



Año Nuevo State Park Seabird Conservation and Habitat Restoration: Report 2017



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I. Introduction

The year 2017 marks a quarter of a century's worth of seabird research and conservation on Año Nuevo Island (ANI) at Año Nuevo State Park. Oikonos has led the seabird research and habitat restoration of the island for the last nine of these 25 years. Through research and habitat restoration, Oikonos seeks to conserve seabirds breeding on the island, understand their prey resources, and protect and restore their breeding habitat. This report places the 2017 seabird breeding and diet monitoring results into the context of our time series datasets, and describes our most recent habitat restoration efforts.

Specific goals for 2017 included:

- **continue** time-series of breeding success and population of the seven breeding seabirds on the island
- **improve** the habitat quality for auklets via soil stabilization and native plant protection
- **increase** our collaboration with California College for the Arts to provide new nest modules for the island's breeding population of Cassin's Auklets
- **educate** the wider community about seabird conservation by engaging Año Nuevo docents and visitors during field days and through blog updates
- **train** undergraduate interns in the field methods of seabird conservation science and **support** these students in their specific learning goals

Summary: 2017 Highlights

- **396 Rhinoceros Auklets bred on the island**, the highest number on record.
- For all 6 species of monitored seabirds on the island, parents had **near average or higher success in rearing chicks in 2017**.
- **Juvenile rockfish and anchovy dominated the diet of Rhinoceros Auklet chicks** and breeding success was the highest on record for this species.
- Clay nest modules provided safe homes for **56 breeders from 3 different burrowing seabird species**. We deployed nine new Cassin's Auklet ceramic nest modules in high density nesting areas.
- We published **peer-reviewed manuscripts** about Pelagic Cormorants (Carle et al. 2017), and Brandt's Cormorants (Ainley et al. 2018).
- We installed **500 square meters of erosion control** material and planted **2,000 native salt grass plants** for seabird habitat enhancement.

II. Seabird Breeding Success and Population Status

Año Nuevo Island provides important breeding and roosting habitat for seabirds and pinnipeds in the California central coast. As a colony close to the continent and halfway between the Gulf of the Farallones and Monterey Bay, the island has a unique ecology that allows seabirds to utilize nearshore resources, as well as resources in nearby submarine canyons (such as Año Nuevo and Ascension Canyons). Additionally, island habitats are limited in central and northern California, and species such as Rhinoceros Auklets that depend on islands for breeding sites are unique to Año Nuevo in the Monterey Bay area.



In 2017, we documented the nesting success and population size of seven species of seabirds that breed at Año Nuevo Island: the Rhinoceros Auklet, Cassin's Auklet, Pelagic Cormorant, Brandt's Cormorant, Western Gull, Pigeon Guillemot, and Black Oystercatcher.

Rhinoceros Auklet

Rhinoceros Auklets (*Cerorhinca monocerata*) breeding on the central terrace portion of the island were monitored via an infrared burrow camera in natural burrows, or by hand in artificial

nest modules. Rhinoceros Auklet burrows located outside of the central terrace area were counted before and after the breeding season, and viable burrows were included in the population size estimate for the island. To determine breeding population for the entire island, the total number of burrows was multiplied by a year-specific burrow occupancy factor calculated from reproductive monitoring. To determine the breeding success for the island, the nest contents of a 35 burrow sub-sample were observed weekly for hatchling and fledgling success. We estimated total chicks produced on the island by multiplying the number of occupied nests by chick fledging success.

Rhinoceros Auklet population

Rhinoceros Auklets were first documented breeding on Año Nuevo Island in 1982 (LeValley and Evans 1982). Between 1993 and 2015, the Rhinoceros Auklet population grew at a rate of 5 birds a year (as modeled by linear regression; $\beta = 94.01$, $R^2 = 0.65$, $P = <0.0001$). In 2015, the population surpassed 300 individuals for the first time. In 2017, a record 396 Rhinoceros Auklets bred on the island (Fig. 1). A total of 350 individuals bred on the restored central terrace (Fig. 2), likewise the highest number ever recorded for this area. On the south terrace, there were 46 breeding individuals. These record population estimates were driven by both an increase in the total number of burrows and above-average occupancy of burrows (98% of monitored burrows were occupied).

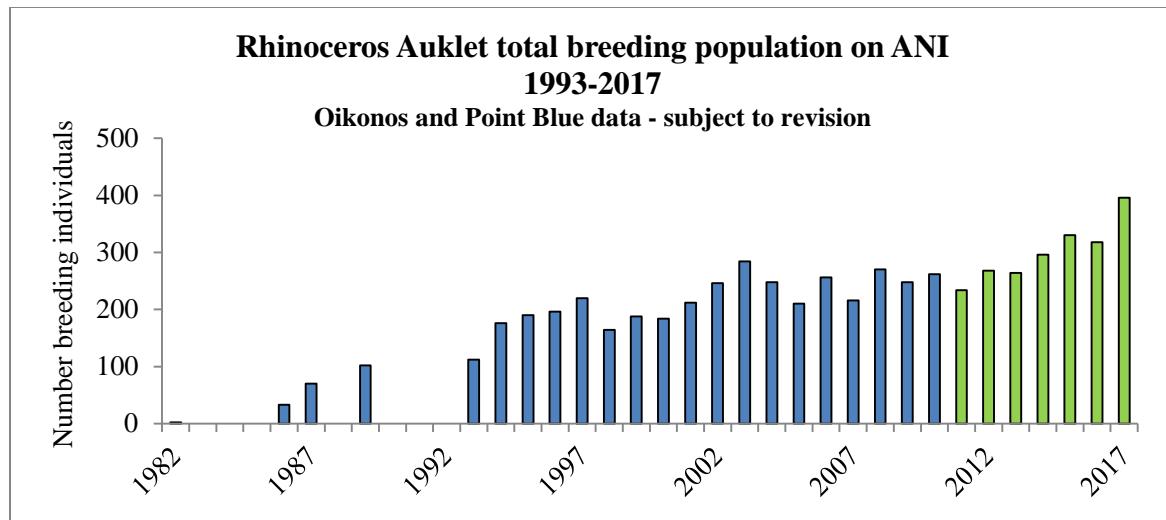


Fig. 1: Total number of Rhinoceros Auklets breeding on ANI from 1982 to 2017. Green bars (2011-2017) represent years of central terrace habitat improvements including erosion control, native plant restoration, and ceramic nest modules. In 1982, at least two breeding birds were believed to be present 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). Methods were standardized 1993-2017.

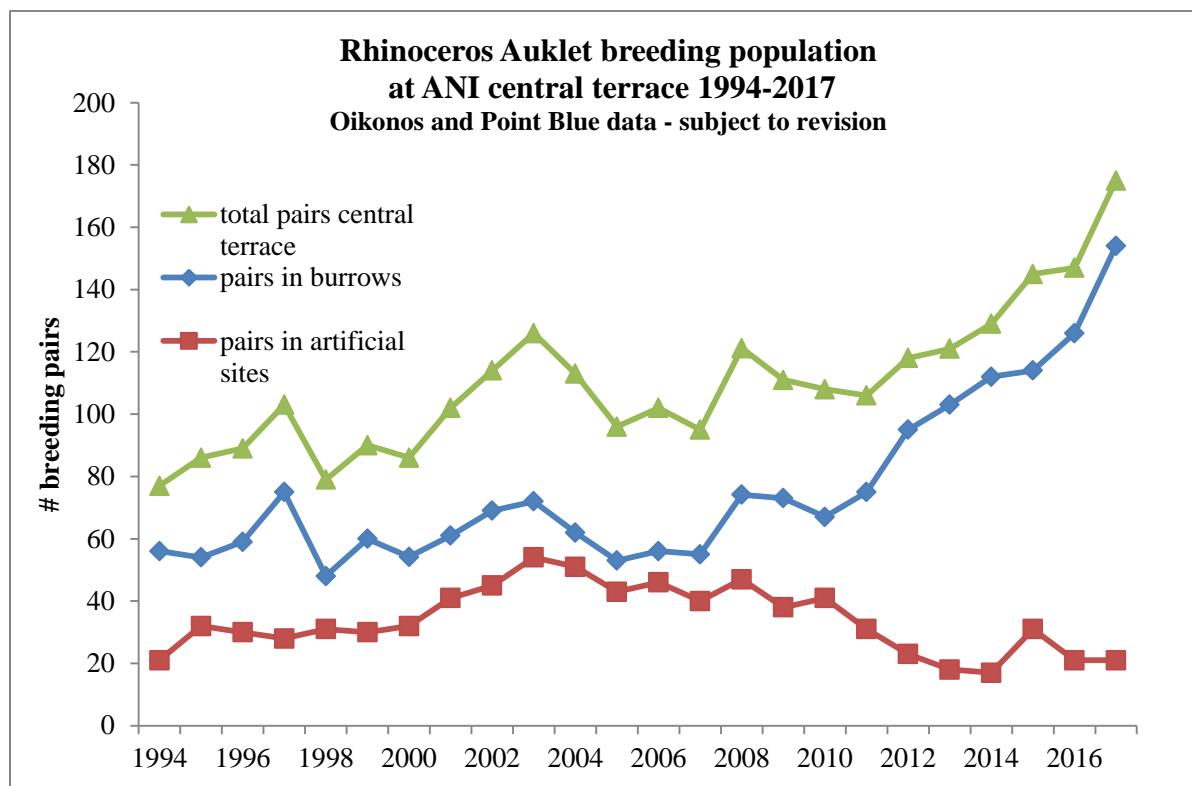


Fig. 2: Rhinoceros Auklet breeding population in the central terrace of Año Nuevo Island, 1994-2017. Green line is total pairs breeding in the central terrace, blue line is pairs breeding in natural burrows, and red line is pairs breeding in artificial nest sites.

Rhinoceros Auklet reproduction

Rhinoceros Auklets had a strong year for burrow productivity. Birds breeding in natural burrows fledged 0.86 chicks per pair (Fig. 3). This was the highest level of Rhinoceros Auklet burrow productivity on record (Fig. 3). High productivity was likely driven by the combination of juvenile rockfish and anchovy in chick diet this year. Productivity in the artificial nest modules was much lower at 0.38 chicks fledged per pair (Fig. 14). See below in Results: Nest Modules (page 19) for discussion of module productivity.

