Farallon Ashy Storm-Petrel Population Status Evaluation
Final Programmatic Report Narrative
to the Pacific Seabird Program of the National Fish and Wildlife Foundation

1. Summary of Accomplishments

In this project, *Farallon Ashy Storm-Petrel Population Status Evaluation,* Point Blue has analyzed survival and abundance of the Farallon ashy storm-petrel population, the world's largest population for the species, and used that information to develop state-of-the-art population models to project future storm petrel population trends and how they may be impacted by potential changes in burrowing owl over-winter attendance resulting from a proposed Farallon mouse eradication project. Because migratory burrowing owls switch to preying on storm-petrels when introduced populations of house mice naturally crash over winter, the proposed mouse eradication project on the islands will have critical positive impacts on storm-petrel population dynamics.

We have quantified the strong negative relationship between the abundance of burrowing owls during the winter and early spring and over-winter survival of ashy storm-petrels. The declining trend in abundance for ashy storm-petrels seen from 2005 to 2010, during the time of increasing burrowing owl attendance, was abated in the period 2010 to 2015, reflecting a modest reduction in burrowing owl attendance. However, further reduction in owl attendance is needed to produce an increasing storm-petrel population. Our analysis shows that increased duration of stay by burrowing owls during the winter and early spring is the key determinant of risk of increased predation to ashy storm-petrels, and that predation risk in turn is strongly influenced by the availability of house mice as the owl's principal prey in late fall and early winter. Our results critically inform current conservation and management of this species of concern. More broadly, the population model we developed can provide guidance to managers in planning and implementing steps to aid in the recovery of species of concern. We also met our goals for monitoring over 50 active breeding sites and demonstrated proof of concept for monitoring breeding storm-petrels with new technology.

2. Project Activities & Outcomes

Activities

a) Test whether reduced burrowing owl abundance in 2012-2015 led to increased survival and abundance of ashy storm-petrels.

We analyzed abundance and activity of burrowing owls and its relationship to survival and trends in abundance of ashy storm-petrels. From 2000 to 2005, burrowing owl occurrence and activity at the Farallon Islands National Wildlife Refuge was low and population size of ashy storm-petrels increased. However, over the next five to six years, burrowing owl activity strongly increased, reaching a peak in 2010/2011. During this period, ashy storm-petrel survival and population size showed a strong decline.. Thus, the evidence clearly points to the increased abundance and activity of burrowing owls leading to increased predation upon ashy storm-petrels, thus decreasing survival and contributing to the observed population decline. However, recent burrowing owl numbers have been moderately lower than those observed from 2010-2011 (Figure 1). As part of this project, we added data from 2013 to 2016 for ashy storm-petrels and burrowing owls and conducted new analyses for these years (our initial analysis was only through the year 2012). We carried out state-of-the-art analyses of survival and population size to determine whether the moderate decrease in burrowing owl abundance resulted in increased survival or changes in the abundance of the Farallon ashy storm-petrel population. Our analyses focused on individuals likely to be part of the breeding population on the South Farallon Islands (rather than transients, passing through), and thus more at risk of being predated.

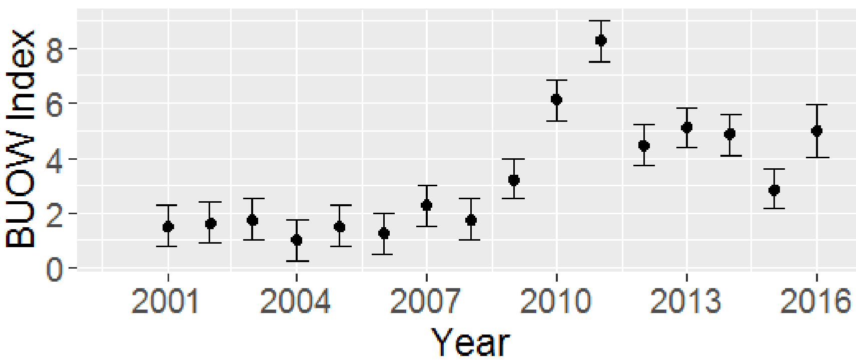

Figure 1. Burrowing owl index of overwinter attendance, 2001-2016, on Southeast Farallon Island. Monthly average of maximum observed owls per month for September of previous year to April of the listed year ± SE.

We hypothesized that, with a lower abundance of burrowing owls, the previously observed decline in population size would be reduced or eliminated, and might even lead to population increase. Such a change in survival and population trend was predicted by our initial modeling exercise[1]. Reduced abundance of burrowing owls in recent years provided the opportunity to assess this hypothesis.

