Monitoring and Restoration of Ashy Storm-Petrels at Santa Cruz Island, California, in 2012

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EXECUTIVE SUMMARY

In 2012, the California Institute of Environmental Studies, Channel Islands National Park, U.S. Fish and Wildlife Service (Arcata Fish and Wildlife Office), and Carter Biological Consulting were funded by the Montrose Settlements Trustee Council to continue implementation of restoration actions and continue gathering data on population size and reproductive performance of Ashy Storm-Petrels (*Oceanodroma homochroa*) at Santa Cruz Island, California. Social attraction using vocalization broadcast was redeployed at Orizaba Rock, as in 2008-11, but 12 concrete roof tile artificial nest sites on the ledge in the upper west cavern at Orizaba Rock were replaced with ceramic nest chambers to prevent access by Common Ravens (*Corvus corax*). Continued increase in colony size at Orizaba Rock occurred with a total of 34 egg-laying pairs documented in 2012 (i.e., 27 natural and 7 artificial). However, raven impacts to 22 artificial sites led to highly reduced reproductive performance in artificial sites in 2012 (i.e., hatching, fledging and breeding success were 29%, 50% and 14%, respectively). These impacts resulted in the losses of 7-9 nests, 5-8 eggs, 2-8 adults, and 1 chick. To prevent possible further predation, most artificial nest sites were removed and vocalization broadcasting was stopped in July.

At three monitored reference colonies and Orizaba Rock, a total of 144 nests were found and monitored in 2012 with a combined breeding success of 64%, lower than what was observed in 2011 (79%, n = 110) but slightly higher than in 1995-97 (55%, n = 477). Breeding success at Orizaba Rock (35%, n = 34) in 2012 was lower than two main reference colonies at Bat Cave (80%, n = 78) and Cave of the Birds' Eggs (52%, n = 27). Five active nests occurred at Cavern Point Cove Caves in 2012, compared to a maximum of two nests per year in 2009-11, following an unusual heavy predation event and near extirpation of Ashy Storm-Petrels at this location by island spotted skunks (*Spilogale gracilis amphiala*) in 2008. In contrast, relatively high numbers of active nests in Bat Cave (n = 82) indicated continued recovery following a similar unusual skunk predation event in 2005. Dry Sandy Beach Cave was not monitored for reproductive performance in 2012 and relatively small numbers (n = 12) of nests were documented on 16 August. Wave wash or high water events appeared to occur at Dry Sandy Beach Cave and Cave of the Birds' Eggs in 2012 which may have affected several nests prior to the start of monitoring at each location. Skunk traps were redeployed in 2012 at Bat Cave, Cave of the Birds' Eggs, and Cavern Point Cove Caves to prevent possible additional predation of storm-petrels by skunks, and no skunks were detected in these sea caves in 2012.

INTRODUCTION

Endemic to California and northwestern Baja California, Mexico, Ashy Storm-Petrels (*Oceanodroma homochroa*) have a small global population size (*ca*. 10,000 birds) and breed from Mendocino County (*ca*. 39° N) to Todos Santos Islands (*ca*. 32° N) (Ainley 1995; Carter et al. 2008a). The largest known nesting colonies occur at the South Farallon Islands in central California, and at Santa Barbara, Prince, and Santa Cruz Islands in southern California (Ainley et al. 1990; Carter et al. 1992, *unpubl. data*; Sydeman et al. 1998a,b; McIver 2002, McIver et al. 2009b). Although nesting was first documented at Santa Cruz Island in 1912 (Wright and Snyder 1913), knowledge of population size and distribution of Ashy Storm-Petrels at Santa Cruz Island increased dramatically during 1991-96 surveys by Humboldt State University (HSU) (Carter et al. 1992, 2007, 2008a, *unpubl. data*). From 1995 to 2002, HSU also implemented standardized monitoring of population size (using nest counts), reproductive performance, breeding phenology, and predation at five locations at Santa Cruz Island, including Orizaba Rock (OR), Bat Cave (BC), Cavern Point Cove Caves (CPC; comprised of two adjacent caves: Cave #4 and Cave #5), Cave of the Birds' Eggs (CBE), and Dry Sandy Beach Cave (DSB) (McIver and Carter 1996; McIver 2002; Carter et al. 2007). In 2003-05, the U.S. Fish and Wildlife Service (USFWS) (Ventura Fish and Wildlife Office) and Carter Biological Consulting (CBC) continued monitoring at these locations (McIver and Carter 2006; Carter et al. 2007).

The Montrose Settlements Trustee Council (MSTC) identified several seabird restoration concepts for implementation with funds obtained through litigation over long-term effects of organochlorine pollutants to wildlife (including raptors and seabirds) in the Southern California Bight (Montrose Settlements Restoration Program [MSRP] 2005). The need for restoration of Ashy Storm-Petrels at Santa Cruz Island was identified based on: a) apparent loss of small colonies (i.e., no nests were found during 1991-96 surveys) at Painted Cave, Scorpion Rocks, and Gull Island where breeding had been previously documented (Carter et al. 1992, 2007, *unpubl. data*); b) contaminant-related eggshell thinning from eggs collected at OR and CBE in 1992, 1996 and 1997 (Fry 1994; Kiff 1994; Carter et al. 2008b); c) reduced numbers of nest sites at OR after 1996 possibly due to bright lights from squid-fishing boats resulting in high avian predation (McIver 2002; Carter et al. 2008a); and d) decimation of the BC colony, the largest known colony at Santa Cruz Island, due to an unusual predation event by island spotted skunks (*Spilogale gracilis amphiala*) in 2005 (McIver and Carter 2006; Carter et al. 2008a). MSRP (2005:6-11) identified potential restoration actions at OR, including installation of artificial nest sites and reduction in human disturbance.

In 2006-07, CBC, USFWS (Ventura and Arcata Fish and Wildlife Offices), and Channel Islands National Park (CINP) were funded by the MSTC to: (a) begin official pre-restoration baseline monitoring for Ashy Storm-Petrels at five locations at Santa Cruz Island. Population size, reproductive performance, breeding phenology, and predation were measured for developing a long-term monitoring program for restoration assessment; 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). Monitoring at Santa Cruz Island also has provided key information on the status of this rare storm-petrel which by 2005 had declined at OR and BC at Santa Cruz Island in southern California and at the South Farallon Islands in central California, but had increased at the Coronado Islands in Baja California (Sydeman et al. 1998b; Carter et al. 2006, 2007, 2008a; Bradley 2011). Prior to 2006, long-term monitoring of Ashy Storm-Petrels was focused at Southeast Farallon Island (Ainley et al. 1990; Ainley 1995; Sydeman et al. 1998a; Bradley 2011). A long-term monitoring program for Ashy Storm-Petrels in the Channel Islands, where half of the world population of Ashy Storm-Petrels breeds, also is a long-term goal for CINP and other state and federal agencies (Carter et al. 1992, 2008a).

In 2008-09, USFWS (Arcata Fish and Wildlife Office [AFWO]), CINP, and CBC were funded by the MSTC to: a) continue annual monitoring work to gather data on population size, reproductive performance, breeding phenology, and predation of Ashy Storm-Petrels at OR and four sea caves at Santa Cruz Island; b) deploy artificial nests at OR; (c) deploy vocalization broadcasting for social attraction to enhance use of artificial sites at OR; (d) deploy skunk traps in sea caves to prevent or reduce further predation of Ashy Storm-Petrels by island spotted skunks (starting in 2009); (e) deploy signs at sea caves to prevent or reduce unauthorized human access (starting in 2009); and (f) lead public outreach to educate CINP visitors and staff regarding impacts to storm-petrel colonies due to human disturbance (McIver et al. 2009a, 2010). We considered that, if many protective artificial nest sites were used by Ashy Storm-Petrels at OR over the long term, a portion of the colony would be better protected from avian predators and human disturbance (especially bright lights from squid fishing boats), resulting in increased reproductive performance and an increase in population size to recover from past decline and reach population sizes beyond its current natural maximum. These long-term benefits would assist the self-sustainability of this small colony in the future for existing in an increasingly human-modified environment. In addition, USFWS and the MSTC funded a preliminary assessment of organochlorine contaminants in Ashy Storm-Petrel eggs collected at Santa Cruz Island in 2008 (Carter et al. 2008b). Additional analyses of organochlorine contaminants and eggshell thickness using eggs collected in 2008 and non-hatched eggs salvaged in 2008-11 are currently underway (Carter et al., unpubl. data).

In 2010, USFWS-AFWO, CINP, CBC, and Simon Fraser University (SFU) were funded by the MSTC to continue restoration and monitoring activities as conducted in 2006-09 (McIver et al. 2011). In addition, we: a) evaluated Ashy Storm-Petrel nocturnal behaviors in relation to vocalization broadcasting; b) evaluated future recruitment and visitation of Ashy Storm-Petrels by initiating a chick PIT-tag banding project; c) evaluated storm-petrel visitation to and attendance of artificial nest sites using temperature loggers; d) deployed signs at OR to prevent or reduce unauthorized human access; and e) gathered data on vocalization levels at CBE and BC using acoustic monitoring devices (“songmeters”). We also first noted Common Raven (*Corvus corax*) impacts to many artificial nest sites in 2010.

In 2011, USFWS-AFWO, CINP, and CBC were funded by the MSTC to 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). Raven visitation was noted but few impacts occurred.

In 2012, CIES, CINP, USFWS-AFWO, and CBC were funded by the MSTC to continue the restoration and monitoring activities as conducted in 2006-11, with modifications described in this report.

METHODS

Study Area

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

Field Logistics

In 2012, the logistics for nest monitoring of Ashy Storm-Petrels at Santa Cruz Island underwent a major transition in personnel and support vessels. Field work, data entry, and project management were shifted mainly to CIES and CINP personnel. However, data analyses and report preparation were retained by USFWS-AFWO, assisted by CBC, as in the past. This general type of transition had been envisioned by the MSTC since project inception, as an intended cost-saving measure once the project had been implemented by a more experienced team to a certain degree.

Transportation to and from Santa Cruz Island was provided aboard the following support vessels: the charter boat *Miss Devin*, operated by R. Fairbanks (Lompoc, CA); the charter boat *Retriever*, operated by Captain D. Carlson and Second Captain T. Shinn (Ventura, CA); the concessionaire boat *Islander*, operated by Island Packers (Ventura, CA); and the charter boat *Fuji III*, operated by Captain F. Mize (Ventura, CA) (Table 1). Nesting habitats were accessed from a 14-foot (4.3 m) inflatable boat powered by a 15, 20 or 25 horsepower outboard engine launched from the support vessel, or by use of sea kayaks (BC and CPC only) launched from nearby Scorpion Anchorage.

Although the *Miss Devin* had been a reliable vessel for almost all trips in 2006-2011, use of the *Retriever* and *Fuji III* permitted more convenient departures for CIES and CINP staff from Ventura and greater accommodations for overnight trips. In addition, use of the *Islander* and kayaks allowed monitoring at BC and CPC to be conducted in association with other field work at Scorpion Rock. The number of field days increased in 2012 (n = 17) compared to 2008, 2009 and 2011 (n = 12-14), because of changes in support vessels and fewer overnight trips than in previous years. Mainland time required for coordination of trip logistics also increased in 2012. As in 2011, trips were originally scheduled to occur near new moons to facilitate video monitoring of storm-petrel activities (see below).

In addition to MSTC-funded field crew from CIES, CINP, USFWS-AFWO and CBC several key project supporters and other interested parties joined certain trips to observe and assist data collection, including Annie Little (USFWS – MSRP), Colin Grant (USFWS - Sacramento), Robert McMorran (USFWS – Ventura), Matt Pickett (Channel Islands National Marine

Sanctuary [CINMS]), Dan Richards (CINP), and Scott Hall (National Fish and Wildlife Foundation [NFWF]).

Nest Monitoring

In March-November 2012, standardized methods (see McIver and Carter 1996, 2006; McIver 2002) in use since 1995 were used during field trips to search for and monitor all nests of Ashy Storm-Petrels found in accessible habitats at BC, CBE, CPC (comprised of two adjacent caves: Cave #4 and Cave #5), DSB and OR (Figure 1). Nest monitoring in 2012 involved 1-4 hour visits during each monthly field trip to each breeding location in June-October, except for DSB which was checked only in August (Table 1). BC and OR also were visited on 19 November and 27 November to monitor remaining nests with late-season chicks.

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 have disappeared without leaving any evidence before our first visit after the egg was laid but we suspect such occurrences were rare. If Ashy Storm-Petrels re-laid at the same nest site or at another nest site, the loss of the odd egg without detection would not affect the number of nests documented in the study year. However, at some locations, the number of nests followed was relatively low and undetected failure of a few first eggs could slightly affect measures of reproductive performance. We searched for and examined nests with the aid of headlamps and small flashlights, completely covering all suitable and accessible habitat at each location. Each nest or suspected nest (i.e., in some cases, an adult in incubating position was present and presence of an egg could not be directly detected) was placed on a field map adapted from Bunnell (1988) and an individually numbered plastic tag, attached to rock or driftwood near the nest entrance. Nest contents were recorded for each marked nest on each visit. Because storm-petrels can be sensitive to disturbance at nest sites (Ainley et al. 1990), we did not handle adults, incubated eggs, or brooded chicks. Stages of chick plumage development were recorded during nest monitoring (McIver and Carter 1996; McIver 2002). Evidence of predation, including carcasses, feather piles and broken eggs, was recorded and removed to facilitate detection of new evidence of predation and replacement eggs and to prevent double counting. Breeding phenology was estimated for each nest (i.e., timing of initiation [egg-laying], hatching, and fledging) by backdating from a range of estimated hatch dates based mainly on estimated ages for chick plumage stages or dates when eggs that failed to hatch were first observed (McIver and Carter 1998).

