# Monitoring and Restoration of Ashy Storm-Petrels at Santa Cruz Island, California, in 2013

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## EXECUTIVE SUMMARY

In 2013, Channel Islands National Park and the California Institute of Environmental Studies were funded by the Montrose Settlements Trustee Council to continue gathering data on population size and reproductive performance of Ashy Storm-Petrels (*Oceanodroma homochroa*), and to assess on-going and future restoration actions for Ashy Storm-Petrels at Santa Cruz Island, California. In order to restore a breeding population on Orizaba Rock, artificial habitat and vocalization broadcasting was conducted in 2008-12. In July 2012, impacts to Ashy Storm-Petrel artificial nesting structures by Common Ravens (*Corvis corax*) were observed, and as a result, unoccupied artificial sites were removed by researchers and vocalization broadcasting was discontinued. The Montrose Trustee Council determined that further work was needed to develop protective artificial nesting structures. Therefore, artificial nesting structures were not deployed and vocalization broadcasting was not implemented at Orizaba Rock in 2013. Thirty-one egg-laying pairs of Ashy Storm-Petrels were found in natural crevices at Orizaba Rock in 2013. At three monitored reference colonies and Orizaba Rock, a total of 164 nests were found and monitored in 2013, and overall breeding success was 53% ($n$ = 158). This level was lower than what was observed in 2012 (64%, $n$ = 144) and 2011 (79%, $n$ = 110), and was the second-lowest breeding success value (lowest in 1996; 45%, $n$ = 173) observed at Santa Cruz Island since monitoring began in 1995. Breeding success in 2013 at Orizaba Rock (43%, $n$ = 28) was lower than two main reference colonies at Bat Cave (52%, $n$ = 93) and Cave of the Birds' Eggs (60%, $n$ = 30). Seven active nests occurred at Cavern Point Cove Caves in 2013 (breeding success = 71%), compared to five active nests in 2012 and a maximum of two active nests per year in 2009-11, following an unusual heavy predation event and near extirpation of Ashy Storm-Petrels at this location by island spotted skunks (*Spilogale gracilis amphiala*) in 2008. In contrast, relatively high numbers of active nests in Bat Cave ($n$ = 97) in 2013 indicated continued recovery following a similar unusual skunk predation event in 2005; however, predation by ravens likely reduced breeding success at Bat Cave in 2013. Dry Sandy Beach Cave was not visited by researchers in 2013. At least one wave wash or high water event appeared to occur at Cave of the Birds' Eggs in 2013 (similar to 2010-12), which may have affected several nests towards the end of the breeding season. Skunk traps were redeployed in 2013 at Bat Cave, Cave of the Birds' Eggs, and Cavern Point Cove Caves to prevent possible additional predation of storm-petrels by skunks, and no skunks were detected in these sea caves in 2013.

## 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, 2008a, *unpubl. data*). From 1995 to 2002, HSU also implemented standardized monitoring of population size (using nest counts), reproductive performance, breeding phenology, and predation at five locations at Santa Cruz Island, including Orizaba Rock (OR), Bat Cave (BC), Cavern Point Cove Caves (CPC; comprised of two adjacent caves: Cave #4 and Cave #5), Cave of the Birds' Eggs (CBE), and Dry Sandy Beach Cave (DSB) (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).

The Montrose Settlements Trustee Council (MSTC) identified several seabird restoration projects 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 [MSRP] 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 OR and CBE in 1992, 1996 and 1997 (Fry 1994; Kiff 1994; Carter et al. 2008b); c) reduced numbers of nest sites at OR 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 BC 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). MSRP (2005:6-11) identified potential restoration actions at OR, including installation of artificial nest sites and reduction in human disturbance.

In 2006-12, the MSTC funded two government agencies (USFWS [Ventura and Arcata Fish and Wildlife Offices] and Channel Islands National Park [CINP]) and three non-governmental organizations (CBC, California Institute of Environmental Studies [CIES], and Simon Fraser University) to monitor Ashy Storm-Petrels and implement restoration actions at Santa Cruz Island. Roles of these participating agencies and organizations varied by year, and the specific monitoring and restoration-related activities conducted at Santa Cruz Island are summarized in Appendix A, and described in detail in the annual reports (Carter et al. 2007; McIver et al. 2008; McIver et al. 2009a; McIver et al. 2010; McIver et al. 2011; McIver et al. 2013; and McIver et al. 2014).

In 2013, the MSTC funded CINP and CIES to continue gathering nest-monitoring information at Santa Cruz Island. In addition, the MSTC funded and supported efforts to evaluate modifications to artificial nest sites at OR.

## METHODS

### Study Area

Santa Cruz Island is located off the coast of southern California, approximately 40 km south of the city of Santa Barbara. It is the largest (249 $km^2$) of the eight major Channel Islands (Minnich 1980). The northern and northwest shores of Santa Cruz Island consist of sheer cliffs and coastal bluffs, with at least 110 sea caves (Bunnell 1988). The Nature Conservancy (TNC) owns the western 75% (approximately) of the island, and CINP owns the eastern 25% (approximately) of the island. Santa Cruz Island also is surrounded by waters within the Channel Island National Marine Sanctuary, which extend to approximately 6 nautical miles (11.1 km) from shore. Three marine protected areas also have been established: Scorpion Marine Reserve (BC and CPC occur within this reserve); Gull Island Marine Reserve; and Painted Cave Marine Conservation Area (CBE occurs within this area). OR and DSB do not occur within reserves.

### Field Logistics

In 2013, field work, data entry, and project management were conducted by CINP and CIES personnel. Data analyses and report preparation were retained by USFWS-AFWO, with assistance from CINP and CIES personnel. Transportation to and from Santa Cruz Island was provided aboard the following support vessels: the charter boat *Retriever*, operated by D. Carlson, T. Shinn, M. Able and K. Peet (Ventura, CA); and the concessionaire boat *Islander*, operated by Island Packers (Ventura, CA) (Table 1). Nesting habitats were accessed from a 14-foot (4.3 m) inflatable boat powered by a 15, 20 or 25 horsepower outboard engine launched from the support vessel, or by use of sea kayaks (BC and CPC only) launched from nearby Scorpion Anchorage. There were 18 field days in 2013, compared to 2012 ($n$ = 17) and 2008-11 (range: $n$ = 12-14). Mainland time required for coordination of trip logistics was similar to 2012. As in 2011 and 2012, nest-monitoring trips in 2013 were scheduled to occur near new moons.

### Nest Monitoring

In February-November 2013, standardized methods (see McIver and Carter 1996, 2006; McIver 2002) in use since 1995 were used during field trips to search for and monitor all nests of Ashy Storm-Petrels found in accessible habitats at BC, CBE, CPC (comprised of two adjacent caves: Cave #4 and Cave #5), and OR (Figure 1). Nest monitoring in 2013 involved 1-5 hour visits during each monthly field trip to each breeding location in June-November (Table 1). DSB, which was visited by researchers at least one time each year during 1995-2012 (except for 2003), was not visited by researchers in 2013.

A storm-petrel nest was defined as a crevice, cavity, or depression containing definite evidence of an egg having being laid in the study year, such as 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

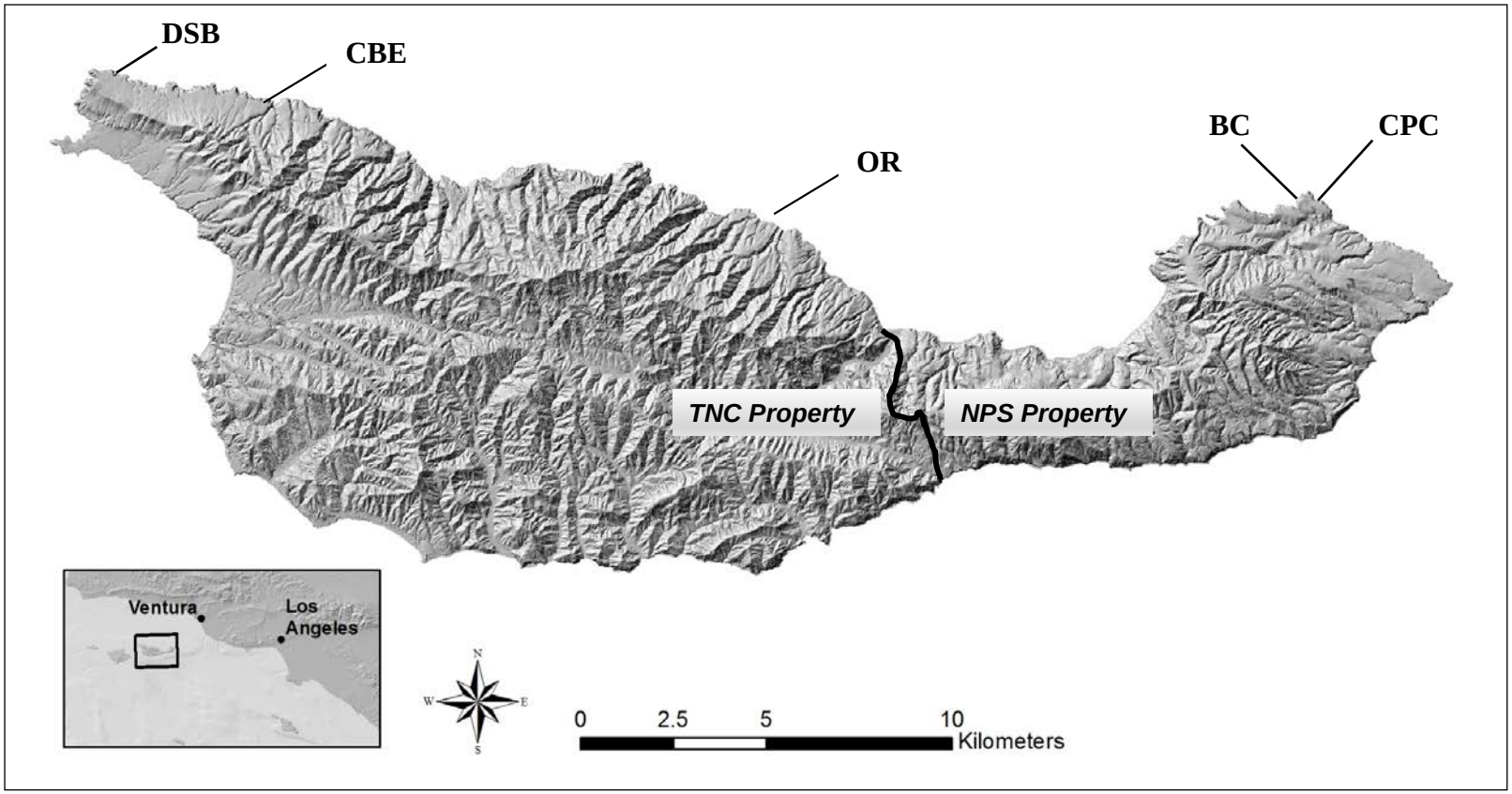


**Figure 1. Approximate locations of monitored Ashy Storm-Petrel colonies at Santa Cruz Island: Bat Cave (BC); Cave of the Birds' Eggs (CBE); Cavern Point Cove Caves (CPC); Dry Sandy Beach Cave (DSB; not monitored in 2013); and Orizaba Rock (OR). The current boundary between National Park Service (NPS) and The Nature Conservancy (TNC) properties is demarcated by the bold black line but all offshore rocks (including Orizaba Rock) also are NPS property.**

**Table 1. Field trips conducted for Ashy Storm-Petrel monitoring at Santa Cruz Island, California, in 2013.**

| Date | Locations[1] | Personnel[2] | Main Activities | Vessel Support |
|---|---|---|---|---|
| 15 February | OR | DM, JH, AY, LH | Deploy cameras & songmeters; monitor sites at OR. | *Retriever* and zodiac |
| 7 June | CBE, OR | DM, JH, AY, KC, LH, EW | Monitor sites; deploy skunk traps; check cameras & songmeters. | *Retriever* and zodiac |
| 9-10 June | BC, CPC | DM, JH, AY, EW, AD | Monitor sites; check traps & cameras; remove artificial nest sites; stop vocalization broadcasting. | *Islander* + kayak |
| 6-7 July | BC, CBE, CPC, OR | DM, JH, AY, KC, LH, FH | Monitor sites; check traps & cameras. | *Retriever* and zodiac |
| 17 July | BC | DM | Deploy & check cameras, collect feather piles. | *Islander* + kayak |
| 18 July | OR | DM, NL, MP | Site visit for research and development of ceramic nest modules. | *Islander* and skiff |
| 4-5 August | BC, CBE, CPC, OR | DM, JH, AY, KC | Monitor sites; check traps & cameras. | *Retriever* and zodiac |
| 22 August | BC | DM | Check cameras and assess habitat. | *Islander* and kayak |
| 6 September | CBE, OR | DM, EW, KC, JK | Monitor sites; check traps & cameras, test artificial sites. | *Islander* and kayak |
| 9 September | BC | DM, JH, AY, EW, KC, LF | Monitor sites; check traps & cameras. | *Islander* and kayak |
| 10 September | CPC | JH, KC, LF | Monitor sites; check traps & cameras. | *Islander* and kayak |
| 7-8 October | CBE, OR, BC, CPC | DM, JH, AY, EW, LF | Monitor sites; check traps & cameras; remove songmeters. | *Retriever* and zodiac |
| 7-8 November | BC, CBE, CPC, OR | DM, JH, AY, CM | Monitor sites; remove traps & cameras. | *Retriever* and zodiac |

