FACTORS INFLUENCING DEPREDATION OF SCRIPPS'S MURRELETS BY BARN OWLS ON SANTA BARBARA ISLAND: SUMMARY RESULTS FROM THE 2011 FIELD SEASON

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Final Report

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Abstract

Scripps's Murrelets (*Synthliboramphus scrippsi*; SCMU) are small (~167g) pursuit diving alcids that have a worldwide breeding distribution of possibly just 10 island groups off the coast of Southern California and Mexico (Whitworth pers. comm., Drost and Lewis 1995, Burkett et al. 2003). Long-term nest monitoring on Santa Barbara Island, their largest breeding colony in California, has revealed a decline in the numbers of nests in some plots. Contributing factors may include adult mortality due to depredation by Barn Owls (*Tyto alba*) as well as egg depredation by the native population of deer mice (*Peromyscus maniculatus elusus)*, the only small mammal on the island (Drost and Fellers 1991). In 2011, there was a dramatic increase in both owl and mouse abundance compared to recent years. As many as 21-32 owl detections were observed during a trail survey in August 2011. Track tube indices showed greater mouse activity in murrelet nesting areas than habitats further away from the shoreline, and Barn Owls were also more frequently detected on line transects through murrelet habitat, especially during the murrelet breeding season. Despite the clear spatial overlap, relatively few murrelets were killed by owls in 2011 compared to 2010, even though the density of owls was greater. Therefore, continuation of baseline data collection throughout a mouse population cycle is critical to the development of effective adaptive management efforts that create and improve safe breeding habitat in an otherwise dynamic predation risk landscape for murrelets.

INTRODUCTION

Scripps's Murrelets (*Synthliboramphus scrippsi*; SCMU), formerly considered conspecific with the Guadalupe Murrelet (*Synthliboramphus hypoleucus;* Birt et al 2012), are small (~167g) pursuit diving alcids that have a worldwide breeding distribution of now possibly just 10 island groups off the coast of Southern California and Mexico (Whitworth pers. comm., Drost and Lewis 1995, Burkett et al. 2003). The largest breeding colony of this State listed Threatened seabird (estimated 321-638 pairs in 2009-2010; Whitworth et al. 2011) in the U.S. is still on Santa Barbara Island (SBI), the smallest of five islands comprising the Channel Islands National Park (CINP). The National Park Service (NPS) began annual monitoring of murrelet reproductive success in 1985 on SBI and since that time numbers of this rare bird have declined in some monitoring plots (Burkett et al. 2003, Harvey and Barnes 2009).

Contributing factors in the observed decline in long-term monitoring plots may include adult mortality due to depredation by Barn Owls (*Tyto alba*) as well as egg depredation by the native population of deer mice (*Peromyscus maniculatus elusus)*, the only small mammal on the island (Drost and Fellers 1991). These deer mice have a 2-4 year population cycle during which they can reach extremely high densities (over 900/ha, NPS unpubl. data) followed by sharp declines (Drost and Fellers 1991) and consumed an average of 42% of murrelet eggs laid over a ten year period, ranging from 8% to 79% (Drost and Lewis 1995). Barn Owl abundance appears to track the mouse population (Drost and Fellers 1991; this study), and predation of murrelets by owls also varies considerably from year to year. Over a six year period in the

1980s, between 16 and 130 murrelets were found preyed upon by owls each year (Drost 1989). However, the factors that mediate the impact of mice and owls on murrelets, including the direct and indirect interactions between mice and owls, are not currently well understood. For example, although the highest numbers of murrelets were found killed in years with low mouse abundance (Drost 1989), it is not clear whether there is a threshold below which the mouse population drops that precipitates changes in owl diet. Furthermore, since owls are predators of mice, this presents a unique challenge for murrelet conservation. It has been suggested that Barn Owls could respond to management efforts directed at reducing mouse density by increasing predation on murrelets (Burkett et al. 2003, Millus 2006). Conversely, management of owls could indirectly lead to increases in egg predation by mice.

It is important to understand the spatial context of murrelet, mouse and owl interactions. For instance, shifts in both habitat use and diet by owls could reflect targeting of seabirds when they become available as prey. Alternatively, if seabirds do not comprise a major contribution to owl diet, this may also reflect a lack of spatial overlap if owls are not often in habitats with seabirds when they are available as prey. In addition, it is imperative to describe the characteristics of safe breeding habitat for murrelets in such a dynamic predation risk landscape, as this has important implications for habitat restoration on Santa Barbara Island as well as other islands. Therefore, in 2011, we started the first year of at least a three year study in order to investigate how owl predation on murrelets varies with the availability of alternative prey and with habitat use of Barn Owls during a mouse population cycle.

