

**FACTORS INFLUENCING DEPREDATION OF SCRIPPS'S MURRELETS BY BARN OWLS  
ON SANTA BARBARA ISLAND:  
SUMMARY RESULTS FROM THE 2012 FIELD SEASON**



**October 19, 2014**  
**Final report**

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**Suggested citation:** Thomsen, S.K. and S. Plumb. 2014. Factors influencing depredation of Scripps's Murrelets by Barn Owls on Santa Barbara Island: Summary Results from the 2012 field season. Unpublished report prepared for: Montrose Settlements Restoration Program. 15 pp.

## ABSTRACT

Scripps's Murrelets (*Synthliboramphus scrippsi*) breeding on Santa Barbara Island, California, are preyed upon by Barn Owls (*Tyto alba*) in substantial numbers in some years. Island deer mice (*Peromyscus maniculatus elusus*) are also important prey for owls, and themselves consume 8-70% of murrelet eggs in a year. Therefore, it is important to understand both the direct and indirect interactions between mice, murrelets and owls, in order to ultimately assist murrelet conservation. Data collection methods begun in 2010-2011 were continued in 2012. Mouse abundance had declined in 2012 after the peak in abundance observed in 2011. Even though mice were far less abundant, the owl population remained at nearly the same high density throughout 2012 as it was in August 2011 (22-32 individuals). Owl predation of murrelets increased by over 1500% compared to the previous year, to at least 172 individual murrelets found killed by owls in 2012. Once again, owls were more often detected adjacent to murrelet habitat, where mouse activity also tended to be highest. In addition, within coastal murrelet habitats, the combination of high owl density and low mouse activity was associated with the island's predation hotspot in Landing Cove, which suggests that the ratio of owls to mice may be important in explaining predation intensity. Finally, we began a new study to investigate the possibility of positive indirect effects of owls on murrelets through changing the behavior of murrelet egg predators. We found that mouse foraging patterns in experimental foraging stations were consistent with our predictions of perceived predation risk with varying cover, moonphase and owl abundance. This indicates the potential for indirect effects of owls on mice may have positive consequences for murrelets, and we recommend further research into this area. We conclude that these data will be useful for evidence-based conservation decisions to benefit Scripps's Murrelets on Santa Barbara Island.

## INTRODUCTION

Scripps's Murrelets (*Synthliboramphus scrippsi*; SCMU) are small (~167g) seabirds that breed on approximately 10 island groups off the coast of southern California and Mexico (Whitworth pers. comm., Drost and Lewis 1995) and are listed as a Threatened species in California. The Channel Islands National Park (CINP) conducts annual monitoring of murrelet reproductive success on Santa Barbara Island, the location of their largest U.S. breeding colony. On this island, numbers of nesting SCMU have apparently declined in some monitoring plots (Burkett et al. 2003, Harvey and Barnes 2009). Although several potential threats occurring at sea could potentially be influencing murrelet population dynamics, these threats were not believed to be as important as those occurring on the islands where they breed (Carter et al 2000).

For example, on Santa Barbara Island, it has been suggested that this decline may be primarily due to native island predators such as Barn Owls (*Tyto alba*) and deer mice (*Peromyscus maniculatus elusus*). This is because in some years, the observed level of predation is very high, with up to 70% of murrelet eggs laid consumed by mice (Drost and Lewis 1995) and up to 30% of annual adult mortality due to owls (Nur et al 2013, data from this study). However, in other years, predation is very low, with few eggs eaten by mice (8%; Drost and Lewis 1995), and few murrelets found killed by owls (Thomsen et al 2013). Therefore, given such extreme variability in predation levels on murrelets by both owls and mice, it is crucial to understand the ecological drivers behind that annual variation in order to properly evaluate the potential effectiveness of conservation actions for murrelets, including predator management.

