



2012 Deer Mouse Monitoring Annual Report

Channel Islands National Park

Natural Resource Data Series NPS/MEDN/NRDS—2013/571





ON THIS PAGE

Deer mice on Santa Barbara Island, Channel Islands National Park
Photograph by National Park Service

ON THE COVER

Deer mouse and coreopsis, Santa Barbara Island, Channel Islands National Park
Photograph by Catherin Schwemm

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Abstract

In 2012 staff at Channel Islands National Park conducted population monitoring of deer mice (*Peromyscus maniculatus*) on three islands, marking the 20th year that deer mouse monitoring has been completed at the park. Population monitoring was conducted using capture-mark-recapture methods at Santa Barbara Island (2 sites), Anacapa Island (1 site) and San Miguel Island (3 sites). Each site is a 10 by 10 grid of small box traps and is trapped for 3 consecutive nights in the spring and in the fall. Captured mice are marked with eartags, sexed and aged. We used the number of unique individuals caught on a grid as a measure of mouse abundance, since that metric is highly correlated with density estimated from programs CAPTURE, MARK and DENSITY. Mouse abundance over time show extensive fluctuation and evidence of seasonal variability, with fall numbers being generally higher than spring numbers, due to annual recruitment. There was evidence of multi-year cycles on Santa Barbara and San Miguel islands. However, when island foxes (*Urocyon littoralis*) were absent from the wild on San Miguel during a period of captive breeding (2000-2004), deer mouse cycles appeared to be more annual in nature, and abundance was generally higher than before or after the captive breeding period. Deer mice are currently at population lows on Santa Barbara and San Miguel, likely due to drought and perhaps to predation, although they have increased on Anacapa Island, where mice may be in the high phase of a population cycle. Lower habitat quality in grasslands was suggested by both abundance data and weights of adult male mice in springtime. On Santa Barbara Island, abundance was generally lower on the grassland grid. On San Miguel Island, spring male weights were lower on the one grassland grid until recently. Weights of males in springtime were generally lower on Santa Barbara Island than on Anacapa or San Miguel, but with little difference between the two grids. Spring male weights were similar on all San Miguel grids in 2010-2012.

Acknowledgments

Deer mouse monitoring in 2012 was conducted primarily by Helen Fitting, with assistance from Karl Bachman, John Reyes, Renae Sattler, Kevin Thompson, Ryan Munes, Robert Kessler, Sean Carr, and Jennifer Price. I thank Lena Lee, database manager for the National Park Service Mediterranean Coast Network, for her assistance in data management. Lena developed the new deer mouse database, and her queries and QA/QC procedures made it remarkably easy to extract the data required for this annual report. Rocky Rudolph produced the excellent maps of deer mouse monitoring grid locations. Thanks to Tim Handley, recently of the U.S. Geological Survey, for compiling and correcting the precipitation records from Santa Barbara and Santa Rosa Islands.

Most of what is known about deer mouse ecology on the islands is due to the sustained efforts of several individuals over time. Charles Drost, Cathy Schwemm, John Orrock and Rob Klinger have studied island mice extensively (in some cases, for 20-30 years!) and continue to generously lend their interest and expertise to the park's monitoring efforts. For that I am grateful. Additionally, fieldwork by Cathy Schwemm, Charles Drost and Paige Martin kept deer mouse monitoring going during times of inadequate staffing. Finally, thanks to Cathy Schwemm, Charles Drost, Kate Faulkner, and Stacey Osterman-Kelm for reviewing this report and suggesting appropriate revisions.

Introduction

Like other nearshore island groups, California's Channel Islands have a depauperate vertebrate fauna when compared to that of the nearby mainland. For example, on most of the 8 islands in the archipelago the only rodent is the deer mouse (*Peromyscus maniculatus*), which is recognized as a separate subspecies on each of the islands. Because it is one of only several vertebrate species occurring on the islands, the deer mouse has considerable ecological influence. Deer mice are a preferred food item for the endemic island fox (*Urocyon littoralis*) (Coonan et al. 2010), and as seed and flower predators they influence the dynamics of both native and non-native vegetation (Schwemm 2008). Deer mice are egg predators for landbirds (Peluc et al. 2008) and for some crevice-nesting seabirds (Schwemm and Martin 2005). Island mice are also important in terms of zoonotic disease. Deer mice on the Channel Islands are a reservoir for the virulent Sin Nombre strain of hantavirus (Graham et al. 1997, Jay et al. 1997, Orrock and Allan 2008), with seroprevalence being higher on islands with greater area, higher precipitation, and fewer predators (Orrock et al. 2011).

Deer mouse population dynamics are well-documented for Santa Barbara Island in Channel Islands National Park (Drost and Fellers 1991). In years of abundant precipitation, deer mice increase to densities considerably higher than those recorded elsewhere, and barn owls (*Tyto alba*) increase in response to the dense prey base. Mice subsequently decline when reproduction declines at high densities, and/or precipitation in following years inevitably declines, and the high barn owl population helps drive down mouse populations to extremely low numbers. Barn owls ultimately decline as well. This results in a multi-year population cycle, in which population highs occur every 3-4 years.

