Año Nuevo State Park
Seabird Conservation and Habitat Restoration: Report 2016

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Nathaniel Smith photo

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I. Introduction

The goals of Oikonos' activities at Año Nuevo State Park (ANSP) are to conserve seabird populations, nesting habitat, and prey resources, and to educate the public about seabirds and their conservation. The 2016 season was the **24th consecutive year** of seabird studies at ANSP, which were initiated by ANSP and Point Blue Conservation Science in 1993 and have been led by Oikonos from 2009-2016. In 2016, Oikonos continued documenting population size, nesting success, and diet of breeding seabirds on Año Nuevo Island and the mainland cliffs. Oikonos also continued restoration efforts that began in 2005. This involved maintenance of plant restoration, habitat studies, and island stewardship, including installing more native plants and erosion control fabric 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: 2016 Highlights

- The Rhinoceros Auklet population in the central terrace restoration area continued to grow, reaching a new high of 294 birds.
- Rhinoceros Auklets in the restoration area fledged an estimated 100 chicks, the greatest number on record.
- Rhinoceros Auklet diet indicated an abundance of young-of-the-year Northern Anchovy in 2016.
- Reproductive success was near average or above average for all species except Black Oystercatchers.
- Western Gull population was a lowest ever recorded in our 18 year time-series (1999-2016), continuing a ten-year decline that began after 2006 and sharpened in 2015. Nest numbers were comparable to counts in the late 1980's.
- A pair of Cassin's Auklets successfully fledged a chick from a prototype Cassin's Auklet clay module design.

II. Seabird Population Status & Breeding Success

In 2016, we quantified 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,** and **Common Ravens**. Incidental monitoring continued on non-breeding species and predatory birds foraging on Año Nuevo Island (ANI).

Rhinoceros Auklet (*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 added to the known number of pairs nesting in artificial sites for an overall population estimate.

Rhinoceros Auklet population

Rhinoceros Auklets were first documented breeding on ANI in 1982 (Fig.1; LeValley and Evens 1982). In 2016, an estimated 318 Rhinoceros Auklets bred on the island (Fig. 1), a slight decline from the 330 birds in 2015 (Fig. 1). However, a record high 294 birds nested in the central terrace restoration area in 2016, representing 92% of the total island population. Twenty-four birds (8% of the total population) nested in an isolated area near the Lightkeeper's House. The slight decline (4%) in overall population between 2015 and 2016 was driven by a lower number of burrows in the Lightkeeper's House area, which is rapidly losing soil to erosion. This area is inaccessible to researchers during the breeding season and has not been managed for restoration of Rhinoceros Auklet habitat.

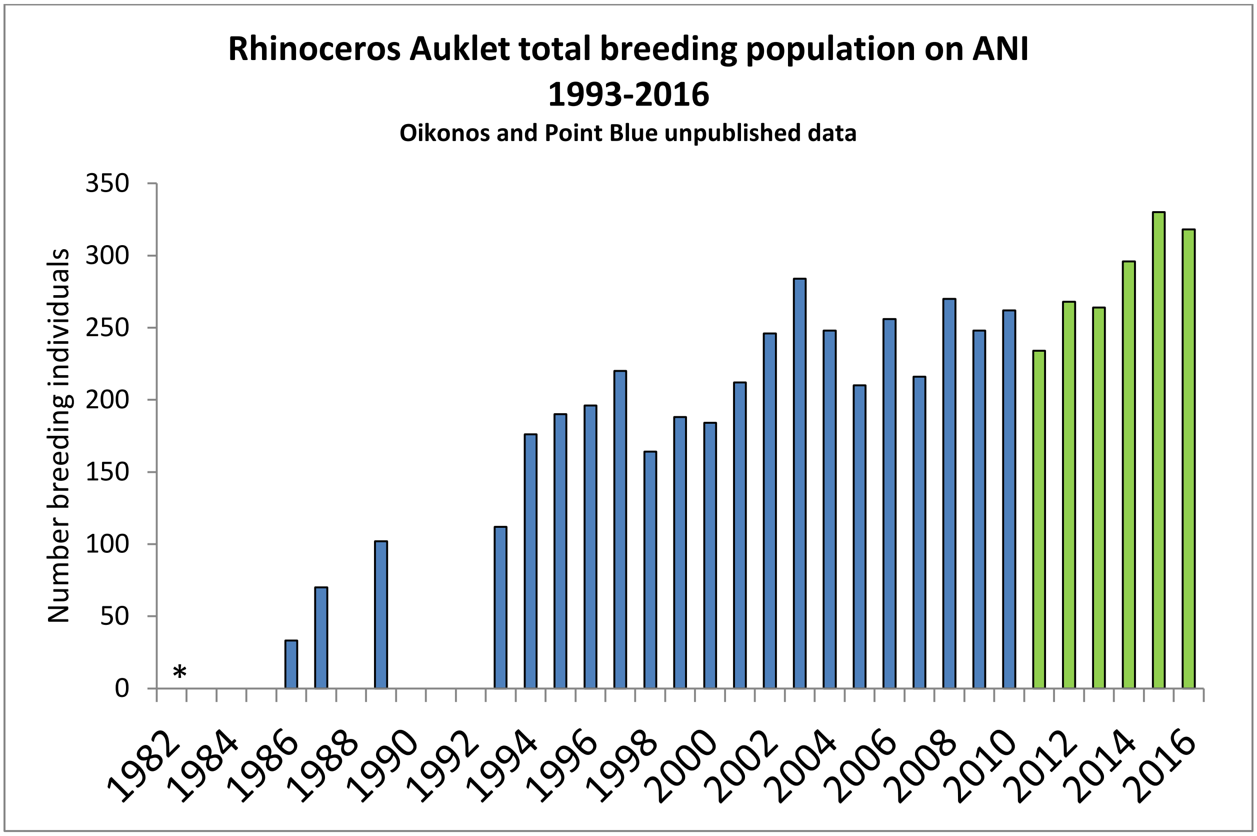


Figure 1. The number of individual breeding Rhinoceros Auklets on Año Nuevo Island (ANI) from 1982 to 2016. Years with blanks have no data. Green bars represent years of central terrace habitat improvements including erosion control, native plant restoration, and ceramic nest modules. Asterisk in 1982 indicates breeding birds were believed to be present but were not counted (Levalley & Evans 1982). Burrow counts from the literature were multiplied by long-term burrow occupancy correction factors to get population estimates for 1986-87 (Lewis & Tyler 1987) and 1989 (Carter et al. 1992).

Photo: Eroding habitat in the isolated Rhinoceros Auklet breeding area near the Lightkeeper's House, October 2016. Until recently, soil covered the pipe in the center of the photo. This area in inaccessible during the breeding season and has not been managed for habitat restoration. An estimated 8% of the island's Rhinoceros Auklets (24 birds) nested in this area in 2016.

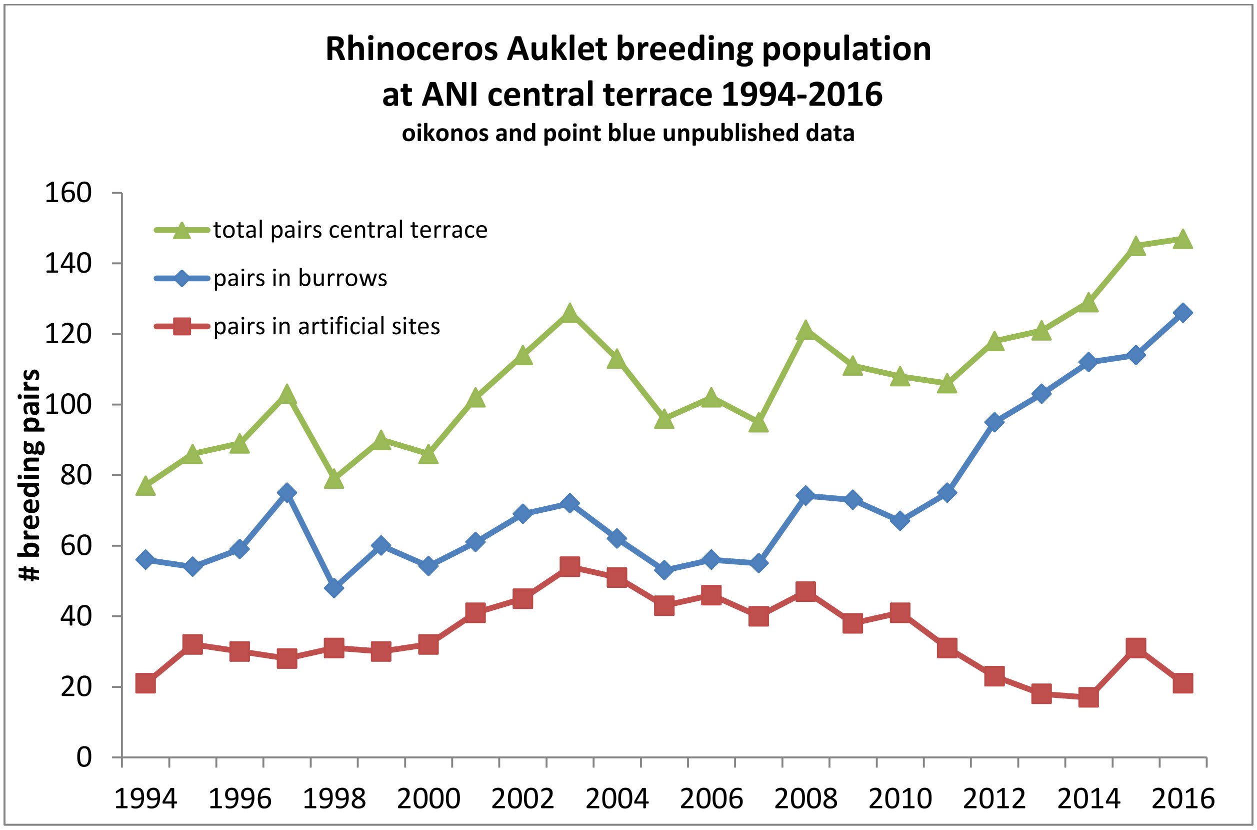


Figure 2: Number of Rhinoceros Auklet pairs breeding a the Año Nuevo Island central terrace in natural burrows (blue), artificial nest sites (red), and overall (green), from 1994-2016.

The number of Rhinoceros Auklets nesting in natural burrows in the central terrace habitat restoration area grew for the 6th consecutive year in 2016 (Fig. 2). Notably, this consistent increase began in 2011 (Fig. 2), the year that we implemented large-scale habitat restoration including sea lion exclusion from the central terrace, native plant revegetation, and erosion control fabric installations. It appears the increase in natural burrow nesting may be a response to improved burrowing habitat. Clay nest modules also replaced wooden nest box designs in 2010, and it is also possible that pairs previously established in wood nest boxes moved to natural burrows, perhaps temporarily, when this change occurred. Likewise, increased vegetation cover in 2011-2014 may have made it more difficult for auklets to locate entrances to clay nest modules, resulting in more natural burrowing activity. However, the overall population also grew annually from 2010-2016 (Fig. 2), indicating that increase in natural burrows was not simply a result of movement from artificial sites.

Rhinoceros Auklet reproduction

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 3 for nest module project details and *Results: Nest Modules,* pages 25-27, for utilization by breeders). On average from 1995-2016, 64 ± 16 SD% of Rhinoceros Auklet pairs fledged chicks in natural burrows. In 2016, nesting success in natural burrows was above average, with 71% of breeding pairs raising a chick to the fledging stage (Fig. 3). Good breeding success in 2016 may be related to an abundance of anchovy in Rhinoceros Auklet chick diet in 2016 (see *Prey studies,* page 21). Anchovy availability has been associated with greater Rhinoceros Auklets reproductive success at ANI in past years (Thayer and Sydeman 2007, Carle et al. 2015).

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 (Fig. 3). Reproductive success is correlated with quantities and types of prey available each year (Thayer and Sydeman 2007), 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.

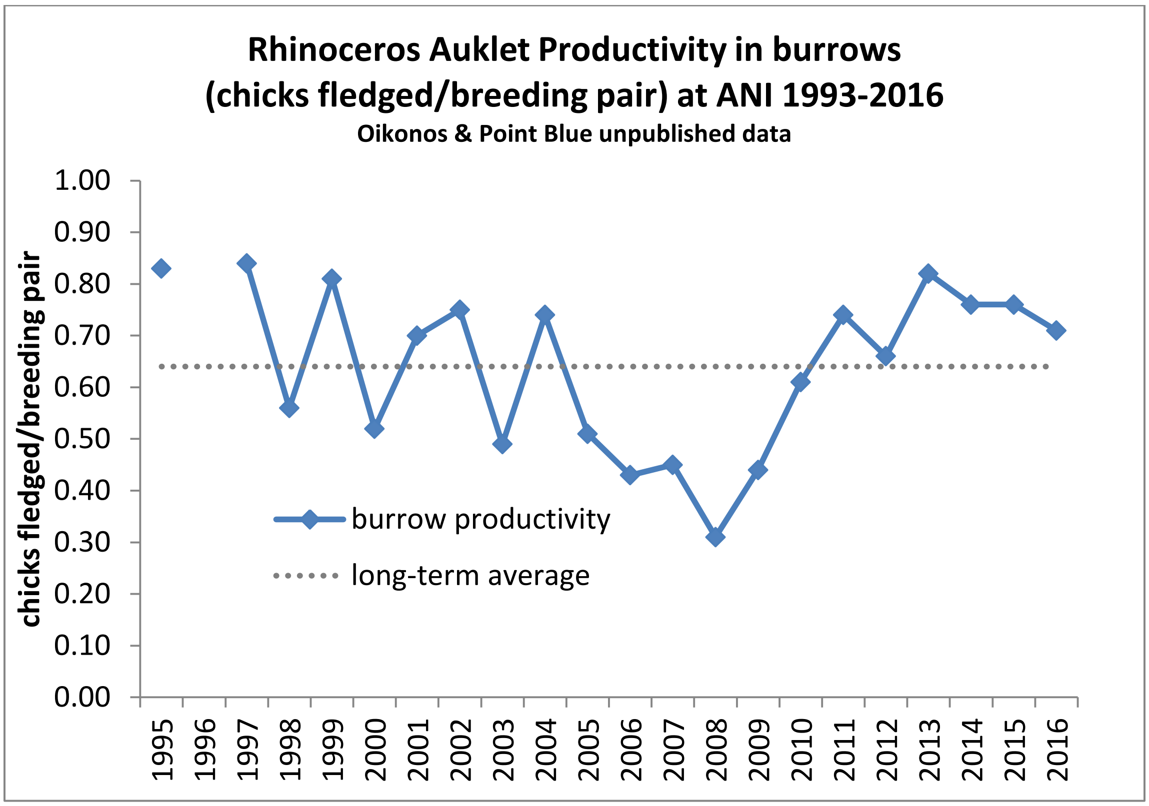


Figure 3. The average number of Rhinoceros Auklet chicks fledged per breeding pair in natural burrows on Año Nuevo Island annually from 1995 to 2016. Burrows were not monitored in 1996. Sample sizes ranged from 51 to 99 breeding pairs monitored. The dashed line marks the 21-year mean of 0.64 chicks fledged per pair.

