

**Año Nuevo State Park
Seabird Conservation and Habitat Restoration: Report 2015**



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I. Introduction

The main goal of Oikonos' activities at Año Nuevo State Park (ANSP) is to conserve seabird populations, nesting habitat, and prey resources. The 2015 season was the **23rd consecutive year** of long-term seabird studies at ANSP (initiated by ANSP and Point Blue Conservation Science in 1993). In 2015, Oikonos Ecosystem Knowledge continued the long term studies by documenting population size, nesting success and diet of breeding seabirds on the island and the mainland cliffs. Oikonos also continued restoration efforts that began in 2005. This involved plant restoration, habitat studies, and island stewardship, including installing more erosion control material and maintaining island infrastructure 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,
- Evaluate impact of Common Raven egg depredation on Pelagic Cormorant reproductive success, and
- Contribute to education and outreach

Summary: 2015 Highlights

- Record high breeding population of Rhinoceros Auklets (330 birds).
- Rhinoceros Auklets in the restoration area fledged an estimated 96 chicks, also the greatest number on record.
- Cassin's Auklets responded differently than Rhinoceros Auklets to conditions in 2015, presumably due to their dependence on krill instead of forage fish in the winter/spring.
- There was a 29% drop in Western Gull nest numbers in 2015 compared with 2014. The 643 Western Gull nests counted in 2015 was the lowest number of nests recorded since 1987.
- Reproductive success was near average or slightly above average for all species except Pelagic Cormorants, which experienced below-average productivity. Poor Pelagic Cormorant breeding success appeared to be related to oceanographic conditions rather than Common Raven predation that was documented in 2013-14.
- The clay nest modules provided safe breeding for 70 seabirds of three different species—Rhinoceros Auklets, Cassin's Auklets, and Pigeon Guillemots.

II. Seabird Population Status & Breeding Success

In 2015, 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 population size and 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.



Rhinoceros Auklets (*Cerorhinca monocerata*) nest sites were monitored with an infra-red burrow camera (natural burrows) or by hand (clay modules) to determine occupancy and reproductive success. To determine population, the total number of viable burrows on the island was multiplied by the burrow occupancy rate of a sample of monitored burrows. The number of birds in burrows was then added to the known number of pairs nesting in artificial sites for an overall population estimate.

Rhinoceros Auklets were first documented breeding on Año Nuevo Island in 1982 (LeValley and Evens 1982). Since 1993, when standardized monitoring began, the Rhinoceros Auklet population grew at a rate of 5 birds a year (as modeled by linear regression; $\beta = 94.01$, $R^2 = 0.65$, $P = <0.0001$). A record 330 Rhinoceros Auklets bred on the island in 2015 (Fig. 1). This was the first time that the population exceeded 300 breeding adults. Eighty-eight percent of the population (290 birds) nested in the restoration area of the central terrace, while the remainder (12%, 20 birds) nested near the east of the Lightkeeper's House.

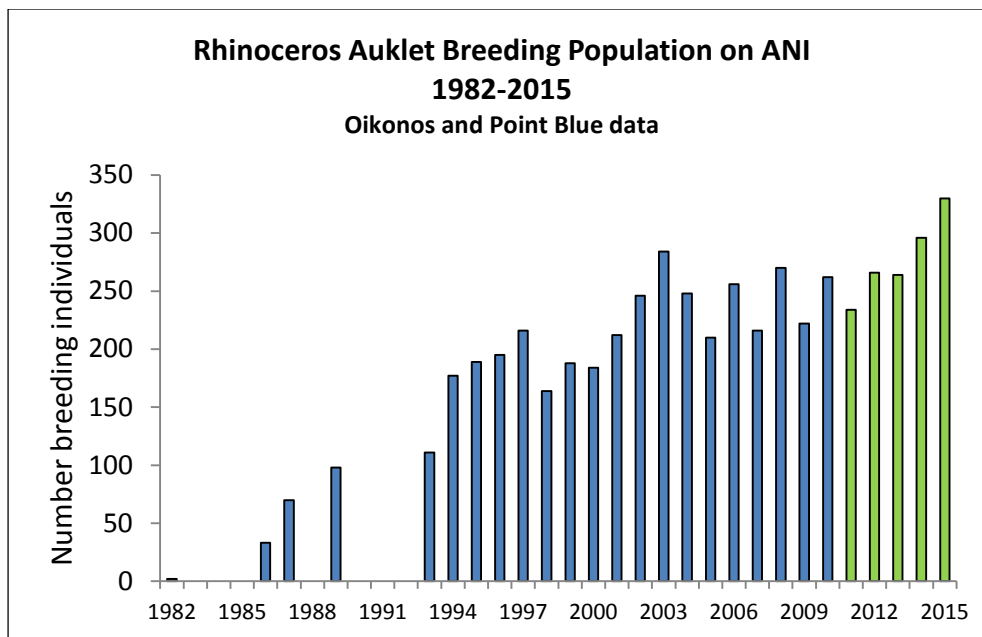


Figure 1. The number of individual breeding Rhinoceros Auklets on Año Nuevo Island (ANI) from 1982 to 2015. Years with blanks have no data. Green bars represent years of central terrace habitat improvements including erosion control and native plant restoration.

Rhinoceros Auklet pairs on ANI attempt to raise one chick a year in long underground soil burrows they excavate themselves or in clay modules buried underground (see Appendix 5 for nest module project details and *Results: Nest Modules*, page 18, for utilization by breeders). On average from 1995-2015, 59 ± 12 SD% of Rhinoceros Auklet pairs fledged chicks (natural and artificial sites combined). In 2015, nesting success was above average for the third consecutive year, with 75% of pairs that laid eggs in burrows and modules raising a chick to the fledging stage (Fig. 2). In 2015, chick diet was composed primarily of young of the year Northern anchovy. Chick diet composed primarily of anchovy has been correlated with greater reproductive success at ANI in past years (Thayer and Sydeman 2007).

From 1995-2015 there was no significant trend in Rhinoceros Auklet reproductive success at ANI (linear regression analysis; $\beta = 0.64$, $R^2 = 0.05$, $P = 0.34$). Annual productivity generally decreased between 2001 and 2009 but rose again from 2010-2015. Reproductive success is correlated with quantities and types of prey available each year, but the fact that productivity has not significantly declined on ANI also indicates that breeding habitat has not degraded to the point of causing increasing amounts of reproductive failure. This was the primary goal of habitat restoration efforts on the island.

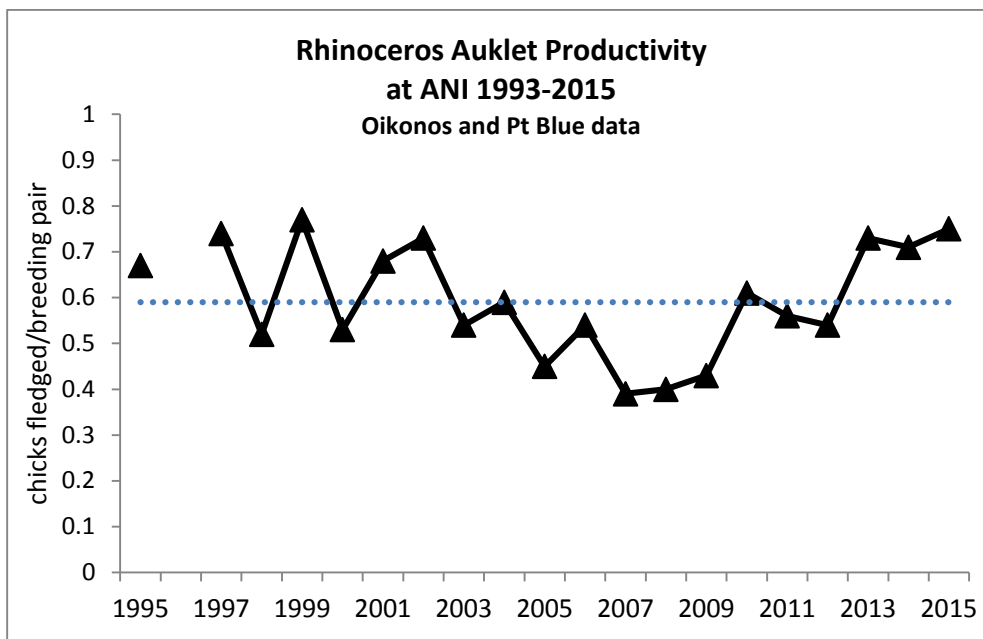


Figure 2. The average number of Rhinoceros Auklet chicks fledged per breeding pair in natural burrows and artificial nests on Año Nuevo Island annually from 1995 to 2015. Burrows were not monitored in 1996. Sample sizes ranged from 51 to 99 breeding pairs monitored. The line marks the



Cassin's Auklets (*Ptychoraphus aleuticus*) were monitored with the same methods as Rhinoceros Auklets. Cassin's Auklets were first discovered breeding on Año Nuevo Island in 1995 (Hester and Sydeman 1995). Until 2015, the number of Cassin's Auklet burrows in the restoration area increased annually since native plants were restored in 2010 (Fig. 3, green bars). Overall Cassin's Auklet population in 2015 dropped to 88 birds, down from 136 in 2014. This drop in population was likely related to oceanographic

conditions that led to delayed prey availability for this krill-eating species at the beginning of the 2015 breeding season. The smaller breeding population at ANI may also be related to poor oceanographic conditions in winter 2014-15, which resulted in a large-scale mortality event of Cassin's Auklets throughout the west coast of North America (Henkel et al. 2015). This mortality event was thought to be caused by starvation related to lack of prey availability (Henkel et al. 2015).

Cassin's Auklet first bred in clay nest modules designed for the larger Rhinoceros Auklets in 2013. In 2015, 6 Cassin's Auklets bred in modules (see Appendix 5 and page 18 and 20 for nest module details and reproductive success metrics). In 2015, we created new clay modules designed specifically for Cassin's Auklets. The prototypes were installed in fall 2015 for use in the 2016 breeding season (see module section, page 20).

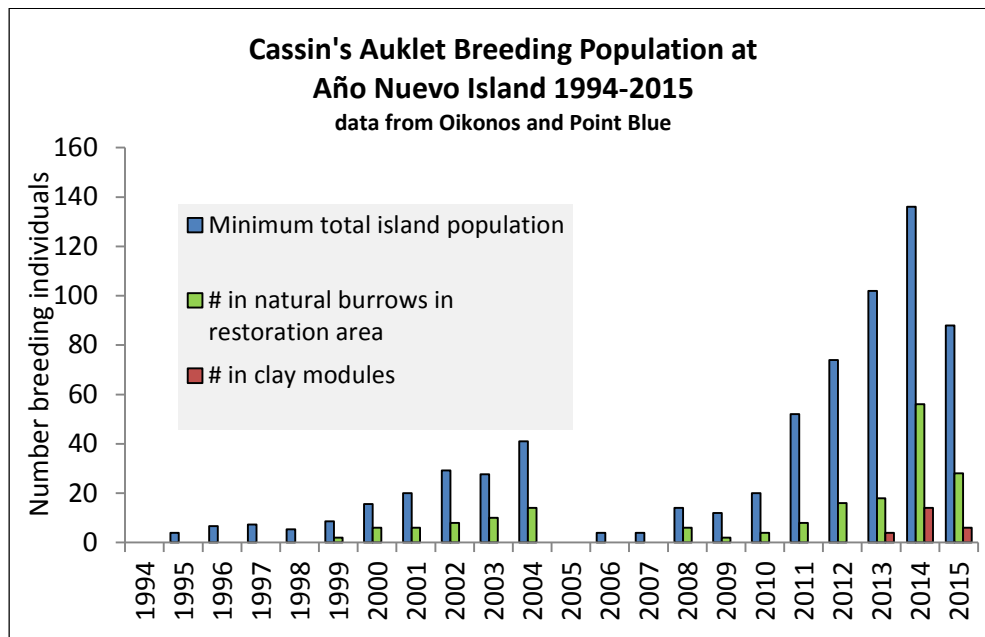


Figure 3. The estimated number of individual breeding Cassin's Auklets on Año Nuevo Island annually from 1994 to 2015. (Blue stacks = all of island, Green stacks = central terrace restoration area, excluding under cistern boardwalk, Red stacks = clay modules). No breeding was documented in 1994 or 2005.