Because of their ecological importance, as well as their status as endemic subspecies, deer mice were chosen for monitoring as part of the park's long-term ecological monitoring program (Fellers et al. 1988). Trapping grids were located in representative stands of island vegetation on Santa Barbara, Anacapa and San Miguel Islands, with capture-mark-recapture sampling occurring twice a year. Despite the vagaries of Federal funding and its effects on staffing, deer mouse data have been collected by park staff and volunteers on a fairly consistent basis since 1992. Data from the early years of the program has previously been reported in a series of annual reports (Schwemm 1995, Austin 1996, Schwemm 1996, Austin 1998) and a trend report (Schwemm and Coonan 2001).

This report presents deer mouse population monitoring data collected from Santa Barbara, Anacapa and San Miguel Islands in 2012. In most cases the data are presented in relation to data collected in previous years.

Methods

Deer mouse monitoring at Channel Islands National Park was established as part of the terrestrial vertebrate monitoring protocol for the park's long-term ecological monitoring program. Development of vertebrate monitoring began in the mid-1980s, and the resulting protocol (Fellers et al. 1988) established 13 deer mouse monitoring grids on Santa Barbara, Anacapa and San Miguel Islands. Due to funding, staffing and logistical constraints, the number of grids that has been consistently surveyed over time is limited to 2 on Santa Barbara Island, 1 on Anacapa, and 3 on San Miguel (Table 1, Figures 1-3), and those were the grids sampled in 2012.

Table 1. Deer mouse monitoring grids sampled at Channel Islands National Park in 2012.

Grid	Habitat Type	Code
<i>Santa Barbara Island</i>		
Terrace Coreopsis	<i>Coreopsis</i> Scrub	TC
Terrace Grassland	Grassland	TG
<i>Anacapa Island</i>		
East Anacapa Island – Inspiration Point	Grassland	EI
<i>San Miguel Island</i>		
Airstrip	<i>Isocoma</i> Scrub	AS
Nidever Canyon	Lupine Scrub	NC
Willow Canyon	Grassland	WC

When the protocol was developed, deer mouse monitoring grids were not randomly located, but instead were placed in representative stands of different habitat types. Habitat characteristics have likely changed to some degree over time on the grids, since vegetation on the islands is generally recovering from decades of grazing by non-native animals. Each grid comprises 100 trap locations in a 10 by 10 configuration, with trap spacing of 7 m. Each grid was trapped twice a year, in the spring and the fall, for three consecutive nights. Monitoring was occasionally conducted in the winter and summer, but not in 2012. Box-type live traps (3 x 3.5 x 9 in., H. B. Sherman Traps, Tallahassee, Florida) were baited with rolled oats and checked once a day, in the morning. Captured mice were weighed, sexed and aged (adult, subadult or juvenile), reproductive condition was recorded, and mice were marked with numbered Monel eartags (National Band and Tag Co., Newport, Kentucky).

Excluder devices (Fig. 4) were used on San Miguel and Anacapa islands to avert trap disturbance by island foxes and western gulls (*Larus occidentalis*), respectively. The excluder device comprises rigid sheet plastic material wrapped around a Sherman trap, and extending beyond each end to prevent other animals from gaining access to the doors of the trap. The device and enclosed trap is anchored to the ground by a surveyor's chaining pin. The devices have been used on San Miguel in both spring and fall and on Anacapa in the spring since 2009.



Santa Barbara Island Deer Mouse Grids



Figure 1. Location of deer mouse monitoring grids on Santa Barbara Island, Channel Islands National Park.



