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Terrestrial Vertebrate Monitoring
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ABSTRACT

Terrestrial vertebrate monitoring was conducted at Channel Islands National Park in 1996. This was the fourth year that island fox (*Urocyon littoralis littoralis*), deer mice (*Peromyscus maniculatus*), and reptiles and amphibians were sampled as part of the monitoring program. Population and density estimates were obtained from three island fox grids on San Miguel Island (SMI). In 1996, we were prevented from monitoring deer mice, and reptiles and amphibians on West Anacapa Island (WAI) in the spring, due to the presence of the federally endangered Brown pelican (*Pelicanus occidentalis*). However, as part of a research study to eradicate the black rat (*Rattus rattus*) from the Anacapa islets, mice were trapped on WAI and Middle Anacapa Island (MAI) in October, to estimate density and population numbers. In 1996, we also began monitoring deer mice on a new grid on San Miguel Island at the Dry Lake Bed (DLB). In all, deer mouse population and density estimates were obtained from three grids on SMI, two grids on MAI and one grid on WAI, and two grids on Santa Barbara Island (SBI). In addition, weight-length regressions were calculated for the reptiles and amphibians, as indicators of animal health, for each species island/combination. Of the six regressions calculated, four indicated a significant slope while the other two did not. Between 1995 and 1996, enough data had been collected on the SBI island night lizard (*Xantusia riversiana*) to conduct a regression comparison between the years; which indicated a significant change, with the slope of the line increasing from 1995 to 1996. Population index values were also calculated for the reptiles and amphibians for each species and transect.

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INTRODUCTION

Natural ranges of variation are poorly known in ecosystems, and can best be understood by long-term monitoring (Davis and Halvorson 1988). At Channel Islands National Park, long-term monitoring programs have been initiated for both marine and terrestrial resources.

In 1993 the terrestrial vertebrate monitoring program began. This program monitors seven species of native amphibians, reptiles, and terrestrial mammals on Anacapa, Santa Barbara, and San Miguel Islands (Fellers et al. 1988).

The island night lizard (*Xantusia riversiana)* is of particular interest because it is federally-listed as a threatened species. Similarly the island fox (*Urocyon littoralis littoralis)* is listed by the state as a threatened species. In addition, the island night lizard and island fox, and the subspecies of the deer mice, Pacific slender salamander (*Batrachoseps pacificus*), and western fence lizard (*Sceloporus occidentalis*) are all endemic to the Channel Islands.

The descriptions and methodologies of the program are explained in the Terrestrial Vertebrate Monitoring Handbook (Fellers et al. 1988). The purpose of the program is to track population trends by annual estimates of population density or indices of abundance for each species (Schwemm, 1996).

ISLAND FOX

Island fox monitoring continued on San Miguel Island (SMI) in 1996. This was the fourth year that island fox were monitored on Willow Canyon (WC) and San Miguel Hill (SMH) grids, and the third year of monitoring at the Dry Lake Bed grids (Figure 1). Density and population estimates were obtained for each of the grids.

Materials and Methods

In 1996 fox monitoring was conducted on WC grid from 31 July - 5 August, on SMH grid from 14-19 August, and on DLB grid from 28 August - 2 September. Trapping and marking protocols were identical to those described in Schwemm (1994) and (1996). The program CAPTURE (White et al. 1982) was used to select the population estimation model, the population estimation (N), and the mean maximum distance moved (MMDM) calculation. MMDM is a measure of the maximum distance an animal moves between successive years. Pups are excluded from the population estimate due to their close association with adults and their potential biasing effect on MMDM (Roemer et al. 1994). Estimates of density were obtained using standard methods for island fox (Roemer et al. 1994). In addition, the data are entered into the computer program ACCESS for long-term database management.

Results and Discussion

In 1996, 35 individuals including pups, were trapped on the 3 grids. Twenty of these (14 pups and 6 adults) were new animals which had never been previously tagged. Density estimates for WC and SMH varied, with WC being over double that of SMH (Table 1). In addition, the population estimates for WC and SMH varied, with the WC population estimate being more than double that of SMH (Table 1). Only 2 adults were captured on the DLB grid. Chapman's modification of the Lincoln-Peterson (LP) estimator for the population size estimation was used.(Table 1). Menkins and Anderson (1988) suggest that, in situations where model selection is poor (i.e., low capture probabilities, small population) use of Lincoln-Peterson estimate is often preferable to use of program CAPTURE.

The 1996 calculated average weights for adult foxes and pups are presented in Table 2. These weights were pooled from all grids for 1996.

Sex ratios for adults and pups are presented in Table 3. Sex ratio value is number of males per 1 female. Adult sex ratio for 1996 was 1.5:1, which was not significantly different from 1:1 ($x^2 = 0.800$, $p = 0.371$). Pup sex ratio for 1996 was 1.33:1, which was not significantly different from 1:1 ($x^2 = 0.286$, $p = 0.593$).

This was the first year of the monitoring program when we did not capture any foxes that were initially marked with collars during the design phase of the vertebrate monitoring program.

ISLAND DEER MICE

Island deer mice monitoring continued in 1996. This was the fourth year of the mice monitoring program. Two grids were monitored twice in 1996, while the remaining 5 grids were monitored once. Density and population estimates were obtained from these grids.

The deer mice are dominant components of the island communities. On Anacapa and Santa Barbara Islands they are the largest native land mammal. As abundant generalist granivores/predators, they undoubtedly have significant influence on the plants and terrestrial invertebrates on the islands, and as prey species, they largely determine the numbers of some of the resident hawks and owls (Fellers et al. 1988).