Social Attraction

Social attraction equipment was first deployed at OR in April-September 2008 (McIver et al. 2009a). A single vocalization broadcast system with two speakers was chosen by Harvey that had been developed previously by the National Audubon Society and had been used widely for social attraction purposes (e.g., Parker et al. 2007). This system involved use of a MP3 player for

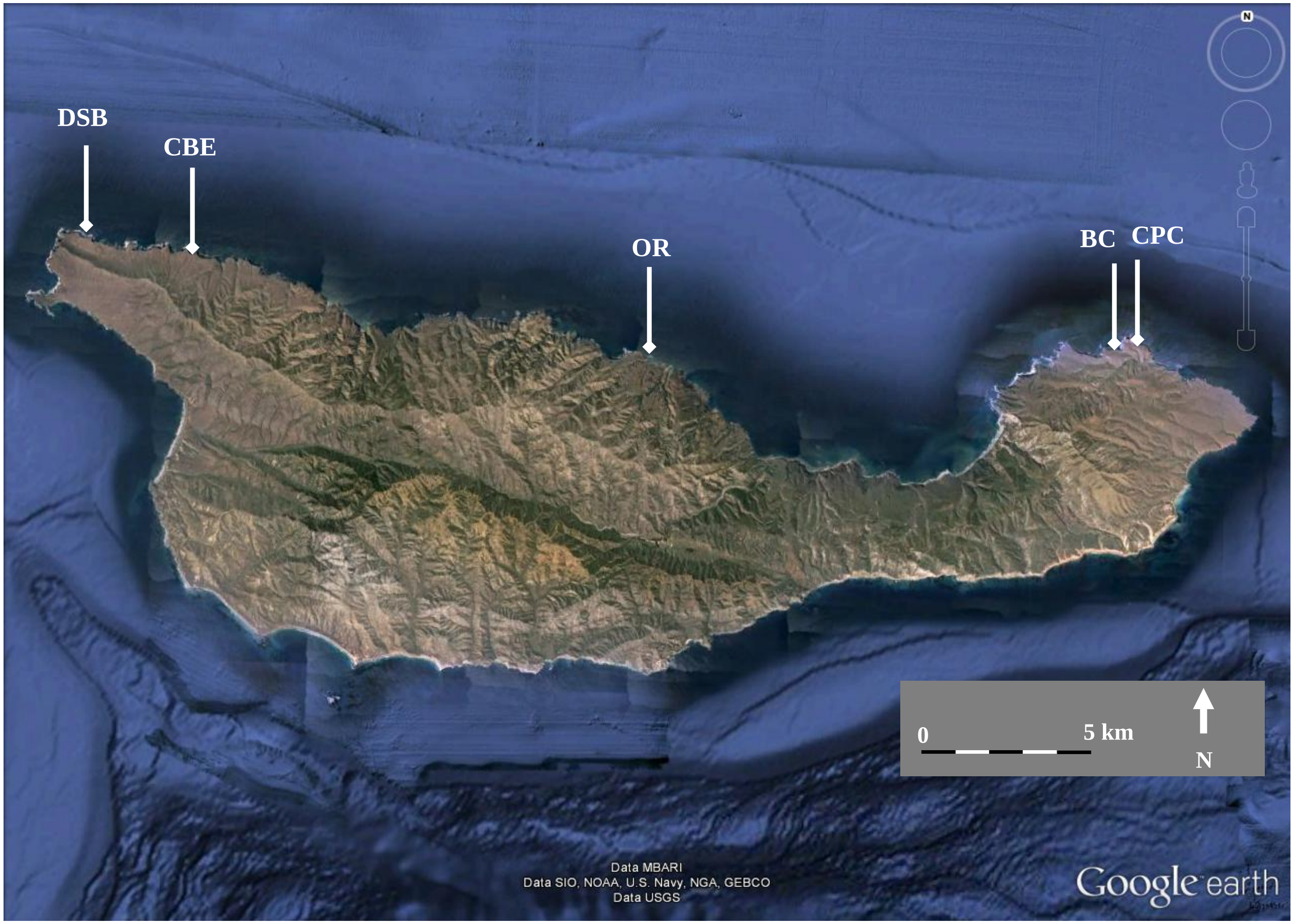


Figure 1. Satellite image of Santa Cruz Island, California, with locations of Ashy Storm-Petrel study sites: Bat Cave (BC); Cave of the Birds' Eggs (CBE); Cavern Point Cove Caves (CPC); Dry Sandy Beach Cave (DSB); and Orizaba Rock (OR).

Table 1. Field trips conducted in 2012 for Ashy Storm-Petrel monitoring and restoration at Santa Cruz Island, California.

Date	Locations[1]	Personnel[2]	Main Activities	Vessel Support
22 March	OR	LH, KB, KC, KR, SH	Deploy social attraction & monitor sites at OR; deploy cameras.	*Retriever* and zodiac
15-17 June	BC, CBE, CPC, OR	LH, KC, KR, RW	Monitor sites; deploy & check skunk traps; check cameras.	*Retriever* and zodiac
16 July	CBE, OR	LH, KC, KR	Monitor sites; check traps & cameras; remove artificial nest sites; stop vocalization broadcasting.	*Miss Devin* and zodiac
17 July	BC, CPC	LH, KR	Monitor sites; check traps & cameras.	*Islander* + kayak
16-17 August	BC, CBE, CPC, DSB, OR	WM, HC, RM, CG	Monitor sites; check traps & cameras; remove social attraction equipment.	*Miss Devin* and zodiac
10 September	CBE, OR	LH, KC, RW	Monitor sites; check traps & cameras.	*Fuji III* and zodiac
13 September	BC, CPC	LH, DR, MP	Monitor sites; check traps & cameras.	*Islander* and kayak
27 September	BC	LH, DM	Monitor sites; check traps & cameras.	*Islander* and kayak
30 September	CBE, OR	LH, AL, KC	Monitor sites; check traps & cameras.	*Fuji III* and zodiac
2 October	BC, CPC	DM	Monitor sites; check traps & camera.	*Islander* and kayak
29-30 October	BC, CBE, CPC, OR	LH, KC, KR, RW	Monitor sites; remove traps, & cameras	*Retriever* and zodiac
19 November	OR	LH, KR, RW, AY	Monitor late sites with chicks	*Retriever* and zodiac
27 November	BC	DM	Monitor late sites with chicks	*Islander* and kayak

Footnotes -

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: AL = Annie Little (USFWS), AY = Andrew Yamagiwa (CINP), CG = Colin Grant (USFWS), DM = David Mazurkiewicz, DR = Dan Richards (CINP), HC = Harry Carter (CBC), KB = Kevin Barnes (CINP), KC = Katy Carter (CIES), KR = Kris Robison (CIES), LH = Laurie Harvey (CINP/CIES), MP = Matt Pickett (CINMS), RM = Robert McMorran (USFWS), RW = Renee Weems (CIES), SH = Scott Hall (NFWF), WM = William McIver (USFWS).

continuous broadcasting of Ashy Storm-Petrel vocalizations during the night. These vocalizations had been originally tape recorded by D.G. Ainley at Southeast Farallon Island, California, and provided to H.R. Carter in 1989 (see Carter et al. 1992). In 2004, vocalizations were transferred from this tape to compact disc (CD) by J. Adams who provided this CD for this restoration project. The MP3 player, marine batteries, light sensor, and amplification system were placed in a locked plastic tote box (Figure 2a). Batteries were recharged by a 3-foot x 5-foot (0.9 m x 1.5 m) solar panel. The solar panel and tote box were securely placed at an inconspicuous location on the west side of OR that received adequate direct sunlight, and was not visible to most passing boats (Figure 2b, Figure 2c). The vocalization broadcast equipment in the tote box was wired to two speakers in the "Upper West Cavern" and the "Lower Cavern." The same vocalization broadcast system was used in 2009-11, although broadcasting was started in March or April and stopped in August each year (McIver et al. 2010, 2011, 2013). In 2012, we continued to broadcast vocalizations using this system from March to July when broadcasting was stopped (see later).

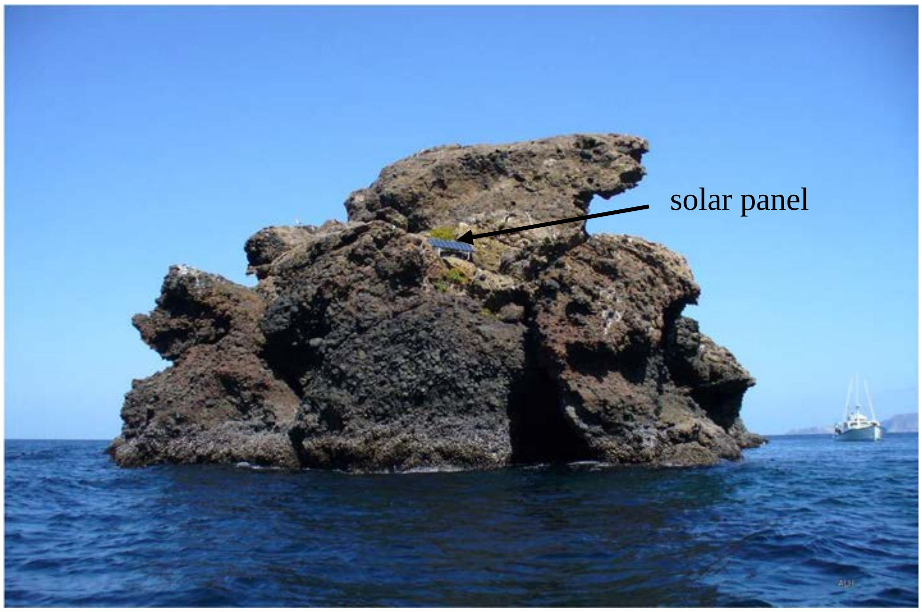
Artificial Nest Sites

In 2007-08, simple artificial nest sites were designed for use at OR by McIver and Carter, focusing on providing adequate breeding conditions that mimicked a natural nest crevice on OR at low cost (McIver et al. 2009). Three factors supported this simple design were: (1) limited available time and funding for site design and testing in 2007-2008; (2) CINP requested that sites needed to be temporary and could be easily removed; and (3) no evidence of predators at storm-petrel nests at OR in 1995-2007. These "Type Ia" sites were created using a single concave cement roofing tile (A.L.L. Roofing and Building Materials Corporation, Ventura, California) that was 36 cm long, 20 cm wide, and 18 cm high (all inside dimensions). One end of each tile was blocked completely by rocks or pieces of cement tile backer boards to provide an enclosed site and to protect the interior of the site from wind. Sites were sufficiently deep with small enough entrances to prevent avian predators from grasping incubating adults or chicks from nest depressions located in the back of the artificial site. In 2008-09, McIver and Harvey deployed 30 Type Ia sites at OR. Ashy Storm-Petrels laid eggs in several of these nest sites and no evidence of predation or predators was noted at nest sites (McIver et al. 2009, 2010).

In 2010, we first observed impacts to several artificial nest sites by ravens (McIver et al. 2011). We felt that it was important to develop more substantial artificial sites to prevent raven impacts and allow continued breeding during the 2011 breeding season during a critical period of occupation and egg laying in these sites after three years of deployment in 2008-2010. In 2010-11, McIver rapidly designed and created the Type II artificial nest site, involving a ceramic chamber (produced by McIver at the Fire Arts Center in Arcata, CA), with a non-linear entrance that prevented direct nest viewing by a predator and a removable (twist-off) lid for access to the nest for chick banding or examination and removal of hatched or non-hatched eggshells (Figure 3c). Type Ia sites located on the cavern floors (n = 12) and one site on the northeast ledge were replaced with Type II sites. However, Type Ia sites on the Upper West Cavern ledge were not replaced but were modified by attaching ceramic pieces with non-linear entrances to the entrances of the Type Ia cement tile sites on the Upper West Cavern ledge, which we then referred to as "Type Ib" sites (n = 16) (Figure 3b). McIver's limited available time and energy had been used primarily for designing and creating Type II artificial nests, and Type Ib sites were considered to be the best temporary solution available at the time to maintain a similar

(a)

(b)



(c)

Figure 2. Vocalization broadcast system on Orizaba Rock, California: (a) tote box containing MP3 player and other equipment (photo by A.L. Harvey); (b) close-up of solar panel and tote box (photo by W.R. McIver); and (c) location of solar panel and tote box on west side of Orizaba Rock, with support vessel *Miss Devin* behind and off the southeast side of the rock (photo by A.L. Harvey)

(a) 

(b) 

(c) 

(d) 

Figure 3. Artificial nest types deployed at Orizaba Rock in 2008-12: (a) "Type Ia" - concrete roof tiles with backer board, deployed in 2008 and 2009 (*n* = 30); (b) "Type Ib" – concrete roof tiles with ceramic front pieces, deployed in 2011 (*n* = 16); (c) "Type II" – ceramic nest chamber with non-linear nest entrance and removable lid, deployed in 2011 (*n* = 13); and (d) "Type III" - a ceramic nest body and removable ceramic front piece with a non-linear entrance and viewing hole, deployed in 2012 (*n* = 12). Photos (a-c) by W. McIver. Photos (d) by A.L. Harvey).

number of ledge nests in the limited space available on a sloping ledge. In early 2011, McIver and Harvey deployed Type II and Type Ib sites at the same locations as previous Type Ia artificial nest sites. This process resulted in a similar number and placement of artificial sites on OR as in 2009-2010. We expected that storm-petrels that had previously bred in artificial sites would lay eggs in new and modified artificial sites if deployed in the same locations as previous artificial sites in 2008-2010. We also hoped that non-breeding storm-petrels visiting other artificial sites without breeding would continue to visit and eventually lay eggs in new and modified sites at the same locations as previously-visited sites. In this way, we took a conservative approach to avoid making major changes to artificial habitat which somehow might have resulted in some or many storm-petrels not continuing to use artificial sites after four years of restoration efforts.