In 2015, Cassin's Auklet productivity was 0.70 chicks fledged per breeding pair. Unlike 2010-2014, no Cassin's Auklet pairs attempt to raise two consecutive chicks in 2015 (termed "double-clutching"). However, overall Cassin's Auklet productivity in 2015 remained above the long-term average (0.65 chicks fledged per pair 1999-2015, n = 14 years; Fig. 4).

Cassin's Auklets are benefitting from the restored central terrace habitat, but their primary nesting area is a steep cliff under a disintegrating historic boardwalk near the Foghorn Building, which could be destroyed in a single southern storm event. Current habitat enhancement efforts involve encouraging breeders to move back from the cliff to habitat with more stable soil by installing smaller nest modules specifically designed for Cassin's Auklets (see section *Results: Cassin's Auklet Nest Modules*, page 20). The Cassin's Auklet is currently designated a California Species of Special Concern and is designated by the U.S. Fish and Wildlife Service as a Bird of Conservation Concern. The innovative protection efforts at ANI can be applied to enhance larger colonies, such as the Farallon Islands, and the wider population (from Mexico to Alaska).

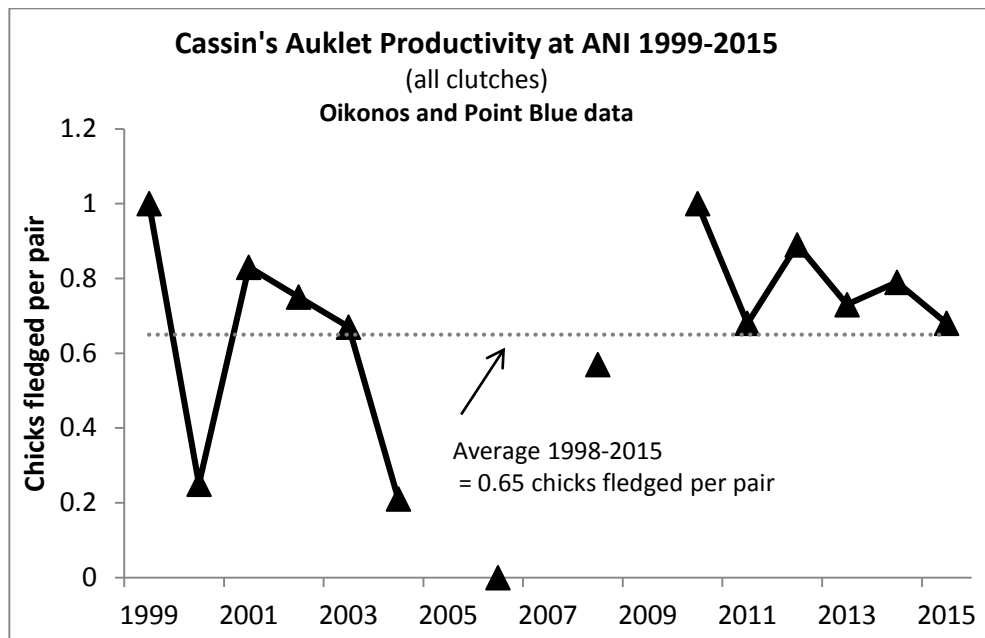
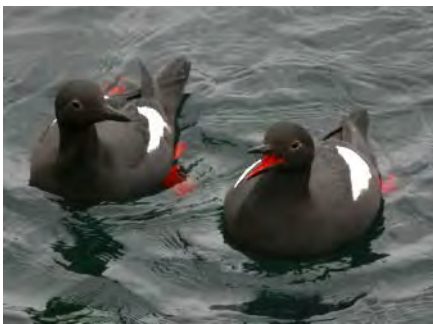


Figure 4. Cassin's Auklet productivity (chicks fledged/breeding pair) at Año Nuevo Island 1999-2015. All accessible nests were monitored. Sample size varied from 3 to 43 pairs per year. In 2005 no CAAU were found nesting. In 2006 only one egg was found and it failed. CAAU nested at ANI in 2007 and 2009 but nests were not checked often enough to quantify productivity.



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

Numbers of Pigeon Guillemots reported from island censuses in the 1970s -80s were relatively high (e.g., 117 individuals in 1989; Carter et al. 1992). The breeding population at ANI has since declined (Fig. 5), possibly in response to Western Gull densities, erosion of adequate crevices, and/or competition for nest

sites with Rhinoceros Auklets. In 2015, we recorded 12 active breeding pairs (24 breeding individuals). One pair of Pigeon Guillemots bred in a clay nest module in 2015.

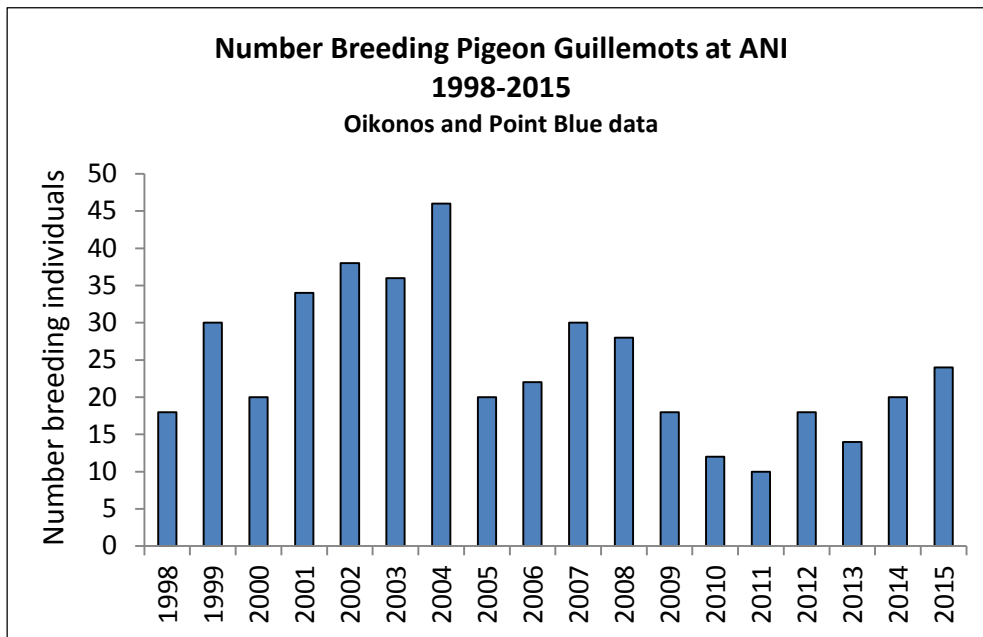


Figure 5. The estimated population of breeding Pigeon Guillemots on Año Nuevo Island visible from central terrace observation points (approximately 70% of the island) from 1998 - 2015.



Brandt's Cormorant (*Phalacrocorax penicillatus*) nesting was first documented at ANI in 1989 (2 nests; Carter et al. 1992). Ground-based censuses of nest numbers have occurred since 1999. Because not all nests are visible from ground observation points, annual aerial photographs were taken by Oikonos and others (see Capitolo et al. 2014) to census the total island population during peak incubation. We are currently coordinating with U.S. Fish and Wildlife Service to standardize photo counting methods.

In 2015, the overall population of nesting birds dropped slightly from previous years (1,647 nests in 2015, down from 1,807 in 2014, Fig. 6) but remained high despite delayed upwelling early in the breeding season. Numbers of Brandt's Cormorants that attempt to breed vary annually in part due to their ability to have larger and variable clutch sizes (up to five eggs per pair) and to adjust breeding effort based on prey availability (Boekelheide et al. 1990).

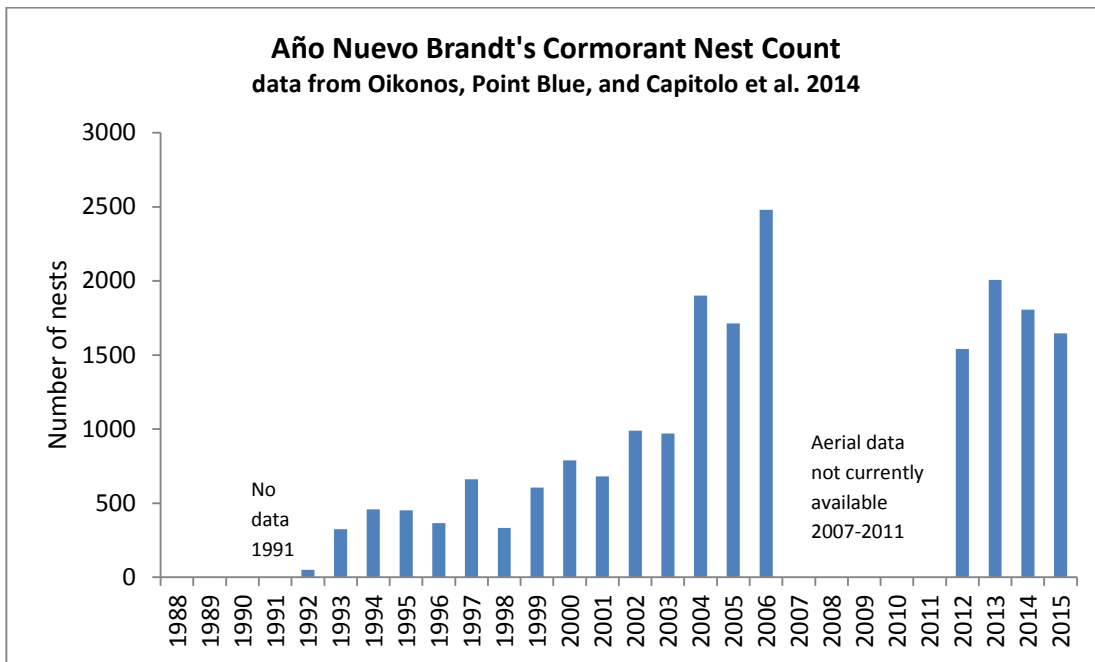


Figure 6. Aerial counts of Brandt's Cormorants nests (with incubating birds or chicks) on Año Nuevo Island from 1988 to 2015. The first documented nesting on ANI was in 1989. Zero nests were recorded in 1988 and 1990, and no data exists for 1991. Aerial counts from 2007-2011 are currently being compiled by US Fish and Wildlife and Oikonos. Data sources: Oikonos 2012-2015. Pt Blue: 1992-94, 1998, 2004-05; Capitolo et al. 2014: 1988-1990, 1995-1997, 1999-2003, and 2006.