Materials and Methods

As stated in Austin (1995), there are 7 grids which are scheduled to be monitored twice a year. Mice were not monitored on SMI in the spring due to the lack of available personnel. In 1996, we created a new mouse trapping grid on SMI at the Dry Lake Bed (DLB) (Figure 2). We trapped the DLB grid (Table 4) during the summer fox monitoring session in order to gather fox prey information. In Spring 1996 we did not monitor mice on WAI due to the presence of the Brown pelican, a species federally listed as endangered. In the past, pelicans have nested at the edge of the mouse grid and we decided not to monitor this grid because monitoring activities may cause disturbance and abandonment of pelican nests. However, mice were trapped in October on MAI and WAI as part of the rat eradication research project and density and population estimates were obtained (Table 4).

For each grid, 100 traps are placed in a 10 x 10 grid with a trap spacing of 7 meters. Each trap is baited with rolled oats and the traps are opened for three consecutive nights. On their first capture, each animal is weighed, sexed, aged and marked with an ear tag. Deer mouse sampling methods are thoroughly described in the monitoring handbook (Fellers et al. 1988)

Capture history data are entered into the program CAPTURE (White et al. 1982), which selects an appropriate estimation model from which it calculates population size and density. The data are also entered into the computer program ACCESS for long-term database management.

Results and Discussion

Estimated population size and density are given for each grid in Table 4. Only two grids were trapped in both the spring and fall of 1996; SBI Terrace Coreopsis (TC) and SBI Terrace Grassland (TG). These were also the only two grids trapped in the spring. The high number of individuals captured at these two grids was similar in both the spring and fall (Table 4). Whereas looking back at SBI 1995 data, it shows that numbers where low in the both the spring (SBI-TC = 3) and fall (SBI-TG = 12). The very high numbers and wide population fluctuations of SBI deer mice are in contrast to the pattern of low to moderate numbers and relative stability normally seen in deer mice (Drost and Fellers, 1991).

Average weights by age class are presented in Table 5. Weights are generally highest in the spring when vegetation is abundant and densities are low, and are lowest in the fall when preferable food sources become scarce and densities increase (Schwemm, 1995). This has been seen on the other island mouse grids when enough data has been collected throughout the entire year (Schwemm 1995, Austin 1996). This also holds true for the average weights of the SBI mice (except that the densities are high in both the spring and the fall). Average adult mice weights for SBI-TC and TG are higher in the spring than in the fall. In addition, many more mice were reproductively active in the spring (SBI-TC, N=35; SBI-TG, N=51) than in the fall (SBI-TC, N=12; SBI-TG, N=3), which will also lead to higher average weights of both males and females.

A slightly higher ratio of males to females has generally been recorded for deer mice in both wild and laboratory experiments (Collins et al. 1979). Tables 6, 7 and 8 show sex ratios for the different age classes. Sex ratios (males:females) for all age classes combined was 1.20:1 (Table 6), which differed significantly from 1:1 ($x^2 = 7.744$, $p = 0.005$). The adult sex ratio was 1.26:1 (Table 7), which also differed significantly from 1:1 ($x^2 = 10.979$, $p = 0.001$). The sex ratio for the sub-adult/juvenile age class was .73:1 (Table 8), which favored females, but it did not differ significantly from 1:1 ($x^2 = 1.895$, $p = 0.169$).

AMPHIBIANS AND REPTILES

In 1996, six reptile and amphibian transects on six different islands were sampled by means of coverboards (Figures 2, 8, 9). All six of the transects were sampled twice, once in the spring and again in the fall.

Materials and Methods

The reptile and amphibian coverboard transects generally consist of 60 boards arranged in two rows of 30. The rows are approximately 5 meters apart and the spacing between boards is approximately 5 meters. However, the SBI cave/middle transect consists of 60 boards arranged in 3 rows of 20. Also, both of the transects on MAI consist of 30 boards; the grassland transect has 30 boards in one line, and the sagebrush transect has 2 rows of 15 each. The boards are 12 in. x 12 in. x 2 in. pieces of pine or fir, and the end board in each row is numbered with a metal tag (eg. 1, 30, 31, 60). Coverboard transects are checked twice a year, once in the spring and once in the fall.

Methods used for sampling amphibians and reptiles are thoroughly described in the monitoring handbook (Fellers et al. 1988).

Results and Discussion

A population index was calculated for lizard species on transects which were checked at least twice throughout the year. The population index values are calculated by dividing the total number of animals found on a transect in a sampling year (this includes all animals which escaped before handling) by the total number of boards checked (Fellers et al. 1988). Most transects have 60 coverboards (some have 30). If there's 60 boards, and spring numbers = x, and fall numbers = y, then the index = x + y/120. Table 9 shows the population indices for transects which were checked twice in 1996.

Short term changes in population indices can be examined by comparing the current with the previous year's population index by using a chi-square contingency analysis (Fellers et al. 1988). This tests the hypothesis that the frequencies of occurrences of one variable (transect) are independent of the frequencies of the second variable (transect) (Zar 1974). Thus, the null hypothesis is that; for each transect (independently), the lizard species will be found in the same proportions in successive years. From 1995 to 1996 a chi-square comparison, using the Fischer exact test, was conducted between the SBI night lizard Cave-Middle Cyn. transect (CM) and Terrace Grassland (TG) transect. No other transects were trapped twice in both 1995 and again in 1996. The P-value calculated is 0.795, thus the null hypothesis was not rejected, i.e., the night lizard proportions were not significantly different between successive years at both CM and TG transects.