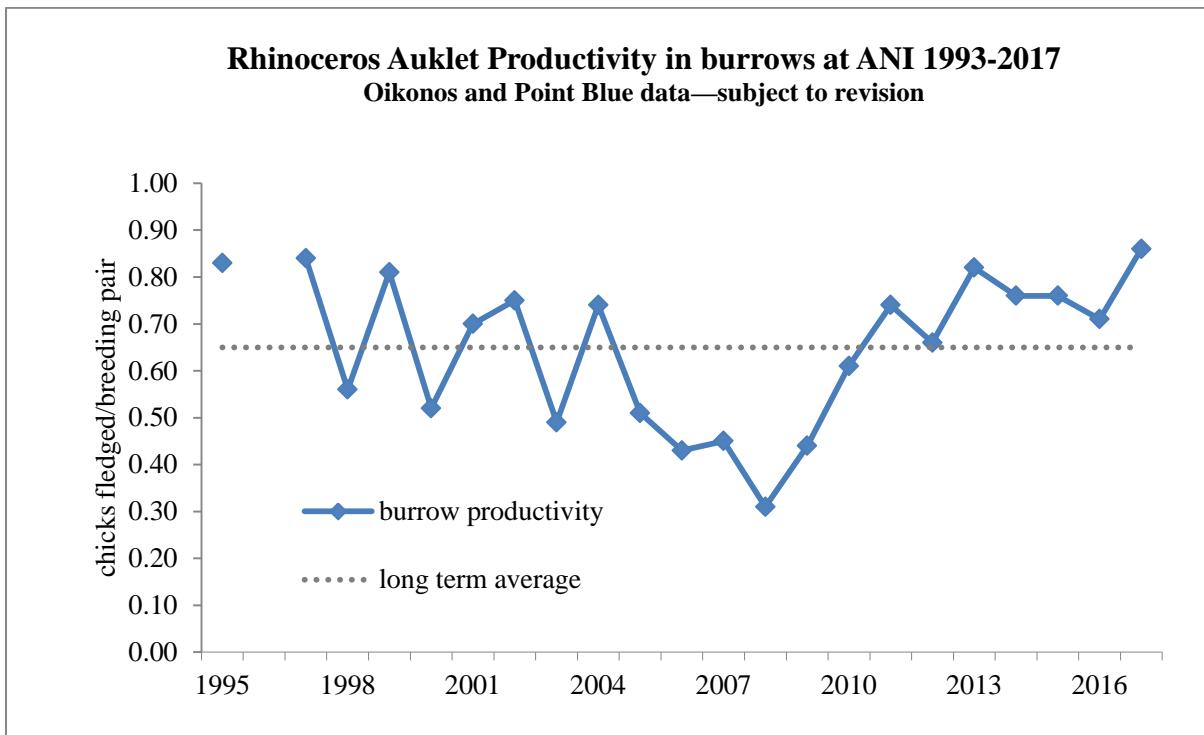


Fig. 3: Average number of Rhinoceros Auklet chicks fledged per pair in natural burrows, 1993-2017. Burrows were not monitored in 1996. The dashed line represents the long term average of 0.65 chicks fledged per pair. Sample size for burrows monitored for productivity ranged from 25 to 72.



Cassin's Auklet

Cassin's Auklets (*Ptychoramphus aleuticus*) were monitored with the same methods as described above for Rhinoceros Auklets.

Cassin's Auklet population

Cassin's Auklets first were recorded breeding on Año Nuevo Island in 1995 (Hester and Sydeman 1995). Over the next 10 years, their numbers slowly increased. No breeding was recorded for 2005 and the data for 2006 and

2007 was insufficient for a definitive count, though the limited data suggest a very low count (i.e. less than 10 breeding pairs) for 2006 and 2007. From 2008 on the population grew, reaching a high point of 136 breeding individuals in 2014. The year 2017 represents the largest population since this high point: there were 126 Cassin's Auklets breeding on the island (Fig. 4). Of these 126, 112 birds (89% of the island's total breeding population) bred in the restored, central terrace portion of the island.

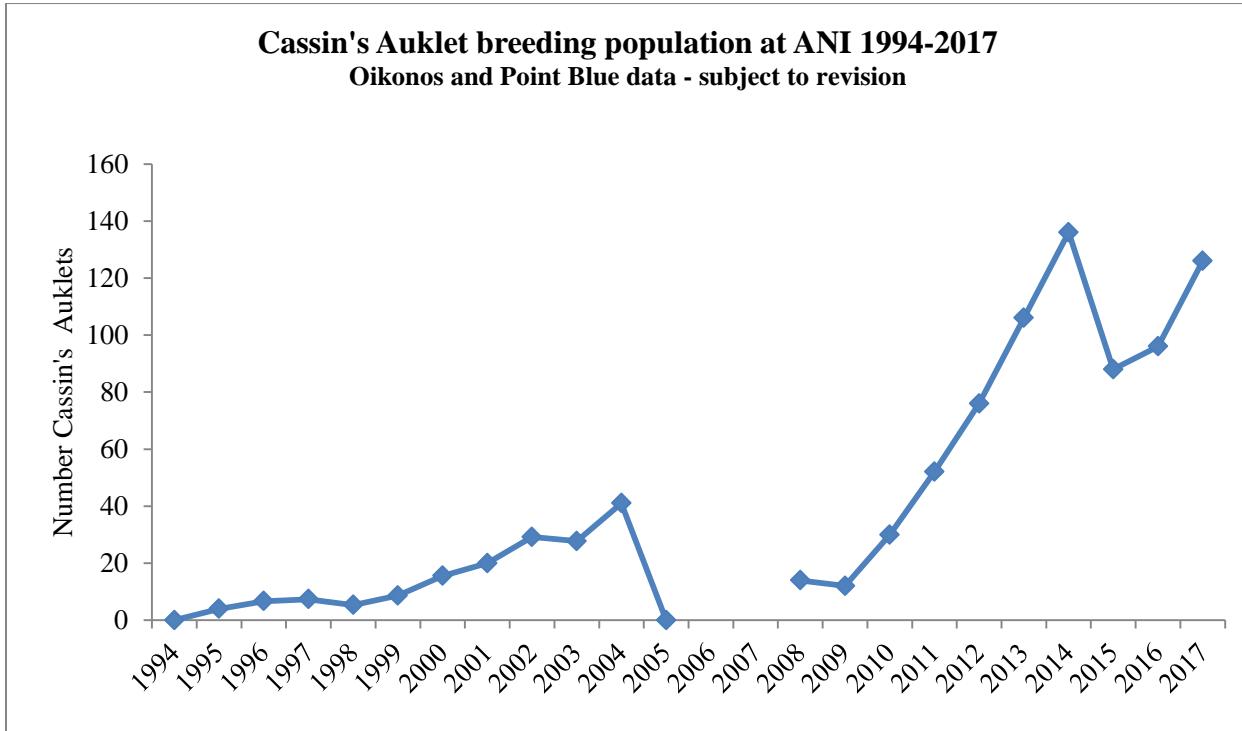


Fig. 4: The estimated number of breeding Cassin's Auklets on Año Nuevo Island annually, 1994-2017. The years 1994-2010 are minimum estimates because the whole of the island was not checked for nests, while the numbers from 2011 - 2017 represent total island estimates.

Cassin's Auklet reproduction

Cassin's Auklets breeding on Año Nuevo Island in 2017 fledged 0.84 chicks per breeding pair (Fig. 5; all site-types and clutches). There were 5 “double clutch” attempts recorded in 2017. “Double clutching” is a second breeding attempt after the breeding pair successfully fledges the first chick. Only one chick produced from a double-clutch successfully fledged, resulting in a productivity of 0.20 chicks fledged per double clutch attempt.

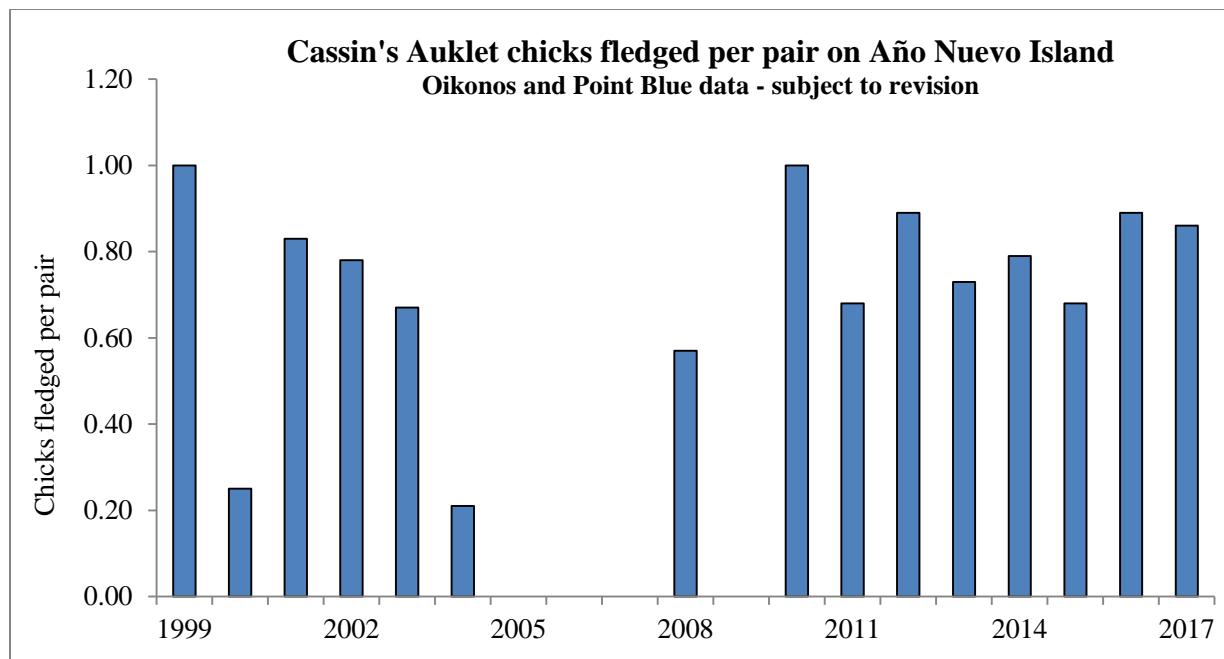


Fig. 5: The average number of Cassin's Auklet chicks fledged per pair per year in both natural burrows and artificial nest modules. The average includes both single and double clutch efforts. There were no Cassin's Auklets breeding on the island in 2005 and insufficient data in 2006, 2007, and 2009.



Brandt's Cormorant

Brandt's Cormorant population

Nesting Brandt's Cormorants (*Phalacrocorax penicillatus*) were first documented at ANI in 1989 (Carter et al. 1992). Counts began in 1999. Each year, the total peak nesting population was estimated using an aerial photograph. Sources of the aerial photos and counts varied by year (see Fig. 6 caption). Population this year was censused via US

Fish and Wildlife Service/UC Santa Cruz aerial photographs. Ground counts of portions of sub-colonies were conducted weekly by Oikonos to assess nesting pulses and determine if the aerial photograph captured the peak of breeding effort at ANI. USFWS/UC Santa Cruz reported 1,985 nests or 3,970 breeding individuals on June 17th (Fig. 6; USFWS/UC Santa Cruz unpublished data). An additional 75 nests were estimated inside the Lightkeeper's House based on post-season ground counts (not included in the total shown in Fig. 6). Ground counts of well-built nests and nesting material/fair built nests peaked on June 22nd. Given the relative closeness in date of the aerial and ground count peaks, we consider the aerial a fair assessment of total peak breeding numbers in 2017.

This year, aerial images captured by Unmanned Aerial Vehicle (UAV) were made available to Oikonos by the UC Año Nuevo Reserve (permits NMFS 19108 and MBNMS-2017-018). Using aerial images taken by the UAV by Patrick Robinson (UCNRS) on June 24th, we counted 1,963 well-built nests, or 3,926 breeding birds, which was fairly close to the 3,970 individuals estimate from the USFWS/UC

Santa Cruz aerial. Given the resolution of UAV images as compared to the USFWS/UC Santa Cruz aerials, we were unable to count fair built nests, perhaps resulting in our lower count. The UC Año Nuevo Reserve UAV aerials may be useful in future years if the coast-wide USFWS/UC Santa Cruz aerials do not coincide with peak Brandt's Cormorant nesting on ANI.