METHODS

Primary research goals for 2011 included 1) quantify changes in owl diet with changing prey densities and 2) quantify owl space use in relation to mice and murrelets. We therefore identified the following field data collection objectives: 1) describe abundance and habitat use of Barn Owls (with trail surveys, banding, telemetry, and line transects); 2) describe rodent prey availability in various habitats for Barn Owls (with track tubes and live-trapping in collaboration with NPS); and 3) determine the contribution seabirds make to barn owl diet by collecting pellets and prey remains. In addition, we monitored Scripps's Murrelet nesting success and mortality rates which was conducted concurrently in collaboration with CIES / NPS.

BARN OWL ABUNDANCE AND SPACE USE

Trail surveys

We repeated the trail survey methods developed by Drost (1989) to monitor the relative abundance of Barn Owls on the island for the second consecutive year. Surveys were conducted on the evenings of January 18, March 18, and August 13, 2011. The survey route in March did not include all of the trails because of nesting Brown Pelicans (*Pelecanus occidentalis*), but the January and August surveys were comparable to those done in 2010. All surveys had similar conditions of winds <15 knots, no precipitation or fog, and took place within 3 nights of the full moon. We began the surveys approximately one hour after sunset, when two observers walked the island trials and recorded the times and locations of any observations (including either auditory or visual detections) of Barn Owls. All observations were marked with a GPS and the identities of the owls, if known through observation of color bands, were recorded. If more than one owl was seen or heard at the same time, we recorded the minimum estimated number of owls detected at that location. Otherwise the total of all detections from observers, excluding those definitely known to be from the same bird, were added together to obtain a maximum count.

Barn Owl capture, marking, and sampling procedures

When weather conditions permitted, we attempted to capture adult Barn Owls on the island using verbail traps, mist-nets, and bal chatri traps (Stewart 1945; Bloom et al 2007). We attempted trapping on 13 nights (Jan 17th,19th, 21st, 22nd, and 24th, Feb 8th, 13th, and 27th, March 12th and 22nd, May 4-5th, and September 18th), using verbails on all nights except for two when mist-nets or bal chatri traps were attempted and failed. All trapping efforts took place on nights with winds <10 knots and with no fog, precipitation, or excessive dew. We set 2-7 verbail traps after dusk and continued trapping efforts until dawn unless weather conditions deteriorated during the night. Traps were continuously monitored either visually with night vision goggles (Morovison PVS-7 Gen 3 Monocular) or with trap transmitters and a receiver (Communication Specialists, Inc., Orange, CA), so that we could respond immediately to retrieve captured owls for processing.

Captured owls were immediately placed inside bird bags and weighed with a 600g Pesola scale to the nearest gram. They were then banded with an aluminum USGS lock-on band, as well as color-marked with unique combinations of colored Darvic leg bands. Colored reflective tape was also applied to the bands to enhance visibility at night (Allison and Destefano 2006). Two portable battery operated ultraviolet (UV) lights were used to assist in determinations of molt limits (Weidensaul et al 2011) and owls were then aged using the criteria in Pyle (1997). Two Barn Owl chicks were also banded from an accessible nest site location by the Seal Rookery Overlook bench on September 20, 2011.

A small amount (≤ 1 ml) of blood as well as three small body feathers were sampled from five adult Barn Owls for future stable isotope and genetic analyses. A 26.5 gauge needle was used to prick the ulnar vein and blood was then collected into capillary tubes and dispensed into a 1.5 ml Eppendorf tube. Blood samples were then frozen within 3 hours. These five owls also were fitted with VHF radio transmitters (Lotek Pip Ag357; 4.5 grams) attached using a leg-loop harness (Rappole and Tipton 1991) made of 0.25 inch (0.63 cm) teflon ribbon (Bally Ribbon Mills, Bally, Pennsylvania). Harnesses were fit using an allometric function (Naef-Daenzer 2007) and fastened with dental floss and cyanoacrylate glue (Steenhof et al 2006). This attachment technique is preferable to a backpack design as it leaves the wings free and has been previously used successfully with Barn Owls (S. Hindmarch, pers. comm.). The radio transmitter and harness together weighed approximately 5.5g, which is less than 1.5% the body mass of the smallest owl captured (380g) and well below the 3% limit required by the USGS Bird Banding Lab.