While Type II and Type Ib sites were used by Ashy Storm-Petrels in 2011 and appeared to successfully prevent raven impacts (McIver et al. 2013), we were concerned that temporary modifications to Type Ib sites on the Upper West Cavern ledge were not adequate and a better long-term solution was needed. In 2011-12, McIver designed another new artificial nest site (Type III) for replacing Type Ib sites on the Upper West Cavern ledge. Each Type III nest was composed of a nest body and a removable front piece (with a non-linear entrance and viewing hole) that was attached to the nest body with twistable wire. As needed, nests in these sites could be viewed or chicks handled. McIver then directed potters at Fire Arts Center, under contract with the MSTC, to make 22 Type III sites. In early March 2012, these nests were shipped to CINP; however, in transit, 10 were broken. Consequently, Harvey deployed 12 Type III artificial nest sites on the Upper West Cavern ledge in mid-March.

Reconnaissance Camera Monitoring

Ravens at OR.– Similar to 2010-11, a reconnaissance camera (model HC500 Hyperfire, RECONYX Inc., Holmen, WI) was redeployed by Harvey on 22 March 2012 in the Upper West Cavern at OR, for detecting ravens visiting the cavern, depredating storm-petrels, or altering artificial nest sites. In 2011, a second reconnaissance camera also had been deployed in the Upper East Cavern but this camera was not redeployed in 2012. Images were taken when the camera was motion-activated within the field of view during day or night; it was pre-programmed to take three images within three consecutive seconds before re-setting with no images taken for the next 10 minutes. The camera was deployed on a small boulder in the middle of the cavern; the lens of this camera was oriented in a west-northwest direction, with a field of view including three artificial nest sites (A-864, A-865, A-866) located on the floor of the cavern, and artificial nests deployed on the ledge. Memory cards and batteries in the camera were changed during nest-monitoring trips. This camera was removed on 29 October.

Human Visitors at BC.– After non-researcher visitation of BC was witnessed by researchers in person on 17 June 2012 (see below), a reconnaissance camera (pre-programmed in the same manner as at OR) was deployed in the main room of BC on 17 July to capture images of any human visitation (non-researcher) to the cave. The lens of the camera was oriented in a north-northwest direction, facing the main entrance of the cave and including the human disturbance sign in its field of view. Memory cards and batteries in the camera were changed during nest-monitoring trips. This camera was removed on 30 October.

Recruitment Study

To better understand how the OR colony and sea cave colonies are sustaining themselves over the long term, we continued methods begun in 2010 and continued in 2011 using passive integrated transponder (PIT) technology to examine future recruitment of Ashy Storm-Petrels at artificial and natural sites at OR, and at natural sites in sea caves. PIT-tags (Model TX1400ST; Biomark, Inc., Boise, ID) are durable microchips that emit a unique identification signal (ID) and a time/date stamp when in range of an appropriate antenna. PIT-tags were incorporated into bands for attachment to up to 250 chicks, with special approval from the U.S. Geological Survey (USGS) Bird Banding Laboratory (Laurel, MD). Following methods described in Zangmeister et al. (2009), each tag was encased in 1.6 mm diameter electrical shrink tubing that was slightly longer than the length of the tag (~1.2 cm) and attached to two plastic black bands (size XCSD Darvic; Avinet Inc., Dryden, NY) at the edge of the tubing. A small amount of quick-drying glue was applied to secure the PIT-tag/shrink tubing assembly to the plastic bands and to encase the shrink tubing. In 2011, PIT-tag bands were modified slightly from the original design used in 2010, so that both plastic bands were adjacent to each other with no space occurred between the bands (see Figure 8 in McIver et al. 2013). As in 2010-11, 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 scanner (APR350 Reader, Agrident GmbH, Barsinghausen, Germany) and recorded on the corresponding nest monitoring data form. 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.

Protection from Predation by Island Spotted Skunks

As in 2009-11 (see McIver et al. 2010, 2011, 2013), lethal “body-grip” skunk traps (model 220 Conibear trap, Oneida Victor Inc. Ltd., Euclid, OH) were set inside protective custom-made wooden boxes (approximate box dimensions: 19 cm x 19 cm x 50 cm) and deployed at BC, CBE, and CPC during the Ashy Storm-Petrel breeding season in 2012 (see Figure 9 in McIver et al. 2013). Earlier skunk predation events at BC in 2005 and CPC in 2008 precipitated the need for skunk trapping to prevent storm-petrel colony extirpations and allow these colonies to recover. In 2005, a live trap had been used previously at Bat Cave to remove one skunk but high trap checking effort was required (McIver and Carter 2006). No skunks were noted in BC in 2006-2008, indicating that access by skunks was an unusual or rare event possibly related indirectly to high skunk densities in upper island habitats. In 2009, CINP considered that: (1) lethal trapping was the most humane method of trapping skunks because live traps need to be checked daily to avoid skunk deaths which was not possible at this remote location in these years; and (2) only a few if any skunks were expected to be trapped because none had been found in BC after 2005 and sea caves at Santa Cruz Island did not have direct access to upper island habitats where skunks normally occur. After deployment, traps were examined on each field trip in 2012 to detect any trapped skunks (or non-target entrapment), ensure proper functioning of traps and boxes, and to replace bait. Traps, protective boxes, and bait were removed from the sea caves during autumn field trips.

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 2012.

Video Monitoring of Nocturnal Storm-Petrel Behaviors

In 2010, a proposed two-year study was initiated to gather information from nocturnal video footage of Ashy Storm-Petrels to assist evaluation of the efficacy of vocalization broadcasting in attracting Ashy Storm-Petrels (see Appendix A in McIver et al. 2011). In 2011, the original study plan was discontinued, and a revised experimental design was developed with the new goal of comparing storm-petrel activities between one night without broadcast vocalizations to the following few nights with broadcast vocalizations (McIver et al. 2013). This simple comparison could be conducted without adding additional field costs and was targeted for a new moon period when moonlight would not affect the activities or numbers of birds present at the colony. One infrared video camera was deployed in June 2011 at the Upper West Cavern to gather continuous data on petrel activities between 22:30 and 02:30 h (PDT). The camera system consisted of a main housing unit built into a large Pelican case containing a digital video recorder (MDVR25; Supercircuits, Austin, TX), a 12v lead acid battery and a power supply timer unit (see Appendix A in McIver et al. 2011 for details). The housing units contained the bulk of the recording equipment. A small infrared security camera (Supercircuits PC168 IR Camera) and a weatherproof microphone (Supercircuits ETS SM1-W) were attached to concealed cables leading back to the unit. By storing the bulk of the recording equipment away from filming areas used frequently by storm-petrels, minimal disturbance to storm-petrels occurred. Various problems with either operating cameras or changing batteries and memory cards led to gathering data only during July and August trips in 2011. Frequencies and types of storm-petrel behaviors with and without broadcast vocalizations can be evaluated from footage archived at CINP.

In 2012, we redeployed an infrared video camera in the Upper West Cavern on 22 March to increase sample sizes of comparisons. The camera was mounted on the same wooden block that had been glued to the south wall of the Upper West Cavern at OR in 2010-11. Due to camera malfunction and stopping of vocalization broadcasting on 16 July, no data were obtained in 2012. This camera was removed on 16-17 August.

Data Handling and Descriptive Statistics

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

Hatching success was defined as the percentage of single and first eggs hatched per egg laid where egg fate was known. For fledging success and breeding success, we examined percentages of chicks fledging from single and replacement eggs (collectively referred to as “last eggs”). Fledging success was defined as the percentage of last chicks fledged per last chick hatched for each breeding pair where last chick fate was determined. Breeding success was defined as the percentage of last chicks that fledged per last egg laid. For hatching, fledging, and breeding success, we excluded a few breeding pairs for which egg or chick fates were not known.

Descriptive statistics for estimated breeding phenology (i.e., midpoint of estimated ranges of dates for egg laying, hatching and fledging) are presented separately for single and first eggs versus replacement eggs. Methods for estimating breeding phenology and hatching, fledging, and breeding success of Ashy Storm-Petrels from monthly data are described elsewhere (McIver and Carter 1996, 1998; McIver 2002; McIver et al. 2010, in prep.). To evaluate breeding phenology at DSB, numbers of active nests containing chicks and observed chick plumage stages during the 16-17 August field trip are described for each location.

RESULTS

Breeding Phenology

Mean dates of egg laying, hatching and fledging in natural and artificial nest sites at each monitored location at Santa Cruz Island are summarized in Table 2. In 2012, estimated average laying dates in natural crevices (all locations [except DSB] combined) ranged from 19 April to 6 September for single and first eggs (*n* = 114) versus 26 July to 10 September for replacement eggs (*n* = 7). Disturbance of most artificial nest sites at OR by ravens during the egg laying period in 2012 (see later) prevented assessment of mean timing of egg laying, hatching and fledging in artificial sites. Eggs laid in two artificial sites without raven impacts at OR averaged 18 May. Hatch dates in natural crevices (all locations [except DSB] combined) ranged from 2 June to 20 October for single and first eggs (*n* = 106) versus 8 September to 25 October for replacement eggs (*n* = 3). Mean hatch date for two artificial nest sites without raven impacts at OR was 2 July. Fledging dates for natural crevices (all locations [except DSB] combined) ranged from 23 August to 28 December for chicks from single and first eggs (*n* = 91), versus 27 November for a chick from a replacement egg (*n* = 1). The fledging date for a single artificial site without raven impacts at OR was 20 September. At DSB, timing of breeding was not determined using standard methods but appeared to be later than other locations (see below).

Bat Cave

Ashy Storm-Petrel: Eighty-two nests were documented at BC in 2012. Sixty-nine active nests were observed on 17 August; 52 of these nests (75%) contained chicks, ranging from "small downy" to "fully-feathered" (McIver and Carter 1996). Ranges of mean dates of egg laying, hatching and fledging for single/first eggs were estimated as: 19 April - 6 September (range 140 d, *n* = 70); 2 June – 20 October (range 140 d, *n* = 67); and 22 August – 25 December (range 125 d, *n* = 61), respectively. Ranges of mean dates of egg laying and hatching for replacement eggs were estimated as 26 July - 10 September (range 46 d, *n* = 3) and 8 September – 25 October (range 47 d, *n* = 2), respectively. Hatching, fledging and breeding success were 82% (*n* = 82), 95% (*n* = 65), and 80% (*n* = 78), respectively (Table 3).

Brandt's Cormorant (*Phalacrocorax penicillatus*): On 17 August, one adult was observed on a cliff ledge adjacent to and about 50 m northwest of the cave entrance.

Scripps's Murrelet (Synthliboramphus scrippsi): Two nests were found in 2012; (tag #1106 - one bird observed sitting in nest on 17 June; tag #1041B – one egg found in back of crevice on 30 October).

Table 2. Average timing of egg laying, hatching and fledging (mean date ± standard error in days) for Ashy Storm-Petrels at Santa Cruz Island, California, in 2012. Sample sizes in parentheses.

Location[1]	Clutch Number[2]	Egg Laying	Hatching	Fledging
BC	1	14 June ± 3 (70)	27 July ± 4 (67)	14 October ± 4 (61)
BC	2	13 August ± 14 (3)	2 October ± 24 (2)	27 November (1)
CBE	1	5 June ± 6 (19)	14 July ± 6 (16)	29 September ± 6 (15)
CBE	2	24 August ± 12 (3)	24 October (1)	-
CPC	1	11 June ± 9 (4)	25 July ± 9 (4)	13 October ± 9 (4)
OR[3]	1	17 June ± 6 (21)	3 August ± 6 (19)	20 October ± 10 (11)
	2	30 August (1)	-	-
OR[4]	1	18 May (2)	2 July (2)	20 September (1)
All[3]	1	13 June ± 3 (114)	26 July ± 3 (106)	12 October ± 3 (91)
	2	20 August ± 7 (7)	9 October ± 16 (3)	27 November (1)
All[5]	1	12 June ± 3 (116)	26 July ± 3 (108)	12 October ± 3 (92)
	2	20 August ± 7 (7)	9 October ± 16 (3)	27 November (1)

Footnotes -

1 Codes defined in Table 1.

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

3 Natural crevices only.

4 Artificial sites only.

5 Natural and artificial sites.

Table 3. Percent hatching, fledging, and breeding success of Ashy Storm-Petrel nests monitored at Santa Cruz Island, California, in 2012. Sample sizes in parentheses.

		Location[1]							
Success (%)	**Clutch Number[2]**	**BC**	**CBE**	**CPC**	**OR[3]**	**OR[4]**	**OR[5]**	**All[3]**	**All[5]**
Hatching	1	81.7 (82)	63.0 (27)	80.0 (5)	70.4 (27)	28.6 (7)	64.7 (34)	75.9 (141)	74.3 (148)
	2	50.0 (4)	25.0 (4)	-	0.0 (1)	-	0.0 (1)	33.3 (9)	33.3 (9)
Fledging	Last	95.4 (65)	77.7 (18)	100.0 (4)	57.9 (19)	50.0 (2)	57.1 (21)	85.8 (106)	85.2 (108)
Breeding	Last	79.5 (78)	51.8 (27)	80.0 (5)	40.7 (27)	14.3 (7)	35.3 (34)	66.4 (137)	63.9 (144)

Footnotes -

[1] Codes defined in Table 1.
[2] Codes defined in Table 2.
[3] Natural crevices only.
[4] Artificial sites only.
[5] Natural and artificial sites.

