Monitoring and Restoration of Ashy Storm-Petrels at Santa Cruz Island, California, in 2015

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Dedication

Ronald Kenneth Fairbanks
(1944-2016)

It is with respect and sorrow that we dedicate this report to our friend, the late Ronald Fairbanks, of Lompoc, California, who passed away on April 30, 2016. “Captain Ron” assisted with seabird restoration work at Santa Cruz Island from 2006-15, by providing logistical support aboard his charter boat *Miss Devin*. Harry Carter first contacted Ron in 2006, when other vessel support became unavailable, and Ron quickly established himself as the primary provider of vessel support for the Ashy Storm-Petrel Restoration Project through 2012, with periodic assistance in 2013-15. For the Ashy Storm-Petrel Restoration Project, Ron and his longtime friend Frank Orsua provided transportation to and from Santa Cruz Island, as well as transportation between study sites at the island during 46 distinct field trips, comprising a total of 75 days. The majority of these field trips were multi-day trips, and Ron provided overnight accommodations for all personnel aboard the *Miss Devin.* It was especially during these overnight trips that we had the opportunity and pleasure to get to know Ron. He spoke often and fondly of his wife Bonnie, and of his children and grandchildren. He had a deep passion for diving and fishing, and the Channel Islands were like a second home to him. Ron’s hospitality and good cheer made each field trip an enjoyable and memorable experience. His availability and skills as a captain made the restoration work at Santa Cruz Island possible. Ron also provided significant support for the Scorpion Rock Restoration Project at Santa Cruz Island. In addition, he provided support for seabird research at Anacapa and San Miguel islands. We miss him, and will continue to remember him on future trips to Santa Cruz Island, or wherever our respective lives may lead us.

– Bill McIver, Harry Carter, Laurie Harvey, David Mazurkiewicz and Jim Howard.

EXECUTIVE SUMMARY

In 2015, Channel Islands National Park, the U.S. Fish and Wildlife Service (Arcata Fish and Wildlife Office), California Institute of Environmental Studies and Carter Biological Consulting were funded by the Montrose Settlements Trustee Council to continue gathering data on the population size and reproductive performance of Ashy Storm-Petrels (*Oceanodroma homochroa*; ASSP), and to implement restoration actions for ASSP 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. Subsequent to impacts in 2012 to ASSP artificial nesting structures by Common Ravens (*Corvis corax*), the Montrose Trustee Council funded Oikonos Ecosystems Knowledge, Rebar Group and California College of the Arts in 2013-14 to develop and manufacture more durable ceramic artificial nesting structures for use by ASSP to deter future alterations and impacts by ravens.

In 2015, notable results from restoration and monitoring work at Orizaba Rock (OR) and Santa Cruz Island (SCZ) included the following:

- At OR, egg laying by ASSP was observed in 4 artificial crevices, and 2 artificial crevices were visited by ASSP; vocalization broadcasting was not initiated.
- Thirty-four egg-laying pairs of ASSP were found in natural crevices at OR.
- Breeding success at OR (44%, n = 36 [natural and artificial crevices combined]) was similar to Bat Cave (BC; 49%, n = 100); breeding success at Cave of the Birds' Eggs (CBE), a prior reference colony, was not determined in 2015, because it was visited by researchers only once due to budgetary constraints.
- Breeding success of four artificial nest sites at OR was 25% in 2015.
- At the SCZ monitoring sites, a total of 144 nests were found and monitored; overall breeding success (49%, n = 144) was influenced by failures during both the egg and chick stages; it was lower than what was observed in 2014 (63%, n = 153), 2012 (64%, n = 144) and 2011 (79%, n = 110), and similar to 2013 (53%, n = 158).
- Data from reconnaissance cameras at OR and BC showed extensive visitation by Common Ravens within the caverns where artificial nest modules were deployed at OR, and within the main room of BC, where five modules were deployed; no impacts to modules were observed. Five predation events upon ASSP were documented from reconnaissance camera data at OR (n = 2) and BC (n = 3).
- Relatively high numbers of active nests at BC (n = 100) indicated continued recovery following an island spotted skunk (*Spilogale gracilis amphiala*) predation event in 2005.
- Ten active nests occurred at Cavern Point Cove Caves (CPC; breeding success = 75%), compared to 2014 (n = 5), 2013 (n = 7), 2012 (n = 5) and a maximum of two active nests per year in 2009-11, following a predation event and near extirpation of ASSP at this location by island spotted skunks in 2008.
- Skunk traps were not deployed in the sea caves in 2015.

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INTRODUCTION

Endemic to California and northwestern Baja California, Mexico, Ashy Storm-Petrels (*Oceanodroma homochroa*; ASSP) 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 (SCZ) 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 SCZ in 1912 (Wright and Snyder 1913), knowledge of population size and distribution of ASSP at SCZ 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 SCZ, 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 ASSP at SCZ 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 SCZ, 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 2006-13, 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 ASSP and implement restoration actions at SCZ. Roles of these participating agencies and organizations varied by year, and the specific monitoring and restoration-related activities conducted at SCZ are summarized in Appendix A, and described in detail in the annual reports (Carter et al. 2007; McIver et al. 2008, 2009a, 2010, 2011, 2013, 2014 and 2015). In 2008-12, 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 2013-14, the MSTC funded Oikonos Ecosystems Knowledge (Benicia, California), Rebar Group (San Francisco, California) and California College of the Arts (San Francisco, California) to develop and manufacture more durable ceramic artificial nesting structures for use by ASSP (beginning in 2014), to deter future alterations and impacts by ravens. In 2013, artificial nest structures were not re-deployed and vocalizations were not broadcasted (McIver et al 2105). In addition, the MSTC and personnel from CINP, USFWS, Oikonos Ecosystems Knowledge, California College of Arts and Rebar Group discussed possible modifications to artificial nesting structures, with the intent of developing and manufacturing more durable ceramic artificial nesting structures for use by ASSP, to deter future alterations and impacts by ravens. On 6 September 2013, artificial nest prototypes developed by the working group were temporarily deployed at OR, to test the efficacy of deploying these various prototypes (McIver et al. 2015).

In 2014-15, the MSTC funded CINP, USFWS, CIES and CBC to continue gathering nest-monitoring information at SCZ and evaluate artificial site use at OR (see Appendix A). Re-designed artificial nest modules were deployed at OR in spring 2014; ASSP did not lay eggs in artificial sites in 2014 (McIver et al. 2015).

METHODS

Study Area

SCZ (34°00'N, 119°43'W) 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 Channel Islands (Minnich 1980). The northern and northwestern shores of SCZ 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. SCZ occurs within the Channel Island National Marine Sanctuary, which extends to approximately 6 nautical miles (11.1 km) from the island shoreline. 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 or conservation areas.

Field Logistics

In 2015, field work, data entry, and project management were conducted primarily by CINP and CIES personnel, with assistance by USFWS and CBC. Data analyses and report preparation were retained by USFWS-AFWO, with assistance from CINP and CIES personnel. Transportation to and from SCZ was provided aboard: support vessels with the CINP concessionaire Island Packers (Ventura, California); and the charter boat *Miss Devin*, operated by the late R. Fairbanks (Lompoc, California) (Table 1). Nesting habitats were accessed from a 14-foot (4.3 m) inflatable boat powered by a 20-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 19 field days in 2015, compared to 2014 (n = 20), 2013 (n = 18), 2012 (n = 17) and 2008-11 (range: n = 12-14). Mainland time required for coordination of trip logistics was similar to 2012-14. As in 2011-14, nest-monitoring trips from June through September in 2015 were scheduled to occur near new moons.

Nest Monitoring

In June-November 2015, field trips were conducted to search for and monitor all nests of ASSP found in accessible habitats at BC, CBE, CPC (comprised of two adjacent caves: Cave #4 and Cave #5), DSB and OR (Figure 1). Nest monitoring in 2015 involved 1-5 hour visits during each monthly field trip to each breeding location (Table 1). Daytrips to BC occurred on 6 March and 26 May, to deploy artificial sites (described in "Artificial Nest Sites" below). In 2005-14, multiple nest checks per year were conducted at CBE, and this colony was used as a reference colony for comparisons to OR. However, due to budgetary constraints, CBE was visited only once in 2015 (25 August), and most trips to SCZ occurred on boats operated by Island Packers.

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 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

Table 1. Field trips conducted for Ashy Storm-Petrel monitoring at Santa Cruz Island, California, in 2015.

Date	Locations[1]	Personnel[2]	Main Activities	Vessel Support
6 March	BC	DM, CC, GK RM	Deploy artificial nest sites, cameras, partial nest check.	IPCO[3] vessel + kayak
26 May	BC	GK, MB	Check cameras, nest check.	IPCO[3] vessel + kayak
17-19 June	BC, CPC, OR	DM, CC, PL, JH, MB, NM	Monitor sites; check cameras.	IPCO[3] vessel + kayak
14, 16-17 July	BC, CPC, OR	JH, DM, CC, MB, NM, PL	Monitor sites; check cameras.	IPCO[3] vessel + kayak
25-26 August	BC, CBE, CPC, DSB, OR	DM, HC, CC, MP, WM	Monitor sites; check cameras.	*Miss Devin* + zodiac
15-17 September	BC, CPC, OR	JH, GK, SC, CC, MJ	Monitor sites & check cameras.	IPCO[3] vessel + kayak
7-9 October	BC, CPC, OR	DM, SC, PL, LA	Monitor sites & check cameras.	IPCO[3] vessel + kayak
13-15 November	BC, CPC, OR	JH, CC, SC, PL	Monitor sites; remove most cameras; kept 1 camera active.	IPCO[3] vessel + kayak

Footnotes for Table 1 -

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

2 Codes: DM = CC = Catherine "Katy" Carter (CIES), David Mazurkiewicz (CINP), GK = Gaby Keeler (CIES), HC = Harry Carter (CBC), JH = Jim Howard (CIES), LA = Lisa Anderson (IPCO), MB = Mike Buratti (CIES), MJ = Marie-Eve Jacques (CIES), MP = Mike Parker (Davis, CA), NM = Nate Melling (IPCO), PL = Peter Larramendy (CIES), RM = Robert Morin (CINP), SC = Samantha Cady (CIES), WM = William McIver (USFWS-AFWO) .

3 IPCO = Islands Packers, Ventura, California.

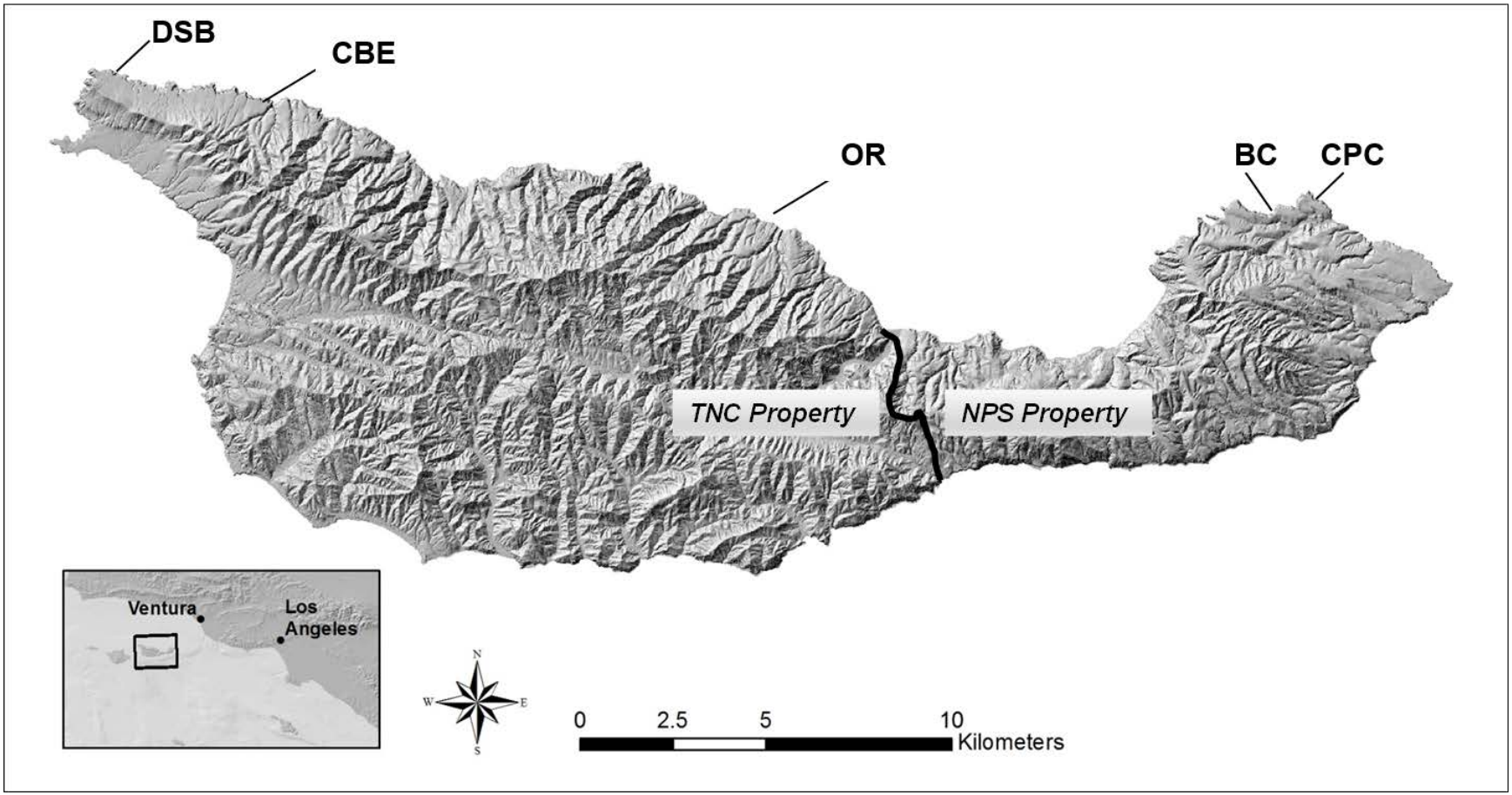

Figure 1. Approximate locations of monitored ASSP colonies at Santa Cruz Island: Bat Cave (BC); Cave of the Birds' Eggs (CBE); Cavern Point Cove Caves (CPC); Dry Sandy Beach Cave (DSB); and Orizaba Rock (OR). The current boundary between National Park Service (NPS) and The Nature Conservancy (TNC) properties is demarcated by the bold black line but all offshore rocks (including Orizaba Rock) are NPS property.

have disappeared without leaving any evidence before our first visit after the egg was laid, but we suspect that such occurrences were rare. If ASSP 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, investigating 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 was attached to rock or driftwood near the nest entrance. On each visit, nest contents for each marked site were recorded on maps and in "personal digital assistants" (PDAs; Socket Mobile "SoMo 650", Newark, New Jersey). 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 (see McIver and Carter 1996; McIver 2002). Evidence of predation, including carcasses, feather piles and broken eggs, was recorded and mapped, and feather piles were collected upon discovery (removal of these items facilitates detection of new evidence of predation to prevent double counting). For this report, predation events were quantified by comparing mapped locations of feather piles and carcasses between field trips, to exclude feather piles found on a previous field trip and possibly not collected. Observations of ravens at study sites were recorded.