Our results showed that the ashy storm-petrel population trend in recent years has indeed changed, associated with the reduction in burrowing owl attendance (Figure 2). The full time series demonstrates three distinct trends. In the first series of years (2000 to 2005), when burrowing owl abundance on the island was low, the petrel population strongly increased (at 37% per year, $P < 0.01$), confirming results from our earlier analysis. However, from 2005 to 2010 petrel population decreased by 11.4% per year ($P < 0.01$), with this decrease coinciding with the period of increase in burrowing owl overwinter attendance (Figure 1).

The trend in storm-petrel population size changed during the period 2010 to 2015; it still declined at an estimated 5.6% per year, but the magnitude was less than in the previous five year period, and was not significantly different from no change ($P > 0.3$). In fact, storm-petrel population size was unchanged from 2014 to 2015, and was similar to the population size estimated for 2010 (Figure 2). Analysis of storm-petrel survival confirmed our earlier finding that storm-petrel survival declined strongly as burrowing owl abundance increased during the period of 2005 to 2010. However, survival remained low for 2013-2015, years in which burrowing owl abundance was moderately high, though not as high as in 2010 and 2011. 2013 had the third highest burrowing owl abundance index. Thus, even with only moderately high owl abundance, survival remained low compared to what it had been during the period 2001-2005 (Figure 3). Our analysis confirmed a strong statistical relationship between burrowing owl abundance and annual survival of ashy storm-petrels ($P < 0.01$). A decrease of 1 unit in the owl abundance index (equivalent to

[1] Nur, N., Bradley, R., Salas, L., & Jahncke, J. 2013. Modeling the impacts of house mouse eradication on Ashy Storm-Petrels on Southeast Farallon Island. Unpublished report to the U.S. Fish and Wildlife Service. PRBO Conservation Science, Petaluma, California. PRBO Contribution Number 1880.

one owl being present for 8 months over the period September-April) is associated with an increase in storm-petrel survival of 0.8% to 1.4%. This result was used in the demographic modeling (see below). Moreover, annual variation in owl abundance index was highly determined by the average length of time individual owls were spending on the islands, from arrival in the fall until their departure in winter or early spring ($P < 0.01$). The longer, on average, owls remained on the island, the greater the owl abundance index, and the greater was storm-petrel mortality that year.

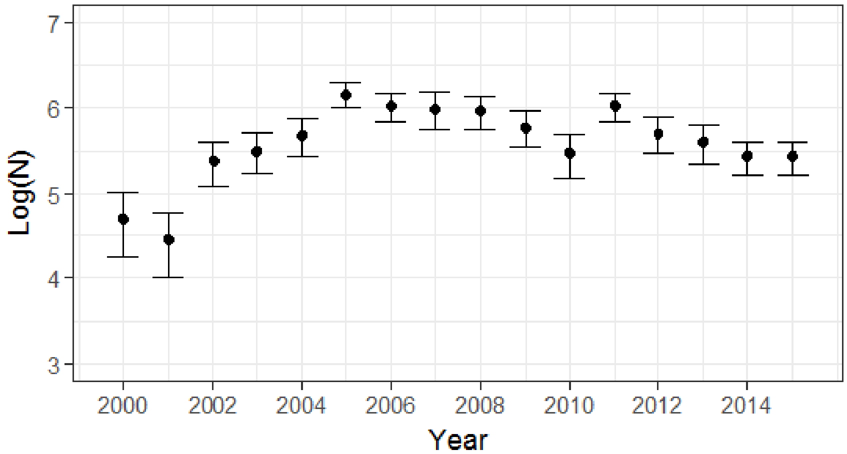

Figure 2. Change in estimated population size index of Farallon ashy storm-petrels over time, based on captures of individually-banded ashy storm-petrels, 1999 to 2016. The index reflects estimated population size, on a log-scale. Shown is each year's estimate ± 1 Standard Error of the estimate. 2016 was the last year of capture in the dataset, and so population size could not be estimated for that year.