Cassin's Auklets (*Ptychoraphus aleuticus*) were monitored using the same methods as Rhinoceros Auklets.

Cassin's Auklet population:

Cassin's Auklets were first discovered breeding on ANI in 1995 (Fig. 4; Hester and Sydeman 1995). The Cassin's Auklet population in 2016 was 92 birds. Eighty-four birds nested in the central terrace restoration area, representing 91% of the population. A drop in population after a high of 136 birds in 2014 (Fig. 4) was likely related to oceanographic conditions that led to poor prey availability in winter 2014-15, resulting 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), among other factors.

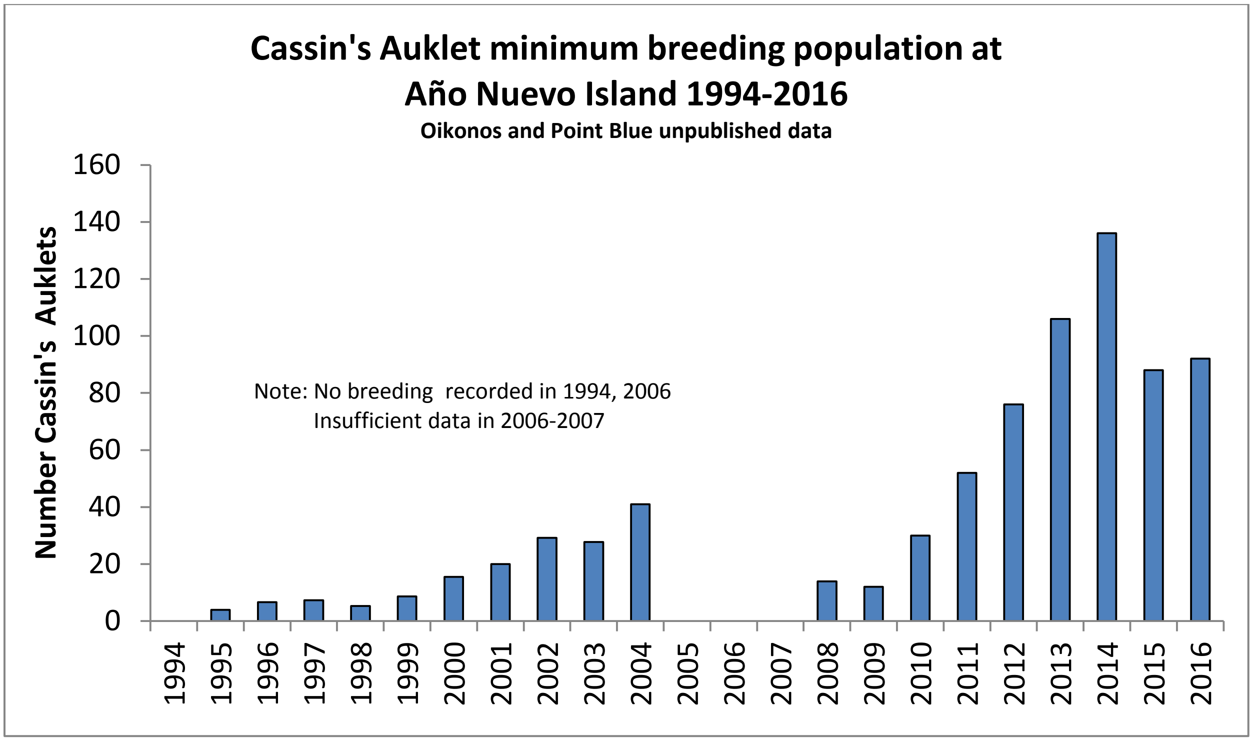


Figure 4. The estimated number of individual breeding Cassin's Auklets on Año Nuevo Island annually from 1994 to 2016. No breeding was documented in 1994 or 2005. Insufficient data existed in 2006 and 2007 to estimate population, though limited data suggest very low breeding population (i.e. less than 10 breeding pairs). 1994-2010 are minimum estimates because not all parts of the island were checked. In 2011-2016 all parts of the island were checked and population estimate is not a minimum.

Cassin's Auklet reproduction:

In 2016, Cassin's Auklet productivity was 0.77 chicks fledged per breeding pair (*n* = 43 nests; natural burrows and artificial sites combined; Fig. 5). Cassin's Auklet productivity in 2016 was above the long-term average (0.66 chicks fledged per pair 1999-2016, *n* = 15 years; Fig. 5). However, only one pair made a second breeding attempt after fledging their first chick (termed "double-clutching"). Double-clutching is a sign of exceptionally good conditions for Cassin's Auklet reproduction and in previous years many more pairs have attempted it.

Cassin's Auklet first bred in clay nest modules designed for the larger Rhinoceros Auklets in 2013. In 2015, 3 pairs of Cassin's Auklets bred in clay modules (see pages 25-27 and 47-48 [Appendix 3] for nest module details and reproductive success metrics). In 2015, we created new clay modules designs specifically for Cassin's Auklets, and installed three final prototypes before the 2016 breeding season. A pair of Cassin's Auklets successfully fledged a chick from one of these prototypes in 2016 (see Cassin's Auklet nest modules section, page 26).

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 clay nest modules specifically designed for Cassin's Auklets (see page 26). The Cassin's Auklet is currently designated a California Species of Special Concern (Adams 2008) and is designated by the U.S. Fish and Wildlife Service as a Bird of Conservation Concern (USFWS 2008). 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).

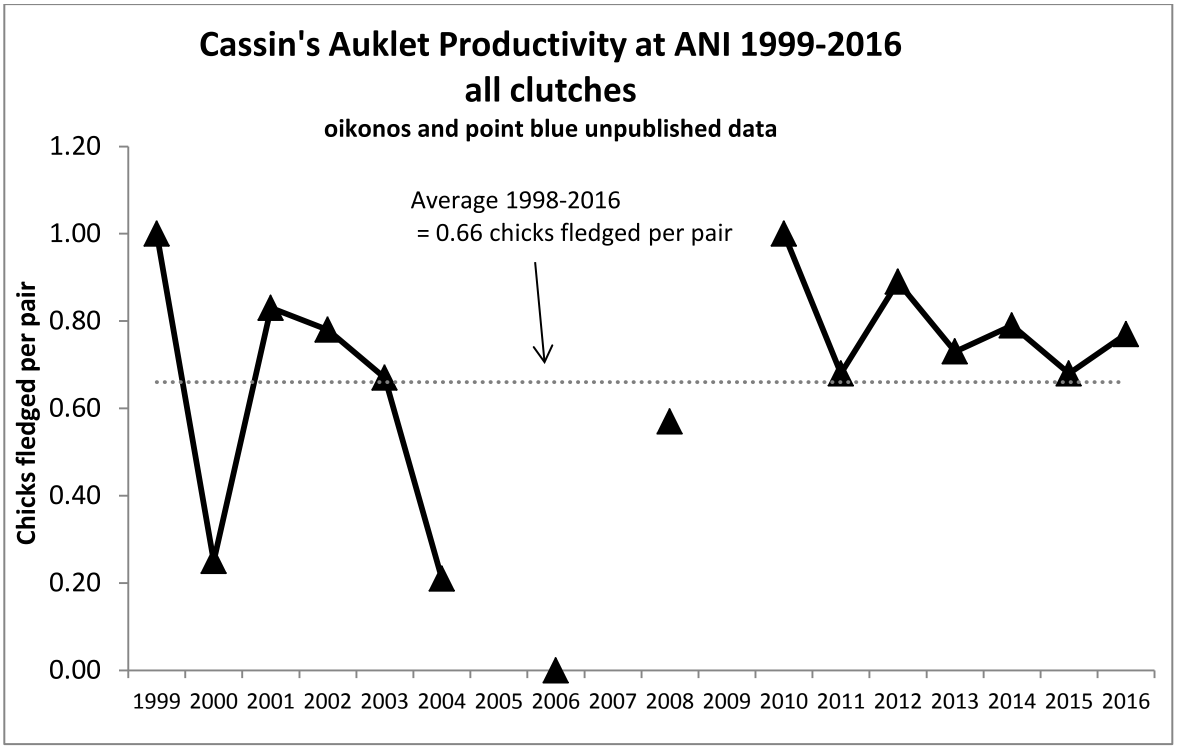
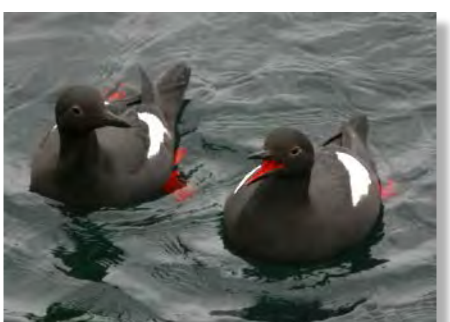


Figure 5. Cassin's Auklet productivity (chicks fledged/breeding pair) at Año Nuevo Island 1999-2016. All accessible nests were monitored. Sample size varied from 3 to 43 nests per year. In 2005 no Cassin's Auklets were found nesting. In 2006 only one egg was found and it failed. CAAU nested at ANI in 2007 and 2009 but nests were not checked often enough to quantify productivity.



Pigeon Guillemots (*Cepphus columba*) nest in rock crevices or earthen burrows on bluff edges, and usually 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. 6), perhaps in response to greater Western Gull densities, erosion of adequate crevices, and/or competition for nest sites with the growing population of Rhinoceros Auklets. In 2016, we recorded 10 breeding pairs (20 breeding individuals; Fig. 6). Two Pigeon Guillemot pairs bred in clay nest modules in 2016, and each pair fledged one chick.

Photo: Pigeon Guillemot chicks in a clay nest module.

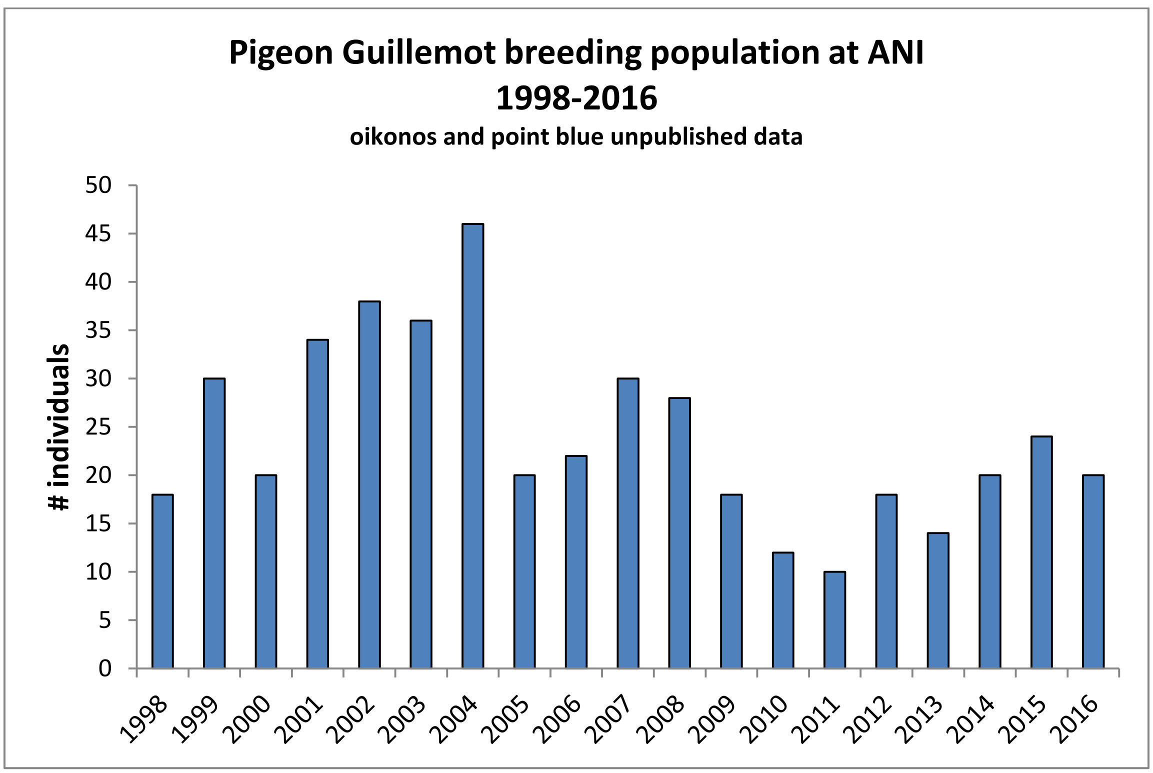
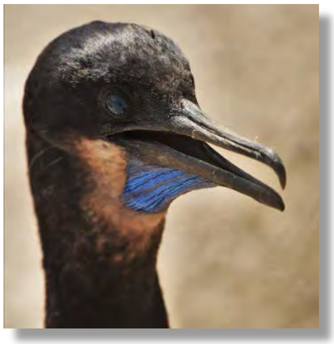


Figure 6. The estimated population of breeding Pigeon Guillemots on Año Nuevo Island visible from central terrace observation points (approximately 70% of the island) from 1998 - 2016.



Brandt's Cormorant (*Phalacrocorax penicillatus*) nesting was first documented at ANI in 1989 (Carter et al. 1992; Fig. 7). 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 the U.S. Fish and Wildlife Service or Oikonos to census the total island population during peak incubation. We are currently sharing data with U.S. Fish and Wildlife Service to standardize photo counting methods.

In 2016, there were 1,195 Brandt's Cormorant nests during the aerial count on June 15th (U.S Fish and Wildlife Service unpublished data, Fig. 7). Population peaked during sub-colony ground counts on May 31st (Fig. 8), indicating that the June 15th aerial count may have slightly underestimated total nesting effort at ANI in 2016. Numbers of Brandt's Cormorants that attempt to breed vary annually in part due to their ability to have large and variable clutch sizes (up to five eggs per pair) and to adjust breeding effort based on prey availability (Boekelheide et al. 1990). Brandt's Cormorants numbers crashed at ANI in 2009 and 2010 but have since recovered, though not back to 2006-2007 levels (Fig. 7).