East Anacapa Island Deer Mouse Grids

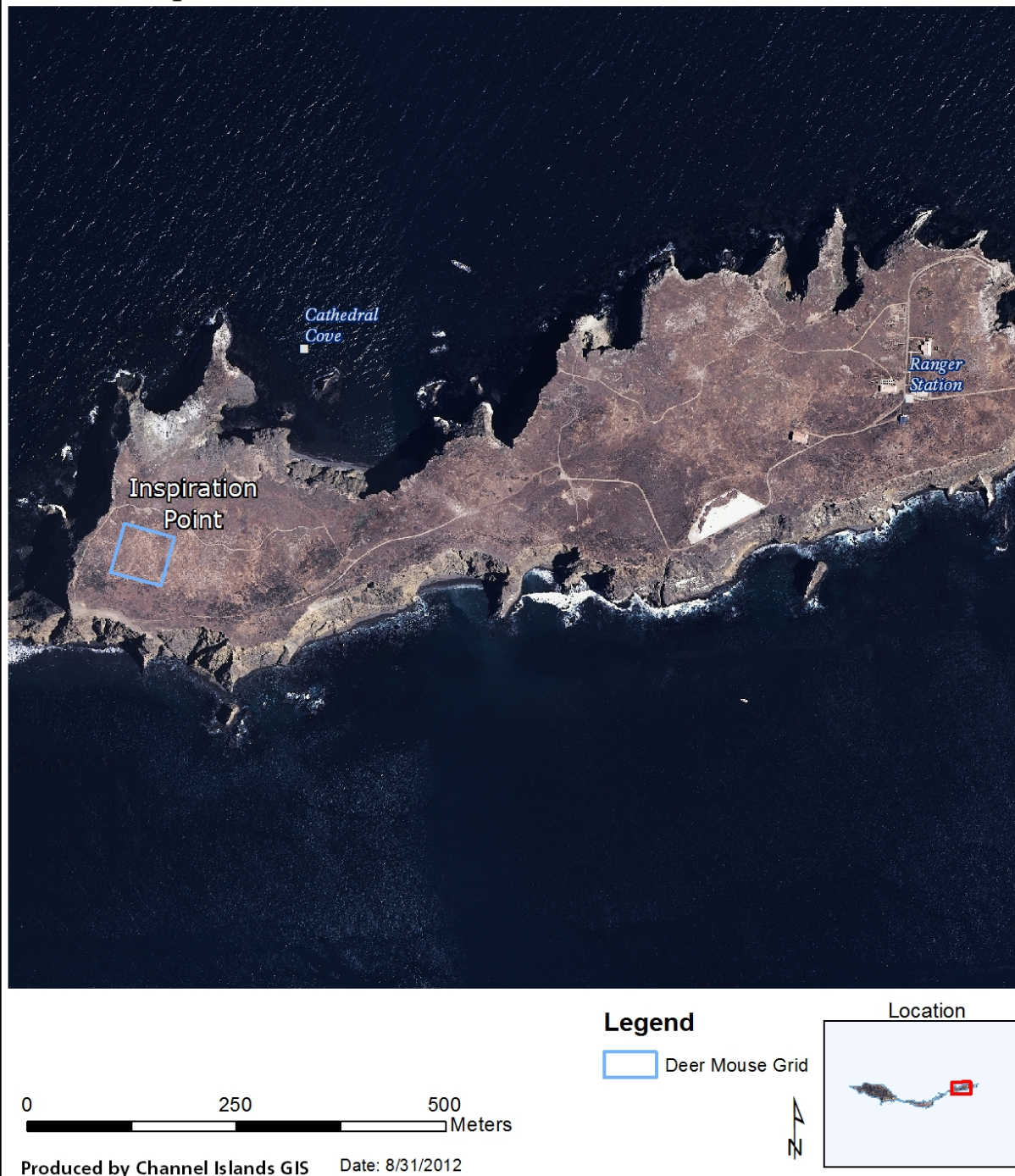


Figure 2. Location of deer mouse monitoring grid on Anacapa Island, Channel Islands National Park.



San Miguel Island Deer Mouse Grids



Figure 3. Location of deer mouse monitoring grids on San Miguel Island, Channel Islands National Park.



Figure 4. Island foxes inspecting Sherman traps with excluder devices on San Miguel Island. Use of excluder devices on San Miguel and Santa Barbara Islands began in 2009.

Prior to being summarized, all electronic data were checked against the datasheets and then validation queries were performed to examine the data for invalid or missing values. Once all checks were complete the data were certified and archived.

In the past, island deer mouse abundance has been reported as density (mice/ha), estimated with the use of program CAPTURE on capture-mark-recapture data from the grids (Schwemm 1995, Austin 1996, Schwemm 1996, Austin 1998, Schwemm and Coonan 2001). Program CAPTURE takes into account detectability and capture probabilities to provide more accurate estimates of abundance than indices of abundance, which do not account for the uncaptured portion of the population. However, in this report we used the number of unique mice caught on a grid during a 3-day grid sampling period as an index of mouse abundance. Such measures are highly correlated with densities estimated via programs CAPTURE, MARK and DENSITY (J. Orrock, University of Wisconsin, unpubl. data), and use of indices is necessary to avoid problems of model selection in cases where captures are too few to use density estimators. We present 2012 values for mouse abundance on the grids alongside similarly calculated values from previous years.

Mouse weight may be a good indicator of individual condition, and hence resource abundance, as influenced by precipitation and habitat type (Zwolak and Foresman 2008). However, there is variability due to sex, age, season and reproductive condition. Males generally weigh more than females, except when females are pregnant, and adults weigh more than juveniles or subadults. Since we were nonetheless interested in looking at mouse weights over time, we controlled for this variability by limiting our longer-term analysis to adult male weights in the spring of each year.

To look at the general influence of precipitation on mice, we used annual precipitation for the water year (July 1 – June 30) on Santa Barbara Island, and on Santa Rosa Island. San Miguel Island does not have a longterm weather record and so we used data from neighboring Santa Rosa. The datasets for both islands were compiled and corrected by T. Handley, U.S. Geological Survey.

Results and Discussion

Table 2. Sampling dates and trapping results for deer mouse monitoring grids surveyed at Channel Islands National Park, 2012.

