

Año Nuevo State Park Seabird Conservation and Habitat Restoration: Report 2013

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I. Introduction

The main goals of Oikonos' activities at Año Nuevo State Park (ANSP) are to conserve seabird populations, nesting habitat, and prey resources. The 2013 season was the **21st consecutive year** of long-term seabird studies at ANSP (initiated by ANSP and Point Blue Conservation Science in 1993). In 2013, Oikonos Ecosystem Knowledge continued the time-series and documented the population size, nesting success and diet of the dominant breeding seabirds on the island and the mainland cliffs. Oikonos also continued restoration efforts and habitat studies, including installing more native plants and raising boardwalks to protect seabird habitat.

Specific objectives included:

- Track the population status of seabirds breeding on the island and mainland,
- Improve nesting habitat quality on the island and document success of the restoration,
- Investigate bio-indicators of prey and ocean conditions, and
- Contribute to education and outreach

Summary: 2013 Highlights

- Most species experienced **above average nesting success** in 2013, likely in response to an increase in juvenile rockfish and Northern Anchovy abundance.
- The **Rhinoceros Auklet breeding population** was stable (264 breeding birds) with an increase in the number nesting in natural burrows in the planted restoration area.
- The **Cassin's Auklet population** continued to grow rapidly, with a new record of 102 breeding birds.
- For the first time **clay modules** were occupied by the smaller auklet species - Cassin's Auklet.
- We spent 540 hours pulling invasive weeds and the **native plant cover** increased to 56% in the summer of 2013.

II. Seabird Population Status & Breeding Success

In 2013, we focused on quantifying the breeding population size and nesting success of the dominant breeding seabirds - **Rhinoceros Auklets, Cassin's Auklets, Brandt's Cormorants, Pelagic Cormorants, and Western Gulls**. In addition, we documented breeding attempts of **Pigeon Guillemots, Black Oystercatchers, Ashy Storm-petrels** and **Common Ravens**. Incidental monitoring continued on Double-crested Cormorants and Canada Geese, non-breeding species (mainly Brown Pelicans), and predatory birds foraging on the island. In 2013, we continued to investigate the influence of winter condition on Rhinoceros Auklet breeding metrics for Ryan Carle's graduate thesis at Moss Landing Marine Laboratories.



Rhinoceros Auklets (*Cerorhinca monocerata*, RHAU) were first documented breeding on Año Nuevo Island in 1982 (LeValley and Evens 1982). The population increased and fluctuated annually (Fig. 1) with an estimated total island population of **264 breeding birds** in 2013. Approximately 92% of the population (242 birds) bred in the habitat restoration area of the central terrace.

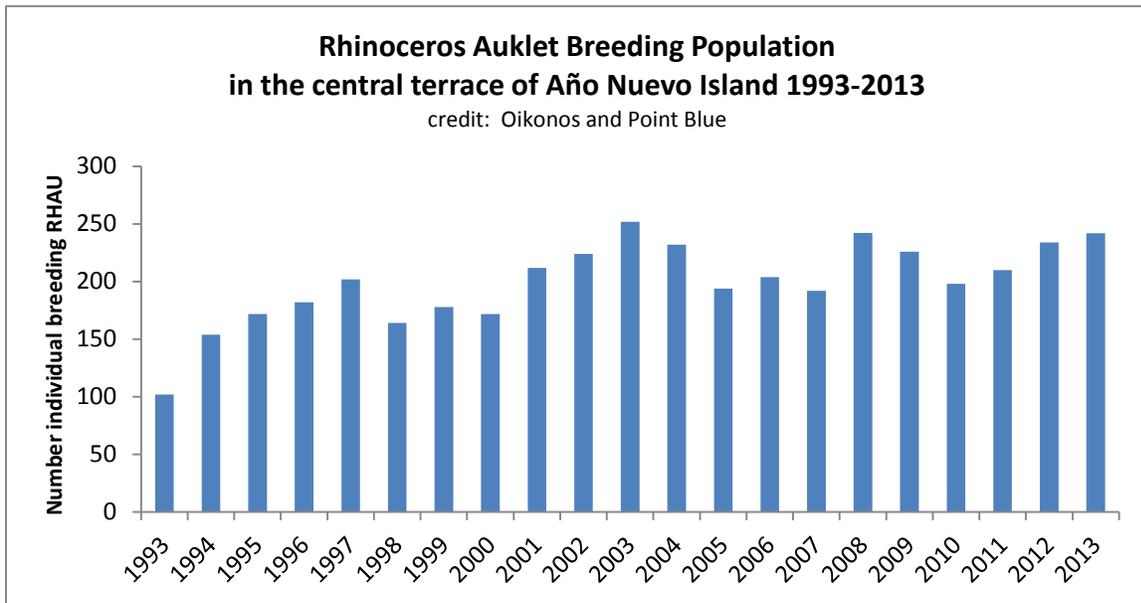


Figure 1. The number of individual breeding Rhinoceros Auklets in the central terrace area on Año Nuevo Island (ANI) from 1993 to 2013. The central terrace is the site of habitat restoration efforts where approximately 92% of ANI Rhinoceros Auklets nest.

RHAUs on ANI attempt to raise one chick a year in long underground soil burrows they excavate themselves and in clay modules buried underground (see Appendix 5 for nest module project details and page 18 for utilization by breeders). The long term average for Rhinoceros Auklet productivity in natural and artificial sites combined from 1995-2012 was 0.56 chicks. In 2013 nesting success was above average and 83% of the parents that laid eggs in burrows raised a chick to the fledging stage (Fig. 2). While Rhinoceros Auklets are able to feed on a diversity of prey and have never experienced extreme breeding failure on ANI, chick consumption of two fish species that were abundant in 2013 have been correlated with improved breeding (see Prey Studies page 16).

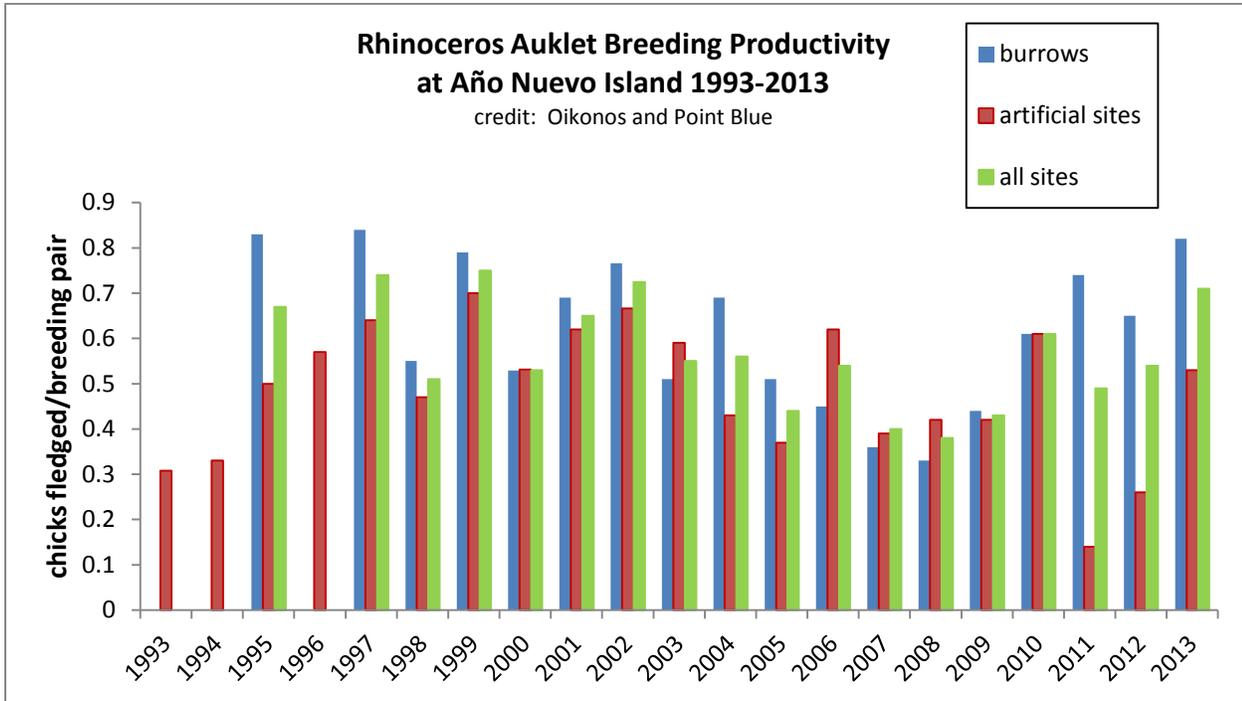


Figure 2. The average number of Rhinceros Auklet chicks fledged per breeding pair in natural (blue bars) and artificial sites (red bars) on Año Nuevo Island annually from 1995 to 2013. From 1993 to 2010, the artificial sites were buried boxes built with wood and plastic tubes. In 2011, all wooden boxes were replaced with new clay modules designed specifically for the species.



Cassin's Auklets (*Ptychoramphus aleuticus*, CAAU) were first found breeding on Año Nuevo Island in 1995 (Hester and Sydeman 1995). This population has grown rapidly from 2010-2013 (Fig.3).

CAAU nest in three locations on the island: (1) under the historic boardwalk west of the Cistern (39% of 2013 population), (2) in burrows along the east side of the Lightkeeper's Residence (14% of 2013 population), and (3) in the burrows and clay modules in the central terrace restoration area (39% of 2013 population). The

number of CAAU pairs breeding in the restoration area has increased every year since plants were restored in 2010. This is likely because the vegetation now offers more visual cover from predatory Western Gulls, and possibly because the growing population is expanding into new nesting areas.

For the first time in 2013 two years after installation, CAAU bred in clay modules designed for the larger Rhinceros Auklets (see Appendix 5 for nest module details). Two pairs of CAAU successfully fledged chicks from the modules, demonstrating that the new clay designs are suitable breeding sites for this species. Rhinceros Auklets may out-compete the smaller CAAU for these sites, so future habitat enhancement for CAAU could include installing modules specifically designed for the smaller species.

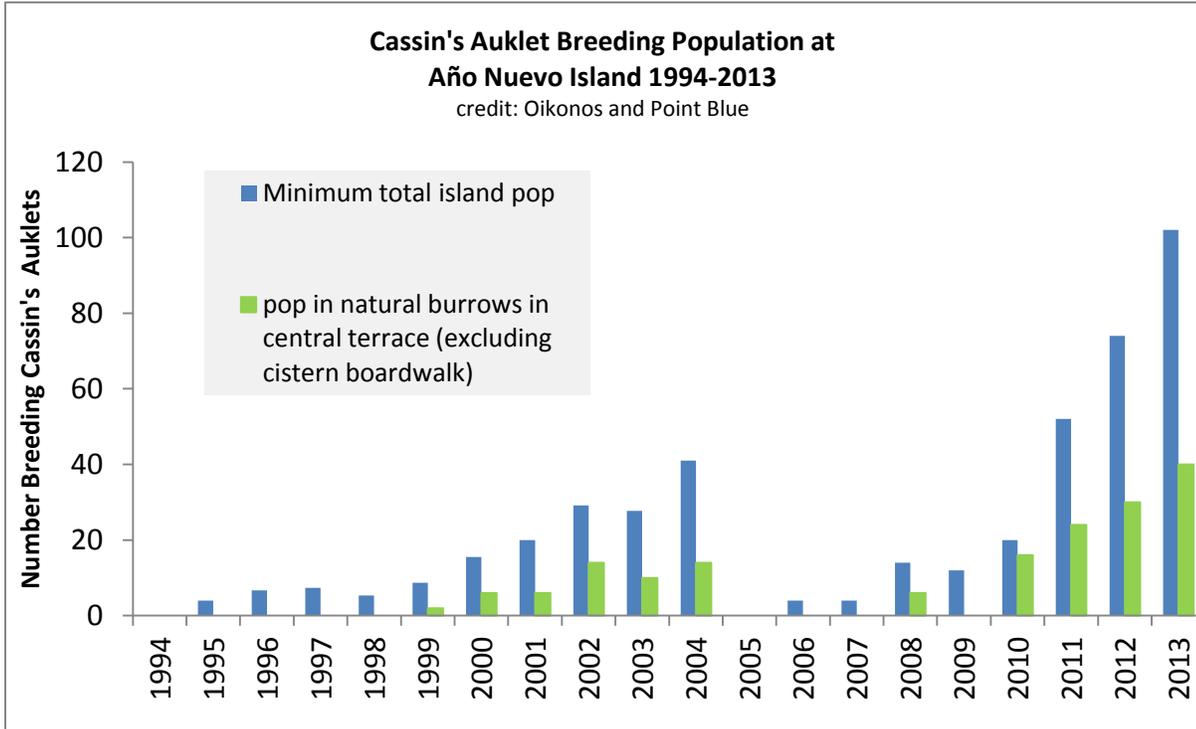


Figure 3. The estimated number of individual breeding Cassin's Auklets on Año Nuevo Island annually from 1994 to 2013. (Blue stacks = all of island, Green stacks = central terrace restoration area, excluding under cistern boardwalk).