The handbook also calls for a calculation of weight-length regressions. As stated in the monitoring handbook, the monitoring program will yield extensive data on the night lizard, and the alligator lizard, and when the ground is sufficiently moist it will also yield extensive data on the salamander, and we finding that this holds true. The mass of an animal relative to its length can provide an indication of its health, because healthier animals of a given length are likely to weigh more (Fellers et al. 1988).. We previously thought that because weight-length regressions are meant to be an indicator of the overall general health of the population, there should be a minimum number of individuals captured to adequately represent the population, and at least 2 samples per year (Austin 1995). However, what needs to be considered is the number of transect samples used for between year comparisons of "population health". Presently, we attempt to check the herp transects twice a year, once in the spring and once in the fall, and the handbook directs that the current year's regressions be compared with the previous year's. Thus when comparing the current year's regression slope with the previous year's, only like sampling seasons should be considered. For example, if a transect was sampled only in the spring of 1995, but sampled in the spring and fall of 1996, only the spring sampling periods should be compared.

Figures 3 through 8 show regressions for 1996. Figure 3 shows a regression for alligator lizards (*Elgaria sp.*) on East Anacapa Island (EAI). The regression indicates a significant slope with P = 0.00 and an R^2 = 0.58, i.e. indicating that weight has a positive linear dependence on length. Both the Inspiration Point and Terrace Grassland coverboard transects were checked in the spring and fall of 1996, and alligator lizards were found during both these trapping sessions and at both transects (Table 9). Figure 4 shows the regression for EAI Pacific slender salamander. This regression indicates a significant slope with P = 0.002 and R^2 = 0.460. *Batrachoseps* were found under the coverboards only during the spring trapping sessions (Table 9). Figure 5 shows the regression for the SBI island night lizard. This regression indicates a significant slope with P = 0.00, and R^2 = 0.920. Island night lizards were found in both the spring and fall at both coverboard transects (Table 9). Figure 6 shows the regression for SMI slender salamander. This regression indicates a significant slope with P = 0.00, and R^2 = 0.899. Salamanders were caught at both the Nidever and Airstrip transects during the spring, and only at the Nidever transect in the fall (Table 9).

The two following regressions do not have a significant slope (i.e. P > .05) indicating that weight did not have a positive linear dependence on length. Figure 7, shows the regression for San Miguel Island (SMI) alligator lizard. This regression indicates that it is not a significant slope (P = 0.4111, R^2 = 0.098). Alligator lizards were found only during the fall trapping session on this transect. One alligator lizard was found at the Airstrip in the spring (and was used in the population index calculation) but escaped before being measured. The data from 2 individuals has been deleted due to their associated large leverage (see below). In 1996, the western fence lizard, was trapped in the fall on the SMI Airstrip grid, N = 5 (Table 9). As pointed out in the protocols, the coverboards do not yield extensive data on the fence lizard. Figure 8 shows the regression for SMI fence lizard. The regression indicates that it is not a significant slope, P = 0.567, R^2 = 0.121, i.e. weight does not have a positive linear dependence on length.

Between 1995 and 1996, only SBI had enough data collected for a regression comparison of the island night lizard. An F test was used to test the equality of the regression coefficients between the 2 years. This tests the hypothesis of whether the slopes of the lines are significantly different. The results show that the computed value is greater than the table critical value: computed value = 59.045, P = 0.000+. $F_{0.05\,(2)1,\,62}$ = 5.25. Since the computed value is greater than the table critical value, the null hypothesis is not accepted. Thus the slopes of the regression functions for SBI island night lizard from 1995 and 1996 are significantly different, with the slope of the line increasing from 1995 to 1996.

In 5 of the 6 preceding regressions, outliers are found. When outliers are present, it is important to study the outlying cases carefully and decide whether they should be retained or eliminated (Neter et al. 1996). A safe rule frequently suggested is to discard an outlier only if there is direct evidence that it represents an error in recording, a miscalculation of equipment, or a similar type of circumstance (Neter et al. 1996). For this report all outliers are retained. Every animal has been handled and treated the same. However, leverage cases are handled differently. Values of leverage less than 0.2 appear to be safe; between 0.2 and 0.5 risky; and above 0.5, to be avoided (SYSTAT, v.6, 1996). In the preceding regressions, any leverage case 0.5 and above has been deleted.

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Figure 1. Island fox sampling grids on San Miguel Island, California.