In 2015 Brandt's Cormorant productivity was 2.26 ± 0.83 chicks per pair (Fig. 7). From 2008-2012 productivity was well below average at 0.89 ± 0.36 SD chicks per pair (average 2002-2015 was 1.67 ± 0.81 SD). Above average productivity from 2013-2015 is likely related to increased availability of Northern Anchovy and juvenile Rockfishes in these years, as indicated by Rhinoceros Auklet diet studies (see *Prey studies* section, page 16).

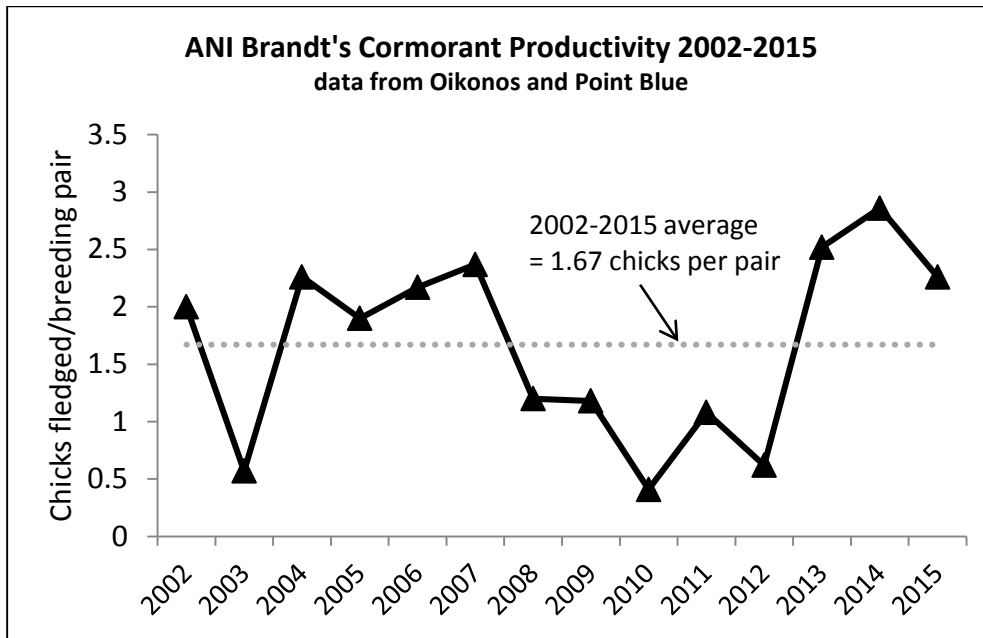
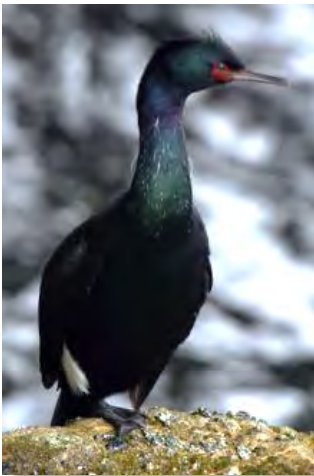


Figure 7. Brandt's Cormorant productivity at Año Nuevo Island 2002-2015. A sub-sample of nests was followed from each of the two main visible sub-colonies, the Light tower and Blind 17 (shown here combined). Sample size ranged from 20 nests (2002) to 57 nests (2004). In 2009, individual nests were not 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. The dashed line represents the average of 1.67 chicks per pair from 2002 – 2015.



Pelagic Cormorants (*Phalacrocorax pelagicus*) were censused sporadically at Año Nuevo from 1967 to 1987 (Carter et al. 1992). Annual standardized population and productivity monitoring began in 1996 on the island and 1999 on the mainland. During the breeding season, biologists recorded the contents of all nests on the mainland cliffs, island bluffs, and the Lightkeeper's Residence. To document Common Raven disturbances to nesting Pelagic Cormorants, we observed interactions at a mainland subcolony with a remote camera daily from April to August 2014-15.

Pelagic Cormorant reproductive effort is sensitive to annual environmental conditions (Boekelheide et al. 1990), and the population and reproductive success at Año Nuevo was highly variable from 1999-2015 (Figs. 8 and 9).

The total population of Pelagic Cormorants was 126 birds, with nearly equal numbers at the island (64 birds) and mainland (62 birds) sub-colonies (Fig. 8).

Reproductive success sometimes differs greatly between the island and mainland, indicating that these habitats are not always equally favorable for nesting. In 2015, however, productivity was similar, and below the long-term average, at both sub-colonies. Low productivity in 2015 appeared to be driven by ocean conditions rather than Common Raven predation. Raven depredation of Pelagic Cormorant eggs on the mainland caused a much lower productivity on the mainland compared with the island in 2013 and 2014, which did not occur in 2015. Raven depredation of eggs was not observed during weekly mainland colony observations in 2015. We hypothesize that this was due to a mismatch in timing between Raven and Pelagic Cormorant reproduction—Pelagic Cormorants began nesting relatively late in 2015 and the

Ravens may have been done nesting and gone before eggs became an available food source. Video of the mainland sub-colony has not yet been analyzed so we cannot yet say with certainty whether ravens depredated nests in 2015.

For more information on the effects of Common Raven predation of Pelagic Cormorant nests, see separate report to State Parks: “Common Ravens and Nesting Seabirds at Año Nuevo State Park 2014 Report.”

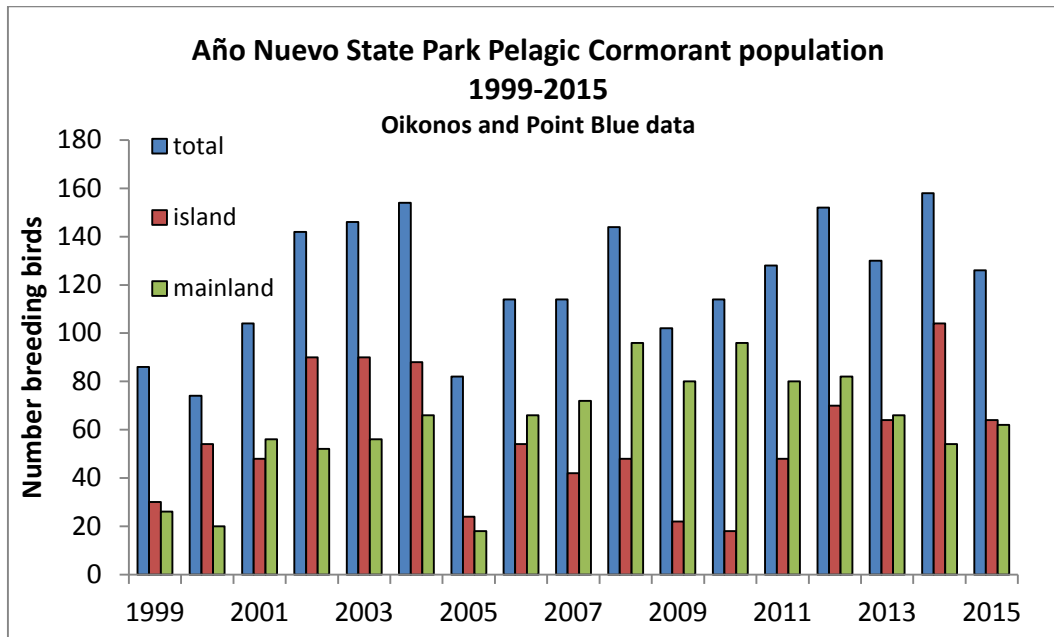


Figure 8. The estimated number of individual breeding Pelagic Cormorants at Año Nuevo State Park (blue - all monitored areas combined, red – island, green – mainland). Population was estimated from standardized ground counts and boat counts from 1999 to 2015.

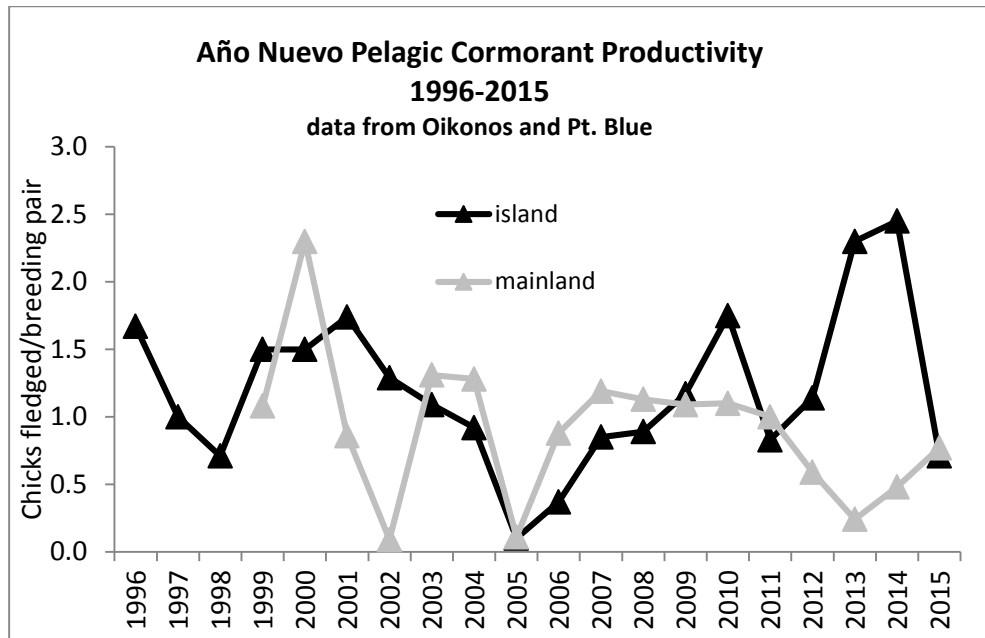


Figure 9. The estimated number of chicks fledged per breeding pair of Pelagic Cormorants on Año Nuevo State Park (black=island, gray=mainland). Data were estimated from standardized monitoring of a subsample from 1996 to 2015 (sample sizes ranged from 3 to 43 nests at each sub-colony).



Western Gulls (*Larus occidentalis*) were first censused at ANI in 1976 (Sowls et al. 1980) and annual standardized monitoring of the breeding colony began in 1998. Annual nest counts of the total island population occurred during peak incubation from 1998 to 2015. To measure reproductive success, a random subsample of at least 30 nests in the central terrace was followed throughout the season.

In 2015, there were 643 Western Gull nests on ANI, the lowest on record since 1987 and a 29% decrease from 2014 numbers (904 nests; Fig. 10). This trend is probably best interpreted as a drop in breeding effort, rather than a drop in absolute population size. Western Gulls, like Cassin's Auklets, subsist in large part on krill, which was relatively less abundant in 2015 than it had been from 2012-2014 (Sakuma 2015). Thus, gulls may have foregone breeding due to poor prey availability. However, krill availability has been lower in past years (Sakuma 2015) without equivalent reductions in breeding effort from gulls at ANI. At Southeast Farallon Island, the largest Western Gull colony in the world, there was a decline of similar proportion in the numbers of Western Gull nests in 2015 (Russell Bradley, pers. comm).