Breeding conditions were favorable for CAAU in the period from 2010-2013. In each year during this period, Cassin's Auklet pairs successfully raised two consecutive chicks in one season (termed double-clutching), and experienced above average productivity and population growth. The double-clutching and the high productivity per breeding pair (Fig. 4) indicated sufficient availability of prey, such as krill and larval rockfishes.

While CAAU are benefitting from the restored central terrace habitat, their main nesting area (a steep cliff under a disintegrating historic boardwalk) could be destroyed in a single southern storm event. Proposed habitat enhancement efforts include encouraging breeders to move back from the cliff to habitat with stable soil around the Cistern. Possible techniques to make this area attractive include planting and installing smaller nest modules specifically designed for CAAU.

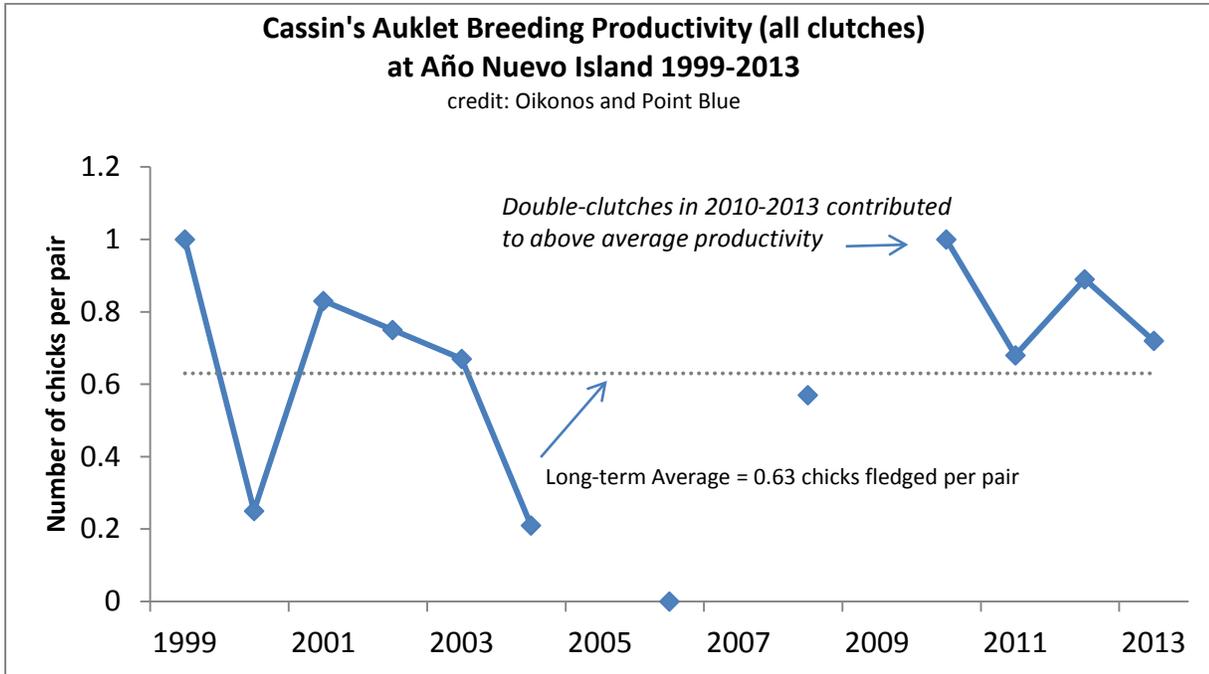


Figure 4. Cassin's Auklet productivity (chicks fledged/breeding pair) at Año Nuevo Island 1999-2013. All accessible nests were monitored. Sample size varied from 1 (2006) to 43 (2013) pairs per year. In 2005 no CAAU were found nesting. CAAU nested at ANI in 2007 and 2009 but nests were not checked often enough to quantify productivity.



Pigeon Guillemots (*Cephus Columba*, PIGU) prefer to nest in rock crevices in vertical cliffs or on bluff edges and often lay 2-egg clutches. Accessible PIGU breeding sites on the island only were monitored by burrow camera and inaccessible sites were surveyed for adults carrying fish (indicating chick provisioning). The population visible from the central terrace was counted once a week (approximately 70% of the total island).

PIGU nesting activity at Año Nuevo Island was recorded in 1976 (Carter et al. 1992). While numbers were high in the 1970s and early 1980s (up to 70 pairs), the breeding population at ANI has steadily declined (Fig. 5), possibly in response to Western Gull densities, the erosion of adequate crevices, and competition for the remaining sites with Rhinoceros Auklets. In 2013, we recorded 7 active nest sites with pairs attending multiple times, 4 of which were confirmed breeding by an observation of eggs, chicks or prey delivery.

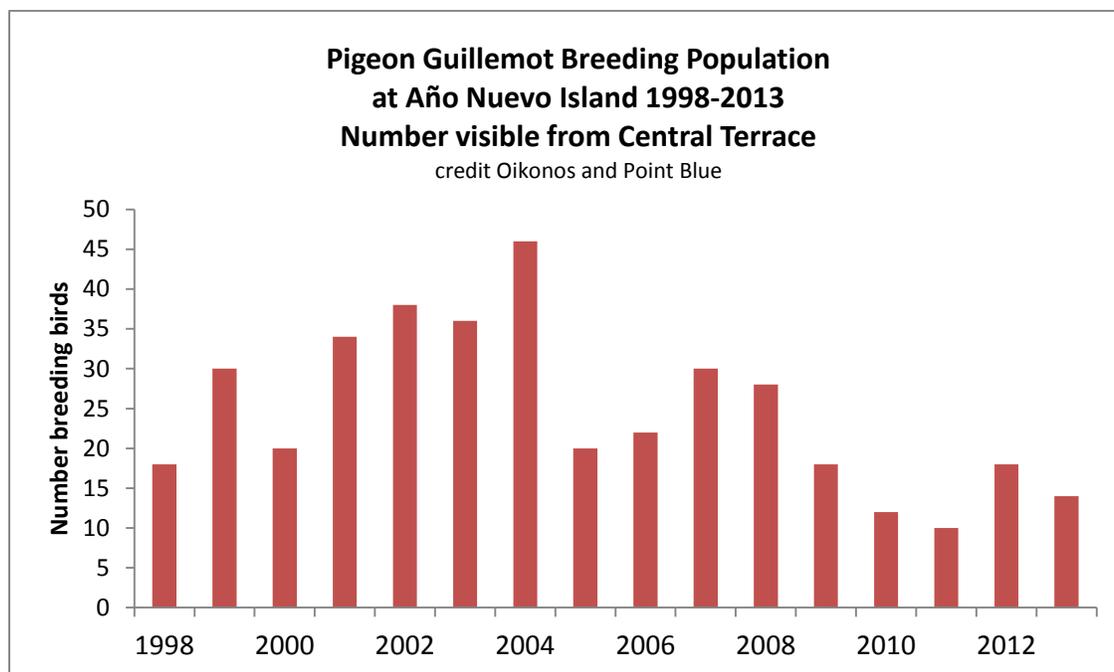


Figure 5. The estimated population of breeding Pigeon Guillemots on Año Nuevo Island visible from central terrace observation points (approximately 70% of the island) from 1998 - 2013.



Brandt's Cormorant (*Phalacrocorax penicillatus*, BRAC) nesting was first documented at Año Nuevo Island in 1989 (Carter et al. 1992). Numbers of Brandt's Cormorants that attempt to breed vary annually due to their ability to have larger and variable clutch sizes (up to five eggs per pair/nest) and to adjust their effort based on food availability (Ainley and Boekelheide 1990). To document the total island population trends, aerial photographs were taken by Oikonos and others during peak incubation. We will coordinate with Point Blue and U.S. Fish and Wildlife Service to standardize photo counting methods when funding

becomes available. A sub-sample of nests were followed each year from both the Light tower and Blind 17 sub-colonies to quantify productivity.

The sub-colonies visible from ground observation points on the island have been monitored annually since 1999 (Fig. 6; also see map below). In 2013, there was an increase in the size of the sub-colony at the Light Tower area as the birds utilized the wind and visual protection of the *Habitat Ridge* (Fig. 6; also see Appendix 5 for *Habitat Ridge* details). BRAC productivity was a record 2.52 chicks per pair in 2013 (Fig. 7). The high productivity and population numbers in 2013 marked a return to pre-2008 levels at the island. From 2008-2012 productivity had been well below average at 0.89 chicks per pair (± 0.36 SD; long term average 1999-2013 1.52 ± 0.76 SD). These recent patterns in BRAC productivity may have been influenced by the local abundance of an important prey species, the northern anchovy (*Engraulis mordax*). Based on RHAU diet (*Prey Studies* section, Fig. 13) and mid-water trawl surveys in the central coast (Wells et al. 2013), northern anchovy was scarce from 2008-2012, but increased in abundance in 2013.

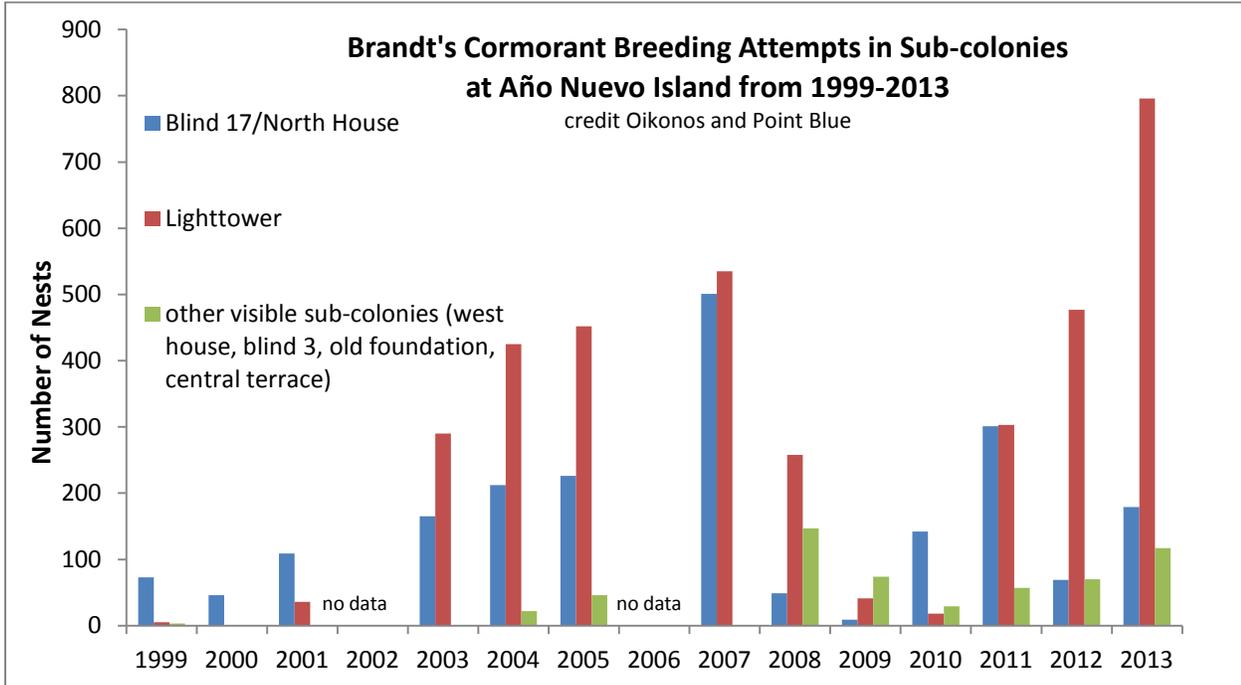


Figure 6. The maximum annual count of breeding attempts (nests) by Brandt's Cormorants on Año Nuevo Island by sub-colony (see map on next page) from 1999 to 2013. Counts are the maximum number of nests with incubating birds or chicks observed from standardized observation points on the island. Data are missing for 2002 and 2006 sub-colony counts.