***Footnotes -***

1 Codes: BC = Bat Cave, CBE = Cave of the Birds' Eggs, CPC = Cavern Point Cove Caves, OR = Orizaba Rock.

2 Codes: AD = Ashley Domsic (CINP), AY = Andrew Yamagiwa (CIES), CE = Cody Ender (CIES), CM = Carolyn Mills (CIES), DM = David Mazurkiewicz (CINP), EW, Eden Wynd (CIES), FH = Fritz Hertel (CSU - Northridge), JH = Jim Howard (CIES), JK = John Knapp (TNC), KC = Katy Carter (CIES), LF = Laurel Fergusen (CIES), LH = Laurie Harvey (CIES), MM = Maya Morales (CINP); MP = Matthew Passmore (Rebar Group), NL = Nathan Lynch (California College of the Arts), SK = Sue Kim (CIES) .

previous years), or a chick. A nest was described as "active" if evidence of egg laying was observed in or associated with the nest, and a nest was described as "visited" if a bird was observed in the nest but no evidence of egg laying was found. In some cases, a few eggs may have disappeared without leaving any evidence before our first visit after the egg was laid but we suspect such occurrences were rare. If Ashy Storm-Petrels re-laid at the same nest site or at another nest site, the loss of the odd egg without detection would not affect the number of nests documented in the study year. However, at some locations, the number of nests followed was relatively low and undetected failure of a few first eggs could slightly affect measures of reproductive performance. We searched for and examined nests with the aid of headlamps and small flashlights, completely covering all suitable and accessible habitat at each location. 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 placed on a field map adapted from Bunnell (1988) and an individually numbered plastic tag, attached to rock or driftwood near the nest entrance. Nest contents were recorded for each marked nest on each visit. Because storm-petrels can be sensitive to disturbance at nest sites (Scott 1970, Ainley et al. 1990), we did not handle adults, incubated eggs, or brooded chicks. If an adult was observed in a site during June, July and August, we scanned the bird with the use of a hand-held wand attached to a PIT-tag scanner (APR350 Reader, Agrident GmbH, Barsinghausen, Germany), to attempt to detect any birds previously banded with PIT-tag bands as chicks (which began in 2010 [McIver et al. 2011]; see "Recruitment Study" section below). Stages of chick plumage development were recorded during nest monitoring (McIver and Carter 1996; McIver 2002). Evidence of predation, including carcasses, feather piles and broken eggs, was recorded but not consistently removed, as in 2006-12 (removal of these items facilitates detection of new evidence of predation and replacement eggs and to prevent double counting). Breeding phenology was estimated for each nest (i.e., timing of initiation [egg-laying], hatching, and fledging) by backdating from a range of estimated hatch dates based mainly on estimated ages for chick plumage stages or dates when eggs that failed to hatch were first observed (McIver and Carter 1998).

**Artificial Nest Sites & Vocalization Broadcasting**

In 2008-2012, artificial habitat was provided and vocalization broadcasting was conducted at OR. In mid-July 2012, artificial sites were removed and vocalization broadcasting was stopped due to raven impacts to artificial sites (McIver et al. 2014). In 2013, the MSTC and personnel from CINP, USFWS, Oikonos Ecosystems Knowledge (Benicia, California) and Rebar Group (San Francisco, California) discussed possible modifications to artificial nesting structures, with the intent of to developing and manufacturing more durable ceramic artificial nesting structures for use by Ashy Storm-Petrels, to deter future alterations and impacts by ravens. Consequently, artificial nest structures were not re-deployed and vocalizations were not broadcasted in 2013. However, artificial nest prototypes developed by Rebar Group were temporarily deployed on OR on 6 September 2013, to test the efficacy of deploying these various prototypes.

**Reconnaissance Camera Monitoring**

*Ravens at OR*.– Similar to 2010-11, multiple reconnaissance cameras (model HC500 Hyperfire, RECONYX Inc., Holmen, WI) were redeployed at OR in 2013 (only one camera was deployed in 2012). On 15 February 2013, one camera was deployed in the Upper West Cavern, where the majority ($n$ = 22) of the artificial nest sites previously (years 2008-12) had been deployed, and one camera was deployed at the Upper East Cavern, where 8 artificial nest sites were deployed. A third

camera was deployed in the Lower Cavern. In the Upper West Cavern, the camera was deployed on a small boulder in the middle of the cavern; the lens of this camera was oriented in a north-westerly direction, with a field of view including the ledge at the northern portion 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. At the Upper East Cavern, the camera was deployed on a wall just east of the east entrance of the camera; the lens of the camera was oriented in a westerly direction. The camera in the lower cavern was orientated to face the eastern wall, encompassing views of floor/wall sites and the entrance rock pile that leads into the lower cavern. Images were taken when the cameras were motion-activated within the field of view during day or night; they were set to take five images within five consecutive seconds before re-setting. Memory cards were changed during each nest check, and batteries changed as needed, usually every other nest check. The camera at the Lower Cavern was removed on 7 October 2013. The cameras in the upper caverns were left in place to record observations of ravens and other birds during the 2013-14 winter months. For all observations of raven and gull from reconnaissance camera images at OR, we recorded date, time duration (to the nearest second) and number of photos taken during "visitations," specific Reconyx camera used, numbers of birds, and behavior of the birds (Appendix B).

*Ravens & Human Visitors at BC*.– As in 2012, when non-researcher visitation of BC was witnessed and documented by researchers (see McIver et al. 2014), a reconnaissance camera (pre-programmed in the same manner as at OR) was deployed in the main room of BC on 9 June (camera #1) to capture images of any human visitation (non-researcher) to the cave. The lens of the camera was oriented in a north-northwest direction, facing the main entrance of the cave and including the "cave closure" sign at the cave entrance in its field of view. Two more cameras were deployed on 17 July: one on the large dirt pile (camera #2) in the west side of the main room of the cave facing east towards the main room of cave; and another (camera #3) mounted to a piece of driftwood at the main driftwood pile in the center of the cave, facing the back south section of cave with the back wall and middle of cave in field of view. These two cameras were placed in response to an increase in storm-petrel feather piles and camera evidence of ravens in the cave from the nest-check on 6 July.

The cameras were moved occasionally to afford different views of cave and to try and better document raven behavior. Camera #2 (back of cave) was adjusted on 5 August and moved further east to another driftwood berm but still focused on activity in back of cave. On 8 October, we moved the following two cameras accordingly: (1) the "dirt pile camera" (camera #2) was moved from the dirt pile to a location a few meters west and along the west cave wall, with the lens pointed in an easterly direction facing towards the main cave opening; and (2) the "entrance camera" (camera #1) was moved from the toe of the outside slope at the eastern cave-mouth edge to the bottom of the slope in the main room, with the lens oriented in a westerly direction towards the entrance of the main room. Memory cards and batteries in the cameras were changed during nest-monitoring trips. The cameras were left in the cave over the 2013-14 winter to record raven (and other) observations. For all observations of ravens (Appendix B) from the BC reconnaissance camera images, we recorded date, time duration (to the nearest second) and number of photos taken during "visitations," numbers of ravens or people, and behaviors of ravens or people.

**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 and continued in 2011-12 using passive integrated transponder (PIT) technology to examine future recruitment of Ashy Storm-Petrels at artificial and natural sites at OR, and at natural sites in sea caves (see McIver et al. 2011, 2013, 2014 for more detailed descriptions of methods). 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 for attachment to up to 250 chicks, with special approval from the U.S. Geological Survey (USGS) Bird Banding Laboratory (Laurel, MD). Following methods described in Zangmeister et al. (2009), each tag was encased in 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. 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 from the original design used in 2010, so that both plastic bands were adjacent to each other with no space occurred between the bands (see Figure 8 in McIver et al. 2013). As in 2010-12, one PIT-tag band was attached to either the left or right tarsus of each banded chick and the unique ID number was read with a PIT-tag scanner and recorded on a paper map of the colony or in a data notebook. Each handled chick was also banded with a uniquely-numbered metal U.S. Geological Survey band (size 1B). Each chick was handled for less than 5 minutes; immediately after banding, each chick was returned to its nest site. As in 2011-12, each adult storm-petrel encountered in a nest site during nest monitoring was “wanded” with a PIT-tag reader attached to a wand antenna, to detect PIT-tags previously attached to chicks.

**Protection from Predation by Island Spotted Skunks**

As in 2009-12 (see McIver et al. 2010, 2011, 2013, 2014), 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 during the Ashy Storm-Petrel breeding season in 2013 (see Figure 9 in McIver et al. 2013). Earlier skunk predation events at BC in 2005 and CPC in 2008 precipitated the need for skunk trapping to prevent storm-petrel colony extirpations and allow these colonies to recover. In 2005, a live trap had been used previously at Bat Cave to remove one skunk but an intensive trap checking effort was required (McIver and Carter 2006). No skunks were noted in BC in 2006-2008, indicating that access by skunks was an unusual or rare event possibly related indirectly to high skunk densities in upper island habitats (Jones et al. 2008). In 2009, CINP considered that: (1) lethal trapping was the most humane method of trapping skunks because live traps need to be checked daily to avoid skunk deaths which was not possible at this remote location in these years; and (2) only a few if any skunks were expected to be trapped because none had been found in BC after 2005 and sea caves at Santa Cruz Island did not have direct access to upper island habitats where skunks normally occur. After deployment, traps were examined on each field trip in 2013 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 autumn field trips.

**Protection from Predation by Ravens**

Based on a review of images from reconnaissance cameras during the 2013 breeding season, it was confirmed that ravens were visiting the main room in BC and preying on Ashy Storm-Petrels. During telephone discussions between MSTC and personnel from CINP and USFWS, it was determined that we would attempt to protect chicks in "open" sites, those sites potentially easily accessed by ravens, by placing pieces of wood and rock cobble near or over the nesting crevices. This method was tested in August, and with no apparent issues for storm-petrels, fortification of sites continued in September and October 2013. Because Ashy Storm-Petrels exhibit high site-fidelity (Ainley 1995), and because procellariid adults and chicks recognize each other by both auditory and olfactory cues (Mínguez 1997, Duckworth et al. 2009), we assumed that protective wooden pieces placed over these sites would not prevent adults from finding their chicks upon their return to the colony for provisioning of chicks.

**Human Visitation Signs**

Signs prohibiting the entry of sea caves by human visitors 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 or replaced, as needed, in 2013.

**Data Handling and Descriptive Statistics**

Like other storm-petrels, Ashy Storm-Petrels are highly philopatric and typically each pair only lays one egg per year, and replacement eggs are uncommon (Ainley et al. 1990, Ainley 1995, McIver 2002). Within a nesting season, if only one egg was laid in a nest site, we considered it to be a "single" egg from a breeding pair. When another egg was found in the same nest site where a previous egg (i.e., "first" egg) had been laid earlier but failed, we considered it to be a replacement egg produced by the same breeding pair as the first egg. In the extremely rare event that another egg was found in the same nest site where a first egg had been laid and successfully fledged a chick, we considered this egg to be a late-season single egg laid by a different breeding pair.

Hatching success was defined as the percentage of single and first eggs hatched per egg laid where egg fate was known. For fledging success and breeding success, we examined percentages of chicks fledging from single and replacement eggs (collectively 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. For hatching, fledging, and breeding success, we excluded a few breeding pairs for which egg or chick fates were not known. Descriptive statistics for estimated breeding phenology (i.e., midpoint of estimated ranges of dates for egg laying, hatching and fledging) are presented separately for single and 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 elsewhere (McIver and Carter 1996, 1998; McIver 2002; McIver et al. 2010). To evaluate breeding phenology, numbers of active nests during the 6-7 July and 4-5 August field trips are described for each location.

## RESULTS

### Breeding Phenology

Estimated dates of egg laying, hatching and fledging in natural and artificial nest sites at each monitored location at Santa Cruz Island are summarized in Table 2. In 2013, laying dates ranged from 22 April to 22 September for single and first eggs ($n$ = 144) versus 6 July to 22 September for replacement eggs ($n$ = 11). Hatch dates ranged from 3 June to 3 October for single and first eggs ($n$ = 108) versus 20 August to 2 October for replacement eggs ($n$ = 6). Fledging dates ranged from 22 August to 7 December for chicks from single and first eggs ($n$ = 82), versus 22 November to 16 December for chicks from replacement eggs ($n$ = 4). A total of 164 active nests were observed at four colonies Santa Cruz Island in 2013; 129 active nests (79%) were observed on the 6-7 July field trip, and 136 active nests (83%) were observed on the 4-5 August field trip.

### Bat Cave

*Ashy Storm-Petrel*: Ninety-five nests were documented at BC in 2013. Seventy-seven active nests (81%) were observed on 7 July 2013, and 78 active nests (82%) were observed on 5 August 2013. Ranges of dates of egg laying, hatching and fledging for single/first eggs were estimated as: 20 April – 23 August (range 125 d, $n$ = 82); 3 June – 3 October (range 122 d, $n$ = 63); and 22 August – 7 December (range 17 d, $n$ = 48), respectively. Ranges of dates of egg laying, hatching and fledging for replacement eggs were estimated as 6 July – 22 August (range 47 d, $n$ = 73); 20 August – 2 October (range 43 d, $n$ = 5); and 22 November – 16 December (range 243 d, $n$ = 3), respectively.

Hatching success for first/single and replacement eggs was 69% ($n$ = 95) and 71% ($n$ = 7), respectively; fledging and breeding success for last eggs were 78% ($n$ = 65), and 52% ($n$ = 93), respectively (Table 3).