Radio telemetry surveys

Radio telemetry surveys were conducted by having one or two observers hike the island trails at night using handheld three element Yagi antennas and portable lightweight receivers (Advanced Telemetry Systems R410). We recorded weather conditions for all surveys, but did not survey on nights with winds over 20 knots. During the murrelet breeding season, we attempted to get precise locations on radio-marked owls by homing in on the signal until a visual sighting (either with a flashlight or with night vision) confirmed the exact location of the owl. Once an owl was sighted, we recorded the behavior of the owl (perched or in flight, silent or vocalizing) and the type of habitat it was associated with, if observed directly. In addition, during telemetry surveys in April, all encounters with all owls, whether banded, unbanded or unknown, were recorded in the same manner. The results of this portion of the study was submitted as a manuscript to the Western North American Naturalist as part of the published proceedings of work presented at the California Islands Symposia in October 2012 (Thomsen et al. submitted).

Line transects

To supplement the results from the telemetry data, twenty-three 200m line transects (n=11 along island edges adjacent to or through murrelet habitat; n=12 in interior habitats) were established to quantify barn owl space use during (April 11-13, 2012) and after (August 29 - September 5) the murrelet breeding season. Observers used handheld spotlights to observe owls along the transects and recorded the times and locations of any observations (including both auditory or visual detections) of Barn Owls. Each individual transect was surveyed 3-4 times. All observations were marked with a GPS and the identities of the owls, if known, were recorded.

DEER MOUSE MONITORING:

Live-Trapping

Mouse trapping was completed during spring and fall of 2011 on the two grids, Terrace Coreopsis (TC) and Terrace Grassland (TG), which have been monitored since the 1980s by NPS staff. Helen Fitting, NPS Wildlife Biologist, once again led the trapping efforts in 2011. Grids were trapped on March 3-5 and March 6-8, 2011 for the TC and TG grids, respectively. The TC grid was also trapped for five days on September 3-7, 2011, and both grids were trapped again by Helen Fitting in October 2011. Monitoring methods are described in detail in the CHIS Terrestrial Vertebrate Monitoring Handbook (Fellers et al 1988). Data will be presented in a future report.

Track tubes

Although the long term mouse monitoring data for SBI provides an invaluable index of mouse abundances over the previous few decades, the lack of any spatial replication limits the inferences that can be made about island-wide habitat associations of mice. Therefore, we supplemented the NPS mouse monitoring data in 2011 by establishing ten track tube grids (Figure 1), specifically to compare the relative abundances of mice in murrelet habitat (n=5) and interior habitats (n=5). Track tubes have a number of advantages over live-trapping. No direct handling of mice is required and more sites can be simultaneously monitored at a time than is possible with live-trapping. Moreover, results have usually been found to correlate with results from live-trapping, including seasonal changes in abundance (Drennan et al 1998, Mabee 1998, Glennon et al. 2002; Connors et al 2005, Wiewel et al. 2007, Wilkinson et al 2012).