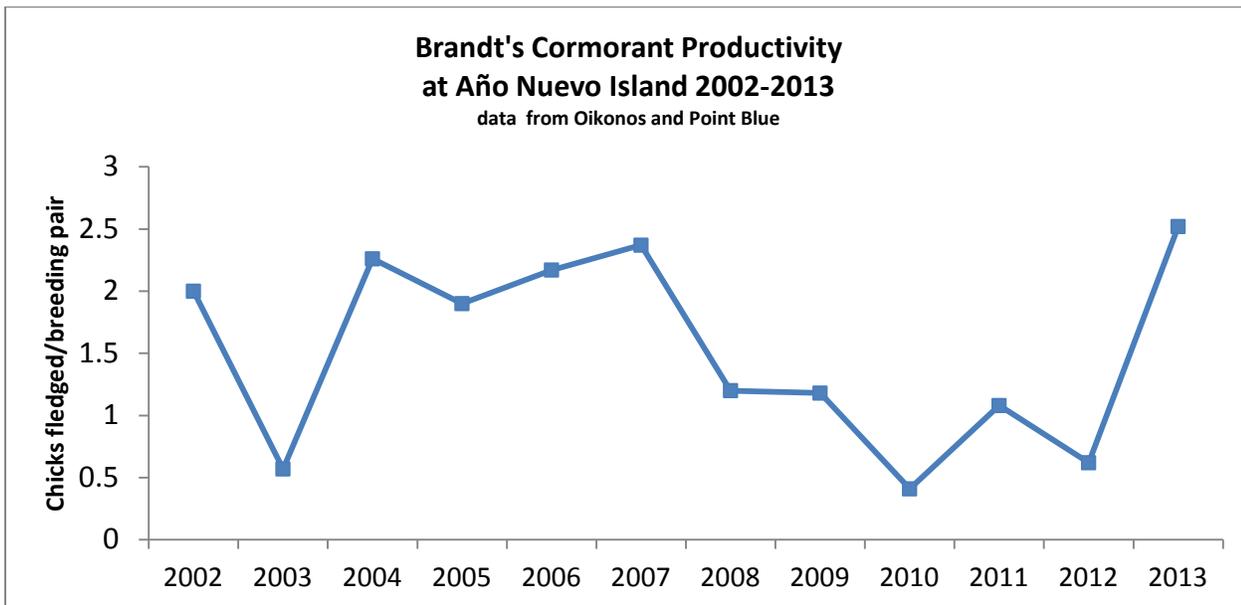
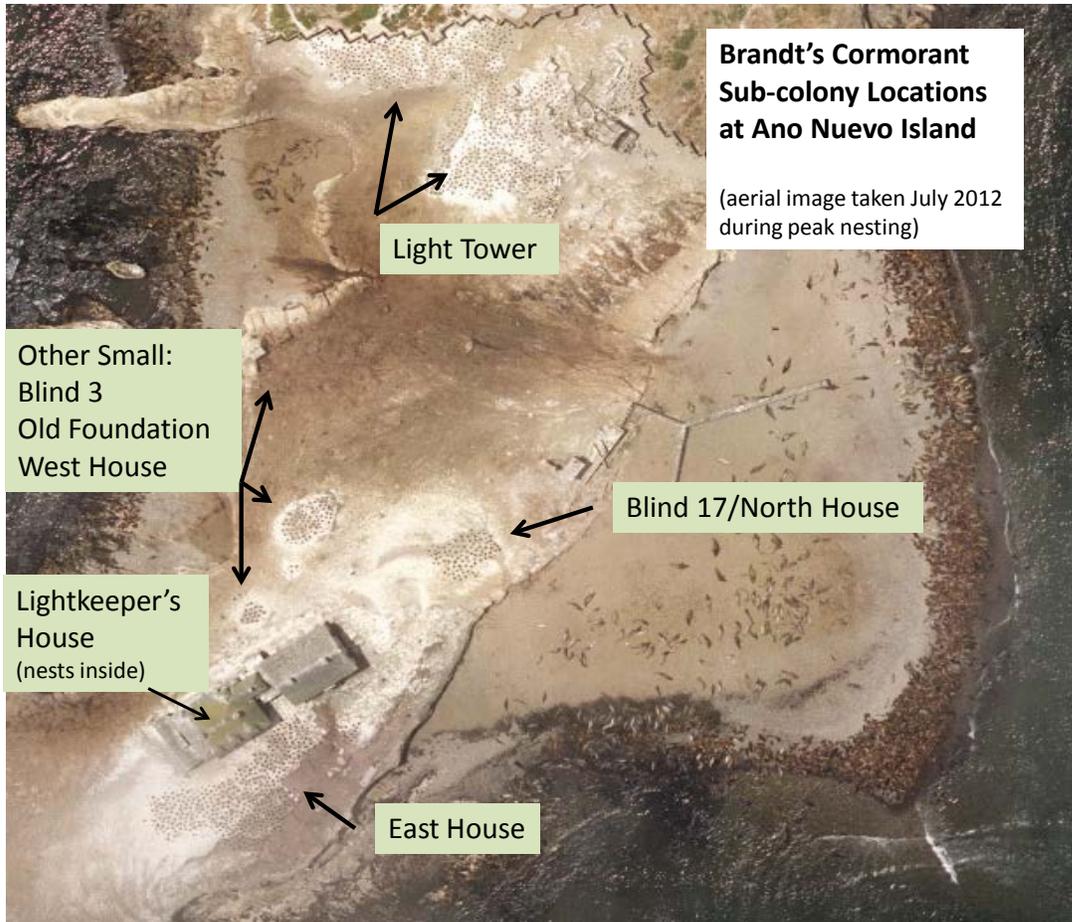
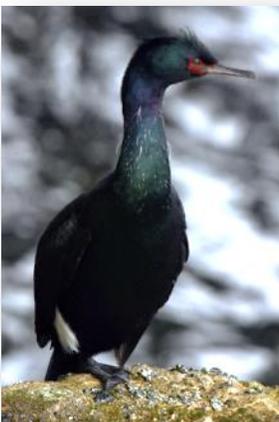


Figure 7. Brandt's Cormorant productivity at Año Nuevo Island 2002-2013. A sub-sample of nests was followed from each of the two main visible sub-colonies, the Light tower and Blind 17 (shown here combined). Sample size ranged from 20 nests (2002) to 57 nests (2004). In 2009, individual nests were not followed, so productivity was calculated as the total number of chicks meeting fledge criteria divided by the total number of nests in the two sub-colonies.



Map: An aerial image of the south terrace of Año Nuevo Island indicating the Brandt's Cormorant sub-colony locations. The black dots in the image are nests with incubating adults (July 2012). The East House and Lightkeeper's House sub-colonies are not visible from island observation points and are not included in Figure 6.



Pelagic Cormorants (*Phalacrocorax pelagicus*, PECO) were censused sporadically at Año Nuevo from 1967 to 1987 (Carter et al. 1992). Annual nest counts of the colonies began in 1998 followed by annual productivity monitoring in 1999. During the breeding season, biologists counted and recorded the contents of all PECO nests on the mainland cliffs, island bluffs, and on the Lightkeepers' Residence.

Breeding population size of the combined colonies at ANSP fluctuated annually and, after increasing between 2009 and 2012, declined in 2013 (Fig. 8 blue bars). From 2005-2012, the nesting population on the mainland cliffs (Fig. 8 green bars) was larger than that on the island (Fig. 8 red bars). However, in 2013, the sub-colony on the island increased as the sub-colony on the mainland decreased, resulting in nearly equal populations (mainland = 66 breeding birds, island = 64 breeding birds).

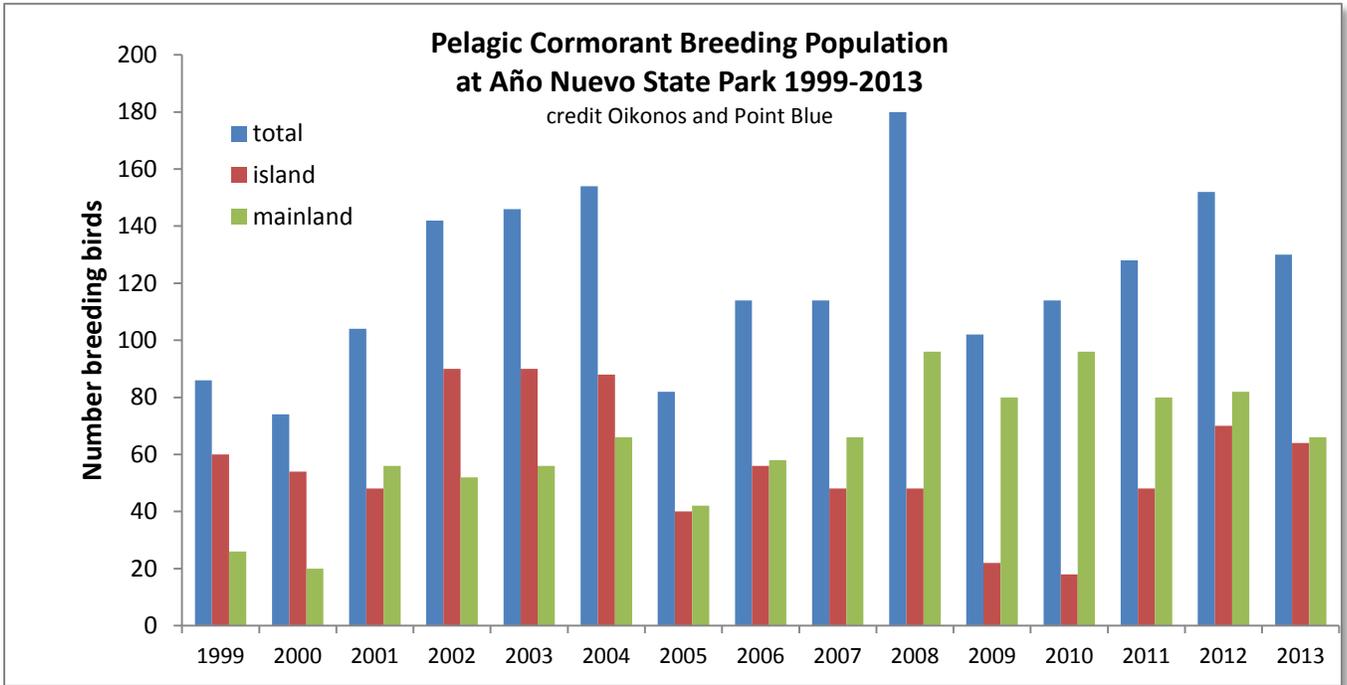


Figure 8. The estimated number of individual breeding Pelagic Cormorants at Año Nuevo State Park (blue - all monitored areas combined, red – island, green – mainland). All counts were estimated from standardized ground counts from 1999 to 2013.

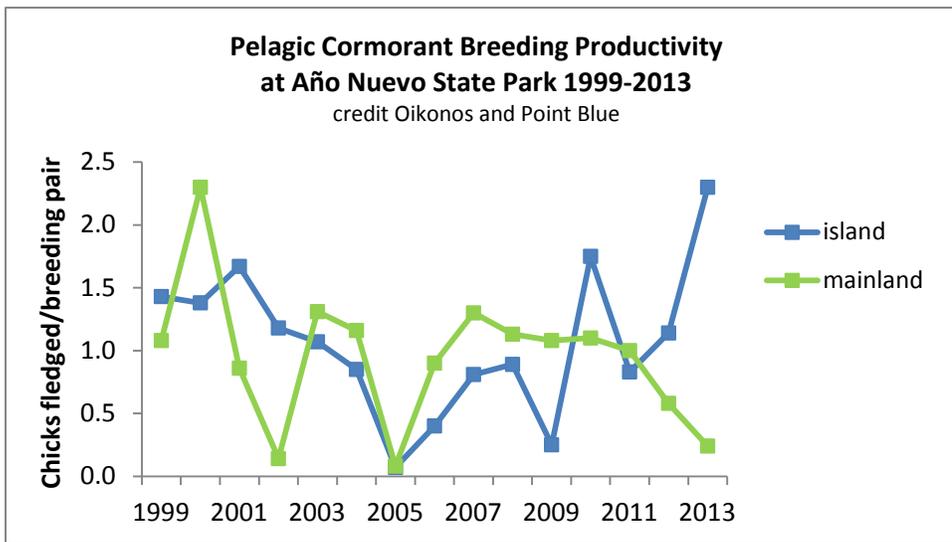


Figure 9. The estimated number of chicks fledged per breeding pair of Pelagic Cormorants on Año Nuevo State Park (blue – island, green – mainland). Data were estimated from standardized monitoring of a subsample of from 1999 to 2013 (approximately 30 - 50 nests annually).

In response to a decreasing trend in productivity at the mainland colony in recent years (Fig. 9), we began monitoring PECO interactions with Common Ravens on the mainland and island. In one nesting area where a Common Raven pair has nested near PECO nests for multiple years (East Cliff 2), only one chick fledged from a total of 20 nests in 2013. In other areas near the Common Raven nest, some PECO abandoned sites closest to the raven nest and shifted distribution farther away. On the island, PECOs are losing nesting habitat due to the disintegration of eaves and gutters on the Lightkeepers' Residence, which may be a factor in the population shift from the island to the mainland. However, the productivity of the PECOs that nested on the island in 2013 was almost 10 times greater than that of the mainland sub-colonies (Fig. 9). This discrepancy in productivity is almost certainly due to CORA predation.



Western Gull (*Larus occidentalis*, WEGU) is an endemic species to the California Current with a total population around 40,000 individuals nesting from southern Washington to southern California (Pierotti and Annett 1995). Breeding Western Gulls were first censused at ANI in 1976 (120 nests; Carter et al. 1992) and annual monitoring of the breeding colony began in 1998. Annual nest counts of the total island population occurred during peak incubation from 1998 to 2013 (no data for 2009). To measure reproductive success, a subsample of 30 nests in each area was randomly chosen and followed throughout the season.

