storm-petrels or at sea before birds move farther offshore for feeding.

Common Ravens are frequently observed near Ashy Storm-Petrel breeding locations at Santa Cruz Island and have been documented in sea caves (e.g., CBE in 1997 [McIver 2002]) and at

OR in 2010 and 2011 (McIver *et* al. 2011; this study), where they may prey on storm-petrels. In addition, ravens were documented with cameras to regularly visit the upper caverns at OR, where artificial nest sites were deployed. Reasons for higher raven visitation of OR in 2010-11 were not determined but may have partly reflected: (1) attraction to the rock by continuous night-time broadcasting of vocalizations in 2008-2011; (2) restoration equipment (i.e., solar panel, artificial nests, cameras); (3) short monthly visits (3-5 hours per visit) by researchers for nest monitoring and restoration work; (4) increased raven populations at Santa Cruz Island; (5) ravens breeding nearby to OR; or (6) increased curiosity of ravens related to campground feeding.. At OR, we documented one feather pile in the lower cavern, indicating at least one Ashy Storm-Petrel was killed by an avian predator in 2011 but it was not clear if it was captured inside or outside of a nest site. In addition, one Cassin's Auklet feather pile was found, also indicating avian predation. Nevertheless, our modifications to artificial habitat in 2011 likely provided additional protection to storm-petrels inside nest sites from avian predators, especially ravens.

Ravens have been common breeders at Santa Cruz Island for at least the past 120 years (Blake 1887, Garrett and Dunn 1981). Anthropogenic food sources at the island available for ravens have varied since the early 19th century, and have included dead livestock (e.g., sheep) (Blake 1887), and food from humans, recently enhanced since 1997 by much larger numbers of campers and day tourists at the east end of the island managed by CINP. Ravens are known to be adept at obtaining food from campgrounds, including using techniques such as opening cardboard boxes and coolers, and unzipping backpacks. Vermeer et al. (1993) suggested that predation of Pigeon Guillemots by Northwestern Crows (*Corvus caurinus*) may have been related to crows following researchers. At least two ravens became experienced with opening artificial structures at OR in 2010-11 and possibly learned to access human structures through foraging in camping areas at Santa Cruz Island. Lack of detection of raven activities at OR in 2008-09 may have reflected: (1) a period of learning (e.g., during which ravens watched researchers entering and departing from caverns at OR); or (2) regular undetected raven occurrence at OR between our visits. Researchers also entered caverns monthly in 1995-97 and 2005-06 without noting extensive raven occurrence, although some predation events ascribed to Barn Owls may have been raven related. Lower breeding success at OR also may be related partly to greater exposure to avian predators, especially ravens and Barn Owls. At OR, providing more protected artificial nesting habitat, and fortifying and augmenting (with ceramic pieces) shallow natural crevices in close proximity to artificial sites, seemed to prevent ravens from depredating Ashy Storm-Petrels inside nest sites at OR in 2011.

Compared to 1995-98, relatively low levels of storm-petrel predation by avian predators (i.e., few carcasses or feather piles) at Santa Cruz Island locations occurred in 2011, as also noted in 2006-10. However, lower numbers of breeding storm-petrels also occurred at BC since 2005 and at CPC since 2008, due to skunk predation events. More work is needed to summarize and assess past predation data in 1995-2004 for comparison to 2005-11 data. At BC, Barn Owls may have switched to hunting elsewhere when storm-petrel numbers were reduced. Future monitoring of predation during storm-petrel nest monitoring will generally assist our understanding of the frequency and type of predation upon storm-petrels. However, to fully examine potential avian predator impacts, greater effort also would be needed to better assess predators through predator surveys and analysis of prey remains at nests and roosts away from storm-petrel colonies.

Pigeon Guillemots at CBE

Fewer numbers of Pigeon Guillemot nests were found at CBE in 2011 (*n* = 12; Table 4) than in 2010 (*n* = 21). Only 7-10 nests were found in 2006-09.

