Space Use and Home-Range Size of Barn Owls on Santa Barbara Island

Authors: Thomsen, Sarah K., Kroeger, Caitlin E., Bloom, Peter H., and Harvey, A. Laurie

Source: Monographs of the Western North American Naturalist, 7(1) : 339-347

Published By: Monte L. Bean Life Science Museum, Brigham Young University

URL: https://doi.org/10.3398/042.007.0125

Monographs of the Western North American Naturalist 7, © 2014, pp. 339–347

SPACE USE AND HOME-RANGE SIZE OF BARN OWLS ON SANTA BARBARA ISLAND

Sarah K. Thomsen[1], Caitlin E. Kroeger[2,3], Peter H. Bloom[4], and A. Laurie Harvey[2,5]

ABSTRACT.—Spatial overlap between predators and prey is often a key component of predator-prey interactions. Barn Owls (*Tyto alba*) are important predators of some species of conservation concern on the Channel Islands in southern California; therefore, understanding patterns of owl space use on these islands could provide insights on variations in predation risk that may be useful for conservation efforts of Barn Owl prey. In this study, our objectives were to investigate home-range size and space use by individual owls on Santa Barbara Island, which at 2.6 km^2 is the smallest island within the Channel Islands National Park. Specifically, we were interested in owl space use in relation to the spatial distribution of owl prey, in particular the state-listed Threatened Scripps's Murrelet (*Synthliboramphus scrippsi*)—a small nocturnal seabird whose largest breeding colony in California is on this island and whose nesting habitat is strictly along the island's perimeter. In contrast, the distribution of the Barn Owl's primary prey, deer mice, includes both murrelet habitat and the island interior. We therefore conducted a radiotelemetry study of Barn Owls in combination with a novel technique of applying colored reflective tape to colored plastic leg bands to aid in the identification of individual owls at night. Home-range size estimates for 3 owls were 0.02–0.53 km^2 using the 100% minimum convex polygon method and were 0.06–1.12 km^2 using a fixed-kernel method. Owl resight locations for 8 marked individuals were no farther than 1.24 km apart, which suggests that owl home ranges do not generally encompass the entire island. Nocturnal observations of owls also tended to be not far from their diurnal roost sites, which were located close to the edges of the island and near murrelet nesting habitat. This spatial overlap suggests there may be patchiness in predation risk for the owls' seabird and rodent prey in relation to proximity to owl roosts.

RESUMEN.—La superposición espacial entre depredadores y presas es a menudo un componente clave en las interacciones depredador-presa. La lechuza común (*Tyto alba*) es un depredador importante de algunas especies cuya conservación es preocupante en las Islas del Canal en el sur de California; por lo tanto, el comprender los patrones de uso de espacio de la lechuza en esas islas puede proporcionar información sobre las variantes en el riesgo de depredación que podrían ser útiles para los esfuerzos por conservar sus presas. En este estudio, nuestro objetivo fue investigar el tamaño del territorio y el uso del espacio por individuos de lechuzas en la Isla Santa Bárbara, la isla más pequeña del Parque Nacional de las Islas del Canal, con sólo 2.6 km^2. Específicamente, nos interesaba el uso de espacio de la lechuza en relación con la distribución espacial de su presa, en particular el mérgulo de Scripp (*Synthliboramphus scrippsi*), clasificado en peligro de extinción, una pequeña ave marina nocturna cuya principal colonia de reproducción en California está en esta isla, y cuyo hábitat de anidación se encuentra estrictamente en perímetro de la isla. En contraste, la distribución de una de las principales presas de las lechuzas, los ratones ciervo, incluye tanto el hábitat del mérgulo como el interior de la isla. Por lo tanto, realizamos un estudio de radiotelemetría de la lechuza común en combinación con una nueva técnica, donde aplicamos cinta de color reflectante a las anillas de plástico de colores de sus patas para ayudar en la identificación de lechuzas individuales de noche. Se estima que el tamaño del territorio de 3 lechuzas era de 0.02–0.53 km^2, usando el método del 100% mínimo de polígono convexo, comparado con los 0.06–1.12 km^2 usando el método de núcleo fijo. La localización de los nuevos avistamientos de lechuzas para 8 individuos marcados estaba separada por no más de 1.24 km, lo cual sugiere que los territorios de las lechuzas no comprenden generalmente la totalidad de la isla. En las observaciones nocturnas, las lechuzas no estaban lejos de sus lugares de asentamiento diurno, los cuales estaban situados cerca de los límites de la isla y cerca del hábitat de anidación del mérgulo. Esta superposición espacial sugiere que podría haber heterogeneidad espacial en el riesgo de depredación para el ave marina y el roedor en relación a la proximidad al asentamiento de la lechuza.