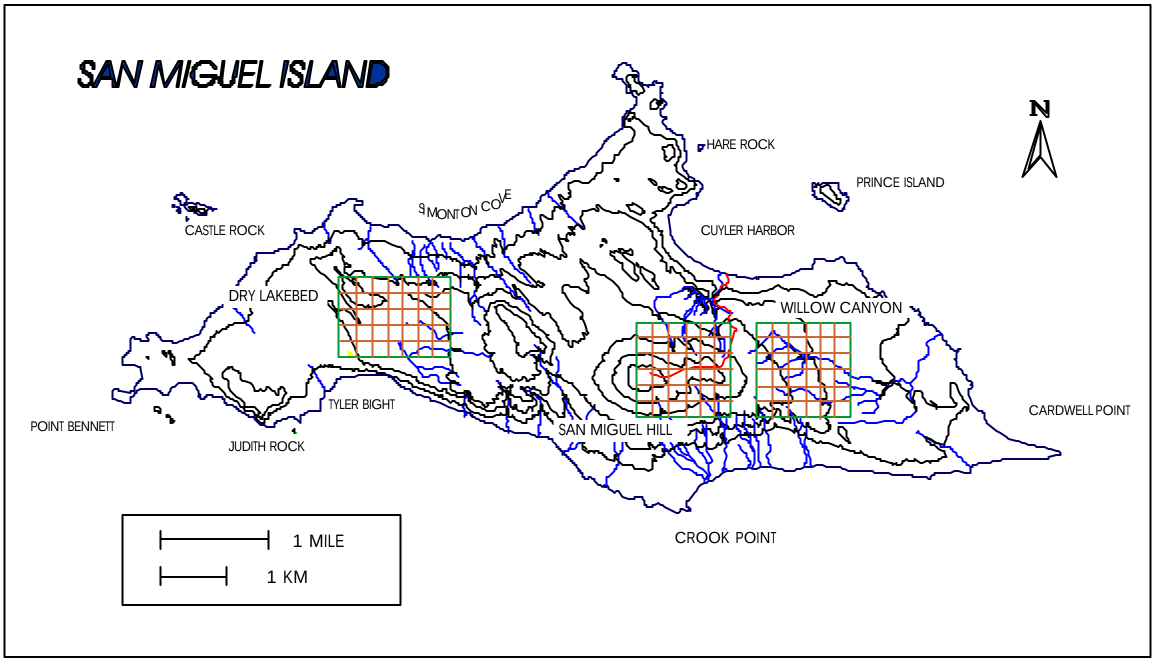


Figure 2. Deer mouse sampling grids and amphibian/reptile sampling transects on San Miguel Island, California.

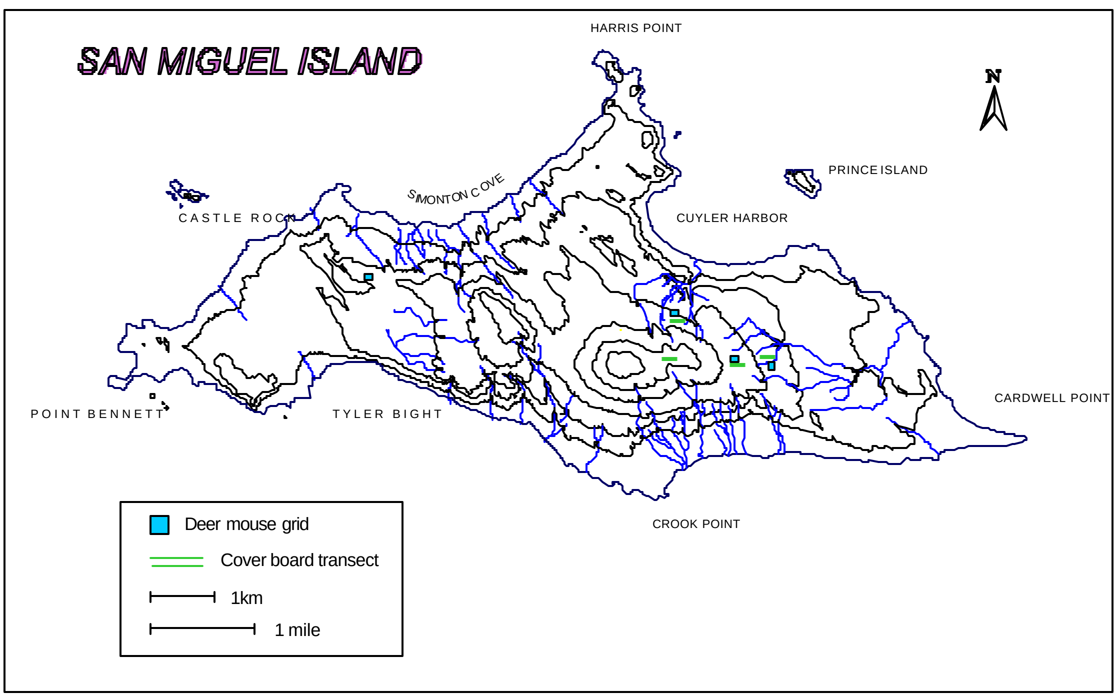


Table 1. Total number of individuals, adults and pups captured, model used, population estimate and 95% confidence interval, capture probability, and density estimate for island fox trapping grids, San Miguel Island, 1996.

	Willow Canyon	**San Miguel Hill**	**Dry Lake Bed**
Trap Nights	6	6	6
Individuals caught	19	11	5
Total adults	13*	6	2
Total pups	6	5	3
CAPTURE model [1] used	M(h)	M(h)	**
Population estimate (95%Confidence Interval)	17 (14-31)	8 (7-15)	2 #
Capture probability	0.2157	0.3125	**
Density estimates w\out pups	4.7/km^2	1.9/km^2	**

[1] M(h) = jackknife estimator
= Chapman's modification of the Lincoln-Peterson estimator used
* = One adult escaped before being worked up.
** = Not enough animals captured to calculate population or density estimates.

Table 2. Average weights of island fox from all grids, San Miguel Island, 1996.

	# of individuals	Ave. Weights (kg.)	Standard Error
Adults			
Males	12	2.36	.040
Females	8	2.07	.071
Pups			
Males	8	1.26	.081
Females	6	1.48	.135

Table 3. Sex ratios of island fox from all grids, San Miguel Island, 1996.

	Adult	Pups
Male	12	8
Female	8	6
Ratio	1.5	1.33

Table 4. Total number of island deer mice captured, model used, density estimate, standard error, population estimate, and 95% confidence interval for mice trapping grids, Channel Islands National Park, 1996.