Management of either the deer mouse population (Millus et al 2007) or the owl population (Nur et al 2013) has recently been under consideration as a potential action to reverse the population decline of murrelets nesting on Santa Barbara Island. Reducing predator abundance, particularly non-native predators, has been a successful conservation strategy for some endangered species (Smith et al 2010). However, these deer mice are native, are the only rodents on the island, and undergo extreme inter-annual variations in abundance where they can reach extremely high densities (over 900/ha, NPS unpubl. data) followed by sharp declines (Drost and Fellers 1991). Efforts to reduce the abundance of mice in one murrelet nest monitoring plot during one breeding season was labor-intensive and only marginally improved hatching success, so it was suggested that owl management might be more effective (Millus et al 2007).

Barn Owls are naturally occurring on all of the Channel Islands, and their abundance appears to track the density of the mouse population on Santa Barbara Island (Drost and Fellers 1991; this study). Barn Owl diet consists predominately of deer mice on Santa Barbara Island, even in years of heavy predation on murrelets (Drost and Fellers 1991, this study). Therefore, management actions that might be considered to benefit murrelets, such as reducing owl density, could have unintended negative consequences, such as increasing egg predation by mice. Conversely, management of mice could indirectly lead to increases in owl predation on adult murrelets. Therefore, as part of a comprehensive study of the predator-prey interactions between murrelets, mice and owls, we briefly report on the results from the third field season.

## **METHODS**

Most methods have been described in detail in previous reports (Thomsen and Harvey 2010, Thomsen et. al 2013), but are briefly summarized here. Methods included: 1) describing habitat use and abundance of Barn Owls using line transects (in April and

August 2012) and trail surveys (in January and July 2012); 2) examining Barn Owl diet using pellets and prey remains collected in February and August 2012 as well as those found throughout the murrelet breeding season in plots and along trails; and 3) describing rodent prey availability for Barn Owls using mouse track tubes (in February, April, May, July and August 2012).

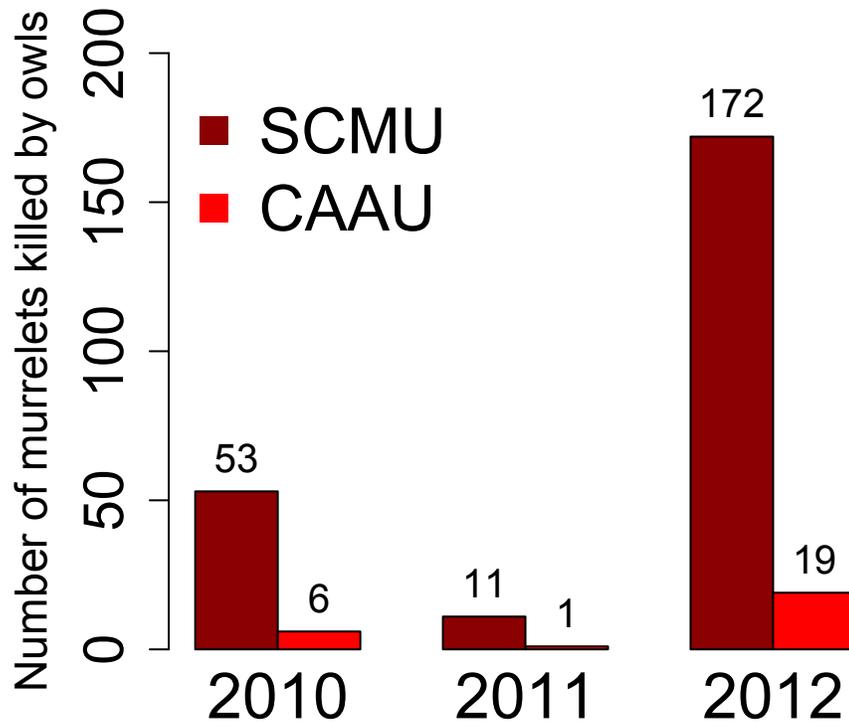
In addition, we began a new project to investigate whether mouse foraging behavior is influenced by owl habitat use and the perception of predation risk from owls. Predators influence prey both directly through killing and consumption, and also indirectly, by influencing the behavior of prey as they seek to avoid situations with a high risk of predation. The magnitude of these changes in prey behavior can equal or even exceed the consumptive effects on prey demographics (Preisser et al. 2005). Mice therefore have to make decisions about how to balance the tradeoffs in predation risk versus the benefits of foraging, and these decisions may in turn influence the encounter rates with and predation of murrelet eggs. Here, we used a well established method that measures the perceived predation risk of small rodents, where the amount of food remaining in a experimental tray after a night of foraging (called the “giving up density”) represents how mice balance the benefits of foraging a patch against the risk of doing so (Brown 1988). Based on other studies, we predicted that the owl activity on nearby transects as well as microhabitat (open vs. under cover) and moonphase (full vs. new) would influence the giving up densities. To test this, we set out 36 foraging stations that contained 1L of sand mixed with 7.5ml of roasted hulled sunflower seed. The amount of seed remaining in each station was sifted out the following day and counted. Here, we briefly describe the results from 2012. However, the complete analyses from two years of these data will be presented in a forthcoming manuscript (Thomsen et al. in prep).