Barn Owls (*Tyto alba*) are found on all 8 of the Channel Islands in southern California; however, these island populations have been poorly studied. Most research has been limited to diet studies and either roadside or trail surveys to detect owl presence/absence or relative abundance on a few of the islands (Rudolph 1970, Drost and Fellers 1991, Condon et al. 2005). But even these few studies suggest that Barn Owls could play a crucial

[1]Department of Biological Sciences, Simon Fraser University, Burnaby, BC V5A 1S6, Canada. E-mail: sthomsen@sfu.ca
[2]California Institute of Environmental Studies, 1901 Spinnaker Drive, Ventura, CA 93001.
[3]Present address: Ocean Sciences Department, University of California Santa Cruz, Santa Cruz, CA 95064.
[4]Western Foundation of Vertebrate Zoology, 439 Calle San Pablo, Camarillo, CA 93012.
[5]Present address: Sutil Conservation Ecology, 30 Buena Vista Avenue, Fairfax, CA 94930.

role as top predators in island ecosystems, particularly on smaller islands that provide critical habitat for rare and endemic species and have few alternative prey types. For example, there is a resident breeding population on Santa Barbara Island, and up to 25 or more owls have been counted on trail surveys, which represents an unusually high density for a 2.6-km^2 island (Drost and Fellers 1991). These owls are also known to consume atypical prey items, due in part to the limited variety of available prey on this island. This variety includes the only extant species of rodent, the island endemic subspecies of deer mouse *Peromyscus maniculatus elusus*, as well as the endemic island night lizard *Xantusia riversiana* (Fellers and Drost 1991) and small nocturnal seabirds such as the state-listed Threatened Scripps's Murrelet (*Synthliboramphus scrippsi;* (Drost and Lewis 1995).

For the murrelet, whose largest breeding colony in the United States is on Santa Barbara Island, predation by owls, along with egg predation by deer mice, has been suggested as being a contributing factor in an apparent population decline of murrelets on the island (Burkett et al. 2003, Millus et al. 2007). Therefore, understanding the space use of owls can potentially provide key insights into the patterns of predation risk that murrelets face. This is because the degree of spatial overlap between predators and prey may determine encounter rates and, therefore, predation rates (Sih 2005). However, there have been few published studies on the spatial ecology of Barn Owls, and the implications of those studies are uncertain for the island. For instance, a single Barn Owl can have a typical foraging range substantially larger than the size of the entire island (up to 31.74 km^2; Hegdal and Blaskiewicz 1984); and with little evidence of territoriality (Marti et al. 2005), it is possible that the home ranges of all the owls could overlap and encompass the entire island. However, home-range size of Barn Owls can vary considerably between individuals and locations, and owls may not use all areas of their range equally (Marti et al. 2005).

If this heterogeneity in owl space use exists on the island, even relatively fine-scale differences could be important for their prey. For example, although mice are found throughout the island (Collins et al. 1979), the patchily distributed boxthorn shrubs (*Lycium californicum*) provide important habitat for night lizards (Fellers and Drost 1991); and most strikingly, murrelet nesting habitat is entirely limited to the rugged periphery of the island's sea cliffs (Drost and Lewis 1995). For this study, we were particularly interested in the space use of owls during the murrelet breeding season in relation to these patterns in the spatial distribution of their potential prey. To investigate this, we tested a novel, inexpensive marking technique of applying colored reflective tape to colored plastic leg bands on owls, in combination with a pilot radiotelemetry study, to provide the first information on home-range size and space use of Barn Owls on Santa Barbara Island.

METHODS

Study Site

Santa Barbara Island (33°29′ N, 119°02′ W) is the smallest of 5 islands comprising the Channel Islands National Park. The island is located about 63 km offshore and 39 km from Santa Catalina Island, its closest neighbor. The shoreline consists primarily of sheer cliffs and steep slopes, rising up to the 2 tallest peaks at 193 m and 171 m above sea level. The interior of the island is a gently sloping terrace covered mostly by nonnative grassland (e.g., *Avena* spp., *Bromus* spp., and *Hordeum* spp.) and patches of low-growing native shrubs (e.g., *Leptosyne gigantea, Eriogonum giganteum* var. *compactum, Constancea nevinii,* and *Lycium californicum*) and cacti (*Opuntia* spp.; Junak et al. 1993). Five small canyons are cut into the south and east sides of the island. The canyons, sea cliffs, and steeply sloping edges of the island have served as refugia for native plants and shrubs after the conversion of the island interior to farmland by the 1920s, from which the vegetation has yet to recover (Halvorson et al. 1988). Currently, there are ~7.5 km of hiking trails and a small campground in the northeast (Fig. 1).