Bats: One bat (likely, a Townsend's big-eared bat [*Corynorhinus townsendii*]) was observed flying from the main room to the "pool room" of BC on 17 June.

Skunks: Two skunk traps were deployed on 17 June and removed on 27 November. No evidence that skunks (or any other mammal or bird) entered trap boxes was found. No smell of skunk or evidence of skunk predation was found in 2012.

Predation/Scavenging: Small numbers of Ashy Storm-Petrel eggshell fragments, a feather pile and a carcass were found away from suitable nest sites, as follows: (1) 17 August — 3 partial eggshell fragments; and (2) 30 October — one carcass in pool room, appeared "drowned not eviscerated," two partial eggshells fragments, and two feather piles. These eggshells indicated either: (a) scavenging or predation by deer mouse (*Peromyscus maniculatus santacruzae*) inside nest sites with mice removing some eggshells from nest sites; (b) scavenging by mice of eggshells found outside nest sites; or (c) removal of eggshells from nest sites by some adult storm-petrels after eggs hatch or fail. The feather piles and possibly the carcass likely indicated predation (or attempted predation; carcass) by Barn Owl (*Tyto alba*) or Common Raven.

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 2012, these signs were intact and in their original locations (i.e., unaffected by ocean wave action or vandalism). However, six discrete visitation events by unauthorized persons (n = 14) were documented in 2012. On 17 June, four visitors were observed landing at BC; three kayakers were landing on the cave beach when researchers arrived at BC to monitor nests, and an additional kayaker landed at the beach during nest monitoring (Appendix A). After deploying a reconnaissance camera in the main room of BC on 17 July, four more discrete visitation events by human visitors with sea kayaks were documented on 25 July (2 persons), 2 August (3 persons), 15 August (2 persons), and 20 October (3 persons) (Appendix A). Most visitors remained on the beach and did not pass the sign but a few briefly moved out of camera view beyond the sign.

Cave of the Birds' Eggs

Ashy Storm-Petrel: Twenty-seven nests were documented at CBE in 2012. Twenty-three active nests were observed on 16 August; 14 of these nests (61%) contained chicks, ranging from "small downy" to "fully-feathered." Ranges of mean dates of egg laying, hatching and fledging for single/first eggs were estimated as 23 April – 23 July (range 91 d, n = 19), 6 June – 5 September (range 91 d, n = 16) and 25 August – 30 October (range 66 d, n = 15), respectively. Hatching, fledging, and breeding success were 63% (n = 27), 78% (n = 18), and 52% (n = 27), respectively (Table 3). Some nests may have been affected by a wave wash event in early June (see below).

Pigeon Guillemot (*Cepphus columba*): Twenty-two adults were observed sitting on the water within the cove adjacent to the cave entrance on 16 June. Fourteen nests (*i.e.*, presence of adult bird and/or evidence of egg laying) were documented at CBE in 2012 (Table 4). At least 13 of these nests showed evidence of laying at least one egg, at least four nests showed evidence of laying two eggs, and at least six nests produced at least one chick. Some nests may have been affected by a wave wash event in early June (see below).

Table 4. Nesting activities of Pigeon Guillemots at Cave of the Birds' Eggs, Santa Cruz Island, California, in 2012.

Nest Number	**Monitoring Date**		
	6/16	**7/16**	**8/16**
A1	B/2E[1]	1NHC + 1E	0
A2	B/2E	0	0
B	1B	1SDC + 1LDC	0
C	SDC	0	0
D	B/1E	0	0
737A	1E	Cdd	1E
821	0	B/1E	1E
900A	2SDC	0	0
942	1E	1E	1E
1049	B/1E	B/1E	1E
AA	1E	1E	0
BB	B	1LDC	0
CC	1E	0	0
DD	B	0	0

Footnote -

[1] Codes: B = adult bird, Cdd = dead chick, E = egg only, LDC = large downy chick, SDC = small downy chick, 0 = empty nest.

Skunks: One skunk trap was deployed on 16 June and removed 29 October, and no evidence that skunks (or seabirds what about other species?) entered trap boxes was found. No evidence of skunk predation nor mouse scavenging/predation was found in 2012.

Predation/Scavenging: Limited evidence of apparent avian predation (likely by Western Gull [*Larus occidentalis*] or Common Raven) was detected on 16 June when an adult Pigeon Guillemot carcass (head & body feathers only) and one Ashy Storm-Petrel wing were found. No evidence of scavenging was found.

Human Visitation: No evidence of human disturbance or non-researcher human visitation was detected in 2012.

Wave Wash Event(s): On our first visit on 16 June, the TNC sign (prohibiting cave entry by unauthorized visitors) was found away from its redeployed position within the cave, likely moved by wave action. This sign had been originally deployed in 2009, and had been moved by winter wave action in 2010 and 2011, before being redeployed in both years despite some damage. In 2012, the sign was completely battered and illegible, was removed from the cave on 16 June, and replaced with a new sign on 16 July. In addition, on 16 June two dead Ashy Storm-Petrels (one adult and one small downy chick) with wet plumage were found in the cave away from suitable nest sites, and pools of water were observed in several low lying places in the cave. Three Pigeon Guillemot nests (942, AA, and CC) had failed prior to the 16 June visit but still contained evidence of nesting and also may have been affected by an earlier wave wash event. Evidence of nesting at some other sites may have been washed away without documentation and may have partly accounted for less nests in CBE in 2011 (*n* = 12) and 2012 (*n* = 14) versus 2010 (*n* = 27). However, loss and alteration of habitat also has occurred at the entrance of the cave since 2010 which may have contributed to lower nest numbers if adults could not move to other sites in the cave. It is possible that a wave wash event occurred on about 5-6 June during a period with high tides and strong winds (see discussion); this timing is consistent with possible evidence of a wave wash event at DSB and OR.

Cavern Point Cove Caves

Ashy Storm-Petrel: Five nests were documented in Cave #5 in 2012. Four active nests were observed on 17 August containing chicks, ranging from "small downy" to "large gawky." Ranges of mean dates of egg laying, hatching and fledging for single/first eggs were estimated as 23 May – 29 June (range 38 d, *n* = 4), 5 July – 12 August (range 38 d, *n* = 4) and 23 September – 31 October (range 38 d, *n* = 4), respectively. Hatching, fledging, and breeding success were 80% (*n* = 5), 100% (*n* = 4), and 80% (*n* = 5), respectively (Table 3). Ashy Storm-Petrel nesting activity was not detected in Cave #4.

Scripps's Murrelet: No nests were found in 2012.

Peregrine Falcon (*Falco peregrinus*): Two birds (probable nesting pair) were observed flying above the cove adjacent to the cliffs on 22 March.

Bats: At least eight bats (likely, Townsend's big-eared bats) were observed flying and hanging on the ceiling in Cave #5 on 17 June.

Skunks: Three skunk traps were deployed on 22 March and were probably removed on 30 October (exact date of removal not recorded in notes). No evidence that skunks (or other species) entered trap boxes was found, no smell of skunk, and no evidence of skunk predation was found in 2012.

Predation/Scavenging: No evidence of avian or mouse scavenging/predation was found in 2012.

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

Dry Sandy Beach Cave

Ashy Storm-Petrel: Twelve nests were documented on 16 August 2012 (Table 5), similar to August 1997 (13 nests) and August 2011 (17 nests), and relatively low compared with August 1995 and 1996 (21 and 26 nests, respectively) and mid-summer (i.e., mid-July through August) 1998-2010 (range = 23-56 nests). Eight nests (75%) had adults in incubating posture (i.e., "bird sit in nest") and one nest contained a downy (11-20 d old) chick (Table 5). Two partial Ashy Storm-Petrel eggshell fragments were found away from suitable nest sites, possibly the result of wave wash events or predation/scavenging by deer mice. Approximately 10 nest crevices near the cave entrance also were filled in with gravel. It is possible that a wave wash event occurred on about 5-6 June during a period with high tides and strong winds (see discussion); this timing is consistent with possible evidence of a wave wash event at CBE and OR. Breeding phenology

Table 5. Ashy Storm-Petrel nests at Dry Sandy Beach Cave, Santa Cruz Island, California, on 16 August 2012.

Nest Number	**Nesting Activity[1]**	**Location Within Cave**
511	LDC	front room rockpile
713A[2]	BSIN	front room rockpile
824	1E	front room rockpile
830	B/0	back room
831	B/E	front room rockpile
1054	BSIN	front room rockpile
1057	BSIN	front room rockpile
1058	BSIN	front room rockpile
1061	BSIN	back room
1065	BSIN	front room rockpile
1078	BSIN	back room
1080	BSIN	back room

Footnotes –

[1] Codes: 0 = no egg, B/E = adult bird incubating egg, BSI*N* = adult bird sit in nest (presence of egg not confirmed), 1E = one egg, LDC = large downy chick.

[2] For natural nests with an alphanumeric nest moniker, the letter (e.g., "A" or "B") describes two or more closely associated crevices used in prior years near a numbered nest tag.

and reproductive performance were not measured at DSB in 2012 but the phenology appeared to be late compared to other monitored locations at Santa Cruz Island, possibly due to a wave wash event.

Brandt's Cormorant: On 16 August, approximately 200 birds were observed roosting on the cliff ledge adjacent to and east of the cave entrance. Two dead cormorants were observed floating in the water in the cove adjacent to the cave entrance.

Pigeon Guillemot: No nests were found in DSB on 16 August.

Bald Eagle (*Haliaeetus leucocephalus*): An adult was observed flying high above the cliff adjacent to the cave entrance on 16 August. A blue patagial tag (numbers not seen) was observed on each wing of the bird.

California Sea Lion (*Zalophus californianus*): No sea lions were observed hauled out in the beach area of the cave.

Skunks: Traps were not set in this cave in 2012. No evidence of avian or skunk predation was found in 2012.

Predation/Scavenging: No evidence of avian or mouse predation or scavenging was found in 2012.

Human Visitation: No evidence of human disturbance or visitation was observed. In 2012, the TNC sign remained intact and undisturbed.

Orizaba Rock

Ashy Storm-Petrel Restoration: On 22 March, the vocalization broadcast system was redeployed and activated. During June and July field trips, vocalization broadcast equipment was tested and found to be functioning properly. Ashy Storm-Petrel vocalizations were broadcasted nightly from 22 March to 16 July, when we turned off the broadcast equipment, due to observed disturbance to artificial nest sites by ravens (discussed below). The solar panel and broadcast equipment, including the speakers, were removed on 16 July and 16 August.

On 22 March, 12 Type III artificial nest sites were deployed on the Upper West cavern ledge where they replaced 12 Type Ib sites in the same locations as placed in 2011. In addition, two Type Ib ledge nest sites (A-857 and A-861) were removed in 2012 and two other Type Ib ledge nest sites (A-862 and A-863) were kept in their 2011 locations. Thirteen Type II nest sites were left in 2011 locations on the Upper West Cavern floor (A-847, A-848, A-864, A-865 and A-866), on the Upper West Cavern ledge (A-1066), and on the floor of the Upper East Cavern (A-850, A-867, A-868, A-869, A-870, A-871 and A-890). One Type Ia nest site (A-849) on the small ledge in the Upper East Cavern (which had not been used by storm-petrels in 2008-11) was determined by Harvey not to be usable for nesting by Ashy Storm-Petrels, and was removed on 22 March. In total, 27 artificial nest sites were available for use by Ashy Storm-Petrels immediately after the 22 March 2012 site visit (Upper West Cavern: 20 sites; Upper East Cavern: 7 sites), similar to 29 available artificial sites available on 31 March 2011.

Ashy Storm-Petrel Nest Monitoring: In 2012, 34 nests were monitored at OR, including 27 nests in natural sites and 7 nests in artificial sites (Table 3). Two new natural nests (tags #1146, #1200) were found and tagged in 2012. Twenty-four active nests (natural and artificial) were observed on 16 August 2012; 13 of these nests (54%) contained chicks, ranging from "small downy" to "medium gawky." For all sites, ranges of mean dates of egg laying, hatching and fledging for single/first eggs were estimated as 27 April – 27 August (range 122 d, n = 23), 10 June – 9 October (range 122 d, n = 21) and 29 August – 28 December (range 122 d, n = 11), respectively. For natural sites, hatching, fledging, and breeding success were 70% (n = 27), 58% (n = 19), and 41% (n = 27), respectively (Table 3). For artificial nest sites, hatching, fledging, and breeding success were 43% (n = 7), 50% (n = 2), and 14% (n = 7), respectively. For all sites (natural and artificial sites combined), hatching, fledging, and breeding success were 65% (n = 34), 57% (n = 21), and 35% (n = 34), respectively (Table 3). Eight chicks were determined to be missing before possible fledge, including seven chicks from natural sites in the Lower Cavern (n = 6) and the Upper West Cavern (n = 1), and one chick from an artificial nest site (A-847B) in the Upper West Cavern.

Ashy Storm-Petrel Use of Artificial Nest Sites: By 16 July 2012 (when raven impacts were discovered), 10 artificial sites had evidence of use by Ashy Storm-Petrels. Eggs were laid in at least seven monitored sites, and adults were detected at three other sites which likely laid eggs (Table 6; see raven impacts below). Two of these artificial nest sites (A-847B and A-863) hatched chicks in 2012, but only the chick from site A-863 fledged (Table 6). Seven sites with adults observed had been used or visited during at least one year between 2008 and 2011. At A-

865 (bird incubating an egg), 2012 was the first year of activity at this site that had been first deployed in 2008 (Table 6, Appendix B).

Table 6. Ashy Storm-Petrel activities at 10 artificial nest sites at Orizaba Rock, California, in 2012.