Together with many collaborators, we co-authored a peer-reviewed publication in 2017 (Ainley et al. 2018) linking Brandt's Cormorant population numbers and diet at colonies from Point Reyes to Año Nuevo Island with prey resources and colony management. The project included datasets extending from the Gulf of the Farallones and Alcatraz to the Monterey Bay, and from seabirds to fishery surveys. This analysis of multiple data-sets provided many insights into Brandt's Cormorant population trends. Our investigations found that in the 2000s, as short-belly rockfish stocks declined and nearshore Northern anchovy stocks increased, Brandt's cormorants moved from offshore colonies at the Farallon Islands to nearshore colonies such as ANI. Coinciding with a crash in anchovy abundance in the central coast, Brandt's Cormorants experienced a large die-off in the late 2000s. However, with high numbers of juvenile rockfish available since 2012, numbers have recovered since 2011 throughout the region, but have not matched the peak breeding populations seen in 2007. Nesting numbers have been relatively high at ANI since 2011, likely because of the strong rockfish recruitment years and a continuing availability of anchovy locally around ANI, as evidenced by Rhinoceros Auklet diet from our studies. For more information and greater discussion of how management of colonies and fisheries affected these population shifts, see Ainley et al. 2018.

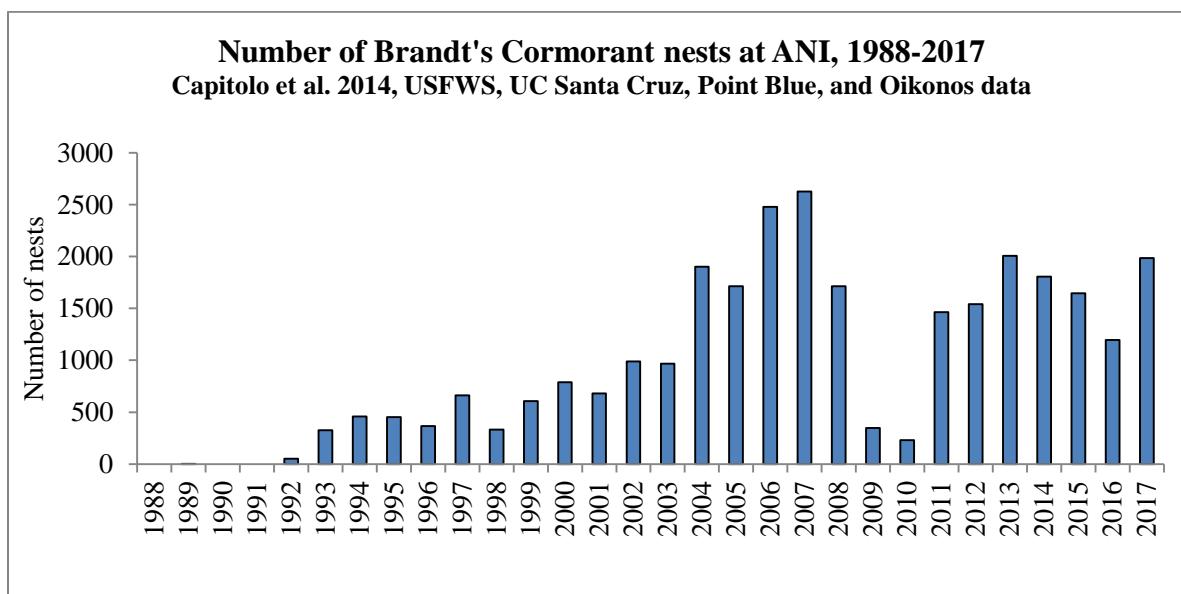


Fig. 6: Aerial counts of Brandt's Cormorants nests on Año Nuevo Island from 1988 to 2017. The first documented nesting on ANI was in 1989. Zero nests were recorded in 1988 and 1990, and no data exists for 1991. Data sources: Capitolo et al. 2014: 1988-1990, 1995-1997, 1999-2003, and 2006; Point Blue counts of National Marine Fisheries Service aerials, unpublished: 1992-94, 1998, 2004-05; US Fish and Wildlife Service and UC Santa Cruz aerials, unpublished: 2007-11, 2016, 2017; Oikonos aerials, unpublished: 2012-2015.

Brandt's Cormorant reproduction

Brandt's Cormorant productivity was calculated by following a subsample of 29 nests within the sub-colony near the fallen light tower on the south terrace of ANI. Subsampled nests were followed weekly for egg and chick counts and feathering status of chicks. Productivity in 2017 was 1.55 ± 1.02 chicks fledged per pair, which was the lowest since 2013, but close to the long-term average of 1.65 ± 0.76 chicks per pair (Fig. 7).

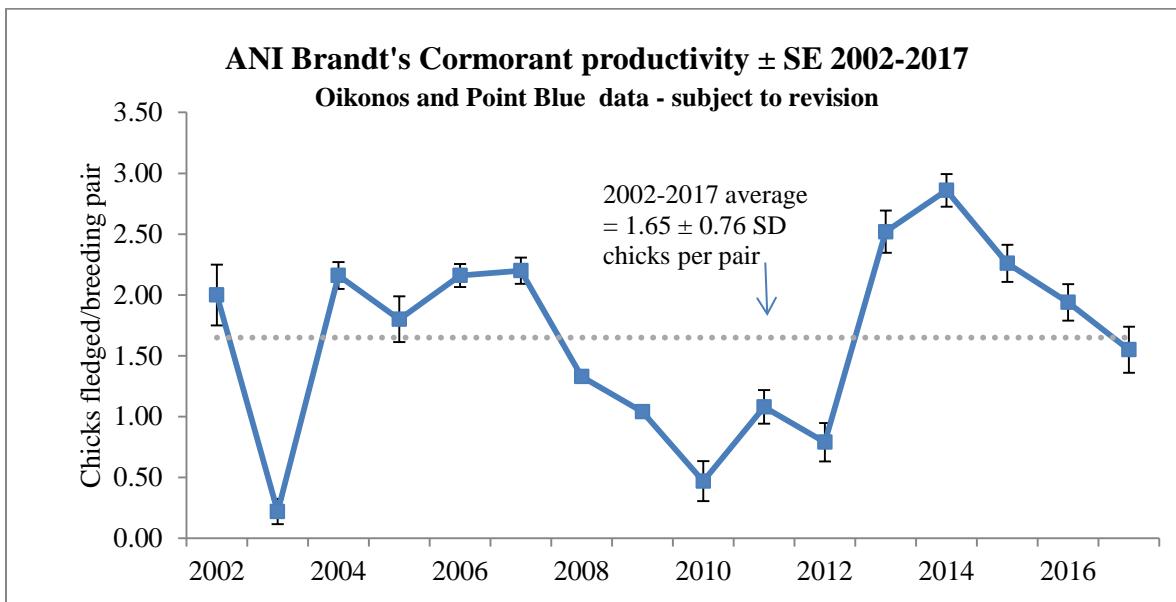


Fig. 7: Brandt's Cormorant productivity (mean \pm SE number of chicks fledged per breeding pair) at Año Nuevo Island 2002-2017. A sub-sample of nests was followed from one or both of two main visible sub-colonies, the Light Tower and Blind 17 (shown here combined). Sample size ranged from 20- 57 nests annually. In 2008 and 2009, productivity was calculated as the total number of chicks that meet 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 1.65 chicks per pair from 2002 – 2017.



Pelagic Cormorant

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 visible 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 2014-17.

Pelagic Cormorant population and productivity

The total number of breeding Pelagic Cormorants on the mainland and island in 2017 was 126 birds (Fig. 8). These birds were split roughly equally between the mainland and the island: 60 birds on the island and 63 birds on the mainland (Fig. 8). While the number of breeding attempts was near equal on the island and mainland during 2017, the reproductive success of the birds was dramatically different on the mainland vs. the island (Fig. 9). The mainland sub-colonies fledged 0.33 ± 0.35 chicks per pair, while the island sub-colonies fledged 1.59 ± 0.81 chicks per pair (Fig. 9). A similar pattern in 2014, when mainland colony productivity was significantly lower than at the island, was caused by Common Raven depredation on eggs at the mainland (Carle et al. 2017). In 2017, we did not observe any Common Raven and Pelagic Cormorant interaction or depredation on the mainland based on field observations. We have not yet analyzed camera data for 2017. It appeared that on the mainland, nests failed primarily during the post-hatching stage, with apparent chick abandonment and starvation, though we are still uncertain as to why this occurred at the mainland and not at the island.

In 2017 we published a peer-reviewed paper on the impact of Common Raven depredation on Pelagic Cormorant reproduction, based on our time-series data and nests monitored by remote camera (Carle et al. 2017). We found a strong and significant impact of Raven depredation on the mainland sub-colonies, in which Ravens took eggs from 100% of the 13 cormorant nests monitored by camera in 2014, averaging 3.3 ± 2.2 eggs taken from each nest (Carle et al. 2017). This resulted in extremely low productivity at the island in 2014, compared to record-high productivity at the island sub-colony that year, where Raven depredation was not detected (Carle et al. 2017). For more information on this topic, see Carle et al. 2017.

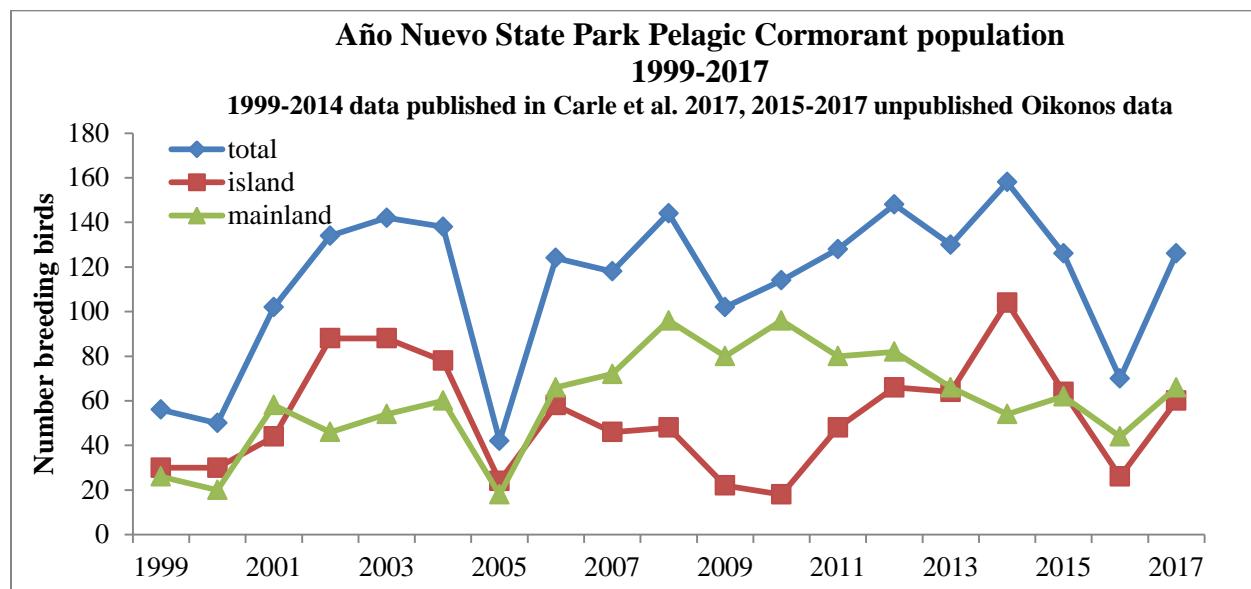


Fig. 8: Pelagic Cormorant population on Año Nuevo Island, 1999-2017. The blue line represents the total number of nesting Pelagic Cormorants on both the island and mainland, while red represents the island sub-colony counts and green represents the mainland sub-colony counts.