Barn Owl Capture, Marking, and Radio-Transmitter Attachment

We captured adult Barn Owls on the island using verbail traps (Stewart et al. 1945, Bloom et al. 2007) between August 2010 and September 2011. All trapping efforts took place on nights with winds <10 knots and no fog, precipitation, or excessive dew. We set 2–7 verbail traps along the hiking trails with 10–50 m

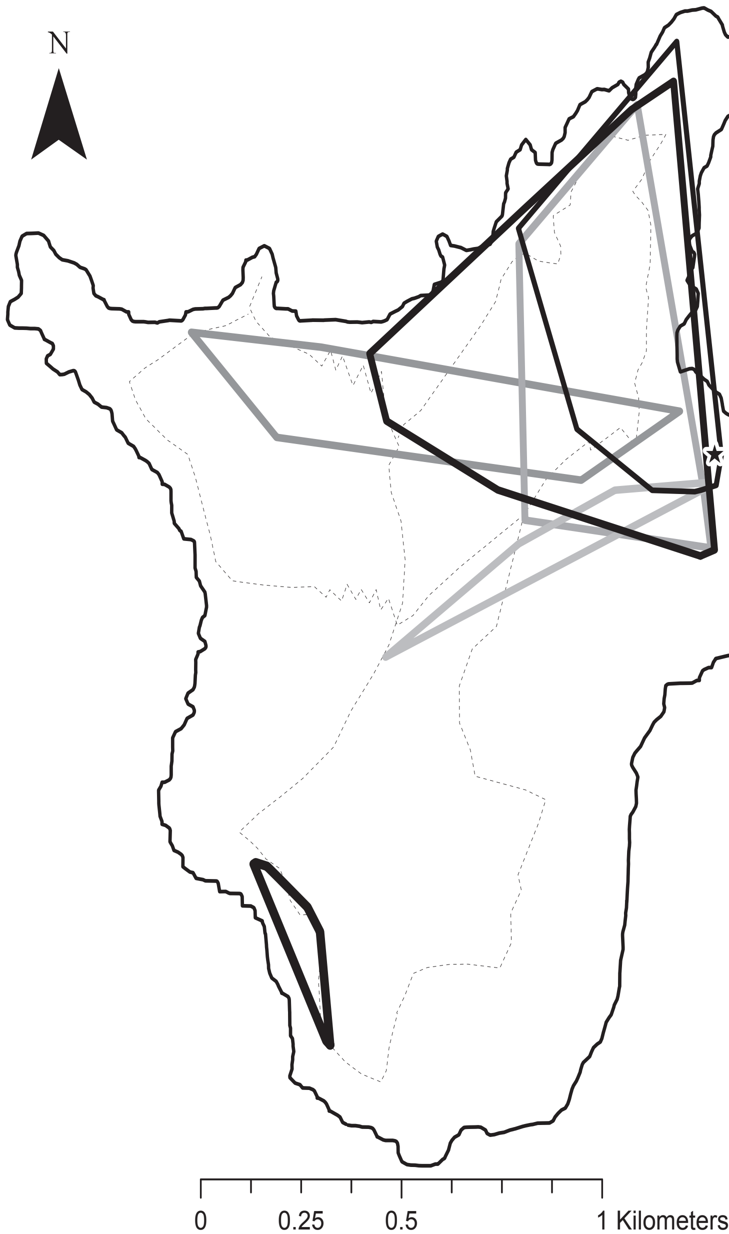

Fig. 1. Home ranges of 6 Barn Owls on Santa Barbara Island during 2011–2012 using the 100% minimum convex polygon (MCP) method. Solid lines represent home ranges. Black: home-range size estimate was calculated. Gray: no home-range size estimate was calculated. Dashed lines indicate hiking trails, and the star illustrates the location of the campground.

between traps. Most of our trapping effort took place on the trails just east of the center of the island and to a lesser extent, in the southwestern part of the island by the cliff edges or near the canyon closest to the campground in the northeast. We set traps after dusk and then continued until dawn unless weather conditions deteriorated. Once set, 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) so that we could respond immediately to retrieve captured owls for processing.

Captured owls were placed inside bird bags and weighed to the nearest gram with a 600-g Pesola scale. They were then banded with an aluminum USGS lock-on band as well as color-banded with unique color combinations using one Darvic plastic band on the right and left legs. Matching colored reflective tape was also applied to the color bands to enhance visibility at night and aid in identification of individuals (Allison and DeStafono 2006). We used only reflective tape colors (orange, yellow, red, blue, white, and green) that were clearly identifiable at night as unique color combinations.