Island	Date	Grid/ Habitat Type	# of Individuals Captured	Model Selected (Capt. Prob.)	Estimated Density/ha, (s.e.)	Population Estimate, (95%C.I)
SBI	27-29 Mar.96	Terrace Coreopsis	131	Mh, (.36)	390 (54.4)	159 (147-181)
SBI	27-29 Mar.96	Terrace Grassland	100	Mh, (.31)	166 (52.9)	135 (120-163)
SMI	29 Aug.-2 Sept.96	Dry Lake Bed Lupine - shrub	131	Mh, (.27)	187 (30)	154 (145-172)
*WAI	4-6 Oct. 96	Grassland	24	Mh, (.54)	127 (20.8)	25 (25-32)
*MAI	4-6 Oct. 96	Grassland	53	Mh, (.51)	229 (23.9)	56 (54-65)
*MAI	4-6 Oct. 96	Slope	57	Mh, (.40)	244 (74.2)	68 (62-84)
SBI	16-18 Oct. 96	Terrace Coreopsis	127	Mh, (.25)	262 (57.8)	212 (190-242)
SBI	16-18 Oct. 96	Terrace Grassland	84	Mt, (.20)	362 (74.7)	158 (122-231)
*WAI	19-21 Oct. 96	Slope	41	Mbh, (.67)	171 (20.8)	42 (42-50)
SMI	24-26 Oct. 96	Airstrip (Grassland- shrub)	127	Mh, (.35)	379 (58.1)	157 (144-179)
SMI	27-29 Oct. 96	Willow Canyon (Grassland)	100	Mh, (.24)	261 (61)	173 (153 -200)

* = 7 x 7 grids

Table 5. Deer mouse average weights (grams), by age class, sex and grid, Channel Islands National Park, 1996.

Island/Grid	Date	Ave. Adult Weights (# of Individuals)		Ave. Sub-Adult Weights (# of Individuals)		Ave. Juvenile Weights (# of Individuals)	
		Female	Male	Female	Male	Female	Male
SBI-TC	27-29 Mar.	24.9 (59)	24 (68)		18.1 (1)		
SBI-TG	27-29 Mar.	28.1 (33)	25.2 (56)	16 (1)	16.2 (5)	11.1 (3)	15.6 (2)
*SMI-DLB	29 Aug.-2 Sept.	16.6 (31)	17.8 (34)	13.8 (3)	14.3 (2)		
WAI	4-6 Oct.	18.1 (11)	18.8 (4)	16 (4)	17.2 (3)		
MAI	4-6 Oct.	19.1 (12)	19.5 (16)	15.5 (4)	15.7 (3)	10.8 (6)	12 (1)
MAI-SLP	4-6 Oct.	18.9 (21)	18.8 (17)	14.3 (12)	10 (1)		
SBI-TC	16-18 Oct.	16.4 (44)	17.2 (72)	13.7 (3)	12.9 (2)		
SBI-TG	16-18 Oct.	16.5 (24)	17.7 (55)	14.8 (4)			
SMI-AS	24-26 Oct.	16.6 (52)	17.5 (67)	14 (1)	14.1 (4)		
SMI-WC	27-29 Oct.	17.1 (49)	17.7 (46)	15.3 (2)	13 (2)		

* This grid was trapped for 5 nights. During the first two days of trapping we did not have a scale for weighing the animals. We were able to weigh all animals on the remaining days, in

addition we weighed any recapture from the first two days, subsequently not all animals were weighed.

Table 6. Sex ratios for deer mice, all age classes, 1996. Sex ratio value is number of males per one female

Island/Grid	N	Male	Female	Sex Ratio
SBI-TC	250	143	107	1.34
SBI-TG	184	119	65	1.83
SMI-DLB	150	79	71	1.11
WAI	24	7	17	.41
MAI	47	22	25	.88
MAI-SLP	52	19	33	.58
SMI-AS	126	72	54	1.33
SMI-WC	100	48	52	.92
Total	933	509	424	1.20

Table 7. Sex ratios for adult age classes, 1996. Sex ratio value is number of males per one female.

Island/Grid	N	Male	Female	Sex Ratio
SBI-TC	244	140	104	1.35
SBI-TG	169	112	57	1.96
SMI-DLB	141	74	67	1.10
WAI	17	4	13	.31
MAI	31	16	15	1.07
MAI-SLP	39	18	21	.86
SMI-AS	120	67	53	1.26
SMI-WC	96	46	50	.92
Total	857	477	380	1.26

Table 8. Sex ratio for sub-adult and juvenile age class, 1996. Sex ratio value is number of males per one female.

Island/Grid	N	Male	Female	Sex Ratio
SBI-TC	6	3	3	1.0
SBI-TG	15	7	8	.88
SMI-DLB	9	5	4	1.25
WAI	7	3	4	.75
MAI	16	6	10	.6
MAI-SLP	13	1	12	.08
SMI-AS	6	5	1	5.0
SMI-WC	4	2	2	1.0
Total	76	32	44	.73

Table 9. Locations, dates, species, and index values for lizards on Channel Islands National Park, 1996.