The drop in Western Gull numbers in 2015 may be related in part to a longer term trend of decreasing colony size at ANI. Gull colony size at ANI increased from 120 nests in 1976 (Sowls et al. 1980) to peak at 1,234 nests in 2005 (Fig. 10), as the population recovered from disturbance and persecution (Tyler 1981). From 2005-2015, however, gull nest numbers declined by 48%, with an annual loss of 42 nests per year (as modeled by linear regression; $\beta = 1239.8$, $R^2 = 0.80$, $P = 0.0005$).

The Western Gull population at Southeast Farallon Island also is declining, and in the next 20 years is predicted to decline by 9% under current environmental conditions, and 27% under “pessimistic” environmental conditions (Nur et al. 2013). This population change may be related to declining overall reproductive success, as well as periods of extremely poor reproductive success (i.e. <0.2 chicks fledged per pair in 2009-2011; Nur et al. 2013). However, annual reproductive success is often greater at ANI than at Southeast Farallon Island, and there was no trend in gull productivity at ANI from 1999-2015 (linear regression; $\beta = 1.1$, $R^2 = 0.02$, $P = 0.6$). Despite low nest numbers/breeding effort in 2015, reproductive success was near average at 1.24 ± 0.19 SE chicks fledged per pair (long-term average is 1.19 ± 0.08 chicks per pair, 1999-2015).

Habitat changes from the restoration treatments at ANI are likely influencing Western Gull nesting. The Habitat Ridge sea lion exclusion fence prevents sea lions from trampling nests, which is a common cause of nest failure outside the restoration area. Likewise, plant restoration and raised boardwalks likely increase the survival of chicks by giving them places to hide during disturbances by researchers, aggression by neighbor gulls, and attacks by aerial predators. Conversely, thick plant cover may reduce the density of nests, potentially reducing nesting populations in vegetated areas.

Trends in Western Gull population revealed by long-term monitoring show the value of these efforts. Western Gulls have the smallest world-population of any seabird nesting at ANI (estimated at 40,000 birds; Pierotti and Annett 1995), are endemic to the California Current system, and will likely continue to decline with climate change (Nur et al 2013). Understanding their population dynamics will continue to be important for conservation and management of this species.

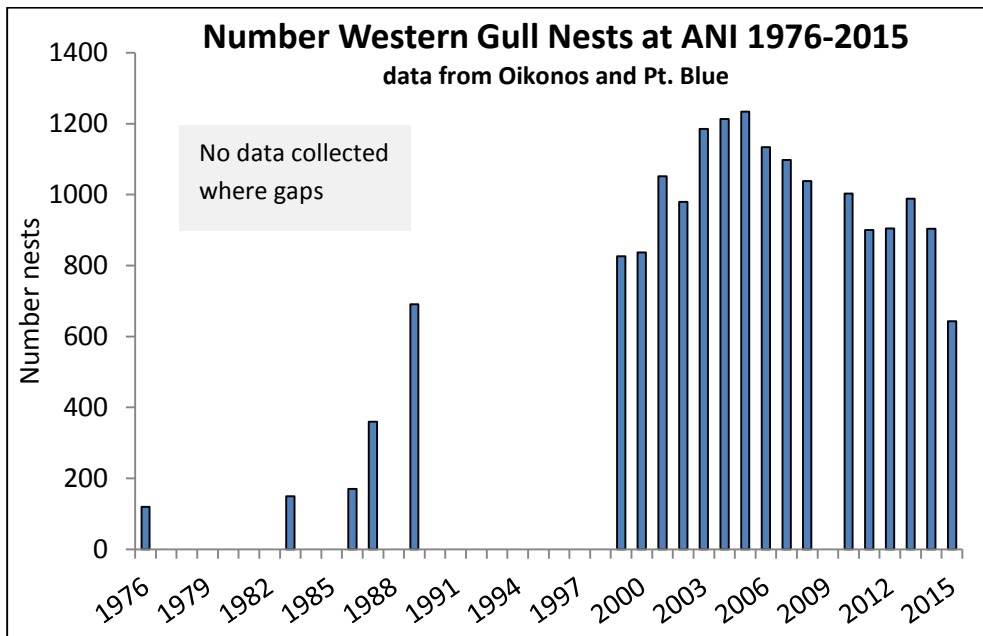


Figure 10. The estimated number of Western Gull nests on Año Nuevo Island (years with no blue bars had no available census data). Counts from 1998 – 2015 were estimated from standardized ground counts. 1976 data from Sowls et al. 1980, 1982-87 data from A. Huntley pers. comm., 1989 data from Carter et al. 1992.

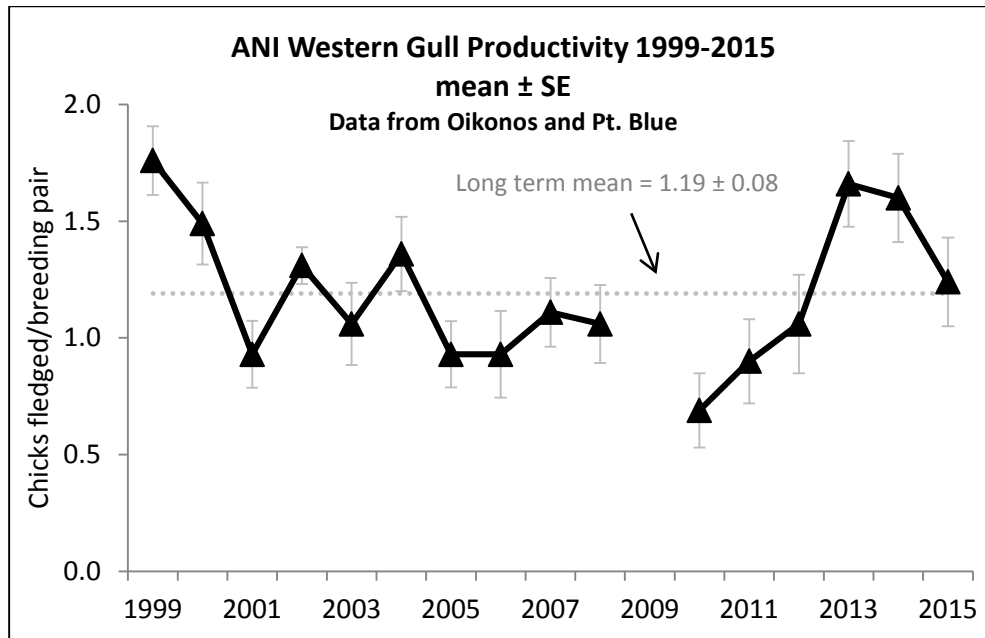


Figure 11. Annual productivity (chicks fledged per breeding pair) of Western Gulls nesting in the central terrace region on Año Nuevo Island from 1999 to 2015 (no data for 2009). Subsamples of 28 – 155 nests were monitored annually for breeding success.



Black Oystercatchers (*Haemaphysalis bachmani*) are a cryptic species that nests in intertidal areas along the west coast of North America. Reproductive success of Black Oystercatchers has generally been poor at ANI (Fig. 12), with chicks fledging from only 7% of observable sites with breeding activity from 1994-2015. In 2015, three active breeding sites were documented, and all failed (Fig. 12). One pair hatched a chick, which quickly disappeared, and the other pairs' eggs disappeared before hatching. Most Black

Oystercatcher breeding attempts fail when eggs or chicks disappear, suggesting that predation contributes to poor breeding success at ANI. Black Oystercatchers have been observed defending nests from Common Ravens frequently since 2004, indicating that ravens are harassing and likely depredating Oystercatcher nests. Interestingly, in 2015 one nesting attempt failed when a Western Gull began incubating the Oystercatcher eggs and apparently took over the nest. The gull incubated the Oystercatcher eggs for several weeks but the eggs did not hatch, and the Oystercatcher pair re-laid at a different site.

A recent population survey of Black Oystercatchers in California estimated a state-wide population of 4749 to 6067 individuals (Weinstein et al. 2014). This estimate was much higher than previous estimates, which emphasized that California is important core-habitat for the species (Weinstein et al. 2014). Despite the increased population estimate, there are still relatively few Black Oystercatchers in California, and available nesting and foraging habitat is limited to the narrow intertidal zone (Weinstein et al. 2014). Sea level rise is expected to threaten much of this habitat, which will increase the importance of elevated island nesting sites like ANI in the future (Weinstein et al. 2014). We plan to use cameras to help understand why Black Oystercatcher reproductive success is typically very low at the island, and

whether management solutions exist to increase their productivity there. A current project is underway to monitor state-wide trends in breeding success (Weinstein et al. 2014), which will help give a broader context for interpretation of reproductive trends at ANI.



Photo: Black oystercatcher parent and chick, 2015. This chick did not survive to fledging age.

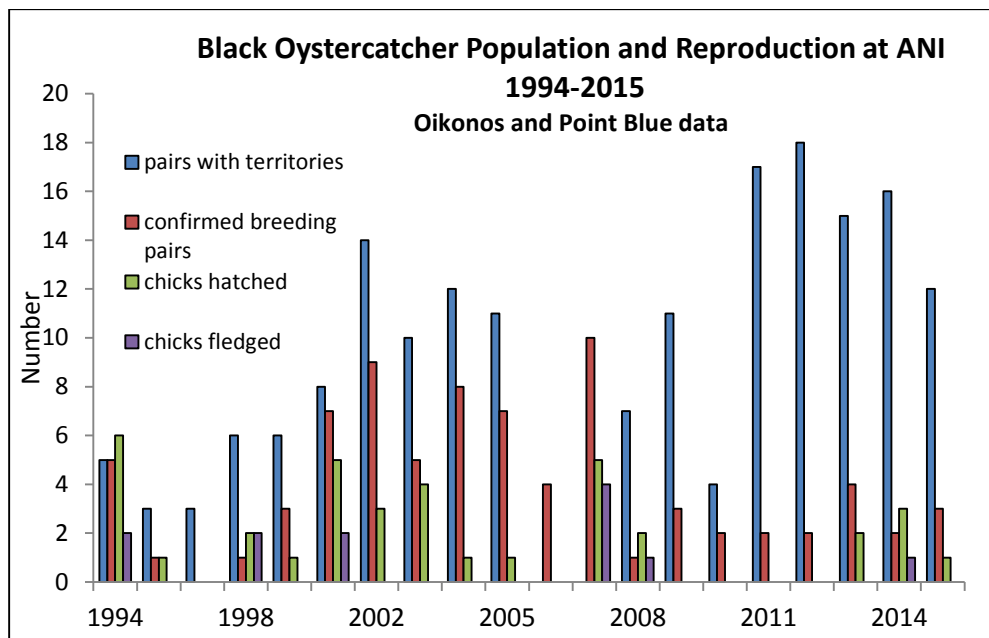


Figure 12. Annual population and breeding metrics of Black Oystercatcher nests visible from Año Nuevo Island ground observations from 1994 to 2015 (purple – total number of chicks fledged, green – total chicks hatched, red - confirmed number of breeding pairs documented with eggs or chicks, blue - total nest sites with regular attendance by a pair). 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*), a tiny seabird related to albatrosses, is a possible breeder on ANI. From 1993-2015, 11 Ashy Storm-petrels have been incidentally caught at ANI during nighttime mist-netting for Rhinoceros Auklet prey (Fig. 13). One Ashy Storm-petrel was captured in 2015. Nearly all of these birds had bare brood patches, indicating that they were of breeding age and possibly incubating an egg that season. No nests or confirmed eggs have been documented on the island, although breeding season surveys for nest sites are limited to mainly the central terrace to avoid pinniped and cormorant disturbance. The Lightkeeper's Residence could provide suitable cave-like habitat under the foundation but this area has not been surveyed. Storm-petrels will also dig burrows in soil and could be located anywhere on the island.