Artificial Nest Sites

Orizaba Rock – In 2015, nesting activities were monitored for the 10 artificial nest modules deployed in 2014. As described in McIver et al. (2015), each module contained 3 chambers for possible nesting by ASSP. Each chamber was large enough to accommodate a storm-petrel pair, which could access the nesting chamber through one nest entrance. An inner wall that a storm-petrel would have to move past to enter the chamber prevented direct viewing and access of nest contents by ravens. On the opposite side of the module from the nest entrance, each nesting chamber also contained small (~ 2-3 cm wide) hole for viewing of nest contents by researchers, and a small (~2-3 cm wide) hole for inserting a PIT-tag wand. Each module weighed on the order of 15-20 kg. As in 2013-14, ASSP vocalization broadcasting was not conducted in 2015.

Bat Cave – Substantial predation of ASSP by ravens was observed at BC in 2013 and 2014 (McIver et al. 2015), particularly at nesting crevices with relatively open nest entrances and accessible nesting chambers. Therefore, in 2015, instead of deploying additional artificial nest modules at OR, five artificial nest modules were manufactured for deployment at BC, using a darker colored clay and textured outer surfaces, to blend in with and match colors and shapes of rocks that occur on the surface of the main room floor at BC (Figures B-1, B-2 and B-3 in Appendix B). On 6 March 2015, these artificial nest modules were deployed at BC, in the main room where raven predation had previously been found. The artificial nest modules were deployed on flat portions of the cave floor in close proximity to natural nesting crevices, and did

not physically replace any natural crevice. ASSP vocalization broadcasting was not initiated in 2015. Artificial nest modules were subsequently monitored on each field trip in 2015.

Reconnaissance Camera Monitoring

Ravens at OR – In 2015, three reconnaissance cameras (model HC500 Hyperfire, RECONYX Inc., Holmen, WI) were deployed at OR, to monitor visitation patterns of ravens in the upper caverns at OR, where ASSP nesting crevices occur and where all artificial nesting modules were deployed (Table 2). Memory cards and batteries in the cameras were changed during nest-monitoring trips. 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 C).

Ravens & Human Visitors at BC – One reconnaissance camera that had been deployed in the main room of the cave in 2014 (see McIver et al. 2015), and three additional cameras (deployed on 6 March) were operational in 2015 (Table 2). Memory cards and batteries in the cameras were changed during nest-monitoring trips. For all observations of ravens 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 followed methods begun in 2010 and continued in 2011-14 using passive integrated transponder (PIT) technology to examine future recruitment of ASSP at artificial and natural sites at OR, and at natural sites in sea caves (see McIver et al. 2011 and subsequent reports for more detailed descriptions of methods). Following similar methods described in Zangmeister et al. (2009), PIT-tags (Model TX1400ST; Biomark, Inc., Boise, ID) were incorporated into bands for attachment to ASSP chicks. Similar to 2010-14, 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 and entered into a PDA. 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 2011-14, a wand antenna attached to an active PIT-tag reader was placed within a few centimeters of each adult storm-petrel (i.e., adult bird was "wanded") encountered in an accessible nest site during the summer to detect previously-tagged chicks returning as adults to breed.

Protection from Predation by Island Spotted Skunks

In 2009-14 (report references as in Appendix A), lethal "body-grip" skunk traps (model 220 Conibear trap, Oneida Victor Inc. Ltd., Euclid, OH) were set inside protective custom-made wooden boxes and deployed at BC, CBE and CPC. Due to reported low numbers of skunks on SCZ during the past few years (D. Mazurkiewicz, personal communication), and no skunk predation events in the sea caves since 2009, skunk traps were not deployed in the sea caves at SCZ in 2015.

Table 2. Descriptions of reconnaissance cameras deployed at Orizaba Rock and Bat Cave, Santa Cruz Island, California, in 2014.

Camera	Deployment date	Location[1]	Approx. Direction	General description of field of view
Orizaba Rock -				
#1	3/7/2014[2]	UEC	335º	Northern side of cavern, + tops of artificial nest modules #9 & #10, deployed on floor of cavern.
#2	3/7/2014[2]	UWC#1	225º	Entrance of cavern facing southwest, artificial sites on floor.
#3	7/26/2015	UWC#2	360º	Ledge at northern side of cavern and partial view of northern entrance to upper chamber.
Bat Cave -				
#1	1/23/2014[2]	Entrance	235°	Entrance and southwest wall of cave.
#2	3/6/2015	Main room	180°	Rear wall of cave, behind "module #5."
#3	3/6/2015	Main room	180°	Rear wall of cave, behind "module #4."
#4	3/6/2015	Main room	180º	Rear wall of cave, behind "module #1."

Footnotes –

[1] Codes: UEC = Upper East Cavern, UWC = Upper West Cavern

[2] Camera kept in place and active at end of 2014 field season, to monitor activities over 2014-15 winter.

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 2015.

Data Handling and Descriptive Statistics

Like other storm-petrels, ASSP 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 ASSP 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 15-17 July and 25-26 August field trips are described for each location. 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).

RESULTS

Breeding Phenology

Estimated dates of egg laying, hatching and fledging in natural and artificial nest sites at each monitored location at SCZ are summarized in Table 3. In 2015, laying dates ranged from 29 April to 6 September for single and first eggs (n = 126) versus 7 July to 6 September for replacement eggs (n = 7). Hatch dates ranged from 11 June to 1 October for single and first eggs (n = 89), versus 20 August for one replacement egg. Fledging dates ranged from 30 August to 20 December for chicks from single and first eggs (n = 71); no chicks fledged from replacement eggs. A total of 142 active nests were observed at three regularly-monitored colonies SCZ (i.e., BC, CPC and OR) in 2015; 125 active nests (89%) were observed on each field trip on 15-17 July and 25-26 August.

Hatching, Fledging, and Reproductive Success

Hatching, fledging, and breeding success for SCZ (three monitored locations in 2015 combined) are summarized in Table 4. In 2015, overall breeding success at SCZ was 49% (n = 144) (Table 4).

Bat Cave (BC)

Ashy Storm-Petrel: One hundred nests were documented at BC in 2015. Eighty-three active nests (83%) were observed on 16 July 2015, and 88 active nests (88%) were observed on 26 August 2015. Ranges of dates of egg laying, hatching and fledging for single/first eggs were estimated as: 29 April – 6 September (range 131 d, n = 88); 11 June – 1 October (range 112 d, n = 61); and 30 August – 19 December (range 112 d, n = 49), respectively. Ranges of dates of egg laying for replacement eggs were estimated as 5 August – 6 September (range 32 d, n = 4; hatching and fledging did not occur). Hatching success for first/single and replacement eggs was 61% (n = 100) and 0% (n = 4), respectively; fledging and breeding success for last eggs were 82% (n = 60), and 49% (n = 100), respectively (Table 4). Two nests (sites #15C and #404) occurred in a side chamber from which eggs previously (in 1995-97) had been collected for contaminants analyses.

Scripps's Murrelet (*Synthliboramphus scrippsi*; SCMU): On 17 June 2015, one SCMU nest was found in a wall crevice (tag #1106 – one eggshell fragment & one full egg) on the "slope" in the main room of the cave. This site was also used by ASSP in 2015 (observations: adult bird on 17 June, eggshell fragment on 16 July).

Common Raven (CORA): CORA were not observed (or were not noted) during field trips at or near BC in 2015. However, at least one and as many as four reconnaissance cameras were active at BC for 267 consecutive days in 2015 (from 1 January to 23 September), and CORA were observed on 122 different days in 2015 (from 29 January to 23 September). No image showed more than two ravens in the field of view. Notable events captured in the images included three predation events (two successful and one possibly unsuccessful, described in "Predation" section below) (Figures D-1 through D-3 in Appendix D), and a CORA feeding a chick, including "wing-begging" behavior exhibited by the chick.

Table 3. Average timing of egg laying, hatching and fledging (mean date ± standard error in days) for Ashy Storm-Petrels at Santa Cruz Island, California, in 2015. Sample sizes in parentheses[1].

Location[2]	Clutch Number[3]	Egg Laying	Hatching	Fledging
BC	1	24 June ± 3 (88)	27 July ± 3 (61)	8 October ± 3 (49)
	2	15August ± 7 (4)	-	-
CBE	1	-	1 August ± 4 (20)	-
CPC[4]	1	11 June ± 9 (9)	19 July ± 6 (8)	3 October ± 6 (6)
DSB	1	-	15 July ± 5 (20)	-
OR[5]	1	21 June ± 5 (29)	23 July ± 4 (20)	10 October ± 5 (16)
	2	15 August ± 20 (3)	20 August (1)	-
All[6]	1	22 June ± 2 (126)	25 July ± 2 (129)	8 October ± 3 (71)
	2	15 August ± 8 (7)	20 August (1)	-

Footnotes –

1 Sample sizes at locations may differ from Table 4, because nests with a wide range of possible egg laying dates (> 30 d), and nests with unknown egg laying dates were excluded from Table 3.

2 Codes defined in Table 1.

3 Codes: 1 = first and single eggs; 2 = replacement eggs.

4 Includes Cave #4 and Cave #5; first nesting in Cave #4 since skunk predation event in 2008.

5 Natural crevices and artificial sites combined. Average time of egg laying for natural sites only was 18 June ± 4 (n = 25), and average times of hatching & fledging for natural sites only not different than values for all sites combined.

6 Natural crevices and artificial sites combined. Average times of egg laying, hatching & fledging for natural sites only not different than values for all sites combined.

Table 4. Percent hatching, fledging, and breeding success of Ashy Storm-Petrel nests monitored at Santa Cruz Island, California, in 2015. Sample sizes in parentheses.

Success (%)	Clutch Number[3]	Location[1,2]					
		BC	CPC[4]	OR[5]	OR[6]	All[5]	All[6]
Hatching	1	61.0 (100)	80.0 (10)	65.6 (32)	61.1 (36)	63.4 (142)	62.3 (146)
	2	0 (4)	-	33.3 (3)	33.3 (3)	14.3 (7)	14.3 (7)
Fledging	Last	81.7 (60)	75.0 (8)	68.2 (22)	69.6 (23)	77.8 (90)	76.9 (91)
Breeding	Last	49.0 (100)	75.0 (8)	46.9 (32)	44.4 (36)	50.0 (140)	49.3 (144)

Footnotes –

1 Codes defined in Table 1.
2 Hatching, fledging and breeding success values not determined for Cave of the Birds' Eggs or Dry Sandy Beach Cave, which were visited only on 25 August 2014.
3 Codes 1 and 2 defined in Table 3; Last = single and replacement eggs.
4 Includes Cave #4 and Cave #5; first nesting in Cave #4 since skunk predation event in 2008.
5 Natural crevices only.
6 Natural and artificial sites.

Table 5. Numbers of distinct Ashy Storm-Petrel feather piles found in Bat Cave, Santa Cruz Island, in 2015.

	Location at Bat Cave					
Date	main room (proper)	main room (slope)	slope room	pool room	outside	Total
6 March	0	0	0	0	0	0
26 May	3	2	1	2	1	9
17 June	12	4	0	2	0	18
16 July	2	1	0	0	0	3
26 August	9	2	0	1	0	12
16 September	1	0	0	0	0	1
7 October	0	0	0	0	0	0
14 November	1	0	0	0	0	1
Total	28	9	1	5	1	44

Predation/Scavenging: In 2015, 44 distinct feather piles were detected at BC (Table 5); 30 of these feather piles were detected by 17 July. The majority (84%) of all feather piles (n = 44) were found in the main room of BC, where the greatest number and concentration of ASSP nests at BC occurs. Images from the reconnaissance cameras showed three predation events in 2015, as follows: (1) 23 June – one CORA pulls one ASSP out of nest site but the ASSP may have escaped (Figure D-1 in Appendix D); (2) 1 July –one CORA with ASSP adult in bill (Figure D-2 in Appendix D); and (3) 9 August – one CORA with ASSP egg in bill (Figure D-3 in Appendix D).

Artificial Nest Sites: Egg laying or visitation by ASSP was not observed in the BC modules in 2015.

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 2015, these signs were intact and in their original locations (i.e., unaffected by ocean wave action or vandalism). On 26 August, we observed a pile of abalone shells on top of a small boulder within the main room of the cave, suggesting a visitor(s) had visited the cave subsequent to our 16 July visit to the cave. Reconnaissance cameras did not detect any human visitation to BC in 2015.

Cave of the Birds' Eggs (CBE)

Ashy Storm-Petrel: Twenty-five nests were found on 25 August 2015, as follows: intact egg only (n = 1); abandoned egg only (n = 2); adult bird incubating egg (n = 2); adult bird brooding chick (n = 1) and; chick only in nest (n = 19, range: small downy to medium gawky). Mean dates of egg laying and hatching (mean date ± standard error) were estimated for 19 nests containing chicks, observed on 25 August 2015, as follows: 18 June ± 4 d (egg laying) and 1 August ± 4 d (hatching). Mean dates of fledging were not estimated, because this colony was not visited after 25 August 2015, and thus status of nests occupied by chicks could not be confirmed later in the season during peak fledging.