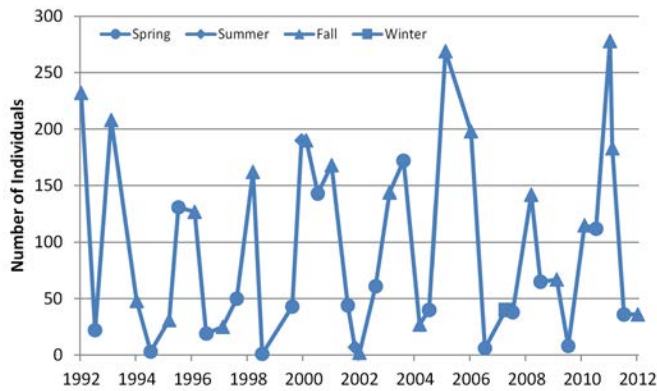
Grid	Dates Sampled	Unique Individuals	Recaptures
<i>Santa Barbara Island</i>			
Terrace Grassland	2/29/2012 – 3/3/2012	38	30
Terrace Coreopsis	3/3/2012 – 3/6/2012	36	26
Terrace Grassland	9/5/2012 – 9/8/2012	8	4
Terrace Coreopsis	9/8/2012 – 9/11/2012	36	24
<i>Anacapa Island</i>			
East Anacapa Island – Inspiration Point	4/20/2012 – 4/22/2012	42	30
East Anacapa Island – Inspiration Point	9/26/2012 – 9/29/2012	134	143
<i>San Miguel Island</i>			
Willow Canyon	4/4/2012 – 4/7/2012	14	13
Airstrip	4/7/2012 – 4/10/2012	42	39
Nidever Canyon	4/26/2012 – 4/29/2012	63	72
Airstrip	10/9/2012 – 10/12/2012	42	29
Willow Canyon	10/12/2012 – 10/15/2012	44	51
Nidever Canyon	11/1/2012 – 11/4/2012	66	56

In both spring and fall of 2012, relatively few individuals were caught on each grid, with the exception of the East Anacapa grid in fall (Table 2). Graphs of abundance over time for each grid indicate that, with the exception of Anacapa, 2012 marked a low point in mouse population cycles (Figs. 5-7).

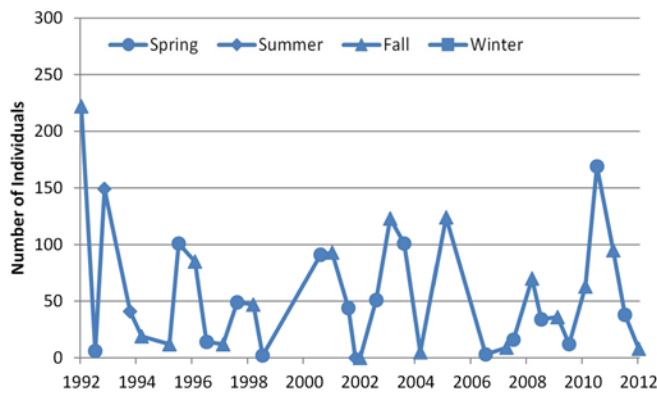
Santa Barbara Island

On Santa Barbara Island, the Terrace Grassland grid had lower population highs over time than did the Terrace Coreopsis grid, suggesting that the grassland habitat was lower quality than the coreopsis scrub. Because those grids were established in the 1980s, it is possible that vegetation composition may have changed since then, as the island gradually recovers from historic grazing. It is possible that the Terrace Coreopsis Grid is more open and contains less closed canopy coreopsis scrub than when first established (C. Drost, U.S. Geological Survey, pers. comm.). However, evaluation of vegetation composition on the grids via recent (2012) aerial photography showed the Terrace Grassland grid to still be 100% grassland, while the Terrace Coreopsis grid comprised 76% dense coreopsis, 12% scattered coreopsis, and 12% grassland (D. Rodriguez, National Park Service, unpublished data).

a)



b)



c)

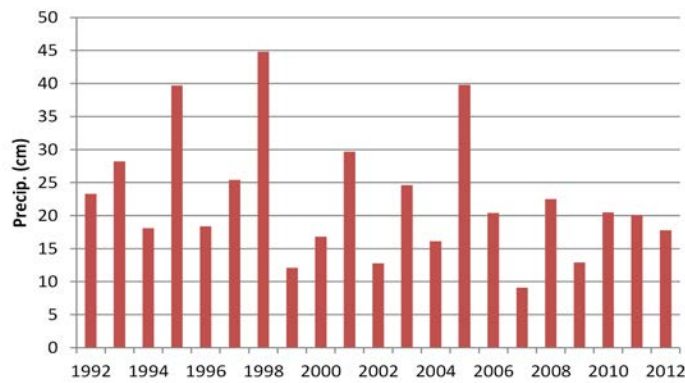


Figure 5. Deer mouse abundance (number of unique individuals) on a) the Terrace Coreopsis grid, and b) the Terrace Grassland grid, Santa Barbara Island, 1992 – 2012, along with c) annual precipitation on Santa Barbara Island for the water year (July 1 – June 30).