Nine (75%) of 12 nests may have had one egg clutches, possibly suggesting many first-time breeders (Asbirk 1979). Six (50%) of 12 nests hatched at least one chick and 2 (17%) of 12 nests fledged at least one chick. In general, breeding success in 2009-11 (with no predation in 2009-10 and low predation in 2011) was relatively high compared to 2006-08 (with extensive predation recorded). Reduced avian predation in 2009-11 likely led to this increase. To date, increased numbers of breeding guillemots at CBE do not appear to have directly affected Ashy Storm-Petrels, but some storm-petrel nest sites may be usurped by guillemots in the future.

Cassin's Auklets at OR

Only two visited nest sites of Cassin's Auklet were found at OR in 2011 (Table 5), compared to five nests in 2010; however, we made more early season visits in 2010 when auklets are attending nest sites. Direct evidence of egg laying by Cassin's Auklets was not found at OR in 2011; the two sites were attended by either adults or fully-feathered chicks but we suspect that they may have been adults because attendance was only observed once (although these sites are very difficult to view). Auklets at OR did not appear to directly affect Ashy Storm-Petrels, but some storm-petrel nest sites may be usurped by auklets in the future, especially if auklet numbers increase in the future. Ainley *et al*. (1990) found that interference by Cassin's Auklets at nest sites reduced reproductive success of storm-petrels. Continued availability of protective artificial habitat for Ashy Storm-Petrels could reduce interspecific competition at natural crevices at OR.

Human Visitation

Natural and artificial nesting habitats at OR and in sea caves 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 at or near nest sites. No evidence of non-researcher human visitation was documented at BC, CBE, CPC, DSB or OR in 2011. While non-researcher human visitation at CPC and BC was observed in 1995-97 and 2005-09, and human visitation was detected at OR in 2009, no evidence of human presence was found at these sites after signs were deployed (in 2009 at BC and CPC; in 2010 at OR), indicating the signs may dissuade tourists from entering caves or lingering on OR.

Monitoring and Restoration Recommendations for 2012

We recommend that vocalization broadcasting should be continued in 2012 for two main reasons: (1) to provide a minimum of five years of social stimuli for encouraging storm-petrels to attend and breed at new and old artificial sites; and (2) to determine if the new design of artificial sites is adequate for long-term use at this location or whether further modifications to artificial sites are needed.

Regardless of the degree of continuing restoration work after 2012, artificial sites should remain on OR, with at least one day-trip per year in (e.g., in February or March) for minimal maintenance, if necessary, prior to egg laying to ensure that artificial nest sites remain suitable for nesting. In most years, maintenance likely will not be required at most sites but, by ensuring that all sites are suitable each year, the maximum number of artificial nest sites would be available to become occupied.

We recommend continued nest monitoring work at OR and Santa Cruz Island sea caves in 2012 and after for the following reasons:

- documenting the degree of visitation and egg laying in new artificial nest sites at OR
- assessing the design of new artificial nest sites and making further alterations as needed
- measure and examine trends in breeding success in artificial and natural nest sites at OR and at natural sites in BC, CPC and CBE.
- examine trends in colony sizes at OR, BC, CPC and CBE
- examine trends in colony size at DSB, using the number of nests in August as an index of total population size
- identify and address natural and anthropogenic factors that might affect colony size and breeding success

After investing significant effort to gather baseline data in 2006-07 and restore this colony in 2008-11, full-scale monitoring should be continued in 2012 to evaluate project success prior to implementing any change in project design in the future.

We recommend the following restoration work at OR and Santa Cruz Island sea caves in 2012:

Artificial Nest Sites at OR

- March-April: Replace the concrete roof tile nests on the ledge in the Upper West Cavern at OR with newly-designed ceramic nests with removable fronts. When concrete roof tiles are removed and before ceramic sites are deployed in their place, care should taken not to dislodge or completely cover gravel and small depressions that were used by storm-petrels under the concrete roof tiles.
- March-April: refurbish all artificial nest sites with gravel and sand, as necessary.