The colony increased from 120 nests in 1976 to 1,234 nests in 2005 (Fig. 10). The population has since declined and fluctuated between 900 and 1,000 nests between 2010 and 2013 (Fig. 10). After a record low of 0.90 chicks per pair in 2010 (WEGUs lay three egg clutches), productivity has increased every year to 1.6 chicks in 2013 (Fig. 11). WEGU productivity may be positively influenced by the protective visual cover provided by vegetation in the restoration area and in 2013 by abundant forage fish resources (see Prey Studies page 16). We expect that given adequate prey conditions, WEGU breeding success may improve inside the restoration area as vegetation cover expands.

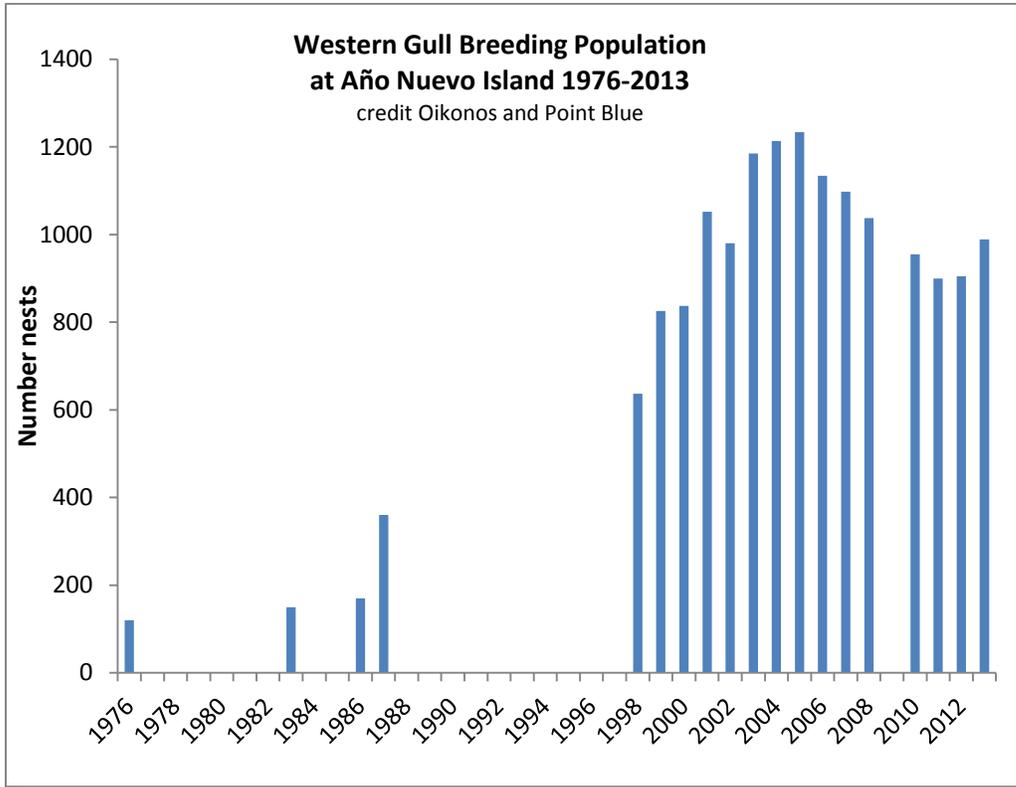


Figure 10. The estimated number of Western Gull nests on Año Nuevo Island (years with no blue bars had no available census data). Counts from 1998 – 2013 were estimated from standardized ground counts.

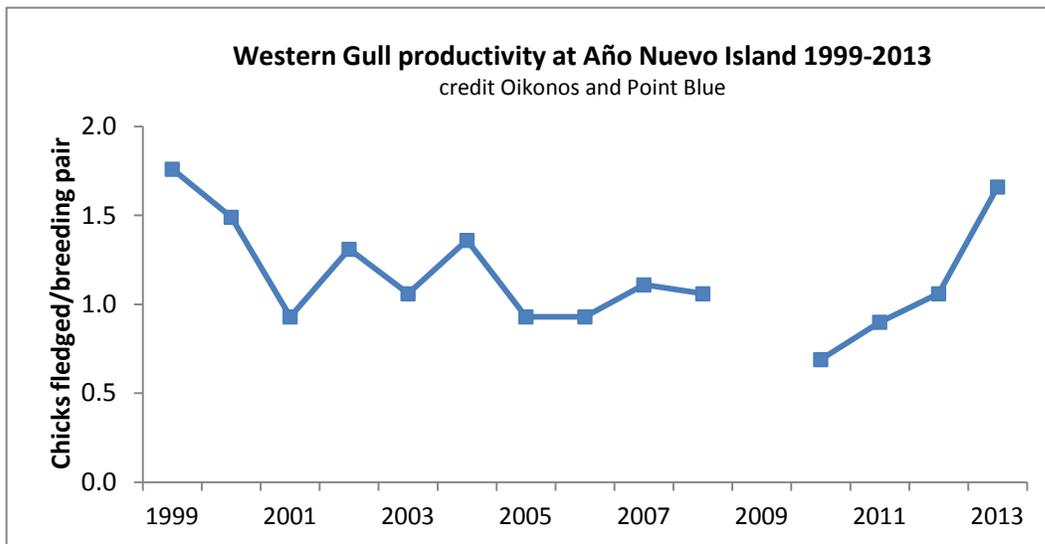


Figure 11. The annual productivity (chicks fledged per breeding pair) of Western Gulls nesting in the central terrace region on Año Nuevo Island from 1999 to 2013 (no data for 2009). Subsamples of 30 – 40 nests were monitored annually for breeding success.



Black Oystercatchers (*Haemastopus bachmani*, BLOY) are a cryptic and difficult to study species that nests in intertidal areas along the west coast of North America. Reproductive success of BLOY has generally been poor at ANI, with chicks fledging from only 7% of sites with breeding activity from 1993-2013. Only 13 chicks have been observed over the 21 year study period. Reproductive success in 2013 was relatively improved compared to 2009-2012. Four BLOY pairs laid eggs and two hatched chicks in 2013 (Fig. 12). These were the first chicks seen at ANI since 2008, but both quickly

disappeared and did not fledge. Most BLOY breeding attempts fail when eggs or chicks disappear, suggesting that predation contributes to poor breeding success at ANI. BLOYs have been observed defending nests from Common Ravens frequently since 2004, indicating that ravens are harassing and are likely depredating BLOY nests.

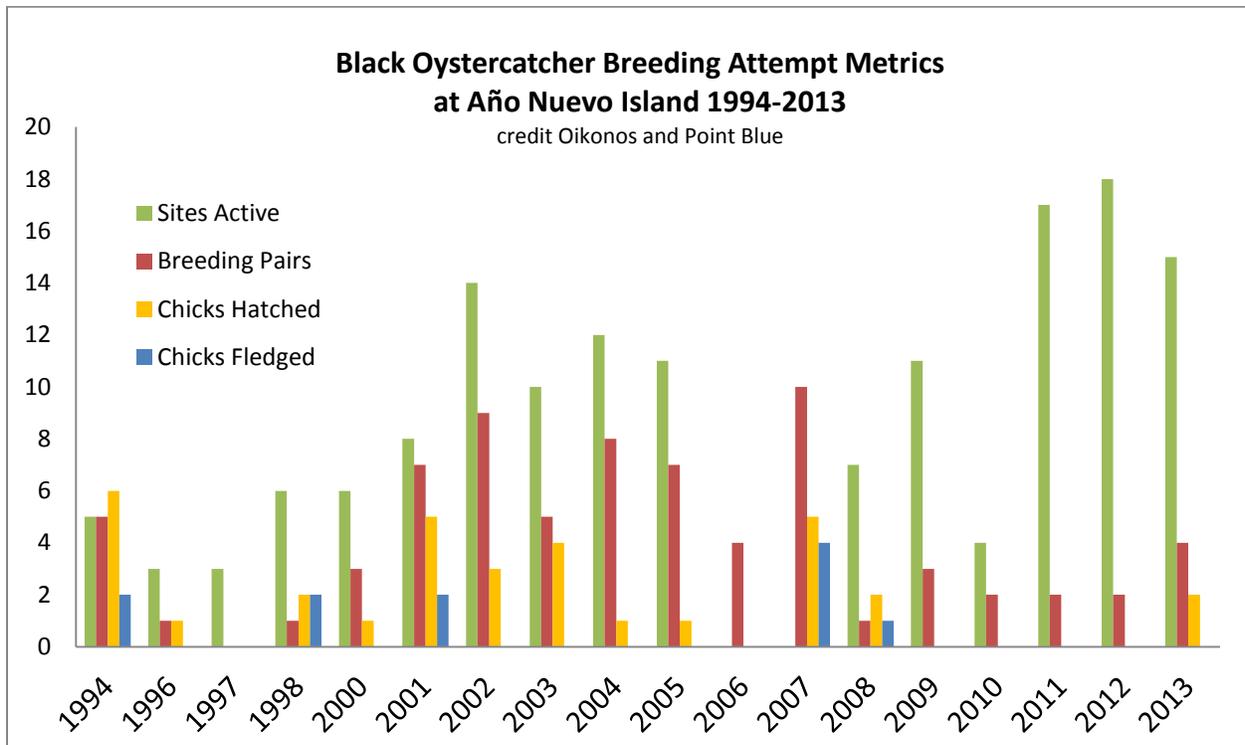


Figure 12. The number of chicks fledged (blue), chicks hatched (orange), confirmed breeding pairs (red), and nest sites with regular attendance by a pair (green) of Black Oystercatchers on Año Nuevo Island from 1994 to 2013. All the habitat visible from central terrace observation points was monitored annually (approximately 70% of the available habitat on the island).



Ashy Storm-petrel (*Oceanodroma homochroa*, ASSP) is a suspected breeder on ANI. Almost every year since 2005, including 2013, at least one ASSP with a bare brood patch has been captured at night during netting for RHAU prey. No nests or confirmed eggs have been documented. ANI likely could not support a large colony of ASSP due to the density of predatory Western Gulls and limited rock wall and crevice spaces.



Canada Geese (*Branta canadensis*, CAGO) first nested at Año Nuevo Island in 2012 and nested again in 2013. The pair built a nest against the *Habitat Ridge* inside the planted restoration area and likely was attracted by the vegetation cover. In 2013 five chicks made it to the ocean with their parents and were seen crossing the channel to the mainland (see left side photo).



Common Ravens (*Corvus corax*, CORA) were first recorded nesting at Año Nuevo in 1987, which was the only breeding record in San Mateo County that year (Lewis and Tyler, 1987). Beginning in 2003, CORA nesting attempts near seabird colonies were monitored annually. There has been one active CORA nest on both the island and mainland every year since 2004. In 2013, the mainland CORA nest was active and direct predation events on Pelagic Cormorant eggs were documented. We could not confirm if the CORA nest on the island contained eggs or chicks. Both sites could be monitored with remote cameras to further understand their behavior and impact on seabird nesting at ANSP.

Photo: A Common Raven observing a Pelagic Cormorant nest on the mainland colony.

III. Prey Studies

Metrics of seabird reproduction and diet can track prey availability and other environmental conditions and are widely used to predict ocean health. We collected diet samples from three breeding seabird species: Rhinoceros Auklets, Brandt's and Pelagic Cormorants (only RHAU results presented in this report).

Rhinoceros Auklets return to the colony at dusk to deliver whole prey (fish or cephalopods) to their chicks. To quantify the species, number, and age class of their prey, since 1993 we have captured a limited number of adults (approximately 40 annually) in stationary mist nets and collected their "bill-loads". Care was taken to not impact nesting success as chicks were deprived of food for only four nights spread throughout the 65 day rearing period.



Photo: RHAU with a bill-load of prey for its chick.

Over the 21 year sampling period, RHAU fed chicks 45 prey species (n = 2,243 individual fish) dominated by juvenile rockfish (*Sebastes* spp.), northern anchovy, Pacific saury (*Cololabis saira*), and market squid (*Doryteuthis opalescens*). From 1993-2013 Juvenile shortbelly (*S. jordanii*) and widow (*S. entomelas*) were the most frequent of 13 rockfish species fed to chicks (Fig. 14). In 2013, RHAU chick diet was dominated by juvenile shortbelly rockfish and northern anchovy (Fig. 13, Fig. 14). The abundance of these prey in the environment was corroborated by trawl data from the central coast, which documented the greatest number of juvenile rockfish since trawl surveys began in 1990, and the greatest numbers of anchovy since 2007 (Wells et al. 2013). Nearly every seabird species breeding at ANI experienced above average productivity in 2013, likely in response to this prey quality and abundance. Thayer and Sydeman (2007) found a correlation between Rhinoceros Auklet chick growth and the amount of anchovy in chick diet at ANI.