Pigeon Guillemot (*Cepphus columba*): A total of 10 nests of Pigeon Guillemot (PIGU) were observed at CBE on 25 August 2015, as follows: sites containing 1 egg (n = 2); sites containing at least 1 egg but possibly 2 eggs (n = 6; notes were vague and did specifically quantify these 1- or 2-egg sites); and, sites containing 2 eggs (n = 2).

Predation/Scavenging: Evidence of apparent avian predation was detected on 25 August 2015, as follows: one PIGU set of wings and two distinct locations with PIGU feathers.

Human Visitation: No evidence of human disturbance or non-researcher human visitation was detected on 25 August 2015.

Wave Wash Event(s): Evidence of flooding or wave wash in the cave was not noted on 25 August 2015.

Cavern Point Cove Caves (CPC)

Ashy Storm-Petrel: Ten nests were documented at CPC in 2015; one nest at Cave #4 and nine nests at Cave #5. Eight active nests (80%) were observed on 15 July 2015, and 10 active nests

(100%) were observed on 26 August 2015. Ranges of dates of egg laying, hatching and fledging for single/first eggs were estimated as 17 May – 3 August June (range 79 d, *n* = 9), 29 June – 20 August (range 52 d, *n* = 8) and 17 September – 20 October (range 33 d, *n* = 6), respectively. Hatching success for first/single eggs was 80% (*n* = 10); fledging and breeding success for last eggs were 75% (*n* = 8) and 75% (*n* = 8), respectively (Table 4).

Bats: Townsend's big-eared bats (*Corynorhinus townsendii*) were observed at CPC in 2015, as follows: a) 18 June — five bats in Cave #5; b) 26 August — 2 bats in Cave #4 and; c) 9 October — "bats present" (number not given) in Cave #4.

Human Visitation: No evidence of human disturbance or non-researcher human visitation was detected in 2015, and CINP signs originally installed in 2009 remained intact.

Dry Sandy Beach Cave (DSB)

Ashy Storm-Petrel: Twenty-two nests were found on 25 August 2015, as follows: adult bird sitting in nest (*n* = 1); adult bird incubating egg (*n* = 1) and; chick only in nest (*n* = 20, range: large downy to fully-feathered). Mean dates of egg laying and hatching (mean date ± standard error) were estimated for 20 nests containing chicks, observed on 25 August 2015, as follows: 1 June ± 5 d (egg laying) and 15 July ± 5 d (hatching). Mean dates of fledging were not estimated, because this colony was not visited after 25 August 2015, and thus status of nests occupied by chicks could not be confirmed later in the season during peak fledging.

Pigeon Guillemot: Two PIGU nests were observed at DSB on 25 August 2015, as follows: one site with one abandoned PIGU egg and one-quarter eggshell fragment; and one site with one "mummified" PIGU carcass (not described in notes whether adult or chick).

Predation/Scavenging: Evidence of apparent avian predation was detected on 25 August 2015, as follows: one location with one PIGU set of wings; and one location with "several" sets of PIGU wings.

Human Visitation: No evidence of human disturbance or non-researcher human visitation was detected on 25 August 2015. The TNC sign, initially installed in 2009, dislodged by winter waves in early winter 2010, and re-installed in December 2010, remained intact.

Orizaba Rock (OR)

Ashy Storm-Petrel Nest Monitoring: A total of 36 nests were found at OR in 2015; 32 in natural crevices and 4 in artificial sites. Thirty-four active nests (94%) were observed on 17 July 2015, and 27 active nests (75%) were observed on 27 August 2015. Ranges of dates of egg laying, hatching and fledging for single/first eggs were estimated as 28 May – 6 August (range 70 d, *n* = 29), 11 July – 9 September (range 60 d, *n* = 20) and 29 September – 28 November (range 60 d, *n* = 16), respectively. Ranges of dates of egg laying and hatching for replacement eggs were estimated as 7 July – 4 September (range 59 d, *n* = 3) and 20 August (*n* = 1); no chicks fledged from replacement eggs in 2015. For natural sites, hatching success for first/single eggs and replacement eggs was 66% (*n* = 32) and 33% (*n* = 3), respectively; fledging and breeding success for last eggs were 68% (*n* = 22) and 47% (*n* = 32), respectively (Table 4). The one chick

that hatched from a replacement egg did not fledge. For artificial sites, hatching, fledging and breeding success was 25% (*n* = 4), 100% (*n* = 1) and 25% (*n* = 4), respectively.

Artificial Nest Sites: In 2015, all 10 nest modules deployed in 2014 were available for use by storm-petrels. Four artificial chambers showed evidence of egg laying in 2015, and one chamber was visited only.

Predation: Regurgitated raven pellets, guano splash (presumed to be from a raven) and one distinct pile of storm-petrel feathers were found in the Lower Cavern on 25 August 2015. The contents and exact number of pellets were not noted. Images from the reconnaissance cameras showed 2 predation events in 2015, as follows: (1) one ASSP in raven bill on 24 January (Figure D-4 in Appendix D); and (2) unidentified prey item (storm-petrel or auklet) in ravens bill on 19 March (Figure D-5 in Appendix D).

Common Raven: One raven was observed on the island bluff adjacent to OR on 25 August 2015; no other observations of ravens were noted on other field trip dates. Descriptions of observations of ravens from the reconnaissance cameras are shown in Appendix C. Reconnaissance cameras deployed at the upper caverns at Orizaba detected ravens on 9 different days after the last date of nest monitoring in 2014, from 22 November to 21 December (Appendix C). In 2015, reconnaissance cameras detected ravens on 111 different days, from 1 January to 6 November, the last day of nest monitoring (Appendix C). Seventy-six percent (*n* = 84 d) of the different days on which ravens were observed consisted of images containing one raven; images with two ravens were observed on 27 different days. No image showed more than two ravens in the field of view. Notable events captured in the images included 2 predation events (described in "Predation" section above), and CORA sticking bills into observation holes of artificial nest modules (Figure D-6 in Appendix D). CORA were observed in cameras on the same day at both OR and BC on 47 different days; on 19 of these days (40%), observations at OR occurred within an hour of at least one observation at BC, and on 5 of these days (11%), observations at OR occurred within 10 minutes of at least one observation at BC (Appendix C).

Black Oystercatcher (*Haematopus bachmani*): Twenty oystercatchers were recorded at OR on 25 August 2015.

Scripps's Murrelet: No crevices were found occupied by SCMU at OR in 2015; nesting activities may have occurred at OR prior to 19 June that were missed.

Cassin's Auklet: Three occupied nest sites were documented at OR in 2015; evidence of egg laying was observed in all three sites (Table 6). Some nesting activities may have occurred at OR prior to 19 June that were missed.

Heermann's Gull (*Larus heermanni*): Roosting Heermann's Gulls (numbers and ages not noted) were recorded roosting on OR on 25 August 2015.

Western Gull (*L. occidentalis*): No information on Western Gull nests at OR in 2015 was provided in field notes.

Table 6. Nesting Activities of Cassin's Auklets at Orizaba Rock, Santa Cruz Island, California, in 2015.

	Monitoring Dates[1]		
Nest Number	**19 June**	**17 July**	**25 August**
49[2]	B	0	Eab
1021	B	SGC[3]	FFC[2]
1157	-	C[3]	0

Footnotes -

[1] Nesting activity codes: 0 = empty or zero, B = adult bird, C = chick, Eab = abandoned egg, FFC = fully-feathered chick, SGC = small gawky chick, dash (-) = not checked or not data.

[2] Site also used by ASSP in 2015.

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

Recruitment Study

A total of 31 ASSP chicks at SCZ were fitted with PIT-tag bands and USGS stainless steel bands in 2015, as follows: BC (n = 21), CBE (n = 5) and OR (n = 5) (Appendix E). In 2015, PIT-tag bands were not detected (with PIT-tag readers & wands) on adult storm-petrels observed and wanded in nesting crevices during nest checks; however, wanding of adult birds may not have been conducted on each trip or at each location from June through August, either due to time constraints or if PIT-tag readers & wands were inadvertently forgotten.

DISCUSSION

Use of Artificial Sites

At OR, artificial nest sites were available for use by ASSP in 2008-12 and 2014-15, and ASSP laid eggs in artificial sites in every year except 2014 (McIver et al. 2015, 2016a; McIver and Carter et al. 2016; this report). Over this time period, five different artificial site designs were deployed (i.e., roof tile and ceramic structures), primarily in response to impacts by ravens, and ASSP laid eggs and fledged at least one chick from each type of artificial site (McIver et al. 2014, 2016a; McIver and Carter et al. 2016; this report). In the 6 years in which egg laying occurred in artificial nest sites (2008-12 & 2015), 19.4% of all ASSP nesting attempts at OR (n = 175) occurred in artificial nest sites. And, in years 2008-12 and 2015, breeding success was higher in natural crevices (47%, n = 141 nests) than in artificial crevices (41%, n = 34 nests), although we did not compare this statistically (Appendix G).

Nocturnal broadcasting of ASSP vocalizations from 1-2 speakers was implemented during the pre-breeding and breeding seasons in each year in 2008-11, and until mid-July in 2012 (when substantial impacts to artificial sites by ravens was observed), and this was the first time this method had been used to encourage nesting by ASSP at specific nesting habitats (McIver and Carter et al. 2016). Nocturnal broadcasting of ASSP vocalizations was not conducted in 2013-15. That ASSP used and visited artificial nest sites in 2015 without the aid of artificially-broadcasted vocalizations suggests that ASSP in natural crevices were successful in facilitating social interactions and egg laying within artificial sites. Bolton et al. (2004) reported a large increase in the number of breeding Madeiran (i.e., Band-rumped) Storm-Petrels (*O. castro*) from the first to the second season, without use of auditory playback in the second season. They suggested that the establishment of a small number of successfully breeding petrels can serve to attract prospecting birds in subsequent years. In European Storm-Petrels (*Hydrobates pelagicus*), De León & Mínguez (2003) and Libois et al. (2012) showed that providing artificial sites in absence of vocalization playback can result in an increase in numbers of artificial sites used for nesting, but it may take longer. Bried et al. (2009) reported an almost fourfold increase in numbers of Band-rumped Storm-Petrel nests in nest boxes over six years (without vocalization playback), and that nesting use of natural sites did not vary significantly between years. Barring substantial reductions in numbers of nesting ASSP at OR in the future, especially in natural crevices near the deployed artificial nest sites, we expect that natural social attraction by ASSP should continue, which could result in greater use of the artificial nest chambers.

Impacts by CORA to artificial nest sites at OR were first observed in 2010 (McIver et al. 2011), and to our knowledge, McIver and Carter et al. (2016) represents the first published account of impacts by avian predators to artificial nest structures used by a seabird species. Substantial alteration of artificial nest sites by CORA in 2012 resulted in a re-evaluation of artificial nest designs in 2013, and subsequent deployment of heavier, more durable artificial nest modules at OR in 2014 (McIver et al. 2014, 2015). Ten re-designed artificial nest modules containing 30 chambers were deployed at OR in 2014, matching the number of artificial nesting chambers provided for ASSP in 2008-12 (McIver et al. 2015). Although egg laying was not detected in the artificial modules in 2014, one artificial nest chamber was visited by a storm-petrel in 2014, and nocturnal images from a reconnaissance camera showed ASSP engaged in socializing activities (as described by L. Halpin in Appendix B of McIver et al. 2011) during the pre-breeding and

breeding (i.e., egg laying and chick-rearing) seasons (McIver et al. 2016a). As in 2014, reconnaissance cameras showed that ravens investigated artificial nest modules during the day, in 2015 including such behaviors as poking bills into the viewing/PIT-tag wand holes of modules deployed in the upper caverns at OR (see Figure D-6 in Appendix D). As in 2014, we found no evidence that ravens were able to move the modules, and the modules were intact by season's end in 2015. However, while we found no evidence that CORA were able to harm ASSP by sticking bills into the viewing holes of the modules, it is evident from the reconnaissance camera images that individual ravens were able to insert a substantial portion of their bills into these viewing holes. In addition, it would appear from the images that a CORA pair worked in tandem inspecting the modules with their bills, each bird exhibiting the same foraging behavior together. Thus, while the heavier nest modules cannot be moved or opened by CORA, ASSP contents (i.e., adult, chick or egg) within the nesting chambers and near the viewing holes may be vulnerable to harm by CORA, and future work may be necessary to evaluate and respond to this potential threat.

At BC, five artificial nest modules deployed in 2015 showed no evidence of use (i.e., egg laying) or visitation by ASSP. However, 2015 represented the first year of deployment of this small number of artificial nest modules at BC, vocalization broadcasting was not implemented, and a substantial amount of available nesting crevices occur in the main room at BC (in driftwood, among rock crevices, along cave walls), compared to 15 total nesting chambers offered by the artificial nest modules, in which ASSP might attempt to nest.

Breeding Success

Overall breeding success at SCZ in 2015 (49%, n = 144) was the second-lowest observed since 1996 (45%, n = 173), and was significantly lower than the long-term average for SCZ in 2005-15 (63%, n = 1269; see Appendix F) (McIver et al. 2009b, this study). The third lowest (53%, n = 158) and fourth lowest (54%, n = 124) breeding success values at SCZ occurred in 2013 and 1995, respectively (McIver et al. 2009b, this study). Low breeding success values in the 1990s coincided with high numbers of broken eggs, likely from organochlorine contaminants, and high levels of predation by Barn Owls (*Tyto alba*; BNOW); for the latter, especially at BC (McIver 2002, McIver et al. 2009b). Carter et al. (2008b) reported a reduction in the levels of organochlorine contaminants between 1992 and 2008, and McIver et al. (2009b) reported an increase in breeding success at SCZ between 1995-98 and 2005-07 (not including skunk predation at BC), likely the result of a decrease in impacts from organochlorine contaminants and decreased avian predation. The low breeding success values observed at SCZ in 2013 and 2015 are likely a result of avian predation (by CORA) on ASSP at BC and OR (discussed in detail in "Predation of ASSP at Santa Cruz Island" below).