	Monitoring Date				
Nest Number	**6/15**	**7/16**	**8/16**	**9/10**	**9/30**
A-847A	B/E[1]	0	-[2]	-	-
A-847B[3]	B/E	LDC	0	0	0
A-848A	0	Ebk	0	0	0
A-858	B/E	0	-	-	-
A-860B	BSIN	0	-	-	-
A-863	B/E	LDC	SGC	MFC	0
A-865	B/E	0	-	-	-
A-868	0	F	-	-	-
A-871	0	F	-	-	-
A-1067	B/E	0	-	-	-

Footnotes –

1 Codes: 0 = no activity, B/E = adult bird incubating egg, BSI*N* = adult bird sit in nest (presence of egg not confirmed), Ebk = broken egg, F = feathers, LDC = large downy chick, MFC = mostly feathered chick, SGC = small gawky chick.

2 Dashes indicate removal of artificial nesting structure by researchers on 16 July, due to raven impacts.

3 Artificial nest numbers followed with a "B" were nests associated with a numbered artificial nest structure (indicated by an "A"). These "B" nests were found behind, under (e.g., in a crevice) or beside artificial nest structures.

Raven Impacts to Artificial Nest Sites: On 16 July, we observed that 22 of the 27 artificial nest sites in the upper caverns had been altered since the previous visit on 15 June, presumably by at least one raven (Figure 4; Appendix B). Four artificial nest sites with adults incubating eggs on 15 June (A-847A, A-858, A-865, A-1067) were empty on 16 July, with adults and eggs undoubtedly lost to raven predation (Table 6). At A-860B, an adult was noted on 15 June that likely was incubating but it was not determined if an egg was present on this date; we suspect strongly that an adult and egg were lost at this site. At A-848A, a broken egg was found on 16 July; we suspect strongly that an adult and egg also were lost at this site. Storm-petrel feathers found at two artificial sites (A-868, A-871) on 16 July which also most likely indicated losses of adults and eggs at each site, although direct evidence of egg laying was not obtained. Chick loss prior to fledging in A-847B also likely reflected raven predation between 16 July and 16 August. In all nine cases, raven predation likely occurred during daylight hours because they have not been detected in caverns during nocturnal periods. Almost all storm-petrels in nest sites during daylight hours in June and July are adults attending eggs or chicks and only the odd adult or subadult attends sites during the day without eggs or chicks at this time of year (W.R. McIver and H.R. Carter, pers. obs.). We suspect that egg laying occurred in three sites (A-848A, A-868,

(a) 

(b) 

(c) 

Figure 4. Artificial nest sites in the “Upper West Cavern” at Orizaba Rock, California, altered by Common Ravens between 16 June and 16 July 2012: (a) overview photo of Upper West Cavern; (b) altered “Type III” nests on ledge; and (c) altered “Type II” nests on floor.

and A-871) where eggs had not yet been laid by 15 June, and that these eggs were laid prior to site alterations. To prevent the possibility of any further use of compromised artificial sites which might lead to further predation of eggs, chicks or adults, 23 altered artificial nest sites were removed and vocalization broadcasting was stopped on 16 July (Appendix B). In summary, 7-9 nests in artificial sites were lost to raven predation, involving losses of 5-8 eggs, 2-8 adults and 1 chick.

Two artificial nest sites (A-851 and A-852) on the ledge in Upper West Cavern remained intact but were removed on 16 July. Four artificial nest sites (A-847, A-848, A-862, A-863) with chicks or eggs also were not removed on 16 July. Site A-863 contained a large downy chick, and researchers placed large rocks in front of the entrance to attempt to protect the chick from predation by ravens. A chick was present in A-847B (i.e., in the crevice below A-847A), and a broken egg was observed at A-848A. In order to provide protection for remaining chicks and eggs associated with artificial sites, these 4 sites were not removed on 16 July. However, ceramic lids were either kept off (A-847) or removed by researchers (A-848) to discourage Ashy Storm-Petrels from using these sites. One artificial site (A-848) in which activity was observed in 2012 was not altered by ravens in 2012 (Appendix B). These four sites were not removed on 19 November (Appendix B), even though no nesting activity was observed at these sites on this date or on 29 October; an explanation as to why these sites were not removed (as were all the other artificial sites) was not recorded in the field notes.

Evaluation of Storm-Petrel Nocturnal Behaviors: On 22 March 2012, one video camera was deployed in the Upper West Cavern. On 15 June, the pelican case housing and the majority of recording equipment was observed to be wet, likely because it had been washed by a large wave or series of large waves. As a result, the recording equipment malfunctioned and nocturnal video footage was not obtained in 2012.

Brown Pelican (*Pelecanus occidentalis*): Adults and immatures (ages combined) were recorded roosting as follows: a) 22 March — 150-175 birds; b) 10 September — 200 birds; and c) 19 November — 45 birds.

Brandt's Cormorant: Adults and immatures (ages combined) were recorded roosting as follows: a) 22 March — 5 birds; b) 16 August — 25 birds; c) 30 September — 10 birds; d) 29 October — "a few" birds; and e) 19 November — 20 birds.

Black Oystercatcher (*Haematopus bachmani*): Oystercatchers were recorded as follows: a) 22 March — 5 birds; b) 15 June — 1 nest with a 1 downy chick; c) 16 August — 3 birds and 1 carcass found (possible Peregrine Falcon kill; see "Avian Predation" below); d) 10 September — 25 birds; e) 30 September — 10 birds; and f) 19 November — 12 birds .

Cassin's Auklet: Four occupied nest sites were documented in 2012 (Table 7). Eggs were observed in two sites. A bird was observed in one site on 22 March and 15 June, suggesting either that a chick hatched but did not fledge or a replacement egg was laid after failure of the first egg but did not hatch. A chick was observed in one site on 15 June. Some nesting activities may have occurred at OR between 22 March and 15 June that were missed. On 16 August, a dead adult was found in the Lower Cavern near nest sites #32 and #33.

Table 7. Cassin's Auklet nests at Orizaba Rock, Santa Cruz Island, California, in 2012.

Nest Number	Monitoring Date			Clutch Number	Egg Hatch	Chick Fledge
	3/22	**6/15**	**7/16**			
33	0[1]	0	EF	1	0	0
49	1B	1B	0	(1/2)[2]	(0/1)[2]	0
1021	B/E	B/E	Eab	1	0	0
S-320	ND	B/C	ND	1	1	Unk

Footnotes -
[1] Codes: B = adult bird, C = chick, Eab = abandoned egg, EF = eggshell fragment, ND = no data, 0 = empty or zero, Unk = unknown.
[2] Either number in parentheses can be inferred from data (see text).

Elegant and Royal Terns (*Sterna elegans* and *S. maxima)*: Adults and immatures (ages combined) were recorded roosting as follows: a) 16 August — 25 birds; b) 10 September — 60 birds; c) 30 September — 75 birds; and d) 29 October — "a few" birds.

Heermann's Gull (*Larus heermanni*): Adults and immatures (ages combined) were recorded roosting as follows: a) 16 August — 1 bird (immature); b) 30 September — 20 birds (most immature); c) 29 October — "a few" birds; and d) 19 November — 10 birds.

Western Gull: No information on Western Gull nests at OR in 2012 was provided in field notes. Adults and immatures were recorded roosting as follows: a) 16 August — 5 immature birds; b) 30 September — 5 adults and 1 immature bird; and c) 29 October — "a few" birds.

Common Raven: A reconnaissance camera documented ravens in the upper caverns at OR on 7 days from 20 July through 24 September: 3 days in July; 2 days in August; and 2 days in September (Appendix C). Ravens apparently did not visit the Upper West Cavern between 23 March and 8 April, when Ashy Storm-Petrels were observed in nocturnal images taken by the camera. A single raven was observed in six of the images, and three ravens were observed in one image. In the Upper West Cavern, raven behaviors included apparent investigations of natural crevices in the floor, Type Ib sites on the ledge, and the reconnaissance camera. No images were taken by the camera between 9 April and 16 July; thus, the camera either malfunctioned or was not properly turned on. Before and after the 15 June visit, batteries and the memory card were changed. Consequently, we have no images from the camera of ravens during the time period when nests were altered (16 June – 16 July). Ravens also were recorded roosting on or flying by OR as follows: a) 22 March — 0 birds; b) 15 June — no observations in notes, presumably 0 birds; c) 16 July — no observations in notes, presumably 0 birds; d) 16 August — 3 birds roost; e) 10 September — 1 bird; f) 30 September — 2 birds on Santa Cruz Island proper; g) 29 October — 2 birds flying westward; and h) 19 November — no observations in notes, presumably 0 birds.

Predation: Evidence of avian predation was detected, as follows: a) 15 June — 3 distinct storm-petrel feather piles (2 in lower cavern and 1 adjacent to A-868); b) 16 July — storm-petrel feathers found at sites A-868 and A-871 and eggs were missing from A-847A, A-858, A-865 and A-1067; and c) 16 August — 1 storm-petrel feather pile at west entrance of Upper West Cavern, 1 dead auklet found near sites #32 and #33, and 1 oystercatcher carcass (sternum picked clean) found at OR. Storm-petrel and auklet carcasses likely were killed by ravens but the oystercatcher carcass appeared to have been killed by a Peregrine Falcon.

Wave Wash Event(s): On the first visit on 22 March, the CINP sign (prohibiting access to OR by unauthorized visitors) and supporting cinder blocks were found tipped over; it was righted and found to be in good shape. On 15 June, the sign and cinder blocks were missing. In addition, the protective plastic "pelican case" (that housed a computer, timer and batteries) was wet. The protective plastic case was deployed at a location approximately 3 m below and west of the Upper West Cavern, at an approximate height of 6 m above mean sea level. In addition, the CINP sign and cinder blocks also were missing on 15 June. The sign had been deployed at a location on OR approximately 20 m east of the upper nesting caverns, at an approximate height of 8 m above mean sea level. Loss of the sign and cinder blocks and the wet pelican case indicated that at least one wave washed over portions of OR between 22 March and 15 June. Nesting habitats in the lower cavern and upper caverns, or elsewhere on the rock, were not described as being wet or otherwise possibly having been washed by waves. It is possible that a wave wash event occurred on about 5-6 June during a period with high tides and strong winds (see discussion); this timing is consistent with possible evidence of a wave wash event at CBE and DSB. However, the timing of mean egg laying was not much different between OR (17 June) and other reference sites (5-14 June; Table 1), suggesting that this event may not have affected any or only a few nests at OR. Nesting areas at OR are located in caverns which are less exposed to waves than the exposed location of the sign which is in an area of high rock erosion likely from wave action.

Hatching, Fledging, and Reproductive Success

Hatching, fledging, and breeding success for Santa Cruz Island (all four monitored locations in 2012 combined) are summarized in Table 3. In 2012, overall breeding success at natural and artificial sites combined was 64% (n = 144) (Table 3).

Recruitment Study

A total of 37 Ashy Storm-Petrel chicks were fitted with PIT-tag bands at Santa Cruz Island in 2012, including one chick that fledged from an artificial nest site (A-863), as follows: BC (n = 28); CBE (n = 5); DSB (n = 1) and OR (n = 3) (Appendix D).

DISCUSSION

Reproductive Performance

Reproductive performance in seabirds is one key demographic variable that should be measured for assessing population growth conditions and population changes over time and can be influenced by food availability, pollutants, weather, and predation (Schreiber and Kissling 2005, Lewis et al. 2009). Habitat factors at breeding colonies that influence reproductive performance in storm-petrels include predation by native and non-native predators, nest site quality and disturbance (Warham 1990, Stenhouse and Montevecchi 2000, De León and Mínguez 2003). At Santa Cruz Island, spatial and temporal variation in breeding success of Ashy Storm-Petrels has been observed in the 12 years (i.e., 1995-1998; 2005-2012) when reproductive success has been examined. To evaluate the success of management actions such as colony restoration actions, reproductive performance should be measured annually at several locations and reasons for variation assessed.

At Santa Cruz Island, reproductive performance of Ashy Storm-Petrels is affected primarily by success or failure during the incubation stage, similar to other storm-petrels (Warham 1990). At Southeast Farallon Island, James-Veitch (1970) reported that disappearance of parents and/or desertion of chicks, and predation affected success or failure of Ashy Storm-Petrel chicks. However, this early study in the late 1960s was intensive and involved near daily nest checks, as well as being conducted during a period of relatively high organochlorine contaminant levels, both factors likely affecting hatching and fledging success to some degree (Coulter and Riseborough 1968; Ainley et al. 1990). In 1971-1983, Ainley et al. (1990) found higher hatching and fledging success at Southeast Farallon Island with much less disturbance during monitoring; in this study, most nest failures of Ashy Storm-Petrels also occurred during incubation with pollutants likely having little effect by the early 1980s. Improved breeding success at Santa Cruz Island in 2005-11, compared to 1995-98, has resulted from higher hatching success and is consistent with: a) reduced levels of organochlorine contaminants which may no longer reduce breeding success of Ashy Storm-Petrels on a population level at least by 2008; and b) reduced avian predation in 2005-12 compared to 1995-97. However, higher hatching success rates at Santa Cruz Island are based on nests examined and do not account for many nests lost due skunk predation on adult storm-petrels during events at BC in 2005 and CPC in 2008.