We began banding incidentally captured Ashy Storm-petrels in 2013. We banded one Ashy Storm-petrel in 2015, on July 14th. This individual was re-captured at Southeast Farallon Island (SEFI) on August 6th. It is unclear what this re-capture indicates, other than that there is connectivity between populations of storm-petrels using ANI and SEFI. It is unknown whether this bird bred on ANI or SEFI, or was just visiting both. Repeatedly capturing the same banded individual at ANI would provide further evidence of the likelihood of breeding on the island. ANI likely could not support a large colony of Ashy Storm-petrels due to the density of predatory Western Gulls and limited rock wall and crevice spaces.

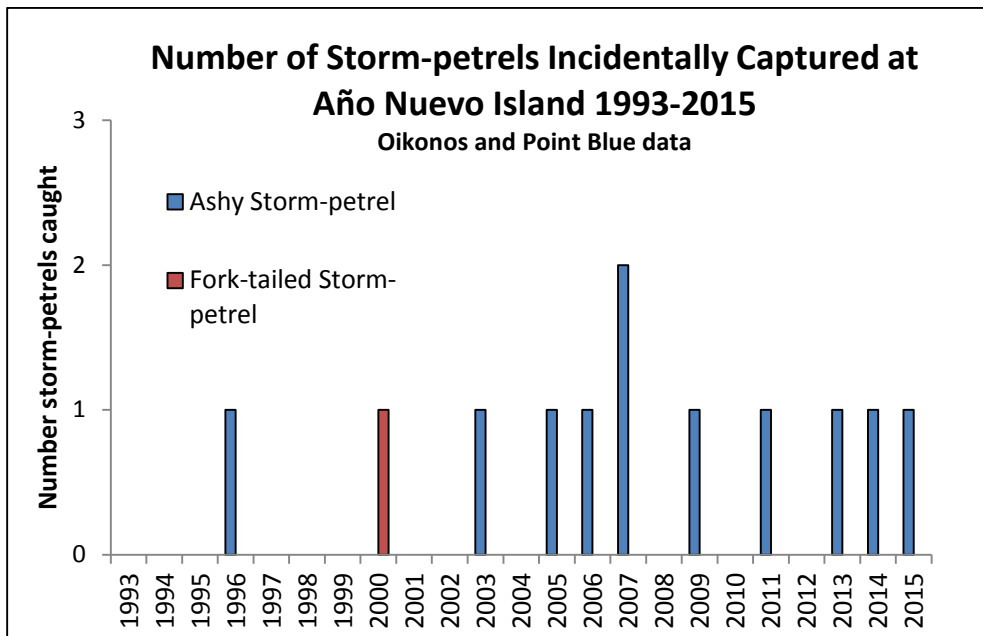


Figure 13. The number of Ashy and Fork-tailed Storm-petrels incidentally captured at Año Nuevo Island from 1993-2015. All storm-petrels were captured during standardized nocturnal mist netting for Rhinoceros Auklet diet samples from late June to early August.



Canada Geese (*Branta canadensis*) raised young on the island from 2012-2014, but did not nest in 2015. This may have been due to decreased vegetation on the island making it a less attractive breeding location for the herbivorous geese.



Common Ravens (*Corvus corax*) were first recorded nesting at Año Nuevo in 1987 (Lewis and Tyler 1987). There has been at least one active Common Raven nest on both the island and mainland every year since 2004. In 2015, the mainland Common Raven nest was active and interactions with a nearby Pelagic Cormorant subcolony were monitored via a remote camera (for results from previous years see Oikonos report *Common Ravens and Nesting Seabirds at Año Nuevo State Park 2014 Report*).

On ANI in 2015, there was one active Raven nest with chicks in the North Cove, and we were unable to ascertain whether another Raven nest on the Lightkeeper's House was active.

Prey Studies



Metrics of seabird reproduction and diet can track prey availability and other marine environmental conditions. Such studies are widely used to assess and predict ocean health. We collected diet samples from three breeding seabird species: Rhinoceros Auklets (1993-2015), and Brandt's and Pelagic Cormorants (2000-2015; only Rhinoceros Auklet results are presented here).

Rhinoceros Auklets return to the colony at dusk to deliver whole prey (fish or cephalopods) to their chicks. Since 1993, we have captured a limited number of adults (approximately 40 annually) in stationary mist nests to quantify the species, number, and age class of the prey they bring back to their chicks (measured as "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. During 2015, young-of-the-year (\bar{x} standard length = 81 ± 10 mm) Northern Anchovy dominated chick diet (Fig. 14). Prior research

at ANI has shown a correlation between the proportions of Northern Anchovy in chick diet and high reproductive success (Thayer and Sydeman 2007), as was observed in 2015.

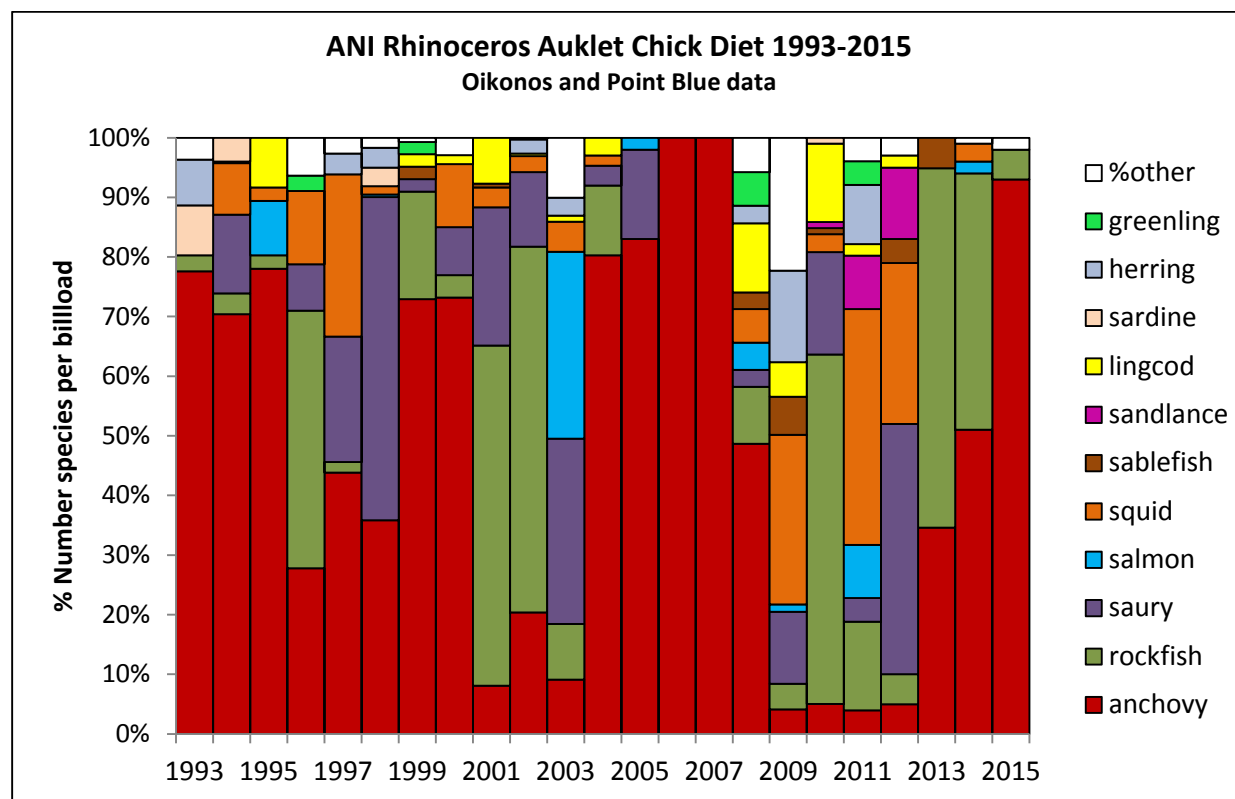


Figure 14. Rhinoceros Auklet chick diet on Año Nuevo Island from 1993 to 2015 quantified as the percent number of prey per bill-load delivered to chicks. Samples ranged from 18 - 47 bill-loads per year.

Migration Studies

In 2014-2015, we investigated the migration and wintering habitat of Rhinoceros Auklets at ANI as part of a collaboration with researchers at other breeding colonies from Alaska, British Columbia, Washington, and California. The lead collaborator is Ph.D. candidate Katie Studholme at Dalhousie University in Nova Scotia, Canada.

We deployed 15 geolocation tags in 2014 on Rhinoceros Auklets captured during mist netting activities conducted to collect diet samples. Geolocation tags record the time of sunset and sunrise and the day length to estimate the latitude and longitude location of the bird carrying the tag. We attached the 1 gram tag to the outside of temporary plastic leg band. Geolocators collected data through the fall and winter. We retrieved 9 of the 15 geolocation tags at nest sites and mist nest in 2015. We will attempt to retrieve the remainder of the tags during 2016.

Preliminary results from this tracking indicate that Rhinoceros Auklets from ANI traveled to waters off of southern California and northern Mexico during winter 2014-2015. These are the first results on the winter distribution of ANI breeders and the information is crucial for understanding year-round threats and how winter conditions influence this population.

IV. Habitat Restoration

The objectives of the restoration project are to mitigate injuries to seabirds from oil contamination (Luckenbach Trustee Council 2006) and protect biodiversity on ANI (see Appendix 5 Habitat Restoration 2009 – 2015).

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 five years since installation, the *Habitat Ridge* has proven to be effective. There have been no wildlife injuries or design concerns associated with the structure and it has required virtually no maintenance.
2. **Nest Modules:** To provide stable and low maintenance auklet nesting sites, we designed, produced and installed 87 clay nest modules for Rhinoceros Auklets and are testing 11 prototypes for Cassin's Auklets.
3. **Restoration:** To stabilize the burrow habitat and improve nesting success, we installed over 17,000 native coastal grasses and shrubs from 2009 – 2015 (see Appendix 2 Plant List). In 2015, we continued to augment the restoration with native seed, and installed erosion control material fabric in areas with the greatest rates of erosion.

Results: Nest Modules

Since 2013, Rhinoceros Auklet annual reproductive success in clay modules has been equal or above the long-term average of previous wooden box designs (0.51 ± 0.13 SD chicks fledged per pair 1993-2010; Fig. 15). Module occupancy increased in 2015 to 62 individual breeding Rhinoceros Auklets. In 2015, 6 individual Cassin's Auklets and 2 Pigeon Guillemots bred in clay modules (Fig. 16).