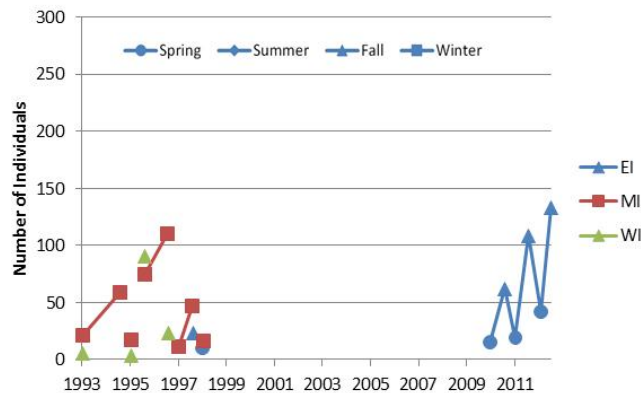


Figure 6. Deer mouse abundance (number of unique individuals) caught on deer mouse monitoring grids on Anacapa Island, 1992-2012. EI = East Anacapa Inspiration Point, MI = Middle Anacapa, WI = West Anacapa Island.

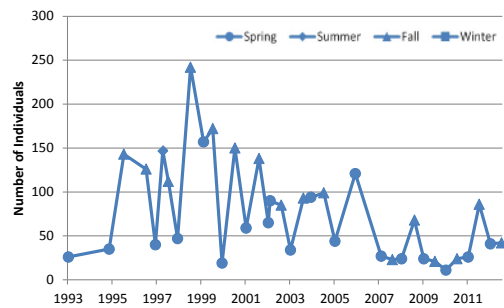
Although fall mouse numbers can often be higher than spring numbers due to recruitment, fall numbers on Santa Barbara Island were not higher than those in spring in 2012. Some recruitment was evident in the number of juvenile and subadult mice in the fall, compared to the spring (Table 3) but abnormally dry conditions beginning in February (www.drought.unl.edu/dm/monitor.html; Tercek and Power *in review*) likely decreased mouse survival and reproduction, resulting in lower fall numbers). On Santa Barbara Island, spring and fall abundance were similar on the Terrace Coreopsis Grid in 2012, but on the Terrace Grassland Grid abundance dropped sharply between spring and fall. The low numbers on Santa Barbara Island in 2012 indicate that mice there are in the low part of a population cycle (Fig. 5). Since monitoring began in 1992, Santa Barbara mice have exhibited a multi-year cycle, with highs occurring once every 2-4 years.

Annual precipitation on Santa Barbara Island averaged 22.3 cm from 1992-2012 and was variable (Fig. 5d). Mouse abundance did not appear to be determined solely by precipitation (although no statistical tests were conducted at this time). Peak mouse years on the grids did not always correspond to peak precipitation years, especially for the Terrace Grassland grid, which exhibited fairly consistent peaks. On the Terrace Coreopsis grid, a fall 2005 population high of >260 mice was associated with previous (July 1, 2004 – June 30, 2005) precipitation of >50 cm.

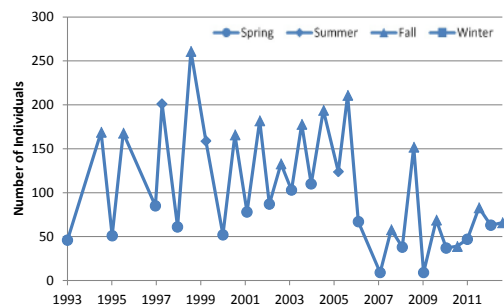
Anacapa Island

Mice on the East Anacapa Inspiration Point grid have exhibited seasonal variability since monitoring began anew there in 2010 (Fig. 6). Fall numbers have been higher than spring numbers, but both have increased since 2010. The East Anacapa mice may be in the increase phase of a cycle. If so, this is unusual in that both Santa Barbara and San Miguel mice are in the decrease phase of a cycle, and the Anacapa mice have increased despite lower than average precipitation. Mice on East Anacapa increased dramatically in 2003, 2 years after removal of rats (*Rattus rattus*) in 2001 (Howald et al. 2005, Gellerman 2007). The current increase in mouse abundance is possibly associated with removal of non-native iceplant (*Malephora crocea*), which has been ongoing since 2009.