In 2012, hatching success (74%; n = 148), fledging success (85%; n = 108), and breeding success (64%; n = 144) at Santa Cruz Island overall continued to be higher than in 1995-98, but 2012 values were lower than in 2005-11. At BC in 2012, breeding success was relatively high (i.e., higher than in 1995-97 and similar to 2006-11), in spite of a major reduction in colony size due to the skunk predation event in 2005. At CBE in 2012, breeding success (52%; n = 27) was the lowest ever recorded at this location, although other low years occurred in 1995 (55%, n = 11) and 2005 (56%, n = 18). Wave wash events may account for several nest failures, and little predation was noted. Bright lights from squid fishing did not occur in waters immediately adjacent to CBE in 2012, which occurs within the Painted Cave State Marine Conservation Area. At OR in 2012, breeding success (natural and artificial sites combined; 35%, n = 34) was the second lowest on record; the lowest value occurred in 1996 (22%, n = 27) but was also low in 1997 (43%, n = 7), both years when bright lights from squid boats were noted nearby (Carter et al. 2008a).

In 2012, reproductive performance at OR was lower than other locations monitored at Santa Cruz Island in 2012, as also noted in 1995-98. Hatching success at OR in 2012 (65%, n = 34) was higher than in 2010 (57%, n = 28) but lower than in 2011 (70%, n = 33). However, fledging success at OR in 2012 (58%, n = 19) was much lower than 2010 (83%, n = 18) and 2011 (80%, n = 20). We did not find any dead chicks in or outside of crevices, and starvation likely was not the cause of death of chicks that did not fledge. Before fledging, storm-petrel chicks are able to walk to the entrance of nest crevices or short distances from their nesting crevice (Mínguez 1997). Such behavior probably put Ashy Storm-Petrel chicks at greater risk of predation by ravens. Natural crevices with chicks that were observed missing before possible fledge in 2012 (n = 7) were generally deep or inaccessible enough to prevent ravens from picking them directly out of the back of crevices. The reconnaissance camera at OR malfunctioned or was not properly turned on periodically throughout the 2012 breeding season, but ravens were documented inside caverns at OR near nest sites during the incubation and chick stages from July through late September. The number of Ashy Storm-Petrel feather piles found at OR in 2012 (n = 6) was the highest ever found there during one year, including 1996 (n = 2), the year of the lowest breeding success of Ashy Storm-Petrels at OR. We suspect that ravens were responsible for reduced breeding success of Ashy Storm-Petrels at all sites (natural and artificial) at OR in 2012.

Wave Wash or High Water Events at CBE and DSB

At CBE, numbers of nests (n = 27) in 2012 were similar to 2008-09 (n = 28-29) but greater than 2010-11 (n = 21-24). At DSB, relatively low numbers of nests in August 2012 (n = 12) matched the low 2010 count (n = 12), the lowest number of nests observed in mid-summer since monitoring began in 1995. We suspect that wave wash or high water events are responsible for reduced breeding at CBE and DSB in 2010-12.

On our 16 June visit to CBE, the inside of the cave was observed to be wet in many areas, including the presence of standing water in low lying areas, and two dead storm-petrels (one adult, one small downy chick) were found in the middle portion of the cave near the north wall. Both carcasses were relatively fresh and not deteriorated, indicating recent death. In addition, the TNC sign (and cinder block to which it was attached) was found battered and located farther inside the cave, away from its deployment location. Together, these observations indicate that a large wave(s) likely entered the cave. We suspect that wave wash events may have occurred when large waves (over 2.0 m) occurred during strong winds (up to 30-35 nautical miles per hour) during high tides (over 5 feet above mean lower low water) in the evenings of 5 and 6 June. In addition, nesting might have been disrupted at as many as three Pigeon Guillemot nests at CBE, as a result of a wave or high water event. On 16 June, we detected storm-petrel nests with eggs, and guillemot nests with chicks, in crevices that occurred towards the portion of the cave nearest the cave entrance. The wave(s) did not inundate all active nesting crevices towards the front portion of the cave, and apparently certain physical characteristics at particular nest sites (e.g., location under or behind large boulders, orientation of nest entrance) allowed certain nesting crevices to escape inundation by waves.

At DSB in 2012, reduced numbers of active nests and delayed egg laying were observed. Active nests also occurred only in the rockpile at the rear portion of the main room of the cave and in the elevated back portion of the cave. Many previously-marked nest crevices near the cave entrance were filled in with gravel. In addition, the TNC sign mounted on a post near the cave entrance was not disturbed. At DSB, two large boulders and a tide pool occur at the cave's entrance, and likely attenuate most large wave events from washing much of the inner portions of the cave. Together, these observations suggest that a wave event may have affected nests at DSB through a broad front of rising water near the cave entrance. The lack of dead adult storm-petrels also supports this mechanism for impacts to nests from wave events, with adults able to escape from rising water. The open sloping nature of nesting habitats in this portion of the cave near the entrance also may have led to little or no evidence remaining of lost eggs and chicks which likely were washed back out to sea.

More work is needed to investigate wave wash events at CBE and DSB which occurred in 2010-2012 prior to the start of standardized nest monitoring in June. Egg laying usually begins in late April and early May. When higher than normal tides are predicted between late April and early June, earlier monitoring trips in April and May should be scheduled at these locations to allow for better assessment of potential nest losses due to high water events. If such impacts can be better documented in the future, we might reconsider that reproductive performance in 2012 was estimated to be higher than the true value, especially if many breeding pairs affected did not relay after nest loss. Also if such events are increasing in frequency or severity (e.g., possibly related to sea level rises associated with climate change), future restoration actions could be taken to prevent colony extirpation and maintain adequate reproductive performance.

Restoration at Orizaba Rock

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

Historical Colony Size: Between 1995 and 2012, the highest recorded number of Ashy Storm-Petrel nests at OR was documented in 2012: 34 total nests in natural (n = 27) and artificial (n = 7) sites. Prior to restoration efforts initiated in 2008, the highest recorded number of Ashy Storm-Petrel nests at OR was documented in 1996: 27 nests in natural sites. Lower numbers of nests were found at OR on single day visits in July 1976 and July 1994 (Hunt et al. 1979; HRC, unpubl. data). Carter et al. (2008a) suggested that lower breeding success and population size of Ashy Storm-Petrels may have occurred in the Channel Islands from the 1950s to 1970s, when organochlorine contaminant levels were much higher and greatly affected Brown Pelicans and Double-crested Cormorants (*Phalacrocorax auritus*) (Gress et al. 1973, Gress 1995). Given documented eggshell thinning and hatching failures of Ashy Storm-Petrels at Santa Cruz Island in 1992-97 (McIver 2002, Carter et al. 2008b), higher numbers of Ashy Storm-Petrels may have historically bred at OR than were documented in 1996. As many as 48 different natural crevices were used for nest sites on OR during at least one year from 1995 through 2011, although these sites likely vary in terms of their suitability for successful chick fledging, and some crevices are periodically created or filled in as a result of small rock slides. Without detailed monitoring of all potential natural crevices and their use by Ashy Storm-Petrels in the past, we cannot specifically measure if greater, similar or lower availability or suitability of natural crevices occurred in the past compared to 1995-2011. However, McIver and Carter consider that overall habitat conditions in 1995-97 were very similar to 2005-12 and that a similar number of natural crevices were available during these periods.

Raven Alteration of Artificial Nest Sites: Common Ravens altered the majority of artificial sites between 15 June and 16 July. Raven impacts caused nest failure in 6-9 altered artificial sites, may have prevented egg laying and visitation in other artificial sites, and caused deaths of 2-8 adults. While Common Ravens also altered some artificial nest sites at OR in 2010 and 2011, reproductive performance did not appear to be substantially affected in these years and no adults were killed. In 2011, we fortified artificial nest sites by deploying Type II sites on the floors of the upper caverns, and Type Ib sites on the Upper West Cavern ledge. These modifications were successful at preventing ravens from altering sites and reducing breeding success of Ashy Storm-Petrels at OR in 2011.

In 2012, structural aspects of Type III and Type II sites likely facilitated alteration of sites by ravens:

(1) front pieces of Type III sites on the ledge were attached to nest bodies with pliable electrical wire, which ravens were able to grab and cut the wire with their bills;

(2) Type III nests deployed on the ledge in 2012 weighed less than Type Ib sites deployed in 2011 and Type I sites deployed in 2008 and 2009. Using the electrical wire as a handle, ravens also pulled sites off their deployed locations on the ledge either during the cutting of the wire or afterwards; and

(3) lids of Type II sites on cavern floors were removable, with a slotted lid design that used a plastic bar to lock the lid in place. In 2011, the bar at one artificial site (A-865) broke off but the lid was kept in place with added weight from a brick placed on top. We forgot to remove this site in fall 2011 and replace it with a properly functioning lid before the 2012 season. We also forgot to remove it in early 2012. Ravens apparently moved the brick securing the damaged lid in 2012 and once the lid was knocked off they could also grab the edge of the top opening and pull the artificial site off of its deployed location.

We suspect that once ravens were "rewarded" with bird(s) and/or eggs from Type III ledge sites in 2012 they then spent more time in the caverns attempting to open more artificial sites and possibly also obtained eggs, chicks or adults from some adjacent natural sites. With more time and energy, ravens were able to alter Type II sites on the floor. However, due to apparent malfunctions to the reconnaissance camera between mid-April and mid-July 2012, reconnaissance camera footage is missing to more thoroughly evaluate raven presence between 16 June and 16 July when alterations occurred.

Based on images from the reconnaissance camera, ravens apparently did not visit the Upper West Cavern during the day or night between 23 March and 8 April, although pre-laying Ashy

Storm-Petrels were present at night. Due to camera problems at OR between 9 April and 16 July, we do not know exactly when ravens disturbed the artificial habitat, nor can we evaluate how the dismantling of artificial sites progressed, including numbers of ravens involved and over how many days these activities took place. In addition, we have incomplete information on raven visitation throughout the breeding season, and so comparisons to 2011 are incomplete. In contrast to 2012 when one reconnaissance camera was deployed, three reconnaissance cameras had been deployed in the upper caverns in 2011, which allowed for more complete coverage of the cavern, and provided backups in case of camera failures.

Increase in Colony Size: Numbers of active nests of Ashy Storm-Petrels at OR increased between 2006 and 2012 (Figure 5). Before restoration actions (2005-07), only 7-14 nest sites were documented at OR; during the first 4 years of restoration actions (2008-11), higher numbers (24-33) occurred, similar to or greater than 1995-97 (8-27 sites).

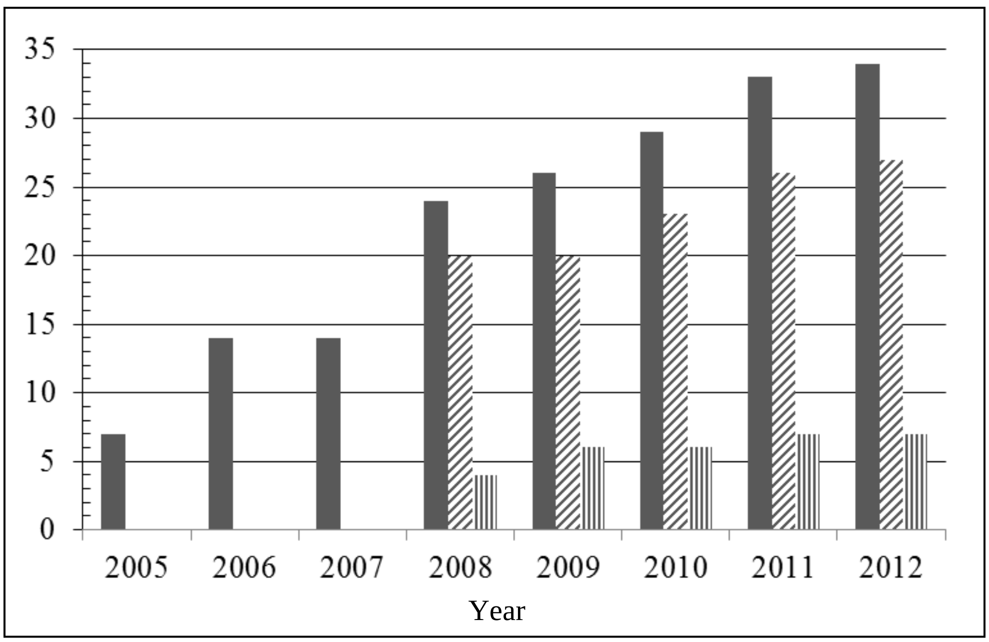


Figure 5. Numbers of Ashy Storm-Petrel nests at Orizaba Rock, Santa Cruz Island, California, in 2005-12. Artificial nest sites were deployed beginning in 2008. Codes: dark bars = total sites; diagonally-striped bars = natural sites; and vertically-striped bars = artificial sites.

However, an increase in the number of nests in natural sites also appeared to occur from 2005 to 2007, likely indicating some natural recovery in this colony just prior to restoration actions. We consider that a portion of this increase in use of natural sites between 2007 (n = 14) and 2012 (n = 27) likely is partly accounted for by continued natural recovery of the OR population in 2008-12, and use of artificial sites also may partly reflect this natural recovery. However, vocalization broadcasting likely increased the rate of increase in natural site use and likely was mainly responsible for use of artificial sites located near speakers. The rapid rate of increase in total sites from 2005 to 2012 was consistent with enhanced natural recovery and the increase may not have been sustained between 2008 and 2012 without restoration actions. We could not ascertain how much of the overall increase in nests from 2005 to 2012 may have occurred without restoration actions. Raven impacts to artificial and natural sites in 2012 led to reduced reproductive performance and adult deaths which likely will impact population size in the future.

Use of Artificial Sites: In 2012, signs of continued success with the use of artificial nest sites at OR by Ashy Storm-Petrels included: (1) continued breeding in association with six artificial sites used in 2008-11, regardless of replacement or modification of these sites when retained in the same locations; (2) breeding at 1 artificial site (A-865) not used in 2008-11; and (3) likely breeding in 2 other sites (A-860B and A-871) not used in 2008-11. While 7 nests had evidence of eggs or chicks in both 2011 and 2012, 3 other nests apparently were depredated by ravens prior to documentation of egg laying in 2012, suggesting continued expansion of use of artificial sites from 2008 to 2012.