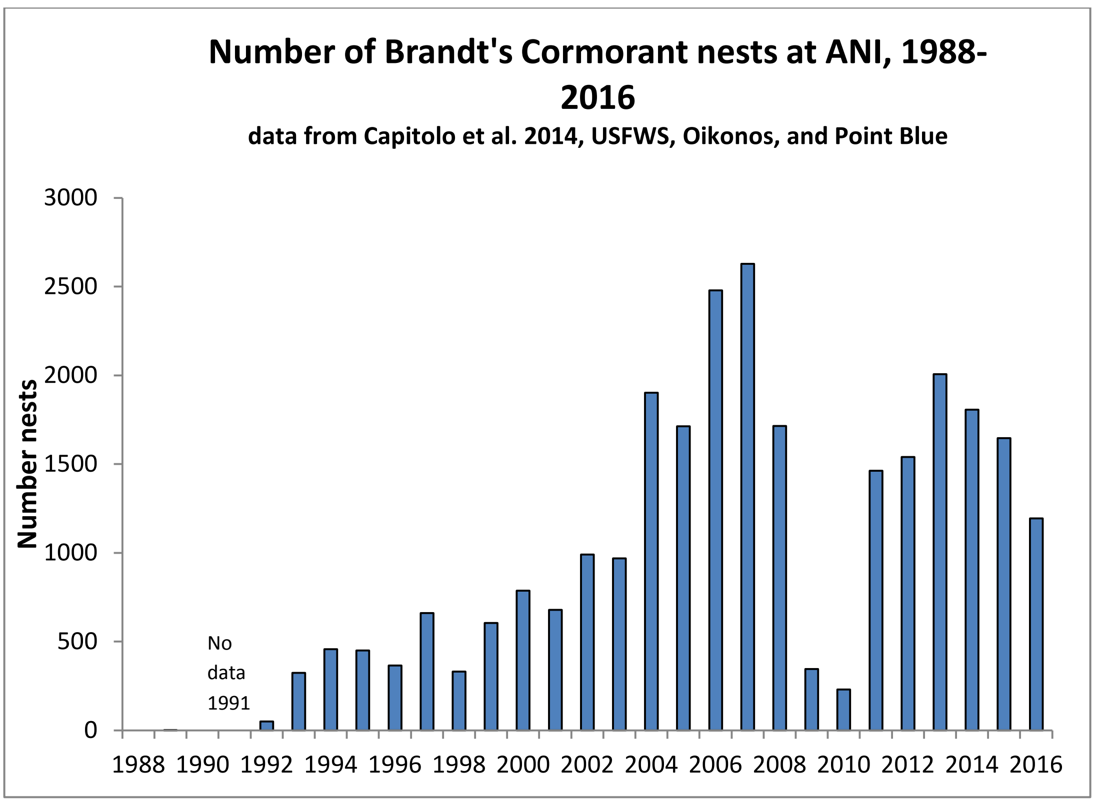


Figure 7. Aerial counts of Brandt's Cormorants nests (with incubating birds or chicks) on Año Nuevo Island from 1988 to 2016. The first documented nesting on ANI was in 1989. Zero nests were recorded in 1988 and 1990, and no data exists for 1991. Data sources Capitolo et al. 2014: 1988-1990, 1995-1997, 1999-2003, and 2006. Point Blue counts of National Marine Fisheries Service aerials, unpublished: 1992-94, 1998, 2004-05; US Fish and Wildlife Service aerials, unpublished: 2007-11, 2016; Oikonos aerials unpublished 2012-2015.

In 2016 Brandt's Cormorant productivity was 1.94 ± 0.86 chicks per pair (Fig. 9). 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; Fig. 9). Above average productivity from 2013-2015 (Fig. 9) 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 21).

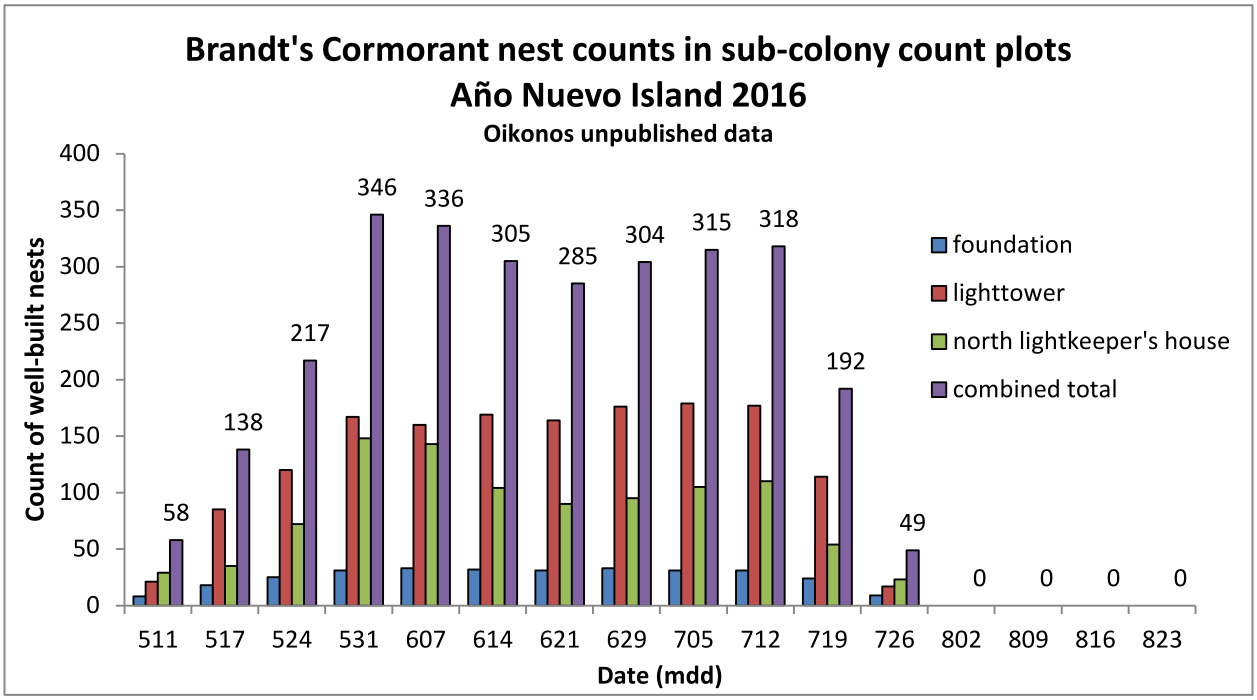


Figure 8. Ground-based counts of visible sub-colonies of Brandt's Cormorants at ANI. Counts were conducted weekly in defined areas in order to identify proportional changes in Brandt's Cormorant nesting effort, rather than total island nest counts, for which aerial photos were used. Numbers above purple bars indicate total nest count on each date for all sub-colonies counted.

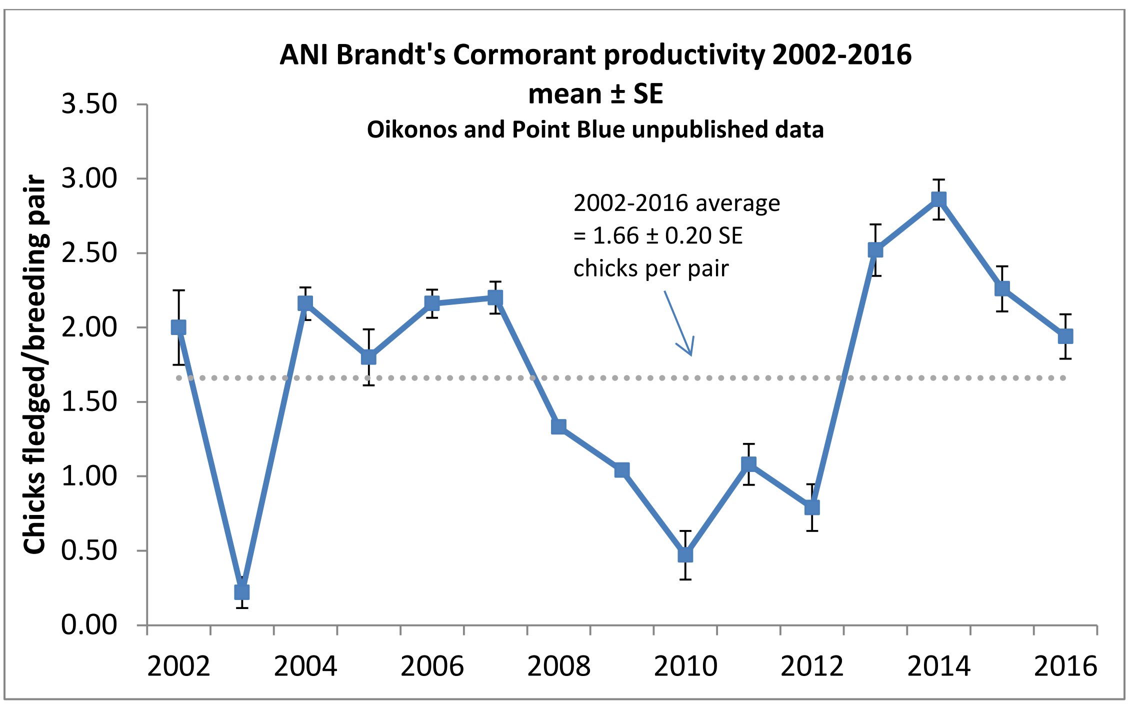
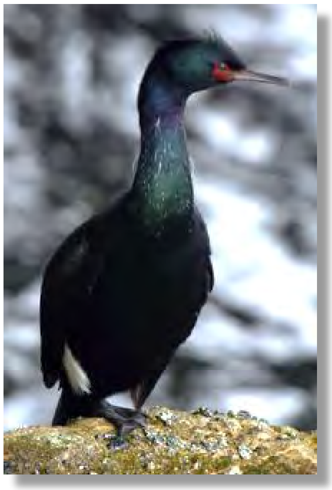


Figure 9. Brandt's Cormorant productivity (mean ± SE number of chicks fledged per breeding pair) at Año Nuevo Island 2002-2016. A sub-sample of nests was followed from one or both of two main visible sub-colonies, the Light tower and Blind 17 (shown here combined). Sample size ranged from 20- 57 nests. In 2008 and 2009, productivity was calculated as the total number of chicks meeting fledge criteria divided by the total number of nests in the two sub-colonies, rather than by following individual nests. Therefore, no error estimate could be generated in 2008-2009. The dashed line represents the average of 1.68 chicks per pair from 2002 – 2016.



Pelagic Cormorants (*Phalacrocorax pelagicus*) were censused sporadically at Año Nuevo from 1967 to 1987 (Carter et al. 1992), and annual standardized population and productivity monitoring began in 1996 on the island and 1999 on the mainland. During the breeding season, we recorded the contents of all nests on the mainland cliffs, island bluffs, and the island Lightkeeper's Residence. To document Common Raven disturbances to nesting Pelagic Cormorants, we observed interactions at a mainland sub-colony with a remote camera daily from March to August 2014-16.

Pelagic Cormorant reproductive effort is sensitive to annual environmental conditions (Boekelheide et al. 1990), and the population and reproductive success at Año Nuevo was variable from 1999-2016 (Figs. 10, 11). The total population of Pelagic Cormorants dropped 45% from 2015 to 2016. There were 70 birds total nesting at ANSP, with 26 birds at ANI and 44 birds at the mainland (Fig. 10). This drop in breeding effort was likely related to El Niño oceanographic conditions in 2016. There was also low breeding effort in 2016 at other California colonies including Southeast Farallon Island (P. Warzybok, pers. comm.) and the Mendocino coast (Ron LeValley, pers. comm.).

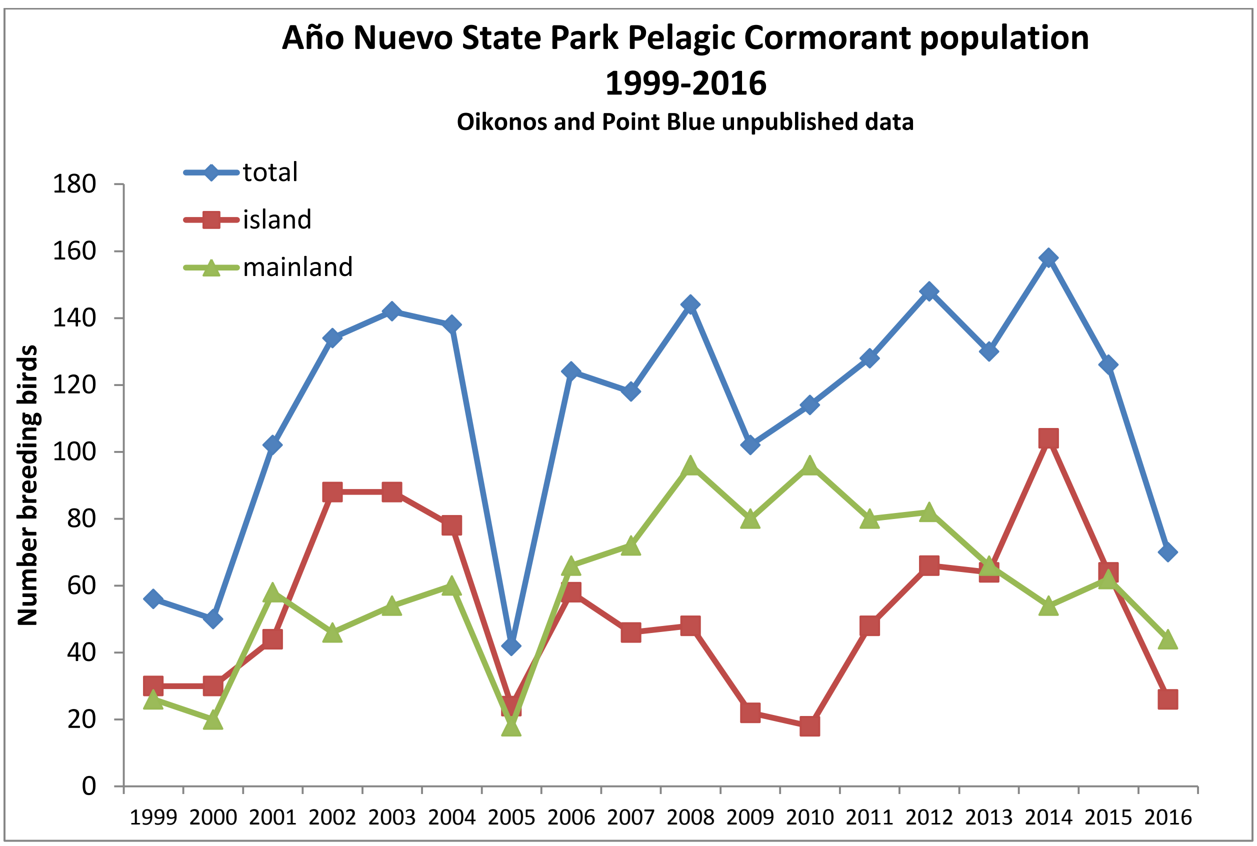


Figure 10. The estimated number of individual breeding Pelagic Cormorants at Año Nuevo State Park (blue - all monitored areas combined, red – island, green – mainland). Population was estimated from standardized ground counts and boat counts from 1999 to 2016.