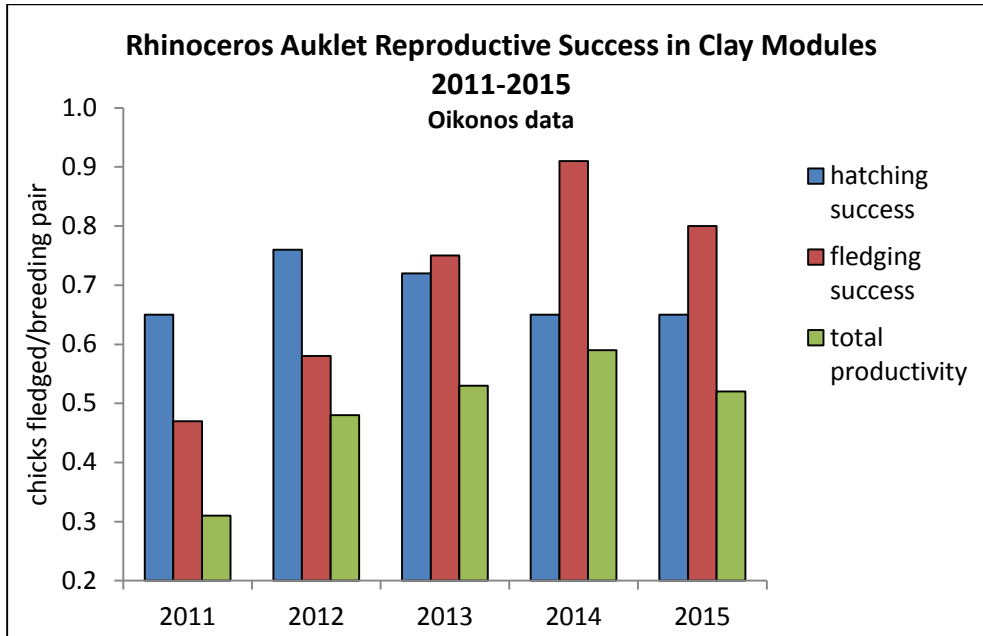


Figure 15: Rhinoceros Auklet reproductive success metrics in clay nest modules at Año Nuevo Island, 2011-2015 (blue – proportion of eggs that hatched per pair, red – proportion of hatched chicks that survived to fledging, green – proportion of chicks that fledged per breeding pair with a confirmed egg).

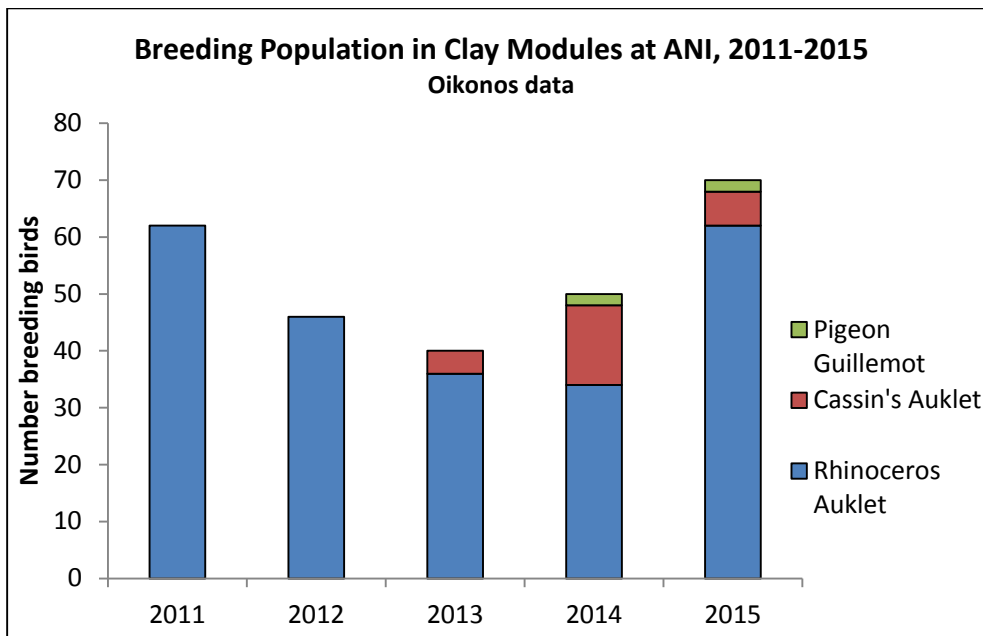


Figure 16: Seabird breeding population in clay nest modules at Año Nuevo Island, 2011-2015. Birds were counted as breeding birds if they had a confirmed egg or chick.

Cassin's Auklet Nest Modules

The goal of this project is to design, test, and deploy clay nest modules specifically for Cassin's Auklets. In 2013-2015, Cassin's Auklets successfully nested in clay modules designed for Rhinoceros Auklets, but a smaller tunnel and chamber design would be more suitable for them, and eliminate competition for nest modules from larger Rhinoceros Auklets. Currently the majority of the Cassin's Auklets breeding on the island nest on a single eroding bluff. This habitat could be entirely destroyed by large swells during a single winter storm, therefore the goal is to provide safer nesting habitat using clay modules on less eroding parts of the island. Nest modules will also be used to experiment with extreme temperature-mitigation and predator-exclusion designs, which will be broadly applicable on seabird colonies worldwide.



In spring 2015, with funding from the Bently Foundation, collaborators Nathan Lynch (a master ceramicist) and Matthew Passmore (an experienced designer and leader of Morelab), and the California College of the Arts conducted a class in which students created prototypes of clay nest modules for Cassin's Auklets. In fall 2015, we installed 8 student prototypes from the class and 3 professional prototype designs made by Nathan Lynch, on the island. Pending funding, we plan to install 60 final-product modules on the island in fall 2016.

Specific activities for this project in 2016 will include:

- Monitoring of prototype Cassin's Auklet modules during spring/summer 2016.
- Deployment of 60 final-product nest modules on the central terrace of the island during fall 2016. These modules will be open for Cassin's Auklets during the 2016 breeding season, which begins around February.

Results: Habitat Restoration

The three main metrics we used to determine the success of the habitat restoration annually were:

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

Burrow Damage Metric

Description: The purpose of the burrow damage metric is to quantify the incidence and severity of direct damage to Rhinoceros Auklet 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 quick quantifiable results.

Method: We recorded the burrow number, erosion type and severity codes, and any injury to adults or chicks on a weekly basis for all burrows in the central terrace restoration area from April through July during pre-restoration (1998 – 2001) and post-restoration (2010 – 2015).

Results: In the four years prior to the restoration applications (1998 – 2001), when habitat was virtually denuded, the percentage of Rhinoceros Auklet burrows damaged by erosion ranged from 42% to 67%, sometimes resulting in the death of an adult or chick. Post-restoration results show a direct and positive response to habitat stabilization efforts, with an average of 10 ± 6 SD% of burrows damaged by erosion per year from 2010-2015 (see Burrow Damage Table below). This metric excludes burrow damage inflicted directly by humans and/or wildlife.

Rhinoceros Auklet Burrow Damage Caused by Erosion in Restoration Area

| Year | Total Damaged Burrows | Burrows in sample | 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% |
| 2014 | 14 | 99 | 14% |
| 2015 | 15 | 125 | 12% |

**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). Burrows that were damaged by humans, sea lions, or pelicans were excluded in this analysis—see text.*

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 to 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 ANI in past years, invasive plants (i.e. *Tetragonia* (New Zealand spinach) and *Malva* spp.) have suffered dramatic die offs.

Method: We conducted two surveys per year quantifying plant species composition in restoration areas in May and October 2010 – 2015 (also in previous years 2003-2005). We quantified percent cover and average height by plant species. Leaf litter (dead plant material) 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. Live native plant cover reached 60% in fall 2012 (Fig. 17), composed primarily of native grasses (salt grass *Distichlis spicata* and American dune grass *Elymus mollis*; Fig. 18).

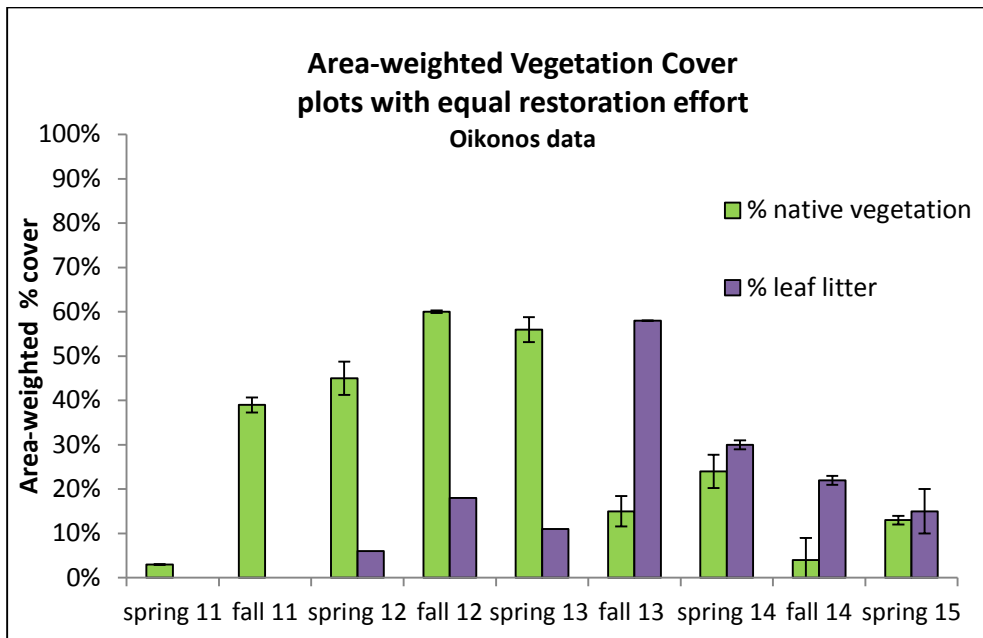


Figure 17. Percent vegetation cover (average area-weighted and standard error) in four restoration plots that experienced equal restoration efforts on Año Nuevo Island, 2011-2015. Plants were first installed in fall 2010.

Sustained trampling in fall 2013 and 2014 by hundreds to thousands of roosting Brown Pelicans caused live native vegetation cover in the restoration area to decline to 4% in fall 2014, with 22% cover of leaf litter (Fig. 18). High roosting densities were likely a result of local prey availability and larger-scale patterns influencing Brown Pelican breeding success in southern California and Baja, Mexico. Roosting pelicans also were concentrated in the restoration area because they did not have to compete with California sea lions for roosting sites.

Live native plant cover recovered from 4% in fall 2014 to 13% in spring 2015 (Fig. 17). This recovery was encouraging, especially given the severe drought conditions during the winter of 2013-2014. Eighty-nine percent of the native vegetation present in spring 2015 was salt-grass (Fig. 18). Woody species succumbed quickly to trampling and did not recover. Some dune grass survived trampling but has been slow to recover. Thus, salt grass was the most resilient species to trampling, and maintaining cover of this species is critical for long-term soil stability.