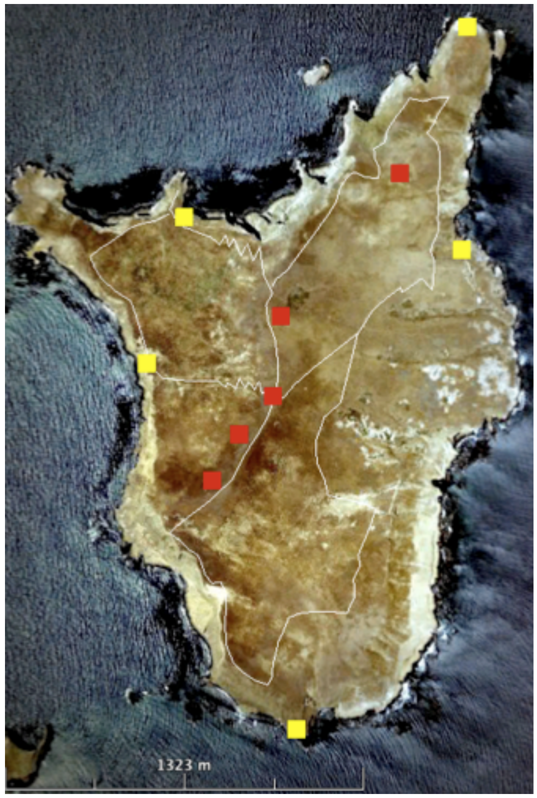

Figure 1. Track tube locations. Murrelet grids = Yellow; Interior grids = Red

Five track tube grid locations in the island interior were established by first generating 300 random points across the island using ArcGIS 9.3 and the extension Hawth's Analysis Tools (Beyer 2004), then creating a random selection of five of those points that were at least 200m from the shoreline. Murrelet habitat locations were obtained by randomly selecting one murrelet nest from each of four murrelet monitoring plots that were monitored in 2010, or the nearest nest where a grid could be safely established along the cliffs (ArchPoint/North Cliffs nest#1301, West Cliffs nest#1397, Cat Canyon nest#27, and Landing Cove nest#247). An additional random point was generated with Hawth's Analysis Tools within a polygon representing the boundaries of the Elephant Seal Point restoration plot, as there has been only one murrelet nest discovered in this plot thus far.

We made modifications to the track tube designs of Connors et al (2005) and Drennan et al. (1998) to make them smaller, lightweight, and still covered from the elements. Track tubes were constructed by cutting and folding corrugated plastic sheeting into triangular tubes (30cm length by ~5.2cm maximum height) with an opening at the top and reinforcing the sides with duct tape. The tracking surface consisted of an acetate sheet painted with a suspension made of ethyl alcohol, graphite, and mineral oil (Connors et al 2005) that covers nearly the whole width (6cm) and length (28cm) of the inside bottom of the tube. Mouse tracks are visible when mice travel across the track sheet, removing the graphite layer from the acetate sheet in the shape of their feet.

Track tubes were deployed in all ten grids in a 3x3 formation with 7m spacing for 24-hr (±2hr) periods in April, May, July and August 2011. Each track tube was examined for the presence or absence of mouse tracks, and the number and location of track tubes that were tracked out of 9 total for each grid was recorded. We did not attempt to determine if more than one individual visited a track tube, however, high resolution images (600dpi) of the tracked surfaces were created to have a permanent record for each tracked tube. Track tubes were not deployed in June due to unusually high sustained winds (35 knots) during the new moon. Track tubes were only deployed within 3 nights of the new moon when lunar illumination is typically ≤3% (US Naval Observatory; http://www.usno.navy.mil/USNO/ astronomical-applications/data-services/). Ground staples or tiles attached to the bottom of the track tubes were used to ensure that typical wind speeds could not easily dislodge them from grid locations.

Barn Owl Diet

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), Black Storm-Petrels (*Oceanodroma melania;* BLSP) and Ashy Storm-Petrels (*O. homochroa;* ASSP)) collected from trails, murrelet monitoring plots, habitat restoration plots and owl roost sites. Not all areas were searched with the same frequency, but generally all trails were checked 1-2 times per week, and murrelet plots and habitat restoration plots as per regular monitoring schedules (about every 5-7 days) from March to July 2011 (Harvey et al. in prep). This comprises the "temporal index", since patterns of predation may be evident over time due to the frequency of checks. All other island habitats are searched at least once annually and are added with the temporal index to comprise the "total index" of predation for that year.

Barn Owl roost sites were visited opportunistically in June-September once they were checked during owl nest searches as habitat became available to search without disturbing nesting Brown Pelicans. This included crevices, small caves and large shrubs within all five canyons (Cliff Canyon, Cave Canyon, Middle Canyon, Graveyard Canyon, and Cat Canyon) as well as shoreline cliff habitat accessible by hiking and non-technical climbing from the top of the island. Due to weather and other logistical challenges, we were unable to get into any sea caves in 2011 except for one visit to Barn Owl Cave in May.

Once a carcass was found, we noted the species, the date, condition of the carcass, and the specific body parts found. The exact location of each carcass was recorded with both a handheld GPS and with digital photographs of where the carcass was found. If a depredated murrelet was found in a nest monitoring plot, we also recorded the site numbers of the nearest murrelet nests to the carcass. Carcasses were then collected into polyethylene bags to prevent double counting and then frozen. Because of the variation in the type of prey remains found could result in double-counting (e.g., decapitated heads may have been part of “wingsets”), the number of individuals killed by owls reported for 2011 is the Minimum Number of Individuals (MNI) represented.