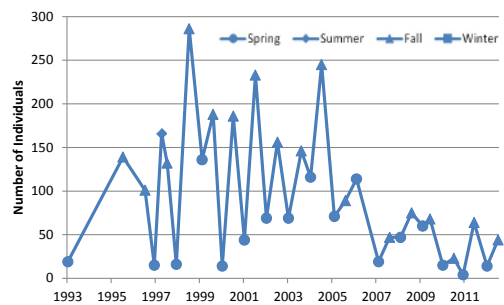
a)



b)



c)



d)

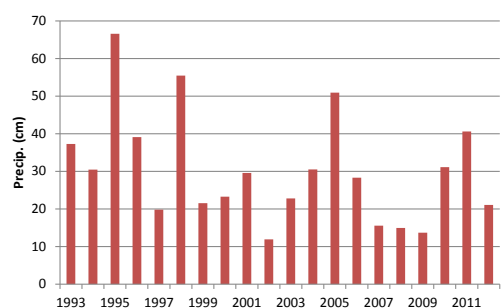


Figure 7. Deer mouse abundance (number of unique individuals) on a) the Airstrip grid, b) the Nidever Canyon grid, and c) the Willow Canyon grid, San Miguel Island, 1993-2012, along with d) annual precipitation for the water year (July 1 – June 30), Santa Rosa Island.

San Miguel Island

Mice on San Miguel appeared to exhibit annual cycles (spring minima, fall maxima) until 2006, when multi-year cycles, as observed on Santa Barbara Island, seemed to begin (Fig. 7). The annual cycles occurred when island foxes were in the final stages of a massive population decline (1995-1999), were subsequently in captivity and absent from the wild (1999-2004), and were at relatively low, recovering, population levels (2004-2006). However, trap saturation at high densities may be masking true population highs, and density estimates derived from program CAPTURE suggest that multi-annual cycles began when foxes entered captivity (C. Drost, U.S. Geological Survey, unpubl. data). The current population pattern on San Miguel with generally low numbers and little seasonal variation, has not been observed before in island mice.

The change in population cycling was more pronounced on the Nidever Canyon and Willow Canyon grids, where mice increased in an annual cycle of spring minima and fall maxima until 2005, when decrease and a multi-annual cycle began.

San Miguel mice were perhaps more influenced by precipitation than were mice on Santa Barbara Island. Average precipitation on Santa Rosa Island (30.6 cm) was greater than that on Santa Barbara Island. Mice maxima in fall 1998 were associated with the second-highest annual precipitation value during the time period (Fig. 7d) and with a wild fox population of <20 individuals. Also, the change in cycle from annual to multi-annual occurred simultaneously with a 4-year decrease in precipitation. Although an increase in precipitation followed (in 2010-2011), mice did not increase, perhaps because of the influence of predation; island fox densities were high by that time.

Overall, the sex ratio of captured mice in 2012 did not differ substantially from 1.0 (Table 8). In the spring, males dominated on Santa Barbara Island and females on San Miguel. In fall, the sex ratio favored females on Anacapa and males on San Miguel. As expected, there were very few juveniles or subadults in the spring, whereas each island had >20 juveniles or subadults in the fall.

Average weights of mice varied by age, sex and island (Table 4). When spring 2012 weights of adult males were compared, Anacapa weights were highest and Santa Barbara weights lowest (Fig. 8). This may indicate higher habitat quality on Anacapa, and may partially explain the recent increase in mice there. Over time, Santa Barbara weights were generally lower than those on San Miguel (with a few exceptions), perhaps reflecting the lower annual precipitation on Santa Barbara Island.

Comparison of spring male weights over time on each island revealed differences among grids. On Santa Barbara Island, weights on both grids tracked closely until 2009 (Fig. 9). Weights were greater on the Terrace Coreopsis grid in 2009 and 2010, and greater on the Terrace Grassland grid in 2011 and 2012.

On San Miguel, there was no difference in spring male weights among the three grids in 2010-2012 (Fig. 10). Prior to that, weights were higher on the Nidever Canyon grid and lower on the Willow Canyon grid, with weights on the Airstrip grid falling between the two.

Table 3. Number of deer mice captured by age class and by sex on Santa Barbara, Anacapa and San Miguel Islands, 2012.

Island	Adults	Juveniles/ Subadults	Males	Females	Sex Ratio
<i>Spring</i>					
Santa Barbara	74	0	42	32	1.31
Anacapa	37	5	22	20	1.10
San Miguel	114	4	55	63	0.87
<i>Fall</i>					
Santa Barbara	23	21	22	22	1.00
Anacapa	107	26	61	72	0.85
San Miguel	126	23	79	70	1.13
Total			281	279	1.01

Summary

It is interesting that on both San Miguel and Santa Barbara Islands, mice on the grassland grids (Terrace Grassland and Willow Canyon) had weights that increased in 2009-2012. If weight is an indicator of habitat quality, grassland mouse weights suggest that there is high, or higher, habitat quality now on those grids than previously. The grids were established in the 1980s when those areas were dominated by nonnative grasses such as *Avena* spp., and mainland grassland habitat is generally poorer for deer mice (Drost and Fellers 1991). Colonization by native forbs and shrubs may be occurring in those on the island grassland grids, with an increase in habitat quality for mice, though, as stated previously, the Terrace Grassland grid is still considered to be 100% grassland. However, there are scattered small patches of California boxthorn (*Lycium californicum*) and island tarweed (*Hemizonia clementina*), which mice undoubtedly use for cover. The lower mouse abundance over time on the Terrace Grassland grid on Santa Barbara suggests that areas of non-native grass do not support mice to the degree that areas of native vegetation do. Such effects are not seen on San Miguel, where they may be swamped by the influence of the island fox as predator.