Natural Nest Sites at OR

- March-April: To the extent feasible, rebuild and fortify (using customized pieces of ceramic) the three natural crevices that were observed as collapsed during 2010. For example, a customized ceramic roof and nest entrance could be placed over #1030, located in a small cavern on the north side of the rock, above the lower cavern of OR. This would restore the crevice nature of this site where Ashy Storm-Petrels previously nested for several years.

Vocalization broadcast at OR

- March-August: Deploy and operate the vocalization broadcast system. Early deployment prior to the main egg laying period may be important for potential attraction of birds (especially those from other colonies) to attend and breed at OR. By using newly-modified artificial sites, we plan to prevent predation by individual ravens inspecting artificial sites, even though we still may be attracting some ravens to OR with early broadcasting. Ravens may be discouraged and stop attending OR prior to storm-petrel egg laying when they cannot access artificial sites. We will assess continued raven activities at OR in 2012.

- Shut down and remove part of the system during the August field trip to prevent attraction of non-breeding birds after the egg-laying period which could lead to increased raven predation of inexperienced birds in fall.

Recruitment of Ashy Storm-Petrels at OR and sea caves

- Because Ashy Storm-Petrels are highly philopatric, most recruitment to OR and sea cave colonies is likely derived from locally-fledged chicks (i.e., “philopatric residents”), with a few from other colonies (i.e., “new residents”). To better understand how the OR colony and sea cave colonies are recruiting breeding birds from chicks fledged from OR over the long term, the PIT-tag study of chicks and subsequent search for future breeding of those birds should occur at all monitored locations. We have incorporated the use of PIT-tag readers and wand antennas into the nest monitoring protocol for each nest site to search for the presence of PIT-tags with after-hatch-year storm-petrels observed in nest sites during nest monitoring visits in future years.

Ashy Storm-Petrel protection from skunks at sea caves

- Continue to implement a storm-petrel protection plan to prevent or reduce skunk predation of storm-petrels at CPC, BC, and CBE, using trapping techniques.

- Gather information on population size, distribution, and behavior of island spotted skunks at Santa Cruz Island from other researchers.

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Appendix A. Appendix A. Reconnaissance camera observations of Common Ravens (CORA) and Western Gull (WEGU) at Orizaba Rock, Santa Cruz Island, in 2011.

Date	Time First Photo	Time Last Photo	Number of Photos	Cavern[a]	Camera[b]	Species	No.	Observations
4/12/2011	11:48:43	11:48:45	3	UW	M	CORA	1	on floor
4/13/2011	10:34:35	10:34:37	3	UW	M	CORA	1	floor, then flies to boulder outside & NW of cavern entrance
4/20/2011	13:38:08	13:38:10	3	UW	M	CORA	1	land on wall near ledge
4/21/2011	11:01:58	11:02:03	6	UW	M	CORA	1	on floor
4/21/2011	12:15:51	12:15:53	3	UE	E	CORA	1	1 on north rock wall at northeast end of Upper East Cavern, at the east entrance
4/21/2011	12:17:08	12:17:29	9	UW	M	CORA	1	on floor
4/23/2011	8:48:06	8:48:08	3	UW	M	CORA	1	on floor
4/24/2011	8:39:08	8:39:10	3	UW	M	CORA	1	on floor, moves towards ledge
4/29/2011	11:21:09	11:21:11	3	UW	M	CORA	1	on floor, appear to be looking down floor crevices, investigated camera, jumped to ledge
4/29/2011	11:22:08	11:22:22	9	UW	M	CORA	1	on floor, appears to look into natural floor site
4/29/2011	11:23:11	11:23:16	6	UW	M	CORA	1	on floor, appears to examine camera
4/29/2011	11:23:29	11:23:36	6	UW	M	CORA	1	on floor, appears to examine camera
4/29/2011	11:23:43	11:23:54	6	UW	M	CORA	1	on floor, appears to examine camera
4/29/2011	11:24:11	11:24:13	3	UW	M	CORA	1	on floor
4/29/2011	11:25:24	11:25:36	6	UW	M	CORA	1	on floor
4/29/2011	11:26:30	11:26:35	6	UW	M	CORA	1	on floor, jumps to ledge
4/29/2011	11:26:59	11:27:01	3	UW	M	CORA	1	at west entrance of cavern
4/29/2011	11:27:07	11:27:09	3	UW	M	CORA	1	just outside west entrance of cavern, apparently leaving.
5/9/2011	17:42:10	17:42:12	3	UE	E	CORA	1	1 on north rock wall at northeast end of Upper East Cavern, at the east entrance
5/9/2011	17:43:13	17:44:11	12	UW	M	CORA	1	on floor, looks towards ledge