Owls captured during February–May 2011 were also fitted with VHF radio-transmitters (Lotek Pip Ag357; 4.5 g) attached using a leg-loop harness (Rappole and Tipton 1991) made of 0.25-inch (0.63-cm) Teflon ribbon (Bally Ribbon Mills, Bally, PN). 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 because it leaves the wings free and has been used successfully with Barn Owls (Almasi et al. 2013). The radio-transmitter and harness together weighed approximately 5.5 g, which is <1.5% of the body mass of the smallest owl captured (380 g) and well below the 3% limit required by the USGS Bird Banding Lab. We did not attempt to determine sex in the field; however, tissue samples for most owls will be archived with the Santa Barbara Museum of Natural History so that molecular determination of sex may still be possible. We also could not be certain of breeding status at capture or during surveys because Barn Owls are capable of breeding nearly year-round in southern California (Bloom unpublished data).

Radiotelemetry and Resighting Surveys

Radiotelemetry surveys were conducted by having one or 2 observers hike along the island trails and cliff edges at night using handheld 3-element Yagi antennas and portable lightweight receivers (Advanced Telemetry Systems R410). We were able to maintain broader spatial coverage of the island during most surveys by having 2 observers divide the island approximately in half between the north and south. During a survey, receivers were set to scan through all frequencies; and each time a signal from a radio-tagged owl was detected, we recorded the observer's location with a handheld GPS unit (Garmin GPSmap 78) and the direction of the radio signal (compass degrees). For this study, we report only results from visually confirmed locations of owls rather than from the relatively error-prone locations obtained from nonsimultaneous compass bearings (Schmutz and White 1990). To get accurate locations on radio-marked owls, we used the homing technique, which involved continuous hiking toward the location where the signal was strongest until a visual sighting confirmed the location of the owl (Mech 1983). After a resight location was recorded with the GPS, we attempted to maintain continuous tracking of a single individual from a distance for at least an hour before obtaining subsequent resight locations from that individual. We selected this time period to reduce temporal autocorrelation in the data while still maintaining "biological independence" (sensu Lair 1987), assuming one hour would be plenty of time for an owl to travel throughout its potential home range.

We spent 98.25 person-hours radio-tracking at night, of which 64 hours were from March to April 2011. These months are the peak of the murrelet breeding season, so during this time period, surveys were generally conducted 1–3 times per week. Weather and logistical constraints delayed deployment of 2 radio-transmitters until May 2011, and 2 more owls were color-banded without radio-transmitters in September 2011. Therefore, the remaining hours of radio-tracking took place sporadically during May–September 2011. All radio-tracking was done between 19:00 and 05:00. We also included a small number of locations obtained from incidental observations that occurred during other fieldwork at night through September 2012 to increase our sample size of sightings for individual owls. We did not survey on nights with sustained winds exceeding 20 knots or if there was rain.

Data Analysis

The GPS coordinates of owl resight locations were brought into ArcGIS 10.1 (Environmental Systems Research Institute Inc.,

TABLE 1. Home-range size (km^2) for Barn Owls on Santa Barbara Island, California.

Owl	Date captured	Marking technique[a]	*n*	Distance[b]	KDE[c] 90%	KDE[c] 50%	MCP[d]
1	Feb 2011	CB, RT	33	1.07	1.12	0.35	0.53
2	Aug 2010	CB	27	1.02	0.46	0.09	0.31
3	Mar 2011	CB, RT	21	0.47	0.06	0.02	0.02
4	May 2011	CB, RT	7	1.01	—	—	—
5	May 2011	CB, RT	7	0.88	—	—	—
6	Sept 2011	CB	6	1.24	—	—	—
7	Feb 2011	CB	4	0.04	—	—	—
8	Sept 2011	CB	3	0.27	—	—	—

[a]CB = color banded, RT = radio-tagged
[b]Maximum distance (km) between resight locations
[c]Fixed kernel density method with bandwidth selected by LSCV, 90% and 50% isopleths
[d]100% minimum convex polygon method

Redlands, CA) for characterization of space use and estimation of home-range size. We used the Geospatial Modeling Environment extension (GME; Beyer 2012) to create home ranges with the 100% minimum convex polygon (MCP) method, as well as with a fixed-kernel method with the bandwidth selected by least squares cross validation (Seaman and Powell 1996). We also measured the Euclidean distances between all pairs of points for individual owls to get the farthest distances between resight locations. For visualization purposes, we created 100% minimum convex polygons for all owls with >5 resight locations. Area-observation curves were then plotted for each of those owls and visually inspected for asymptotes, which indicate whether the number of locations is sufficient for unbiased estimates of home-range size (Odum and Kuenzler 1955).