Pellets were also collected into polyethylene bags and frozen at least overnight to kill invertebrates, and then stored at room temperature until dissection. Approximately 400 pellets were collected in 2011. Analysis is currently ongoing; however, at this time 166 pellets have been dissected. Pellets have been processed by first measuring the length and width of each individual pellet, then briefly soaking the pellet in a mixture of warm tap water and anhydrous ethyl alcohol to allow easier separation of all bones from the pellet matrix. Once the bones have been separated out, deer mice, island night lizards (*Xantusia riversiana*), and avian prey were identified using reference skeletons, if necessary. The number of skulls and/or lower mandibles present was obtained to get the number of prey items (MNI) of each prey type per pellet. Data presented in this report are percent frequency of prey types only.

Murrelet mortality and nest monitoring

Murrelet nests in Cat Canyon, Landing Cove, and Arch Point / North Cliffs were checked every 5-7 days for nest contents as per normal monitoring schedules (Harvey et al. in prep).

RESULTS AND DISCUSSION

Barn Owl and Deer Mouse Abundance and Space Use

The trail survey in January had 13-15 owl detections, but dropped to 7-8 detections in March, and then rebounded in August with 21-32 owl detections. The decreased number of detections in March may have been related to the fact that not all trails were open at this time. The March survey is thus not considered comparable to the January and August surveys nor with any survey completed in 2010. During the trail surveys in January, more than twice as many owls were detected as on any of the surveys in 2010, indicating that breeding activity may have been occurring before January 2011. The August 2011 survey represented some of the highest numbers of owl detections on the island, with similarly high numbers seen in 1983, 1987, and 1999. (Figure 2; data from Drost 1989, Wolf et al 2000).

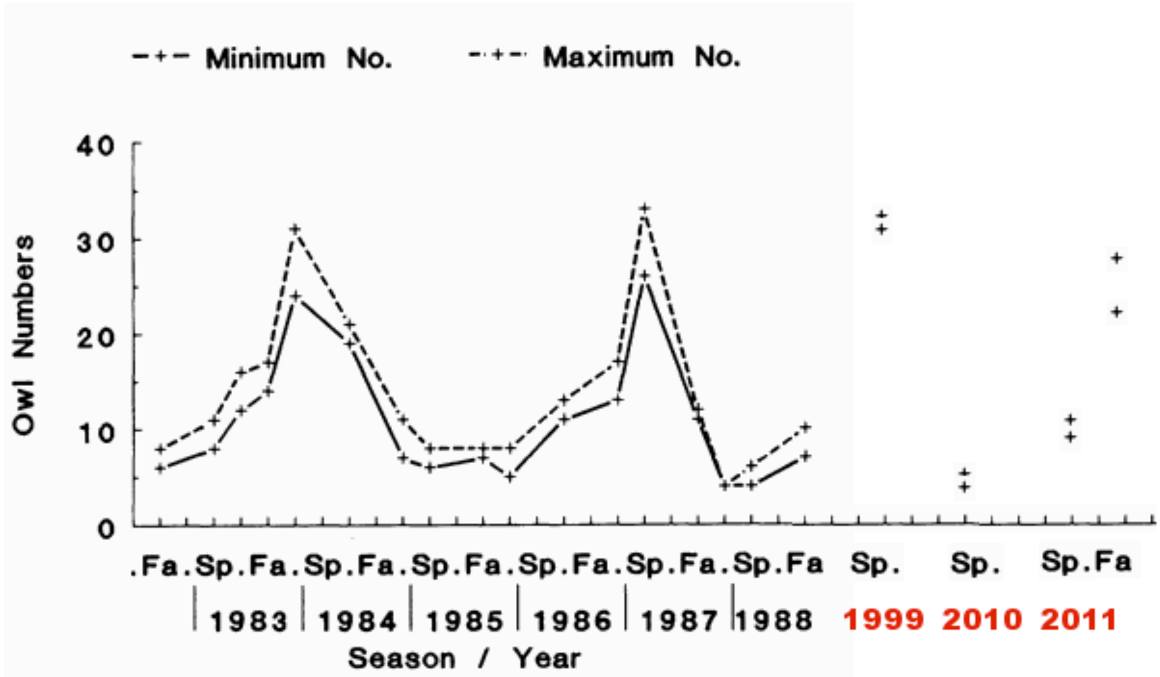

Figure 2. Changes in owl detections on trail surveys in 1982-1987, 1999, and 2010-2011.