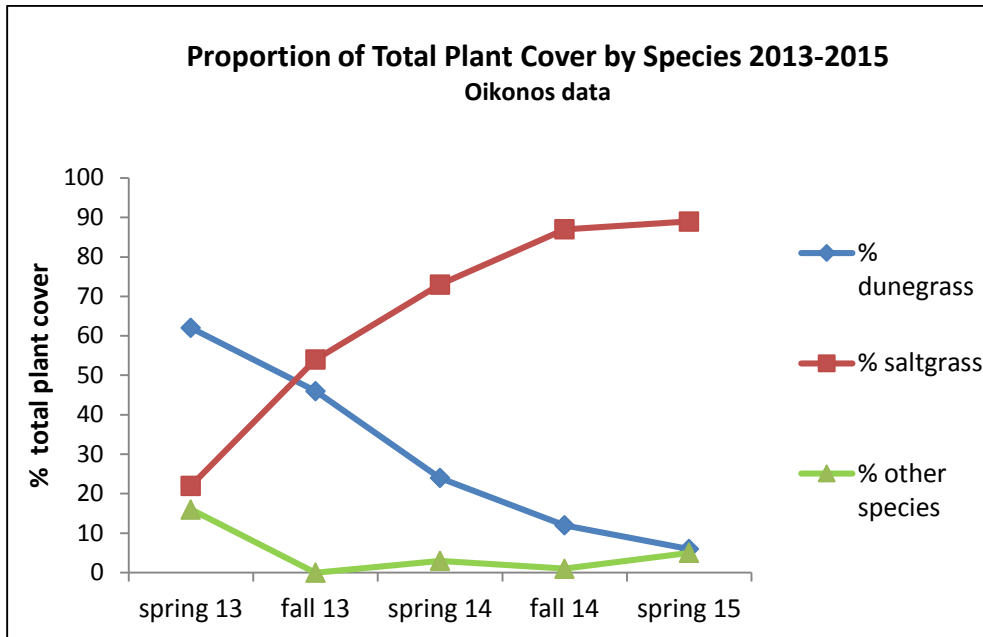


Figure 18. Average percent of total plant cover by species category (salt grass *Distichlis spicata*, American dune grass *Elymus mollis*, or other species) in the central terrace restoration area of Año Nuevo Island in spring and fall 2013-2015.



Photo: American dunegrass and salt grass in a relatively-untrampled part of the restoration area in November 2015. Plant cover remains high in patches that have received less trampling.

In 2015, roosting numbers of pelicans at ANI were once again high, but for a shorter duration than in 2014 (Figs. 19a, 19b). Overall, this resulted in plants being less intensely trampled in 2015. We surveyed plants in fall 2015 but have not yet analyzed results. Qualitatively, in fall 2015 plants were trampled over much of the restoration area, with only small patches of salt grass remaining, and some areas that were not trampled remained well-covered with native plants.

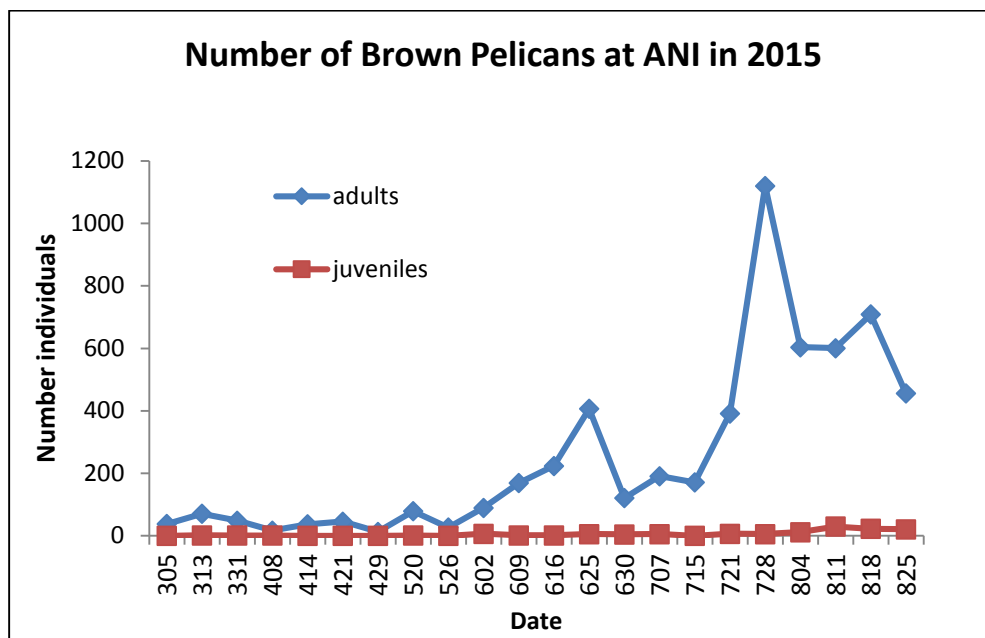


Figure 19. Number of Brown Pelicans on ANI in 2015. Counts were conducted from the central terrace and opportunistically by boat.

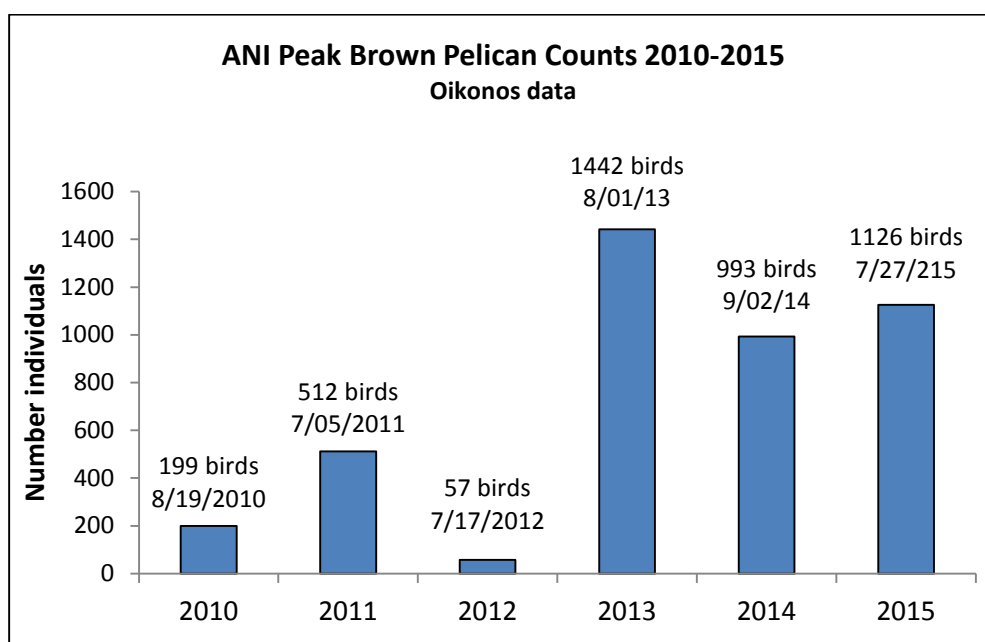


Figure 20. Annual peak counts of Brown Pelicans at Año Nuevo Island, 2010-2015

Dense pelican congregations do not occur every year at Año Nuevo (Fig. 19 and 20), but it is clear that restoration goals and plans must take irregular pelican trampling into account. We have adapted restoration goals to focus primarily on cover of resilient native grasses that contribute to soil stability.

Restoration plans/goals have been adapted in the following ways:

- More focus on maintaining and increasing cover of the most resilient species--salt grass
- Acknowledgment that % cover will fluctuate annually, with the goal of maintaining live cover between 25-75%
- Increased restoration treatments in areas the most prone to burrow damage
- Replacement of erosion control coconut fabric in areas with high amounts of erosion every 5 years as needed

Seabird Mitigation Metrics

Description: With no restoration efforts, it was estimated that burrowing seabirds would rapidly decline and 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 (Russell 1999). The annual reproductive metrics will demonstrate success if the breeding population remains stable and nesting attempts produce a healthy percentage of fledglings. Since restoration was implemented in 2010, the total number of chicks fledged in the restoration area has increased annually. This increase may be related to oceanographic conditions, prey availability, and/or demographic factors, as well as improved habitat quality. The annual increase in chicks fledged since 2009, however, is a clear indication of the restoration's success at preventing colony loss.

Methods: See nest monitoring methods in Appendix 3.

Results: From 2009 – 2015, an estimated **528 fledged chicks were produced in the restoration area** (see Mitigation Table below). In 2015, the central terrace population produced an estimated 96 fledged chicks, the greatest number on record.

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 |
| 2014 | 258 | 85 | 10 | 95 |
| 2015 | 290 | 80 | 16 | 96 |
| Total | | 432 | 96 | 528 |



Island Stewardship

In addition to vegetation restoration efforts, Oikonos works with ANSP and the University of California Natural Reserve system to ensure long-term stewardship of seabirds and their habitat. The primary focus of this work is maintaining aging infrastructure on the island to ensure that it is wildlife-safe.

Raised Boardwalks

Starting in 2011, Oikonos began raising boardwalks on the island 12 inches off the ground on posts. This solution improves seabird habitat in multiple ways:

- By preventing damage from human foot-traffic to auklet burrows
- By allowing plants to grow freely underneath, contributing to soil stability
- By providing safe hiding places for vulnerable Western Gull chicks

Raising boardwalks also reduces maintenance needed by preventing plants from growing over boardwalks and reducing wood exposure to the ground.

From 2010-2014, we raised approximately 200 feet of boardwalks. In fall 2015, we replaced original eucalyptus posts on raised boardwalks installed in 2010 with redwood posts. Redwood posts will have a much longer lifespan. Pending funding, we plan to raise a remaining 130 feet of boardwalk in the future in order to connect all currently raised sections. Several sections of boardwalk that are highly visible to marine mammals and have limited or no burrow activity will be left unraised.

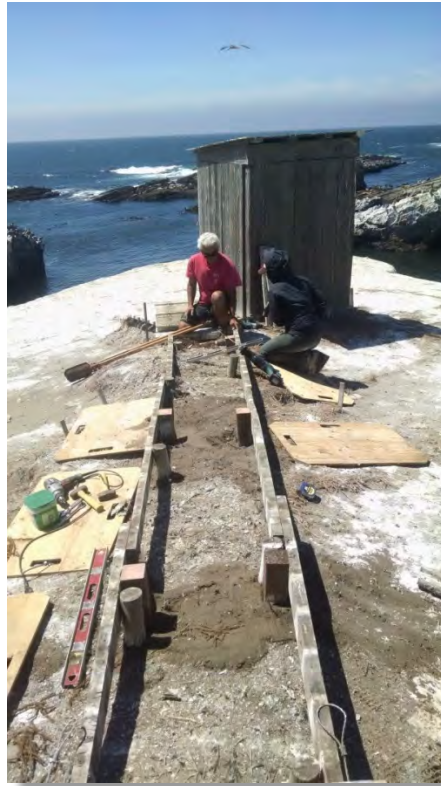


Photo: Volunteer Ron Brost and project manager Jessie Beck installing redwood posts on raised boardwalks in fall 2015.

VI. Future -2016 field season and beyond

In 2016, 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.

In addition we are participating in a collaborative fisheries project, Advancing Ecosystem-based Fisheries Management in the California Current System: Metrics of Prey Availability to Predators for Modelling Allowable Biological Catches. The 23-year time series of population size, breeding success and diet data from Año Nuevo will be analyzed with similar seabird data from the Farallon Islands and fishery trawl data. The goal is the creation of better models using the best regional data in existence to inform harvest management of prey populations.