If the number of locations was adequate, we then calculated home-range size estimates with the GME extension using the 100% MCP method, as well as with the 90% and 50% isopleths of the utilization distribution from the fixed-kernel method. These 2 isopleths have been recommended as an appropriate range for producing reliable home-range estimates with as few as 10 locations (Börger et al. 2006), with the smaller isopleth representing the "core areas" of space use. Although use of the minimum convex polygon method has long been criticized for its biologically unreasonable assumptions, in particular its sensitivity to outliers (White and Garrott 1990), it remains one of the most commonly reported metrics of home-range size. Therefore, we also include it here. We used these metrics to facilitate comparisons with other studies.

RESULTS

We captured and banded 11 adult Barn Owls between August 2010 and September 2011. All owls were given unique combinations of colored reflective tape on their color bands, and 5 of them also had radio-transmitters attached. We obtained a total of 108 resight locations (mean number of locations per owl = 13.5, SE 4.14) between August 2010 and September 2012 from 8 of those owls (Table 1). Area-observation curves reached asymptotes for only 3 owls. Home-range size estimates using the 100% minimum convex polygon method for these 3 owls were 0.53 km^2, 0.02 km^2, and 0.31 km^2 (Fig. 1). In contrast, home-range estimates with the 90% isopleth of the utilization distribution from the fixed-kernel method were larger: 1.12 km^2, 0.06 km^2, and 0.46 km^2, respectively. The maximum distance between subsequent resight locations for individual owls ranged from 40 m to 1.24 km (Table 1). In addition, resights for these 3 owls tended to be clustered by their respective primary diurnal roost sites, which is shown by the 50% isopleths of their utilization distributions (Fig. 2).

Of the remaining 5 owls for which we obtained few observations, one was recovered dead on the island 4 months after capture, although the cause of death could not be determined. One owl banded in September 2011 was subsequently observed by a roost site in August 2012 after having been seen only once prior. The radio signal of one owl disappeared shortly after transmitter deployment in February 2011, and the owl was never resighted. The last 2 owls were never seen more than once after capture and have not been recovered dead.