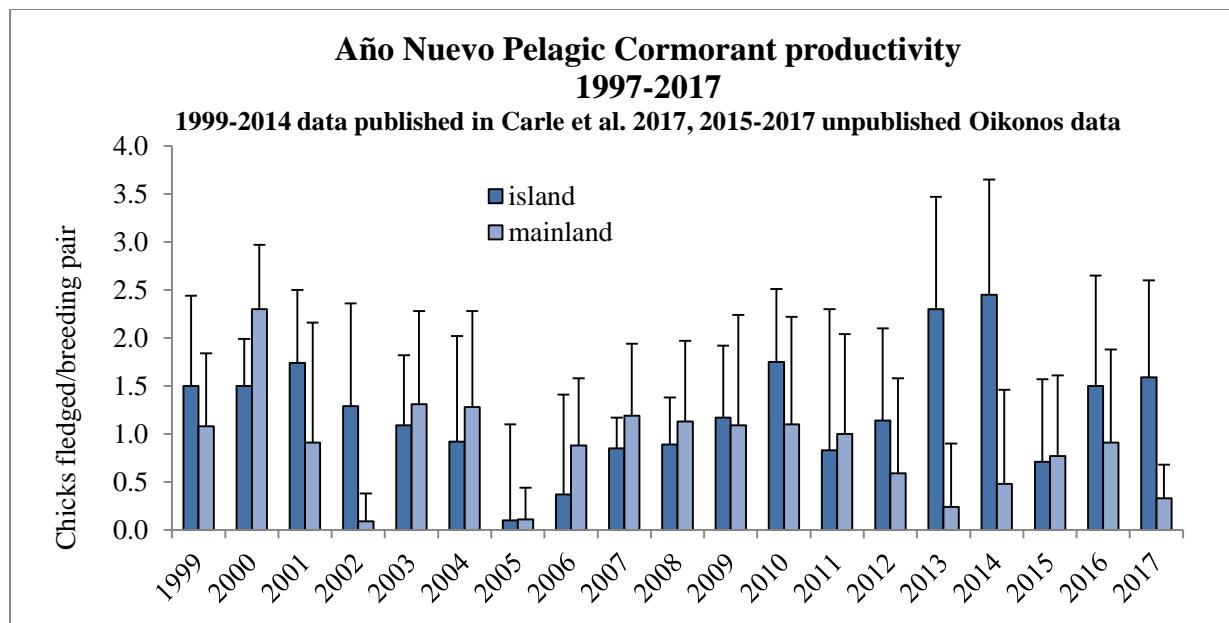


Figure 9: Average number of chicks fledged per breeding pair of Pelagic Cormorants on the island (dark blue) and on the mainland (light blue) + 1 SD (error bar).

Western Gull



Population counts of breeding Western Gulls (*Larus occidentalis*) on Año Nuevo Island began in 1976 (Sowls et al. 1980) and standardized monitoring began in 1999. Since 1999, ground- and boat-based counts of Western Gull nests were conducted during peak egg incubation. Depending on the conditions and year, sometimes areas such as the extreme north terrace were not accessible by ground or boat, in which case we used aerial photographs for supplemental counts (2016 USFWS/UC Santa Cruz aerial, 2017 UCNRS drone aerial). In order to measure reproductive success, we followed a subsample of 31 nests in the central terrace during 2017.

Western Gull population

In 2017, we counted 646 Western Gull nests on the island (Fig. 10).

This was a slight increase from last year's 608 nests. Western Gull nest numbers on ANI historically have been affected by human disturbance on the island in the form of a lighthouse station (operating from 1872-1948) and unrestricted human access until 1967 (Tyler and Briggs 1981). From extremely low nesting numbers in the 1970s and early 1980s, Western Gull population rapidly grew and peaked in 2005 at 1,234 (Fig. 10). The years since have seen a significant decline in Western Gull nests, with only around half the 2005 nest total in 2015 and 2016. There was a drop of around 30% in nesting numbers between 2014 and 2015 at both ANI and Southeast Farallon Island (Russ Bradley, Point Blue, pers. comm.), see discussion in our 2016 annual report (Carle et. al 2016).

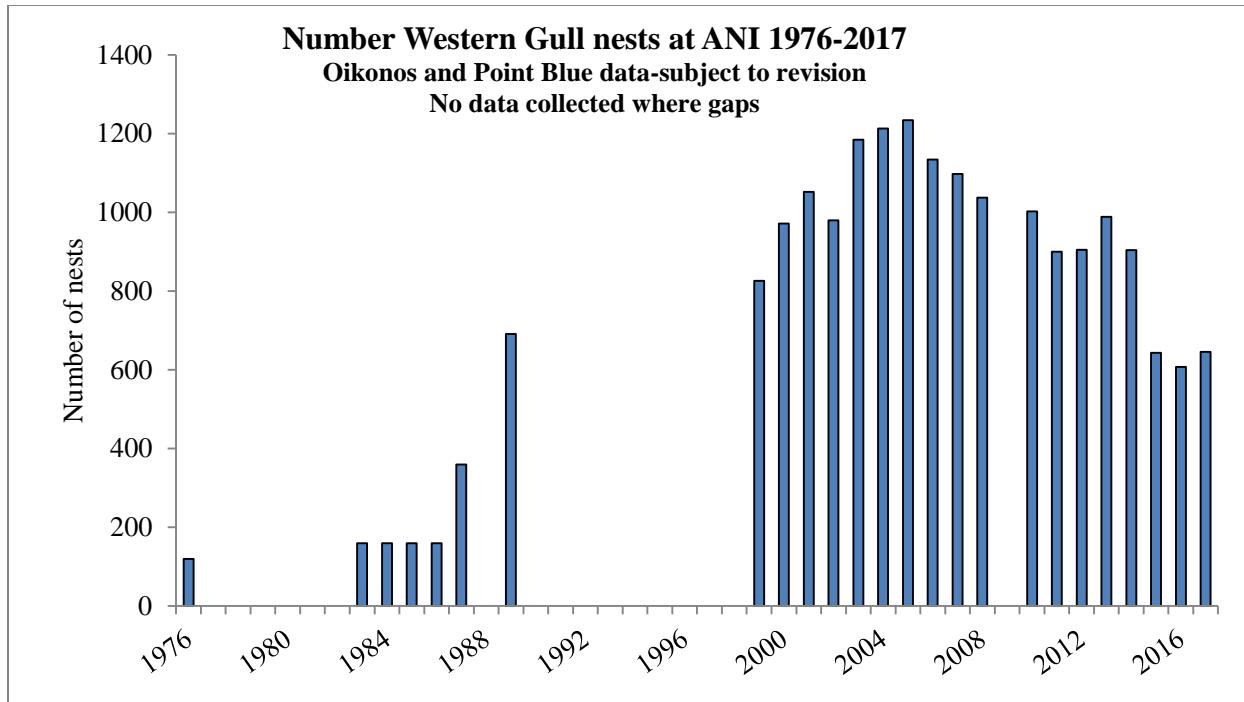


Fig. 9: Western Gull nests on Año Nuevo Island 1976-2017. In 2017, nests were counted via ground counts and by boat with the exception of a small portion of the north terrace which was counted using UCNRS aerial drone photographs. The years 1999-2017 are standardized ground counts, all previous years are 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).

Western Gull productivity

Western Gulls in 2017 fledged 1.58 ± 0.99 chicks per pair. This was above the 1999-2017 average of 1.25 ± 0.08 chicks fledged per pair (Fig. 10).

In 2016, we began an annual island wide Western Gull chick census during late June, just before chicks start to fledge, to compare the density of fully-grown chicks in the managed central terrace to the north and south terraces. In 2016 and 2017, this census has shown the central terrace to have a much higher density of Western Gull chicks. In 2016, the central terrace had a density 17 times greater than the north terrace, and five times greater than that of the south terrace. In 2017, the central terrace had a density 9 times greater than the north terrace, and 6 times greater than the south terrace (Fig. 11). We believe this is primarily because sea lions crush many nests on the north and south terraces, but are excluded from the central terrace. The major difference in chick density between terraces may also indicate that productivity numbers shown in Fig. 10 are representative of only the central terrace, where our sub-sample was located, and not the entire island's productivity. This is likely especially true in the years since the habitat ridge sea lion exclusion fence was constructed (2011 on).



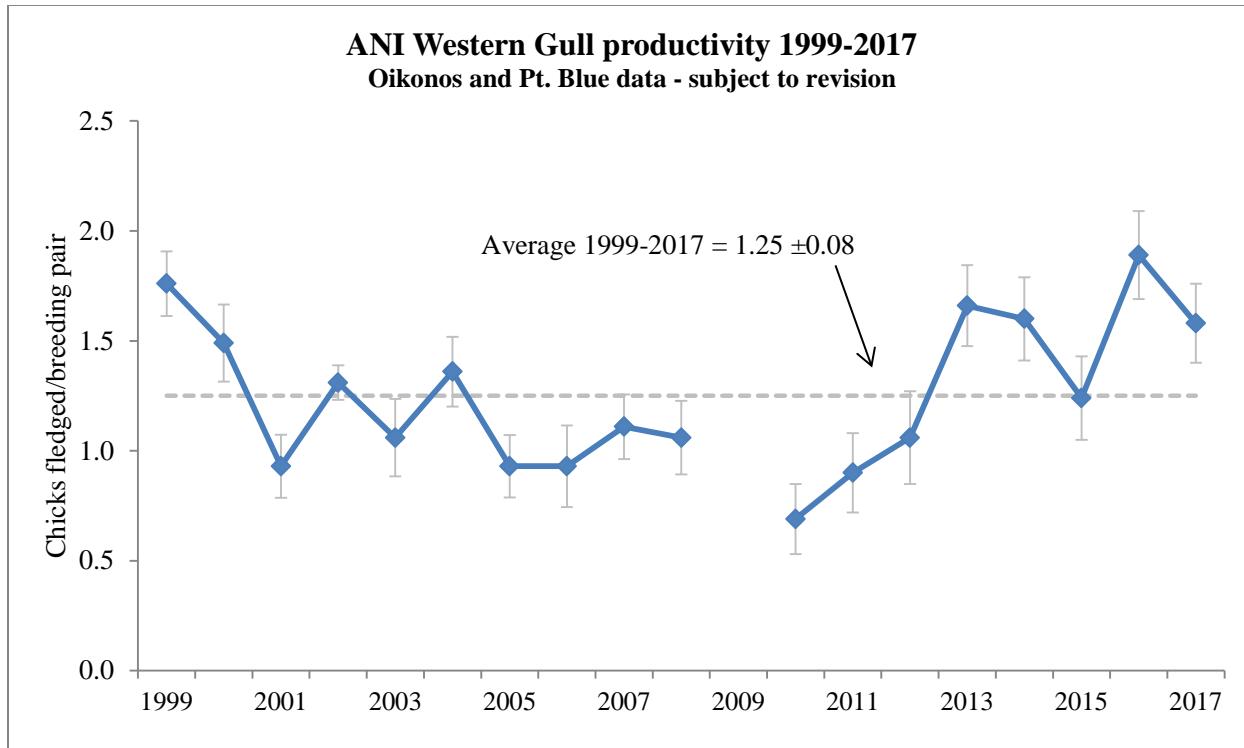


Fig. 10: Annual productivity (average chicks fledged per breeding pair \pm standard error) of Western Gulls nesting in the central terrace region on Año Nuevo Island, 1999-2017 (no data for 2009). Subsamples of 28–155 nests were monitored annually for breeding success.