## RESULTS AND DISCUSSION

Mouse abundance had declined abruptly by March 2012 from the peak of abundance seen in March 2011, which is consistent with the previously observed patterns in the population cycles of this species on the island (Drost and Fellers 1991; NPS unpubl. data). The trail survey in January 2012 had 26-32 owl detections and then remained similarly high in July with 22-28 owl detections. These counts are only slightly lower than the high count of 21-32 owl detections in August 2011. Owl detections on the line transects in April 2012 were similar to August 2011, with 45% of transect surveys having at least 1 observation of an owl. This indicates that the owl population remained high throughout 2012, despite the declining mouse population.

Within that context, we assessed the diet of Barn Owls through the collection of both pellets and avian prey remains (Scripps's Murrelets, Cassin's Auklets (*Ptychoramphus aleuticus*, CAAU)) collected from trails, murrelet monitoring plots, habitat restoration plots and owl roost sites (Thomsen et al. 2013). There were 172 murrelet carcasses collected in 2012, representing the minimum number of individuals (MNI) killed by owls. We report the MNI because of the variation in the type of prey remains found could otherwise result in double-counting (e.g., decapitated heads may have been part of "wingsets") and make inter-annual comparisons unreliable. The search effort covered the same areas of the island in each year (Thomsen and Harvey 2012, Thomsen et al 2013). This is an increase of an order of magnitude (>1500%) from 2011, when only 11 murrelets were found killed (Figure 2; Thomsen, unpubl. data). Owl pellet analysis is ongoing, but the percent frequency of occurrence for murrelets, mice and lizards was 21.9%, 84.4%, and 26.6%, respectively (n=237 pellets from which 868 prey items were identified to species). This is an increase from a low of <1% of pellets

containing murrelet remains in 2011 (total n=210 pellets), and suggests a substantial increase in the importance of murrelets in owl diet in 2012.



**Figure 1.** Seabird predation by Barn Owls, 2010-2012, on Santa Barbara Island. Counts are the Minimum Number of Individuals (MNI) represented in the prey remains collected.

We have previously found that owls appear to be generalist predators that consume prey in accordance with the alternative prey hypothesis (APH). Briefly, this hypothesis states that predators will consume the more abundant prey until that primary prey population declines and the predator switches to alternative prey (Lack 1954, McKinnon et al 2014). In 2011, there was a high density of owls, but very few murrelets were killed and instead the owls consumed the extremely abundant mice (Thomsen et al