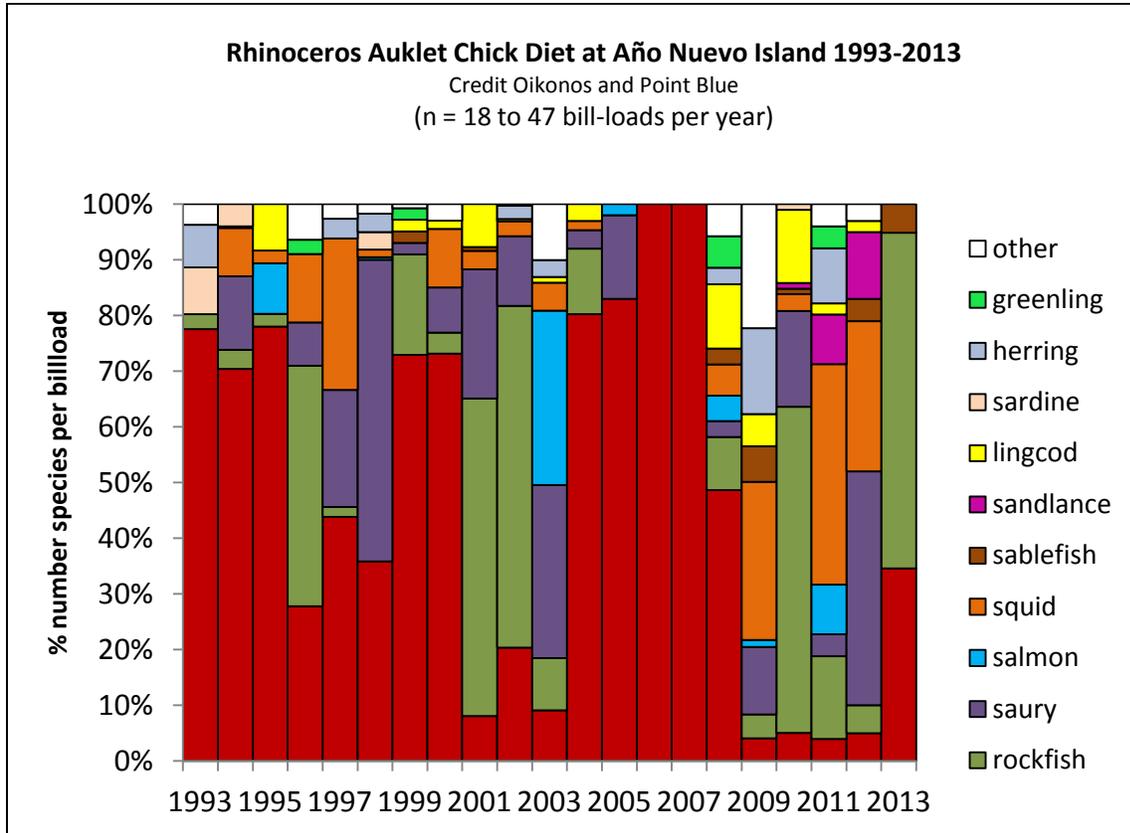


Figure 13. Rhinceros Auklet chick diet on Año Nuevo Island from 1993 to 2013 quantified as the percent number per bill-load delivered to chicks. Samples ranged from 18 - 47 bill-loads collected per year.

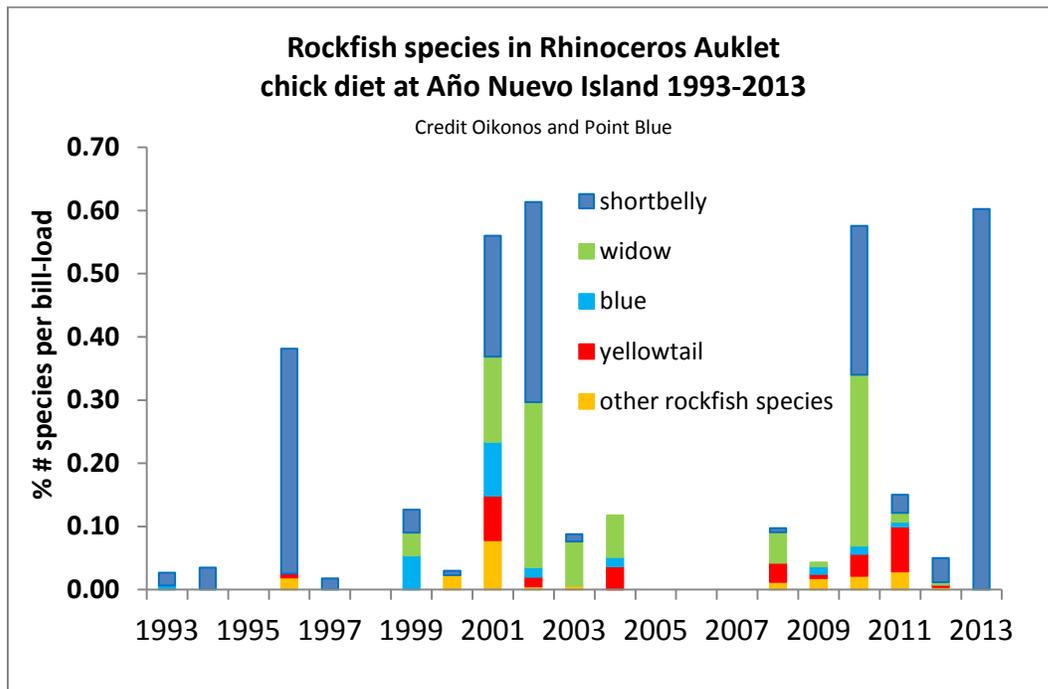


Figure 14: Rockfish species in Rhinceros Auklet chick diet on Año Nuevo Island from 1993 to 2013 quantified as the percent number per bill-load delivered to chicks. Samples ranged from 18 - 47 bill-loads collected per year.

IV. Habitat Restoration

The objectives of the restoration project are to mitigate injuries to seabirds from oil contamination (Luckenback Trustee Council 2006) and protect biodiversity on Año Nuevo Island (see Appendix 5 Habitat Restoration 2009 – 2012).

Accomplishments

1. **Protection:** To protect the seabird nesting area from destructive trampling by California sea lions, we designed and built an innovative Habitat Ridge. In the three years since installation, the Ridge has been proven to be effective. There have been no wildlife injuries or design concerns associated with the structures.
2. **Nest Modules:** To provide stable and low maintenance auklet nesting sites, we designed, produced and installed 87 clay nest modules. In 2013, Rhinoceros Auklet reproductive success in the modules improved but occupancy did not increase. The success of plant restoration may be limiting recruitment into these sites because plants grow over the entrances so they are not visible to prospecting birds (see Clay Module Table below). Also, there has been an increasing number of birds nesting in natural burrows from 2010-2013, suggesting that the restored burrowing habitat may be attracting more birds to natural burrows, with fewer relying on artificial sites. In 2013, the smaller Cassin’s Auklets laid eggs in clay modules for the first time, and both pairs that attempted successfully fledged one chick.
3. **Restoration:** To stabilize the burrow habitat and improve nesting success, we installed over 15,000 native coastal grasses and shrubs from 2009 - 2013 (see Appendix 2 Plant List). In 2013, we continued to augment the restoration and planted 600 native salt grass and dune grass plugs, spread 20 gallons of native seed, pulled invasive weeds (540 person hours), and raised 240 feet of boardwalk to prevent trampling on vegetation and burrows.

Clay Modules			
Rhinoceros Auklet			
Nesting Activity Metrics	2011	2012	2013
Active <i>Number that contained fresh nest material or had confirmed breeding</i>	91 %	74 %	65%
Breeding <i>Number of pairs that laid eggs</i>	29 pairs	25 pairs	18 pairs
Hatching success <i>Percent that successfully hatched a chick</i>	65 %	76 %	72 %
Fledging success <i>Percent of chicks that successfully fledged to 40 days old and mostly feathered stage</i>	47 %	58 %	75 %
Total Productivity <i>Proportion of breeding pairs that fledged a chick</i>	0.31	0.48	0.53
	chicks/pair	chicks/pair	chicks/pair

Clay Modules	
Cassin's Auklet	
Nesting Activity Metrics	
Breeding	2 pairs
<i>Number of Pairs that laid eggs</i>	
Total Productivity	1.0
<i>Proportion of breeding pairs that fledged a chick</i>	chicks/pair



Photo: A Cassin's Auklet chick raised in one of the clay nest modules in 2013.

Documenting Success

The three main pre and post metrics we measured to determine the success of the restoration annually included:

1. Nesting attempts damaged by erosion
2. Vegetation cover in burrow-nesting areas
3. Mitigation of injured Rhinoceros Auklets

Burrow Damage Metric

Description: The purpose of the burrow damage metric is to quantify the incidence and severity of direct damage to RHAU nesting burrows by soil erosion annually. This burrow damage metric is ideal because the response to habitat stability improvements to nesting birds is immediate showing results within the span of short grant cycles.

Method: We recorded the burrow number, erosion type and severity codes, and any injury to adults or chicks on a weekly basis for all active (open) burrows in the central terrace restoration area from April through July during pre-restoration (1998 – 2001) and post-restoration (2010 – 2013).

Results: In the four years prior to the restoration applications (1998 – 2001), when the habitat was virtually denuded, the percentage of RHAU burrows damaged by erosion ranged from 42% to 67%, sometimes resulting in the death of an adult or chick. Results from the last four years post-restoration (2010 – 2013) show a direct and positive response to habitat stabilization efforts (see Burrow Damage Table below).

Rhinoceros Auklet Burrow Damage Caused by Erosion

Restoration Area

Year	Total Damaged Burrows	Total Burrows	Percent Burrows Damaged
Pre-Restoration			
1998	29	69	42%
1999	34	81	42%
2000	42	63	67%
2001	28	67	42%
Post-Restoration			
2010	8	71	11%
2011	3	91	3%
2012	6	97	6%
2013	19	106	18%

**Damage was defined as any burrow that was crushed, had a hole in the tunnel, or had at least two records of erosion to the entrance (caused by environmental factors, not crushed by humans or sea lions).*

Vegetation Metrics

Description: The purpose of the vegetation metrics is to quantify the growth of stabilizing plant cover in the restoration area. Root structure in the sandy soil will improve the ability of auklets to dig burrows able withstand extreme wind events without collapse. A main objective was to encourage a mostly native plant community to improve natural resilience. While non-native species can improve soil stability as well, on Año Nuevo Island in past years, invasive plants (i.e. *Tetragonia* (New Zealand spinach) and *Malva* species) have suffered dramatic die offs.

Method: We conducted three surveys per year quantifying plant species composition in restoration areas in May, July, and October 2010 – 2013 (also in previous years 2003, 2004,



2005). We quantified percent cover and average height by plant species. Leaf litter (native and non-native) and bare categories were also recorded.

Results: Prior to the plant installments in 2010, vegetation cover was between zero and 15% in the burrow plots. A recent survey (conducted May 2013) documented average percent cover of live vegetation was 56% with the majority being native salt grass (*Distichlis spicata*) and American dune grass (*Elymus mollis* ssp. *mollis*) green bars in graph below).

Live vegetation cover in the restoration area declined between vegetation surveys in May and October 2013 (Fig. 16&17) due to sustained trampling from July through December by large numbers of Brown Pelicans (Fig. 15). The duration of high roosting densities (over 4 months) was anomalous and likely caused by local prey conditions. The roosting pelicans also were concentrated in the restoration area because there were no California sea lions to compete for space.

The reduction in live plant cover was primarily driven by leaves dying back on grasses as plants were trampled and covered in pelican feces. In many cases the roots of the salt grass and dune grass were still alive despite this reduction in leaves. Salt grass and dune grass were specially selected for their resilience to trampling, so we expect that these plants will survive and recover when pelican pressure drops and rain increases in winter. Also, total habitat cover, and protection from erosion, remained high because of dead native leaf litter (Fig. 17). Sporadic pelican trampling will continue to be a factor for the restoration effort, but the events of this year will be a good test of the resilience of several key plant species.

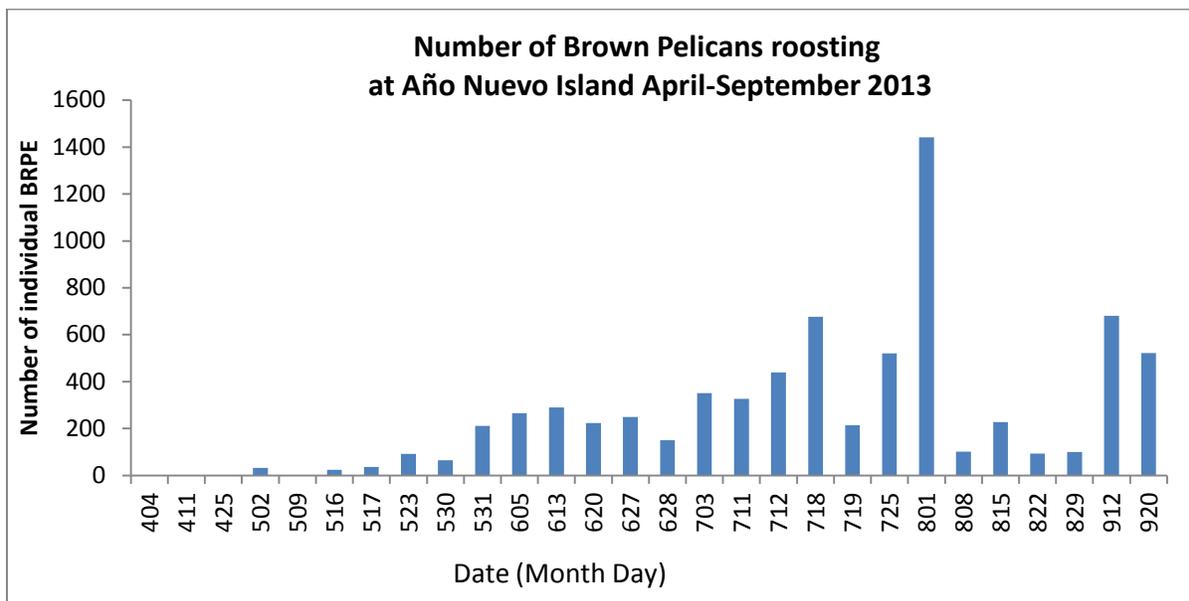


Figure 15. Number of individual Brown Pelicans (all age classes) roosting on Año Nuevo Island from April to September in 2013. High numbers of pelicans remained at the island through December (not shown).