*Northern Fulmar* (*Fulmarus glacialis*): One northern fulmar was observed on the water in the cove adjacent to BC on 8 October.

*Scripps's Murrelet (Synthliboramphus scrippsi)*: On 9 June 2013, one nest was found in a wall crevice (tag #1106 - one hatched eggshell and one full egg) on the "slope" in the main room of the cave.

*Bats*: One Townsend's big-eared bat [*Corynorhinus townsendii*]) was observed in a side cavern of the main room of BC on 8 November.

*Skunks*: Three skunk traps were deployed on 9 June and removed in the autumn (exact date not noted). No evidence that skunks (or any other mammal or bird) entered trap boxes was found. No smell of skunk or evidence of skunk predation was found in 2013.

*Predation/Scavenging*: Evidence of predation of Ashy Storm-Petrels (i.e., 45 distinct feather piles) was detected at Bat Cave, as follows: (1) 9 June — 8 feather piles and one owl pellet with storm-petrel remains; (2) 7 July — 18 feather piles; (3) 4 August — 7 feather piles; (4) 9 September — 9 feather piles; (5) 8 October — 1 feather pile; and (6) 8 November — 2 feather piles. Forty-two (98%) of the feather piles were found in the main room of Bat Cave, and the feather piles indicated predation by Barn Owl (*Tyto alba*) or Common Raven. Common Ravens

were observed on 32 different days over a 205-day period (9 June 2013 to 1 January 2014) in images from four reconnaissance cameras deployed in BC.

**Table 2. Average timing of egg laying, hatching and fledging (mean date ± standard error in days) for Ashy Storm-Petrels at Santa Cruz Island, California, in 2013. Sample sizes in parentheses.**

| Location[1] | Clutch Number[2] | Egg Laying | Hatching | Fledging |
|---|---|---|---|---|
| BC | 1 | 15 June ± 3 (82) | 21 July ± 4 (63) | 8 October ± 4 (48) |
| BC | 2 | 1 August ± 7 (7) | 8 September ± 7 (5) | 2 December ± 7 (3) |
| CBE | 1 | 18 June ± 7 (29) | 19 July ± 6 (23) | 2 October ± 6 (18) |
| CBE | 2 | 22 September (1) | - | - |
| CPC[3] | 1 | 27 May ± 8 (6) | 1 July ± 4 (5) | 22 September ± 4 (4) |
| CPC[3] | 2 | 22 July (1) | 4 September (1) | 23 November (1) |
| OR[4] | 1 | 8 July ± 7[5] (27) | 3 August ± 7 (17) | 18 October ± 7 (12) |
| | 2 | 21 August ± 32 (2) | - | - |
| All | 1 | 19 June ± 3 (144) | 22 July ± 3 (108) | 7 October ± 3 (82) |
| | 2 | 5 August ± 7 (11) | 7 September ± 6 (6) | 29 November ± 6 (4) |

***Footnotes –***

1 Codes defined in Table 1.

2 Codes: 1 = first and single eggs; 2 = replacement eggs. Sample sizes at locations may differ from Table 3, primarily because nests with a wide range of possible egg laying dates (> 30 d) were excluded from Table 2.

3 Nests in Cave #5 only; no active nests in Cave #4 since skunk predation in 2008.

4 Natural crevices only; artificial sites not deployed in 2013.

5 See "Orizaba Rock" section in Results regarding early egg laying at nest site #1157.

**Table 3. Percent hatching, fledging, and breeding success of Ashy Storm-Petrel nests monitored at Santa Cruz Island, California, in 2013. Sample sizes in parentheses.**

| | | Location[1] | | | | |
|---|---|---|---|---|---|---|
| **Success (%)** | **Clutch Number[2]** | **BC** | **CBE** | **CPC[3]** | **OR[4]** | **All** |
| Hatching | 1 | 69.5 (95) | 74.2 (31) | 71.4 (7) | 58.1 (31) | 68.3 (164) |
| | 2 | 71.4 (7) | 0 (1) | 100.0 (1) | 0 (2) | 54.5 (11) |
| Fledging | Last | 78.5 (65) | 81.8 (22) | 83.3 (6) | 70.6 (17) | 78.2 (110) |
| Breeding | Last | 51.6 (93) | 60.0 (30) | 71.4 (7) | 42.9 (28) | 52.5 (158) |

***Footnotes -***

1 Codes defined in Table 1.

2 Codes 1 and 2 defined in Table 2; Last = single and replacement eggs.

3 Nests in Cave #5 only; no nests in Cave #4 since 2008 skunk predation event.

4 Natural crevices only; artificial sites not deployed in 2013.

*Human Visitation*: CINP signs prohibiting cave entry by human visitors (i.e., non-researchers) have been deployed inside both the main room and slope room since 2009. In 2013, these signs were intact and in their original locations (i.e., unaffected by ocean wave action or vandalism). However, one discrete visitation event by an unauthorized person (one person recorded on camera) was documented in 2013. On 5 August, a group of kayakers (approximately 3 or 4 individuals) were observed pulled ashore at a small beach located 100-200 m northeast of BC. Reconnaissance cameras deployed in the main room of BC detected one discrete visitation event by a human visitor arriving with a kayak at 13:11, on 27 June 2013. In the camera images, a man walked in the cave and looked around for about 5 seconds before walking out of camera view towards the cave entrance. The cameras did not detect any other visitation or movement further into the cave.

**Cave of the Birds' Eggs**

*Ashy Storm-Petrel*: Thirty-one nests were documented at CBE in 2013. Twenty-two active nests (71%) were observed on 6 July 2013, and 28 active nests (90%) were observed on 4 August 2013. Ranges of dates of egg laying, hatching and fledging for single/first eggs were estimated as 23 April – 22 September (range 152 d, $n$ = 29), 7 June – 1 October (range 116 d, $n$ = 23) and 25 August – 19 October (range 86 d, $n$ = 18), respectively.

The date of egg laying for one replacement egg at CBE was estimated as 22 September ($n$ = 1). Hatching success for first/single eggs and replacement eggs was 74% ($n$ = 31) and 0% ($n$ = 1), respectively; fledging and breeding success for last eggs were 82% ($n$ = 22) and 60% ($n$ = 30), respectively (Table 3).

*Pigeon Guillemot* (*Cepphus columba*): Pigeon Guillemots were observed at CBE as follows: 7 June – 20 adults flushed from cave upon researchers' arrival; 6 July – 20 adults on water in cove outside cave entrance upon researchers' arrival; and 4 August – 3 adults flush from cave upon researchers' arrival, and 20 adults observed sitting on water upon researchers' departure. Pigeon Guillemots were not observed in nests or on the water outside the cave on 6 September. Twelve nests (*i.e.*, presence of adult bird and/or evidence of egg laying) were documented at CBE in 2013 (Table 4). All twelve of these nests showed evidence of laying at least one egg, at least five nests showed evidence of laying two eggs, at least seven nests produced at least one chick, and at least one nest produced two chicks.

*Pelagic Cormorant (Phalacrocorax pelagicus)*: On 7 June, two Pelagic Cormorant nests were observed on the cliff outside of and adjacent to the entrance of CBE: a) nest #1— small to medium young-of-year (exact numbers not noted) sitting in nest; and b) nest #2— one adult sitting in nest. On 6 July, two Pelagic Cormorant nests were again observed, each nest with one adult and two medium-sized chicks; the adults flushed upon arrival of researchers. There were no other observations of Pelagic Cormorants on subsequent visitation dates.

*Common Raven*: Ravens were recorded roosting near or flying by CBE as follows: a) 15 February — 2 birds fly above cove; b) 7 June — 2 birds above cove; and c) 6 September — 1 bird calling and flying outside cave, interacting with a "small hawk" and Western Gull.

**Table 4. Nesting activities[1] of Pigeon Guillemots at Cave of the Birds' Eggs, Santa Cruz Island, California, in 2013.**

| Nest Number | Monitoring Date | | |
|---|---|---|---|
| | 7 June | 6 July | 4 August |
| A | 1LGC[2] | 0 | 0 |
| 737A | 0 | 0 | 1E |
| 801B | 1E | 1E | 1E |
| 900B | 0 | 1E | 1E |
| 942B | 0 | B/1E | 1LDC[2] |
| 1014 | 1B/2E | 1DC[2] | 0 |
| 1049A | 0 | 1E | 1E |
| 1049B | 1B+2MDC[2] | 1B+1FFC[2] | 0 |
| 1087 | EF | 0 | 0 |
| 1198 | 0 | B/1E+1SDC[2] | 1SGC[2] |
| AA | 1LGC[2] | 1E | 0 |
| BB | B/2E | 1LDC[2] | 0 |

***Footnote -***

[1] Codes: B = adult bird, Cdd = dead chick, DC = downy chick, E = egg only, FFC = fully-feathered chick, LDC = large downy chick, LGC = large gawky chick, MDC = medium downy chick, SDC = small downy chick, SGC = small gawky chick, 0 = empty nest.

[2] Stages of chick plumage development based on observers' description only; no estimated age ranges associated with different guillemot chick descriptions (e.g,, small downy chick, fully feathered chick).

*Skunks*: One skunk trap was deployed on 7 June and removed in the autumn (exact date not noted), and no evidence that skunks (or any other mammal or bird) entered trap boxes was found. No evidence of skunk predation nor mouse scavenging/predation was found in 2013.

*Predation/Scavenging*: Evidence of apparent avian predation (likely by Western Gull [*Larus occidentalis*] or Common Raven) was detected, as follows: 7 June — 2 Ashy Storm-Petrel feather piles, 2 Pigeon Guillemot carcasses, 1 dead bird (species not given); and 6 July — 1 Pigeon Guillemot feather pile.

*Human Visitation*: No evidence of human disturbance or non-researcher human visitation was detected in 2013.

*Wave Wash Event(s)*: On 7 November, researchers noted that "bottom of cave was flooded [and] several nest sites [specific tag numbers not noted] compromised."

**Cavern Point Cove Caves**

*Ashy Storm-Petrel*: Seven nests were documented in Cave #5 in 2013. Five active nests (71%) were observed on 6 July 2013, and four active nests (57%) were observed on 4 August 2013. Ranges of dates of egg laying, hatching and fledging for single/first eggs were estimated as 7 May – 23 June (range 47 d, $n = 6$), 21 June – 15 July (range 24 d, $n = 5$) and 18 September – 3 October (range 15 d, $n = 4$), respectively. The dates of egg laying, hatching and fledging for one

replacement egg were estimated as 22 July ($n$ = 1), 4 September ($n$ = 1) and 23 November ($n$ = 1), respectively. Hatching success for first/single eggs and replacement eggs was 71% ($n$ = 7) and 100% ($n$ = 1), respectively; fledging and breeding success for last eggs were 83% ($n$ = 6) and 71% ($n$ = 7), respectively (Table 3). Ashy Storm-Petrel nesting activity was not detected in Cave #4 in 2013.

*Eared Grebe* (*Podiceps nigricollis*): Three Eared Grebes were observed on the water in the cove adjacent to CPC on 8 October.

*Scripps's Murrelet*: One nest (not tagged; "one-quarter eggshell fragment" nesting activity) was found at Cave #5 on 10 June.

*Bats*: Townsend's big-eared bats were observed at CPC as follows: a) 4 August — approximately 30 roosting bats in Cave #5; b) 9 September — 2 bats in Cave #5; and c) 7 November — 2 bats in Cave #4.

*Santa Cruz Island Gopher Snake* (*Pituophis melanoleucus pumilis*): A live gopher snake was found in intertidal area in front of the cave, captured and released at a beach across from Scorpion Rock on the west side of the cove.

*Skunks*: Three skunk traps were deployed on 10 June and removed in the autumn (exact date not noted). No evidence that skunks (or any other mammal or bird) entered trap boxes was found. No smell of skunk or evidence of skunk predation was found in 2013.

*Predation/Scavenging*: No evidence of avian or mouse scavenging/predation was found in 2013.

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

**Dry Sandy Beach Cave**

DSB was not checked by researchers in 2013.

**Orizaba Rock**

*Ashy Storm-Petrel Nest Monitoring*: Thirty-one nests, all in natural crevices, were documented at in 2013 (Table 3). Artificial nests were not deployed in 2013. Twenty-five active nests (81%) were observed on 6 July 2013, and 26 active nests (84%) were observed on 4 August 2013. An adult was observed apparently incubating an egg on 15 February (tagged site #1157). However, an early date of egg laying could not be estimated (because there was no nest check previous to the February visit by researchers), and this nest site was not subsequently followed in 2014; therefore, this nest is not included in Table 2. Ranges of dates of egg laying, hatching and fledging for single/first eggs were estimated as 7 May – 22 September (range 138 d, $n$ = 27), 21 June – 1 October (range 102 d, $n$ = 17) and 9 September – 19 November (range 71 d, $n$ = 12), respectively. Ranges of dates of egg laying for replacement eggs were estimated as 20 July – 22 September (range 64 d, $n$ = 2). Hatching success for first/single eggs and replacement eggs was 58% ($n$ = 31) and 0% ($n$ = 1), respectively; fledging and breeding success for last eggs were 71%

(*n* = 17) and 43% (*n* = 28), respectively (Table 3). One Ashy Storm-Petrel nest (nest #1021) that fledged a chick was also used previously in the season by Scripps's Murrelet and Cassin's Auklet (Table5).

*Brandt's Cormorant:* Adults and immatures (ages combined) were recorded roosting as follows: a) 15 February — 15 birds roosting; and b) 7 October — 9 birds roosting.