In summary, mice on Santa Barbara and San Miguel Islands appeared to be in the low phase of multi-year population cycles, whereas Anacapa mice may be in the high phase of a cycle. Except on Anacapa, fall 2012 abundance was not higher than in the spring. There were consistent 3-4 year population cycles on Santa Barbara, but on San Miguel, cycles changed over time. Annual cycles with spring minima and fall maxima, and overall increasing numbers, predominated through 2004, when island foxes were absent from the wild or at low densities. Multi-year cycles and decreasing numbers occurred from 2005-2012, when island foxes were at increasing to high densities. Lower habitat quality in grassland was suggested by decreased abundance and lower weights on grassland grids.

Table 4. Average weights of deer mice by age and sex class, 2012.

Season	Grid	Age	Sex	Average Weight (g)	n	SE
<i>Santa Barbara Island</i>						
Spring	TC	A	F	19.4	18	0.418
	TC	A	M	22.0	18	0.433
	TG	A	F	20.2	14	0.638
	TG	A	M	23.0	24	0.480
Fall	TC	A	F	19.0	7	0.359
	TC	A	M	18.1	11	0.508
	TC	J	F	12.5	1	0.000
	TC	S	F	13.6	10	0.491
	TC	S	M	14.4	7	0.180
	TG	A	F	17.5	3	0.764
	TG	A	M	18.8	2	1.750
	TG	S	F	16.3	1	0.000
	TG	S	M	14.8	2	0.500
<i>Anacapa Island</i>						
Spring	EI	A	F	26.3	17	0.983
	EI	A	M	24.2	20	0.532
	EI	S	F	15.9	3	0.300
	EI	S	M	16.6	2	0.375
Fall	EI	A	F	20.3	57	0.417
	EI	A	M	20.6	50	0.449
	EI	S	F	17.9	15	0.649
	EI	S	M	19.3	11	0.731
<i>San Miguel Island</i>						
Spring	AS	A	F	22.9	19	0.709
	AS	A	M	23.2	22	0.404
	NC	A	F	25.0	33	0.456
	NC	A	M	23.3	26	0.309
	NC	J	F	7.8	2	0.750
	NC	S	F	15.8	2	0.250
	WC	A	F	23.7	7	2.217
	WC	A	M	23.1	7	0.916
Fall	AS	A	F	18.5	15	0.555
	AS	A	M	18.9	24	0.564
	AS	S	M	15.8	2	0.250
	NC	A	F	18.8	23	0.552
	NC	A	M	19.3	28	0.507
	NC	S	F	16.5	10	0.293
	NC	S	M	16.8	3	0.167
	WC	A	F	17.9	19	0.407
	WC	A	M	18.6	17	0.670

Table 4. Average weights of deer mice by age and sex class, 2012 (continued).

Season	Grid	Age	Sex	Average Weight (g)	n	SE
<i>San Miguel Island</i>						
Fall	WC	S	F	15.7	3	0.441
	WC	S	M	15.3	5	0.122

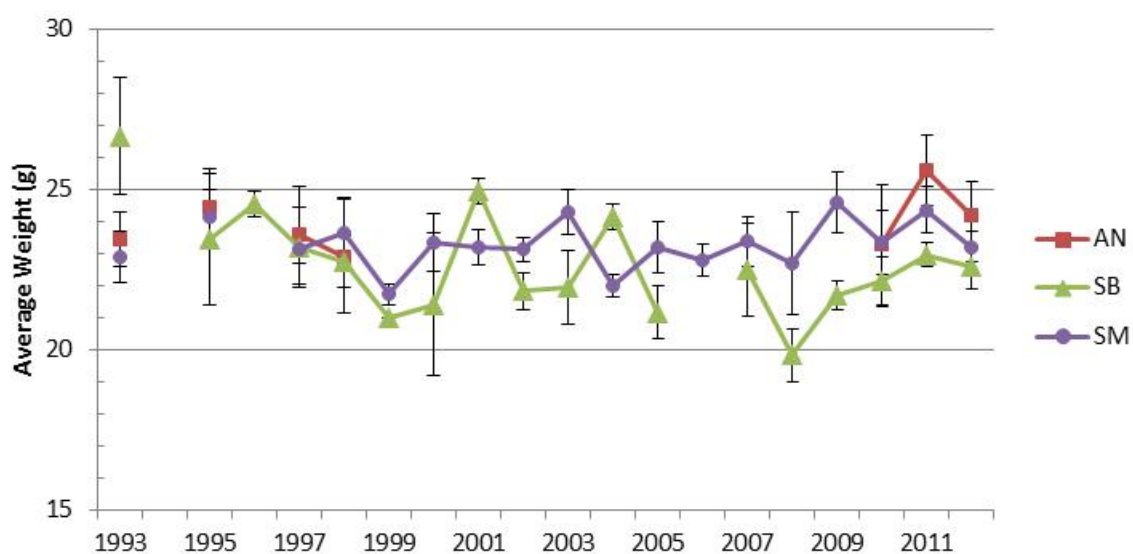


Figure 8. Average weights of adult male deer mice in springtime, for Anacapa (AN), Santa Barbara (SB) and San Miguel (SM) islands, Channel Islands National Park, 1993-2012.