Date	Time First Photo	Time Last Photo	Number of Photos	Cavern[a]	Camera[b]	Species	No.	Observations
5/9/2011	17:54:12	17:54:14	3	UW	M	CORA	1	on floor, looks towards ledge
5/10/2011	18:22:31	18:23:15	21	UW	M	CORA	1	perches on A-864, looks to ledge, looks at camera
5/10/2011	18:24:11	18:24:20	9	UW	M	CORA	1	peers into camera
5/11/2011	14:45:31	14:45:33	3	UW	M	CORA	1	perches on A-866
5/11/2011	14:46:02	14:46:04	3	UW	M	CORA	1	moves towards ledge out of camera view
5/11/2011	14:47:47	14:47:52	6	UW	M	CORA	1	moves directly in front of camera
5/12/2011	19:10:30	19:10:37	6	UW	M	CORA	1	lands at A-866, looks to ledge
5/12/2011	19:16:27	19:16:27	6	UW	M	CORA	1	lands at A-866, looks at camera, moves out of camera view
5/13/2011	17:33:59	17:34:34	21	UW	M	CORA	1	lands atop A-866, looks to ledge, moves in front of camera
5/14/2011	17:17:05	17:17:07	3	UW	M	CORA	1	in front of camera.
5/14/2011	17:19:30	17:19:36	6	UW	M	CORA	1	on floor, looks and moves towards ledge.
5/14/2011	17:24:22	17:24:38	9	UW	M	CORA	1	lands on A-864, moves to floor
5/14/2011	17:25:13	17:25:24	9	UW	M	CORA	1	on artificial nest, then looks into camera
5/14/2011	18:30:13	18:30:13	6	UW	M	CORA	1	looking at camera
5/14/2011	18:30:51	18:30:53	3	UE	E	CORA	1	1 on north rock wall at northeast end of Upper East Cavern, at the east entrance, jumps to & perches on artificial site #A-871
5/15/2011	18:42:52	18:42:55	3	UW	M	CORA	1	lands atop A-866
5/16/2011	11:34:49	11:34:51	3	UW	M	CORA	1	lands on ledge
5/17/2011	16:27:52	16:28:25	12	UW	M	CORA	1	perches atop A-866, A-865, and on floor
5/20/2011	15:35:54	15:36:09	9	UW	M	CORA	1	lands on A-864, looks to ledge
5/22/2011	19:24:06	19:24:08	3	UW	M	CORA	1	partly in front of camera
5/23/2011	8:01:22	8:01:24	3	UW	M	CORA	1	on floor, looks towards ledge
5/23/2011	9:15:14	9:15:16	3	UW	M	CORA	1	flew up to ledge or behind camera
5/25/2011	18:08:41	18:08:50	6	UW	M	CORA	1	in front of camera, looks towards camera