Photo: Pelagic Cormorant chicks and adult (far right) at Año Nuevo Island

Pelagic Cormorant reproduction

In 2016, Pelagic Cormorant productivity was 1.5 ± 1.18 SD chicks fledged per pair on ANI, and 0.91 ± 0.97 SD at the mainland (Fig 11). Camera monitoring of mainland sub-colonies in 2014 showed that Raven depredation of Pelagic Cormorant eggs caused the very low productivity on the mainland in 2014 (Fig. 11). We believe that ravens also were responsible for low productivity at the mainland in 2013 (Fig. 11), based on mismatches in productivity in 2013 between the mainland and ANI and observed raven predation at the mainland that year. However, in 2015 and 2016, ANI and mainland productivity were more similar (Fig. 11). Raven depredation of eggs was not observed during weekly mainland colony observations in 2015 or 2016. We hypothesize that this was due to a mismatch in timing between Raven and Pelagic Cormorant reproduction—Pelagic Cormorants began nesting relatively late in both 2015 and 2016 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 or 2016.

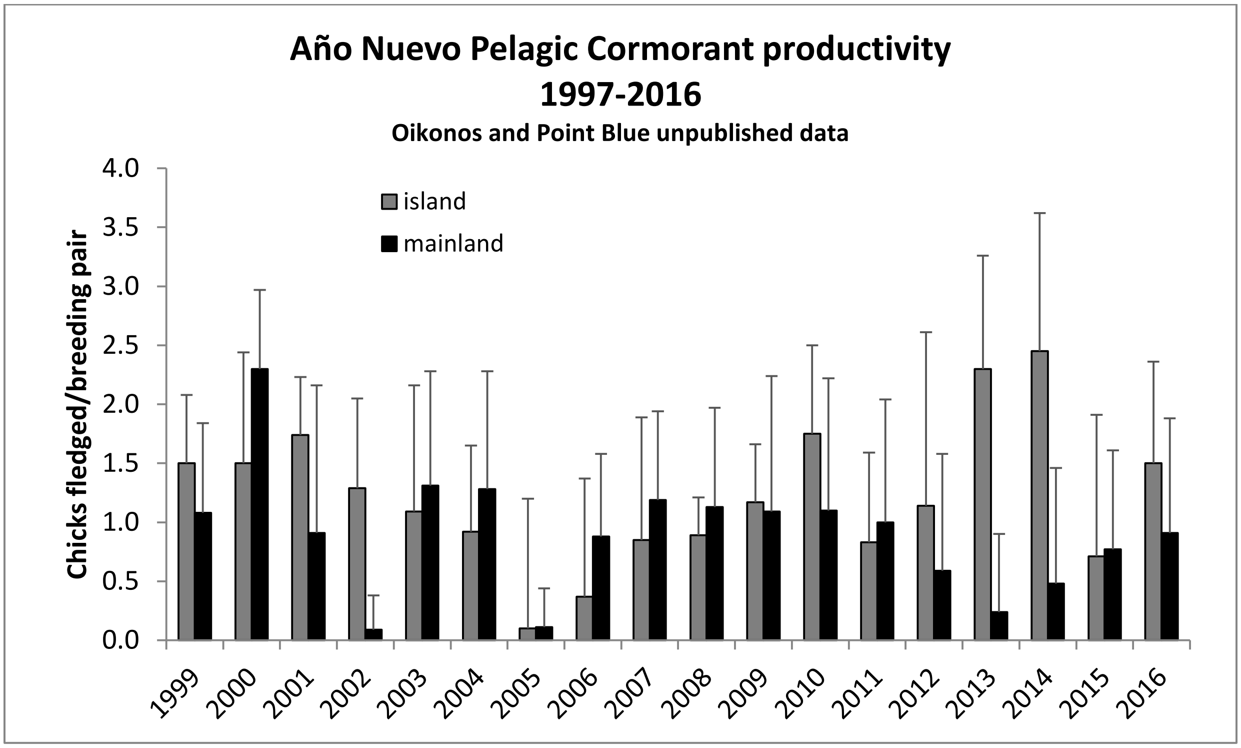


Figure 11. The estimated number of chicks fledged per breeding pair (mean ± SD) of Pelagic Cormorants on Año Nuevo State Park (black=island, gray=mainland). Data were estimated from standardized monitoring of a subsample from 1996 to 2016 (sample sizes ranged from 3 to 43 nests at each sub-colony).

Western Gulls (*Larus occidentalis*) were first censused at ANI in 1976 (Sowls et al. 1980) and standardized monitoring of the breeding colony began in 1999. Annual ground-based counts of Western Gull nests were conducted during peak incubation from 1999 to 2016. In 2016, we additionally used aerial photos taken by the U.S. Fish and Wildlife Service to count the north terrace section of the island because it was not accessible by foot due to large numbers of sea lions. To measure reproductive success, a random subsample of at least 30 nests in the central terrace was followed weekly.

In 2016, we counted 608 Western Gull nests on ANI--the lowest population on record in our 18 year time-series of standardized monitoring (Fig. 12). The next lowest count on record previous to 2016 was 360 nests in 1987 (Lewis and Tyler 1987), at a time when the population was growing rapidly (Fig 12). Gull population was very low in the 1970s and 1980s (Fig 12), probably due to persecution during operation of the lighthouse station (1872-1948) and unrestricted human disturbance to the island until it was closed to the public in 1967 (Tyler and Briggs 1981). Thus, 120 Western Gull nests at ANI in 1974 (Sowls 1980; Fig. 12) was probably a much deflated population, and should not be considered a natural baseline. Western Gulls at ANI recovered once the island was protected, and the population grew to a peak of 1,234 nests by 2005 (Fig. 12).

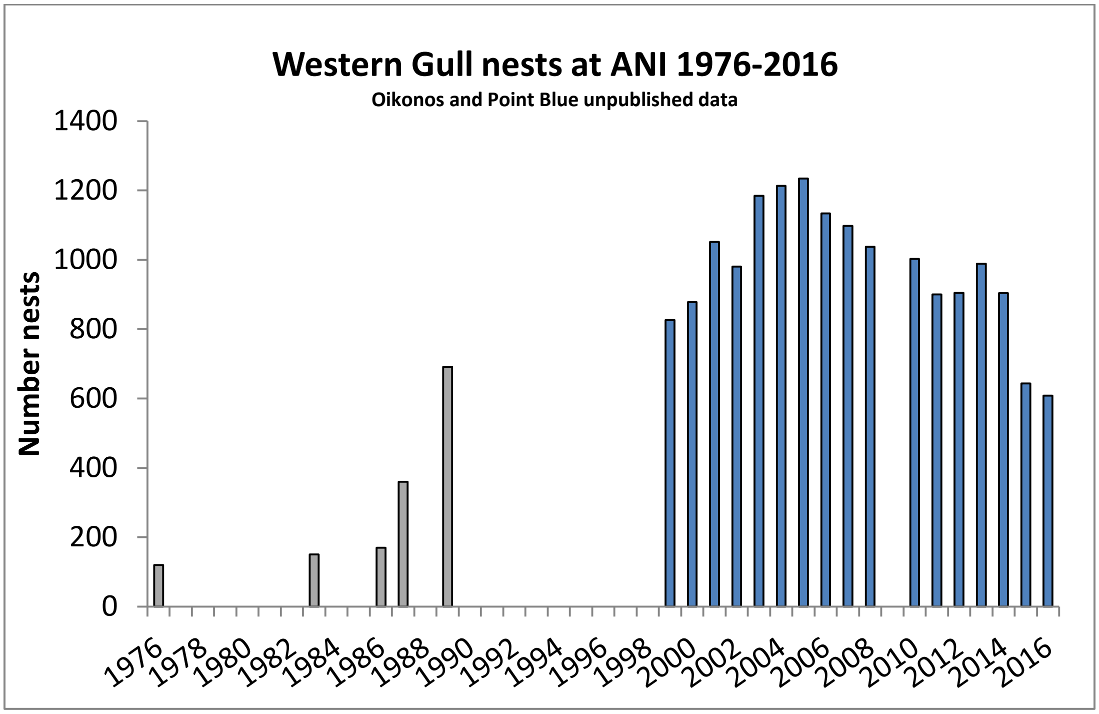


Figure 12. Western Gull nests on Año Nuevo Island 1976-2016. In 2016, nests were counted via ground counts with the exception of the north terrace which was counted using aerial photographs from the US Fish and Wildlife Service. Blue bars are years of standardized ground counts (1999-2016) and gray bars from the literature. In years with no bars, population was not estimated. 1976 data is from Sowls et al. 1980, 1982-87 data is from A. Huntley pers. comm. in Lewis and Tyler 1987, 1989 data from Carter et al. 1992. 1983-1987 had 150-170 nests each year (A. Huntley pers. comm. in Lewis & Tyler 1987).

Between 2005 and 2016, however, there was a highly significant decline in Western Gull nests at ANI (Figs. 12, 13), with an annual loss of 47 nests as modeled by linear regression (β = 46.7, R^2 = 0.84, P = <0.0001; Fig. 13). Between 2014 and 2015 there was a 29% decrease in nest numbers, and there was another 5% drop in nest numbers between 2015 and 2016 (Figs. 12, 13). Similar proportional drops in nest numbers were recorded in 2015 and 2016 at Southeast Farallon Island (SEFI), the largest Western Gull colony in the world, during 2015 and 2016 (Pete Warzybok, Point Blue, pers. comm.). It is unlikely that the gulls simply moved elsewhere considering a 30% drop at SEFI and ANI represents thousands of birds, and we are aware of no concurrent increases of nesting effort at that scale elsewhere.

Western Gulls are a California Current endemic breeder (Pierotti and Annett 1995), and are predicted to decline due to climate change (Nur et al. 2013). The Western Gull population at SEFI was predicted to decline by 9% over 20 years under current environmental conditions, and 27% under “pessimistic” environmental conditions (Nur et al. 2013). More analysis is needed to determine the causes of observed >30% decline in Western Gulls nests at ANI in just two years from 2014-2016 (Fig. 12), though poor oceanographic conditions and prey availability are likely reasons. Western Gulls at ANI, like Cassin’s Auklets, subsist in large part on krill (Cassell 2016), which was relatively less abundant in 2015 than it had been during 2012-2014 (Sakuma 2015). There was a similar 35% drop in Cassin’s Auklet breeding population at ANI in 2015, suggesting that perhaps krill availability contributed to declines in nest numbers that year.

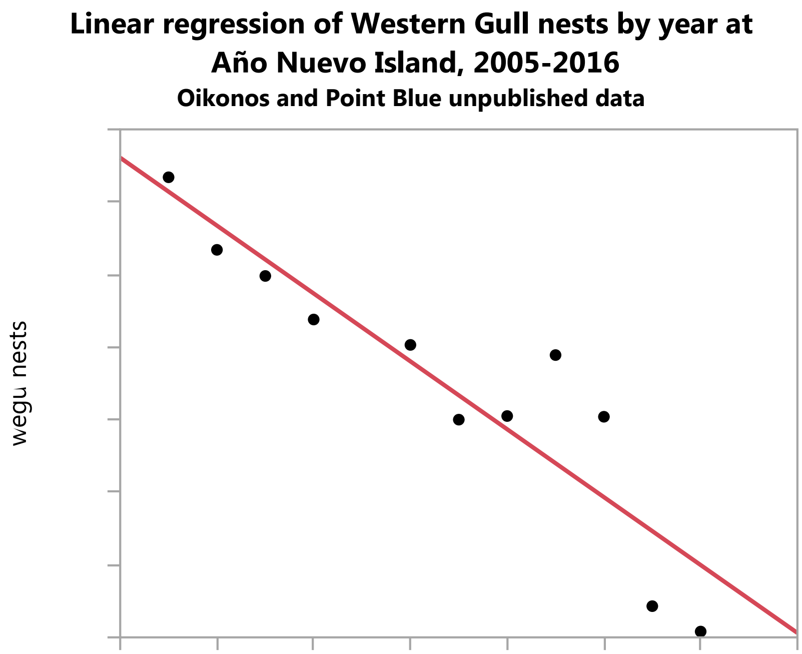


Figure 13: Linear regression of number of Western Gull nests at Año Nuevo Island vs. year, 2005-2016. There was a highly significant decreasing trend in gull nests during these years (β = 46.7, R^2 = 0.84, *P* = <0.0001)

Western Gull reproduction

Despite declining nesting population at ANI, there has been no significant trend from 1999-2016 in Western Gull reproductive success (linear regression; $\beta =$ 0.03, R^2= 0.12, *P* = 0.17; Fig. 14). This is in contrast to reproductive success at SEFI which has been declining overall (Nur et al. 2013). Western Gull productivity was the greatest on record at ANI in 2016 (1.89 ± 1.16 SD chicks fledged per pair; Fig. 14), despite low nesting effort. A possible reason for above average productivity in 2016 is that lower density of nesting gulls at ANI resulted in increased survival of chicks, which are vulnerable to being pecked to death by neighboring adults. Interestingly, a recent tracking study of foraging areas of Western Gulls from ANI and SEFI showed that birds breeding at ANI forage in terrestrial environments more than birds breeding at SEFI (Shaffer et al. 2016, in review). Thus, it is possible that reproductive success of birds at ANI is buffered in poor oceanographic years by being able to access nearby terrestrial food sources.