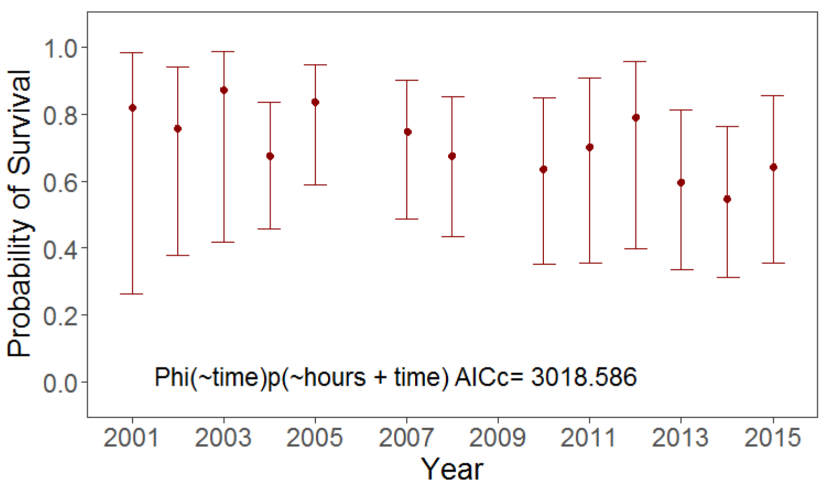

Figure 3. Variation among years for annual survival probability of ashy storm-petrels on Southeast Farallon Island to the year shown in the Figure; thus "2001" refers to survival from 2000 to 2001. Shown are year-specific model estimates and the 95% Confidence Interval around those estimates. 2016 was the last year of capture in the dataset and thus survival could not be estimated for that year. Recapture data were inadequate to estimate year-specific survival estimates for 2005/2006 and 2008/2009.

To summarize, the three part-trend in storm-petrel population size mirrored the three part-trend in burrowing owl abundance and the storm-petrel population:

- Increased during 2000-2005 when burrowing owl numbers were low,
- Declined from 2005-2010 during the time that burrowing owl numbers were increasing, and

- Showed reduced decline from 2010-2015 when burrowing owl numbers were slightly reduced or stabilizing.

b) Assess the current status of the Farallon population of ashy storm-petrels through updated demographic modelling.

We used the information on population trend, baseline survival values, and the relationship between burrowing owl abundance and storm-petrel survival to model future population trajectories for the ashy storm-petrel under different scenarios of burrowing owl reduction. The future population trend for ashy storm-petrels, in the absence of any management directed at reducing burrowing owls on the South Farallon Islands, is not known. Hence we considered three "baseline" trend scenarios (i.e., projected trends in the absence of a change in owl numbers): moderately strong decline, moderate decline, and population stability. For each baseline trend, we considered the impact of a change in owl numbers (either 50% or 80% reduction in the average number, with reference to 2009 to 2012 owl abundance) on survival of subadult and adult storm-petrels and thus on population trend. Our demographic modeling included environmental stochasticity of demographic parameters, thus providing more realistic scenarios to evaluate. It allowed us to quantify uncertainty of population outcomes, which is important information for wildlife managers. Thus, we can project a range of likely outcomes, as well as estimate the probability that the population will decline over the next 5 to 20 years.

We found that reduction in owl abundance is projected to have strong positive population impacts under all scenarios examined and can reduce or reverse the decline expected with no owl reduction. More specifically, under a moderately strong declining trend based on island data from 2006 to 2012, 80% owl reduction can eliminate the decline (i.e., the trend changes from an average of 63% decline after 20 years, to an average increase of 2% after 20 years), while 50% owl reduction can change a moderate decline (an expected 40% decline after 20 years) to an average increase of 6% after 20 years.

Of equal significance is the variability in outcome. To provide an example, if we assume a moderately strong decline as the baseline trend (i.e., with no change in owl abundance), then there is a 99% probability that the population will have declined to some degree after 20 years. However, with 50 and 80% owl reduction, the probability of decline is reduced to 76% and 48%, respectively.

c) Improve our capacity to detect storm-petrel breeding sites for long-term monitoring.

We further increased our capacity to collect high quality reproductive success data for ashy storm-petrels breeding on the Farallon Islands in 2017 by utilizing crevice camera systems. To improve our ashy storm-petrel monitoring efforts during the 2017 breeding season, we used radio-frequency identification (RFID) readers and passive integrated transponder (PIT) tags on leg bands to detect nest sites and to track nest attendance patterns of breeding birds. We constructed RFID readers, each with two circular antennae (10 cm diameter) for detecting PIT tags. We began PIT tagging adult ashy storm-petrels during our routine mist netting sessions. In total, we deployed 361 PIT tags on the same number of birds. We surveyed both artificial rock walls and natural scree, using crevice cameras to investigate sites where birds were detected.

In total, we recorded 121 detections from 37 unique PIT-tagged individuals. All detections occurred in the artificial rock wall habitat. From all detections, 19 individuals were detected only once and 18 individuals were detected on multiple occasions. Multiple detections of the same individual either occurred when an individual remained in close proximity to the RFID reader antenna or when an individual used the same entrance on multiple occasions. Using the location of RFID readers with detections to focus our search, we ultimately located five additional active nests sites, which is about 9% the total number of active nests.