Date	Time First Photo	Time Last Photo	Number of Photos	Cavern[a]	Camera[b]	Species	No.	Observations
5/25/2011	18:33:19	18:33:21	3	UE	E	CORA	1	1 on north rock wall at northeast end of Upper East Cavern, at the east entrance
5/25/2011	18:38:09	18:38:11	3	UW	M	CORA	1	on floor looking up to ledge
5/27/2011	16:20:11	16:20:25	12	UW	M	CORA	1	on floor, inspects floor, looks to ledge
5/28/2011	19:47:00	19:49:04	24	UW	M	CORA	2	1st bird on A-866, 2nd bird on rock outside cavern; 1st bird moves out of view and possibly behind camera, 2nd bird peers into camera, then moves away towards west cavern entrance. 2 birds seen in 6 photos
5/29/2011	16:07:16	16:07:21	6	UW	M	CORA	1	on A-865, looks at and moves towards camera
5/29/2011	17:05:32	17:05:34	3	UW	M	CORA	1	on floor, moves east through cavern
6/2/2011	19:27:14	19:27:16	3	UW	M	CORA	1	on floor
6/3/2011	18:24:14	18:24:17	3	UW	M	CORA	1	on floor in front of camera
6/4/2011	14:22:29	14:23:40	21	UW	M	CORA	2	1st bird on floor, 2nd bird lands on rock outside cavern; 1st bird moves out of camera view and likely to the ledge, 2nd bird moves in front of camera; 1st bird jumps over 2nd bird and lands on rock outside cavern, then departs; 2nd bird moves towards cavern entrance. 2 birds seen in 14 photos
6/5/2011	15:47:54	15:47:57	3	UW	M	CORA	1	on floor of cavern
6/6/2011	14:00:31	14:00:34	3	UE	E	CORA	1	on north rock wall at northeast end of Upper East Cavern, at the east entrance
6/8/2011	10:56:54	10:57:22	15	UW	M	CORA	1	lands on A-866, moves towards camera, then jumps up to ledge
6/8/2011	13:20:09	13:20:11	3	UW	M	CORA	1	perched on rock outside of cavern
6/9/2011	19:01:00	19:02:06	15	UW	M	CORA	1	at west entrance, moves to camera, looks to ledge
6/12/2011	15:35:36	15:35:38	3	UW	M	CORA	1	directly in front of camera, facing ledge
6/12/2011	15:47:00	15:47:02	3	UW	W	CORA	1	lands on ledge; all ceramic pieces appear intact

Date	Time First Photo	Time Last Photo	Number of Photos	Cavern[a]	Camera[b]	Species	No.	Observations
6/12/2011	17:47:08	17:47:14	6	UW	M	CORA	1	on ledge
6/12/2011	17:48:04	17:48:44	12	UW	M	CORA	1	directly in front of camera, moves in direction behind camera
6/13/2011	16:17:47	16:18:16	12	UW	M	CORA	1	in front of camera, jumps to ledge
6/14/2011	14:57:55	14:57:57		UW	W	CORA	1	on ledge; ceramic front pieces from A-856 and/or A-861 appear to have been dislodged
6/14/2011	14:58:21	14:58:35	12	UW	M	CORA	1	in front of camera
6/15/2011	17:13:25	17:13:27	3	UW	W	CORA	1	on floor, looks up to ledge
6/15/2011	18:12:09	18:12:11	3	UW	W	CORA	1	on floor
6/17/2011	18:27:38	18:27:40	3	UW	W	CORA	1	on ledge, jumps to floor
6/17/2011	18:27:52	18:27:56	3	UW	M	CORA	1	in front of camera
6/18/2011	13:44:32	13:44:40	6	UW	M	CORA	1	in front of camera
6/19/2011	16:58:38	16:58:43	6	UW	M	CORA	1	in front of camera
6/19/2011	17:24:05	17:30:48	12	UW	M	CORA	1	in front of and looking into camera
6/21/2011	19:24:08	19:24:25	6	UW	M	CORA	1	in front of camera
6/23/2011	14:51:23	14:51:55	21	UW	M	CORA	1	in front of camera
6/23/2011	17:57:05	17:57:11	6	UW	M	CORA	1	in front of camera
6/24/2011	13:18:47	13:24:40	36	UW	M	CORA	1	in front of camera, jumps to ledge, looks into an artificial site (likely, site A-856)
6/24/2011	13:24:46	13:24:48	3	UW	W	CORA	1	on ledg.
6/24/2011	14:16:58	14:17:00	3	UW	W	CORA	1	on floor
6/24/2011	16:17:31	16:20:05	45	UW	M	CORA	1	moves back and forth in front of camera, jumps to ledge
6/24/2011	16:56:14	16:56:16	3	UW	W	CORA	1	on ledge
6/24/2011	17:22:51	17:22:53	3	UW	M	CORA	1	moves in front of camera
6/25/2011	15:08:04	15:08:15	6	UW	M	CORA	1	moves in front of and looks into camera
6/25/2011	18:48:35	18:48:49	12	UW	M	CORA	1	on ledge, looks into artificial site (likely, site A-856)