Island/Grid	Date(s)	Species	# of Lizards	Population Index Value
EAI-IP*	3/20/96	BP♦	8	
	10/8/96	BP	0	.07
EAI-IP	3/20/96	EM	3 + 1	
	10/8/96	EM	6 + 1	.09
EAI-TG	3/20/96	BP	20	
	10/8/96	BP	0	.17
EAI-TG	3/20/96	EM	8 + 2	
	10/8/96	EM	6	.13
SBI-CM	3/28/96	XR	19 + 9	
	10/16/96	XR	8 + 4	.33
SBI-TG	3/27/96	XR	+ 2	
	10/17/96	XR	5	.06
SMI-AS	4/25/96	BP	5	
	10/24/96	BP	0	.04
SMI-AS	4/25/96	EM	1	
	10/24/96	EM	9	.08
SMI-AS	4/25/96	SO	0	
	10/24/96	SO	5 + 1	.05
SMI-NI	4/23/96	BP	6 + 1	
	10/31/96	BP	3	.08
SMI-NI	4/23/96	EM	0	
	10/31/96	EM	2	.02

A "+" before any number means that an animal was present but it escaped before being handled. Escaped animals are used as part of the population index calculation, whereas they are not used for weight-length regressions.

* EAI -IP = East Anacapa Island, Inspiration Point
EAI-TG = East Anacapa Island, Terrace Grassland
SBI-CM = Santa Barbara Island, Cave Middle
SBI-TG = Santa Barbara Island, Terrace Grassland

SMI-AS = San Miguel Island, Airstrip
SMI-NI = San Miguel Island, Nidever

♦BP = *Batrachoseps pacificus* = Pacific slender salamander
EM = *Elgaria multicarinatus* = Southern alligator lizard
SO = *Sceloporus occidentalis* = Western fence lizard
XR = *Xantusia riversiana* = Island night lizard

Figure 3. East Anacapa Island alligator lizard weight-length regression, 1996.

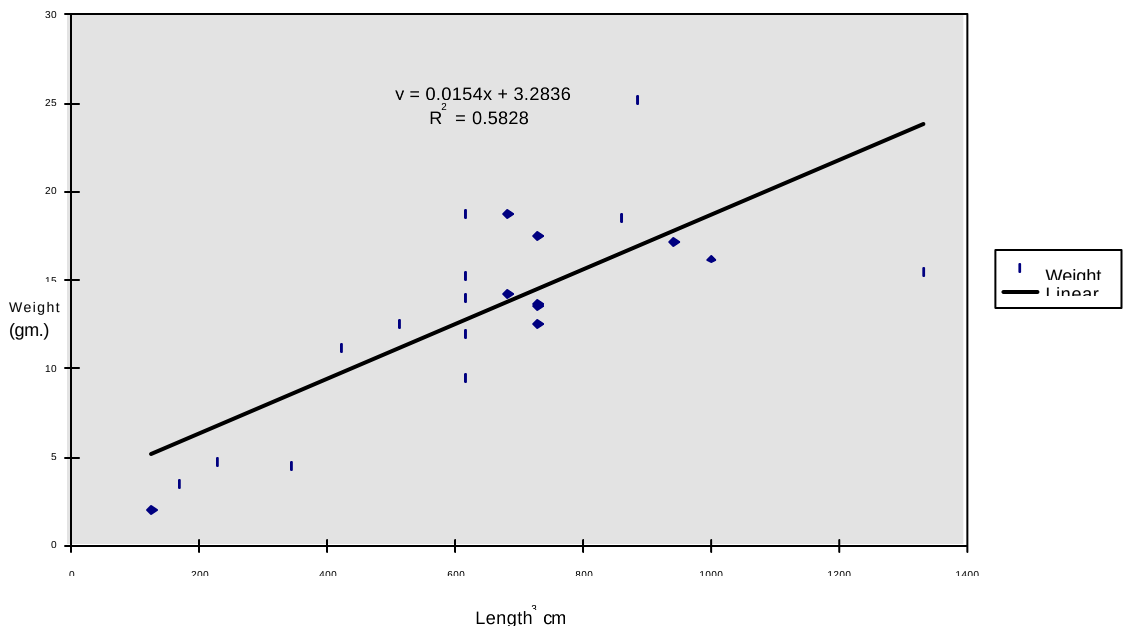


Figure 4. East Anacapa Island pacific slender salamander weight-length regression, 1996**.**