Continuing studies/restoration actions planned for 2016

- Monitoring of population and reproductive success of all breeding seabirds
- Vegetation and burrow erosion monitoring to document restoration success
- Planting of salt grass in March 2016

- Diet studies of Rhinoceros Auklets, Brandt's Cormorants, and Pelagic Cormorants
- Contributing time-series seabird data to improve fishery models assessing allowable catch limits for forage fish
- Camera monitoring of mainland Pelagic Cormorant sub-colony to assess Raven interactions
- Retrieval of geolocation tags from Rhinoceros Auklets currently carrying them; no new tags are planned to be deployed in 2016
- Pending funding, installation of 60 Cassin's Auklet nest modules in fall 2016

Proposed studies pending funding:

- Document the diving depth and foraging effort of adult Rhinoceros Auklets and Brandt's Cormorants using small tags attached to their back feathers with tape

Proposed Island stewardship projects, pending funding

- Complete raised boardwalks to reduce burrow trampling and erosion
- Install composting toilet and remove the old outhouse

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This Citation:

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All photos in this report are those of Oikonos Ecosystem Knowledge unless otherwise specified.

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 2015 (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**. The other key partners were **Go Native, California College of the Arts, Nathan Lynch, Morelab, Rebar, 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 160 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 2009-15, 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**. In 2015 a complimentary project to analyze the Año Nuevo seabird time-series data was funded by NOAA. Direct matching for designing safe artificial nests 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 **Patagonia Santa Cruz Outlet, Peninsula Open Space Trust, the Robert and Patricia Switzer Foundation, the Michael Lee Environmental Foundation, the Bently Foundation, and USGS**. We also acknowledge the **Coastal Conservancy** for funding the pilot work and initial restoration efforts from 2003 - 2005.

Key Project Personnel 2009 - 2015

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



We thank the following individuals who volunteered their time and muscles on Año Nuevo Island from 2009 to 2015. 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.

Año Nuevo State Park Seabird Conservation & Habitat Restoration 2015 Report: Page 32

Data herein are unpublished and subject to revision, contact Oikonos before citing or distributing

| Year | Total 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 |
| 2014 | 19 | 11 | 70 | 558 | 7 |
| 2015 | 25 | 11 | 91 | 728 | 7 |
| Totals | 224 | 134 | 587 | 4694 | |

| Año Nuevo Island Volunteers 2010-2015 | | | | | | | |
|---------------------------------------|-------------------|-----------------|--------------------|-------------------|--------------------|---------------------|--------------------|
| Aaron Haebert | Brittany Guest | David Hyrenbach | Helen Christianson | Kathy Kellerman | Madeline Pots | Patrick Furtalo | Signe Jul Andersen |
| Abe Borker | Bryan Schatz | Deasy Lontoh | Helen Davis | Katy Saunders | Marilyn Cruikshank | Patti Kenyon | Sonja Murphy |
| Adam Fox | Catie Kroeger | Delaney Wong | Hugo Ceja | Keith Hernandez | Marina Maze | Patty | Sophie Webb |
| Adam Garcia | Chris Tarango | Dena Spatz | Inger Johansson | Kelly Iknayan | Maris Brenn-White | Peck Euwer | Sparrow Baranyai |
| Adam Green | Christine Chi | Diana Powers | Jackie Lindsey | Kira katzner | Martha Brown | Petrusjka Skjerning | Stan Hooper |
| Alaina Valenzuela | Chuck Boffman | Eliza Powers | Janet Carle | Kira Maritano | Masha Slavnova | Phil Curtiss | Steve Kurtagh |
| Alayne Meeks | Clair Nasr | Ellen Little | Jeb Bishop | Kit Clark | Matt Madden | Portia Halbert | Susan McCarthy |
| Alex Rinckert | Claire Sawyer | Emily Golson | Jeff Powers | Kolle Kahle-Riggs | Matthew McCown | Rachel Eastman | Teresa Aguilera |
| Alex Wang | Colleen Young | Emma Hurley | Jenny Garcia | Kristen Saunders | Matthew Passmore | Randy Chapin | Terry Sawyer |
| Allan Kass | Coral Wolf | Emma Kelsey | Jessica Kunz | Kristen Hill | Maya Whitner | Rebecca Cook | Tiffany Bailie |
| Andrea van Dexter | Corey Clatterbuck | Emma Wheeler | Jessie Beck | Kristen Swehla | Melinda Conners | Rhett Frantz | Tim Brown |
| Andrew Fisher | Corrine Gible | Eric Woehler | Jim Harvey | Laird Henkel | Michael Hanrahan | Rick Condit | Tim Gledich |
| Angela Szezorkia | Crosbie Walsh | Erica Donnelly | Jo Anne Dao | Lana Meade | Molly Baird | Ron Brost | Tim Shaffer |
| Ann Garside | Damien Sosa | Evan Barbour | John Bela | Laura Webb | Natahsa Vokshoori | Rosemarie Willmann | Trinidad Mena |
| Anne Cassell | Dan Barnard | Evan Barbour | John Finch | Lena Molinari | Nick Slobodian | Ryan Carle | Valeria Ruopollo |
| Arlene Davis | Dana Page | Gabriella Layi | Jonathan Felis | Linda Brodman | Nicole Hicock | Sacha Heath | Vladimir Vlad |
| Becky Hendricks | Dave Calleri | Gary Strachen | Josh Adams | Lindsey Graves | Noreen Yee | Sara Mclean | Will Spangler |
| Bill Henry | Dave Carle | Grant Ballard | Josh Berliner | Lloyd Fales | Parker Forman | Sarah Lenz | Yoel Kirschner |
| Benny Drescher | David Calleri | Guy Oliver | Josie Moss | Louis Wertz | Pat Kittle | Sarah Peterson | Zach Michelson |
| Breck Tyler | David Greenberger | Haleigh Damron | JT Keeley | Luke Hass | Pat Morris | Scott Shaffer | Zoe Burr |



Appendix 2. Plant Species List

Native San Mateo County coast species planted or seeded on Año Nuevo Island in 2010-2015 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> | Cottonbattling Plant |
| <i>Schoenoplectus pungens</i> | Common Threesquare |
| <i>Scrophularia californica</i> | California Bee Plant |

Appendix 3. Seabird Population and Reproduction Study Methods – 2009 to 2015

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.

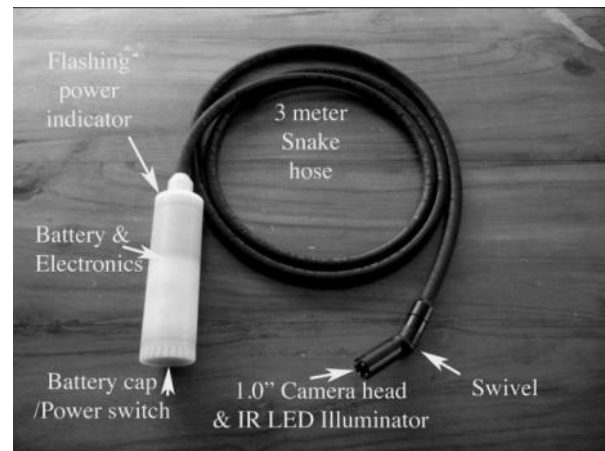


Photo: The Pukamanu 2.2 burrow camera was used to monitor underground seabird burrows. The image is illuminated by infrared light invisible to the birds and transmitted wirelessly to a head-set display. Designed by Abyssal Hawaii and Oikonos.

Appendix 4. – Año Nuevo State Park Seabird Program Resources: Articles, Videos, Outreach, Images, Links - 2009 to 2015

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 - 2014 with inkind and matching support:

- Two Project Videos
 - [A Plan Was Hatched](https://vimeo.com/oikonos/ano-nuevo-island-restoration) produced by Lloyd Fales and Peck Ewer, Swell Pictures
vimeo.com/oikonos/ano-nuevo-island-restoration
 - [Students Design Auklet Nests](https://vimeo.com/oikonos/students-design-seabird-homes) produced by a CCA Student, Justin Holbrook
vimeo.com/oikonos/students-design-seabird-homes
- ANSP Docent and Volunteer Newsletter – Vocalizations Winter 2014
- California State Park Rangers Association *Wave* Newsletter, summer 2015 : Año Nuevo Island: A Seabird Haven
- Coastside State Parks Association Newsletter– “[A success story: Preserving breeding habitat for Auklets on Año Nuevo Island](#)”
- Bay Nature Magazine “[Art for Auklets](#)”
- Santa Cruz Sentinel, “[Restoration project aims to bolster population of rhinoceros auklets](#)”
- 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.
- [Real-world Art School](#) – article in American Craft Magazine
- [Not Your Average Birdhouse](#), UC Santa Cruz Science Communication Blog
- [Habitat Restoration: One Bird At a Time](#), Moss Landing Marine Lab blog



Art by Sonja Murphy, CCA Student

Scientific Publications

Temporal and sex-specific variability in Rhinoceros Auklet diet in the central California Current system.
2015. Journal of Marine System 146: 99-108.

Scientific Presentations

Pacific Seabird Group Conference – Feb 2014, Juneau, AK

Contributed to presentation by Ron LeValley entitled:
PELAGIC CORMORANT POPULATION AND REPRODUCTIVE STATUS: THE BEGINNING OF AN
ASSESSMENT

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

Seal Adventure Weekend – February 2012-2015, Año Nuevo State Park, CA

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

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

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

Año Nuevo Docent Trainings

Presentation entitled:
THE SEABIRDS OF AÑO NUEVO ISLAND- September 2015

Año Nuevo bird walk led by Ryan Carle—September 2015

Presentation entitled:
AÑO NUEVO ISLAND SEABIRD HABITAT RESTORATION AND RESEARCH—2012

University Guest Lectures

Guest lecture to Pajaro Valley High School

Guest lecture to UC Santa Cruz Restoration Ecology class, winter quarter 2016

Guest lecture to UC Santa Cruz Restoration Ecology class, Spring quarter 2014

Guest lecture to UC Santa Cruz Restoration Ecology class, Fall quarter 2011

Meetings

California Seabird Coordination Meeting, annually 2010-2015

Santa Cruz Seabird Coordination Meeting, December 2015

Appendix 5. – Habitat Restoration Accomplishments 2009 - 2015

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 – 2015, 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 17,000 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. Improved burrowing habitat also benefits Cassin's Auklets, whose population increased from 4 birds in 1995 to 139 birds in 2014.

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 2011-2015, 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 - 2015 |
|---|---|---|---|
| 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 ✓ Prototyped Cassin's Auklet 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 8,000 grasses and shrubs in selected areas ✓ Seeded with native species ✓ Raised boardwalks ✓ Weeded invasive plants |

Other annual activities completed (2009 – 15):

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.

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.

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.

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

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 five 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 2011-2015 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.

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 22 years, we have documented that Rhinoceros Auklets will successfully raise young in artificial nests on Año Nuevo Island (Hester 1998). 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.

For nest modules results, see this report *Results: Nest Modules* section, page 18.

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



Photo: American dune grass (Elymus mollis) growing in Go Native's greenhouse in preparation for island restoration.

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.

In support of the current effort, from 2008 to 2015 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 2011-2015, we augmented the entire area with native seed and added an additional 8,000 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).



For plant restoration results, see this report section *Vegetation Metrics*, page 22.

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)