Date	Time First Photo	Time Last Photo	Number of Photos	Cavern[a]	Camera[b]	Species	No.	Observations
6/25/2011	18:48:40	18:48:42	3	UW	W	CORA	1	on floor
7/2/2011	15:41:45	15:44:23	12	UW	M	CORA	1	moves in front of camera, moves towards cavern's west entrance
7/3/2011	14:35:36	14:35:40	3	UW	M	CORA	1	moves in front of camera
7/8/2011	16:27:59	16:28:01	3	UW	M	CORA	1	in front of camera
7/11/2011	15:28:42	15:29:05	12	UW	M	CORA	1	lands at west end of cavern, moves to floor
7/11/2011	15:35:05	15:35:07	3	UE	E	CORA	1	perched on artificial site #A-890
7/11/2011	15:37:03	15:37:05	3	UW	M	CORA	1	in front of camera
8/1/2011	18:48:48	18:48:50	3	UE	E	WEGU	1	lands on rock slope outside of east entrance of Upper East Cavern, looking towards the cavern
8/12/2011	11:58:19	11:59:43	30	UW	M	CORA	2	1st bird on A-866, 2nd bird on rock outside cavern; 1st bird moves in to look into the camera, 2nd bird follows 1st and perches on A-866, the westernmost floor artificial site. 2 birds seen in 15 photos
8/12/2011	12:04:16	12:04:18	3	UE	E	CORA	1	lands on rock slope outside of east entrance of Upper East Cavern
9/3/2011	13:10:52	13:11:33	18	UW	M	CORA	1	lands on A-866, moves towards camera
11/7/2011	11:10:08	11:10:08	3	UE	E	CORA	1	lands on rock slope outside of east entrance of Upper East Cavern

[a] UW = "Upper West Cavern," UE = "Upper East Cavern."

[b] Reconnaissance camera abrreviations, as follow: M = "Middle"; ; E = "East"; W = "West".

Appendix B.

Protocol for Implanting PIT-tags into Ashy Storm-Petrel (*Oceanodroma homochroa*) Chicks

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Introduction

The purpose of this study is to evaluate success of restoration efforts for Ashy Storm-Petrel (*Oceanodroma homochroa*) at Santa Cruz Island, California, by PIT-tagging Ashy Storm-Petrel chicks and monitoring future return to and use of natural and artificial sites by these birds. In 2010, 50 Ashy Storm-Petrel chicks were individually fitted with a PIT-tag band, adapted after methods described in Zangmeister *et al*. (2009); each band was attached to a tarsus of each banded chick. In spring 2011, U.S. Geological Survey (USGS) personnel at the Bird Banding Laboratory (Laurel, MD) expressed concerns about external PIT-tag attachment, and recommended implementation of a sub-cutaneous implantation method, instead of external PIT-tag attachment. Beginning in August 2011, passive integrated transponder (PIT) tags (each measuring 12.5 mm in length and with a unique identification number; Biomark, Inc., Boise, ID) will be injected subcutaneously into Ashy Storm-Petrel chicks encountered in accessible artificial and natural nest sites Orizaba Rock, and accessible natural sites at four other locations: Dry Sandy Beach Cave, Cave of the Birds' Eggs, Bat Cave and Cavern Point Cove Caves.