Orizaba Rock

Thirty-six nests (32 in natural crevices and 4 in artificial sites) were found at OR in 2015, the fifth consecutive year in which ASSP egg laying was detected in more than 30 crevices per year at OR (Figure 8). For the period 2005-15, numbers of total nests per year at OR showed an increase of 16% per year (Figure 8). Some ASSP pairs using artificial nest sites in 2008-12 may have used natural crevices in 2013 and 2014, although we are uncertain of the identity of birds in nesting crevices at SCZ. Breeding success in all sites at OR in 2015 (44%, n = 36) was influenced primarily by low fledging success (70%, n = 23), similar to low fledging success in

2012-14 (range: 57-71%) (see McIver et al. 2014, 2015, 2016a; Appendix G), due to impacts and predation by CORA. Breeding success at OR has not exceeded 50% since 2012 (Appendices F & G).

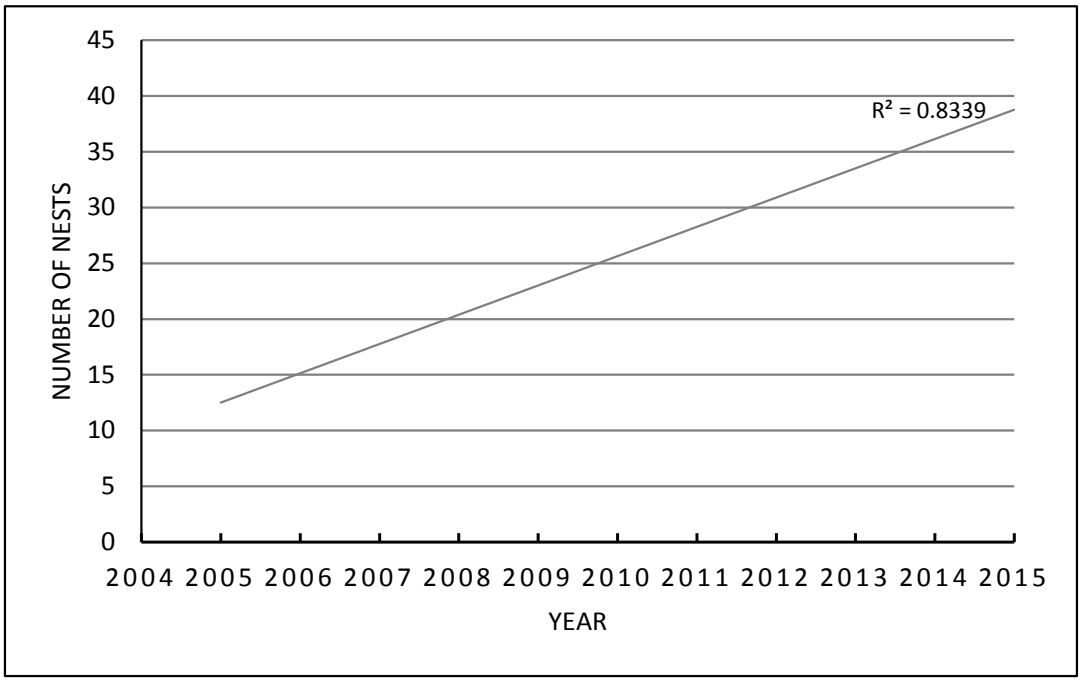

Figure 8. Numbers of total nests per year (with trendline and R^2 value) at Orizaba Rock, Santa Cruz Island, California, in 2005-15.

Bat Cave

Forty-four distinct feather piles, evidence of avian predation, were detected at BC in 2015, which was similar to numbers of feather piles detected in 2013 (n = 45) and more than in 2014 (n = 22 feather piles) (see McIver et al. 2015, 2016a). McIver et al. (2015) also found one BNOW pellet at BC in 2013, indicating possible predation by and at least presence of BNOW. Breeding success in 2015 (49%, n = 100) was similar to 2013 (52%, n = 93) (see McIver et al. 2015) and was lower than in 2014 (65%, n = 94) (see McIver et al. 2016a). Breeding success at BC in 2015 matched the previously lowest recorded breeding success value for this colony, which occurred in 1996 (49%, n = 88), a year of extensive predation of ASSP by BNOW (see McIver 2002, McIver et al. 2009b). Thus, avian predation, primarily by CORA and also likely including BNOW, has significantly affected ASSP breeding success in two of the past three years at BC. In 2015, two nests (sites #15C and #404) occurred in a side chamber from which eggs previously (in 1995-97) had been collected for contaminants analyses. In previous research (McIver 2002, McIver et al. 2009b), nests from this chamber were not included in analyses of breeding success, and between -year comparisons of numbers of nests and breeding success in a manuscript currently in preparation (McIver et al., in preparation; topic, predation at BC), will exclude nests found in this chamber in 2013-15, and which were included in respective annual reports for these years, to accurately compare numbers of nests between years.

Cave of the Birds' Eggs
In 2005-14, nesting activities at CBE were monitored regularly during each breeding season; compared to other colonies at SCZ, CBE has experienced fewer impacts from avian or mammalian predation. For these reasons, in previous annual reports for the MSTC and in McIver et al. (2016), CBE served as the best reference colony for comparisons to OR. However, in 2015, CBE was visited only on 25 August, and thus, breeding success values could not be obtained for 2015. Numbers of active nests at CBE on 25 August 2015 (n = 25 nests) were similar to numbers of nests observed at this colony during late summer in recent years.

Cavern Point Cove Caves
In 2015, numbers of active nests (n = 10) were the highest recorded for this colony since skunk predation in 2008, and breeding success (75%, n = 8) was the third-highest recorded value for this colony since monitoring began in 1995 (see McIver et al. 2009b, Appendix F). Prior to 2008, ASSP nested in two caves at CPC (Cave #4 and Cave #5), and from 2009 through 2014, nesting by ASSP at CPC occurred only in Cave #5. In 2015, however, one ASSP nest was found in Cave #4. Numbers of active nests in 2015 were lower than numbers observed in 1995-97 (range: 11-17 nests) and 2005 and 2007 (n = 13 nest in each year) (McIver et al. 2009b). The gradual increase in numbers of active nests at this colony since 2009 and the active nest found at Cave #4 in 2015 suggest that this colony is slowly recovering from the skunk predation event of 2008. In comparison to BC, the more gradual recovery at CPC suggests that, relative to colony sizes, a higher proportion of adult ASSP were killed by skunks at CPC than at BC.

Dry Sandy Beach Cave
DSB was visited only on 25 August, and thus, breeding success values could not be obtained for 2015. Numbers of active nests at DSB on 25 August 2015 (n = 22 nests) were similar to numbers of nests observed at this colony during late summer in recent years.

Predation of ASSP at Santa Cruz Island
Predation of ASSP at SCZ has been well-documented since regular nest monitoring efforts began there in 1995, especially in years of regular (i.e., numerous nest-check field trips per year) nest monitoring efforts (see McIver 2002; McIver et al. 2009b, 2016). Mammalian predators have included: (1) deer mice (*Peromyscus maniculatus santacruzae*), which have been reported as predators or scavengers of a few ASSP eggs in sea caves (specifically, BC, CPC and DSB) (McIver 2002); and (2) island spotted skunks, which killed at least 108 adult ASSP in distinct and major predation events at BC (76 adult ASSP killed in in 2005) and CPC (32 adult ASSP killed in 2008) (McIver and Carter 2006, McIver et al. 2009a). Mammalian predation has been documented at three sea cave colonies: BC (skunks, mice), CPC (skunks, mice) and DSB (mice), and has not been documented at CBE or OR. Known avian predators have included BNOW (probably, at all SCZ colonies) and CORA (confirmed at BC and OR, possible at other locations) (McIver 2002, McIver et al. 2016, this study). The Western Gull is a known predator of ASSP at Southeast Farallon Island (Ainley et al. 1990), storm-petrel remains were found in nests of Bald Eagle (*Haliaeetus leucocephalus*) at Santa Catalina Island (Newsome et al. 2015), and ASSP remains have been found in nests of Peregrine Falcon (*Falco peregrinus*) at San Miguel Island (P. Collins, unpublished data). Thus, we consider these latter three species as potential avian predators of ASSP at SCZ, although predation of ASSP by these species has not been documented at SCZ. McIver et al. (in prep) will evaluate in greater detail the topic of predation

of ASSP at SCZ from 1995 to the present; the remainder of this discussion in this report will focus upon recent avian predation of ASSP at SCZ, in context with a cursory examination of overall predation of the species at SCZ.

McIver (2002) reported that the BNOW was the primary avian predator of ASSP at SCZ in 1995-97, based upon: (1) the presence of feather remains and contents of 13 owl pellets at BC (*n* = 9) and OR (*n* = 4), 11 of which contained ASSP feathers and bones; (2) the documented use of two perches by BNOW at BC, based on presence of excrement, and pellets beneath; (3) a daytime observation of a BNOW roosting in BC; and (4) nighttime observations (during mist-netting) of BNOW at OR. Field notes in 2002 and 2004 also report BNOW pellets with storm-petrel remains at BC and OR, BNOW roost sites at BC, and a CAAU carcass (from notes: "…no head and chewed sternum…") at OR. During 2005-15, predation of ASSP by BNOW appeared to be much reduced at SCZ, particularly at BC (McIver et al. 2009, 2013, 2015, 2016a). A reduction in predation by BNOW at BC may have been related to the major skunk predation event there in 2005, and the significant reduction in numbers of ASSP at BC in that year, due to direct predation of adults and abandonment of nesting efforts by surviving adults. While we cannot discount that some feather piles found in BC in 2005 may have been due to predation by BNOW, the majority of feather piles and carcasses were likely the result of predation by island spotted skunks (McIver and Carter 2006). In 2006-11, no feather piles were found at BC, which suggests that BNOW may have switched to hunting elsewhere. Evidence of BNOW presence was noted at BC in April 2010, when a pellet was found, which contained ASSP bones (including two skulls) and feathers (McIver et al. 2011). Since no ASSP feather piles were found at BC in 2010 (McIver et al. 2011), BNOW may have hunted ASSP elsewhere at SCZ and utilized BC as a roost site, where the pellet was regurgitated. In 2012, two ASSP feather piles were found in October at BC (McIver et al. 2014), and significantly more ASSP feather piles were found in 2013 (*n* = 45), 2014 (*n* = 22) and 2015 (*n* = 44) (McIver et al. 2015, 2016a, this study). In 2013, one BNOW pellet was found in BC (McIver et al. 2015); however, based on the numerous images of CORA detected by reconnaissance cameras deployed at BC, we think that ravens were the primary predators of ASSP over the past 3 years. To summarize, in 1995-97, 75 ASSP were reported as killed as a result of avian predation, presumably BNOW (McIver 2002). In 2013-15, 111 ASSP were killed as a result of avian predation, primarily CORA.

ASSP arrive to and depart from nesting colonies at night, to avoid diurnal avian predators (Ainley 1995). BNOW hunt mostly at night, occasionally hunt diurnally, and most hunting is done by low flight above the ground in open habitats, while some hunting occurs from perches (Bunn et al. 1982, Lenton 1984, Marti 1992). At nesting colonies and at night, ASSP exhibit individual and pair-bonding behaviors (e.g., pecking, searching, entering nests and fighting; see Appendix A [Halpin (2010)] in McIver et al. 2011) outside of nest sites that keep them in the open and likely increase their vulnerability to predation by BNOW. After an egg is laid during the season, most of these socializing behaviors cease. The two individuals of a nesting pair alternate and share in egg incubation and chick-brooding duties, and one parent will attend a nest while its mate is at sea (James-Veitch 1970). While attending the colony during the day, an ASSP adult remains at a nest site (usually, in a crevice, but sometimes at the edge of a cave wall) and generally remains silent, although some vocalization occurs (W. McIver, personal observation). ASSP that are established breeders and engage in fewer nocturnal socializing behaviors above ground are likely less vulnerable to predation by BNOW. It stands to reason that

BNOW predation could impact younger, prospecting ASSP that spend more time above ground engaging in socialization behaviors, and older birds exhibiting socializing behaviors earlier in the breeding season.

McIver (2002) reported that 77% of ASSP nests at SCZ occurred in crevices in which the depth of the nest (distance from nest entrance to egg or bird) was shallower than 30 cm. He did not report values of nest depth by colony, but this habitat characterization is likely similar in the main room of BC, where nests occur in relatively shallow crevices among rock, driftwood and along cave walls (W. McIver, personal observation). In 2013-15, reconnaissance cameras at BC detected multiple CORA (as many as three birds in a set of images) actively patrolling the driftwood pile where many ASSP nests occur (McIver et al. 2015, 2016a, this study). In 2015, a CORA pair at OR was observed (by reconnaissance camera) to work in tandem and inspect the modules with their bills, each bird exhibiting the same foraging behavior. These behaviors are suggestive of cooperative hunting, which was reported in Brown-necked Raven (*C. rufficollis*) (Yosef and Yosef 2010). MacKinnon (1988) reported that American Crows (*C. brachyrhynchos*) and CORA were the major predator of adults and the second greatest cause of chick mortality for Leach's Storm-Petrel on Bon Portage Island, Nova Scotia. Corvids were frequently observed walking throughout the storm-petrel colony, and he thought that these corvids located storm-petrel chicks by cueing into their vocalizations in nesting burrows, and that they excavated burrows to find adults and chicks. ASSP nesting in shallow and accessible nest sites at BC and OR are defenseless against a diurnal predator as large, intelligent and persistent as a raven. In addition, ASSP adults, chicks and eggs are all vulnerable to predation by CORA, in contrast to BNOW, which preys only on birds (adults or mobile chicks) found outside of nests at night. Thus, a greater proportion of ASSP at BC and OR are likely vulnerable to predation by CORA than to predation by BNOW. If it continues, CORA predation may have the effect, over time, of significantly reducing the number of breeding birds at BC and/or OR, and selecting for ASSP pairs that nest in deeper crevices or in artificial nest modules.