*Brown Pelican* (*Pelecanus occidentalis*): Seventy adults and immatures (ages combined) were recorded roosting on 18 July.

*Bald Eagle* (*Haliaeetus leucocephalus*): Eagles were observed flying near OR as follows: a) 15 February — 1 adult with a blue patagial tag (identification number not seen) and 1 immature with no patagial tag; b) 6 July — 1 bird (silhouette only, age not noted); and c) 7 October — 1 bird (age not noted).

*Black Oystercatcher* (*Haematopus bachmani*): Oystercatchers were recorded as follows: a) 15 February — 6 birds; b) 6 July — 5 total adult birds, 1 nest with 1 dead downy chick, and 1 nest with 2 intact eggs; c) 18 July — 2 birds flying around; d) 4 August — 1 bird in intertidal zone; e) 6 September — 3 birds; and f) 7 October — 13 birds roosting.

*Scripps's Murrelet*: Three nests were observed at OR in 2013; one of these nests (nest #1021) was also used subsequently in 2013 by Cassin's Auklet and Ashy Storm-Petrel (Table 5). Evidence of egg laying was observed in one site (nest #1106), but may have occurred and gone undetected after observations of adults in two nests (nests #853B and #1021) on 15 February (Table 5). Other nesting activities may have occurred at OR between 15 February and 7 June that were missed.

*Cassin's Auklet*: Seven occupied nest sites were documented in 2013; evidence of egg laying was observed in six sites (Table 5). Some nesting activities may have occurred at OR between 15 February and 7 June that were missed.

*Heermann's Gull* (*Larus heermanni*): Adults and immature birds were recorded roosting as follows: a) 15 February — "a few" immature birds; b) 6 July — 20 adults and 20 immature); and c) 18 July — 30 birds (ages not noted) on OR and adjacent water.

*Western Gull*: No information on Western Gull nests at OR in 2013 was provided in field notes. Adults and immature birds were recorded roosting as follows: a) 15 February — "a few" birds; b) 18 July — 2 chicks on south side of OR; and c) 6 September — 4 adults and 19 immature birds.

*Elegant and Royal Terns* (*Sterna elegans* and *S. maxima)*: Adults and immature birds (ages combined) were recorded roosting as follows: a) 6 September — 17 birds; and b) 7 October — 2 birds (Royal Tern) roosting.

*Common Raven*: Reconnaissance cameras deployed at the upper caverns at Orizaba detected ravens on 31 different days, from 17 February through 12 October 2013; the vast majority of images showed one raven in the field of view (Appendix B). On 21 February, a raven attacked

**Table 5. Nests of Scripps's Murrelets and Cassin's Auklets at Orizaba Rock, Santa Cruz Island, California, in 2013.**

| Nest Number | Species[1] | Monitoring Date[2] 2/15 | 6/7 | 7/6 | Clutch Number | Egg Hatch | Chick Fledge |
|---|---|---|---|---|---|---|---|
| 853B | SCMU | 1B | 0 | 0 | 1 | (0-2)[3,4] | Unk |
| 1021[5] | SCMU | 1B | 0 | 0 | 1 | (0-2)[3,4] | Unk |
| 1106 | SCMU | 0 | EFh+Eab | 0 | 1 | 1 | 1 |
| 49[5] | CAAU | 1B | g/fthrs | 0 | 1 | 0 | 0 |
| 320 | CAAU | B/E | 1B/SDC[6] | 0 | (1/2)[3] | (1/2)[3] | Unk |
| 1021[5] | CAAU | 0 | 1B | SDCdd[6] | 1 | 1 | 0 |
| 1036 | CAAU | 0 | EF | 0 | 1 | 0 | 0 |
| 1037 | CAAU | NC | NC | 1E | 1 | 0 | 0 |
| 1144 | CAAU | 1B | 0 | 1E | (1/2)[3] | (0/1)[3] | 0 |
| 1151B | CAAU | 0 | 1B/SDC[6] | MGC[6] | 1 | 1 | 1 |

***Footnotes*** -

1 SCMU = Scripps's Murrelet (formerly, Xantus's Murrelet); CAAU = Cassin's Auklet.

2 Nesting activity codes: 0 = empty or zero, B = adult bird, dd = dead, E = egg, Eab = abandoned egg, EF = eggshell fragment, EFh = eggshell fragment from hatched egg, fthrs = feathers, g = guano, MGC = medium gawky chick, NC = nest not checked, SDC = small downy chick, Unk = unknown.

3 Either number in parentheses can be inferred from data (see text).

4 SCMU breeding females typically lay two eggs (see text).

5 Nest site used by Ashy Storm-Petrel later in season.

6 Stages of chick plumage development based on observers' description only; no estimated age ranges associated with murrelet auklet chick descriptions in this report.

the Upper West Cavern camera and dislodged it from its deployed position, altering the field of view of the camera. The camera apparently continued to function, but images taken were generally indiscernible until after 7 June, when the camera was re-deployed more securely in its original position. Ravens also were recorded roosting on or flying by OR as follows: a) 15 February — 1 bird flying by beach; b) 7 June — no observations in notes, presumably 0 birds; c) 6 July — 2 birds flying by; c) 18 July — no observations in notes, presumably 0 birds; d) 4 August — 2 birds on cliff adjacent to "Orizaba Beach"; e) 6 September — no observations in notes, presumably 0 birds; f) 7 October — 1 bird flying by and joining with 1 bird roosting on adjacent cliff; and f) 7 November — no observations in notes, presumably 0 birds. In addition, on 7 June, two regurgitated pellets were found and scat containing berries was detected on Orizaba Rock; presumably the pellets and scat were deposited by ravens.

*Predation*: Evidence of avian predation was detected, as follows: a) 6 July — 1 distinct storm-petrel feather pile near nest tag #49; b) 4 August — regurgitated storm-petrel feathers and bones

found near nest tag #1030; and c) 7 November — 1 dead storm-petrel chick (large gawky) found away from a suitable nest site in the lower cavern. Storm-petrels likely were killed by ravens.

*Artificial Nest Site Prototypes*: On 6 September, three different artificial nest module prototypes were temporarily deployed on the ledge of the Upper West Cavern, to test how they would fit on the ledge in relation each other, and to assess the ease at which potential nest contents could be viewed (see Appendix E). The prototypes were removed at the end of the nest monitoring visit on 6 September. General observations of the three deployed prototypes were written in notes, as follows:

- "Cross-style" - *"Hard to see all the way in the back, fits well on the shelf, lighter weight. Most space efficient."*
- "Palm Springs" - "*Heavy, good space use with three nests, good visibility into sites. 8 or so across ledge.*"
- "Spaceships" - "*Very heavy, not space efficient w/ only two nests per site. If used w/out doors could get 4 sites into one? Could only fit about 4-6 across ledge total."*

**Hatching, Fledging, and Reproductive Success**

Hatching, fledging, and breeding success for Santa Cruz Island (all four monitored locations in 2013 combined) are summarized in Table 3. In 2013, overall breeding success at Santa Cruz Island was 53% ($n$ = 158) (Table 3).

**Recruitment Study**

A total of 18 Ashy Storm-Petrel chicks were fitted with PIT-tag bands at Santa Cruz Island in 2013, as follows: BC ($n$ = 12), CBE ($n$ = 5) and CPC ($n$ = 1) (Appendix C). In addition, one PIT-tagged adult was detected on 6 July (CBE, nest tag #1197); the PIT-tag band was originally placed on this bird on 15 September 2010 (CBE, nest tag #942), when it was a chick. Thus, this bird was 3-year old breeding adult.

## DISCUSSION

**Reproductive Success**

Breeding success at Santa Cruz Island in 2013 (53%, $n$ = 158) was similar to reduced breeding success observed in 1995-98 (55%, $n$ = 477) (McIver et al. 2009b) (Figure 5), and was the second-lowest recorded (lowest in 1996 [45%, $n$ = 173]), influenced primarily by raven predation upon storm-petrels at OR and BC. In the absence of skunk and raven predation, improved breeding success of Ashy Storm-Petrels at Santa Cruz Island (in 2005-11, compared to 1995-98) mainly reflected higher hatching success, consistent with 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). Higher success rates in 2005-11 did not account for major impacts from skunk predation events at BC in 2005 and CPC in 2008. 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 and Double-crested Cormorants (*Phalacrocorax auritus*) (Gress et al. 1973, Gress 1995).

*Orizaba Rock*

Ravens likely were predators of Ashy Storm-Petrels at OR in 2013, based on the presence of feather piles, and regurgitated pellets and storm-petrel remains. Predation upon Ashy Storm-Petrels by Common Ravens was also suspected at OR in 2012, when ravens dismantled the majority of artificial nest sites deployed there, and reproductive success in natural and artificial sites was reduced (McIver et al. 2014). Thirty-one nest sites were found at Orizaba Rock in 2013, the highest number observed in natural sites, compared to 1996 ($n$ = 27) and 2012 ($n$ = 27) (McIver et al 2009b, McIver et al. 2014). By protocol, adult 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. In 2008-12, egg laying was confirmed on at least one occasion in 12 different artificial sites, and adults from some of these sites likely returned to breed in natural crevices at OR in 2013, when artificial sites were not available. In addition, some proportion of chicks produced from artificial and natural sites at OR in 2008-10 may have returned to prospect for sites or attempt to breed, which may explain the increase in numbers of nests in natural crevices in 2013.

Breeding success at OR was variable between years in 2005-13 (see Figure 6 in Appendix D. Overall breeding success at OR in 2005-13 (including artificial nest sites in 2008-12) was 48% ($n$ = 202) (McIver et al., unpublished data). In 2005-07, prior to implementation of restoration actions, breeding success at OR was 60% ($n$ = 35), compared to restoration years 2008-11 (49%, $n$ = 105). A total of 36 chicks fledged during 2008-10, the three years of fewest chicks produced during 2008-11, compared to 2005-07 ($n$ = 21 chicks; McIver et al 2009b). A total of 52 chicks fledged in 2008-11, when predation of storm-petrels by ravens is presumed to have been slight. At OR in 2012-13, years of increased predation of storm-petrels by ravens, a comparable number of chicks fledged ($n$ = 24) compared to 2005-07 ($n$ = 21). Thus, while breeding success at OR since 2008 has not been as high as in 2005-07, restoration actions likely facilitated a natural recovery that seemed to begin there in 2007, resulting in an increase in numbers of nesting Ashy Storm-Petrels, and an increase in numbers of chicks produced there.

*Bat Cave*

Avian predators, primarily ravens but also barn owls, caused a reduction in breeding success at BC in 2013, compared to previous years. Breeding success in 2013 (52%, $n$ = 93) was similar to 1995 (53%, $n$ = 59) for the second- and third-lowest values observed at BC, respectively; the lowest breeding success reported for BC occurred in 1996 (49%, $n$ = 88) (McIver et al. 2009b). Breeding success at BC was somewhat variable in 2006-13, with highest values observed in 2008 (84%, $n$ = 33) and 2011 (89%, $n$ = 58) (see Figure 7 in Appendix D). In 2006-12, overall breeding success at BC was 79% ($n$ = 317), and overall breeding success in 2006-13 was 73% ($n$ = 410) (McIver et al., unpublished data), illustrating reduced breeding success due to raven predation in 2013. Causes for reduced breeding success at BC have varied since 1995. Predation

by barn owls and reduced hatching success due to organochlorine contamination and shell thinning caused a reduction in breeding success in 1995-97 (McIver 2002, Carter et al. 2008a, 2008b). Carter et al. (2008b) reported reduced levels of organochlorine residues in eggs collected in 2008, compared to 1992-97. McIver et al. (in preparation) reported that avian predation was lower at BC in 2006-12, compared to 1995-97 and 2013.

*Cave of the Birds' Eggs*

Thirty-one nest sites were found at CBE in 2013, the highest number observed since nest monitoring began there in 1995. Breeding success at CBE in 2013 (60%, $n = 30$) was the third-lowest value recorded there since 2005 (see Figure 8 in Appendix D). Causes for reduced breeding success at CBE in 2013 are not known. Although evidence of avian predation upon storm-petrels was found at CBE in 2013, it comprised two storm-petrel feather piles found on 7 June; thus, avian predation upon storm-petrels was not substantial at CBE in 2013. As observed in recent years, the cave was apparently washed by at least one wave in 2013, between 8 October and 7 November. Notes taken on 7 November indicate that "several nest sites were compromised," although specific marked and "compromised" sites were not identified. One site (nest tag #1005) that contained a large downy chick on 7 October was empty on 8 November. Although this chick was determined to have been missing before possible fledge, it is not known whether it wandered from its nest, was taken by a predator (e.g., raven) or a wave washed it away. Breeding success from 2005 through 2013 was variable, and overall breeding success at CBE in 2005-13 was 67% ($n = 214$) (Figure 8 in Appendix D).