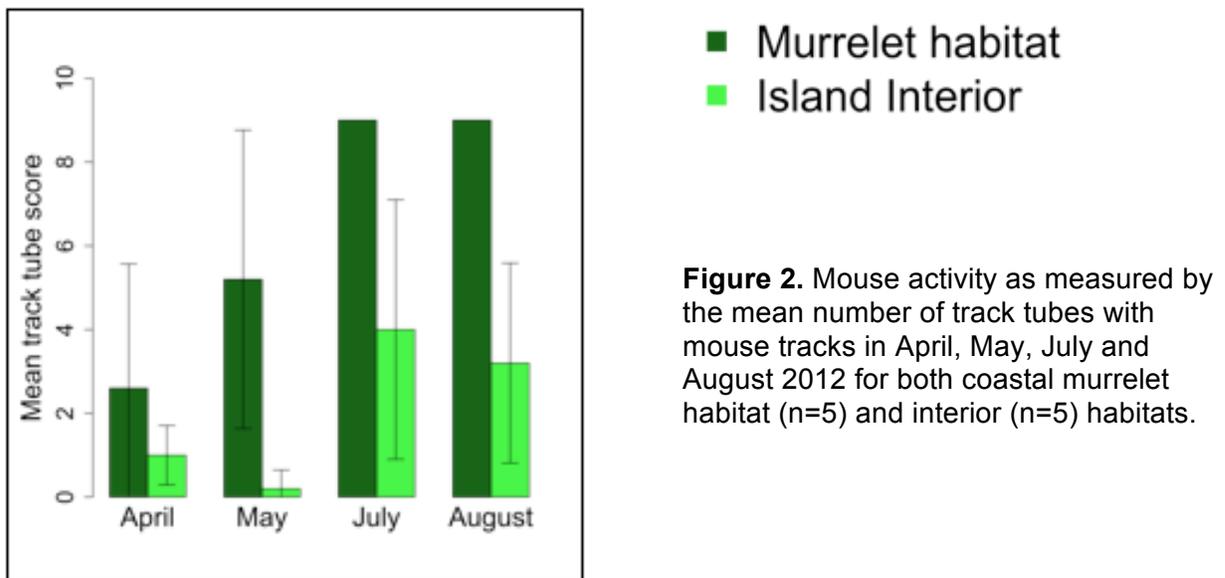
2013). Our results for 2012 are also consistent with the APH, as the owls switched their diet to include substantially more murrelets and lizards after the mouse population had fallen (Figure 2).

Our results further suggest that the interactions amongst murrelets, mice and owls could be viewed as a form of short term apparent competition (Holt and Kotler 1987). For example, in one predator two prey systems similar to this one, an increase in the density of the preferred prey species (i.e. mice) can enhance predator density. If the preferred prey species subsequently declines, the predator can then suppress the population of the alternative prey, a relationship known as apparent competition (Holt 1977). If the decline of the preferred prey is severe enough and does not recover, predation on the alternative prey could even lead to its extinction and is sometimes called hyperpredation (Courchamp et al 2000, Kristan and Boarman, 2003). Although this dynamic has been increasingly recognized for its potential role in contributing to species declines (e.g. DeCesare et al 2009), the Santa Barbara Island system is more complex because of the additional direct impact that mice have on murrelet reproductive success as well as the dynamic nature of the mouse-owl population cycles. As this project extends into the final year in 2013, both of these unique aspects will be addressed in forthcoming manuscripts.

It is important to understand the spatial context of murrelet, mouse and owl interactions. For instance, in 2011, murrelets were not an important part of owl diet, even though owls were more often detected on transects adjacent to murrelet habitat (Thomsen et al 2013). During the 2012 murrelet breeding season, owls were once again more frequently detected along line transects located adjacent to coastal murrelet habitat (4.84 owls/km) rather than in the island interior (4.14 owls/km). However, the difference is slight because there were high numbers seen (up to 10 individuals on one survey) on one interior transect in the northeast section of the island. This transect is

located close to several owl roost sites in Cave Canyon, which may have influenced the numbers observed (Thomsen et al, *in press*). When this one survey was removed, there were only 2.85 owls/km on the interior transects.