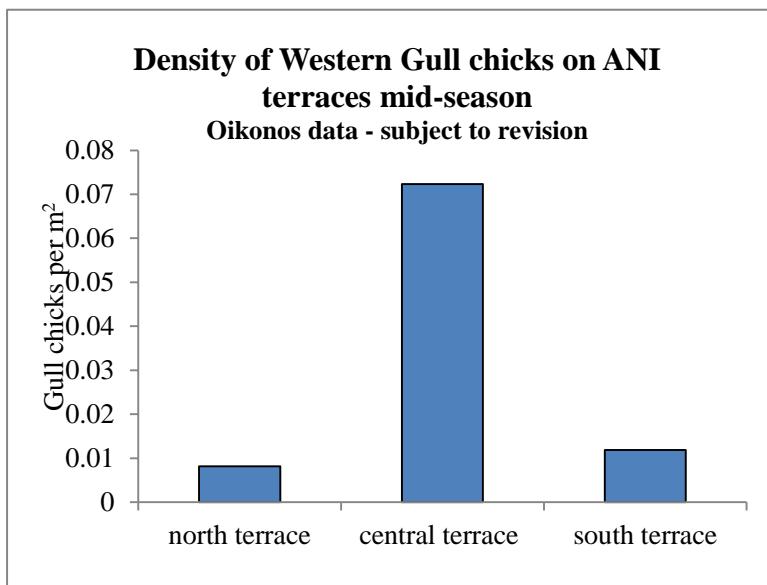


Fig. 11: Western Gull chick density (chicks per m^2) on ANI terraces on July 12, 2017. At the time of the count, most chicks were mostly- to fully-feathered, just before fledging age. The central terrace was defined as all areas inside the Habitat Ridge sea lion exclusion fence (396 chicks; 5,474 m^2). North terrace was all areas north of the Habitat Ridge (49 chicks; 5,978 m^2), and South Terrace was all areas south of the Habitat Ridge (72 chicks; 6,078 m^2). Only the top of the raised part of the island was considered “terrace.”



Pigeon Guillemot

Pigeon Guillemot (*Cepphus columba*) breeding sites were monitored by burrow camera or by hand in the accessible central portion of the island, and by site attendance and fish carrying for inaccessible sites. ANI had a breeding population of at least 13 Pigeon Guillemot pairs in 2017 (Fig. 12). Of these pairs, five bred in artificial clay modules designed for Rhinoceros Auklets, one pair bred in an experimental module design, and the rest nested in crevices or burrows (see Fig. 17). Of these 13 pairs on the island,

we were able to assess the productivity for seven pairs: 1.00 ± 0.73 chicks fledged per pair. Nest modules provide a higher degree of researcher accessibility and allow for detailed productivity data.

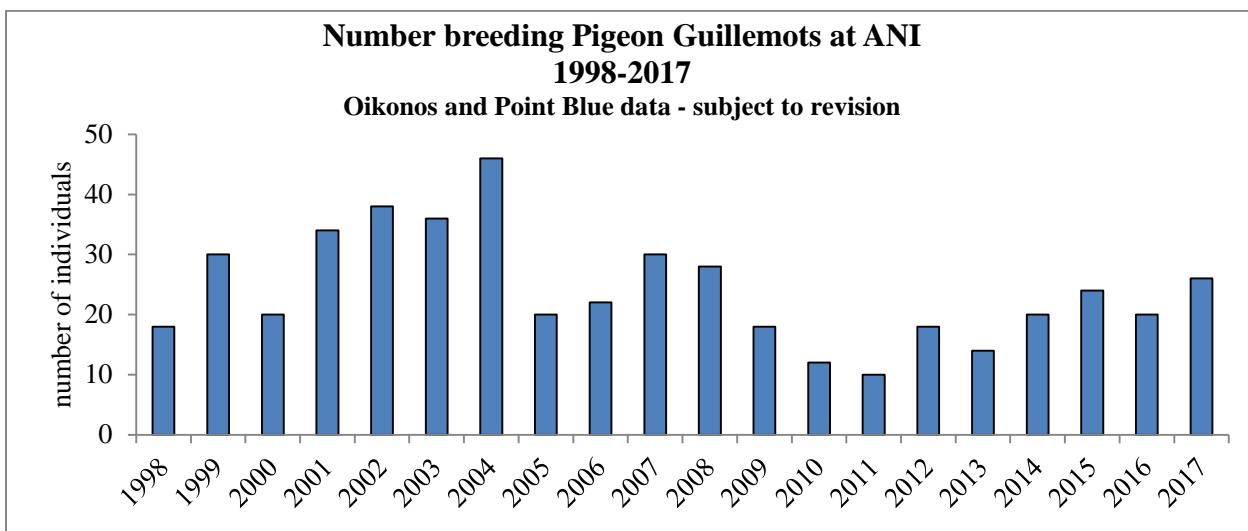
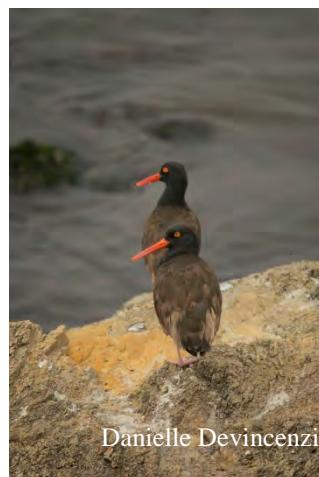


Fig. 12: Pigeon Guillemot breeding population on Año Nuevo Island 1998-2017.

Black Oystercatcher

Black Oystercatcher (*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. 13). In 2017, there were three confirmed active breeding pairs. Of these three, only one pair successfully hatched and fledged chicks. One other pair had a confirmed hatch, but the chick disappeared before fledging age. Most nests fail at ANI due to disappearance of eggs or chicks, suggesting predation or perhaps trampling by pinnipeds. Black Oystercatchers have been observed defending nests from Common Ravens frequently since 2004.



Danielle Devincenzi

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 Black Oystercatcher reproductive success data to a current project led by California Audubon to monitor breeding success state-wide.

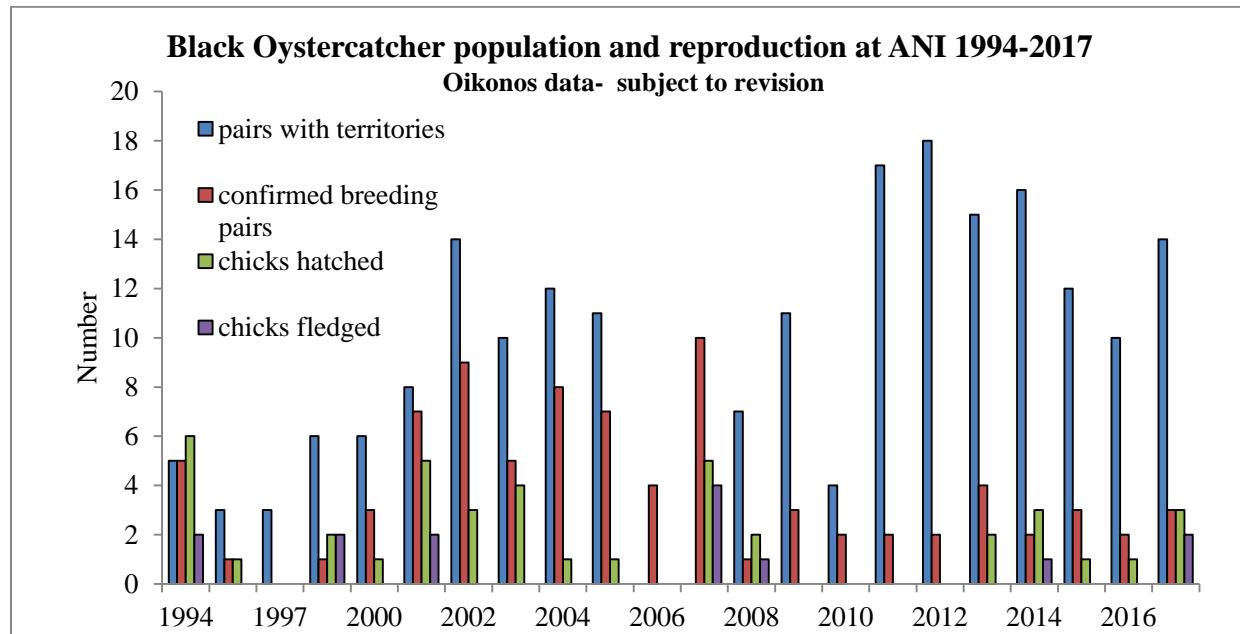


Fig. 13: Annual population and breeding metrics of Black Oystercatcher nests visible from ANI ground observations from 1994 to 2017 (purple – total number of chicks fledged, green – total chicks hatched, red - confirmed number of breeding pairs documented with eggs or chicks, blue - total nest sites 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

The Ashy Storm-petrel (*Oceanodroma homochroa*) is a tiny seabird related to albatrosses and is a possible breeder on ANI. From 1993-2017, 12 Ashy Storm-Petrels have been recorded at ANI (Fig. 14). 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. One Ashy Storm-Petrel was captured during mist-netting in 2017.



Ashy Storm-petrel caught during 2017.

This year we temporarily placed a song-meter sound recording device on the west side the Lighthouse Keeper's House in collaboration with USGS, to assess Ashy Storm-petrel activity. As of this writing, USGS has not analyzed the audio data.

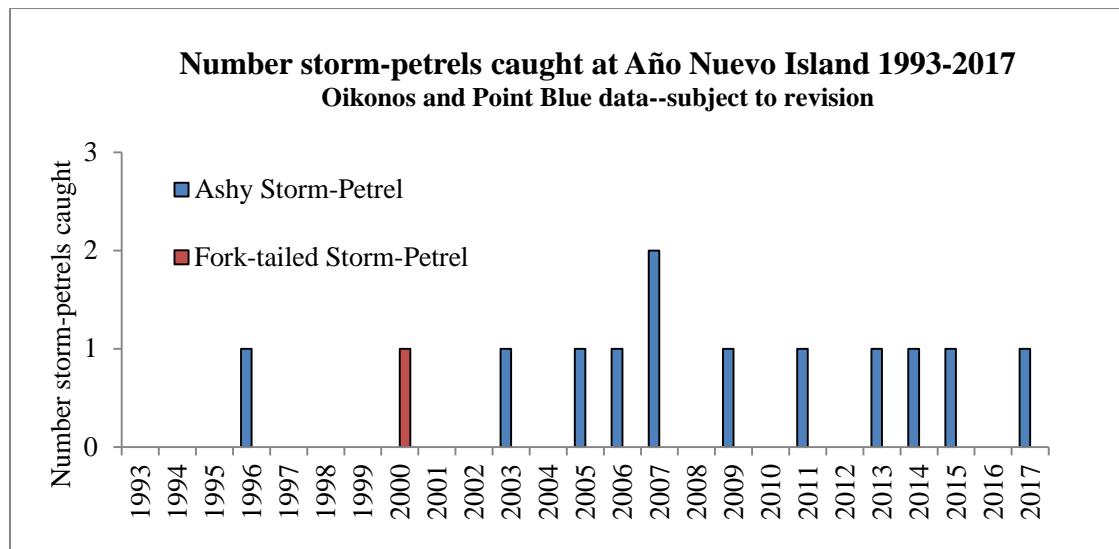


Fig. 14: The number of Ashy and Fork-tailed (*Oceanodroma furcata*) Storm-petrels incidentally captured at Año Nuevo Island from 1993-2016. All storm-petrels were captured during nighttime mist-netting targeting Rhinoceros Auks, from late June to early August.