In a review of field notes prior to 2005 (W. McIver and H. Carter, *unpublished notes*), we found the following references to CORA: (1) one CORA feather was found in BC on 19 August 1997, and (2) CORA footprints in sand and CORA feathers “throughout cave” in DSB on 18 August 2002. McIver (2002) also reported one CORA inside CBE during a nest check in 1997, and attributed the death of one PIGU chick to predation by CORA, based upon the disposition of the carcass (i.e., dragged from a nest site) and presence of peck marks in the carcass. While McIver (2002) did not discount the possibility of predation of ASSP by CORA, he considered the presence of CORA in sea caves to be an uncommon occurrence. McIver (2002) may have attributed some predation events to BNOW that were CORA-caused. In 1999-2004, nest monitoring field trips to SCZ occurred only once per year and were opportunistic, in that field trips were conducted as resources and logistical support allowed; as such, there were no reporting requirements for information derived from these trips, and hence no detailed evaluation, at the time, of factors (including predation) affecting ASSP at SCZ. However, we consider that the assertion in McIver (2002) that BNOW was the primary avian predator at SCZ is accurate, even through 2004, because, despite evidence of CORA in caves in 1997 and 2002, there are more BNOW-related observations (i.e., pellets, roosts) than CORA-related observations during the same time period, and no detections of CORA pellets at ASSP breeding colonies, as reported at BC and OR in 2013-15 (McIver et al. 2015, 2016a, this study). A review of predation

events by late summer in 1995-2015 (Figure 9) shows that avian predation by CORA in 2013-15 (*n* = 81 predation events by late summer) was greater than avian predation observed in any other consecutive 3-year period (e.g., 1995-97: *n* = 63 late summer predation events).

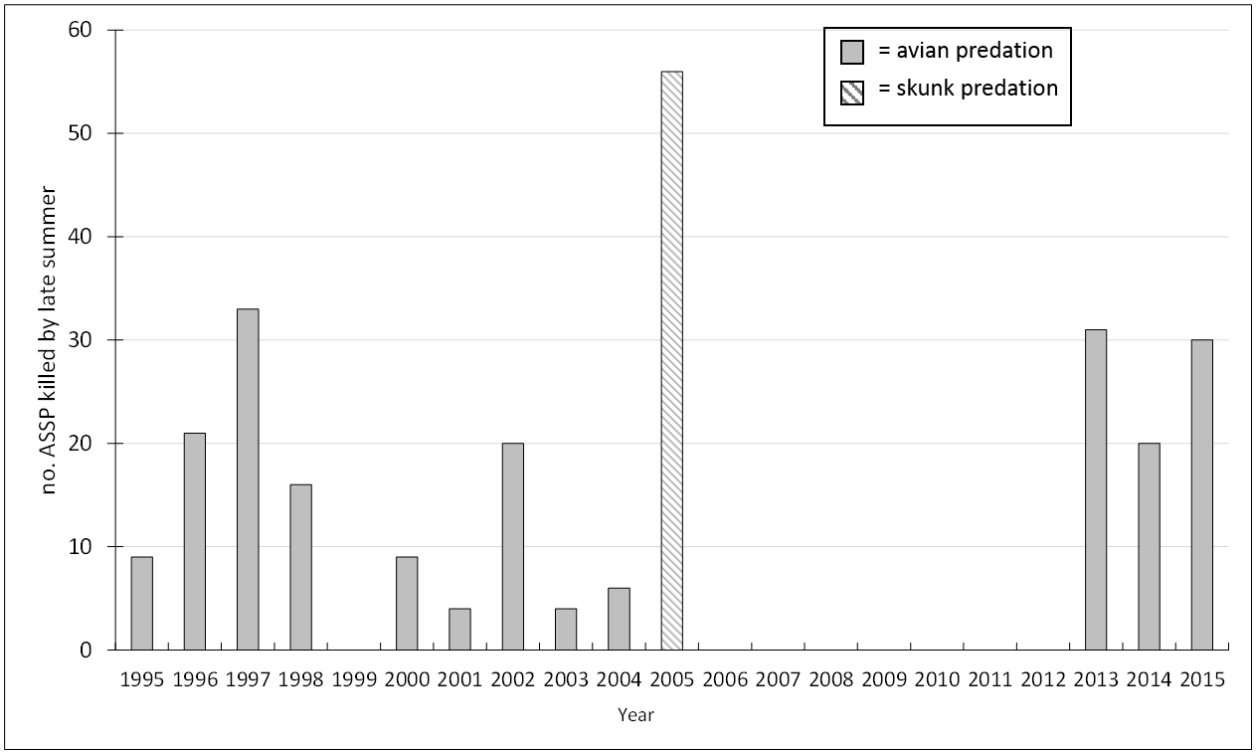

Figure 9. Numbers of Ashy Storm-Petrels killed by late summer at Bat Cave, Santa Cruz Island, California, 1995-2015, based on detected feather remains and carcasses.

Since 1849 (year of California statehood), human activities at Santa Cruz Island have varied, but for much of this time period (ca. 1850-1980) human activities on the island consisted primarily of ranching (sheep, cattle, pigs), and to a smaller degree, agriculture (e.g., wine, olives) (Gherini 1997). 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 SCZ 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. In addition, since the 2000s, Prisoner's Harbor, which is located on the north-central portion of the island, has become a popular destination for tourists.

CORA is a generalist omnivore that eats live meat, eggs, insects, grains, fruit, garbage, and carrion (Boarman and Heinrich 1999); all of these foods are available to CORA at SCZ to varying degrees. Blake (1887) described ravens as common breeders at SCZ. 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). CORA are omnivorous, highly intelligent and can quickly adapt to the presence of humans (Liebezeit

and George 2003). Marzluff and Neatherlin (2006) hypothesized 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). CORA are frequently observed in coastal habitats at SCZ, and individuals can specialize in feeding behaviors (Marzluff and Angell 2005). Considered together, many of these factors may have contributed to increased predation upon ASSP at BC in 2013-15 and at OR in 2014-15 (McIver et al. 2015, 2016a, this study).

Vermeer et al. (1993) suggested that predation of PIGU by Northwestern Crows (*C. caurinus*) may have been related to crows following researchers. At SCZ, researchers visited ASSP breeding locations monthly in 1995-97 and 2005-12 without noting much raven occurrence (exception, on raven CBE in 1997 [McIver 2002]), although some predation events assigned to BNOW may have been raven-related. McIver et al. (in preparation) thinks that lack of detection of ravens during these time periods also may have reflected: (1) a process of learning (e.g., including investigation of vocalization broadcasting and watching researchers entering and departing from caverns at OR and at BC), and (2) raven avoidance of OR and BC during nest-check visits but regular occurrence at these locations between nest-check visits. While we cannot discount the possibility that ravens may have cued into researchers visiting OR and BC, we think also that the presence of large numbers of tourists at SCZ, particularly along the east end of the island, warrants further consideration. Further study at SCZ regarding the presence of ravens, use of stable food sources (e.g., figs, olives) and interactions between humans and ravens may help in identifying factors that may contribute to increased presence of ravens at BC and OR.

Pigeon Guillemots at CBE

The number of PIGU nests found on 25 August 2015 (n = 10) was comparable to numbers of nests found in 2006-09 and 2011-2013 (range: 7-14 nests) but less than number found in 2010 (n = 21). To date, numbers of breeding PIGU at CBE recorded in 2005-14 do not appear to have directly affected ASSP.

Cassin's Auklets at OR

Three nest sites of CAAU were found at OR in 2015, compared to 2014 (8 nests), 2013 (7 nests), 2012 (4 nests), 2011 (2 nests) and 2010 (5 nests). Auklets at OR did not appear to directly affect ASSP. Ainley et al. (1990) found that interference by CAAU at nest sites reduced reproductive success of storm-petrels. As observed in previous years, at least one site (site #49) was also used by ASSP. Continued availability of protective artificial habitat for ASSP could reduce interspecific competition at natural crevices at OR.

Scripps's Murrelet at OR and BC

In contrast to 2013 and 2014, SCMU were not found nesting at OR in 2015, although nesting may have occurred and gone undetected prior to our first regular nest-monitoring trip to OR on 19 June. Nocturnal at-sea vocalization surveys in 1996 detected the species on the water near OR (Whitworth and Carter, unpublished notes), and a SCMU nest (contents: 1 egg + eggshell fragments) was found at OR on 19 July 2000 (W. McIver & H. Carter, *unpubl. notes*). In

addition, SCMU nest from February-July (Drost and Lewis 1995, Whitworth et al. 2009), so it is likely that the species has nested previously at OR and gone undetected by researchers looking for ASSP, which nest later in the season. At BC, one nest of Scripps's Murrelet (#1106) was detected in 2015, similar to previous years; this crevice was also used by ASSP in 2015.

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 are vulnerable to being crushed or disturbed by unaware human visitors at or near nest sites. In contrast to recent years, human visitation was not detected at OR in the sea caves in 2015.

Monitoring and Restoration Recommendations for 2016 and After

We recommend that nest monitoring should be continued for ASSP at OR and SCZ sea caves in 2016 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 different materials (e.g., wood-concrete; as in Bedolla-Guzmán (2016) or different artificial nest designs might be appropriate at SCZ, during future considerations of deployment of artificial nest modules.
- to assess whether vocalization broadcasting should be re-initiated at OR;
- to continue long-term nest monitoring at SCZ, as has been identified as a priority research need for the specie in the "Draft Conservation Plan for Ashy Storm-Petrels" (Parker, in preparation);
- to assess and address the impacts that ravens might be having upon breeding success of ASSP 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 SCZ, and possible impacts upon ASSP in 2016 and after, we recommend:

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

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

- an evaluation of raven responses to human presence at SCZ, 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 2006-15.

Year	Research Entities	Actions	Annual Report(s)
2006-07	CBC; USFWS-VFWO, -AFWO; CINP	(a) Pre-restoration baseline monitoring for ASSP at five locations at SCZ; 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 ASSP at SCZ; (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 ASSP 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 ASSP nocturnal behaviors in relation to vocalization broadcasting; (c) evaluated future recruitment and visitation of ASSP 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)

Appendix A. (continued)

Year	Participating Entities	Actions	Annual Report(s)
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)
2013	CIES, CINP, USFWS-AFWO, CBC, OEK, RG	Continue the monitoring activities as conducted in 2006-12. Discuss needed modifications to artificial nesting structures and evaluate various prototypes for the eventual manufacture and deployment of more durable ceramic artificial nesting structures for use by ASSP, to prevent raven impacts.	McIver et al. (2015)
2014	CIES, CINP, USFWS-AFWO, CBC, OEK, RG	Continue the monitoring activities as conducted in 2006-13. Manufacture and deploy (at Orizaba Rock) newly-designed artificial nesting structures.	McIver et al. (2016a)
2015	CIES, CINP, USFWS-AFWO, CBC	Continue the monitoring activities as conducted in 2006-14, and evaluate use of artificial nesting modules at Orizaba Rock.	McIver et al. (2016b [i.e., this report])

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 USA; CINP = Channel Islands National Park, Ventura, California USA; Oikonos Ecosystems Knowledge, Benicia, California USA; RG = Rebar Group, San Francisco, California USA; SFU = Simon Fraser University, Burnaby, British Columbia Canada; VFWO = Ventura Fish and Wildlife Office, Ventura, California USA; USFWS = U.S. Fish and Wildlife Service.

Appendix B. Images related to re-designed artificial nest modules deployed at Bat Cave, Santa Cruz Island, California, in 2015.

Figure B-1. Articial nest module ("Palm Springs" or "breadloaf" design) designed and manufactured by Oikonos Ecosystems Knowledge, MoreLab and California College of the Arts, for deployment at Bat Cave in 2015. Each module contains: 3 nesting chambers (not seen here but see Figure B-2); three nest entrances (shown in photo); and 6 pairs of holes (2 holes per chamber; not shown in photo, opposite side of module) for viewing nest contents and inserting a PIT-tag wand. Photo credit: Oikonos Ecosystems Knowledge.

Appendix B. (continued)

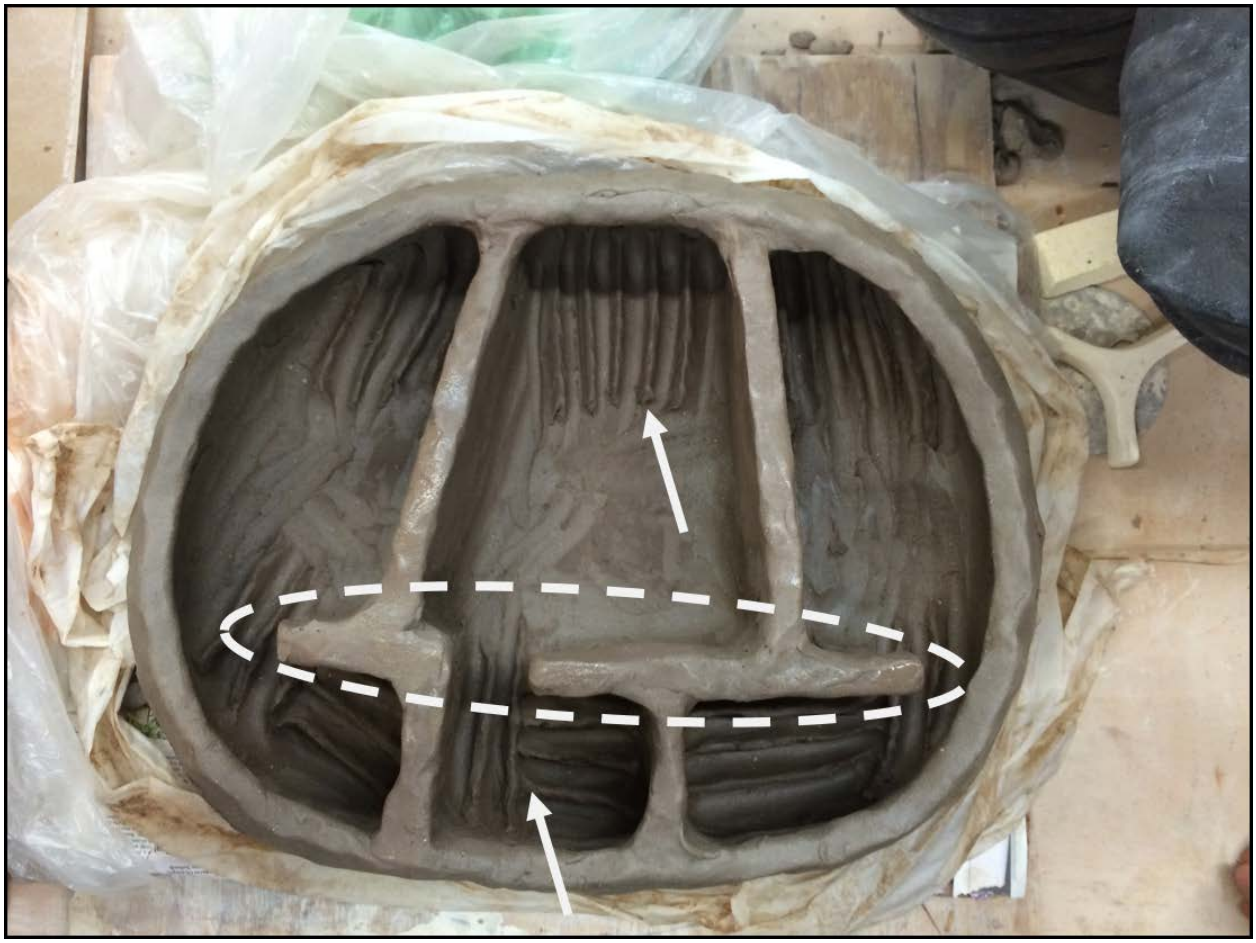

Figure B-2. View of inside features of an artificial nest module deployed at Bat Cave in 2015. Notable interior features include: 3 separate nesting chambers; grooves (see arrows) within the floors to prevent egg laying by storm-petrel at locations within the chambers near entrances or viewing holes; and interior walls that block access to nesting chamber by raven bills (see dashed oval). This image was taken during construction of the module, prior to construction of the roof of the module. Photo credit: Oikonos Ecosystems Knowledge.