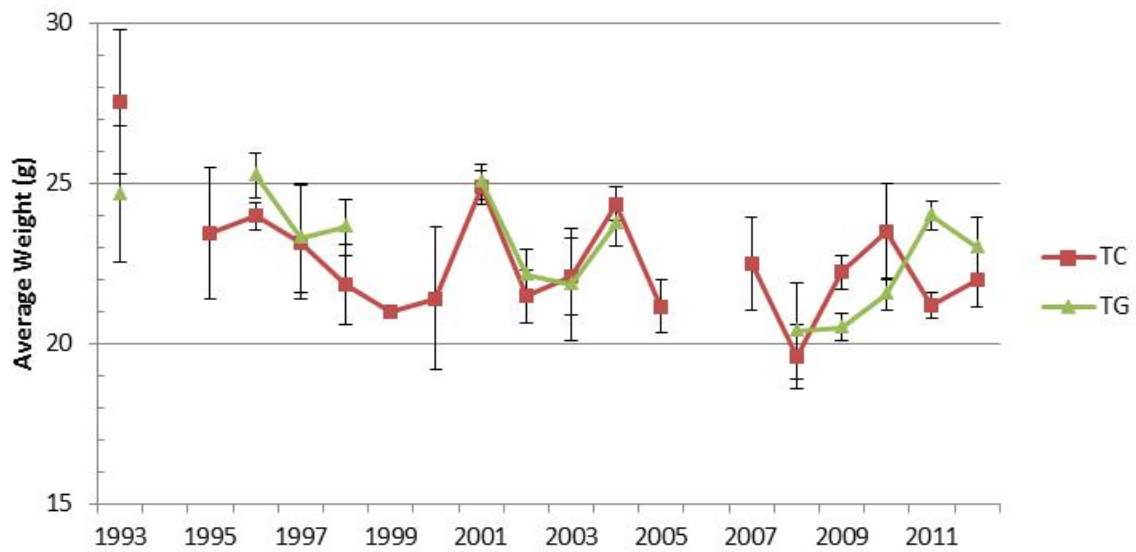


Figure 9. Average weights of adult male deer mice in springtime, on Santa Barbara Island, for the Terrace Coreopsis (TC) and the Terrace Grassland (TG) grids, 1993-2012.

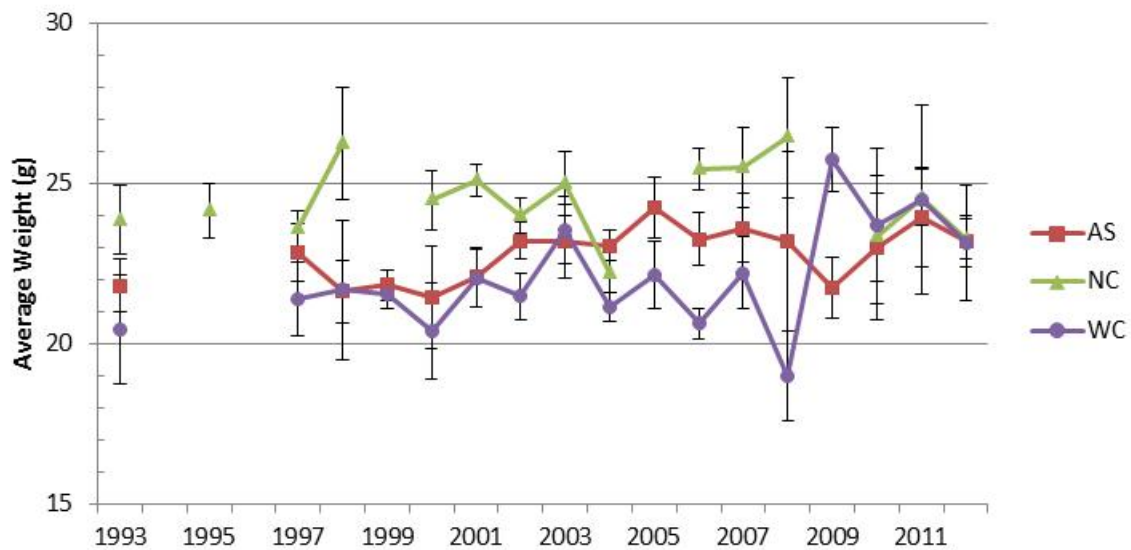


Figure 10. Average weights of adult male deer mice in springtime, on San Miguel Island, for the Airstrip (AS), Nidever Canyon (NC) and Willow Canyon (WC) grids 1993-2012.

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