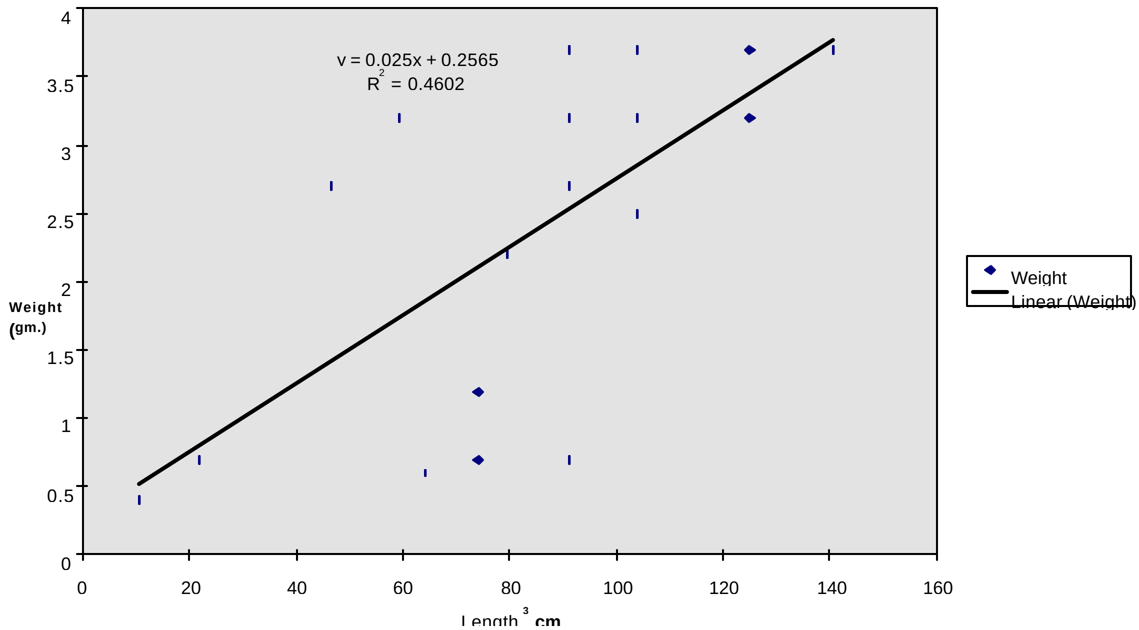


Figure 5. Santa Barbara Island island night lizard weight-length regression, 1996.

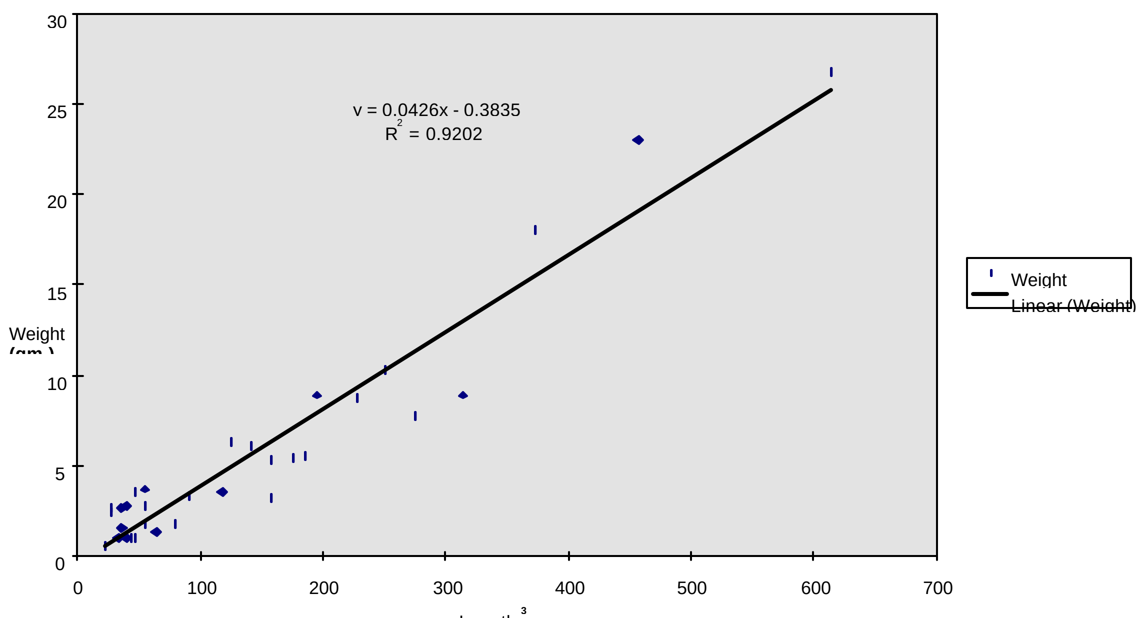


Figure 6. San Miguel Island pacific slender salamander weight-length regression, 1996.