Common Raven

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, with the exception of 2016 during which we were unable to ascertain if the island nest was active. In 2017, the mainland Common Raven nest had an adult on the nest twice during monitoring. No interactions between Pelagic Cormorants and Common Ravens on the mainland were observed, though remote camera images could reveal otherwise. We have yet to analyze camera image data for 2017. The island's Common Raven nest on the Lighthouse Keeper's House appeared to be active this year. We captured a photo of a Common Raven in early July flying near the well-built nest on the east-facing awning on the Lighthouse Keeper's House (photo above). We are continuing to monitor raven impacts on breeding seabirds.



Common Raven flies towards a nest on Lighthouse Keeper's House.

III. Prey Studies

Seabirds are top marine predators and understanding what they eat and what they provision their young gives us a picture of the health of the marine ecosystem and fisheries. In 2017, we collected diet samples from Rhinoceros Auklets, Pelagic Cormorants, and Brandt's Cormorants. Rhinoceros Auklet diet sample results are presented below. See Ainley et al. 2018 for Brandt's Cormorant diet results from ANI from 2000-2016.

Rhinoceros Auklet Prey Study:

Rhinoceros Auklets return to the breeding colony at night to provision their chicks with whole fish and/or cephalopods carried cross-wise in their bills (Hester 1998). This assemblage of prey is called a “bill-load.” Since 1993, we have collected data on Rhinoceros Auklet bill-loads by mist-netting provisioning adults in the central terrace four nights a year. In 2017, we caught a total of 108 Rhinoceros Auklets and collected 41 complete bill-loads of prey.

Juvenile rockfish (*Sebastodes spp.*) and Northern Anchovy (*Engraulis mordax*) represented the most prevalent prey species in the Rhinoceros Auklet diet this year. When analyzing the number of prey items per bill load, Rockfish made up $48 \pm 43\%$ and Northern Anchovy made up $33 \pm 43\%$ of prey provisioned to auklet chicks. When analyzing prey by the % mass of each species, Northern Anchovy represented a higher percentage per bill load at $40 \pm 46\%$, with rockfish at $38 \pm 41\%$. Other prey observed in 2017 in smaller proportions were market squid (*Doryteuthis opalescens*), juvenile lingcod (*Ophiodon elongatus*), and juvenile coho salmon (*Oncorhynchus kisutch*; Fig. 15).

Rhinoceros Auklet chick growth and fledging success are typically higher in years when they are provisioned with either juvenile rockfish, anchovy, or both (Thayer and Sydeman 2007). Indeed, Rhinoceros Auklet productivity was the highest on record in 2017 (Fig. 3), when rockfish and anchovy were the dominant prey type (Fig. 15). See Thayer and Sydeman 2007 and Carle et al. 2015 for more information on Rhinoceros Auklet foraging ecology and chick diet at ANI.

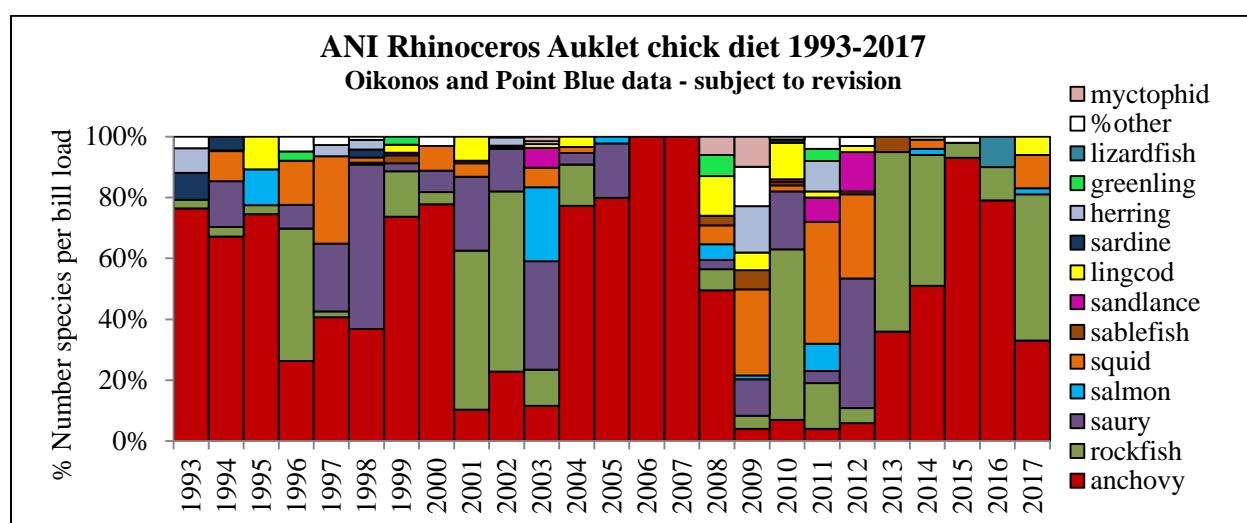


Fig. 15: Rhinoceros Auklet chick diet on Año Nuevo Island from 1993-2017 quantified as the percent number of prey per bill-load delivered to chicks. Sample size ranged from 18-47 bill-loads annually. 2017 sample size was 41 bill-loads.

IV. Habitat Restoration

The habitat restoration on ANI seeks to mitigate injuries to seabirds from oil contamination (Luckenbach Trustee Council 2006) and to protect biodiversity on ANI. After a public review process, the Luckenbach Trustee Council determined that oil spill damage to Rhinoceros Auklets could be addressed by habitat restoration efforts to improve reproductive success at Año Nuevo Island. If no action was taken, the breeding colony was predicted to decline rapidly due to soil erosion. Thus, the restoration benefits are derived from the difference between colony growth/persistence versus decline/loss of the colony without the project.

Restoration Accomplishments in 2017

1. **Nest Modules:** This year we deployed nine Cassin's Auklet specific nest modules, one of which was a prototype model constructed by 3d printing clay. We also deployed two more Rhinoceros Auklet modules. These 11 new modules join the 92 Rhinoceros Auklet modules and 10 prototype Cassin's Auklet modules already in place on the island.
2. **Restoration:** We continued to reduce erosion of the central terrace portion of ANI by installing erosion control material, spreading native seed and sterile barley, and strategically planting the hardiest and most resilient of our native plants: salt grass.

Clay Nest Modules

In the seven years since installation of clay nest modules, they have proven to be attractive to breeding Rhinoceros Auklets. Since 2011, Rhinoceros Auklets have laid 168 eggs and fledged 75 chicks from the modules. Twenty-one pairs of Rhinoceros Auklets nested in modules in 2017. Cassin's Auklets and Pigeon Guillemots have also bred successfully in the Rhinoceros Auklet module design. Without a doubt, the clay modules have provided homes safe from erosion for many seabird pairs and have required less maintenance than previous wood and PVC box designs.

However, productivity of Rhinoceros Auklets breeding in clay modules from 2011-2017 averaged 0.28 ± 0.13 chicks fledged per pair, lower than in natural burrows (range 0.16-0.48 lower; $n = 7$ years), when the same fledging criteria was used in both site types. Long-term clay module productivity was also 0.13 chicks per pair lower in clay modules (0.38 ± 0.13 , 2011-2017) than in wooden boxes (0.51 ± 0.13 , 1993-2010) when the same fledging criteria was applied to both site types. In 2017, module productivity was 0.38 ± 0.38 chicks fledged per pair (Fig. 16).

It is still unclear why Rhinoceros Auklet productivity has been relatively low in clay modules. In 2011 and 2012, the first years after installation, productivity was low due mainly to low survival of chicks ("fledging success"; Fig. 16). In recent years, and especially in 2017, low productivity appeared to be driven by low hatching success (e.g. only 52% of eggs laid in modules hatched in 2017, Fig. 16), rather than chick survival. No design features have caused obvious problems with nesting success. It is possible that research disturbance at nest sites during incubation could cause lower hatching success; however, research effort was identical for wood boxes. Another possibility is that, for unknown reasons, modules are selected by lower-quality breeding pairs, resulting in lower productivity. These might be young and inexperienced birds, or newly-formed pairs. We plan to investigate these patterns using demographic data from banded birds nesting in modules.

Interestingly, from 2013-2017 Cassin's Auklet productivity in clay nest modules (0.80 ± 0.26) was virtually identical to productivity in natural burrows (0.80 ± 0.08), though sample size in modules was limited ($n = 2-7$ nests). In 2017, Cassin's Auklet productivity in clay modules was 1.00 ± 0.42 chicks fledged per pair ($n = 2$ pairs). Six pairs of Pigeon Guillemots nested in clay modules in 2017 (Fig. 17), the highest number of this species nesting in the modules since their installation. Nine pairs of Pigeon Guillemots have attempted to breed in modules from 2014-2017, and have fledged 7 chicks total, for a productivity of 0.77 ± 0.66 for all breeding attempts (maximum possible productivity for Pigeon Guillemots is 2.0 because they lay two eggs, vs. the one-egg clutches of Rhinoceros and Cassin's Auklets.) We do not have a large enough sample size of Pigeon Guillemot nests to be able to compare this to natural burrows.

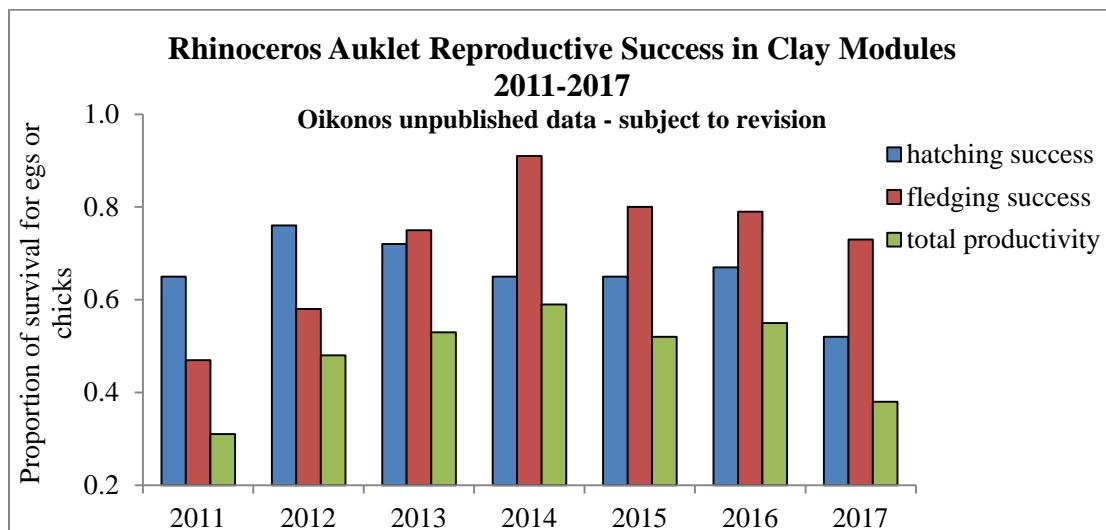


Fig. 16. Rhinoceros Auklet reproductive success metrics in clay nest modules at Año Nuevo Island, 2011-2017 (blue – proportion of eggs that hatched per pair, red – proportion of hatched chicks that survived to fledging, green – proportion of chicks that fledged per breeding pair). Sample sizes were between 20-39 nests annually.