In addition, up to 14-15 unbanded owls were seen at one time in and nearby Cave Canyon during the summer months, and when added with the number of banded owls at that time (10), the minimum population of owls was estimated to still be at least 24. Although we intended to capture many more owls, the nights with owl capture success were very strongly associated with very calm wind conditions, which was rare and unpredictable during January to May 2011 (< 5% of night-time hours; data summarized from http://www.raws.dri.edu/wraws/ccaF.html). Effort was therefore focused on taking full advantage of these nights when they occurred. Eight adult Barn Owls were captured with verbail traps and color-banded. Five of these adults also had radio transmitters attached. Two chicks from a nest were also banded, bringing the total to 13 Barn Owls that have been banded on Santa Barbara Island since August 2010.

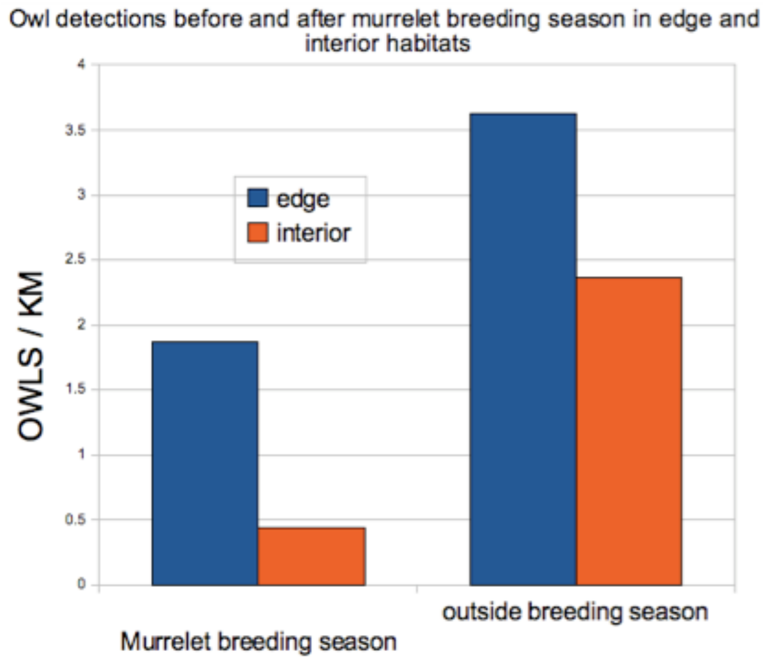

Figure 3: Owl detections per km in edge and interior habitats, before and after the murrelet breeding season in 2011

Line transects adjacent or through murrelet ("edge") habitat had significantly more owls detected per km than in interior ("interior") habitats (Figure 3) during the murrelet nesting season. Results from the radio telemetry surveys in April also demonstrated a similar pattern for individual owls, with a high proportion (>75%) of resight locations that were within approximately 200 meters of the island shoreline (Thomsen, unpubl. data). More owls were still detected in murrelet habitat compared to interior habitat after the murrelet nesting season, however, the difference was less than during the murrelet season. This could reflect greater use of interior habitats as the mouse population increased in these areas.

The track tube score for mice increased in all ten grids from April to August, however the increase was not uniform across the island (Figure 4). Track tube scores (number of tubes tracked) in grids in murrelet habitat were consistently higher than the interior grids. Furthermore, even as track tube scores increased overall, the rate of increase was faster for edge grids. Previous studies have also found relatively high densities of mice in murrelet habitat (Murray 1983, Millus 2006), at least during some phases of the mouse population cycle, which may be due to greater shrub and rock cover in these areas (Millus 2006).