Unfortunately, a manufacturing error resulted in an estimated 60% of our tags failing within one month of being deployed. The manufacturer has diagnosed the tag failure as the result of improper sealant curing in the tag, resulting in damage to the tag circuitry. This issue was discovered after recapturing a number of individuals with PIT tags that could not be detected by our RFID readers. After realizing this high failure rate, we ceased tagging efforts. As a result of the large number of tag failures, the total number of individuals that could possibly be detected over the whole breeding season was relatively low (about 145 individuals). As such, given that a total of 37 individuals were detected, the detection rate of individuals with functioning tags was relatively high. It should be noted that this comparison does not account for the timing of tag deployment relative to when it was detected, which is relevant given that tags did generally operate adequately for several weeks.

Outcomes

a) Strengthen scientific support for management actions to benefit ashy storm-petrels. Through validation of our previous modelling efforts, this project could show strong scientific support for the quantified population level impacts to ashy storm-petrels by reducing burrowing owl numbers through mouse eradication.

The recent storm-petrel population trend demonstrates that the previous decline in population size, when burrowing owl abundance was increasing, is now much reduced and suggests that the storm-petrel population may be stabilizing. Our analysis provides support for the hypothesized population-level positive impacts for ashy storm-petrels of reducing burrowing owl numbers in the winter and early spring, an expected outcome of eliminating house mice, the principal prey of burrowing owls on the South Farallon Islands in the fall and early winter. At the same time, our analysis indicates that a substantial change in storm-petrel population trend may require a significant decrease in burrowing owl over-winter attendance, which is the objective of the proposed mouse eradication. Variation in the owl abundance index was shown to be directly related to the length of time owls are spending on the South Farallon Islands in the fall and winter. The proposed mouse eradication project can, therefore, be expected to result in a dramatic decrease in the “stop-over” time of owls, and thus a reduction in predation on storm petrels, since the scientific evidence indicates that owls will not be able to persist on the South Farallon Islands from October until January in the absence of house mice.

b) Provide the scientific basis, in terms of estimated colony population status, for listing or not listing the ashy storm-petrel under the Endangered Species Act. Evaluation of current demographic trends for the Farallon storm-petrel population will determine if recent declines have continued. These analyses could provide further solid science basis to conservation action.

We have achieved improved estimation of storm-petrel population trend, adult survival, and the relationship of survival to variation in burrowing owl abundance. We have determined that recent declining trends have been reduced and were statistically no different from stable as of 2015. Our population model incorporates variation in demographic parameters and thus can project future population trends, and the variability around those trends, in relation to management scenarios. Specifically, we have quantified the probability of further decline if no management actions are taken to reduce burrowing owl numbers, critical information in considering a change in listing.

c) Increase quality of long-term monitoring data. Utilize high quality reproductive success data to obtain a better understanding of how ashy storm-petrel populations can be expected to behave in the future, when coupled with the better information on survival and trends in b) and also in a), above. Increased use of high quality cameras and pilot studies using PIT tags will allow us to monitor a minimum of 50 active storm-petrel breeding sites annually for many years to come.

We monitored 53 active storm petrel breeding sites in 2017, thanks to additional sites found through new technology. Overall, we feel that the 2017 field season has provided a proof of concept for the use of RFID readers to identify new ashy storm-petrel nest sites and to monitor nest activity, despite technical issues.

3. Lessons Learned

Key lessons learned from this project include: the value of continuous long term data, the ability of established trends to change through time, and the challenges of implementing new technology for research.

To assess population trends on storm-petrels and impacts of owls through time, multiple long-term datasets collected every year were required. These datasets can be expensive to obtain and difficult to maintain but are crucial in analyses of this kind. Metrics like adult survival, which requires extensive effort in capture-mark-recapture studies, were critical for this analysis and should be targets for population assessments of species of conservation concern.

Our work showed that established patterns, such as population level effects of owl predation on storm-petrels, can change through time and need to be periodically examined to determine current relationships and the variability in them. This continuous assessment, rather than relying only on past patterns, is crucial to effectively inform conservation planning.

Finally, we learned that implementing new technology in monitoring methods can often bring challenges. New methodologies may not be as effective as planned initially and may require extensive trouble shooting. Projects implementing new technology should have realistic expectations and be prepared for their first year of operations to be primarily a proof of concept as methods are refined and unexpected technical issues are identified and addressed.

4. Dissemination

Results of this work have been conveyed to the US Fish and Wildlife Service, the management agency for Ashy Storm- petrels. This work will be published in a future paper for an appropriate peer reviewed science journal

5. Project Documents

See attached uploads