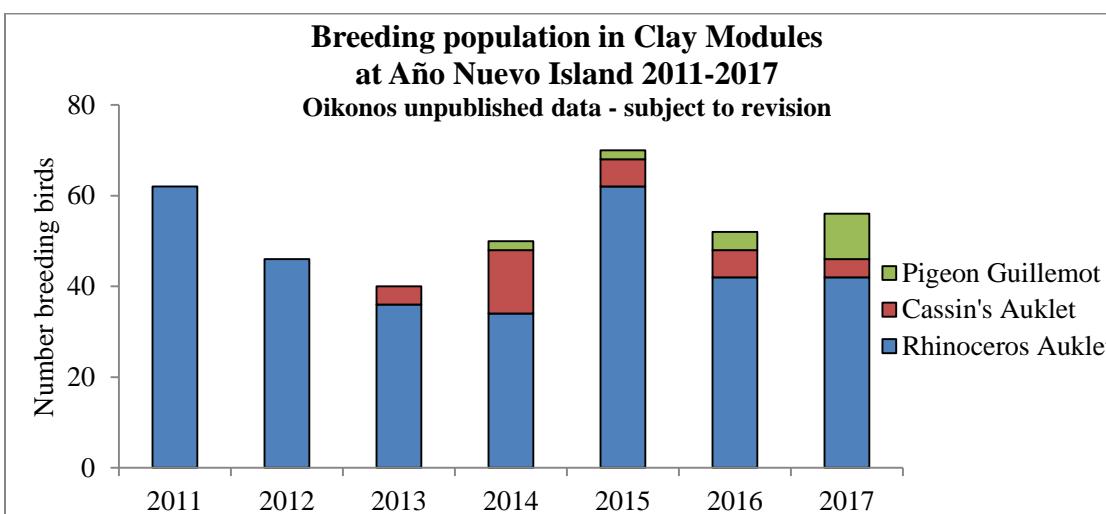


Fig. 17: Seabird breeding population in clay nest modules at Año Nuevo Island, 2011-2017. Birds were counted as breeding birds if they had a confirmed egg or chick.



Project Ecologist Emily Coletta maps the placement of the Cassin's Auklet modules.



The 3D printed Cassin's Auklet specific nest module.

Cassin's Auklet nest modules

In collaboration with California College of the Arts (CCA) and Patagonia-Santa Cruz, we designed, built, transported, and installed nine new Cassin's Auklet specific nest modules on ANI in November 2017. The design is overall elbow shaped, with a separate tunnel, nest cavity, and heat shield. The tunnel excludes Pigeon Guillemots and Rhinoceros Auklets by narrowing to Cassin's Auklet-sized passage. The nest cavity has holes for ventilation. The heat shield sits atop the nest cavity on clay ridges, effectively allowing air flow between the two clay pieces. One of these modules is 3D printed (pictured below to right). In this design, the nest cavity and heat shield functions are combined into one curved unit, wherein the interior wall is an open matrix of piped clay.

Inside of each deployed module we placed a temperature and light logger to monitor maximum temperatures reached and light levels within the modules. Outside of the modules we installed another logger to gather ambient light and temperature data for comparison.

We installed these modules in a line above the old, wooden tramway between the cistern lip and adjacent bluff edge. We are hoping that these modules will be occupied by birds otherwise nesting in this tramway which is dangerous for Cassin's Auklets given its precarious, eroding nature and dangerous for researchers given the proximity of the bluff edge. The tightly clustered nature of the modules has not yet been attempted for Cassin's Auklets on the island. Numbers of Cassin's

Auklets in nest modules is relatively low on the island, and we hope that this placement and the Cassin's Auklet-unique modules will increase the numbers of Cassin's Auklets who use these safe breeding options.

Vegetation Metrics

Description: The purpose of the vegetation metrics is to quantify the growth of stabilizing plant cover in the restoration area. Plant cover and associated root structure in the island's sandy soil improves burrow stability. The objective of plant restoration is to stabilize soil to reduce damage to auklet nesting burrows and loss of auklet nesting habitat through erosion.

Method: We conducted two surveys per year quantifying plant species composition in restoration areas in May and October 2010 – 2017 (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. We surveyed vegetation during August in 2017, to capture the state of plants before large numbers of pelicans arrived and damaged plants in the fall.

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 (Figure 18). A combination of drought and hundreds to thousands of roosting Brown Pelicans (*Pelecanus occidentalis*) caused vegetation cover to decline to 4% in 2014 (Figure 18). Brown Pelican numbers remained high in 2017, with peak numbers comparable to the past four years (Figure 20). Since then the low point of vegetation cover in 2014, native vegetation cover has slowly rebounded and stabilized at between 12-17%. In 2017, total vegetation cover was 26% in the spring and 19% in the fall (the difference largely having to do with *Malva parviflora* spring growth and fall die-back cycle); native vegetation cover was 17% in both spring and fall.

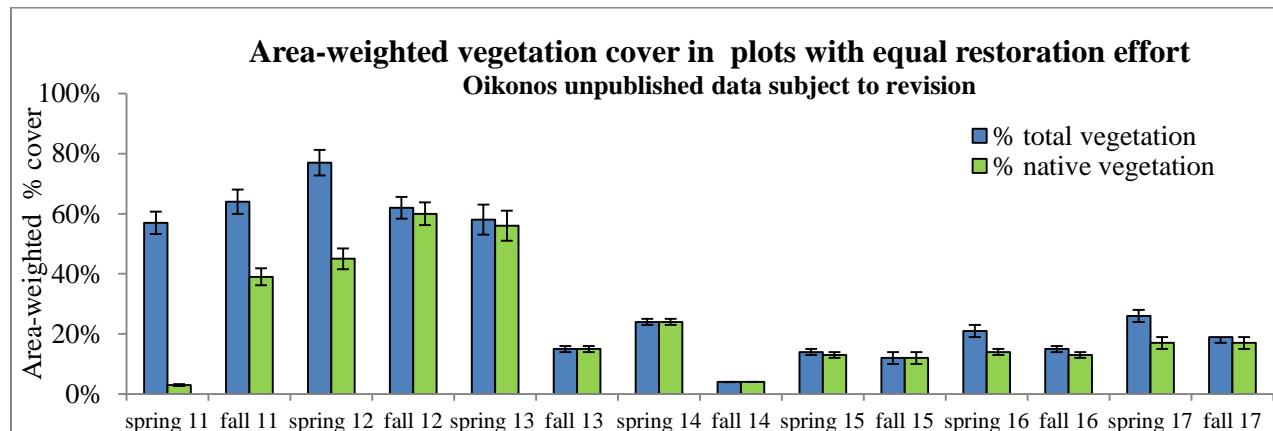


Fig. 18. Percent vegetation cover (average area-weighted \pm SE) in four restoration plots that experienced equal restoration efforts on Año Nuevo Island, 2011-2017. Plants were first installed in fall 2010.

In 2017, salt grass (*Distichlis spicata*) made up 41% of total vegetation cover in the spring survey and 57% in the fall survey. The other most common plant, American dune grass (*Elymus mollis*) made up 22% of total vegetation cover in the spring and 30% in the fall (Fig. 19). Dunegrass has modestly recovered from pelican trampling, especially in areas where we protected this species from pelicans with circles of stakes. Salt grass continues to be the plant species most resilient to pelican trampling and harsh island conditions.

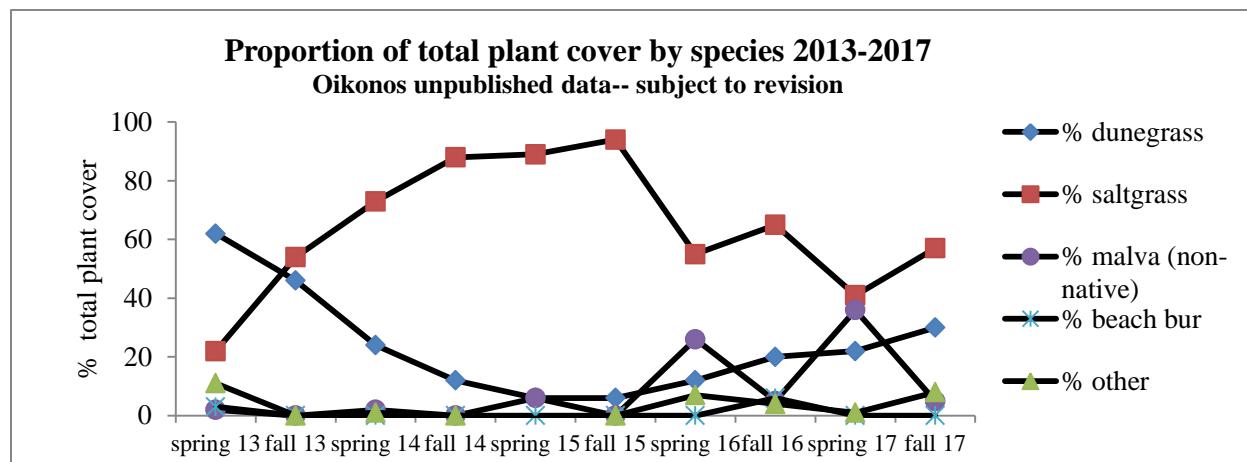


Fig. 19: Average percent of total plant cover by species in the central terrace restoration area of Año Nuevo Island in spring and fall 2013-2017.



Area 8 in the restored portion of the central terrace

Given the possibility of sustained Brown Pelican trampling and drought years, this spring we chose to plant the most resilient of our native plant cover: salt grass. This spring we planted 2,000 salt grass starts. We planted these starts and covered them with erosion control fabric: this layer of erosion control material prevents their extraction by Western Gulls and protects young plants from the elements. We also protected plants already established on the island from pelican trampling by surrounding them with a tightly clustered circle of wooden stakes, which pelicans do not like to enter.

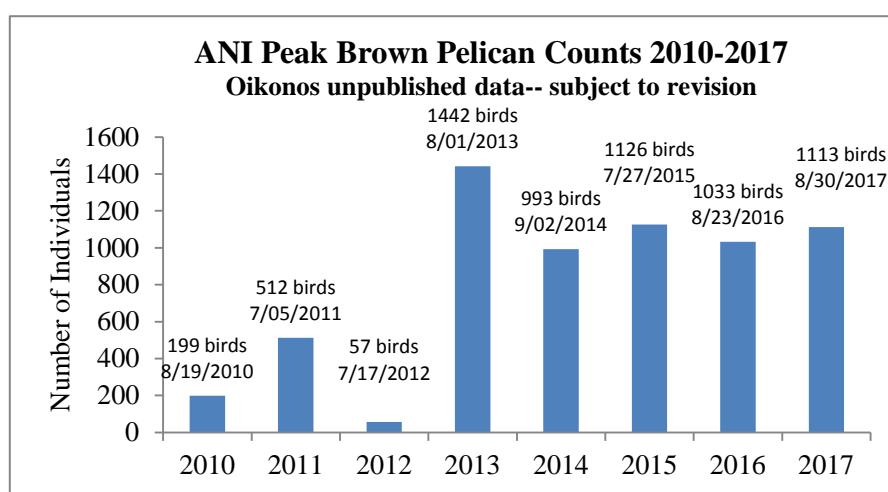


Figure 20 Annual peak number of adult and juvenile roosting Brown Pelicans, as counted from the central terrace, 2010-2017.



Distichlis spicata starts

In addition to planting and protecting native plants, in 2017 we deployed 500 square meters of erosion control material. Under this erosion control material we spread both native seed and sterile barley.