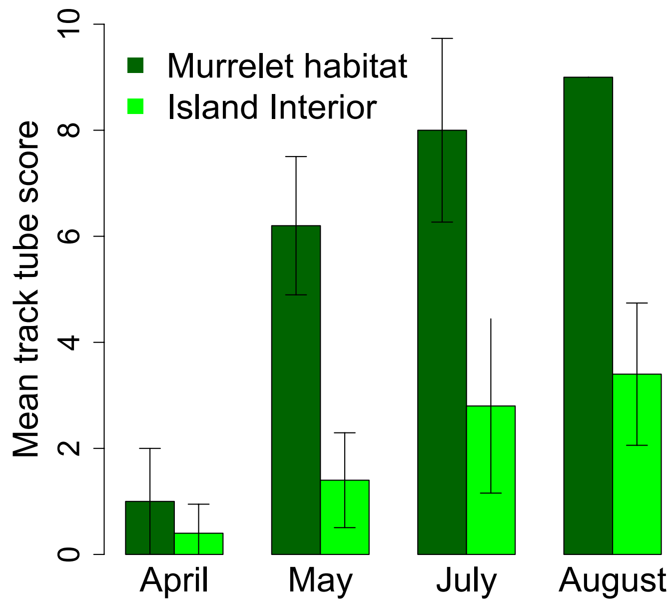

Figure 4: Mean track tube score for April, May, July and August 2011 in edge (n=5) and interior (n=5) habitats.

BARN OWL DIET

In 2011, seabirds were not an important component of owl diet. There were zero murrelets found killed by owls within the murrelet monitoring plots, habitat restoration areas, or along trails (i.e., the "temporal index"), which contrasts with results in 2010 (Table 1). There was one Cassin's Auklet found killed in the Landing Cove plot in 2011, and four Ashy Storm-Petrels by Arch Point or North Peak. However, the total index of predation includes 4 murrelet keels collected from an owl roost in Cat Canyon (outside the plot) when it was searched in August 2011, as well as 6 murrelet wingsets collected from Barn Owl Cave in May 2011 and one murrelet wing found in Cliff Canyon (Figure 6). This pattern is also reflected in the pellets (Table 2), with no evidence of murrelet predation yet found in 166 pellets, although there are still over half of the pellets left to analyze.

Table 1. Murrelet carcasses in nest monitoring plots in 2010 and 2011

Murrelet Plot	**2010**	**2011**
Boxthorn	3	Not monitored 2011
Landing Cove	10	0
West Cliffs	1	0
Bunkhouse	3	0
Arch Point / North Cliffs	1	0
Cat Canyon	0	0