Nesting in artificial sites located near speakers in 2008-12 suggested that Ashy Storm-Petrels were attracted to vocalizations and bred in nearby suitable nest sites. By deploying artificial sites, we increased the number of suitable nest sites on OR. Since artificial sites were more protected than most natural sites on OR, we also increased the number of higher quality nest sites at OR in 2008-2011 (i.e., until 2012 when serious raven impacts developed). The majority of artificial sites where Ashy Storm-Petrels laid eggs from 2008 through 2012 were within approximately 3 m of the speaker in the Upper West Cavern. By placing these suitable cavities in proximity to the speaker, we likely facilitated the rapid use of these artificial sites that were located in a part of the cavern with few if any natural sites.

Alteration of many Type II and III artificial nest sites by ravens in 2012 (as well as Type I artificial sites in 2010) demonstrated that artificial nest site designs used at OR in 2008-12 have been inadequate at providing long-term protection for nesting Ashy Storm-Petrels at OR. However, we have learned a great deal from these early designs and discovered that significant impacts from ravens can occur. Our work in 2008-12 has informed the development of Type IV artificial habitat in 2014 that has removed design flaws from Type III sites and uses larger, heavier and more costly artificial sites in an expanded effort to prevent raven impacts (D. Mazurkiewicz, pers. comm.). However, the time and effort required to conduct tests, develop the Type IV design, and deploy Type IV sites resulted in a lack of artificial sites at OR in 2013. In addition, vocalization broadcasting has not been conducted in 2013 and 2014. These factors may slow or reduce the use of Type IV artificial habitat in 2014 and beyond. Continued monitoring is needed to evaluate the success of Type IV sites without vocalization broadcasting for nesting use by Ashy Storm-Petrels and for preventing raven impacts at OR. If raven impacts are prevented but use of sites is relatively low, resuming vocalization broadcasting could be reconsidered in the future to stimulate increased use of Type IV nest sites or later models.

Breeding Success. Higher breeding success at OR in 2005-11 was accompanied by lower pollutant levels, lower avian predation, reduced squid fishing in southern California, and possibly reduced squid fishing off the north side of Santa Cruz Island. In 2012, breeding success was lower at OR, due to raven impacts to artificial and natural sites. Breeding success at OR in 1995-2012 also remained lower than other Santa Cruz Island reference sites, which may reflect differences in breeding habitats (e.g., more egg loss at OR from eggs rolling out of nest sites), predation (e.g., higher raven predation at OR due to greater exposure of nest sites to ravens or raven attraction to restoration activities) or exposure to bright lights from squid fishing. However, other factors (e.g., skunk predation events and wave wash events) likely have impacted breeding success at reference sites at many nests that were not monitored for breeding success.

Skunk Predation at Sea Caves

Bat Cave: Skunks were not detected during monitoring at OR and sea caves in 1995-2004. At least two island spotted skunks somehow gained access to BC in 2005 and at least 70 adult or sub adult Ashy Storm-Petrels were killed, mainly before the egg laying period (although a few depredated eggshells were noted), resulting in a lack of successful breeding in the cave that year (McIver and Carter 2006). Numbers of active nests were greatly reduced to only 19 active nests in 2006 but have increased rapidly to 82 nests in 2012 (Table 8), the second highest number of nests ever observed at this location, exceeded only by 1996 (n = 97) (McIver 2002, McIver et al. 2009b). BC appears to have recovered rapidly from the skunk predation event for four main reasons: (1) the relatively large floor area and high roof of this cave apparently allowed many adults or perhaps almost all subadults to escape during 2005 predation events; (2) the relatively large population size and relatively high reproductive performance at this cave prior to the predation event likely provided relatively high recruitment for at least five years after the event; (3) relatively low avian predation in 2005-12 compared to 1995-97; and (4) skunks did not access the cave in 2006-12. The same number of nests in 2010 and 2011 likely reflected little or no recruitment in 2011 (due to the lack of successful breeding in 2005 and low numbers of nests in 2006). The jump in nest numbers between 2011 and 2012 likely reflected an increase in recruitment due to increased breeding in 2007-2008.

Table 8. Numbers of Ashy Storm-Petrel nests at Bat Cave and Cavern Point Cove Caves in 2006-12.

	Year						
Location[1]	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
BC	19	28	35	48	60	61	82
CPC	12	14	1[2]	2	0	2	5

Footnote -

[1] Codes: BC = Bat Cave; CPC = Cavern Point Cove Caves.

[2] Only one depredated egg was documented at a nest site but others may have been removed by skunks without leaving broken eggshells behind.

Cavern Point Cove Caves: Skunks were not detected during monitoring in 1995-2007, but at least two island spotted skunks gained access to CPC in 2008 (McIver et al. 2009a). In 2008, at least 32 adult or subadult Ashy Storm-Petrels were killed mainly before laying eggs, resulting in a lack of successful breeding that year (McIver et al. 2009a). Only 14 nests had been documented at this small colony in 2007; the loss of 32 adults or subadults therefore appeared to represent most breeders and some future breeders. In 2009, only two active nests (#54 and #1040 in Cave #5) were found. In 2010, no active nests were found. In 2011, the same two nests were active as in 2009; in addition, a bird was observed without evidence of egg laying at a new tagged site

(#1111) in Cave #5. In 2012, a total of five nests were found, all in crevices in which nesting previously has been observed, and chicks fledged from four of these sites. In contrast to BC, CPC appears to be experiencing a slower or reduced natural recovery from the skunk predation (Table 8). We suspect that few adult and subadult storm-petrels escaped skunk predation at CPC in 2008, due to the small cavern floor areas and low ceilings of these two caves that allowed fewer birds to escape than at BC in 2005. Skunks that entered CPC also were likely more able to quickly investigate available nesting habitats and potentially prey upon both adults of each nesting pair and many subadults, compared to BC where one or both adults escaped and possibly many subadults escaped. Future monitoring is needed to determine if and when this colony recovers.

Overview: In 1991-2004, skunk predation of Ashy Storm-Petrels had not been recorded at Santa Cruz Island during surveys and monitoring (Carter et al. 1992; McIver 2002; W.R. McIver and H.R. Carter, unpubl. data). Island spotted skunks occur only on Santa Cruz Island and Santa Rosa Island, although they historically also occurred on San Miguel Island. In recent years, island spotted skunk population numbers at the island have increased dramatically, possibly in response to reduced numbers of island foxes (*Urocyon littoralis santacruzae*), changes in island vegetation, or other factors (Bakker et al. 2005, Jones et al. 2008). Although recent population estimates are not available, Jones et al. (2008) reported that island skunk populations were at unnaturally high densities on Santa Cruz Island as recently as 2004. We are not aware of any recent estimates of population size of island spotted skunks at Santa Cruz Island, but based on a review of recent information (Coonan 2012), densities or population numbers of spotted skunks at Santa Cruz Island still appear to be elevated, compared to the 1990s (i.e., prior to the decrease in island fox numbers, when island spotted skunk population numbers were lower). In 2010, island fox population numbers at Santa Cruz Island were estimated at about 1,300 total individuals (about 800 adults), compared to historical estimates of 1,465 individuals (Coonan 2011, Friends of the Island Fox 2011). As the fox population at Santa Cruz Island recovers, island spotted skunks numbers may decrease, but this interaction will need to be tracked with future monitoring (Coonan and Guglielmino 2012). In 2012, no island spotted skunks were detected or captured in any of the Ashy Storm-Petrel colonies, but continued preventative efforts (i.e., trapping and possibly artificial nest sites) and monitoring will be necessary to ensure that these locations remain free of skunk impacts. Continued annual monitoring at BC and CPC is needed: (1) to evaluate the process of recovery of Ashy Storm-Petrel populations from such mortality events; and (2) to measure the frequency of skunk occurrence and impacts at these locations.

Avian Predators

During monitoring in 1995-98, Barn Owls were well documented as predators of Ashy Storm-Petrels at Santa Cruz Island, specifically at BC, CPC, CBE, and OR (McIver 2002). However, during monitoring in 2005-11, predation by Barn Owls was rarely observed. Western Gulls are known predators of Ashy Storm-Petrels at Southeast Farallon Island when both breed in the same parts of the island (Ainley et al. 1990, Sydeman et al. 1998a). At Santa Cruz Island, single Western Gulls have been rarely observed to fly inside sea caves during nest monitoring and only a few pairs of gulls nest on OR, with little evidence of gull predation on seabirds there (McIver 2002). Peregrine Falcons are commonly observed near Ashy Storm-Petrel breeding locations at the bases of steep cliffs at Santa Cruz Island (McIver 2002; McIver et al. 2011, unpubl. data). Falcon predation of storm-petrels at breeding colonies may occur on late-departing storm-petrels at first light or predation may occur at sea near colonies before storm-petrels move farther offshore to forage.

Common Ravens are frequently observed in coastal habitats at Santa Cruz Island, have been documented in sea caves (e.g., CBE in 1997 [McIver 2002]), and were suspected of depredation of Ashy Storm-Petrels and Pigeon Guillemots in CBE in 2005-08 (McIver and Carter 2006; Carter et al. 2007; McIver et al. 2008, 2009). In 2010-12, ravens were observed on OR and documented with cameras to regularly visit the upper caverns at OR, where artificial nest sites were deployed (McIver et al. 2011, 2013; this study). Reasons for apparently higher raven visitation of OR in 2010-12 may have partly reflect: (1) attraction to the rock by night-long broadcasting of Ashy Storm-Petrel vocalizations during the breeding and pre-breeding seasons in 2008-2012; (2) restoration equipment (i.e., solar panel, artificial nests, cameras); (3) short monthly visits (3-5 hours per visit) by researchers for nest monitoring and restoration work; (4) increased raven populations at Santa Cruz Island; (5) ravens breeding near OR; and/or (6) increased curiosity of ravens related to increased campground feeding. At OR in 2012, we documented six distinct feather piles in the upper caverns, indicating at least six Ashy Storm-Petrels were killed by an avian predator. We did not detect any down feathers within feather piles, which would have indicated that a non-fledged chick had been preyed upon. However, we cannot discount the possibility that ravens may have preyed upon as many as eight Ashy Storm-Petrel chicks that were missing before possible fledging. In addition, one Cassin's Auklet carcass was found in the lower cavern, also indicating avian predation. Unlike 2011, modifications to artificial habitat in 2012 did not provide adequate protection to storm-petrels inside nest sites from avian predators, especially ravens.

Ravens have been recorded as common breeders at Santa Cruz Island for at least 120 years (Blake 1887, Garrett and Dunn 1981). 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 (Blake 1887). In the late 1980s, ranching ceased on most of the island when management began by TNC. Since the late 1990s, ranching ceased on the east end of the island when management began by CINP but large numbers of campers and day visitors now occur, especially on weekends, at Scorpion Ranch. Ravens are known to be adept at obtaining food from campgrounds, including using techniques such as opening cardboard boxes and coolers, and unzipping backpacks. Vermeer et al. (1993) suggested that predation of Pigeon Guillemots by Northwestern Crows (*Corvus caurinus*) may have been related to crows following researchers. At least two ravens became experienced with opening artificial structures at OR in 2010-12 and possibly learned to access human structures through foraging in camping areas at the east end of Santa Cruz Island. Lack of detection of raven activities at OR in 2008-09 may have reflected: (1) a period of learning (e.g., during which ravens watched researchers entering and departing from caverns at OR); or (2) regular undetected raven occurrence at OR between our visits. In any case, ravens occur regularly in adjacent coastal habitats near OR. Researchers entered caverns monthly in 1995-97 and 2005-06 without noting raven occurrence on OR, although some predation events assigned to Barn Owls may have been raven-related. Lower breeding success at OR in 1995-97 and 2005-11 also may be related partly to greater exposure to avian predators, especially ravens and Barn Owls.

Compared to 1995-98, relatively low levels of storm-petrel predation by avian predators (i.e., few carcasses or feather piles) at BC, CPC and DSB occurred in 2012, as was also noted in 2005-11. However, lower numbers of breeding storm-petrels also occurred at BC since 2005 and at CPC since 2008, due to skunk predation events. At CBE, predation in 2005-08 was higher than in 2009-12 or 1995-98. More work is needed to summarize and assess past predation data in 1995-2004 for comparison to 2005-12 data. At BC, Barn Owls may have switched to hunting elsewhere when storm-petrel numbers were reduced in 2005. Future monitoring of predation during storm-petrel nest monitoring will generally assist our understanding of the frequency and type of predation upon storm-petrels. However, to fully examine potential avian predator impacts, greater effort also would be needed to better assess predators through predator surveys and analysis of prey remains at nests and roosts away from storm-petrel colonies.

Pigeon Guillemots at CBE

Numbers of Pigeon Guillemot nests found at CBE in 2012 (n = 14) were comparable to 2011 (n = 12), but less than 2010 (n = 21), possibly due to nest loss without documentation in 2011-12 during wave wash events. Only 7-10 nests were found in 2006-09 when extensive predation of adults occurred. Seven (50%) of 14 nests may have had one egg clutches, possibly suggesting many first-time breeders (Asbirk 1979). However, we could not confidently determine clutch size with monthly monitoring visits that began in June. Six (43%) of 14 nests hatched at least one chick. Only one out of eight chicks noted was found dead in the cave and the rest likely fledged. A wave wash event likely occurred in early June at CBE and contributed to reduced breeding success of Pigeon Guillemots in 2012. To date, numbers of breeding guillemots at CBE recorded in 2005-2012 do not appear to have directly affected Ashy Storm-Petrels, but some storm-petrel nest sites may be usurped by increased numbers of guillemot nests in the future.