*Cavern Point Cove Caves*

Numbers of active nests in 2013 ($n = 7$) were the highest observed since skunk predation in 2008 (see Figure 9 in Appendix D), but lower than numbers observed in 1995-97 (range: 11-17 nests) and similar to numbers observed in 2006 ($n = 7$) (McIver et al. 2009b). Prior to 2008, storm-petrels nested in two caves at CPC (Cave #4 and Cave #5); however, since 2009, no nesting by storm-petrels or other crevice-nesting seabirds has been observed in Cave #4. Overall breeding success at CPC in 2005-13 was 67% ($n = 48$) (McIver et al., unpublished data)

**Avian Predation**

In 2013, ravens were observed at OR and BC and documented with cameras to regularly visit nesting areas at these locations, and were documented predators of Ashy Storm-Petrels at these locations. In 2010-12, ravens were also observed on OR and documented with cameras to regularly visit the upper caverns, where artificial nest sites were deployed in 2008-12 (McIver et al. 2011, 2013, 2014). McIver et al. (2014) speculated that higher raven visitation at OR in 2010-12 may have been related to (in part) restoration actions (i.e., broadcasted vocalizations and presence of artificial nest sites) underway during that time. In 2013, artificial nest sites were not present at OR and storm-petrel vocalizations were not broadcast, and yet ravens were regularly detected in the upper caverns at OR throughout breeding season. In addition, we documented at least three instances of feather piles, carcass (non-fledged chick) or regurgitated remains in the caverns at OR, indicating at least three Ashy Storm-Petrels were killed by an avian predator. Individual Common Ravens can become specialized in their feeding behaviors (Marzluff and Angell 2005); the success of ravens in 2010-12 in finding storm-petrels as prey items at OR likely contributed to a continuation of this foraging behavior in 2013. Storm-Petrels nesting in shallow and accessible natural crevices at OR were vulnerable to predation by ravens. At BC in 2013, we documented at least 45 distinct storm-petrel feather piles and at least one owl pellet,

indicating that at least 45 Ashy Storm-Petrels were killed by avian predators (ravens and Barn Owls). Based on numerous of images of ravens in reconnaissance cameras during the daytime at BC, we suspect that ravens were responsible for the majority of kills of Ashy Storm-Petrels at BC in 2013.

Predation by corvids has been reported in at least two previous storm-petrel studies. In a study of Leach's Storm-Petrel on Bon Portage Island, Nova Scotia, Canada, MacKinnon (1988) reported that American Crows (*Corvus brachyrhynchos*) and Common Ravens were the major predator of adults, and the second greatest cause of chick mortality. Corvids were frequently observed walking throughout the storm-petrel colony. He speculated that corvids located storm-petrel chicks by cueing into their vocalizations in nesting burrows, and that crows and ravens excavated burrows to find adults and chicks. In a study of Leach's Storm-Petrels at Daikoku Island, Japan, Watanuki (1986) reported that although Jungle Crows (*Corvus macrorhynchos*) excavated storm-petrel burrows and ate adults, chicks, and eggs, predation by the crows was not significant.

Blake (1887) described ravens as common breeders at Santa Cruz Island. The main food source at the island available for ravens from the mid-19th century to the late 20th century was dead livestock, especially sheep, which ravens scavenged (Blake 1887, Schuyler 1993). Ranching ceased on most of the island when management began by TNC in the late 1970s, and sheep were removed from TNC-owned land by 1989 (Schuyler 1993). Since the late 1990s, ranching ceased on the east end of the island when management began by CINP in the late 1990s (Faulkner and Kessler 2011). Since the late 1990s, the eastern part of Santa Cruz Island has become a popular destination for tourists, and thousands of recreationists per year camp and visit the island, especially at Scorpion Ranch and Scorpion Anchorage, including the coastlines near BC. Common ravens are omnivorous, highly intelligent and can quickly adapt to the presence of humans (Liebezeit and George 2003). Marzluff and Neatherlin (2006) hypothesize that food is the most important anthropogenic resource driving the increase in corvids near settlements and campgrounds. Ravens are known to be adept at obtaining food from campgrounds, including using techniques such as opening gate latches, backpack zippers and food containers (Janiskee 2010; D. Mazurkiewicz, personal observation). Ravens that nest in close proximity to anthropogenic resources have improved probabilities of juvenile survival (Webb et al. 2004). Common Ravens are frequently observed in coastal habitats at Santa Cruz Island, have been documented in sea caves (e.g., CBE in 1996 [McIver 2002]). Considered together, many of these factors may have contributed to increased predation upon Ashy Storm-Petrels at BC in 2013.

Vermeer et al. (1993) suggested that predation of Pigeon Guillemots by Northwestern Crows (*Corvus caurinus*) may have been related to crows following researchers. At Santa Cruz Island, researchers entered sea monthly in 1995-97 and 2005-12 without noting much raven occurrence (exception, on raven CBE in 1996 [McIver 2002]), although some predation events assigned to Barn Owls may have been raven-related. While we cannot discount the possibility that ravens may have cued into researchers entering BC, we think that the presence of large numbers of tourists along the east end of the island and along the coastline near BC warrants further consideration. Similar to previous years of nest monitoring, researchers visited BC a total of 8 times in 2013, at approximately monthly intervals, whereas tourists in sea kayaks were likely present daily on the east end of the island. We don't have specific information regarding the numbers of sea kayakers present along the coastline near BC in the intervals between our nests

checks. However, we have observed kayakers along this stretch of coastline during the majority of our nest-monitoring checks at BC in recent years (W. McIver, personal observation), and therefore it is reasonable to presume that at least a few kayakers are likely present along this coastline each day during summer months. In addition, each nest-monitoring trip to BC was short in duration (about 2-6 hours), and researchers did not observe ravens entering the cave or roosting at the cave entrance during nest monitoring visits. Further study regarding the presence of ravens and interactions between humans and ravens at Santa Cruz Island may help in identifying factors that may contribute to increased presence of ravens at BC.

**Artificial Nest Deployment**

In 2013, the MSTC and personnel from CINP, USFWS, Oikonos Ecosystems Knowledge and Rebar Group discussed possible modifications to artificial nesting structures, with the intent of to developing and manufacturing more durable ceramic artificial nesting structures for use by Ashy Storm-Petrels, to deter future alterations and impacts by ravens. Based on these discussions, in spring/early summer 2013, Nathan Lynch (California College of Arts, San Francisco, California) and Rebar Group (San Francisco) manufactured three artificial nest module prototypes for temporary deployment on OR and assessment of their suitability as potential artificial nest modules. On 6 September, researchers deployed the three prototypes on the ledge in the Upper West Cavern. Based on the previous discussions and the field tests of the prototypes, the aforementioned parties subsequently decided that the "Palm Springs" nest module, each containing three crevices, 3 "front-facing" viewing holes, 3, "front-facing" PIT-tag wand holes, 3 "rear-facing nest entrances and a floor, was the preferred prototype on which additional nest modules would be based (Appendix E).

**Pigeon Guillemots at CBE**

Numbers of Pigeon Guillemot nests found at CBE in 2013 ($n$ = 12) were comparable to 2012 ($n$ = 14), 2011 ($n$ = 12), but less than 2010 ($n$ = 21), possibly due to nest loss (due to wave wash events) without documentation in 2011-13. Only 7-10 nests were found in 2006-09 when extensive predation of adults occurred. Eight (75%) of 12 nests may have had one egg clutches, possibly suggesting many first-time breeders (Asbirk 1979). However, we could not confidently determine clutch size with monthly monitoring visits that began in June. Seven (58%) of 14 nests hatched at least one chick. No chicks were found dead in crevices, and at least 5 chicks likely fledged. A wave wash event likely occurred in October or early November at CBE, but this would not have affected guillemots nesting in 2013, occurring several months after the end of their breeding season. To date, numbers of breeding guillemots at CBE recorded in 2005-2013 do not appear to have directly affected Ashy Storm-Petrels, but some storm-petrel nest sites may be usurped by increased numbers of guillemot nests in the future.

**Cassin's Auklets at OR**

Seven nest sites of Cassin's Auklet were found at OR in 2013 compared to four nests in 2012, two nests in 2011 and five nests in 2010. 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. Ainley et al. (1990) found that interference by Cassin's Auklets at nest sites reduced reproductive success of storm-petrels. Two of the sites occupied by Cassin's Auklets in 2013 (#49 and #1021) are commonly used by auklets and storm-petrels in most years, and one of these sites (#1021) was used by all three species in 2013. Continued

availability of protective artificial habitat for Ashy Storm-Petrels could reduce interspecific competition at natural crevices at OR.

**Scripps's Murrelet at OR and CPC**

Three nest sites of Scripps's Murrelet were found at OR in 2013. This is the first time that Scripps's Murrelets have been documented nesting at OR, although nocturnal at-sea vocalization surveys in 1996 detected the species on the water near OR (Whitworth and Carter, unpublished notes). Scripps's Murrelets nest from February-May (Drost and Lewis 1995), so it is likely that the species has nested previously at OR and gone undetected by researchers looking for Ashy Storm-Petrels, which nest later in the season. At CPC, one nest of Scripps's Murrelet was detected in 2013, the first time the species has been observed at this location since 1997 (Carter and McIver, *unpublished notes*).

**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. Through direct observation during our August nest monitoring trip, and indirectly through use of a reconnaissance camera, we documented one instance of human visitation to BC in 2013, and one group of kayakers 100-200 m down-coast from the cave. All visitors accessed the cave and coastline via sea kayaks, apparently launched from nearby Scorpion Anchorage. In general, each instance of visitation to BC was relatively short in duration, lasting only a few minutes, and most stayed on the beach area. We did not observe adverse effects to nesting habitat in BC after these visitations.

**Monitoring and Restoration Recommendations for 2014 and After**

We recommend that nest monitoring should be continued for Ashy Storm-Petrels at OR and Santa Cruz Island sea caves in 2014 and after, for the following reasons:

- to document the degree of visitation and egg laying in new artificial nest sites at OR;
- to assess the design of new artificial nest sites and make further alterations as needed;
- to assess whether vocalization broadcasting should be re-initiated at OR;
- to assess and address the impacts that ravens might be having upon breeding success of Ashy Storm-Petrels at OR and BC;
- to measure and examine trends in breeding success in artificial and natural nest sites at OR and at natural sites in BC, CPC and CBE;
- to examine trends in colony sizes at OR, BC, CPC and CBE; and
- to identify and address natural and anthropogenic factors that might affect colony size and breeding success.

In addition, regarding ravens at Santa Cruz Island, and possible impacts upon Ashy Storm-Petrels in 2014 and after, we recommend:

- an evaluation of any combination of measures that might be taken to reduce predation upon Ashy Storm-Petrels by ravens at BC and OR;

- an evaluation of raven distribution and abundance at Santa Cruz Island, similar to Boarman and Coe (2002); and

- an evaluation of raven responses to human presence at Santa Cruz Island, similar to Marzluff and Neatherlin (2006).

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**Appendix A. Restoration and monitoring actions at Santa Cruz Island, funded by the Montrose Trustee Council in 2006-12.**

| Year | Research Entities | Actions | Annual Report |
|---|---|---|---|
| 2006-07 | CBC; USFWS-VFWO, -AFWO; CINP | (a) Pre-restoration baseline monitoring for Ashy Storm-Petrels at five locations at Santa Cruz Island; and (b) develop and test artificial nest sites and vocalization broadcasting techniques for larger-scale implementation in 2008. | Carter et al. (2007); McIver et al. (2008) |
| 2008-09 | USFWS-AFWO, CINP, CBC | (a) Continue annual monitoring work to gather data on population size, reproductive performance, breeding phenology, and predation of Ashy Storm-Petrels at Santa Cruz Island; (b) deploy artificial nests at OR; (c) deploy vocalization broadcasting for social attraction to enhance use of artificial sites at OR; (d) deploy skunk traps in sea caves to prevent or reduce further predation of Ashy Storm-Petrels by island spotted skunks (starting in 2009); (e) deploy signs at sea caves to prevent or reduce unauthorized human access (starting in 2009); and (f) lead public outreach to educate CINP visitors and staff regarding impacts to storm-petrel colonies due to human disturbance. | McIver et al. (2009a); McIver et al. (2010) |
| 2010 | USFWS-AFWO, CINP, CBC, SFU | (a) Continue restoration and monitoring activities as conducted in 2006-09; (b) evaluated Ashy Storm-Petrel nocturnal behaviors in relation to vocalization broadcasting; (c) evaluated future recruitment and visitation of Ashy Storm-Petrels by initiating a chick PIT-tag banding project; (d) evaluated storm-petrel visitation to and attendance of artificial nest sites using temperature loggers; (e) deployed signs at OR to prevent or reduce unauthorized human access; and (f) gathered data on vocalization levels at CBE and BC using acoustic monitoring devices | McIver et al. (2011) |
| 2011 | USFWS-AFWO, CINP, CBC | Continue the restoration and monitoring activities as conducted in 2006-10, but with modified artificial sites to prevent raven impacts and without continued effort on documenting nocturnal behaviors. | McIver et al. (2013) |

| Year | Participating Entities | Actions | Annual Report |
|---|---|---|---|
| 2012 | CIES, CINP, USFWS-AFWO, CBC | Continue the restoration and monitoring activities as conducted in 2006-11, but with continued modification of artificial sites to prevent raven impacts and without continued effort on documenting nocturnal behaviors. | McIver et al. (2014) |

***Footnotes*** –

[1] Codes: AFWO = Arcata Fish and Wildlife Office, Arcata, California USA; CBC = Carter Biological Consulting, Victoria, British Columbia Canada; CIES = California Institute of Environmental Studies, Davis, California; CINP = Channel Islands National Park, Ventura, California; SFU = Simon Fraser University, Burnaby, British Columbia; VFWO = Ventura Fish and Wildlife Office, Ventura, California; USFWS = U.S. Fish and Wildlife Service.