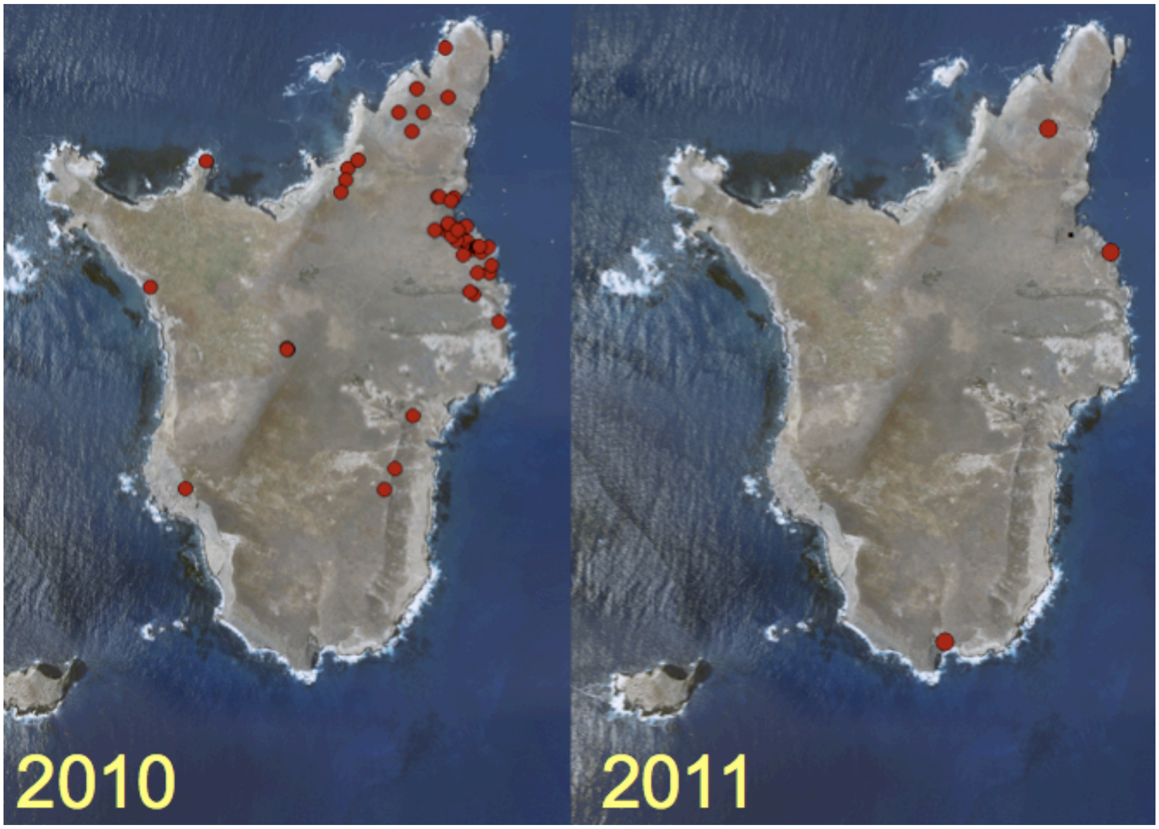

Figure 5. Locations of murrelet carcasses on Santa Barbara Island in 2010 and 2011.

Table 2. Results of Barn Owl pellet analysis for 2011	
Prey item	**Percent frequency of occurrence** (n=166 pellets)
Mice	100%
Seabirds	0%

We can therefore evaluate evidence for two competing hypotheses for describing the impact of owl predation on murrelets. One is the shared predation hypothesis (Norrdahl & Korpimäki 2000) which proposes that owls are unselective and that predation of murrelets would increase along with the density of owls. Since owl abundance increased in 2011, in order to have support for this hypothesis, data would have shown that owl predation of murrelets would have increased even higher than 2010 levels. However, since murrelet predation decreased well below that observed in 2010, the results are more consistent with the alternative prey hypothesis, which states that owls are generalist predators that will consume the more abundant primary prey (deer mice) and will switch to alternative prey (seabirds) only when densities of the primary prey decline. Hence, it is the density of mice relative to owls that mediates the impact of owls on murrelets.

Although several auklets were killed in 2010 in Landing Cove, the social attraction system was moved and a few nests were subsequently initiated in 2011 in newly available artificial habitat. This resulted in the first ever auklet chick banded on the island (Harvey, unpubl. data). However, the density of owls in this particular area (Thomsen, upubl. data) may mean that all nesting seabirds, including both murrelets and auklets, are at risk when mouse populations decline.

CONCLUSIONS AND RECOMMENDATIONS

In 2011, there was a dramatic increase in both owl and mouse abundance compared to recent years. During mouse trapping in the Terrace Coreopsis grid in September, there were some nights when more mice than traps were captured, (i.e., 103 mice captured in one night in 100 traps, pers obs.). Such incredible densities have been noted previously (Schwemm 2009), but have not been recorded recently. It is likely that the high density of mice was due to increased rainfall during the winters of 2009-10 and 2010-11 (NPS unpubl. data), an effect that has also been observed in other locations with similar climates, where small mammal populations and their predators increase in response to years with heavy rainfall (Jaksic et al 1997; Lima et al 2002).

The spatial overlap between owls and mice during the murrelet breeding season in 2011 indicates that owls were present in seabird habitat regardless of the availability of seabirds as prey and that there was no evidence that seabirds were targeted as prey. We also cannot rule out the possibility that Barn Owls may have had positive indirect effects on murrelets in 2011, if they were consuming murrelet egg predators precisely where murrelets would benefit. Fieldwork in 2012 and possibly 2013 will also include further studies of egg predation by mice as it relates to changes in owl space use as the mouse population is expected to decline.

Continuation of baseline data collection throughout a complete mouse population cycle is critical to the development of effective adaptive management efforts that are designed to create and improve safe breeding habitat in an otherwise dynamic predation risk landscape for murrelets. Upon conclusion of this study, a final report will include discussion of several management options to reduce the impacts of both mice and owls and the most appropriate timing of possible interventions in the context of a mouse population cycle. These interventions include, but are not limited to, removal/translocation of owls to locations off island (Smith et al. 2010, Catlin et al. 2011), physical alteration of habitat to limit access by owls at particular roost locations that are near high densities of nesting murrelets, conditioned taste aversion for mice in murrelet plots (Baylis et al. 2012), temporary supplemental feeding of mice (Vander Lee et al. 1999), artificial perches added in the interior to encourage owl hunting in these areas (Kay et al. 1994; Widen 1994), or enhancement of the perception of predation risk for mice by playback of owl vocalizations (Hendrie et al. 1998). This report will also include recommendations for including some aspects of this work into regular monitoring efforts by NPS biologists to help evaluate the timing and effectiveness of adaptive management techniques if they are implemented.

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