Cassin's Auklets at OR

Four nest sites of Cassin's Auklet were found at OR in 2012 compared to two nests in 2011 and five nests in 2010. Auklets at OR did not appear to directly affect Ashy Storm-Petrels, but some storm-petrel nest sites may be usurped by auklets in the future, especially if auklet numbers increase. Ainley et al. (1990) found that interference by Cassin's Auklets at nest sites reduced reproductive success of storm-petrels. Two of the sites occupied by Cassin's Auklets in 2012 (#49 and #1021) are commonly used by auklets and storm-petrels in most years. Continued availability of protective artificial habitat for Ashy Storm-Petrels could reduce interspecific competition at natural crevices at OR.

Human Visitation

Natural and artificial nesting habitats at OR and in sea caves are fragile and prone to movement or collapse if carelessly stepped upon. During the breeding season (April-November), storm-petrel adults, chicks, and eggs within nest sites also are vulnerable to being crushed or disturbed by unaware human visitors at or near nest sites. Through direct observation during our June nest monitoring trip, and indirectly through use of a reconnaissance camera, we documented five separate instances of human visitation to BC in 2012. All visitors accessed the cave via sea kayaks, apparently launched from nearby Scorpion Anchorage. One visitor was observed to move past the visitation sign, towards storm-petrel nesting habitat in the main room of the cave and out of the field of view of the camera. In general, each instance of visitation to BC was relatively short in duration, lasting only a few minutes, and most stayed on the beach area. We did not observe adverse effects to nesting habitat in BC after these visitations. When non-researcher visitors were interviewed by researchers on the June nest monitoring trip, the visitors indicated that they had not been informed of cave closures or of seabirds nesting in the sea caves.

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Appendix A. Human visitation at Bat Cave, Santa Cruz Island, California, 17 June – 20 October 2012.

Date	Time	No. of visitors	Observations
17 June[1]	12:00	3	Upon arrival of researchers to monitor Ashy Storm-Petrel nesting activities at Bat Cave, one group of three kayakers were observed landing at the cobble beach adjacent to the main entrance of the cave.
17 June[1]	14:00	1	During nest monitoring activities, researchers observed at least one kayaker land at the cobble beach adjacent to the main entrance of the cave. The visitor was interviewed, and stated that he/she (gender not provided in notes) attended an orientation by Island Packers but that there was no mention during the orientation of nesting birds or cave closures.
25 July[2]	13:30-13:34	2	One group of two kayakers entered the main entrance of the cave at 13:30. At first, they stood by the large rock directly in front of the camera (near the "Area Closed" sign) then one of the kayakers went farther into the cave past the camera view (past the sign) and out of sight. They both left the cave by 13:34.
2 August[2]	14:27-14:28	3	One group of three kayakers shown in images from the camera. They arrived at 14:27, stood in the front of the cave and looked around. One of the kayakers walked farther into the cave, but was still in view of the camera. They left the cave at 14:28.
15 August[2]	11:26-11:28	2	One group of two kayakers shown in images from camera. One person stayed only in the front of the cave, the other came up to look at the camera, then they both left. They were in the cave for about 2 minutes.
20 October[2]	13:40	3	One group of 3 kayakers entered the cave as far as the sign, scratched their heads while looking at it, and turned around and left (after urinating on camera).

Footnotes -

[1] Human visitors detected by researchers during monthly Ashy Storm-Petrel nest-monitoring trip.

[2] Human visitors detected by reconnaissance camera (see Methods) deployed in BC on 17 July 2012.

Appendix B. Artificial site use by Ashy Storm-Petrels at Orizaba Rock, Santa Cruz Island, California, in 2008-12. Dashes indicate that artificial site was not deployed, or no applicable data.

Nest Number	**Initial Deployment (Year/Type)**	**Later Fortification (Year/Type)**	**Nest Fates[2]**					**Date Removed**
			2008	**2009**	**2010**	**2011**	**2012**	
A-847A	2009/Ia[1]	2011/II[2]	-	U/f	0[3]	0	0[3]	not removed
A-847B	-	-	-	-	U/f	U/mbf	U/mbf	-
A-848A	2009/Ia	2011/II	-	0	0	0	0	not removed
A-848B	-	-	-	-	-	U/b	U/dnh	-
A-849	2009/Ia	-	-	0	0	0	-	3/22/2012
A-850	2009/Ia	2011/II	-	0	0[3]	0	0[3]	7/16/2012
A-851	2008/Ia	2008/Ia	0	0	0	0	0	7/16/2012
A-852	2008/Ia	2008/Ia	0	0	0	0	0	7/16/2012
A-853A	2008/Ia	2008/Ia	0	0	0	0	0[3]	7/16/2012
A-853B	-	-	U/f	U/f	U/dnh	0	0	-
A-854	2008/Ia	2011/Ib 2012/III	0	0	0	0	0[3]	7/16/2012
A-855	2008/Ia	2011/Ib 2012/III	0	0	0[3]	0	0[3]	7/16/2012
A-856	2008/Ia	2011/Ib 2012/III	0	0	0[3]	0	0[3]	7/16/2012
A-857	2008/Ia	2011/Ib 2012/none	0	0	0[3]	0	-	3/22/2012
A-858	2008/Ia	2011/Ib 2012/III	0	0	0	U/f	U/dnh[3]	7/16/2012
A-859	2008/Ia	2011/Ib 2012/III	0	U/f	U/mbf	0	0[3]	7/16/2012
A-860A	2008/Ia	2011/Ib 2012/III	0	0	U/dnh[3]	U/f	0[3]	7/16/2012
A-860B	-	-	-	-	-	-	V	-

Nest Number	Initial Deployment (Year/Type)	Later Fortification (Year/Type)	Nest Fates[2]					Date Removed
			2008	2009	2010	2011	2012	
A-861	2008/Ia	2011/Ib 2012/none	0	0	0[3]	0	-	3/22/2012
A-862	2008/Ia	2011/Ib	0	0	0	0	0[3]	not removed
A-863	2008/Ia	2011/Ib	0	V	U/f[3]	U/mbf	U/f[3]	not removed
A-864	2008/Ia	2011/II	0	0	0[3]	0	0[3]	7/16/2012
A-865	2008/Ia	2011/II	0	0	0[3]	0	U/dnh[3]	7/16/2012
A-866	2008/Ia	2011/II	0	0	0[3]	0	0[3]	7/16/2012
A-867	2008/Ia	2011/II	0	0	0[3]	0	0[3]	7/16/2012
A-868	2008/Ia	2011/II	U/f	U/f	U/d[3]	0	0[3,5]	7/16/2012
A-869	2008/Ia	2011/II	U/dnh	U/dnh[4]	V[3]	U/f	0[3]	7/16/2012
A-870	2008/Ia	2011/II	0	0	V[3]	0	0[3]	7/16/2012
A-871	2008/Ia	2011/II	0	0	0[3]	0	0[3,5]	7/16/2012
A-890	2009/Ia	2011/II	-	0	0[3]	0	0	7/16/2012
A-1000[6]	-	-	U/dnh	U/dnh	0	0	0	-
A-1066	2010/Ia	2011/II	-	-	-	0	0	7/16/2012
A-1067	2010/Ia	2011/Ib 2012/III	-	-	-	U/f	U/dnh[3]	7/16/2012
A-1068	2010/Ia 2011/Ib	2011/Ib 2012/III	-	-	-	0	0[3]	7/16/2012
A-1069	2010/Ia 2011/Ib	2011/Ib 2012/III	-	-	-	0	0[3]	7/16/2012

Footnotes –

1 For definitions of types of artificial sites (Ia, Ib, II, III), see methods and results.

2 Codes: 0 = no activity, b = egg broken, d = chick died, dnh = egg did not hatch, f = chick fledged, mbf = chick missing before fledge, U = site used, V = site visited only (no egg laying).

3 Nest site physically altered by ravens (McIver et al. 2011; this report).

4 Two egglaying attempts at this site in 2009; first egg and replacement egg did not hatch.

5 Evidence of predation at site (i.e., storm-petrel feathers found at site); egg laying likely.

6 >1 m from a nearest artificial nest structure but still considered related to an artificial site.

Appendix C. Reconnaissance camera observations of Common Ravens at Orizaba Rock, Santa Cruz Island, California, in 2012[1].

Date	Time	Picture No.	Notes	Viewing Location
7/20/2012	1312-1347	61-350	1 raven enters and checks out camera, walks off screen to interior of cavern, back out and eventually 2 more ravens arrive in cavern. Investigating upper shelf to right and directly in front of camera for approx. High count of 3 ravens, 35 min	South from interior of Upper Cavern
7/20/2012	1445-1528	351-600	3 ravens arrive and investigate cavern, eventually knocking over camera at14:54	South from interior of Upper Cavern
7/21/2012	1348-1351	601-610	1 raven	South from interior of Upper Cavern
7/26/2012	1636-1637	611-615	1 probable raven	South from interior of Upper Cavern
8/6/2012	1453-1500	621-630	1 raven	South from interior of Upper Cavern
8/23/2012	1708	0056-65	1 raven	West toward A-862/863 from inside Upper Cavern
9/3/2012	1426	66-70	1 raven	West toward A-862/863 from inside Upper Cavern
9/24/2012	1306	0036-0040	1 raven	South from interior of Upper Cavern

Footnotes –

[1] Reconnaissance camera was deployed on 22 March 2012, and was operational at least through 8 April. Thereafter, the camera experienced periodic malfunctions, and so raven visitation at OR was incompletely documented. In 2011, three reconnaissance cameras were deployed at OR; in 2012, only one camera was deployed.

Appendix D. Banding and PIT-tag information for 41 Ashy Storm-Petrel chicks at Santa Cruz Island, California, in 2012.

Location[1]	**Nest Number**	**Date**	**Chick Plumage Stage[2]**	**USGS Band Number**	**PIT-tag Band Identification Number**
BC	1017[3]	7/17/2012	SGC	4501-41726	-
BC	818[3]	7/17/2012	SGC	4501-41727	-
BC	802[4]	7/17/2012	MGC	4501-41729	-
BC	1123	8/17/2012	MGC	1401-56268	985121021085157
BC	1090	8/17/2012	SGC	1401-56272	985121021086006
BC	1017[3]	8/17/2012	MFC	4501-41726	985121021086464
BC	1074	8/17/2012	MGC	1401-56279	985121021086640
BC	1041A	8/17/2012	SGC	1401-56271	985121021105067
BC	1093	8/17/2012	MGC	1401-56267	985121021113826
BC	1092	8/17/2012	SGC	1401-56274	985121021116802
BC	1118	8/17/2012	MGC	1401-56281	985121021128415
BC	1119	8/17/2012	SGC	1401-56276	985121021129493
BC	1046	8/17/2012	LGC	1401-56282	985121021130185
BC	835-W	8/17/2012	SGC	1401-56277	985121021132246
BC	1043	8/17/2012	SGC	4501-41730	985121021141370
BC	1018	8/17/2012	MGC	1401-56278	985121021142783
BC	818[3]	8/17/2012	LGC	4501-41727	985121021143112
BC	1071	8/17/2012	MGC	1401-56270	985121021146271
BC	1091	8/17/2012	MGC	1401-56273	985121021158983
BC	1100	9/13/2012	MFC	1401-56308	985121021127829
BC	1099	9/13/2012	LGC	1401-56309	985121021131574
BC	837	9/13/2012	MGC	1401-56307	985121021132277
BC	1044	9/13/2012	MGC	1401-56305	985121021142383
BC	1045	9/13/2012	MGC	1401-56306	985121021145552
BC	1106	10/30/2012	MGC/LGC	1401-56318	985121021129260
BC	1042	10/30/2012	MGC	1401-56313	985121021144408
BC	1156	10/30/2012	SGC	1401-56314	985121021144692
BC	1121	10/30/2012	MGC	1401-56312	985121021145407
BC	1019	10/30/2012	FFC	1401-56311	985121021157056
BC	823	10/30/2012	SGC	1401-56315	985121021159477
BC	1112	10/30/2012	SGC	1401-56317	985121021161315
CBE[5]	1087	7/16/2012	SGC	4501-41723	-
CBE	718	7/16/2012	MGC	4501-41724	-
CBE	719	7/16/2012	SGC	4501-41725	-
CBE	942B	9/10/2012	SGC	1401-56301	985121021117995
CBE	828	9/10/2012	MFC	1401-56302	985121021142442

Location[1]	Nest Number	Date	Chick Plumage Stage[2]	USGS Band Number	PIT-tag Band Identification Number
CBE	769	9/10/2012	MGC	1401-56303	985121021146996
CBE	844	9/10/2012	LGC	1401-56304	985121021158976
CBE	1198	9/30/2012	SGC	1401-56310	985121021147513
DSB	511	8/16/2012	LGC	1401-56263	985121021146252
OR	1148	8/16/2012	LGC	1401-56264	985121021104657
OR	1149	8/16/2012	LDC	1401-56265	985121021129212
OR	A-863[6]	8/16/2012	SGC	1401-56266	985121021144918

Footnotes –

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

2 Codes: LDC = large downy chick (11-20 d); SGC = small gawky chick (21-30 d); MGC = medium gawky chick (31-45 d); LGC = large gawky chick (46-60 d); MFC = mostly-feathered chick (61-75 d); and FFC = fully-feathered chick (76+ d).

3 Chick banded on 7/17/2012 with USGS metal band and banded with PIT-tag band on 8/17/2012.

4 PIT-tag band not applied because chick not present in crevice on dates subsequent to initial banding with USGS band.

5 PIT-tag bands not applied to chicks in CBE on 8/17/2012, due to time constraints during nest monitoring.

6 Artificial nesting habitat.