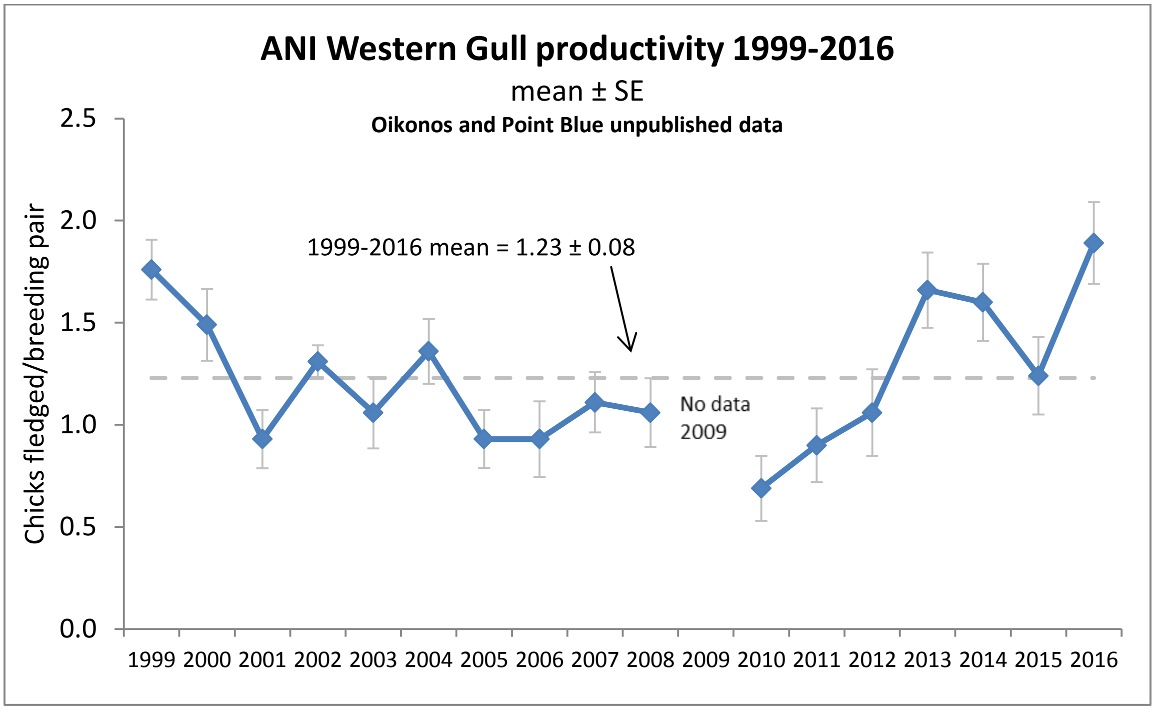


Figure 14. Annual productivity (chicks fledged per breeding pair) of Western Gulls nesting in the central terrace region on Año Nuevo Island from 1999 to 2016 (no data for 2009). Subsamples of 28 – 155 nests were monitored annually for breeding success.

Finally, habitat restoration at ANI appears to positively influence Western Gull nesting. On July 26, 2016, when most gull chicks just short of fledging age, we counted gull chicks on each terrace and calculated density of chicks per m^2. On the central terrace, defined as the area within the Habitat Ridge sea lion exclusion fence, there was 17 times greater density of gull chicks than on the north terrace, and five times greater density than on the south terrace (Fig 10). Based on field observations, we believe that this difference was caused by trampling of gull eggs and chicks by large numbers of California sea lions (*Zalophus californianus*) in areas outside the Habitat Ridge. Also, plant restoration and raised boardwalks inside the restoration area likely increase the survival of chicks by giving them places to hide during disturbances by humans, aggression by neighbor gulls, and attacks by aerial predators.

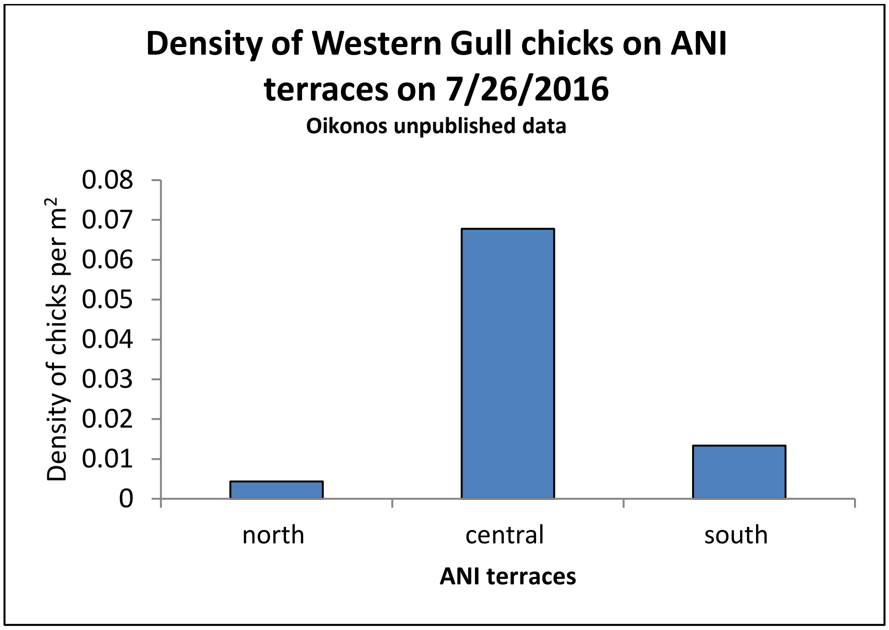


Figure 15. Western Gull chick density on Año Nuevo Island terraces on July 26, 2016. At the time of the count, most chicks were mostly- to fully-feathered, just before fledging age. The central terrace was defined as all areas inside the Habitat Ridge sea lion exclusion fence (371 chicks; 5,474 m^2). North terrace was all areas north of the Habitat Ridge (26 chicks; 5,978 $m^{2)}$, and South Terrace was all areas south of the Habitat Ridge (81 chicks; 6,078 m^2). Only the top of the raised part of the island was considered "terrace."

Black Oystercatchers (*Haematopus bachmani*) nest in intertidal areas along the west coast of North America. Reproductive success of Black Oystercatchers has generally been poor at ANI (Fig. 16), with chicks fledging from only 6% of monitored breeding attempts from 1994-2016. In 2016, breeding attempts by two pairs were documented and both failed (Fig. 16). One pair hatched a chick, which quickly disappeared, and the other pairs' eggs disappeared before hatching. Most Black Oystercatcher breeding attempts at ANI fail due to the disappearance of eggs or chicks, suggesting that predation or perhaps trampling by pinnipeds contributes to poor breeding success at ANI. Black Oystercatchers have been observed defending nests from Common Ravens frequently since 2004.

A recent population survey of Black Oystercatchers in California estimated a state-wide population of 4,749 to 6,067 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 are contributing ANI oystercatcher reproductive success data to a current project led by California Audubon to monitor breeding success state-wide to conduct a population viability analysis for the California population of the species.

Photo: Black oystercatcher parent and chick, 2016. This chick did not survive to fledging age.

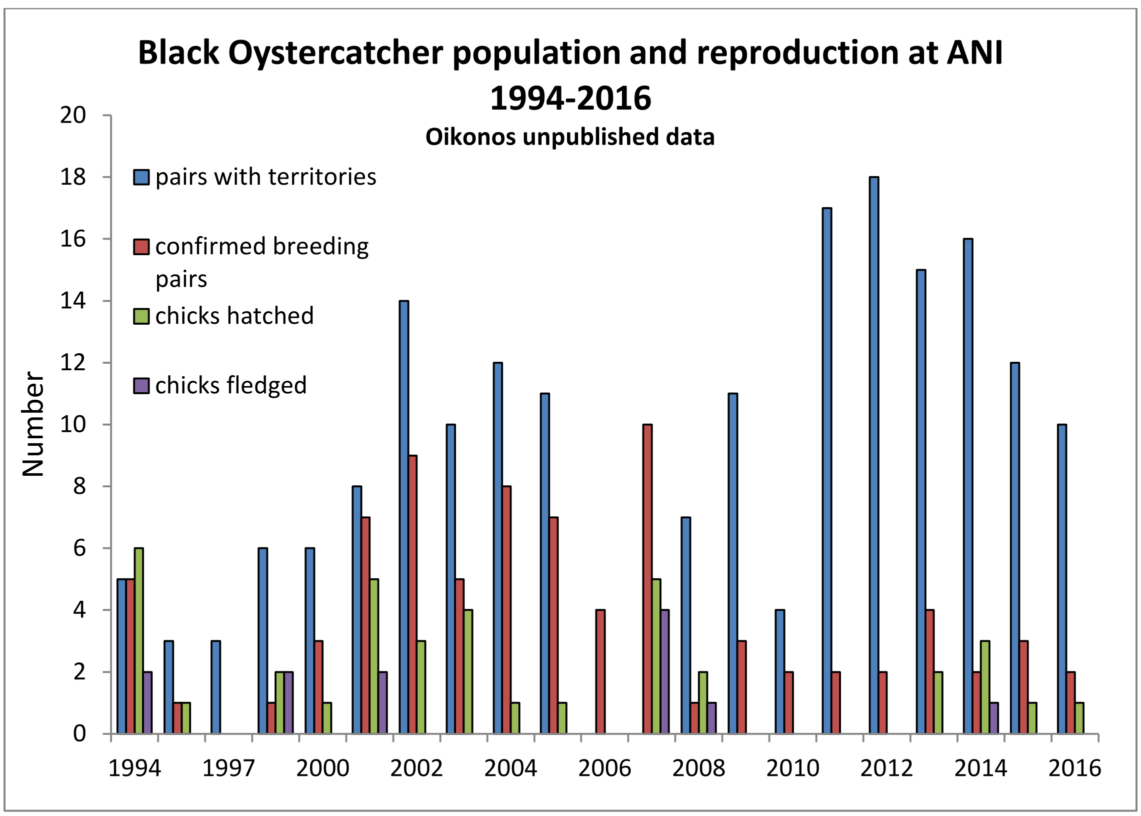


Figure 16. Annual population and breeding metrics of Black Oystercatcher nests visible from Año Nuevo Island ground observations from 1994 to 2016 (purple – total number of chicks fledged, green – total chicks hatched, red - confirmed number of breeding pairs documented with eggs or chicks, blue - total 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 1993-2016, 11 Ashy Storm-Petrels have been incidentally caught at ANI (Fig. 17). All were captured during nighttime mist-netting for Rhinoceros Auklet prey, which takes place four nights a year during June and July. We began banding incidentally captured Ashy Storm-Petrels in 2013. No Ashy Storm-Petrels were captured in 2016.

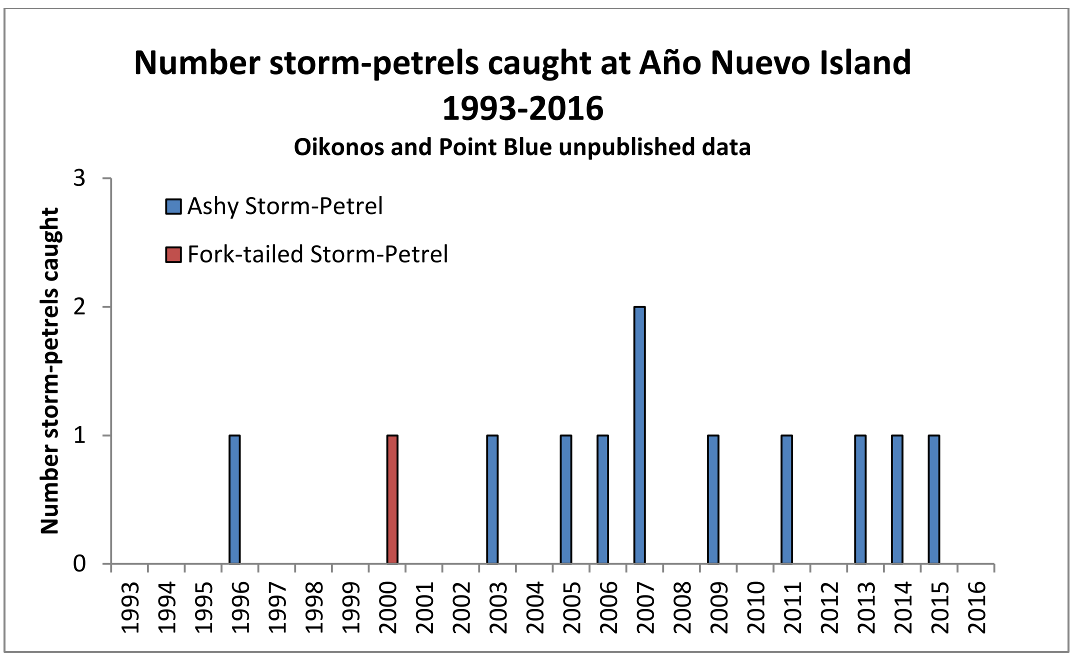


Figure 17. The number of Ashy and Fork-tailed Storm-Petrels incidentally captured at Año Nuevo Island from 1993-2016. All storm-petrels were captured during standardized nocturnal mist netting for Rhinoceros Auklet diet samples from late June to early August.

Canada Geese (*Branta canadensis*) raised young on ANI from 2012-2014, but did not nest in 2015 or 2016. This may be 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 2016, the mainland Common Raven nest was active and interactions with a nearby Pelagic Cormorant sub-colony were monitored via a remote camera. On ANI in 2016 we were unable to ascertain whether a Raven nest on the Lightkeeper's House was active.

Ravens significantly impacted Pelagic Cormorant reproductive success at the mainland in 2014, but did not appear to interact with nests on ANI (see *Pelagic Cormorant* section, page 12). We have not reviewed 2015 or 2016 camera footage.We are continuing to monitor raven impacts on breeding seabirds and submitted a scientific manuscript entitled "Egg depredation by Common Ravens negatively effects Pelagic Cormorant reproductive success in central California" to the journal Marine Ornithology in December 2016.

Prey Studies

A Rhinoceros Auklet chick with a bill-load of Northern Anchovy delivered by a parent.

Metrics of seabird reproduction and diet can track prey availability and other marine environmental conditions. Seabird prey studies are widely used to assess and predict ocean health. We collected diet samples from three breeding seabird species: Rhinoceros Auklets (1993-2016), and Brandt's and Pelagic Cormorants (2000-2016; Pelagic Cormorant results are not presented here).