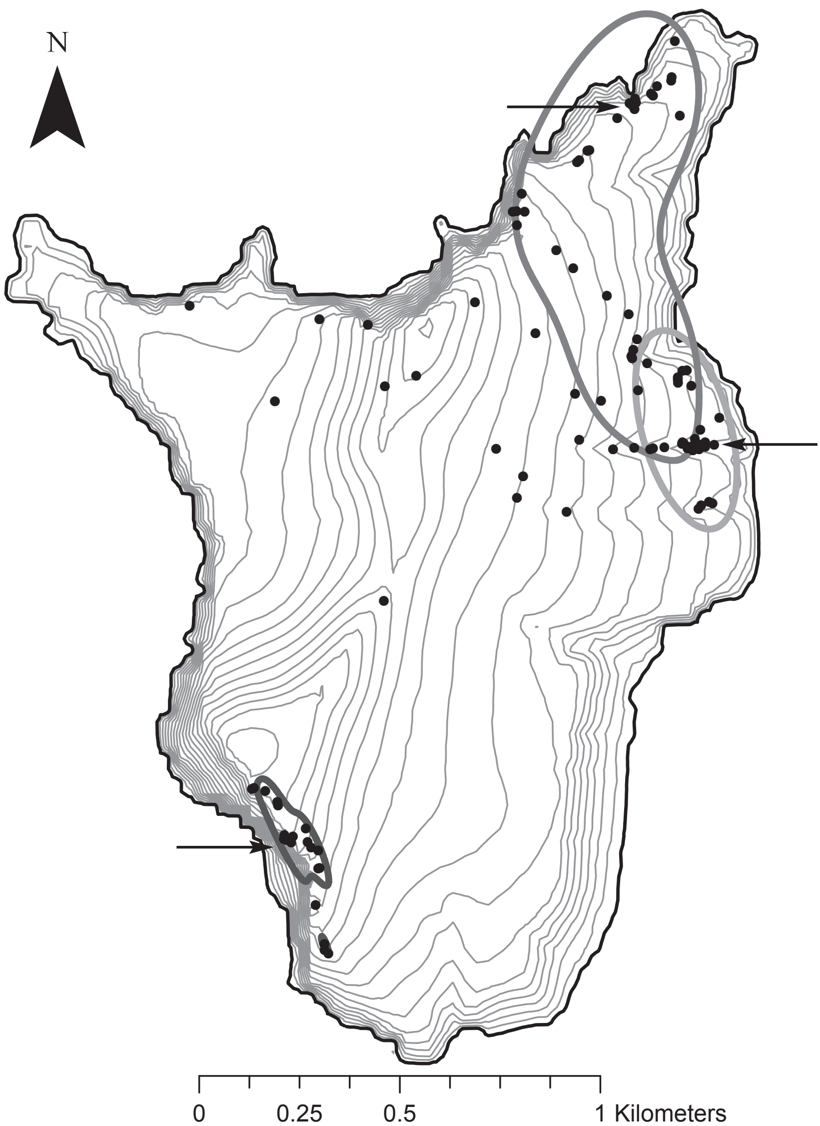

Fig. 2. Space use of Barn Owls on Santa Barbara Island during 2011–2012 and island topography at 10-m contour intervals. Points represent locations where marked owls were observed. Solid, thick gray lines represent the 50% isopleth of the utilization distribution for 3 individual owls. Isopleths were generated using the fixed-kernel method. Arrows point toward the approximate location of the primary diurnal roost site for each of the 3 owls.

DISCUSSION

Despite the island's small size, the estimated home-range size (100% MCP) of 3 owls ranged from a mere 0.02 km^2 to 0.53 km^2. Although few comparable studies have been published, these data represent some of the smallest home-range estimates yet reported for Barn Owls, though a similarly small home range of 0.2 km^2 was found for one individual owl tracked for 33 days in New Jersey (100% MCP; Hegdal and Blaskiewicz 1984). Although we were able to estimate home-range size for only 3 owls, we would have expected that if island-wide movements were frequent, we would have detected them during our surveys for any of the 11 marked owls. Barn Owls are capable of flight speeds up to 80 km · h^{-1} (Bunn et al.

1982), and individuals could have easily circumnavigated the island in just a few minutes and possibly been resighted by both observers located in distant parts of the island. Instead, the farthest distance between resight locations was only 1.24 km, and for some owls this distance was far less (Table 1). This suggests that owls had home ranges that did not encompass the entire island, at least during our study.

We also found that for individual owls, the areas of concentrated use represented by the 50% isopleths tended to be near their respective diurnal roost sites (Fig. 2). This behavior is not unusual for Barn Owls (Taylor 2003); however, for the island, this also means more extensive use of cliff habitat than we had expected. The owl with the smallest home range is notable in that even though all resight locations were close to the top of the highest cliff in the southwestern part of the island (Fig. 2), the radio signal was frequently moving along the cliffs below us where we could not hike down to resight the owl's location more precisely. This observation indicates a spatial overlap with nocturnal seabirds that nest in these areas and also suggests possible patchiness in predation risk related to proximity to owl roost sites. Because we also found that owls seemed to have overlapping home ranges in the northeastern part of the island (Fig. 1), the resultant high concentration of owls could potentially lead to areas of high predation risk for owl prey.

These patterns suggested by our results (e.g., small home ranges and concentrated use by roost sites) may have been influenced by other biotic and abiotic conditions on the island during our study. First, variations in home-range size for raptors may be related to prey densities (Peery 2000), and indeed, the peak densities of deer mice recorded on Santa Barbara Island are among the highest recorded (Drost and Fellers 1991). Mouse population densities were very high throughout 2011 on Santa Barbara Island (NPS unpublished data), and mice composed an overwhelming majority of prey items consumed by Barn Owls that year (Thomsen et al. in preparation). Thus, these high densities of mice may have been related to the apparently small home ranges we found. Second, although perhaps less important, another potential factor is the high winds that the island experienced at night during our study. We did not collect data on nights with sustained winds higher than 20 knots; but on windier nights, there were wind gusts of >50 knots during March–April 2011 (data from Western Regional Climate Center, http://www.wrcc.dri.edu). Wind speed can influence space use and hunting strategy of avian predators (Gilchrist et al. 1998) and in this case could lead to owls spending more time in wind-protected areas of the island. However, because we did not survey on the windiest nights, we do not think that owl movements would have been limited during our surveys. Unfortunately, our sample sizes were not large enough to fully examine either of these possibilities.

The disappearance of 3 owls without a known cause reduced our already low sample size. Barn Owls are known to disperse to oceanic islands much farther than the distances from the mainland to any of the Channel Islands (Lees and Gilroy 2014), so dispersal away from the island cannot be entirely ruled out as a reason for the disappearances. However, Barn Owls in southern California are known to have relatively short dispersal distances compared to those in other parts of North America (Langdon 2007, Bloom unpublished data). In addition, 3 of the radio-marked owls have been recovered dead on the island since completion of this study, and all were found within the home ranges originally identified by our radio-tracking study. Exact causes of death could not be determined for these or for several other unmarked owls recovered dead during the same time period, but Barn Owls are relatively short-lived raptors (Marti et al. 2005) and are known to decline steeply in abundance in relation to cyclic population declines of their main prey, deer mice (Drost and Fellers 1991). This mortality does not appear to be unusual, but future studies should consider this attrition of sample size as part of their research design.