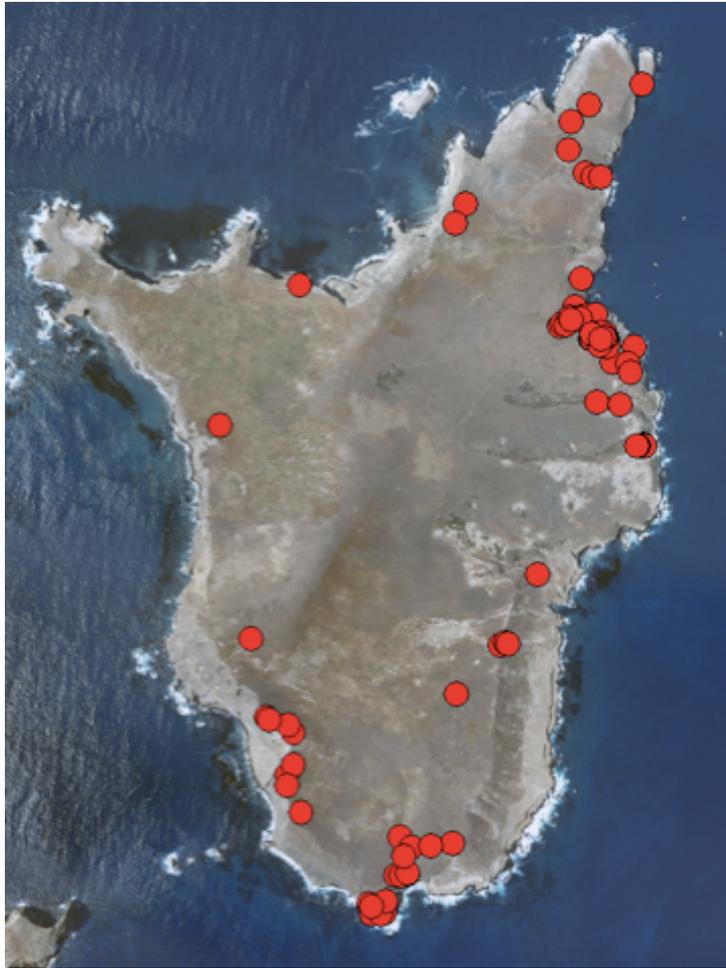
In addition, there was also higher mouse activity within the murrelet plots than the interior habitats for all months (Figure 2). Each track tube grid (n=10) had 9 track tubes, and each track tube was checked for the presence/absence of mouse tracks. For each habitat type, we calculated the mean number of track tubes with mouse tracks. This indicates there was a spatial overlap of mice, owls, and murrelets along the island's coastal habitat that generally persisted during the murrelet breeding seasons in both 2011 and 2012.



**Figure 2.** Mouse activity as measured by the mean number of track tubes with mouse tracks in April, May, July and August 2012 for both coastal murrelet habitat (n=5) and interior (n=5) habitats.

The island-wide murrelet predation hotspot, as measured by mapping the locations of owl killed murrelet carcasses, was in and around Landing Cove, as it was in 2010 (Figure 3; Thomsen and Harvey 2012). Although this is near island housing, it is unlikely that this pattern is solely due to increased human presence there, since other restoration and murrelet plots are visited as frequently each week or more so (see

Harvey et al 2013, 2014). Instead, this is perhaps due to the high density of owl roost sites in the northeast section of the island. For example, up to 14 owls roosted in nearby Cave Canyon in 2011 and 2012 (Thomsen, unpubl. data). Individually marked Barn Owls on the island tended to be re-sighted near their roost sites and were rarely observed further than 1km away (Thomsen et al. *in press*); therefore, the northeast part of the island would be expected to have higher owl densities. In addition, the track tube grid in Landing Cove had zero detections of mice with the track tubes until the May survey. The high density of owls, in combination with the drastic decline in mice in Landing Cove, could explain why this area is particularly dangerous for murrelets. Conversely, on the northwest side of the island, there were relatively few murrelets found killed. Track tube grids in this area (Elephant Seal Cove and West Cliffs) had relatively high mouse activity and few owls, suggesting that the ratio of owls to mice may be important in explaining spatial patterns of predation risk.