Prior to PIT-tag implantation work at Santa Cruz Island, during summer 2011, William McIver will be trained by Jamie Bettaso (wildlife biologist, Arcata, CA) in the implantation technique, using poultry chicks and following PIT-tag implantation methods as described in Jamison (2000). During the August 30-31 fieldtrip to Santa Cruz Island, W. McIver will train L. Harvey and H. Carter and field assistants in the proper PIT-tag implantation technique.

One PIT-tag will be injected into the nape of the neck of each storm-petrel chick using a plastic syringe-style implanter (model MK-10; Biomark, Inc.) with 12-gauge needle (model N125; Biomark Inc.) Beginning in 2011, Ashy Storm-Petrel adults observed (during regular nest-monitoring activities) occupying nest sites at Santa Cruz Island were scanned with a PIT-tag reader (model APR 350, RFID Oregon, Portland, OR) with a wand antenna, to detect presence of PIT-tagged storm-petrels. This technique is proposed to be repeated in subsequent years during nest-monitoring efforts at Santa Cruz Island.

Methods

Materials:

- plastic syringe-style implanter (model MK-10; Biomark, Inc.)
- 12-gauge needle (model N125; Biomark Inc.)
- 12.5mm PIT-tags
- cosmetic cotton balls
- Q-tips
- denatured isopropyl alcohol
- veterinary skin adhesive (*e.g.*, Dermabond, Nexaband)

- Betadine antiseptic
- small tray
- paper towels
- sterile surgical gloves
- Pesola 100g. scale
- cotton weigh bag
- Sharps container or plastic Tupperware
- PIT-tag reader

General Procedures:

The following PIT-tag implantation methods will be followed by personnel at study sites. Implantation of PIT-tags into each Ashy Storm-Petrel chick will be performed by a two-person team. One team member (either McIver, Harvey or Carter) will serve as an "Implanting Lead," and the other team member will assist the Implanting Lead in securing the chick, implanting the PIT-tag and recording data and notes onto data forms. Only Ashy Storm-Petrel chicks that are easily accessible, found alone (with no adult present in site when found), and are large enough (*i.e.*. larger than "small downy," per chick descriptions in McIver and Carter [1996]) will be handled, and no nests will be dismantled to attempt to obtain a chick. Prior to PIT-tagging, each storm-petrel chick that is temporarily removed from a nest site will be examined for health and vigor; PIT-tags will be implanted only in chicks that demonstrate good health and vigor. Implanter Lead and assistant will wear sterile surgical gloves during implantation procedures. Each injecting needle will be sterilized before each use and will be used <u>no more than 10 times</u> before being discarded in Sharps container. PIT-tags will be implanted accordingly:

PIT-tag Implantation Procedures:

1. Implanting Lead obtains Ashy Storm-Petrel chick from nest site
2. Examine chick; if found to be unhealthy, weak or moribund, return immediately to nest site
3. Place healthy chick belly-side down on clean paper towel on the small tray (serves as operation platform)
4. Assistant ensures chick stays on tray
5. Implanting Lead sterilizes PIT-tag and injecting needle with isopropyl alcohol, inserts PIT-tag into needle, inserts needle into implanting syringe
6. Lightly part down or contour feathers at nape of neck (dorsal side of neck)
7. Dip Q-tip into denatured alcohol, lightly apply to nape of neck (do not drench down or feathers)
8. Assistant holds chick and extends neck of chick
9. Implanting Lead lifts flap of skin on the nape, inserts needle anterior to posterior under the skin flap, and injects the tag by depressing the plunger of the syringe.
10. Skin is relaxed and massaged lightly to ensure proper subcutaneous placement of PIT-tag on dorsal side of nape of neck.
11. Examine entry hole, stop any bleeding by lightly applying pressure with Q-tip or cotton ball.
12. Treat implant site with small amount Betadine antiseptic applied to Q-tip.
13. Daub dry the skin around implant site with cotton and apply small amount of skin adhesive to skin at implant site.

14. Scan nape region of chick with PIT-tag reader & record PIT-tag identification number on nest form
15. Weigh chick and record weight on nest form.
16. Return chick to nest site from which it was removed.

References

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McIver, W.R., and H.R. Carter. 1996. Breeding phenology and success of the Ashy Storm-Petrel at Santa Cruz Island, California: 1996 data collection protocol. Unpublished report, National Biological Service, California Science Center, Dixon, California. 7 p.

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Appendix C. PIT-tag identification numbers of 28 Ashy Storm-Petrel chicks tagged at Santa Cruz Island, California, in 2011. Abbreviations for locations: BC = Bat Cave, CBE = Cave of the Birds' Eggs, OR = Orizaba Rock.

Location	Date Banded	PIT-tag ID Number	USGS Band Number	Nest Tag Number	Chick Stage[1]
BC	9/23/2011	985121021086000	4501-41773	819	LGC
BC	9/23/2011	985121021089844	4501-41770	1106	SGC
BC	9/23/2011	985121021105085	4501-41745	825	FFC
BC	9/23/2011	985121021113361	4501-41753	834	LDC
BC	9/23/2011	985121021113587	4501-41738	341	FFC
BC	9/23/2011	985121021117339	4501-41739	837	SGC
BC	9/23/2011	985121021118185	4501-41771	836	MGC
BC	9/23/2011	985121021118260	4501-41769	1090	MGC
BC	9/23/2011	985121021142999	4501-41772	1092	MGC
BC	9/23/2011	985121021183674	4501-41754	1042	LGC
BC	10/18/2011	985121021145639	4501-41744	1043	MGC
BC	10/18/2011	985121021157000	none	835-W	SGC
CBE	9/22/2011	985121021105009	4501-41758	829	MGC
CBE	9/22/2011	985121021127660	4501-41757	769	MFC
CBE	9/22/2011	985121021131690	4501-41761	1095	LGC
CBE	9/22/2011	985121021132241	4501-41756	1086	FFC
CBE	9/22/2011	985121021133429	4501-41764	942	LGC
CBE	9/22/2011	985121021142582	4501-41759	1087	LGC
CBE	9/22/2011	985121021143145	4501-41763	1001	MFC
CBE	11/8/2011	985121021128979	4501-41780	844	MGC
OR	9/22/2011	985121021088553	4501-41755	A-858	LGC
OR	9/22/2011	985121021129019	4501-41768	33	FFC
OR	9/22/2011	985121021132201	4501-41766	483A	FFC
OR	9/22/2011	985121021146661	4501-41767	832	SGC
OR	9/22/2011	985121021156710	4501-41765	A-869	MFC
OR	10/18/2011	985121021147262	none	1102	MGC
OR	11/8/2011	985121021118836	4501-41722	483B	LGC
OR	11/8/2011	985121021142154	4501-41775	A-1067	LGC

[1] Chicks stages and estimated age ranges (in days) as described in McIver and Carter (1996), as follows: LDC = large downy chick (11-20 d); SGC = small gawky chick (21-30 d); MGC = medium gawky chick (31-45 d); LGC = large gawky chick (46-60 d); MFC = mostly-feathered chick (61-75 d); and FFC = fully-feathered chick (76+ d).