Despite the challenges, we were still able to obtain valuable information that will be useful for future studies of Barn Owls on Santa Barbara Island. The use of radiotelemetry was critical, as resights of owls without radiotelemetry were rare despite many hours of searching. This rarity is not surprising considering that raptors are difficult to survey, and owls in particular have low detectability (Anderson 2007, Kissling et al. 2010). Nonetheless, for our study, the use of reflective tape allowed us to collect sightings on some owls long after their radiotransmitters failed and on additional owls that were never radio-tagged. We therefore recommend that future studies use radiotelemetry or GPS data loggers as the primary method of obtaining data on home-range sizes and space use of owls on small islands. Colored reflective tape may also be used as a useful and inexpensive additional technique. We further suggest that future studies consider whether home-range size for individual owls varies over the mouse-population cycle and in different habitats of the island. These data would increase our understanding of the changing landscape of predation risk to species of conservation concern on the island. The results from such studies on the island would be important in an applied conservation context and also would have broader implications for the spatial ecology of predator-prey interactions.

ACKNOWLEDGMENTS

We greatly appreciate the field assistance of S.L. Avery, S.A. Auer, K.W. Barnes, K. Carter, S. Plumb, J. Savage, M.E. Jacques, and A.A. Yamagiwa. We also are deeply grateful for the support of D.J. Green, P. Baird, R. Ydenberg, J. Boyce, A. Little, F. Gress, D. Mazurkiewicz, H. Fitting, and C. Drost. We thank the staff of the Channel Islands National Park for logistical support; pilots at Aspen Helicopters, Inc., for transportation to the island; and Spence Porter of Communication Specialists, Inc., who kindly provided the trap transmitters and receiver. An earlier draft was improved by comments from anonymous reviewers. Funding was provided by the Montrose Trustee Council.

LITERATURE CITED

ALLISON, N.L., AND S. DESTEFANO. 2006. Equipment and techniques for nocturnal wildlife studies. Wildlife Society Bulletin 34:1036–1044

ALMASI, B., A. ROULIN, AND L. JENNI. 2013. Corticosterone shifts reproductive behaviour towards self-maintenance in the Barn Owl and is linked to melanin-based coloration in females. Hormones and Behavior 64:161–171.

ANDERSON, D.E. 2007. Survey techniques. Pages 89–100 *in* D.M. Bird and K.L. Bildstein, editors, Raptor research and management techniques. Raptor Research Foundation, Blaine, WA.

BEYER, H.L. 2012. Geospatial modelling environment [software]. Available from: http://www.spatialecology.com/gme

BLOOM, P.H., W.S. CLARK, AND J.W. KIDD. 2007. Capture techniques. Pages 193–219 *in* D.M. Bird and K.L. Bildstein, editors, Raptor research and management techniques. Raptor Research Foundation, Blaine, WA.

BÖRGER, L., N. FRANCONI, G. DE MICHELE, A. GANTZ, F. MESCHI, A. MANICA, S. LOVARI, AND T. COULSON. 2006. Effects of sampling regime on the mean and variance of home range size estimates. Journal of Animal Ecology 75:1393–1405.

BUNN, D.S., A.B. WARBURTON, AND R.D.S. WILSON. 1982. The Barn Owl. Buteo Books, Vermillion, SD.

BURKETT, E.E., N.A. ROJEK, A.E. HENRY, M.J. FLU-HARTY, L. COMRACK, P.R. KELLY, A.C. MAHANEY, AND K.M. FIEN. 2003. Report to the California Fish and Game Commission: status review of Xantus's Murrelet (*Synthliboramphus hypoleucus*) in California. California Department of Fish and Game, Habitat Conservation Planning Branch Status Report 2003–01.

COLLINS, P.W., J. STORRER, AND K. RINDLAUB. 1979. Vertebrate zoology: the biology of the deer mouse. *In*: D.M. Power, editor, Natural resources study of the Channel Islands National Monument, California. Santa Barbara Museum of Natural History, Santa Barbara, CA.

CONDON, A.M., E.L. KERSHNER, B.L. SULLIVAN, D.M. COOPER, AND D.K. GARCELON. 2005. Spotlight surveys for grassland owls on San Clemente Island, California. Wilson Bulletin 117:177–184.

DROST, C.A., AND G.M. FELLERS. 1991. Density cycles in an island population of deer mice, *Peromyscus maniculatus.* Oikos 60:351–364.