**Appendix B. Reconnaissance camera observations of Common Ravens at Orizaba Rock, Santa Cruz Island, California, in 2013[1].**

| Date | Time | Camera location[2] | Picture nos. | Species[3] | No. | Observations[4] |
|---|---|---|---|---|---|---|
| 15-17 Feb | see pics | UWC | 251-716 | ASSP | 2 | Max. 2 petrels in frame 2/16-2/17. No daytime pics; many nocturnal pics; petrels only. 1 or 2 birds appear to be circling west entrance, probably visiting ledge. |
| 17 Feb | 12:52:- 12: 54 | UWC | 796-810 | CORA | 1 | One CORA perched on/in front/to north of camera |
| 17 Feb | night pics | UWC | 811-825 | Unk. | | blurry images, nothing clear |
| 17 Feb | night pics | UWC | 717 | ASSP | 3 | 1st photo with 3 birds in fame but can't be certain they are all petrels (I think they are). |
| 17 Feb | night pics | UWC | 718-795 | ASSP | | same as comment #3 |
| 19 Feb | 10:52 exact | UWC | 886-890 | CORA | 1 | 1 CORA Exploring upper ledge and camera (1 minute only) |
| 19 Feb | night pics | UWC | 825-885 | CAAU | | Hanging out in front of camera; no other spp. |
| 20 Feb | 10:39 to 10:40 | UWC | 891-900 | CORA | 1 | 1 CORA Exploring upper ledge and camera |
| 21 Feb | 13:08 | UWC | 911 | CORA | 1 | 1 CORA returns; attacks camera |
| 21 Feb | 13:08 | UWC | 912 | CORA | 1 | Camera turned upside down |
| 21 Feb | 13:11 | UWC | 937-965 | CORA | 1 | Camera is turned over several more times; CORA in view; last shot at 13:11; camera is facing straight up at cavern ceiling. |
| 21 Feb | 09:42-09:43 | UWC | 901-910 | CORA | 1 | 1 CORA Exploring upper ledge and camera |
| 21 Feb | 13:05-13:13 | UEC | 36-45 | CORA | 1 | Camera field of view is distorted by light at west cavern entrance. Images very blurry for all records. |
| 21 Feb | NA | UWC | 913-936 | CORA | 1 | 1 CORA pecking at camera. |
| 22 Feb to 8 Mar | no images | UWC | none | none | | No images 22 Feb to 8 March. |
| 23 Feb | 8:53 | UEC | 46-50 | CORA | 1 | 1 CORA |

| Date | Time | Camera location[2] | Picture nos. | Species[3] | No. | Observations[4] |
|---|---|---|---|---|---|---|
| 25 Feb | 14:22 | UEC | 51-55 | CORA | 1 | 1 CORA |
| 7 Mar | 14:13-14:49 | UEC | 56-100 | CORA | 1 | 1 CORA |
| 8 Mar | night pics | UWC | 966-970 | unk. | ? | blurry images, nothing clear |
| 12 Mar | night pics | UWC | 971-980 | unk. | ? | blurry images, nothing clear |
| 14 Mar | 00:11 to | UEC | 101-105 | unk. | ? | First night photos since deployment; cannot discern. |
| 16 Mar | 9:52 | UEC | 106-110 | unk. | ? | blurred images. One sequence of 5 photos only. |
| 17 Mar | 9:37 | UEC | 111-115 | CORA | 1 | 1 CORA |
| 18 Mar | night pics | UWC | 971-980 | unk. | ? | blurry images, nothing clear |
| 19-20 Mar | 3:00 | UWC | 981-995 | unk. | ? | Unidentified spp. CAAU? Owl? approx.. 03:00 each night |
| 21 Mar | 12:13 | UEC | 116-120 | CORA | 1 | 1 CORA |
| 22 Mar | 14:03 | UEC | 121-130 | CORA | 1 | 1 CORA |
| 24 Mar | 8:24 | UEC | 131-140 | CORA | 1 | 1 CORA |
| 26 Mar | 8:27 | UEC | 141-145 | unk. | ? | blurred images. One sequence of 5 photos only. |
| 26 Mar | 12:40-41 | UEC | 146-159 | CORA | 1 | 1 CORA |
| 27 Mar | 13:44 | UEC | 151-155 | unk. | ? | blurred images. One sequence of 5 photos only. |
| 20 Apr | 13:36 | UEC | 156-160 | unk. | ? | blurred images. One sequence of 5 photos only. |
| 23 Apr | 11:39-40 | UEC | 161-185 | CORA | 1 | 1 CORA |
| 4 May | 10:58-11:00 | UEC | 186-195 | CORA | 2 | 2 CORA |
| 6 May | 9:13 | UEC | 196-205 | unk. | ? | Blurry. Same pattern as previous CORA shots |
| 7 May | 02:14 | UEC | 206-210 | unk. | | First night pics since14 Mar. Blurry. |
| 13 May | 15:50 | UEC | 211-230 | CORA | 2 | 2 CORA; good sequence |
| 21 May | 9:08 | UEC | 231-245 | CORA | 2 | 2 CORA |
| 24 May | 16:46 | UEC | 245-250 | CORA | 1 | 1 CORA |
| 3 Jun | 13:28-13:48 | UEC | 251-260 | unk. | ? | Blurry. Same pattern as previous CORA shots |
| 14 Jul | 11:50 | UWC | NA | CORA | 1 | directly in front of camera |
| 14 Jul | 11:53 | UEC | NA | CORA | 1 | inspect and fly |
| 14 Jul | 11:57 | UWC | NA | CORA | 1 | above camera looking around |
| 14 Jul | 14:47 | UWC | NA | CORA | 1 | above camera |

| Date | Time | Camera location[2] | Picture nos. | Species[3] | No. | Observations[4] |
|---|---|---|---|---|---|---|
| 28 Jul | 14:10 | UWC | NA | CORA | 2 | looking around in cavern |
| 28 Jul | 14:11 | UWC | NA | CORA | 1 | standing in one spot looking around |
| 28 Jul | 14:12 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 28 Jul | 14:12 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 28 Jul | 14:52 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 28 Jul | 14:52 | UWC | NA | CORA | 1 | leaving cavern |
| 30 Jul | 2:13 | UEC | NA | CORA | 1 | directly in front of camera |
| 30 Jul | 2:14 | UEC | NA | CORA | 1 | walking by art. habitat |
| 30 Jul | 2:15 | UEC | NA | CORA | 1 | directly in front of camera |
| 30 Jul | 8:37 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 30 Jul | 8:39 | UEC | NA | CORA | 1 | walking along rocks and out of cavern |
| 30 Jul | 11:29 | UEC | NA | CORA | 1 | walking into E. cavern in ASSP nesting area |
| 1 Aug | 9:25 | UWC | NA | WEGU | 1 | walking around directly outside cavern |
| 1 Aug | 11:45 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 1 Aug | 11:47 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 1 Aug | 11:47 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 1 Aug | 11:49 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 1 Aug | 11:56 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 4 Aug | 8:44 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 5 Aug | 8:32 | UWC | NA | CORA | 1 | on upper ledge, can only see tail feathers |
| 5 Aug | 12:26 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 5 Aug | 12:26 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 5 Aug | 12:26 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 5 Aug | 12:26 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 6 Aug | 10:48 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 6 Aug | 10:49 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 6 Aug | 17:00 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 8 Aug | 12:10 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 8 Aug | 12:13 | UWC | NA | CORA | 1 | moving and looking around cavern |

| Date | Time | Camera location[2] | Picture nos. | Species[3] | No. | Observations[4] |
|---|---|---|---|---|---|---|
| 9 Aug | 9:55 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 12 Aug | 13:52 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 18 Aug | 10:41 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 18 Aug | 10:41 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 18 Aug | 10:42 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 18 Aug | 10:43 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 26 Aug | 13:02 | UWC | NA | CORA | 1 | on upper ledge, can only see tail feathers |
| 26 Aug | 13:03 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 2 Sep | 13:33 | UWC | NA | CORA | 1 | moving and looking around cavern |
| 5 Oct | 12:18 | UWC | NA | GBHE | 1 | great blue heron at west entrance |
| 5 Oct | 16:14 | UWC | NA | GBHE | 1 | great blue heron at west entrance |
| 12 Oct | 13:23 | UWC | NA | CORA | 1 | moving and looking around cavern |

***Footnotes*** –

[1] Reconnaissance cameras deployed 15 February 2013. Camera UEC removed 7 October and camera UWC removed 7 November 2013. Camera UWC likely malfunctioned or was moved out of position (by ravens) from mid-March to early June 2013.

[2] UEC = "Upper East Cavern, UWC = "Upper West Cavern."

[3] ASSP = Ashy Storm-Petrel, CORA = Common Raven, GBHE = Great Blue Heron, WEGU = Western Gull, unk. = unkown.

[4] From June 2013 onwards, only CORA were noted in this table, although storm-petrels continued to be observed in nighttime images from cameras.

**Appendix C. Banding and PIT-tag information for 18 Ashy Storm-Petrel chicks and 1 Ashy Storm-Petrel adult at Santa Cruz Island, California, in 2013.**

| Location[1] | Nest Number | Date | Chick Plumage Stage[2] | USGS Band Number | PIT-tag Band Identification Number |
|---|---|---|---|---|---|
| BC | 1165 | 8/5/2013 | SGC | 4501-41609 | 985121021090067 |
| BC | 1038 | 8/5/2013 | SGC | 4501-41698 | 985121021205188 |
| BC | 1163 | 9/9/2013 | SGC | 4501-41697 | 985121021089605 |
| BC | 404 | 9/9/2013 | MFC | 4501-41617 | 985121021119434 |
| BC | 1090 | 9/9/2013 | LGC | 4501-41614 | 985121021128348 |
| BC | 1174 | 9/9/2013 | LDC | 4501-41618 | 985121021146078 |
| BC | 837 | 9/9/2013 | SGC | 4501-41613 | 985121021147268 |
| BC | 833 | 9/9/2013 | MGC | 4501-41612 | - |
| BC | 1143 | 9/9/2013 | LDC | 4501-41615 | - |
| BC | 1100 | 9/9/2013 | MFC | 4501-41616 | - |
| BC | 1127 | 9/9/2013 | FFC | 4501-41620 | - |
| BC | 1188 | 11/8/2013 | MGC | 4501-41624 | - |
| CBE | 1197 | 7/6/2013 | B/E | 4501-41323 | 985121021146776[3] |
| CBE | 1087 | 8/4/2013 | MGC | 4501-41694 | 985121021103743 |
| CBE | 718 | 8/4/2013 | SGC | 4501-41695 | 985121021118135 |
| CBE | 844 | 9/6/2013 | LGC | 4501-41700 | 985121021119450 |
| CBE | 1006 | 9/6/2013 | LDC | 4501-41611 | 985121021142211 |
| CBE | 255 | 10/7/2013 | LGC | 4501-41622 | - |
| CPC5 | 1139 | 10/7/2013 | SGC | 4501-41623 | - |

***Footnotes*** –

1 Codes: BC = Bat Cave, CBE = Cave of the Birds' Eggs, DSB = Dry Sandy Beach Cave, OR = Orizaba Rock.

2 Codes: 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).

3 Adult with PIT-tag detected with PIT-tag reader on 6 July (nest tag #1197); originally banded as chick on 9/15/2010 in CBE (nest #942).

**Appendix D. Breeding success of Ashy Storm-Petrels at Orizaba Rock (Figure 6), Bat Cave (Figure 7), Cave of the Birds' Eggs (Figure 8) and Cavern Point Cove Caves (Figure 9), Santa Cruz Island, California, from 2005 through 2013.**

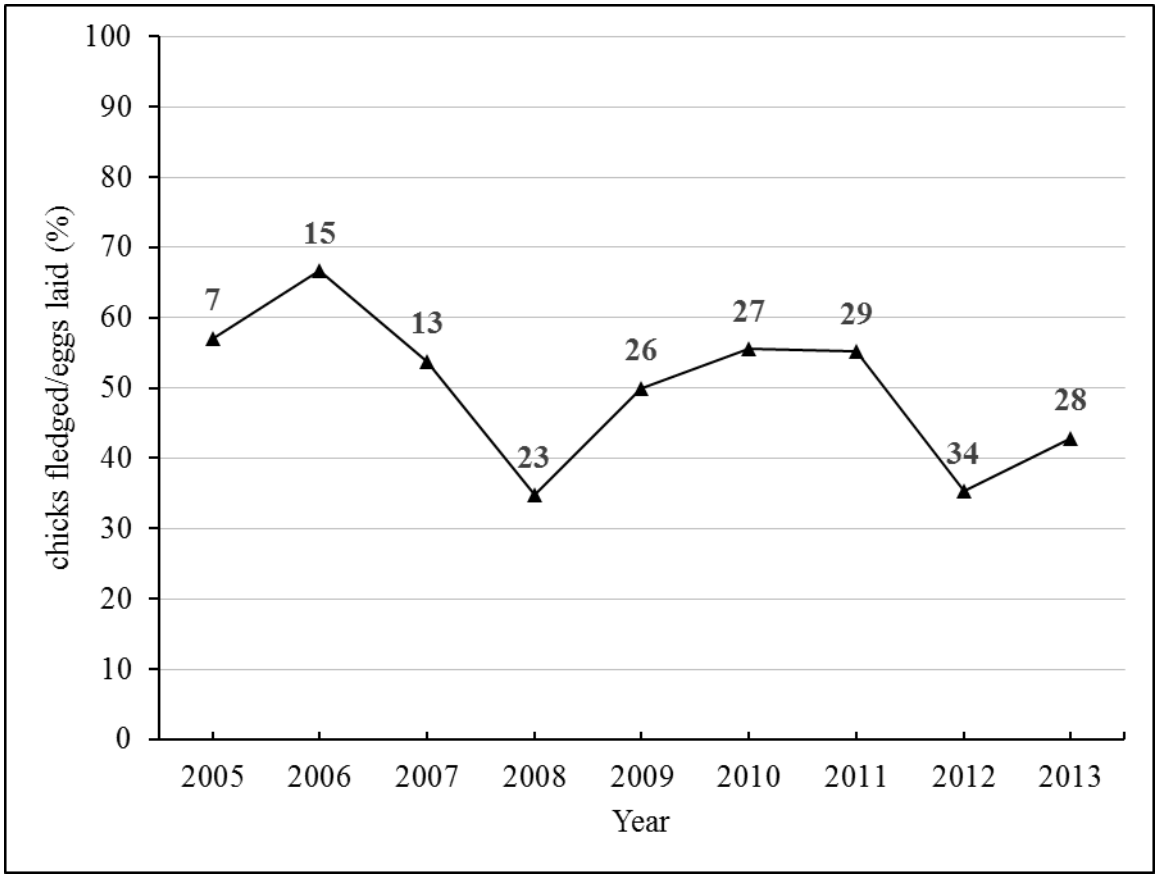


**Figure 6. Breeding success of Ashy Storm-Petrels at Orizaba Rock, Santa Cruz Island, California, in 2005-13. Years 2008-12 include natural crevices and artificial nest sites, combined. Samples sizes above markers.**