Rhinoceros Auklets return to the colony at dusk or night to deliver whole prey (fish or cephalopods) to their chicks (Hester 1998). 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"). During 2016, young-of-the- year Northern Anchovy

(*Engraulis mordax*) dominated chick diet overall, making up 79 ± 34 SD %N per bill-load. However, the proportion of anchovy in chick diet changed throughout the breeding period: during mid- to late June, 94% of fish collected were anchovy, whereas anchovy dropped to 63% of fish collected in early to mid-July. The majority of anchovy captured by auklets in 2016 were from the young-of-the-year age class (i.e. <100 mm length; 2016 $\bar{x}$ fork length = 86 ± 12 mm), which was similar to 2014 and 2015 (Fig. 19). Juvenile rockfish (*Sebastes* spp.) and California Lizardfish (*Synodus lucioceps*) also appeared in chick diet in 2016 (Fig. 18). It was notable that California Lizardfish made up 10 ± 27 SD %N per bill-load of overall chick diet in 2016 (Fig.18) because this prey has never been previously recorded in chick diet at ANI. California Lizardfish is a regular member of the fish community south of Point Conception, California, but is normally uncommon further north (Lea & Rosenblatt 2000). However, during El Niño events California Lizardfish have been recorded as far north as Washington State (Lea & Rosenblatt 2000). Increased abundances of California Lizardfish have been documented in southern California during past El Niño events (Allen 2008), as well as general increases in the species in seabird diets in southern California since around 2009 (Horne & Whitcombe 2015). The appearance of lizardfish in Rhinoceros Auklet diet was probably due to the El Niño oceanographic conditions present in 2016. This result underscores the usefulness of Rhinoceros Auklet diet sampling as a means of tracking large-scale changes in the California Current ecosystem.

Photo: California Lizardfish (Synodus lucioceps) specimen from Rhinoceros Auklet chick diet at Año Nuevo Island in 2016.

Rhinoceros Auklet breeding success at ANI is typically greater in years with larger proportions of anchovy in chick diet (Thayer and Sydeman 2007). The slightly above average productivity observed in 2016 was probably related to the abundance of anchovy in chick diet, although chick growth rates declined concurrently with the drop off of anchovy in chick diet in July.

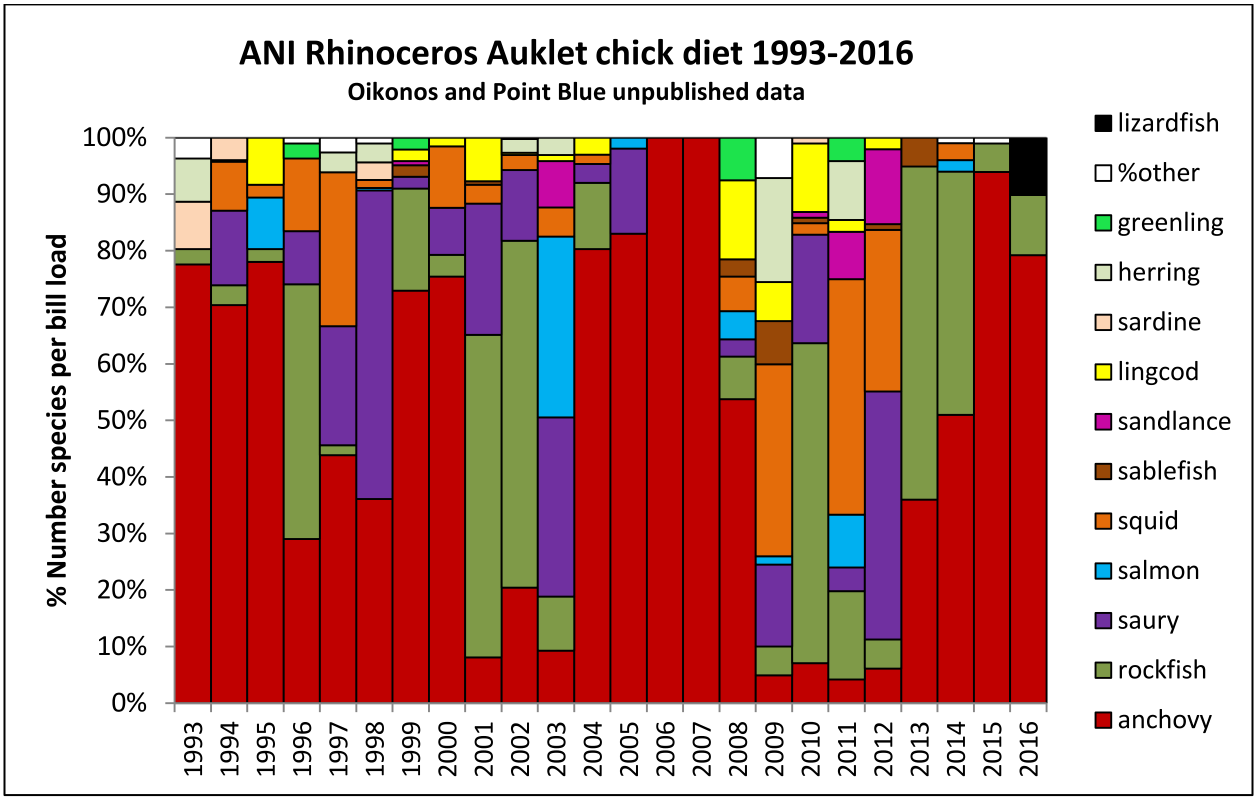


Figure 18. Rhinoceros Auklet chick diet on Año Nuevo Island from 1993-2016 quantified as the percent number of prey per bill-load delivered to chicks. Sample size ranged from 18-47 bill-loads per year.

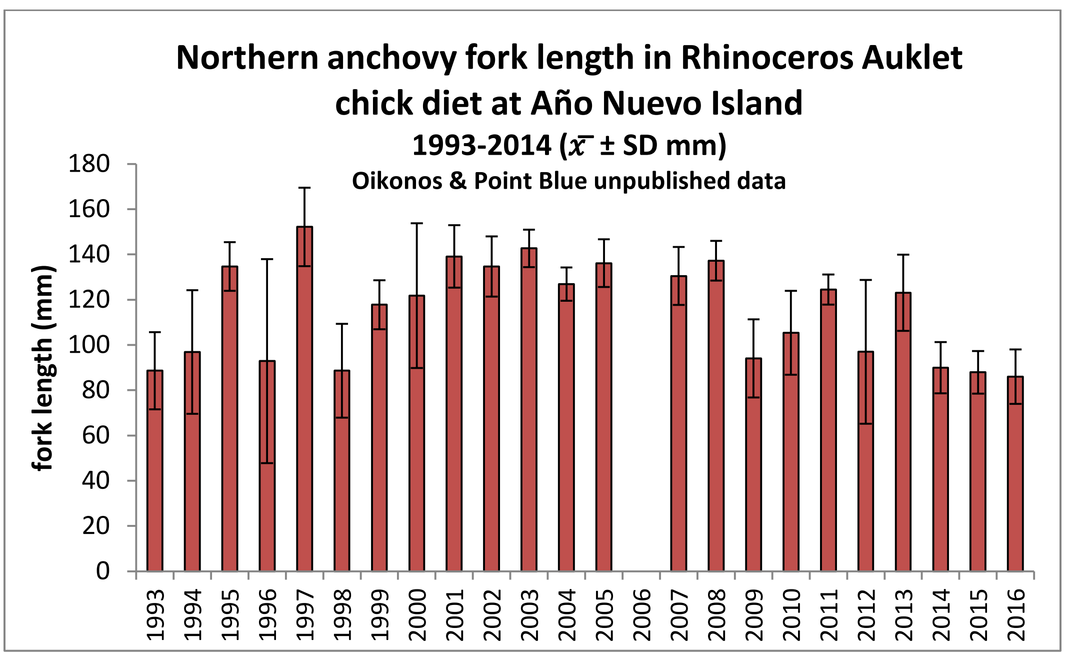
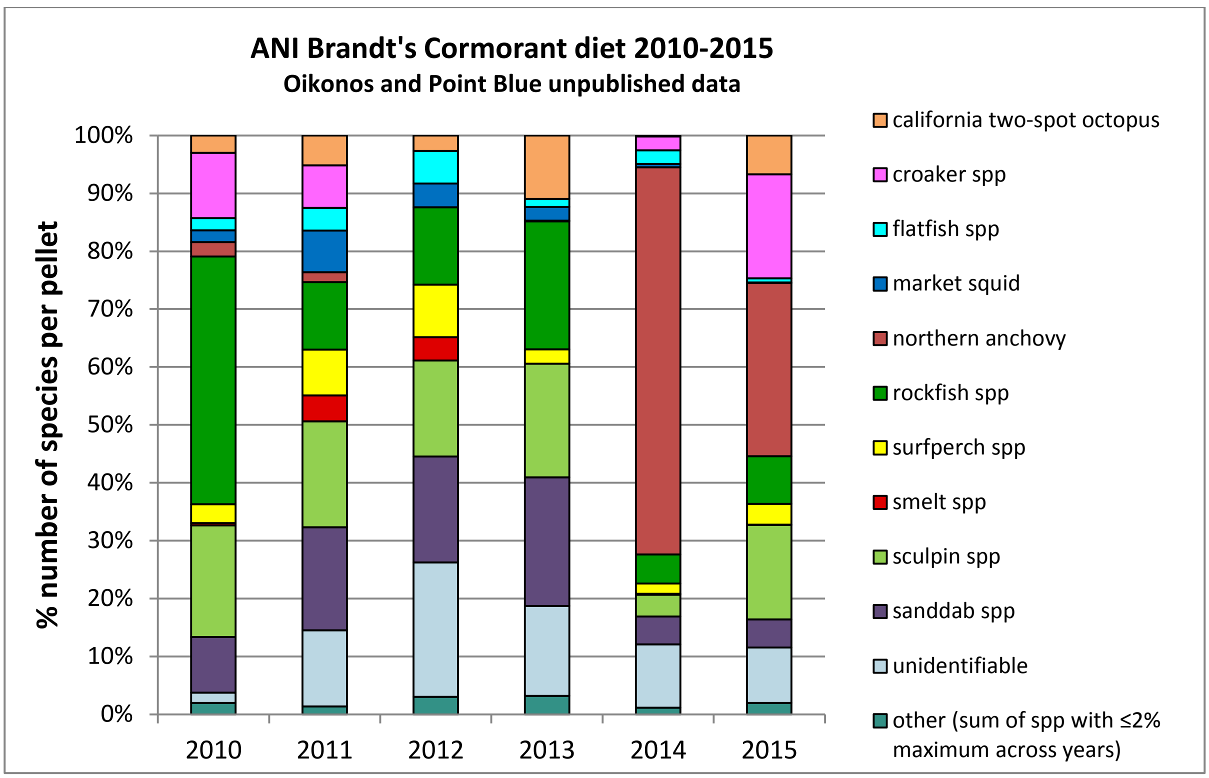


Figure 19: Fork lengths ($\bar{x}$ ± SD mm) of Northern Anchovy (Engraulis mordax) in Rhinoceros Auklet chick diet at Año Nuevo Island, 1993-2014. No data is currently available for 2006. Sample sizes ranged from 3 to 92 fish annually, with a mean sample size of 28 ± 24 SD fish over 23 years.

In 2016, we sorted and identified archived Brandt's Cormorant pellets collected at ANI from 2010-2015. Cormorants regurgitate indigestible material such as bone and chiton in the form of pellets. We collected approximately 45 pellets per year from the Brandt's colonies on ANI in between August-October annually. Fish species were identified by their otoliths, tiny ear bones unique to each prey species. 2016 pellets have not yet been analyzed. The most common prey items in Brandt's Cormorant diet were Northern Anchovy, rockfish spp., sculpin spp., (family *Cottidae*) sanddab spp. (genus *Citharichthys*), and croaker spp. (family *Sciaenidae*). Brandt's Cormorant reproductive success was shown to be positively correlated with anchovy in fall diet in other parts of the California Current (Elliott et al. 2016). Brandt's Cormorant diet showed relatively similar trends in anchovy as Rhinoceros Auklet chick diet (Figs. 19, 20). Anchovy was absent from Brandt's Cormorant diet from 2010-2013, but was the most common prey item in 2014 and 2015 (Fig. 20). In 2013 Rhinoceros Auklets chick diet contained 36% anchovy but Brandt's Cormorant diet contained no anchovy (Figs. 19, 20). This could have been due to the seasons in which these samples were collected—Rhinoceros Auklet in June and July, and Brandt's Cormorant in the fall.



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 3 Habitat Restoration 2009 – 2016).

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 six years since installation in fall 2010, 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 little 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 in 2010 and are tested 11 prototypes for Cassin's Auklets in 2016.

3. **Restoration**: To stabilize the burrow habitat and improve nesting success, we installed over 19,000 native coastal grasses and shrubs from 2009 – 2016. In 2016, 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

From 2011-2016, average productivity of Rhinoceros Auklet was 0.50 ± .10 chicks fledged per pair (*n* = 20 to 39 nests; Fig. 21). Average productivity of Cassin's Auklets in clay modules was 0.80 ± 0.27 chicks fledged per pair (*n* = 3 to 7 nests). Forty-two Rhinoceros Auklets, 6 Cassin's Auklets and 4 Pigeon Guillemots bred in clay modules in 2016 (Fig. 22).

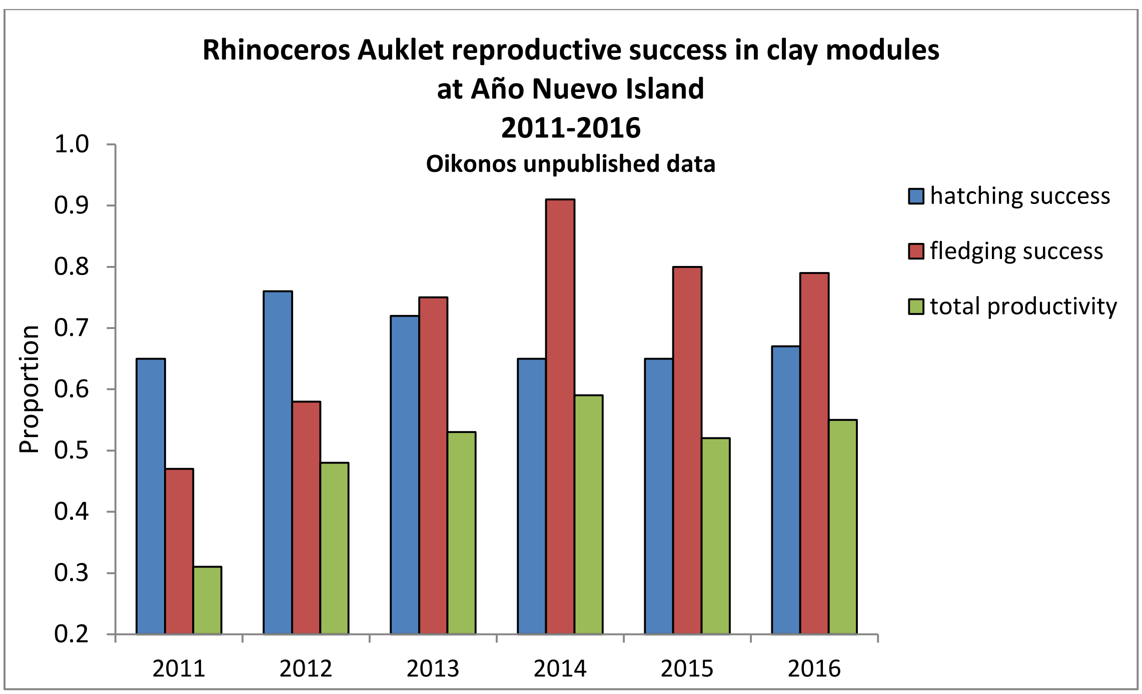


Figure 21. Rhinoceros Auklet reproductive success metrics in clay nest modules at Año Nuevo Island, 2011-2016 (blue – proportion of eggs that hatched per pair, red – proportion of hatched chicks that survived to fledging, green – proportion of chicks that fledged per breeding pair with a confirmed egg). Sample size was 20-39 nests annually.