DROST, C.A., AND D.B. LEWIS. 1995. Xantus's Murrelet (*Synthliboramphus hypoleucus*). *In*: A. Poole and F. Gill, editors, The Birds of North America, No. 164. Academy of Natural Sciences, Philadelphia, PA, and American Ornithologists' Union, Washington, DC.

FELLERS, G.M., AND C.A. DROST. 1991. Ecology of the island night lizard, *Xantusia riversiana*, on Santa Barbara Island, California. Herpetological Monographs 5:28–78.

GILCHRIST, H.G., A.J. GASTON, AND J.N. SMITH. 1998. Wind and prey nest sites as foraging constraints on an avian predator, the Glaucous Gull. Ecology 79: 2403–2414.

HALVORSON, W.L., D.B. FENN, AND W.R. ALLARDICE. 1988. Soils and vegetation of Santa Barbara Island, Channel Islands National Park, California, USA. Environmental Management 12:109–118.

HEGDAL, P.L., AND R.W. BLASKIEWICZ. 1984. Evaluation of the potential hazard to Barn Owls of Talon (brodifacoum bait) used to control rats and house mice. Environmental Toxicology and Chemistry 3:167–179.

JUNAK, S., R. PHILBRICK, AND C. DROST. 1993. A revised flora of Santa Barbara Island. Santa Barbara Botanic Garden, Santa Barbara, CA.

KISSLING, M.L., S.B. LEWIS, AND G. PENDLETON. 2010. Factors influencing the detectability of forest owls in southeastern Alaska. Condor 112:539–548.

LAIR, H. 1987. Estimating the location of the focal center in red squirrel home ranges. Ecology 68: 1092–1101.

LANGDON, S. 2007. Natal dispersal of Barn Owls (*Tyto alba*) banded in southwestern California: a GIS study. Master's thesis, California State University, Long Beach, CA.

LEES, A.C., AND J.J. GILROY. 2014. Vagrancy fails to predict colonization of oceanic islands. Global Ecology and Biogeography 23:405–413.

MARTI, C.D., A.F. POOLE, AND L.R. BEVIER. 2005. Barn Owl (*Tyto alba*). *In:* A. Poole, editor, The Birds of North America Online. Cornell Lab of Ornithology, Ithaca, NY; [cited October 2012]. Available from: http://dx.doi.org/10.2173/bna.1

MECH, L.D. 1983. A handbook of animal radio-tracking. University of Minnesota Press, Minneapolis, MN. 108 pp.

MILLUS, S.A., P. STAPP, AND P. MARTIN. 2007. Experimental control of a native predator may improve breeding success of a threatened seabird in the California Channel Islands. Biological Conservation 138: 484–492.

NAEF-DAENZER, B. 2007. An allometric function to fit leg-loop harnesses to terrestrial birds. Journal of Avian Biology 38:404–407.

ODUM, E.P., AND E.J. KUENZLER. 1955. Measurement of territory and home range size in birds. Auk 72: 128–137.

PEERY, M.Z. 2000. Factors affecting interspecies variation in home-range size of raptors. Auk 117:511–517.

RAPPOLE, J.H., AND A.R. TIPTON. 1991. New harness design for attachment of radio transmitters to small passerines. Journal of Field Ornithology 62:335–337.

RUDOLPH, D.C. 1970. Predation ecology of the Barn Owl, *Tyto alba.* Doctoral dissertation, University of California, Santa Barbara, CA.

SCHMUTZ, J.A., AND G.C. WHITE. 1990. Error in telemetry studies: effects of animal movement on triangulation. Journal of Wildlife Management 54:506–510.

SEAMAN, D.E., AND R.A. POWELL. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. Ecology 77:2075–2085.

SIH, A. 2005. Predator-prey space use as emergent outcome of a behavioral response race. Pages 240–255 *in* P. Barbosa and I. Castellanos, editors, Ecology of predator-prey interactions. Oxford University Press.

STEWART, R.E., J.B. COPE, AND C.S. ROBBINS. 1945. Live trapping hawks and owls. Journal of Wildlife Management 9:99–105.

STEENHOF, K., K.K. BATES, M.R. FULLER, M.N. KOCKERT, J.O. MCKINLEY, AND P.M. LUKACS. 2006. Effects of radiomarking on Prairie Falcons: attachment failures provide insights about survival. Wildlife Society Bulletin 34:116–126.

TAYLOR, I. 2003. Barn Owls: predator-prey relationships and conservation. Cambridge University Press, Cambridge.

WHITE, G.C., AND R.A. GARROTT. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, CA.

Received 11 April 2013
Accepted 18 March 2014