Appendix B. (continued)

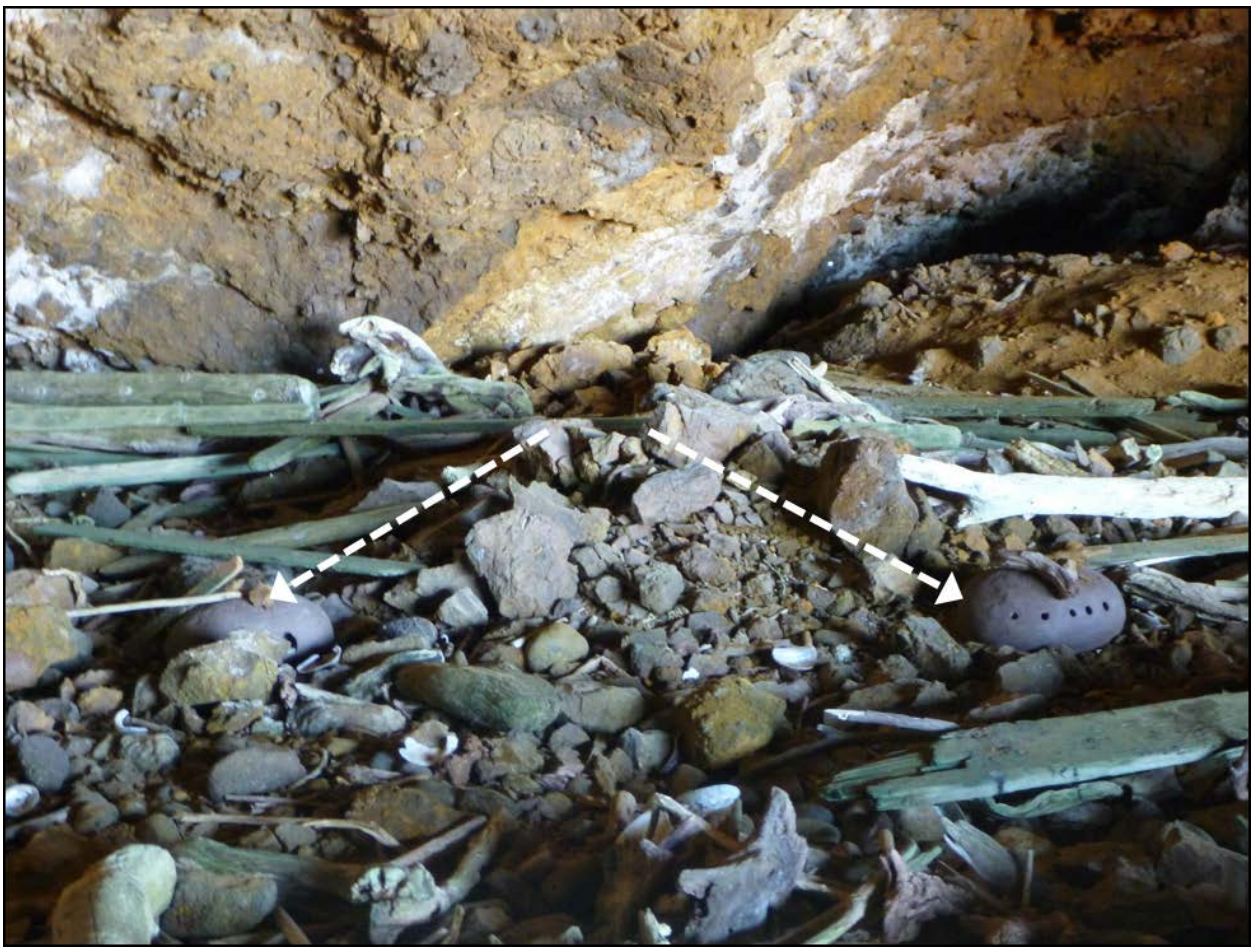

Figure B-3. View of two of five artificial nest modules (shown by dashed arrows) deployed in main room at Bat Cave, Santa Cruz Island, California, on 6 March 2015. Photo credit: D. Mazurkiewicz.

Appendix C. Reconnaissance camera observations of Common Ravens at Orizaba Rock (OR), Santa Cruz Island, California, in 2014-15[2].

Date	Time	Camera	Photo nos.	No. birds	Observations
11/22/2014	12:54	OR #1	26-45	2	both CORA perching on and around AB
11/22/2014	10:58	OR #2	11-15	1	unknown bird head appears on bottom of screen
11/29/2014	15:02	OR #2	16-20	1	walks across bottom of screen
12/06/2014	12:59	OR #1	46-80	2	both CORA investigating area and perching on and around AB
12/6/2014	12:58	OR #2	26-35	2	one walks across screen, other appears in top R corner
12/07/2014	12:29	OR #1	81-90	1	perches on AB
12/08/2014	12:45	OR #1	91-100	1	investigates area
12/8/2014	12:46	OR #2	36-40	1	stands in front of camera
12/12/2014	11:51	OR #1	101-170	2	investigates area
12/12/2014	13:51	OR #1	171-205	1	investigates area
12/12/2014	11:51	OR #2	46-48	1	stands in bottom R corner of screen, moves off screen
12/12/2014	12:07	OR #2	51-55	1	head appears at bottom L of screen
12/13/2014	09:42	OR #1	206-210	1	investigates area
12/13/2014	09:43	OR #2	61-65	1	walks across bottom of screen
12/15/2014	13:03	OR #1	211-255	1	investigates area
12/15/2014	13:02	OR #2	66-70	1	unknown bird appears at bottom L of screen (likely cora)
12/17/2014	11:56	OR #1	256-260	1	investigates area
12/21/2014	13:25	OR #1	261-265	1	investigates area
1/01/2015	12:19	OR #1	266-420	1	initially investigates area, then spends the rest of the time standing on top of AB
1/1/2015	12:24	OR #2	81-90	1	stands in middle of screen, looks at camera, walks toward camera
1/08/2015	21:50	OR #1	421-460	1	421-447 hard to tell what is there, very close to camera. 447-460 cora stands on AB, then flies to left.
1/14/2015	12:27	OR #2	191-195	1	tail appears at bottom L of screen
1/20/2015	12:56	OR #1	471-565	2	investigates area
1/20/2015	13:06	OR #2	291-302, 306-315	1	investigates at bottom L of screen, walks across screen and off screen to R, reappears on bottom L of screen

Date	Time	Camera	Photo nos.	No. birds	Observations
1/21/2015	15:21	OR #1	566-580	1	investigates area
1/24/2015	14:50	OR #1	581-795	2	predation event at 15:02, assp caught in ravens mouth (pic 0591). 2nd bird appears 15:06. 1st bird pellet at 15:08. both investigate area until 15:23.
1/24/2015	14:49	OR #2	316, 321-356, 361-365	1	tail appears at bottom L of screen, reappears at bottom of screen and walks across screen and investigates
1/25/2015	12:25	OR #1	796-820	1	investigates area
1/26/2015	11:13	OR #1	821-865	2	2nd bird at 11:17. both investigate area, including the AB.
1/26/2015	11:19	OR #2	371-377	1	stands near L of screen and investigates, walks across screen
1/30/2015	12:45	OR #1	876-910	1	investigates area
2/01/2015	14:14	OR #1	916-1155	1	stands on AB, occasionally preening, briefly investigates nearby as it walks off to left.
2/1/2015	14:13	OR #2	441-455	1	investigates around bottom of screen, walks across screen
2/02/2015	14:06	OR #1	1156-1265	2	2nd bird at 14:14. both cora investigate area
2/2/2015	14:11	OR #2	456-475	1	investigates and moves around bottom and L of screen
2/06/2015	15:16	OR #1	1271-1565	1	stands on AB, occasionally preening, briefly investigates nearby
2/6/2015	12:30	OR #2	551-560	1	investigates and moves around bottom of screen
2/6/2015	15:16	OR #2	561-567	1	walks across bottom of screen and moves L off screen
2/6/2015	15:29	OR #2	571	1	walks off screen to R
2/08/2015	12:27	OR #1	1586-1625	2	investigates area
2/09/2015	10:38	OR #1	1626-1655	1	stands on AB, preens
2/09/2015	16:28	OR #1	1656-1705	1	investigates area
2/9/2015	16:29	OR #2	816-826, 831-870	1	moves off screen, reappears on L of screen, stands, moves R across screen, reappears in front of camera, moves across screen
2/10/2015	11:46	OR #1	1711-1720	1	investigates area
2/10/2015	13:30	OR #1	1721-1750	1	investigates area
2/10/2015	13:31	OR #2	871-890	1	moves across bottom of screen, investigates, preens, stands in front of camera
2/11/2015	11:44	OR #1	1761-1930	2	2nd bird at 11:51. both investigate area, 2nd cora gone after 11:55. first bird stays until 12:05
2/11/2015	11:58	OR #2	911-924	1	investigates at lower L corner, stands in front of camera, moves L off screen

Date	Time	Camera	Photo nos.	No. birds	Observations
2/13/2015	15:08	OR #1	1941-1980	2	investigate area, short squabble
2/13/2015	15:13	OR #2	1036-1061	1	investigates on L side of screen, stands in front of camera, investigates in middle of screen, moves L off screen
2/15/2015	11:50	OR #1	1986-2010	1	investigates area, flies to left
2/18/2015	13:05	OR #1	2011-2186	2	standing on ABS, one bird leaves , then 2nd bird preens on AB. Both leave view 13:11, one back at 13:53.
2/18/2015	13:05	OR #2	1211-1213, 1216-1218, 1221-1230	1	tail appears at bottom L of screen, bird reappears at top L corner and moves off screen, bird reappears center screen and walks towards bottom of screen
2/19/2015	13:03	OR #2	1241-1245	1	tail visible in lower L corner
2/22/2015	11:02	OR #1	2193-2210	1	investigates area
2/22/2015	11:03	OR #2	1316-1330	1	perching in lower L corner
2/23/2015	13:38	OR #1	2211-2230	1	investigates area
2/23/2015	13:39	OR #2	1341-1355	1	perching in front of camera
2/24/2015	10:16	OR #1	2231-2240	2	investigate area
2/24/2015	12:26	OR #1	2241-2275	1	investigates area
2/24/2015	15:32	OR #1	2276-2280	1	walks across, exits to right
2/24/2015	10:16	OR #2	1356-1360	1	walks off screen to R
2/25/2015	12:21	OR #1	2286-2305	1	investigates area
2/25/2015	14:52	OR #1	2306-2350	2	investigate area, 2nd bird seems to go behind rock outcropping
2/25/2015	12:22	OR #2	1361-1365	1	appears in lower L corner, then walks to center bottom of screen
2/27/2015	13:29	OR #1	2356-2365	1	investigates area
2/28/2015	15:14	OR #1	2366-2370	1	investigates area
2/28/2015	15:15	OR #2	1396-1410	1	perching on L side of screen, moves to middle, then off screen to L
3/02/2015	08:17	OR #2	1411-1440	1	walks across to L twice, then investigates the camera
3/03/2015	11:53	OR #1	2376-2455	2	investigate area and perch on AB
3/03/2015	11:26	OR #2	1441-1460	1	Walks L, perches and calls in lower R of screen, then walks across field of view to L
3/04/2015	13:22	OR #1	2456-2490	2	investigate area
3/05/2015	12:07	OR #2	1461-1465	1	tail in lower L corner