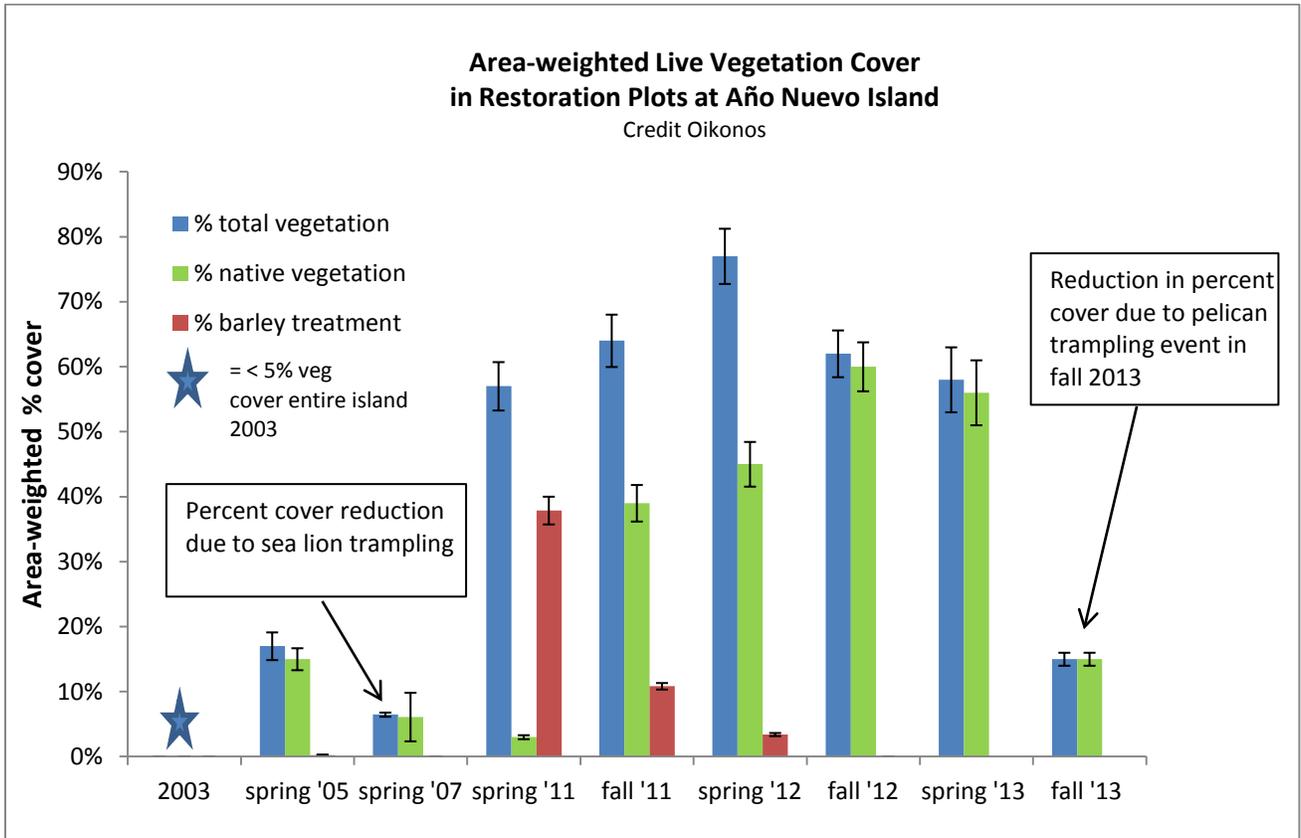


Figure 16. Percent vegetation cover (average area-weighted and standard error) in four restoration plots that experienced equal restoration efforts on Año Nuevo Island. The year 2003 is a pre-restoration metric when the areas had less than 5% vegetation cover.

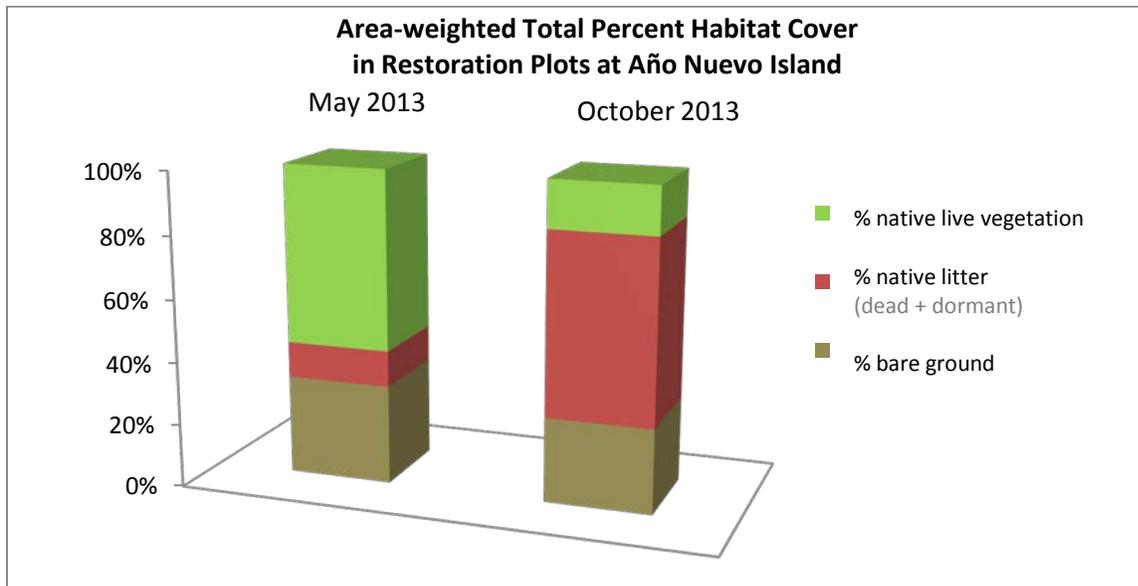


Figure 17. Percent habitat cover (average area-weighted) in four restoration plots that experienced equal restoration efforts on Año Nuevo Island. The plots were categorized into three categories (green) native live vegetation, (red) native litter that includes dead and dormant vegetation, and (brown) bare ground or bare erosion control material.

Seabird Mitigation Metrics

Description: With no restoration efforts, it was estimated that the burrowing seabirds would no longer successfully nest on ANI due to habitat loss from erosion. Seabird populations often respond slowly to restoration efforts because they are long-lived, have low productivity, and chicks do not return for 3-7 years to breed as adults (Thayer 2009). The annual reproductive metrics will demonstrate success if the breeding population remains stable and nesting attempts produce a healthy percentage of fledglings.

Methods: See nest monitoring methods in Appendix 3.

Results: From 2009 – 2013, an estimated **337 fledged chicks were produced in the restoration area** (see Mitigation Table below). In 2013, the population produced a record number of fledglings (94 fully feathered chicks).

Mitigation Table:

**Replacement of Rhinoceros Auklets injured by oil contamination
 by reducing habitat loss at Año Nuevo Island**

Year	Breeding Adults	Chicks Fledged		
		Natural Burrows	Chicks Fledged Artificial Sites	Chicks Fledged Total
2009	226	33	16	49
2010	198	33	25	58
2011	210	55	9	64
2012	234	61	11	72
2013	242	85	9	94



VI. Future

In 2014, Oikonos will focus on documenting the success of restoration efforts that will include conducting studies to quantify the response of the flora and fauna to the improvements in habitat quality. We will measure native plant cover, erosion rates, and breeding success in relation to habitat characteristics of three focal seabird species: Rhinoceros Auklet, Cassin's Auklet, and Western Gull.

Future project activities will provide insight into the success of the soil stabilization, clay nest modules, and the *Habitat Ridge*. It is our hope that the knowledge gained during this project can be applied to other islands that have degraded habitat from human use and/or introduced species and are in need of restoration to conserve wildlife populations.

Additional activities proposed for summer and fall 2014 are pending funds:

1. Build a shelter for the composting toilet and remove the old outhouse
2. Complete raised boardwalks to reduce burrow trampling and erosion
3. Repair the Field Station Fence protecting seabirds and pinnipeds from researcher disturbance
4. Document the diving depth and foraging effort of adult Rhinoceros Auklets using small tags attached to their back feathers with tape

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This Citation:

- Hester, M., Carle, R., Beck, J., and Calleri, D. 2013b. Seabird Conservation and Habitat Restoration: 2013. Unpublished Report to California Dept. of Parks and Recreation, Año Nuevo State Park.

Appendix 1. Acknowledgements, Partners, Volunteers

The successes and accomplishments described in this report are just a sample of the contributions made by the talented and dedicated individuals from many disciplines that helped the project between 2009 and 2013 (key personnel listed below).

The restoration project is a collaborative, multi-disciplinary endeavor managed by **California Department of Parks and Recreation, Año Nuevo State Park, and led by Oikonos - Ecosystem Knowledge, Go Native and Rebar**. In 2009-2011, the other key partners were **California College of the Arts, Nathan Lynch, UC Natural Reserve System, and Point Blue Conservation Science**. We acknowledge the staff and volunteers who began the initial restoration work in 2002 – 05 and on whose shoulders we stand.



We are grateful for the **over 140 volunteers** who gave their expertise and muscles to the efforts. In addition, we thank the crew at Parker Diving for safe Landing Craft operations, and Lloyd Fales, Peck Ewer and Justin Holbrook for creating the restoration project videos. Mark Hylkema, Portia Halbert, and Jennifer Boyce gave many hours guiding the project through permitting.

In 2009-13, direct funding was provided by the USCG National Pollution Fund Center for oil spill mitigation actions managed by the **Luckenbach and Command Oil Spill Trustee Councils**. Direct matching was awarded by the **Creative Work Fund** in 2011, a program of the Walter and Elise Haas Fund, supported by the William and Flora Hewlett Foundation and The James Irvine Foundation. All the partners provided substantial matching in the form of time, tools, and materials. Other donors included Peninsula Open Space Trust, Patagonia, and USGS. We also acknowledge the Coastal Conservancy for funding the pilot work and initial restoration efforts from 2003 - 2005.

In 2012-13, direct funding was also awarded from the Robert and Patricia Switzer Foundation and the Michael Lee Environmental Foundation for Ryan Carle's graduate thesis.

Key Project Personnel 2009 - 2013

Oikonos	Go Native	Rebar	CCA	CA State Parks	UCNRS
Josh Adams	Juan Arevalos	Teresa Aguilera	Kolle Kahle	Ziad Bawarshi	Pat Morris
Jessie Beck	Mario Aquino	John Bela	Nathan Lynch	Portia Halbert	Guy Oliver
David Calleri	John Barnett	Blaine Merker	Sonja Murphy	Tim Hyland	Patrick Robinson
Ryan Carle	Javier Castro	Matthew Passmore	Carlos Ramirez	Mark Hylkema	
Phillip Curtiss	Gilberto Chompa	Josh Berliner	Nathan Ring	Paul Keel	Point Blue
Michelle Hester	Shawn Dardenelle		Vladimir Vlad	Terry Kiser	Sara Acosta
Josie Moss	Kathy Kellerman			Chris Spohrer	
Dana Page	Chuck Kozak			Gary Strachan	
Julie Thayer	Carlos Rangel			Docents	
Viola Toniolo	David Sands			Natural	
Alaina Valenzuela	Norine Yee			Resource Crew	

We thank the following individuals who volunteered their time and muscles on Año Nuevo Island from 2009 to 2013. To those missing, you were crucial and we apologize for skipping your name. We also acknowledge the volunteers who helped with the initial restoration work from 2002 to 2005 and all the volunteers helping off island to support the project not listed.