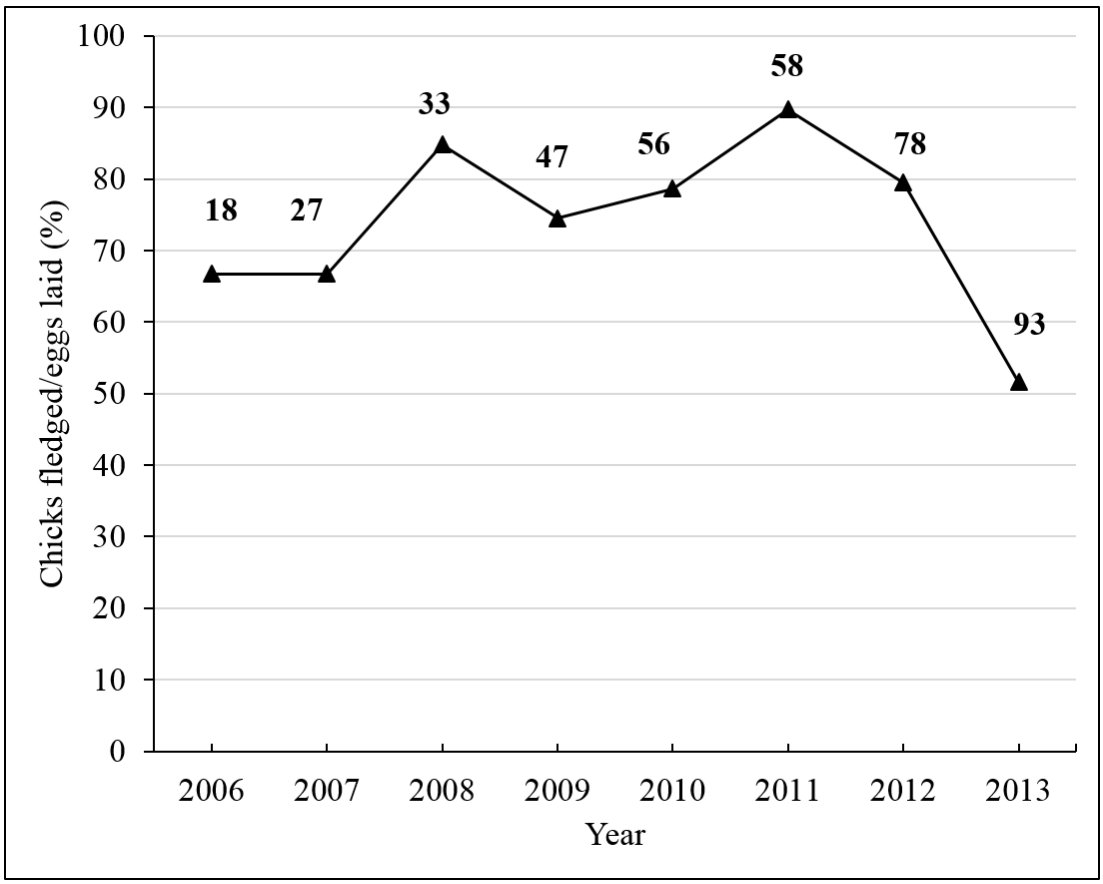


**Figure 7. Breeding success of Ashy Storm-Petrels at Bat Cave, Santa Cruz Island, California, in 2006-13. Samples sizes above markers. No data for 2005 due to skunk predation.**

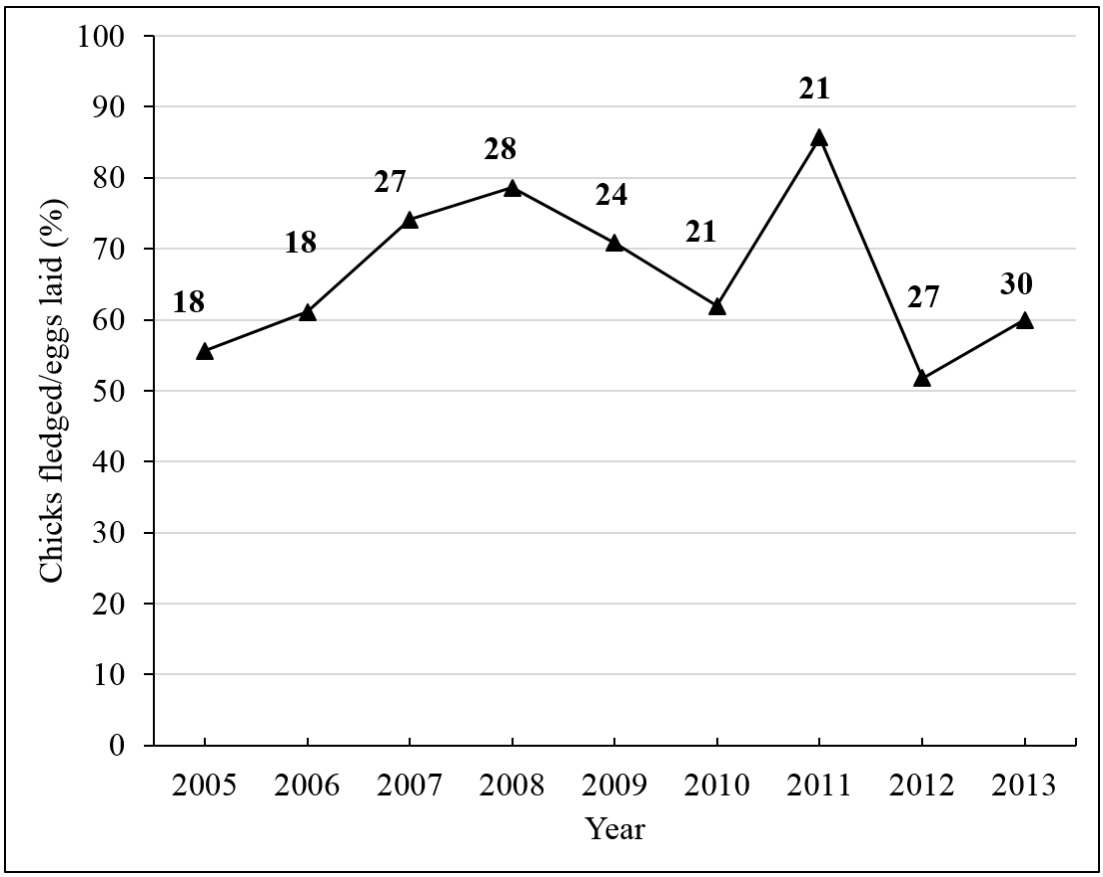


**Figure 8. Breeding success of Ashy Storm-Petrels at Cave of the Birds' Eggs, Santa Cruz Island, California, in 2005-13. Samples sizes above markers.**

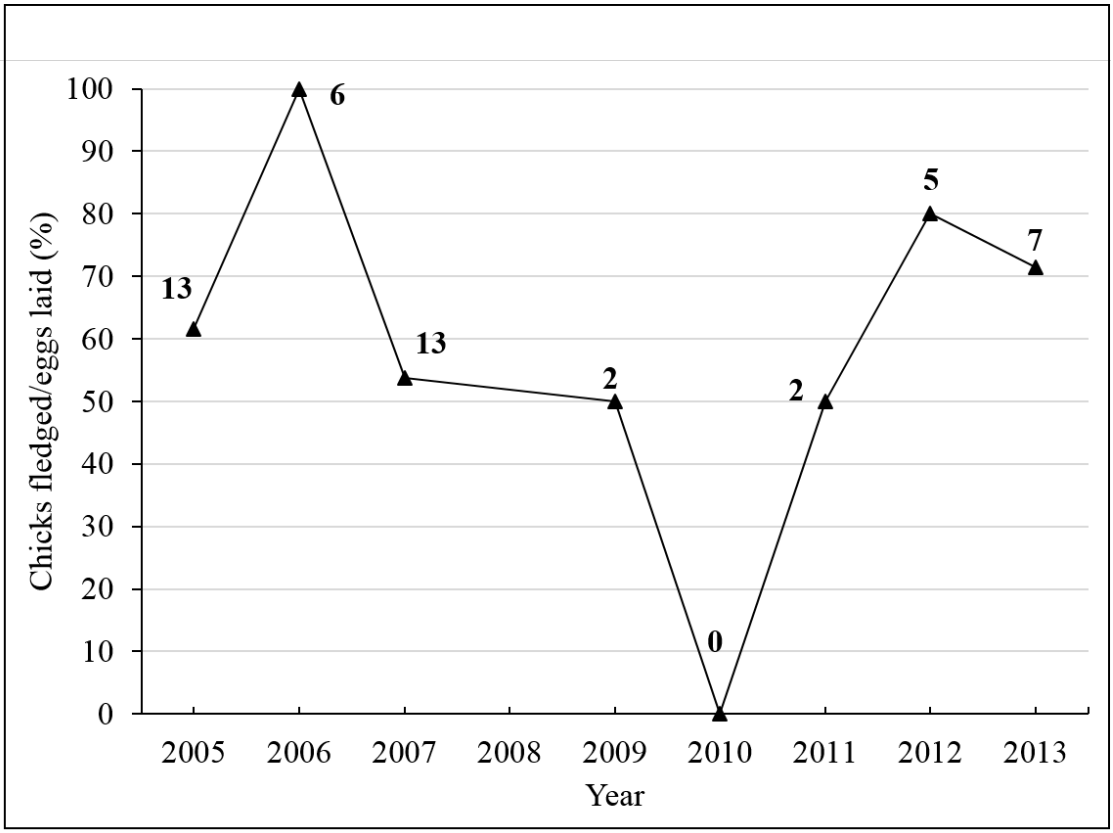


**Figure 9. Breeding success of Ashy Storm-Petrels at Cavern Point Cove Caves, Santa Cruz Island, California, in 2005-13. Sample sizes above or adjacent to markers. No data for 2008 due to skunk predation.**

**Appendix E. Summary of artificial nest habitat design and testing, Orizaba Rock, Santa Cruz Island, California, in fall 2013. (Summary provided by D. Mazurkiewicz)**

*Orizaba Site Visit: Artificial Nest Habitat Testing September 6, 2013*

-Arrive Orizaba Rock at 1300h. Offloaded nest sites onto ORI and conducted nest checks while test fitting the 3 nest prototypes onto the shelf in the Upper west cavern. We were under some time constraints so only examined how the modules fit, accessibility, ability to look into site etc.
-All three prototypes nested well in the loose dirt on the shelf and were easily placed see photo below (Figure 10) for the placement and current naming scheme to address the different module types.

**Figure 10. The 3 prototypes nested on the shelf in Upper West Cavern, Orizaba Rock, 6 September 2013. Three tested designs included: cross design ("Normandy") on left, "Palm Springs" in middle (also called the "bread loaf") and the "horseshoe" (or "spaceship") on the right.**

**Cross Design ("Normandy")**

This design was one that was the most space efficient and allowed for the largest number of modules to be nested in this particular location (Figures 11, 12). It was the lightest of the three, the shape of the chamber made it difficult to look all the way through the module. Ideally a bird would be nested in towards the back so it perhaps wouldn't present an issue, however, if an individual were up towards the entrance it would be hard to see all the way through looking back to front. Space efficiency, size and the ability to interlock the modules to some degree were several notable features of this design. The viewing locations and field of view inside the module were a little difficult to manage. This site in general requires a deal of awkward positioning to "comfortably" view items placed on the shelf. They would have the ability to wedge nicely further back into the depths of the shelf.