Date	Time	Camera	Photo nos.	No. birds	Observations
3/06/2015	11:37	OR #1	2491-2755	1	perches on AB, then investigates area around ABs. leaves to right at 11:54
3/09/2015	11:17	OR #1	2761-3125	2	preening and allopreening, perching on ABs until 14:20
3/10/2015	14:13	OR #1	3126-3140	1	walks across area to right
3/10/2015	14:12	OR #2	1606-1610	1	walks across field of view to L
3/12/2015	14:05	OR #1	3151-3230	2	allopreening and perch on AB
3/12/2015	14:00	OR #2	1646-1705	1	from lower L corner, walks R, then investigates camera
3/13/2015	15:23	OR #2	1731-1735	1	center of screen, calling.
3/14/2015	11:38	OR #1	3231-3365	2	investigating area until 1156-return at 1305.
3/14/2015	11:56	OR #2	1746-1765, 1766-1770	1	walks across field of view to R twice, leaves for an hour, then tail visible in lower L corner
3/17/2015	13:51	OR #1	3366-3375	1	walking to left
3/17/2015	13:52	OR #2	1866-1870	1	perched lower L corner
3/18/2015	13:17	OR #1	3376-3410	2	investigating area
3/18/2015	13:21	OR #2	1906-1915	2	cross field of view to R
3/19/2015	12:56	OR #1	3411-3480	1	unidentified prey item at 1256
3/20/2015	15:29	OR #1	3481-3490	1	walking to left
3/21/2015	11:33	OR #1	3491-3495	1	perched on AB
3/21/2015	15:25	OR #1	3496-3525	2	investigate area
3/21/2015	15:24	OR #2	1991-1995	1	perched in front of camera
3/22/2015	13:12	OR #1	3526-3535	1	investigating area, perched on ab
3/25/2015	10:38	OR #1	3536-3555	1	investigating area, leaved for ~1hr, returns to AB perch.
3/25/2015	11:54	OR #2	2431-2436	1	perched in lower L corner
3/27/2015	10:19	OR #1	3556-3585	1	investigates area
3/27/2015	17:16	OR #1	3586-3600	1	investigates area
3/27/2015	17:19	OR #2	2961-2970	2	two birds on L side of screen, one perches in front of camera, one moves off screen to L
3/28/2015	16:23	OR #1	3601-3610	1	walks left across ABs
3/28/2015	16:23	OR #2	3001-3015	1	moves from lower left of screen across bottom, does not look to be actively foraging
3/29/2015	14:52	OR #2	3021-3025	1	bill visible in lower L

Date	Time	Camera	Photo nos.	No. birds	Observations
3/31/2015	11:57	OR #1	3616-3625	1	investigates area
4/01/2015	09:43	OR #1	3626-3640	1	investigates area, walks to camera
4/01/2015	09:42	OR #2	3091-3095	1	walks from lower R to center of view
4/04/2015	14:17	OR #1	3641-3650	1	investigates area, walks to camera
4/04/2015	14:17	OR #2	3106-3110	2	walk from lower R to center of view
4/05/2015	09:14	OR #1	3651-3660	2	perch on ABs, investigate briefly
4/10/2015	14:37	OR #2	3216-3220	1-2	barely visible at edge of screen, could be two birds, but cannot tell for certain
4/12/2015	15:57	OR #1	3661-3665	1	perch to left of ABs
4/12/2015	15:59	OR #2	3376-3380	1	perched in front of camera
4/14/2015	07:19	OR #1	3676-3685	1	investigates area
4/16/2015	13:17	OR #1	3691-3695	1	walks to left
4/17/2015	18:03	OR #1	3696-3700	1	investigates area behind ABs
4/23/2015	13:56	OR #1	3711-3725	1	investigates area behind ABs
4/23/2015	17:10	OR #1	3726-3730	1	investigates area behind ABs
4/23/2015	13:56	OR #2	3941-3945	1	walks across to L
4/26/2015	17:42	OR #1	3731-3740	1	investigates ABs
4/29/2015	14:38	OR #1	3741-3750	1	investigates ABs
4/30/2015	16:19	OR #1	3751-3765	1	presumably cora, blurry camera from dirty lens
4/30/2015	16:19	OR #2	4131-4135	1	takes flight from center of screen to R
5/02/2015	15:42	OR #1	3771-3780	1	poss two, but cant tell from blurry pictures. Bird (s) exit to right.
5/02/2015	15:42	OR #2	4216	1	possible cora trips camera, only black blur visible barely on left side of view. Cannot verify species.
5/04/2015	08:23	OR #1	3781-3785	1	walks across ABs
5/04/2015	08:35	OR #2	4301-4305	1	leaves to L of screen
5/05/2015	09:06	OR #1	3786-3790	1	walks across ABs
5/07/2015	14:49	OR #1	3791-3795	1	takes off from close left of camera
5/08/2015	15:34	OR #1	3796-3800	1	walks across ABs
5/08/2015	15:33	OR #2	4571-4580	1	walks across to L, then back toward camera from middle L of field of view
5/09/2015	18:10	OR #1	3801-3805	1	walks across ABs

Date	Time	Camera	Photo nos.	No. birds	Observations
5/09/2015	18:10	OR #2	4771	1	cora shaped blur, but cannot ID for sure. Only one frame.
5/10/2015	12:33	OR #1	3806-3815	1	walks across ABs
5/10/2015	17:26	OR #1	3816-3820	1	perched on AB
5/10/2015	12:33	OR #2	4876-4880	1	tail just visible on L side of screen
5/13/2015	10:40	OR #1	2826-3835	1	investigates AB, then flies to L
5/14/2015	08:42	OR #1	3836-3860	1	investigates ABs, and walks around in circle
5/14/2015	18:15	OR #1	3861-3880	1	investigates AB, then flies to L
5/14/2015	08:47	OR #2	5166-5175	1	investigates camera
5/15/2015	06:52	OR #1	3881-3905	1	investigates ABs
5/17/2015	11:35	OR #2	5221-5225	1	tail visible in lower L corner
5/18/2015	17:07	OR #1	3906-3925	1	investigates ABs
5/18/2015	17:09	OR #2	5276-5280, 5281-5285	1	investigates area in lower L, then leaves, returns 1744 investigates camera
5/19/2015	17:34	OR #1	3926-3935	1	investigates ABs
5/21/2015	15:13	OR #1	3946-50	2	investigates ABs
5/21/2015	15:12	OR #2	5371-5375	2	walk off to L
5/24/2015	14:57	OR #2	5446-5450	1	investigates lower L corner
5/24/2015	16:29	OR #2	5451-5455	1	investigates lower L corner
5/27/2015	10:24	OR #2	5456-5460	1	leaves to L of screen
5/28/2015	11:53	OR #2	5466-5475	1	leaves to L of screen, then walks back across to R
5/30/2015	15:44	OR #2	5486-5490	1	walks R across screen
6/03/2015	13:03	OR #2	5491-5495	1	leaves to L of screen
6/05/2015	12:53	OR #2	5501-5515	1	walks L, then from center to camera, reappears at center for one frame, then gone
6/08/2015	17:25	OR #2	5516-5520	1	walks across bottom to R
7/26/2015	14:33	OR #3	41-45	1	appears on L side of screen, below ABS, perches
7/27/2015	11:03	OR #3	46-55	1	appears in foreground to R, moves off screen. Reappears on L side. Peers into AB
7/28/2015	11:49	OR #3	56-70	1	moves from lower right to ledge, perches, looks at AB, then gone
7/29/2015	14:47	OR #3	71-80	1	at ledge ABS to R, perches then gone
8/03/2015	12:10	OR #3	81-85	1	barely visible at edge of screen

Date	Time	Camera	Photo nos.	No. birds	Observations
8/09/2015	09:51	OR #3	86-90	1	investigates ABs
8/14/2015	12:17	OR #3	91-95	1	investigates ABs
8/26/2015	14:09	OR #1	21-50	2	one cora investigating area, joined briefly by second. Both appear to be adults
8/27/2015	11:08	OR #1	51-70	1	investigates area
8/27/2015	14:18	OR #1	71-130	1	One investigate area over one hour
8/27/2015	16:12	OR #3	76-80	1	tail just visible on R side of screen
8/28/2015	11:54	OR #1	131-320	2	both investigate area for 45 minutes
8/28/2015	15:35	OR #1	321-335	1	investigates area
8/29/2015	09:20	OR #1	336-345	1	investigates area
8/29/2015	14:48	OR #1	346-395	1	investigates area
8/31/2015	13:51	OR #1	396-585	2	Cora1 investigates area for 1 hour, Cora2 only visible for 4 pics early on.
9/01/2015	11:46	OR #1	586-595	1	investigates area
9/02/2015	11:46	OR #1	596-635	1	investigates area
9/03/2015	12:13	OR #1	636-680	1	investigates area
9/05/2015	14:23	OR #1	681-690	1	investigates area
9/09/2015	09:44	OR #1	691-825	2	both investigate area for 6 minutes, lots of preening and standing
9/09/2015	15:07	OR #1	826-870	1	investigates area
9/10/2015	14:43	OR #1	871-885	1	investigates area
9/11/2015	12:21	OR #1	886-995	1	pellet 0907, picks at pellet for 4 minutes
9/11/2015	13:24	OR #1	996-1010	1	perches on AB with pellet
9/12/2015	11:19	OR #1	1011-1025	1	investigates area
9/14/2015	12:01	OR #1	1026-1035	1	investigates area
9/14/2015	14:08	OR #1	1036-1055	1	investigates area
9/15/2015	11:58	OR #1	1056-1065	1	investigates area
9/16/2015	12:22	OR #1	1066-1070	1	stands on AB
9/17/2015	15:20	OR #3	281-285	1	investigates #1A viewing hole
9/27/2015	15:46	OR #1	6-40	1	bill in AB 0025, looks into view hole C, investigates area
10/02/2015	15:12	OR #1	41-65	1	CORA investigates AB
10/06/2015	13:39	OR #3	291-295	1	perches in front of AB #8

Date	Time	Camera	Photo nos.	No. birds	Observations
10/11/2015	13:05	OR #1	66-115	1	CORA investigates AB
10/21/2015	13:44	OR #1	16-25	2	CORA investigates AB
10/22/2015	16:09	OR #1	26-30	1	CORA investigates AB
11/06/2015	13:40	OR #1	31-70	2	CORA investigate AB, both looking into holes and reaching in with bills

Footnotes –

[1] For BC, observations in table are only on dates where CORA were also observed at OR; observations in italics occurred within 1 hour of an OR observation.

[2] Camera locations and dates of deployment described in Table 2 on page 8.

[3] OR: UEC = "Upper East Cavern, UWC = "Upper West Cavern."

[4] ASSP = Ashy Storm-Petrel, CORA = Common Raven, SDC = small downy chick, SGC = small gawky chick.

Appendix D. Images captured from reconnaissance cameras deployed at Bat Cave and Orizaba Rock, Santa Cruz Island, California, in 2015.

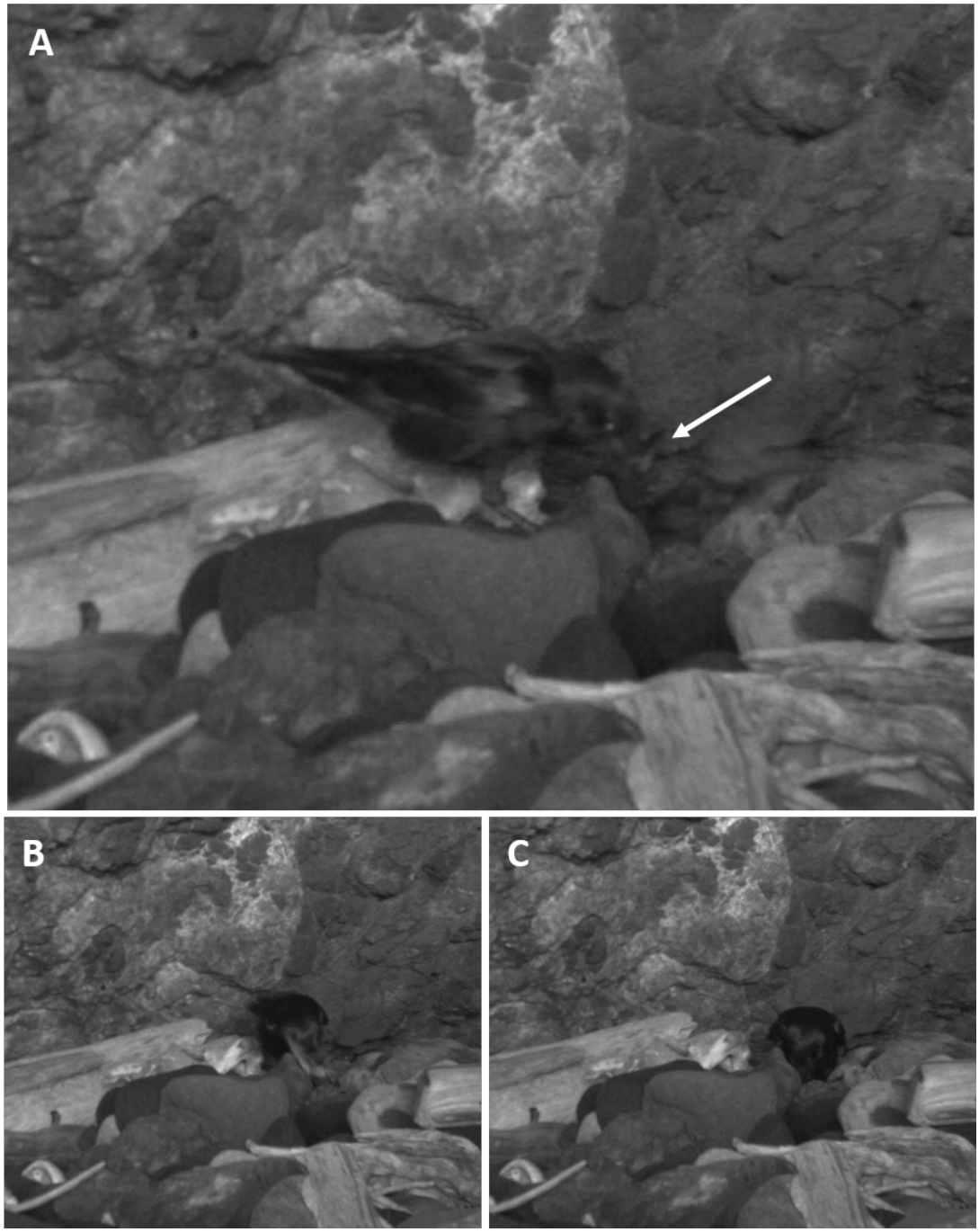

Figure D-1. Common Raven with Ashy Storm-Petrel adult or chick (see arrow in image "A"; time 15:26:41) likely pulled from a nest site at the edge of the main room of the cave, Bat Cave, Santa Cruz Island, California, 23 June 2015. Images "B" (15:26:43) and "C" (15:26:44) show the raven with its back to camera either investigating a crevice after a possible escape by the storm-petrel, or the raven plucking or eating captured storm-petrel. Storm-petrel feathers were not found at this location on the subsequent nest-monitoring field trip. Images in this figure were cropped and enlarged from original images.

Appendix D (continued).

Figure D-2. Common Raven with Ashy Storm-Petrel adult in bill (see arrow), Bat Cave, 1 July 2015.