**Figure 3.** Locations of murrelet carcasses on Santa Barbara Island in 2012.

Despite the clearly negative impacts of owls on murrelets, this spatial overlap also indicates the potential for positive indirect effects of owls through consuming murrelet egg predators precisely where murrelets would benefit. Owl diet was still primarily composed of mice in 2012, accounting for 79.7% of all prey items identified. Assuming an average of 3 mice per pellet (mean=2.92 of 237 pellets), and an owl population of at least 25 that produced between 1 and 2 pellets per night, owls would have consumed an estimated total of 27,375 to 54,750 mice over the entire year.

Although this is a crude calculation, it demonstrates the potential impact that owls may have had on the mouse population.

In addition, mean giving up densities were consistent with our a priori predictions of perceived predation risk by mice, based on very similar patterns that have been observed in other studies (Clarke 1983, Kotler et al. 1991, Longland and Price 1991, Orrock and Fletcher 2014). Mean giving up densities were higher in the open than under cover and higher during the full moon than the new moon. Giving up densities also tended to be higher with greater numbers of owls counted on nearby transects. This suggests that patterns in egg predation could also be related to how mice respond to predation risk from owls. Even relatively modest decreases in egg predation could substantially influence murrelet population dynamics (Sydeman et al. 1998, Nur et al. 2013). However, evidence for this pattern as well as more extensive statistical analyses that accounts for both repeated measures and includes mixed effects will be included in the forthcoming manuscript that combines data collected in 2013.

## **CONCLUSIONS AND RECOMMENDATIONS**

It is important to understand both the direct and indirect interactions between mice, murrelets and owls, in order to ultimately assist murrelet conservation. Data collection methods begun in 2010-2011 were continued in 2012 during a decline phase in the mouse population cycle while the owl population remained at nearly the same high as in 2011 (22-32 individuals). Owl predation of murrelets increased by over 1500% from the previous year, to at least 172 individual murrelets found killed by owls. However, we also found that mouse foraging patterns in experimental foraging stations were consistent with predictions of perceived predation risk with varying cover, moonphase and owl abundance. This indicates the potential for indirect effects of owls on mice that may have positive consequences for murrelets. A recently developed model that is

applicable to owl-mouse-murrelet interactions clearly demonstrates the importance of the top predator in reducing the impact from the mesopredator (i.e. mice) on the prey (Nishijima et al, 2014). We therefore recommend continued field research in the future on whether the potential for these positive impacts outweigh the clearly negative impacts of heavy owl predation on murrelet adults in some years.

To do so, priority should go towards addressing knowledge gaps on murrelet biology to better parameterize models of extinction risk, including 1) estimating annual survival with mark-recapture studies, 2) following the breeding status and success of marked individuals across years, and 3) determining the causes of apparent second clutches in some nest sites (Whitworth, pers. comm). Continuation of baseline data collection as part of a long-term dataset (including mouse and owl abundance, and assessment of murrelet predation from both owls and mice) throughout several mouse-owl population cycles is critical to more fully understand these complex predator-prey interactions. However, we conclude that these data from our short-term study will still be useful for evidence-based conservation decisions to benefit Scripps's Murrelets on Santa Barbara Island.

## **ACKNOWLEDGEMENTS**

We are very grateful for the Montrose Settlements Restoration Program for providing the funding for this research, and particularly the support of Jen Boyce and Annie Little. Much gratitude goes to Helen Fitting and Pete Bloom for providing training, equipment and/or support. This work also could not have been completed without the help of the 2012 SBI field crew: Renee and Kris Robison, Andrew Yamagiwa, Marie-Eve Jacques, Sasha Auer, and Kevin Barnes. Thanks also to Katy Carter and Dave Mazurkiewicz for logistical assistance, Rocky Rudolph with GIS assistance, and the NPS boat crew and pilots with Aspen Helicopters for safe transportation out to the island and back. Cover photo by Wes Fritz. This work was greatly enhanced by discussions and comments on study design from Dr. David Green, Dr. Patricia Baird, and Dr. Ron Ydenberg at Simon Fraser University. This project was conducted under BBL Permit # 22539, NPS research permit #CHIS-2010-SCI-0007 and CINP project review # 10-13, SFU Animal Care Protocol #993B-10 and a Memorandum of Understanding from CDFW.

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