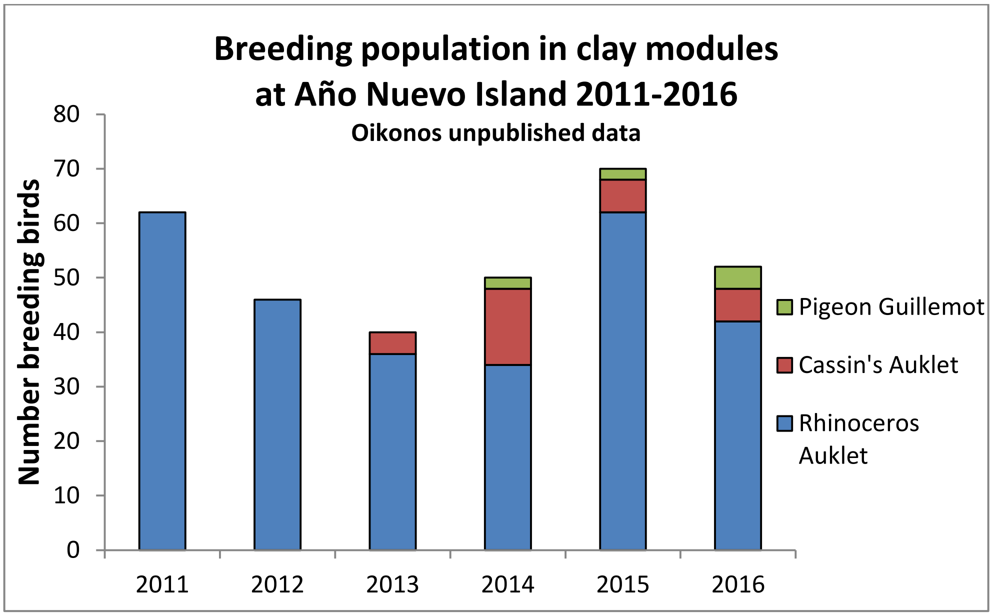


Figure 22. Seabird breeding population in clay nest modules at Año Nuevo Island, 2011-2016. Birds were counted as breeding birds if they had a confirmed egg or chick.

Cassin's Auklet Nest Modules

Photo: The Cassin's Auklet chick that fledged from a prototype Cassin's Auklet nest module on Año Nuevo Island in 2016.

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 in 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 erosion-prone 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 and California College of the Arts (CCA), collaborators Nathan Lynch (a master ceramicist) and Matthew Passmore (an experienced designer and leader of Morelab), conducted a class at CCA 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 ANI. In collaboration with Point Blue Conservation Science we also installed 4 prototypes on Southeast Farallon Island in fall 2015. In 2016 one Cassin's Auklet pair nested in a prototype module and successfully raised a chick on both ANI and SEFI. Pending funding, we plan to do a larger installation of Cassin's Auklet modules on ANI in 2017. Tests are ongoing at SEFI.

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 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 – 2016).

Results: In years prior to any restoration applications (1998 – 2001), when habitat was denuded, 42% to 67% of Rhinoceros Auklet burrows damaged by erosion, 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 11 ± 4 SD% of burrows damaged by erosion per year from 2010-2016 (see Burrow Damage Table below). 11% of burrows were damaged by erosion in 2016. This metric excludes burrow damage or crushing inflicted directly by humans and/or wildlife.

Rhinoceros Auklet Burrow Damage* Caused by Erosion

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%**
2016	11	138	**11%**

Vegetation Metrics

*Photo: American dune grass (Eleymus mollis) in front of the foghorn building, summer 2016***.**

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 improves the ability of auklets to dig burrows that can withstand extreme wind events without collapsing. 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 periodically suffered dramatic die offs.

Method: We conducted two surveys per year quantifying plant species composition in restoration areas in May and October 2010 – 2016 (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 around 5% in the burrow plots. Live native plant cover reached 60% in fall 2012 (Fig. 23). Species composition has primarily consisted of native grasses (salt grass *Distichilis spicata* and American dune grass *Eleymus mollis*; Fig. 24).

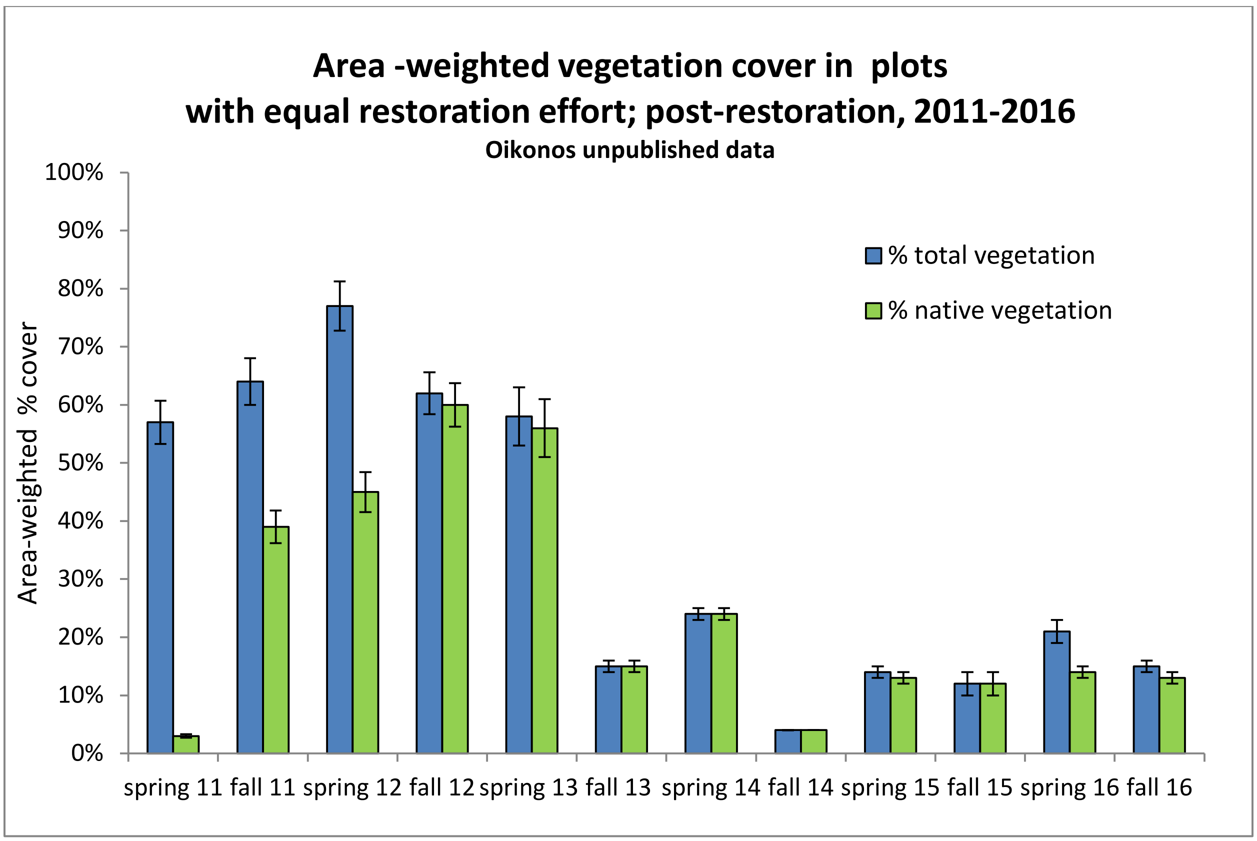


Figure 23. Percent vegetation cover (average area-weighted ± SE) in four restoration plots that experienced equal restoration efforts on Año Nuevo Island, 2011-2016. Plants were first installed in fall 2010.

Sustained trampling in the restoration area in fall 2013 and 2014 by hundreds to thousands of roosting Brown Pelicans caused total vegetation cover to decline to 4% in fall 2014 (Fig. 23). Live plant cover recovered from a low of 4% in fall 2014 to 21% in spring 2016 (Fig. 23). High roosting densities of pelicans were likely a result of local prey availability and larger-scale patterns influencing pelican breeding success in southern California and Baja, Mexico. Roosting pelicans also appeared to concentrate in the restoration area because they did not have to compete with California sea lions for roosting sites.

55% of vegetation present in spring 2016 was salt-grass, down from 89% the previous year (Fig. 24). This was due to modest recovery of American dune grass in some areas (Fig. 24), as well as refocused weeding effort in 2016, in which non-native species were only removed from areas in which they were in competition with natives. This allowed us to minimize competition between native and non-native plants while maximizing the total amount of vegetation cover. Salt grass remains the most resilient species to trampling (Fig. 24), and maintaining cover of this species is critical for long-term soil stability.

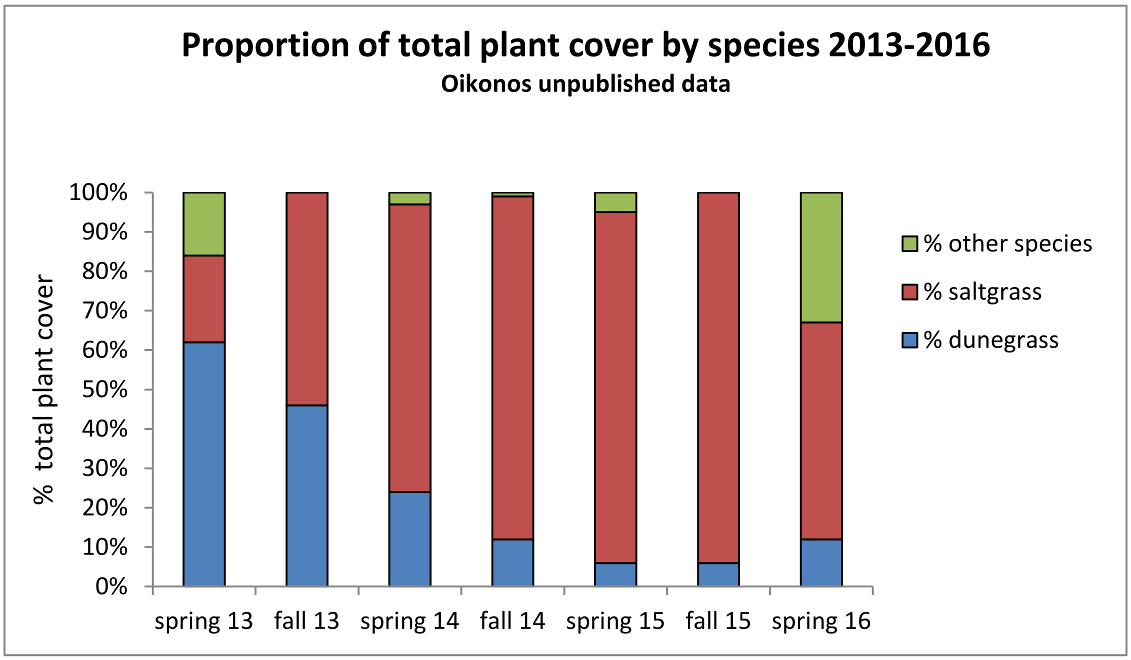


Figure 24. Average percent of total plant cover by species category (salt grass Distichlis spicata, American dune grass *Elymus mollis, or other species) in the central terrace restoration area of Año Nuevo Island in spring and fall 2013-2016.*

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

In 2016, roosting numbers of pelicans at ANI were once again high (Figs. 25, 26). From 2013-2016, peak annual counts have been at over 900 birds at once. Despite the continuing high pelican numbers at ANI, native vegetation cover has remained consistently between 12-14% from spring 2015 to fall 2016, and has not declined since fall 2014 (Fig. 23). This is probably because we have implemented measures to protect the plants from trampling, such as putting circles of wooden stakes around patches of plants to keep pelicans from trampling them. Greater precipitation in winter of 2015-16 also likely helped plants recovery after multiple years of severe drought and pelican trampling.

Dense pelican congregations do not occur every year at ANI (Fig. 26), but it is clear that restoration goals and plans must take sporadic 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 salt grass, the most resilient species
- Less emphasis on increasing diversity of native plant species—while still desirable, woody species are unlikely to maintain self-sustaining populations
- Acknowledgment that % cover may fluctuate annually, with the goal of maintaining live cover between 25-75%
- Increased focus on planting 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

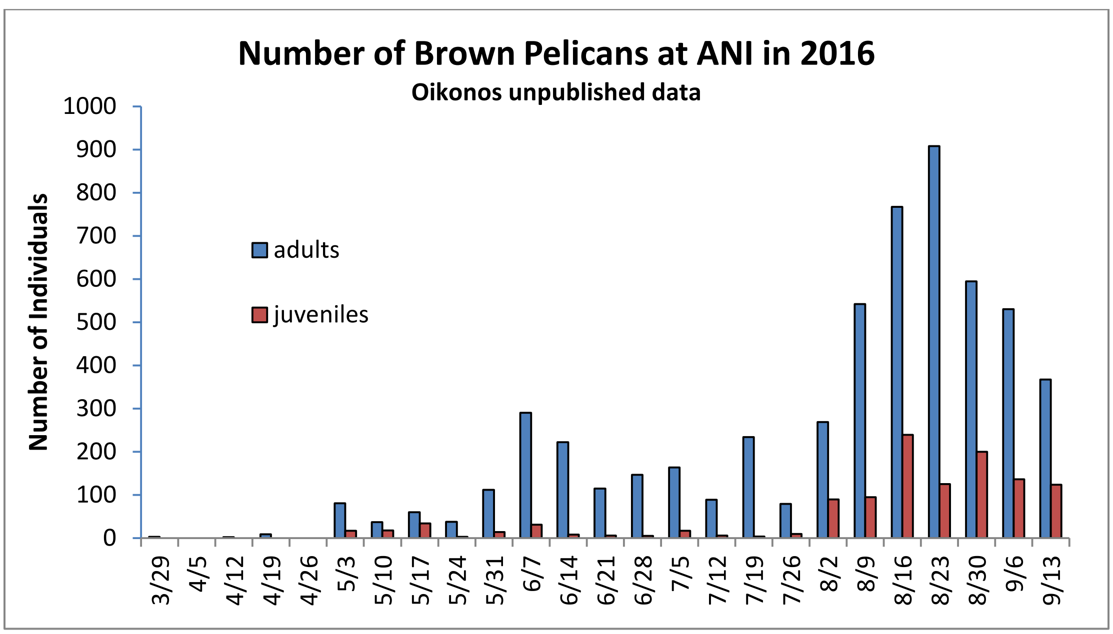


Figure 25. Number of Brown Pelicans on Año Nuevo Island in 2015. Counts were conducted from the central terrace.