Figure D-3. Common Raven with Ashy Storm-Petrel egg in bill (see arrow), Bat Cave, 9 August 2015. Image was corrected to increase brightness/contrast.

Appendix D (continued).

Figure D-4. Common Raven with Ashy Storm-Petrel in bill, 24 January 2015, “Upper East Cavern” at Orizaba Rock.

Figure D-5. Common Raven with unidentified prey item (likely Ashy Storm-Petrel or Cassin’s Auklet) in bill, 19 March 2015, “Upper East Cavern” at Orizaba Rock.

Appendix D (continued).

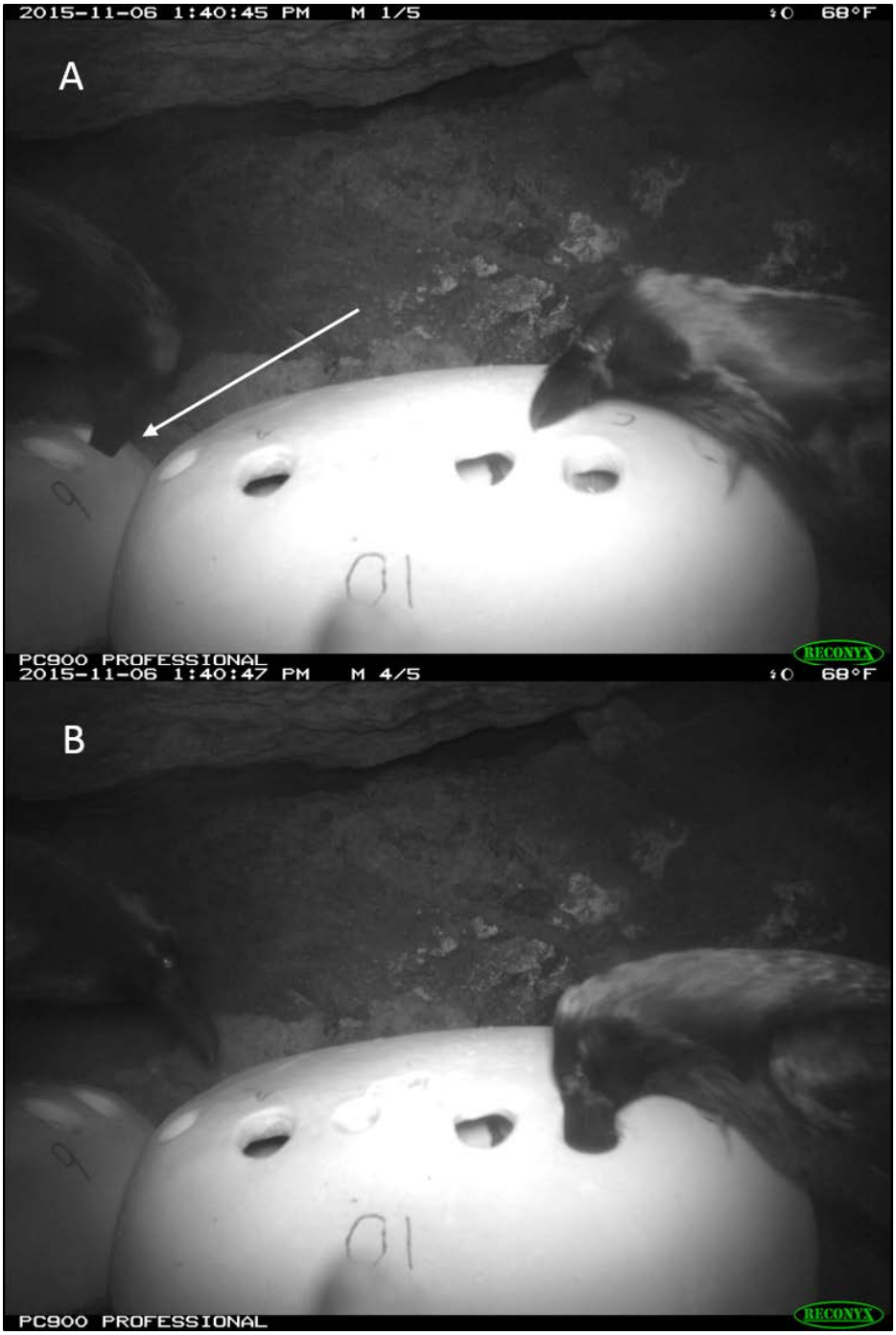

Figure D-6. Successive images of each individual of a pair of Common Ravens poking a bill into observation holes of artificial nest modules, "Upper East Cavern" at Orizaba Rock, 6 November 2015. Image "A" shows raven to the left poking bill into observation hole in nest module #9 (see arrow), and image "B" shows raven to the right poking bill into observation hole in nest module #10 (numbers written upside down on module) 2 seconds later. Images were corrected to increase brightness/contrast.

Appendix E. Banding and PIT-tag information for 31 Ashy Storm-Petrel chicks banded at Santa Cruz Island, California, in 2015.

Colony[1]	Date	Nest Tag No.	Chick Stage[2]	USGS Band No.	PIT-Tag ID	Observer[3]	Recorder[3]
BC	26-Aug	1090	MGC	1971-02733	121021141242	WRM	DMM
BC	26-Aug	836	SGC	1971-02734	121021115824	WRM	DMM
BC	26-Aug	15c	LGC	1971-02735	121021117440	WRM	DMM
BC	26-Aug	404	MGC	1971-02736	121021144152	WRM	DMM
BC	26-Aug	1258	SGC	1971-02737	121021102091	HRC	CAC
BC	26-Aug	1165	SGC	1971-02738	121021029884	HRC	CAC
BC	26-Aug	1099	MGC	1971-02739	121021042459	HRC	CAC
BC	26-Aug	1205	MGC	1971-02740	121021132316	WRM	DMM
BC	16-Sep	836	MGC	1971-02734	121021115824	CAC	SMC
BC	16-Sep	404	LGC	1971-02736	121021144152	CAC	SMC
BC	16-Sep	1072	MGC	1971-02744	121021160877	CAC	SMC
BC	16-Sep	1219	MGC	1971-02745	121021132568	CAC	SMC
BC	16-Sep	837	MGC	1971-02746	121021186623	CAC	SMC
BC	16-Sep	1248	MFC	1971-02747	121021142953	CAC	SMC
BC	16-Sep	1221	SGC	1971-02748	121021128911	CAC	SMC
BC	16-Sep	1140	LGC	1971-02749	121021129684	CAC	SMC
BC	16-Sep	833	MFC	1971-02750	121021129790	CAC	SMC
BC	16-Sep	1174	FFC	1971-02751	121021143357	CAC	SMC
BC	7-Oct	833	FFC	1971-02750	121021129790	DMM	DMM
BC	7-Oct	1233	SGC	4501-41801	121021132137	SMC	PTL
BC	7-Oct	912[4]	FFC	4501-41802	121021141372	SMC	PTL
CBE	25-Aug	1087	LGC	1971-02725	121021143444	MWP	DMM
CBE	25-Aug	1229	LDC	1971-02726	121021127251	MWP	DMM
CBE	25-Aug	1231	SGC	1971-02727	121021144663	MWP	DMM
CBE	25-Aug	769	LDC	1971-02728	121021113402	MWP	DMM
CBE	25-Aug	828	LDC	1971-02729	121021127277	MWP	DMM
OR	25-Aug	1226a	MGC	1971-02730	121021090371	WRM	CAC
OR	25-Aug	1102	LGC	1971-02731	121021132847	WRM	CAC
OR	25-Aug	1208	SGC	1971-02732	121021132654	HRC	DMM
OR	15-Sep	1146	SGC	1971-02742	121021114222	SMC	CAC
OR	15-Sep	1129	MFC	1971-02743	121021145341	SMC	CAC

Appendix E (continued).

Footnotes for Appendix E –

[1] Codes: BC = Bat Cave, CBE = Cave of the Birds' Eggs, OR = Orizaba Rock.

[2] Codes, as in McIver & Carter (1996): 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] Personnel: CAC = Catherine Carter, DMM = David Mazurkiewicz, HRC = Harry Carter, MWP = Mike Parker, PTL = Peter Larramendy, SMC = Samantha Cody, WRM = William McIver.

[4] In field notes, this FFC was described as being banded on 7 October at nest site #1140, which is adjacent to site #912. The LGC observed in site #1140 on 16 September likely fledged before 7 October, and the chick from #912 (SGC on 16 September) likely wandered into site #1140 on or before 7 October.

Appendix F. Breeding success (chicks fledged per nest; expressed as percentages)[1] of Ashy Storm-Petrel nests monitored at five locations, Santa Cruz Island, California, 2005-15. Sample sizes in parentheses. ND indicates no data.

	Years											
Location[2]	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2005-15**
BC[3]	ND	66.7 (18)	66.7 (27)	84.8 (33)	74.5 (47)	78.6 (56)	89.7 (58)	79.5 (78)	51.6 (93)	67.8 (90)	49.0 (100)	68.2 (600)
CBE[4]	55.6 (18)	61.1 (18)	74.1 (27)	78.6 (28)	70.8 (24)	61.9 (21)	85.7 (21)	51.8 (27)	60.0 (30)	62.1 (29)	ND	66.3 (243)
CPC[3]	61.5 (13)	100 (6)	53.8 (13)	ND	50.0 (2)	0 (0)	50.0 (2)	80.0 (5)	71.4 (7)	60.0 (5)	75.0 (8)	57.4 (61)
DSB[4]	57.9 (38)	ND	ND	ND	73.7 (38)	50.0 (22)	ND	ND	ND	ND	ND	62.3 (98)
OR[5]	57.1 (7)	66.7 (15)	53.8 (13)	31.6 (19)	45.0 (20)	61.9 (21)	54.5 (22)	40.7 (27)	42.9 (28)	48.3 (29)	46.9 (32)	48.5 (233)
OR[6]	57.1 (7)	66.7 (15)	53.8 (13)	34.8 (23)	50.0 (26)	55.6 (27)	55.2 (29)	35.3 (34)	42.9 (28)	48.3 (29)	44.4 (36)	47.6 (267)
All[5]	57.9 (76)	68.4 (57)	65.0 (80)	70.0 (80)	68.7 (131)	67.5 (120)	80.6 (103)	66.4 (137)	52.5 (158)	62.8 (153)	50.0 (140)	63.1 (1235)
All[6]	57.9 (76)	68.4 (57)	65.0 (80)	69.0 (84)	68.6 (137)	65.9 (126)	79.1 (110)	63.9 (144)	52.5 (158)	62.8 (153)	49.3 (144)	62.5 (1269)

Appendix F (continued)

Footnotes for Appendix F –

[1] Breeding success values only. See specific annual reports for hatching & fledging success values for particular locations & years.

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

[3] No breeding success data due to skunk predation events & complete reproductive failure at BC (2005) and CPC (2008).

[4] No breeding success data for years when CBE or DSB were visited by researchers only once, except 2013, when DSB was not visited by researchers.

[5] For 2008-12 at OR, breeding success values are for natural & artificial nests combined. See Appendix G in this report for hatching, fledging & breeding success values by particular nest type.

5 Natural sites only.

6 Includes artificial sites at OR in years 2008-12, 2015.

Appendix G. Hatching, fledging and breeding success (expressed as percentages[1]) of Ashy Storm-Petrel nests monitored at Orizaba Rock, Santa Cruz Island, California, 2005-15. Eggs are coded: 1 - first and single; 2 - replacement; and L - last. Sample sizes in parentheses. Note: page size is 8.5 x 14 inches.

		Years																				
		Nest Types[2,3]																				
		2005	2006	2007	2008		2009		2010		2011		2012		2013	2014	2015		2005-15		2008-12, 2015[4]	
		N	N	N	N	B	N	B	N	B	N	B	N	B	N	N	N	B	N	B	N	A
HS	**1**	85.7	80.0	50.0	70.0	66.7	63.6	64.3	54.5	57.1	65.4	69.7	70.4	64.7	58.1	71.9	65.6	61.1	65.7	65.2	65.1	58.8
		(7)	(15)	(14)	(20)	(24)	(22)	(28)	(22)	(28)	(26)	(33)	(27)	(34)	(31)	(32)	(32)	(36)	(248)	(282)	(149)	(34)
	2	-	-	-	33.3	33.3	0	0	75.0	75.0	50.0	50.0	0	0	0	50.0	33.3	33.3	39.9	38.0	42.8	0
					(3)	(3)	(1)	(2)	(4)	(4)	(2)	(2)	(1)	(1)	(2)	(4)	(3)	(3)	(20)	(21)	(14)	(2)
FS	**L**	66.7	83.3	53.8	42.9	50.0	75.0	81.3	92.9	83.3	85.7	80.0	57.9	57.1	70.6	63.6	68.2	69.6	68.5	69.0	69.5	72.7
		(6)	(12)	(13)	(14)	(16)	(12)	(16)	(14)	(18)	(14)	(20)	(19)	(21)	(17)	(22)	(22)	(23)	(165)	(184)	(95)	(22)
BS	**L**	57.1	66.7	53.8	31.6	34.8	45.0	50.0	61.9	55.6	54.5	55.2	40.7	35.3	42.9	48.3	46.9	44.4	48.5	47.6	46.8	41.2
		(7)	(15)	(13)	(19)	(23)	(20)	(26)	(21)	(27)	(22)	(29)	(27)	(34)	(28)	(29)	(32)	(36)	(233)	(267)	(141)	(34)

Footnotes for Appendix G –

1 HS = hatching success (percentage of eggs hatched per egg laid, where egg fate was known); FS = fledging success (percentage of last chicks fledged per last chick hatched for each breeding pair, where last chick fate was determined); BS = breeding success (percentage of last chicks that fledged per last egg laid, where egg fate was known). See "Data Handling and Descriptive Statistics" in Methods section.

2 Codes: A = artificial nest sites (years 2008-12, 2015), B = natural crevices & artificial nest sites combined (years 2008-12, 2015), N = natural crevices.

3 Artificial nest sites were deployed at Orizaba Rock in 2008-12 & 2014-15; eggs were not laid in artificial sites in 2014.

4 Includes only the 6 years (2008-12 & 2015) in which egg laying occurred in artificial nest sites.