Year	Total Island Volunteers*	New Volunteers	Total Volunteer Days (person days)	Total Volunteer Hours	Total Organizations
2009	10	9	31	248	4
2010	73	51	108	864	10
2011	26	16	99	792	9
2012	28	13	78	624	9
2013	43	23	110	880	11
Totals	180	112	426	3408	

Aaron Haebert	Emma Hurley	Luke Hass	Steve Kurtagh
Abe Borker	Eric Woehler	Marilyn Cruikshank	Susan McCarthy
Adam Fox	Erica Donnelly	Martha Brown	Teresa Aguilera
Adam Garcia	Evan Barbour	Masha Slavnova	Tiffany Bailie
Adam Green	Gabriella Layi	Matt Madden	Tim Gledich
Alaina Valenzuela	Gary Strachen	Matthew McCown	Tim Hyde
Alayne Meeks	Grant Ballard	Matthew Passmore	Tim Shaffer
Alex Wang	Guy Oliver	Maya Whitner	Valeria Ruopollo
Allan Kass	Helen Davis	Melinda Conners	Vladimir Vlad
Andrea van Dexter	Inger Johansson	Nadia Hamey	Yoel Kirschner
Andrew Fisher	Janet Carle	Nathan Lynch	Zach Michelson
Anne Cassell	Jeff Powers	Nick Slobodian	Zoe Burr
Arlene Davis	Jessie Beck	Noreen Yee	Linda Brodman
Becky Hendricks	Jim Harvey	Pat Morris	Chuck Boffman
Bill Henry	Jo Anne Dao	Patrick Furtalo	Ann Garside
Blaine Merker	John Bela	Patti Kenyon	Jeb Bishop
Breck Tyler	Jonathan Felis	Peck Euwer	Pat Kittle
Brittany Guest	Josh Adams	Petrusjka Skjerning	Michael Hanrahan
Bryan Schatz	Josh Berliner	Phil Curtiss	Tim Brown
Catie Kroeger	Josie Moss	Portia Halbert	Will Spangler
Christine Chi	JT Keeley	Rachel Eastman	Chris Tarango
Colleen Young	Kathy Kellerman	Randy Chapin	Angela Scezorkia
Coral Wolf	Kira katzner	Rebecca Cook	Keith Hernandez
Corey Clatterbuck	Kira Maritano	Rick Condit	Emily Golson
Crosbie Walsh	Kit Clark	Rosemarie Willimann	Natahsa Vokshoori
Damien Sosa	Kolle Kahle-Riggs	Ryan Carle	Alex Rinckert
Dan Barnard	Kristen Saunders	Sacha Heath	Maris Brenn-White
Dana Page	Kristen Swehla	Sarah Lenz	Lena Molinari
Dave Carle	Laird Henkel	Sarah Peterson	John Finch
David Calleri	Lana Meade	Scott Shaffer	Jenny Garcia
David Greenberger	Laura Webb	Signe Jul Andersen	Nicole Hicock
David Hyrenbach	Leslie Sample	Sonja Murphy	Helen Christianson
David Sands	Lindsey Graves	Sophie Webb	Ellen Little
Diana Powers	Lloyd Fales	Sparrow Baranyai	Clair Nasr
Eliza Powers	Louis Wertz	Stan Hooper	Parker Forman

Appendix 2. Plant Species List

Native San Mateo County coast species planted or seeded on Año Nuevo Island in 2010-2013 to stabilize the soil and encourage a resilient plant community.

Transplants

Key Species

<i>Ambrosia chamissonis</i>	Beach Bur
<i>Baccharis pilularis</i>	Coyote Bush
<i>Distichlis spicata</i>	Saltgrass
<i>Elymus mollis</i> ssp. <i>mollis</i>	American Dune Grass
<i>Elymus tetricoides</i>	Creeping Wild Rye
<i>Eriophyllum staechadifolium</i>	Lizard Tail

Species to build biodiversity

<i>Achillea millefolium</i>	Common Yarrow
<i>Artemisia pycnocephala</i>	Beach Sage Wort
<i>Calystegia soldanella</i>	Beach morning glory
<i>Camissonia cheiranthifolia</i>	Beach Evening Primrose
<i>Ericameria ericoides</i>	Mock Heather
<i>Erigeron glaucus</i>	Seaside Daisy
<i>Eriogonum latifolium</i>	Coast Buckwheat
<i>Fragaria chiloensis</i>	Beach Strawberry
<i>Grindelia stricta</i> var. <i>stricta</i>	Coastal Gum Plant
<i>Juncus patens</i>	Common Rush
<i>Lasthenia maritima</i>	Maritime Goldfields
<i>Mimulus guttatus</i>	Seep Monkey Flower
<i>Plantago maritima</i>	Maritime Plantain
<i>Salix lasiolepis</i>	Arroyo Willow
<i>Schoenoplectus pungens</i>	Common Threesquare
<i>Spergularia macrotheca</i>	Sticky Sand Spurry
<i>Tanacetum bipinnatum</i>	Dune Tansy

Seed

<i>Abronia latifolia</i>	Yellow Sand Verbena
<i>Achillea millefolium</i>	Common Yarrow
<i>Ambrosia chamissonis</i>	Beach Bur
<i>Baccharis pilularis</i>	Coyote Bush
<i>Camissonia cheiranthifolia</i>	Beach Evening Primrose
<i>Dudleya farinosa</i>	North Coast Dudelya
<i>Elymus triticoides</i>	Beardless Wild Rye
<i>Ericameria ericoides</i>	Mock Heather
<i>Erigeron glaucus</i>	Seaside Daisy
<i>Eriogonum latifolium</i>	Coast Buckwheat
<i>Eriophyllum staechadifolium</i>	Lizard Tail
<i>Grindelia stricta</i> var. <i>stricta</i>	Coastal Gum Plant
<i>Lasthenia maritima</i>	Maritime Goldfields
<i>Lupinus arboreus</i>	Yellow Bush Lupine
<i>Pseudognaphalium stramineum</i>	Cottonbatting Plant
<i>Schoenoplectus pungens</i>	Common Threesquare
<i>Scrophularia californica</i>	California Bee Plant

Appendix 3. Seabird Population and Reproduction Study Methods – 2009 to 2013

Methods – Underground Nesting Seabirds

We monitored the nesting activity and reproductive success of three species that nest underground (in soil burrows and rock crevices): Rhinoceros Auklets, Cassin's Auklets, and Pigeon Guillemots. To observe the presence of adults, eggs, and chicks, we used three methods: (1) a wireless miniature camera (*photo right*) to view inside natural nest sites without damaging fragile soil burrows, (2) buried artificial nest sites (wooden boxes and clay modules) with a lid on the top to allow the birds to be handled for weighing and banding, and (3) observations of adults carrying fish which confirmed a live chick was present.

Metrics included counts of confirmed breeding pairs, hatching and fledging success, and chick growth. The reproductive metric presented here is “productivity” defined as the mean number of chicks successfully reared to fledging per breeding pair. The maximum productivity for species that produce only one egg a season is 1 chick. Cormorants and other species that lay multiple eggs have higher and more variable productivity (up to 5 chicks in Brandt's Cormorant nests).

Methods – Ground and Cliff Nesting Seabirds

Brandt's Cormorants, Pelagic Cormorants, Western Gulls, Black Oystercatchers, and Common Ravens are ground and cliff nesting species that have been monitored at ANSP using a variety of aerial, scope, and binocular observation methods.

Double-crested Cormorants have built only one nest (on the island) in the last two decades and this species is followed incidentally when present.

Brown Pelicans do not raise chicks at ANSP but the island and mainland are important roosting sites throughout the year and seasonal attendance has been documented at varying levels.

In 1999, yearly nest censuses of Brandt's Cormorants began using a combination of aerial counts and ground surveys. Ground surveys were used to coordinate timing of aerial surveys with peak occupation. In some years, aerial surveys were not conducted and population numbers were extrapolated from ground counts. In 2010 we attempted to follow nest success remotely with the live island video transmission, but the camera system was frequently not working and caused loss of breeding data.

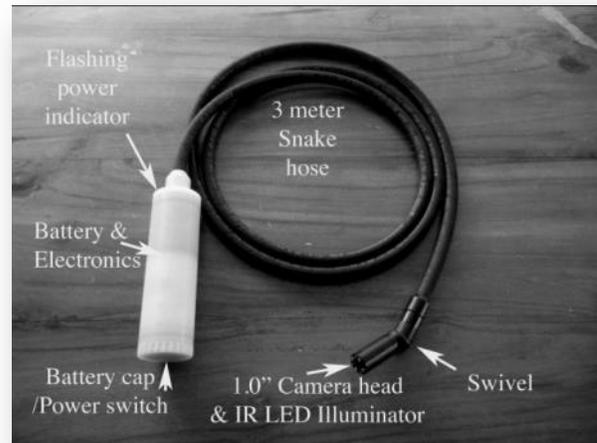


Photo: The Pukamanu 2.2 burrow camera was used to monitor underground seabird burrows. The image is illuminated by infrared light invisible to the birds and transmitted wirelessly to a head-set display. Designed by Abyssal Hawaii and Oikonos.

Appendix 4. – Año Nuevo State Park Seabird Program Resources: Articles, Videos, Outreach, Images, Links - 2009 to 2013

Oikonos' mission includes sharing knowledge gained through our conservation projects with diverse audiences and engaging communities. Oikonos and partners created the following products in 2009 - 2013 with inkind and matching support:

- Two Project Videos
 - [A Plan Was Hatched](http://www.anonuevoisland.org/video/restoring-an-island) produced by Lloyd Fales and Peck Ewer, Swell Pictures
<http://www.anonuevoisland.org/video/restoring-an-island>
 - [Students Design Auklet Nests](http://www.anonuevoisland.org/video/cca-engage-students-design- auklet-nests) produced by a CCA Student, Justin Holbrook
<http://www.anonuevoisland.org/video/cca-engage-students-design- auklet-nests>
- Project website, gallery and blog
AnoNuevoIsland.org
- California College of the Arts, Engage Program
“Designing Ecology” Course [Article](#)
- Project outreach to urban communities through the [ENGAGE program](#) at the [Center for Art and Public Life](#) at the California College of the Arts.
- Bay Nature Magazine “[Art for Auklets](#)”
- [Real-world Art School](#) – article in American Craft Magazine
- [Not Your Average Birdhouse](#), UC Santa Cruz Science Communication Blog
- [Rebar’s Doxa](#), blog about the restoration
- [Habitat Restoration: One Bird At a Time](#), Moss Landing Marine Lab blog
- ANSP Docent and Volunteer Training [Presentations](#)
- Luckenbach Trustee Council [Newsletters](#)



Art by Sonja Murphy, CCA

Scientific Presentations

CalCOFI Forage Fish Conference - December 2013, La Jolla, CA

Presentation entitled:

DIET OF AN ADAPTABLE SEABIRD HIGHLIGHTS THE IMPORTANCE OF PREY-SWITCHING IN RESPONSE TO DYNAMIC PREYSCAPES OVER TWO DECADES

Pacific Seabird Group Conference – February 2013, Portland, OR

Presentation entitled:
IMPROVING BURROWING SEABIRD HABITAT WITH NATIVE PLANT RESTORATION AND SEA LION
EXCLUSION: RESULTS FROM AÑO NUEVO ISLAND, CALIFORNIA

Pacific Seabird Group Conference – February 2010, Long Beach, CA

Presentation entitled:
DESIGNING ECOLOGY: RECONSTRUCTING SEABIRD HABITAT ON AÑO NUEVO ISLAND

Public Events

California Native Plant Society Presentation—July 2013, Santa Cruz, CA

Seal Adventure Weekend – February 2012 & 2013, Año Nuevo State Park, CA

Migration Festival – February 2013, Natural Bridges State Beach, CA

Santa Cruz Bird Club Presentation – April 2011, Santa Cruz, CA

High resolution images showing the progress of the restoration that can be downloaded and used for non-commercial purposes from this online album:

- <http://www.anonuevoisland.org/photo/albums/restoration-slideshow>

Two project videos created by Swell Pictures and a CCA Student can be viewed and shared online:

- <http://www.anonuevoisland.org/video/restoring-an-island>
- <http://www.anonuevoisland.org/video/cca-engage-students-design- auklet-nests>

Appendix 5. – Habitat Restoration Accomplishments 2009 - 2012

Summary

The main goal of the Año Nuevo Island Seabird Habitat Restoration Project is to **increase the number of breeding Rhinoceros Auklets** on Año Nuevo Island by restoring and creating stable breeding habitat. The habitat restoration efforts were successfully completed during 2009 – 2012, accomplishing three core objectives:

- 1. Protection:** To protect the seabird nesting area from destructive trampling by California sea lions, we designed and built an innovative *Habitat Ridge*.
- 2. Nest Modules:** To provide stable and low maintenance auklet nesting sites, we designed, produced and installed 87 clay nest modules.
- 3. Restoration:** To stabilize the burrow habitat and improve nesting success, we installed over 15,000 native coastal grasses and shrubs.

Introduction & Methods

Restoration Area

The objectives of the restoration project are to mitigate injuries to seabirds from oil contamination and protect biodiversity on Año Nuevo Island. Mortality to Rhinoceros and Cassin's Auklets by oil contamination from leakages of the sunken *S.S. Jacob Luckenbach* and other mystery spills off the coast of San Mateo County, California, were estimated to be 593 and 1,509 adults, respectively, from 1990 to 2003 (Luckenbach Trustee Council 2006).