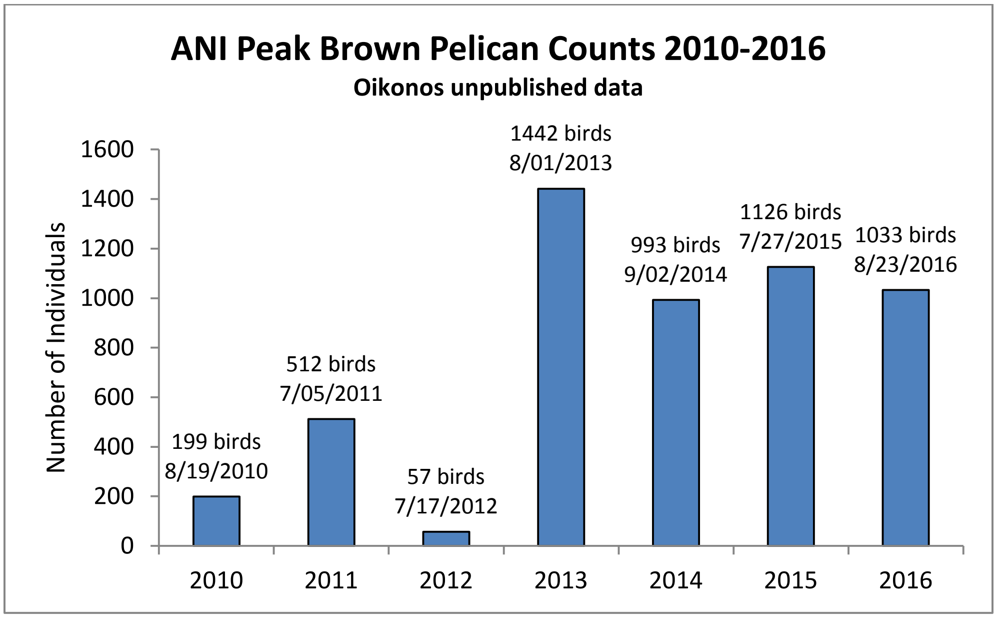


Figure 26. Annual peak counts of Brown Pelicans at Año Nuevo Island, 2010-2016

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 Carle *et. al.* 2015.

Results: From 2009 – 2016, an estimated **628 fledged chicks were produced in the restoration area** (see Mitigation Table below). In 2016, the central terrace population produced an estimated 100 fledged chicks, the greatest number on record. The 100 chicks produced in the restoration area in 2016 were more than double the 49 chicks produced in 2009. The number of chicks produced in the restoration area has increased every year since 2009. Significantly, the number of chicks fledged from the restoration area between 2009 and 2016 was 628, which is more than the 593 Rhinoceros Auklets estimated killed in the Luckenbach Oil Spill (Luckenbach Trustee Council 2006). Although fledglings are not a direct replacement for the adults lost in the spill, this is nevertheless an important achievement, as it is likely that many of these chicks would not have been produced without the habitat restoration efforts.

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
2016	294	89	11	100
Total		**521**	**107**	**628**

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 Rhinoceros and Cassin’s 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 2010-2016, we raised approximately 270 feet of boardwalks. There is still one span of about 100 feet of boardwalk that we'd like to raise in the future. Several sections of boardwalk that are highly visible to marine mammals and have limited burrow activity will be left unraised.

Photo: Volunteers Henry Smith and Greg Meyer raising boardwalks in summer 2016, while Western Gulls observe.

VI. Future - 2017 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. 24 years of data on population size, breeding success and diet data from Año Nuevo are being 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. We are also contributing data to NOAA's integrated ecosystem assessment report, which will inform management decisions by the Pacific Fisheries Management Council, which is currently considering management measures for Northern Anchovy stocks.

Continuing studies/restoration actions planned for 2017

- Monitoring of population and reproductive success of all breeding seabirds
- Vegetation and burrow erosion monitoring to document restoration success
- Planting of salt grass and installation of erosion control fabric in March 2017
- 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
- Pending funding, installation of 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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All photos in this report are those of Oikonos Ecosystem Knowledge unless otherwise specified. Thanks to Nathanial Smith for taking of many of the Oikonos photos.

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 2016 (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 **hundreds of volunteers** who gave their expertise and muscles to the efforts, and have donated over 5,000 hours to the project since 2009 (See Project Volunteers table below). 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 2015-16 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 - 2016

Oikonos	***Go Native***	***Rebar & Morelab***	***CCA***	***CA State Parks***	***UCNRS***
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
Michelle Hester	Javier Castro	Matthew Passmore	Sonja Murphy	Mark Hylkema	
Emily Coletta	Gilberto Chompa	Josh Berliner	Carlos Ramirez	Paul Keel	***Point Blue***
Hugo Ceja	Shawn Dardenelle		Nathan Ring	Terry Kiser	Sara Acosta
Nathaniel Smith	Kathy Kellerman		Vladimir Vlad	Mike Merritt	
Adam Fox	Chuck Kozak			Chris Spohrer	
Phillip Curtiss	Carlos Rangel			Gary Strachan	
Josie Moss	David Sands			Docents	
Dana Page	Norine Yee			Resource crew	
Jonathan Felis					
Julie Thayer					
Viola Toniolo					
Verónica López					
Alaina Valenzuela					

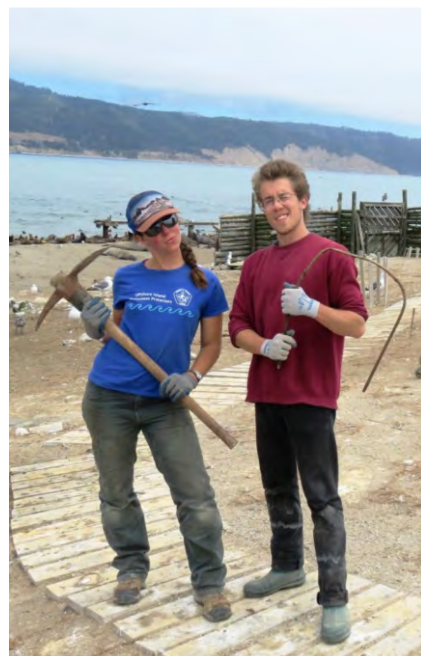
Photo: The 2016 Año Nuevo Island Oikonos crew. From back to front, Project Manager Jessie Beck, Ecologist Emily Coletta, and Ecologist Nathaniel (Zeke) Smith.

We thank the following individuals who volunteered their time and muscles on ANI from 2009 to 2016 (see Project Volunteers table below). 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 Island Volunteers 2010-2016							
Aaron Haebert	Catie Kroeger	Delaney Wong	Hugo Ceja	Keith Hernandez	Marilyn Cruikshank	Peck Euwer	Stan Hooper
Abe Borker	Chris Tarango	Dena Spatz	Inger Johansson	Kelly Iknayan	Marina Maze	Petrusjka Skjerning	Steve Kurtagh
Adam Fox	Christian Cormier	Diana Powers	Irene Espinosa	Kevin Greenan	Maris Brenn-White	Phil Curtiss	Susan McCarthy
Adam Garcia	Christine Chi	Eliza Powers	Jackie Lindsey	Kira katzner	Martha Brown	Portia Halbert	Teresa Aguilera
Adam Green	Chuck Boffman	Ellen Little	Janet Carle	Kira Maritano	Masha Slavnova	Rachel Eastman	Terry Sawyer
Alaina Valenzuela	Clair Nasr	Emily Golson	Jeb Bishop	Kit Clark	Matt Madden	Rae Engert	Tiffany Bailie
Alayne Meeks	Claire Sawyer	Emma Hurley	Jeff Powers	Kolle Kahle-Riggs	Matthew McCown	Randy Chapin	Tim Brown
Alex Rinckert	Colleen Young	Emma Kelsey	Jenny Garcia	Kristen Saunders	Matthew Passmore	Rebecca Cook	Tim Gledich
Alex Wang	Coral Wolf	Emma Wheeler	Jessica Kunz	Kristen Hill	Maya Whitner	Rhett Frantz	Tim Shaffer
Allan Kass	Corey Clatterbuck	Eric Woehler	Jessie Beck	Kristen Swehla	Melinda Conners	Rick Condit	Trinidad Mena
Andrea van Dexter	Corey Pigott	Erica Donnelly-Greenan	Jim Harvey	Laird Henkel	Michael Hanrahan	Ron Brost	Valeria Ruopollo
Andrew Fisher	Corrine Gibble	Evan Barbour	Jim Kellogg	Lana Meade	Molly Baird	Rosemarie Willimann	Verónica López
Angela Scezorkia	Crosbie Walsh	Evan McGiffert	Jo Anne Dao	Laura Webb	Natahsa Vokshoori	Ryan Carle	Vladimir Vlad
Ann Garside	Damien Sosa	Gabriella Layi	John Bela	Lena Molinari	Nick Slobodian	Sacha Heath	Will Spangler
Anne Cassell	Dan Barnard	Gary Strachen	John Finch	Linda Brodman	Nicole Hicock	Sara Mclean	Yoel Kirschner
Arlene Davis	Dana Page	Grant Ballard	Jonathan Felis	Lindsey Graves	Noreen Yee	Sarah Lenz	Zach Michelson
Becky Hendricks	Danielle Mingo	Greg Meyer	Josh Adams	Liz Martinez	Ora Gessler	Sarah Peterson	Zoe Burr
Bill Henry	David Calleri	Guy Oliver	Josh Berliner	Lloyd Fales	Parker Forman	Scott Shaffer	
Benny Drescher	Dave Carle	Haleigh Damron	Josie Moss	Louis Wertz	Pat Kittle	Signe Jul Andersen	
Breck Tyler	David Greenberger	Helen Christianson	JT Keeley	Luke Hass	Pat Morris	Sonja Murphy	
Brittany Guest	David Hyrenbach	Helen Davis	Kathy Kellerman	Madeline Pots	Patrick Furtalo	Sophie Webb	
Bryan Schatz	Deasy Lontoh	Henry Smith	Katy Saunders	Marilyn Beck	Patti Kenyon	Sparrow Baranyai	

Project volunteers 2009-2016.

Year	Total Volunteers	New Volunteers	Volunteer 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
2016	23	19	67	536	3
Totals	**247**	**153**	**654**	**5230**	

Photos: Left to right—Volunteer Christian Cormier holding a Cassin's Auklet chick for measurements; visiting Chilean Oikonos scientist Verónica López displaying a Rhinoceros Auklet bill-load; Project Manager Jessie Beck and volunteer Evan McGiffert maintaining boardwalks.

Appendix 2. Año Nuevo State Park Seabird Program Resources: Articles, Videos, Outreach, Images, Links - 2009 to 2016

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 produced by Lloyd Fales and Peck Ewer, Swell Pictures *vimeo.com/oikonos/ano-nuevo-island-restoration*
    - Students Design Auklet Nests 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

Peer-reviewed Scientific Publications

Carle, R., Beck, J., Calleri, D., and Hester, M. 2015.Temporal and sex-specific variability in Rhinoceros Auklet diet in the central California Current system. Journal of Marine System 146: 99-108. DOI: 10.1016/j.jmarsys.2014.08.020

Carle, R., Calleri, D., Beck, J., Halbert, P., and Hester M. Common Raven depredation negatively affects reproductive success of Pelagic Cormorants in central California. Manuscript in review at Marine Ornithology, submitted December 2016.

Scientific Presentations

Beyond the Golden Gate Research Symposium–Dec 2016, Tiburon, CA

Presentations entitled:

CLAY NEST MODULES FOR SEABIRDS: A VERSATILE AND SUSTAINABLE SOLUTION TO DIVERSE THREATS

COMMON RAVEN DEPREDATION NEGATIVELY AFFECTS REPRODUCTIVE SUCCESS OF PELAGIC CORMORANTS AT AÑO NUEVO STATE PARK, CENTRAL CALIFORNIA.

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 and High School Guest Lectures

Guest lecture at Pajaro Valley High School, January 2016

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 2010-2016

Santa Cruz Seabird Coordination Meeting, December 2016

Appendix 3. – Habitat Restoration Accomplishments 2009 - 2016

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 – 2016, 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). Since restoration began in 2010, the population of Rhinoceros Auklets has steadily increased. Improved burrowing habitat also benefits Cassin's Auklets, whose population increased from 4 birds in 1995 to 136 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 2011-2016, 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 - 2016
Habitat Ridge 	✓ Created *Ridge* designs ✓ Built prototypes on the mainland ✓ Installed a temporary barrier on the island	✓ Removed and cut 850 Eucalyptus poles ✓ Transported poles by landing craft ✓ Built 400 ft. of the *Ridge* (85% completed)	✓ Removed and cut 150 Eucalyptus poles ✓ Transported all materials by small boat ✓ Completed the *Ridge* to 6 ft. in all areas
Nest Modules 	✓ Held 4 design meetings ✓ Planned the CCA college course	✓ CCA students designed and created prototypes ✓ Installed five underground in the nesting habitat	✓ CCA ceramicists produced 90 modules ✓ Installed 87 in the restoration area ✓ Monitored nesting success in modules ✓ Held CCA college course focused on Cassin's Auklets ✓ Prototyped Cassin's Auklet modules
Plant Restoration 	✓ Propagated, collected and grew native species in Go Native's greenhouse ✓ Patched sensitive areas with erosion control	✓ 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	✓ Planted 10,000 grasses and shrubs in selected areas ✓ Seeded with native species ✓ Raised boardwalks ✓ Weeded invasive plants

Other annual activities completed (2009-2016):

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 at the top 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 six 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 2011-2016 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 24 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 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: American dune grass (Elymus mollis) growing in Go Native's greenhouse in preparation for island restoration.

In support of the current effort, from 2008 to 2016 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 2011-2016, we augmented the entire area with native seed and added an additional 8,000 plants to selected areas (see 2015 Oikonos report for complete list of species). 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 and information on adaptive management of the plant restoration, see report section *Vegetation Metrics*, page 29.

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)