**Figure 11. "Cross" (or "Normandy") design prototype placed on the Upper West Cavern at Orizaba Rock, shelf with the front height of shelf delineated, 6 September 2013.**

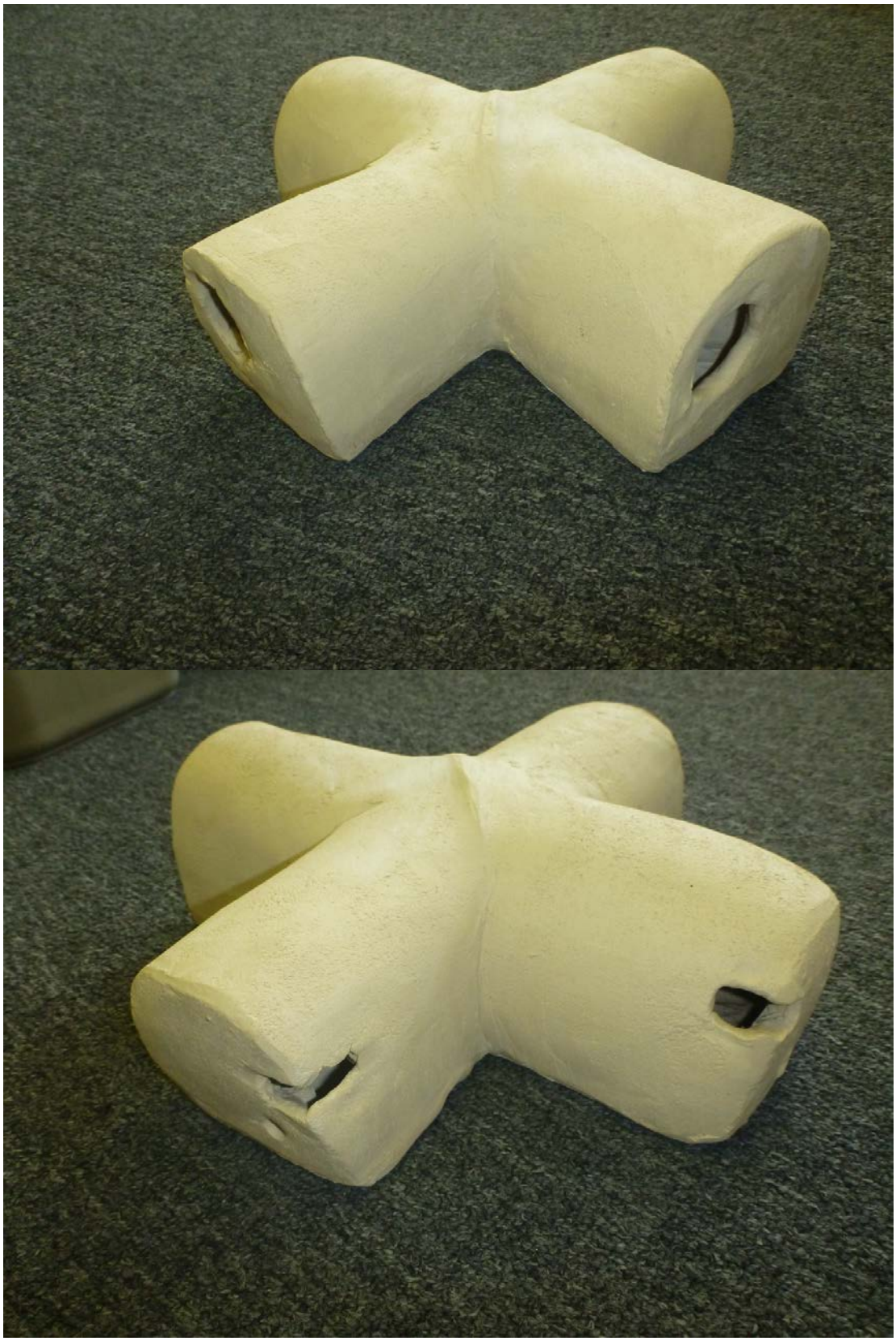

**Figure 12. Cross design or "Normandy" artificial nest prototype.**

**Palm Springs (Bread loaf) Design**

Overall good and heavy, it had the best space use within the module itself with 3 total sites available within footprint (Figure 13, 14). The smooth surface did not leave anything to grab for ease of movement by the Ravens. The visibility through the view hole was good in all three sites. Could fit about 8 sites (24 nest site possibilities total) across the ledge and still access without pushing them further back. This design was a good one if accessibility was not a consideration.

**Figure 13. "Palm Springs" or "bread loaf" design prototype placed on the Upper West Cavern at Orizaba Rock, shelf with the front height of shelf delineated, 6 September 2013.**

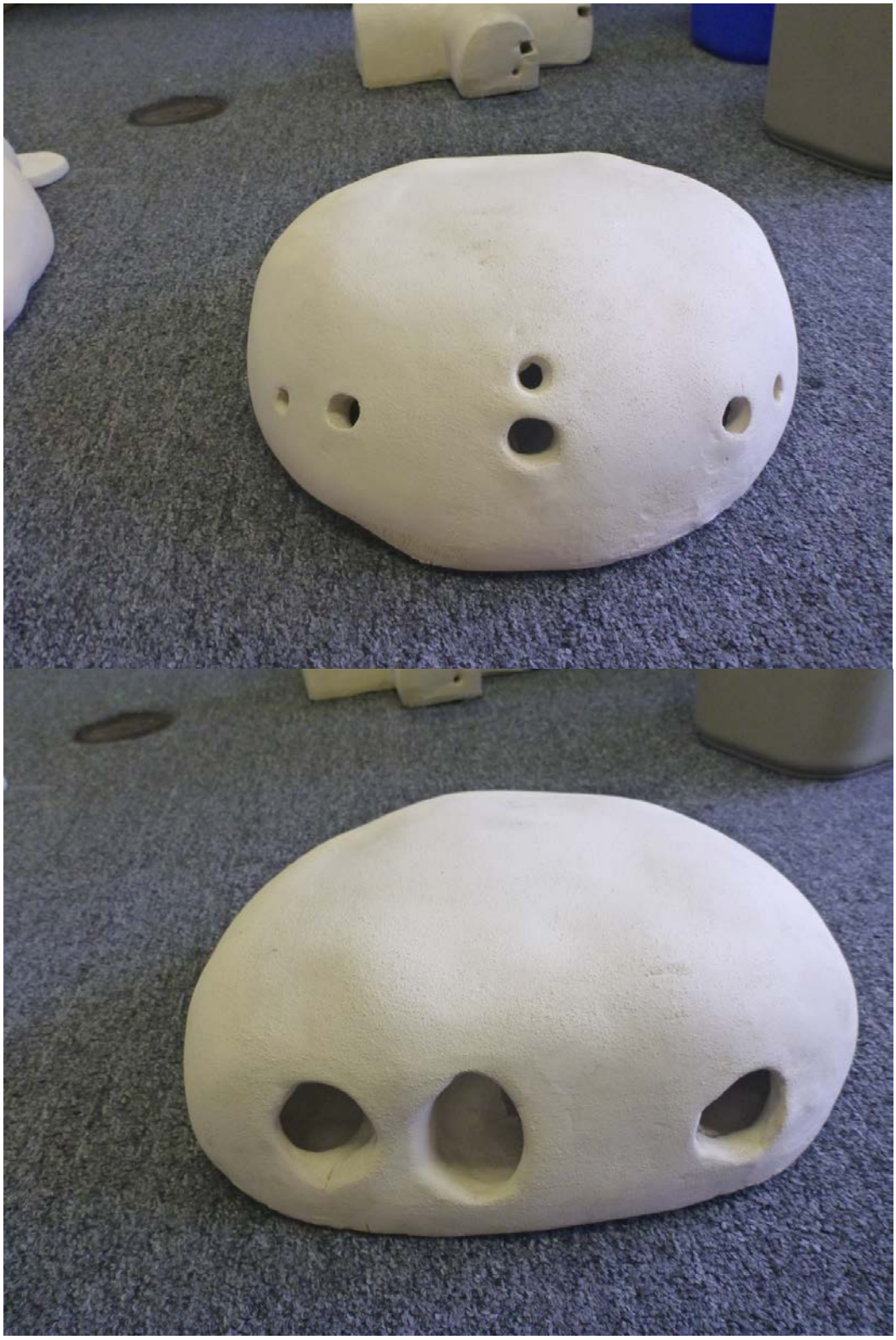

**Figure 14. "Palm Springs" (or "bread loaf") design prototype. Module side with holes to view nest contents are shown in top photo; module side with nest entrances shown in bottom photo.**

**Horseshoe (Spaceship)**
Heaviest site overall amongst the three, it was the largest in size however the least space efficient with two sites in the footprint (Figure 15, 16). Could fit a total of about 4-6 across the site and still access the fronts, without reaching to the back of the shelf. This design would allow researchers to (1) access nest contents, and (2) secure the access doors with threaded studs. The nesting cavity was the most complex of the three designs and allowed for plenty of options for an individual bird to locate a suitable site.

**Figure 15. Artificial nest prototypes on ledge of Upper West Cavern, Orizaba Rock. Left: "Palm Springs" (or bread loaf); right: "Horseshoe," 6 September 2013.**

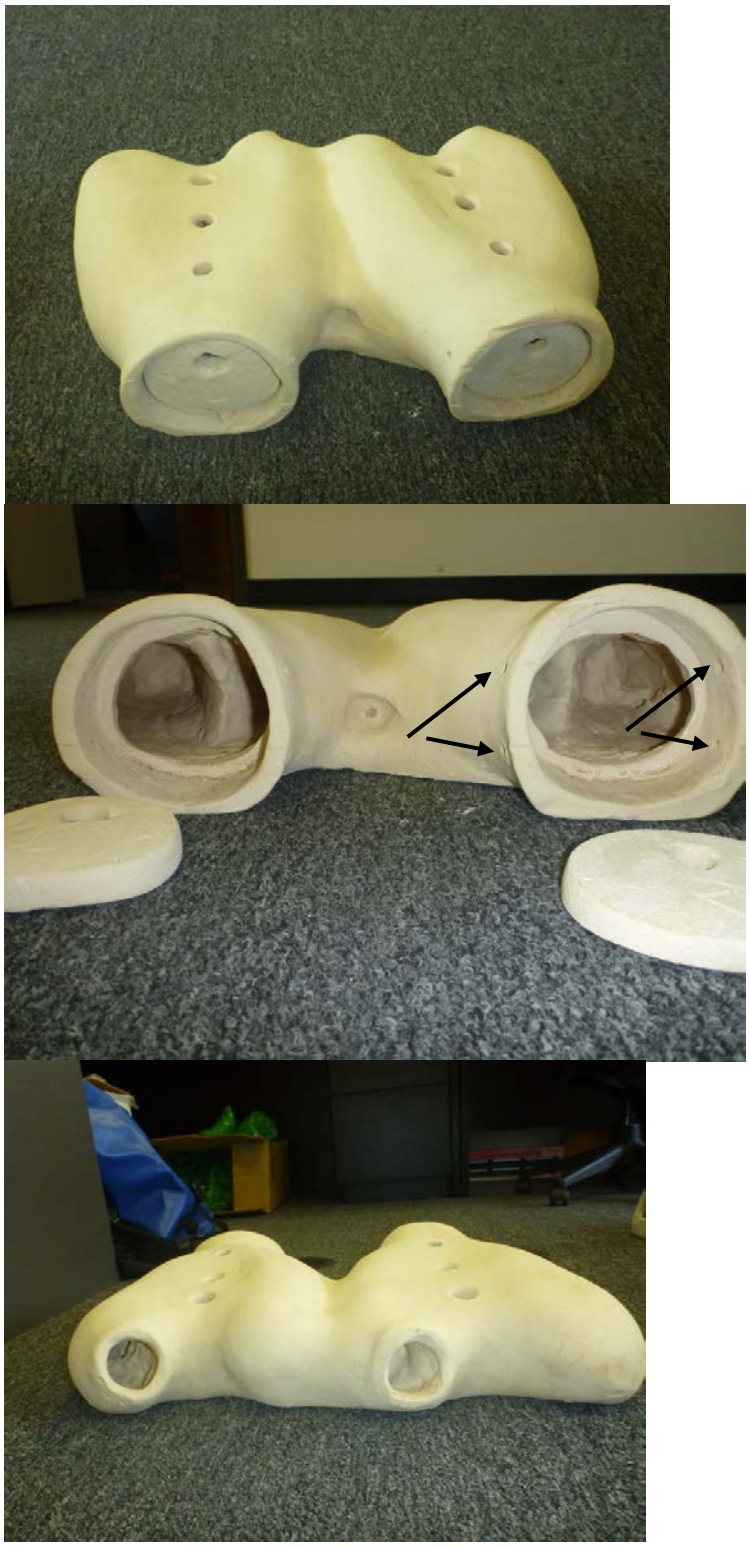

**Figure 16: "Horseshoe" design prototype. To secure the door of entranceway, a threaded rod would be positioned in the holes you can see in the mouth of the opening (arrows in middle photo) and span across the opening to wedge the door in place.**

**Summary and some things to discuss:**

Overall, the nest designs were all well-made and each had some benefits and drawbacks. As a whole, it seems given the need for modules to be heavy, the latter two (bread loaf and horseshoe) would be preferred over the cross design. In this particular location there would only be the possibility of a single line of modules across the front of the shelf if they would ultimately need to be accessed to monitor consistently through the viewing holes or removal of doors. The use of a burrow scope or other camera method for monitoring would allow the sites to be placed deeper onto shelf and more modules to be placed on the shelf as well.

A couple more points to consider as we move forward with the process:
-Ideally the final design would be able to be used elsewhere without major modification, so shouldn't necessarily revolve around making it fit specifically to just this site at Orizaba.
-The ability to access the sites and whether that is an important design element should be considered and decided upon.
-Would it be possible to incorporate a third chamber in the current footprint of the horseshoe design that wouldn't need to be accessed besides general viewing? This would help add more habitat for the size of the overall module.
-Testing the modules still needs to be looked at in some form and whether it should be conducted on island or elsewhere so the sites could be baited and thoroughly tested.