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 has almost certainly been facilitated by improved habitat quality on the island, though it may be influenced by other factors including prey availability, immigration from other colonies, and demography of the population. The annual increase in chicks

fledged since 2009, however, is a clear indication of the restoration's success at preventing colony decline and loss.

Methods: See nest monitoring methods in Carle *et. al.* 2015.

Results: Since 2011, the central terrace habitat restoration area has produced more chicks every year, with a total of 661 fledged chicks 2011-2017. The Luckenbach Oil Spill killed an estimated 593 Rhinoceros Auklets (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. In 2017, the central terrace population produced an estimated 140 fledged chicks, the greatest number on record.



Volunteers Dave Calleri and Ron Brost and UCSC intern Danielle Devincenzi drive stakes around native plants, such as this stand of *Ambrosia chamissonis* pictured in the foreground.

Table 1. Replacement (mitigation) of Rhinoceros Auklets injured by oil contamination during the Luckenbach oil spill, through reductions in habitat loss at Año Nuevo Island from 2011-2017. Note: all values are for the central terrace restoration area.

Year	Breeding Adults	Chicks Fledged Natural Burrows	Chicks Fledged Artificial Sites	Chicks Fledged Total
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
2017	350	132	8	140
Total		587	74	661

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Appendix 1. Acknowledgements, Partners, Volunteers

Success of this project depends upon the hard work and collaboration of many different individuals and organizations. **California Department of Parks and Recreation, Año Nuevo State Park, and Oikonos - Ecosystem Knowledge** have partnered in the restoration of Año Nuevo Island. The other key partners were **Go Native, California College of the Arts, Nathan Lynch, Morelab, Rebar, UC Natural Reserve System, US Fish and Wildlife Service, UC Santa Cruz, 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 6,000 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.



The Patagonia Santa Cruz crew and Project Manager Ryan Carle return from the island after a long day transporting and installing Cassin's Auklet Nest Modules.

tools, and materials. Other donors included the **Sand Hill Foundation, Grant Program, 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 thank many **individual donors** who have helped sustain this program. We additionally acknowledge the **Coastal Conservancy** for funding the pilot work and initial restoration efforts from 2003 - 2005. Individual donors also have funded our project. Thanks to all who have donated their time and money to this effort!

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, the **NOAA Saltonstall-Kennedy**

Key Project Personnel 2016 - 2017

<i>Oikonos</i>	<i>CCA</i>	<i>Morelab</i>	<i>Go Native</i>	<i>CA State Parks</i>	<i>UCNRS</i>
Jessie Beck	Nathan Lynch	Matthew Passmore	Chuck Kozak	Ziad Bawarshi	Pat Morris
David Calleri			David Sands	Portia Halbert	Guy Oliver
Ryan Carle				Tim Hyland	Patrick Robinson
Emily Coletta				Mark Hylkema	
Daneille Devincinzi				Terry Kiser	
Michelle Hester				Mike Merritt	
Verónica López				Chris Spohrer	
Trinidad Mena				ANSP Docents	
Kirsten Moy					
Tamara Russell					
Nathaniel Smith					



Volunteer Ben Nokes collects native seed for ANI plant restoration (left); volunteer Morgan Gilmore holds a Rhinoceros Auklet chick (right).

Project Volunteer Days/Hours 2009-2017

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
2017	35	30	106	842	7
Totals	282	183	760	6,072	



Volunteer Rozy Bathrick holds a Cassin's Auklet during mist netting.



UC Santa Cruz intern Danielle Devincenzi places a Rhinoceros Auklet back inside its artificial nest module.



UC Santa Cruz intern Tammy Russell stands ready in her field gear at the height of breeding season.

We thank the following individuals who volunteered their time and energy on ANI from 2010 to 2017 (see Project Volunteers table below). 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.

Aaron Haebert	Brittany Guest	David Greenberger	Haleigh Damron	Josie Moss	Linda Brodman	Nick Slobodian	Rozy Bathrik	Tyler Gagne
Abe Borker	Bryan Schatz	David Hyrenbach	Helen Christianson	JT Keeley	Lindsey Graves	Nicole Hicock	Ryan Carle	Valeria Ruopollo
Adam Fox	Catia Kroeger	Deasy Lontoh	Helen Davis	Kacie Ring	Lisa Sheffield Guy	Noreen Yee	Sacha Heath	Verónica López
Adam Garcia	Chris Tarango	Delaney Wong	Henry Smith	Kate Jaffe	Liz Martinez	Ora Gessler	Sara Mclean	Vladimir Vlad
Adam Green	Christian Cormier	Dena Spatz	Hugo Ceja	Kathy Kellerman	Lloyd Fales	Parker Forman	Sarah Lenz	Will Spangler
Alaina Valenzuela	Christine Chi	Diana Baetscher	Ilona Wilde	Katy Saunders	Louis Wertz	Parmis Taidy	Sarah Peterson	Yoel Kirschner
Alayne Meeks	Chuck Boffman	Diana Powers	Inger Johansson	Keith Hernandez	Luke Hass	Pat Kittle	Scott Shaffer	Zach Michelson
Alex Jones	Clair Nasr	Eliza Powers	Irene Espinosa	Kelly Iknayan	Madeline Pots	Pat Morris	Signe Jul Andersen	Zeka Glucs
Alex Philippides	Claire Sawyer	Ellen Little	Jackie Lindsey	Kevin Condon	Marilyn Beck	Patrick Furtalo	Sonja Murphy	Zoe Burr
Alex Rinckert	Claire Shady	Emily Golson	James Farber	Kevin Greenan	Marilyn Cruikshank	Patti Kenyon	Sophie Webb	
Alex Wang	Claire Stremple	Emma Hurley	Janet Carle	Kira katzner	Marina Maze	Peck Euwer	Sparrow Baranyai	
Allan Kass	Colleen Young	Emma Kelsey	Jeb Bishop	Kira Maritano	Maris Brenn-White	Peter Julber	Stan Hooper	
Amelia DuVall	Coral Wolf	Emma Wheeler	Jeff Powers	Kit Clark	Martha Brown	Peti Robinson	Steve Kurtagh	
Andrea van Dexter	Corey Clatterbuck	Eric Woehler	Jenny Garcia	Klea Bajala	Masha Slavnova	Petrusjka Skjerning	Susan McCarthy	
Andrew Fisher	Corey Pigott	Erica Donnelly-Greenan	Jessica Kunz	Kolle Kahle-Riggs	Matt Madden	Phil Curtiss	Tammy Russel	
Angela Scezorkia	Corrine Gibble	Erika Perloff	Jessie Beck	Kristen Hill	Matt Miller	Portia Halbert	Tara Johnson-Kelly	
Ann Garside	Crosbie Walsh	Evan Barbour	Jim Harvey	Kristen Saunders	Matthew McCown	Rachel Eastman	Teresa Aguilera	
Anne Cassell	Damien Sosa	Evan McGiffert	Jim Kellogg	Kristen Svehla	Matthew Passmore	Rae Engert	Terry Sawyer	
Arlene Davis	Dan Barnard	Franny Gardner	Jo Anne Dao	Kyle S. Van Houtan	Maya Whitner	Randy Chapin	Tiffany Bailie	
Becky Hendricks	Dana Page	Gabriella Layi	John Bela	Laird Henkel	Melinda Connors	Rebecca Cook	Tim Brown	
Benjamin Nokes	Danielle Devincenzi	Gary Strachen	John Finch	Lana Meade	Michael Hanrahan	Rhett Frantz	Tim Gledich	
Benny Drescher	Danielle Mingo	Grant Ballard	Jonathan Felis	Laura Webb	Molly Baird	Rick Condit	Tim Shaffer	
Bill Henry	Dave Carle	Greg Meyer	Josh Adams	Lena Molinari	Morgan Gilmore	Ron Brost	Trinidad Mena	
Breck Tyler	David Calleri	Guy Oliver	Josh Berliner	Lilian Carswell	Natahsa Vokshoori	Rosemarie Willimann	Troy Guy	

Appendix 2. Año Nuevo State Park Seabird Program Resources: Articles, Videos, Outreach - 2016 to 2017

Oikonos' mission includes sharing knowledge gained through our conservation projects with diverse audiences and engaging communities. Oikonos and partners created the following products in 2016 - 2017 with in-kind and matching support:

Project Website

<http://oikonos.org/ano-nuevo-island/>

Social Media

<https://www.facebook.com/Oikonos/>

Public Outreach

- Radio Story
 - [Año Nuevo Island is off-limits to humans- but not these scientists](#)— produced by Claire Stremple, KALW Radio – September 2017
- Informational Booth
 - Patagonia Santa Cruz Environmental Community Night—March 2017
- Project Presentation
 - Patagonia Santa Cruz—November 2017

Peer-reviewed Scientific Publications (Oikonos-affiliated co-authors bolded)

Ainley, D.G., Santora, J.A., Capitolo, P.J., Field, J.C., **Beck, J.N.**, **Carle, R.D.**, **Donnelly-Greenan, E.**, McChesney, G.J., Elliott, M., Bradley, R.W., Lindquist, K., Nelson, P., Roletto, J., Warzybok, P., **Hester, M.**, and J. Jahncke. 2018. [Ecosystem-based management affecting Brandt's Cormorant resources and populations in the central California Current region](#). Biological Conservation 217:407-418.

Carle, R., Calleri, D., Beck, J., Halbert, P., and Hester, M. 2017. [Depredation by Common Ravens Corvus corax negatively affects Pelagic Cormorant Phalacrocorax pelagicus reproduction in central California](#). Marine Ornithology 157: 149-157.

Scientific Presentations

California Collaborative Oceanic Fisheries Investigation Conference-- December 2017, La Jolla, CA

Ecosystem-based management affecting Brandt's Cormorant resources and populations in the central California Current region—presented by Ryan Carle (see co-authors on publication citation, above)

Beyond the Golden Gate Research Symposium—December 2016, Tiburon, CA

Presentations entitled:

Clay nest modules for seabirds: a versatile and sustainable solution to diverse threats—presented by Ryan Carle; Authors Michelle Hester, Nathan Lynch, Ryan Carle, Jessie Beck, and Matthew Passmore.

Common Raven depredation negatively affects reproductive success of Pelagic Cormorants at Año Nuevo State Park, central California—presented by Ryan Carle (see co-authors on publication citation, above)

Año Nuevo State Park Docent Outreach

Año Nuevo Bird Walk by Ryan Carle—September 2017

ANSP Docent and Volunteer Blog – Monthly updates

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

Meetings

California Seabird Coordination Meeting, annually 2010-2016

Santa Cruz Seabird Coordination Meeting, December 2016

Appendix 3. – Habitat Restoration Accomplishments 2009 - 2017

Accomplishments

Activity	2009	2010	2011 - 2017
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 ✓ Completed yearly maintenance work
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 92 Rhinoceros Auklet modules ✓ Installed 94 in the restoration area ✓ Monitored nesting success in modules ✓ Held CCA college course focused on Cassin's Auklets ✓ Prototyped Cassin's Auklet modules ✓ Created and deployed final Cassin's Auklet module designs
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 12,000 grasses and shrubs in selected areas ✓ Seeded with native species ✓ Raised boardwalks ✓ Weeded invasive plants



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 2011-2017, we expanded the restoration treatments to an additional 0.25 acres where Cassin's Auklet nesting is concentrated (not shown above).

Further Restoration Information

To learn more about the historic details about Habitat Ridge construction, nest module developments, and vegetation management, please see our 2016 Annual Report.