After a public review process, the Trustee Council determined that damages could be addressed by restoration efforts that improve auklet reproductive success at Año Nuevo Island. If no action was taken, the breeding colony would likely decline rapidly due to soil erosion. Thus, the restoration benefits are derived from the difference between modest colony growth versus loss of the colony without the project.

Año Nuevo Island was selected for the following reasons: it is the closest colony to the leaking vessel, oiled Rhinoceros Auklets were documented on the colony, the island is free from introduced predators, and public access is not permitted. No other significant predator-free habitat exists in the region to support Rhinoceros Auklets if this colony became uninhabitable.

Rhinoceros Auklets naturally began colonizing the island in the early 1980s (Lewis and Tyler 1987) and Cassin's Auklets in the mid-1990s (Hester and Sydeman 1995). Given the highest density of burrows in prime habitat on Año Nuevo Island (1 burrow per 6 meter squared), the restoration area could potentially support four times the current population of Rhinoceros Auklets (~ 900 breeding birds). Prior to 2003, the colony's population was increasing, underscoring the potential for population growth when habitat quality is improved.

In 2013 the estimated island-wide population of Cassin's Auklets was 102 breeding birds, the highest number on record. While most of the Cassin's Auklets currently nest in areas outside the priority restoration plots, in 2013 there were 24 pairs in the planted areas with Rhinoceros Auklets. In addition, Cassin's Auklets experienced high breeding success from 2010-2013, indicating the potential for further population growth in response to restoration.

The restoration project improved nesting conditions for three other seabird species injured by oil pollution: Pigeon Guillemot, Western Gull, and Brandt's Cormorant. In addition to the threats that Año Nuevo Island seabirds encounter at sea (oil pollution and reduced prey availability), their main threats on the colony are soil erosion, human disturbance, sea lion trampling, and inter-species interference for nesting space. This project reduced all four of these colony threats by stabilizing the soil with a native plant community, designing variable habitat structure to reduce direct conflict among species, preventing California sea lion access to prime burrow nesting space, and creating visual barriers to protect wildlife from human disturbances.



Map: The central terrace (green shading) was selected for restoration because it harbors the majority of the burrowing seabirds and the highest elevation with soil on the island. The target area was approximately one acre. The Habitat Ridges create the southern and northern border of the planted area. In 2011-2013, we expanded the restoration treatments to an additional 0.25 acres where Cassin's Auklet nesting is concentrated (not shown above).

Accomplishments

Activity	2009	2010	2011 - 2013
Habitat Ridge 	<ul style="list-style-type: none"> ✓ Created <i>Ridge</i> designs ✓ Built prototypes on the mainland ✓ Installed a temporary barrier on the island 	<ul style="list-style-type: none"> ✓ Removed and cut 850 Eucalyptus poles ✓ Transported poles by landing craft ✓ Built 400 ft. of the <i>Ridge</i> (85% completed) 	<ul style="list-style-type: none"> ✓ Removed and cut 150 Eucalyptus poles ✓ Transported all materials by small boat ✓ Completed the <i>Ridge</i> to 6 ft. in all areas
Nest Modules 	<ul style="list-style-type: none"> ✓ Held 4 design meetings ✓ Planned the CCA college course 	<ul style="list-style-type: none"> ✓ CCA students designed and created prototypes ✓ Installed five underground in the nesting habitat 	<ul style="list-style-type: none"> ✓ CCA ceramicists produced 90 modules ✓ Installed 87 in the restoration area ✓ Monitored nesting success in modules
Plant Restoration 	<ul style="list-style-type: none"> ✓ Propagated, collected and grew native species in Go Native's greenhouse ✓ Patched sensitive areas with erosion control 	<ul style="list-style-type: none"> ✓ Transported all materials and gear to the island via landing craft ✓ Seeded and planted 10,000 grasses and shrubs ✓ Stabilized area with erosion control material ✓ Installed temporary irrigation 	<ul style="list-style-type: none"> ✓ Planted 6,000 grasses and shrubs in selected areas ✓ Seeded with native species ✓ Weeded invasive plants

Other annual activities completed (2009 – 13):

1. Measured Vegetation Composition
2. Measured Seabird Breeding Response
3. Coordinated and Trained Volunteers
4. Managed Boat Operations
5. Maintained Island Field Station
6. Tested for Rodent Presence
7. Coordinated Partners
8. Managed Permitting



Photo: Ryan and Jessie collecting vegetation cover data to quantify restoration progress. © Oikonos

Habitat Ridge

The first objective of the restoration project was to safely exclude California sea lions from the burrow nesting area while creating additional seabird nesting habitat. This was accomplished by the construction of a modular *Habitat Ridge* structure around the restoration area. The total linear length of the *Habitat Ridge* is approximately 440 feet in variable sections (photo below). The height is between 6-7 vertical feet, enough to prevent male California sea lions from making purchase with their fore flippers. No marine mammals pup in the restoration area (central terrace), so this project will not negatively impact these populations.



Photo: *Habitat Ridge* built across the North Terrace with California sea lions in the background. ©Oikonos

We carefully chose locally sourced, bio-degradable, and site sensitive construction materials for the *Ridge*. The final design was built entirely from Eucalyptus logs and wooden dowels, and installed on the island in October-November 2010 and 2011. When the lifespan of the *Ridge* has expired, these materials will become driftwood rather than toxic trash. The materials and design also match the color and contours of the island, making the *Ridge* blend in from the mainland. We constructed four gates for human access with reclaimed redwood and recycled stainless steel hinges (the only metal used in the entire *Ridge*) forged by master blacksmith David Calleri.

Designing and building this unique structure required extensive efforts that spanned four years. *Ridge* prototypes were developed on the mainland at a site provided by the Peninsula Open Space Trust. Go Native, Rebar, Oikonos, and volunteers experimented for a year before deciding on the final *Ridge* design. The Santa Cruz District State Parks natural resource crew cut over 1,000 eucalyptus logs from the Año Nuevo watershed. We transported materials, tools and people to the island using a landing craft and small inflatable zodiacs.

In the two years since installation, the *Habitat Ridge* has been proven to be effective. There have been no wildlife injuries or design concerns associated with the structures. In 2011-2013 Brandt's Cormorants nested against the outside wall of the southern portion of the *Ridge*, taking advantage of the visual barrier from human activity that it provides.

Habitat Ridge Innovations

- Built a strong barrier made of biodegradable recycled materials
- Wind blows through the structure to reduce scour and erosion
- Adaptable, modular design for variable slopes and topography

Nest Modules

We replaced wooden nest boxes with 87 clay nest modules for Rhinoceros Auklets that are able to withstand trampling by sea lions, require minimal maintenance, and allow researcher access to the nest cavity. The modules augment existing breeding habitat by acting as ‘permanent’ nest sites below ground. Over the last 21 years, we have documented that Rhinoceros Auklets will successfully raise young in artificial nests on Año Nuevo Island (Hester 1998, Thayer 2009). The design of the new clay modules addressed the problems with previously used wooden and plastic boxes that required regular maintenance, were prone to flooding and high temperatures, and had a short lifespan (3 - 5 yrs.).

Nest Module Innovations

- Responsible materials—built entirely of clay
- Transportable by small boat and carried by hand
- Un-crushable by occasional sea lion trampling
- Mimics natural burrow qualities
- Life span 15+ years



Photo: The CCA students and instructors remove the plaster from a clay module before firing. © Rebar

In the spring semester of 2010, an interdisciplinary design course at the California College of the Arts in Oakland (CCA) was taught by project partners Nathan Lynch and Rebar with the goal to design, create, and deploy a new, sustainable, reproducible system of nest modules. The modules were built using clay-based “grog” - a strong, porous type of clay that has the consistency of sand. Nathan Lynch, the chair of the CCA Ceramics Department, provided matching support in the form of ceramic studio access, mold materials, and significant kiln costs for firing 90 large modules (reserving some for outreach).

Five nest module prototypes designed by students in the class were installed in April 2010 in the restoration area. A pair of auklets successfully fledged a chick in one of the prototypes in summer 2010, demonstrating that the modules are suitable breeding sites. One design was created incorporating the best ideas from the prototypes and consisted of a curved nest chamber and a detachable entrance tunnel. A two-piece design was decided on for ease of transport and adaptability in sloping terrain. We installed 87 underground in the restoration area in November 2010.

Because Rhinoceros Auklets often breed in the same burrow in consecutive years, we installed the clay modules in the exact locations of old nest boxes if at least one of the following criteria was met:

- i. The nest box was occupied in 2010
- ii. At least 2 chicks fledged in the last five years
- iii. Breeding activity in the last 2 years and at least one chick fledged in the last 5 years

If old nest box sites did not meet any of these criteria, it indicated that we would not be disrupting a pair bond by removing it. We also selected new locations proportional to the density of natural burrows by restoration plot. We will document occupancy and reproductive performance for at least eight years to evaluate the success of these modules as quality nesting sites for Rhinoceros Auklets.

To monitor the success of clay modules as quality nesting sites, several parameters were documented. We were encouraged by signs of significant prospecting, with fresh nesting material found in 91% of the modules the first season. While the percentage of chicks that survived to fledging stage in modules was below that in natural burrows in 2011-2012, the main contributing factor was poor growth after hatching. Birds initially nesting in these sites might be younger, less experienced, and/or breeding with a new mate, potentially limiting their success at chick provisioning after hatching. Lower productivity was expected in the first years after installation. When the wooden nest boxes were first installed in

1993, productivity of pairs using new boxes took three years to match that of pairs in burrows (Hester 1998). In 2013, after three years of use by auklets, productivity in clay modules seems to have normalized. 2013 productivity in clay nest sites was 0.53 chicks/pair, slightly above the long-term average of wooden nest boxes (1993-2010) of 0.51 (± 0.12 SD).

Occupancy of modules in 2013 was 23% (including two pairs of Cassin's Auklets). We expect that RHAU occupancy in the modules will eventually meet or exceed the 16-year mean of 58% ($\pm 6\%$ SD) documented in the wooden boxes. This occupancy rate would potentially result in at least 100 adults attempting to breed annually in clay modules.

Burrow Nesting Habitat Restoration

For three years (2002 to 2005), we experimented with plant species, erosion control, and irrigation methods on Año Nuevo Island to meet restoration goals, taking into account the variable winds, salt influence, and resilience to periodic trampling, growth season, water requirements, and logistical constraints of the field site. Based on these trials, we refined the techniques to stabilize the Rhinoceros Auklet burrowing habitat and conducted the first plantings in 2004 and 2005.



Photo: The final Rhinoceros Auklet nest module design installed underground on Año Nuevo Island. © Rebar



Photo: American dune grass (Elymus mollis) growing in Go Native's greenhouse in preparation for island restoration. This is one of the key native plants adapted to salt and wind, and excellent at stabilizing loose sandy soil.

In support of the current effort, from 2008 to 2013 Go Native propagated and grew plants at their nursery in Pacifica, CA. We collected seed at Año Nuevo State Park and nearby coastal dunes. We initiated the full scale habitat work after seabirds and marine mammals finished raising young in October 2010. Once the *Habitat Ridge* was constructed to a sufficient height, it was safe to transport and install the 10,000 native grasses and shrubs in November 2010. In 2011-2013, we augmented the entire area with native seed and added an additional 6,000 plants to selected areas (complete list of plant species Appendix 2). In addition, we expanded treatments into areas where Cassin's Auklet nesting density was higher and where plants were more protected from weather to serve as a local seed source (an additional 0.25 acres).

Transplants in 2010 and 2011 were helped along by a wet winter, and many species sprouted and survived from seed. Positive impacts of soil stabilization were quickly evident by the low incidence of burrow erosion during the following breeding seasons. In November 2011, 2012 and 2013 we adapted the planting techniques, plant species, and locations as necessary and filled in remaining bare patches with plants and seed. An interesting indicator of success was that we began removing non-native plant species. In previous years, even weeds considered invasive on the mainland were allowed to remain on the island to slow erosion. We now need to remove these species so they do not compete with native plants more adapted in the long-term to the island environment.

Habitat Stabilizing Treatment Methods

1. Planted mature native grasses every 1 - 2 foot on center: salt grass (*Distichlis spicata*) and American dune grass (*Elymus mollis*) are the core stabilization ground cover
2. Planted native shrubs and spread native seed in site-specific areas (see Appendix I for species list)
3. Applied sterile barley seed for temporary and rapid soil stability
4. Distributed straw over seeds and plants to hold moisture and provide temporary structure
5. Wrapped biodegradable erosion control matting on top of the plant and seed layer
6. Installed a temporary manual irrigation system to safely water the restoration plots without disrupting breeding birds
7. Created edges and burrow-starts to encourage new prospecting breeders (recruitment)
8. Opened holes in erosion control material so established breeders can access their burrows (auklets usually return to the same nest site in consecutive seasons)