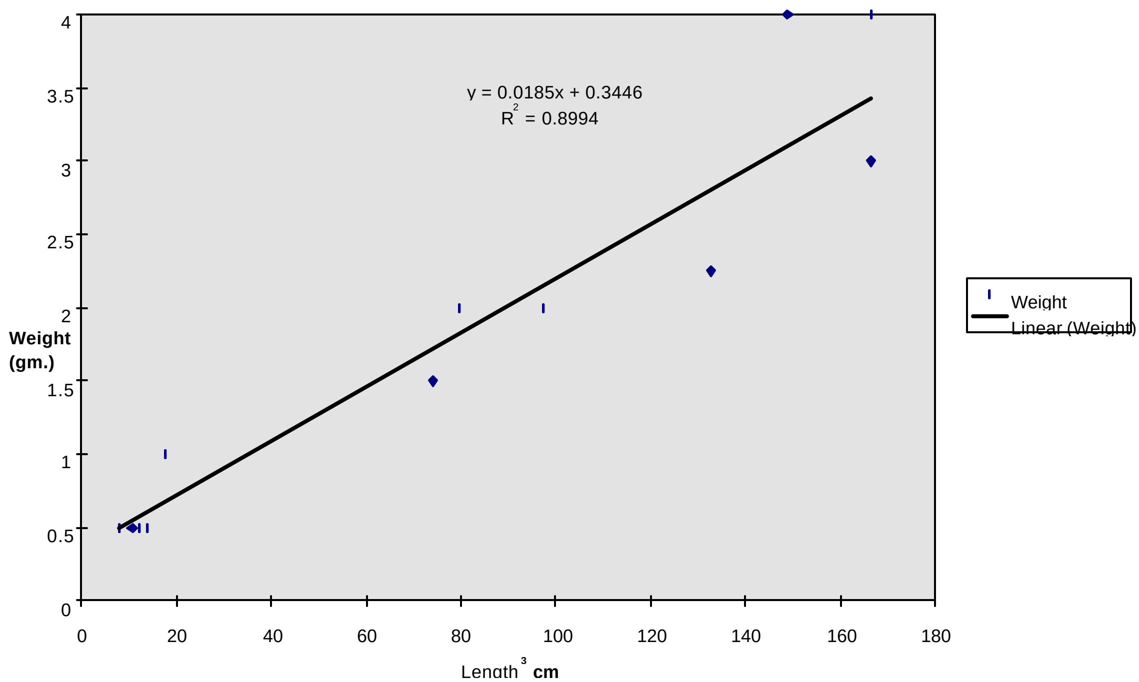


Figure 7. San Miguel Island alligator lizard weight-length regression, 1996

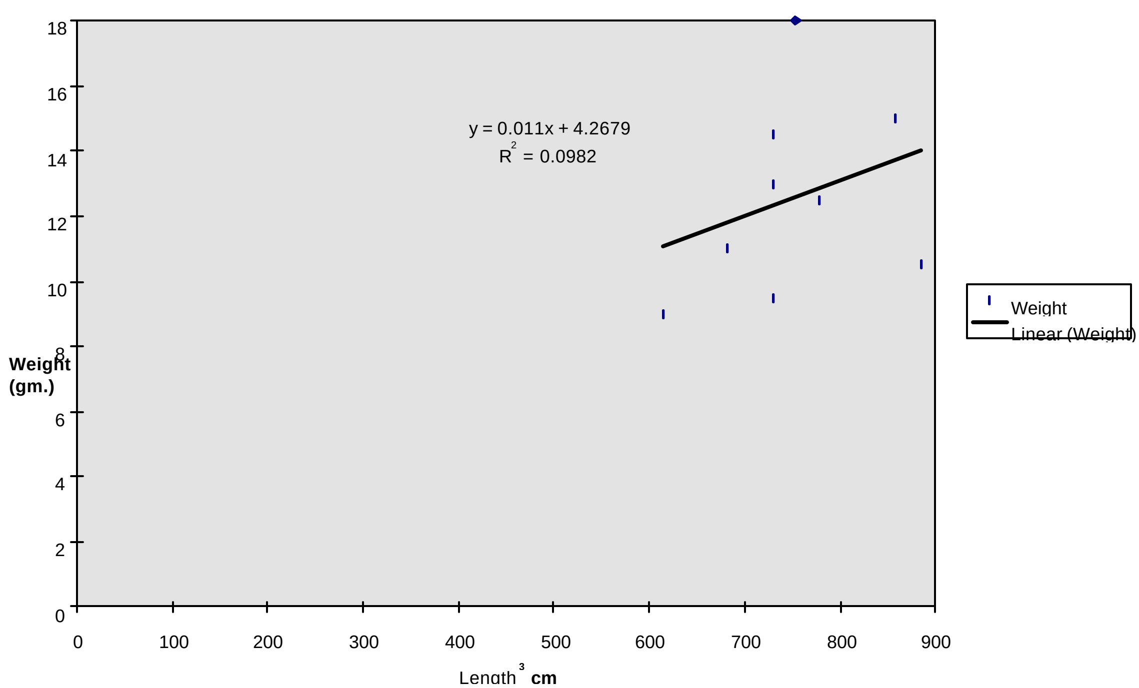
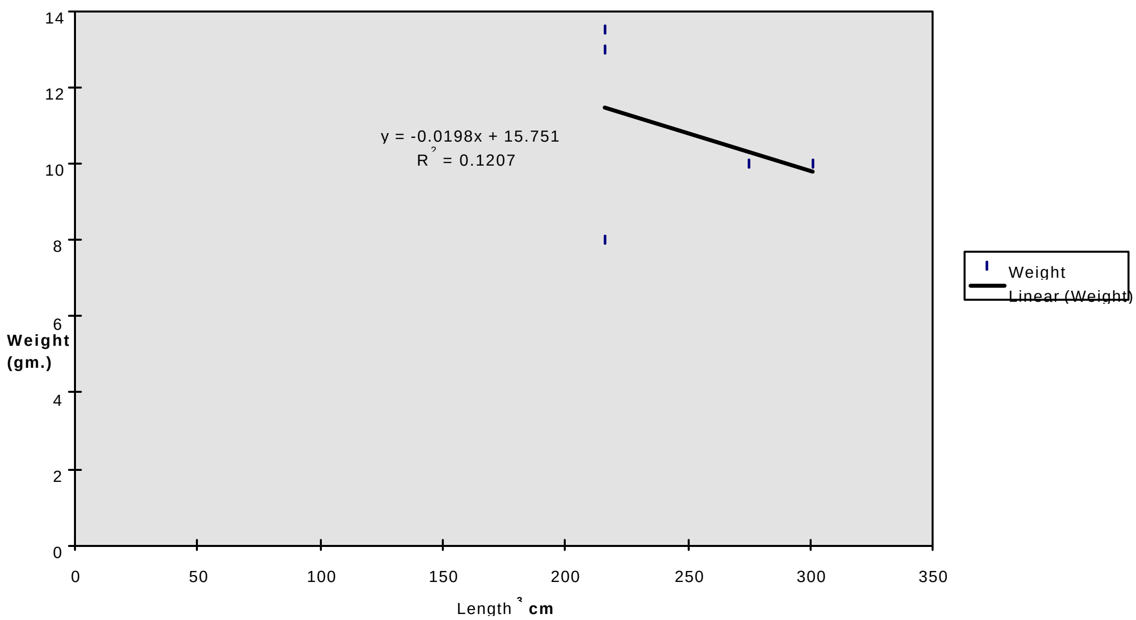


Figure 8. San Miguel Island western fence lizard weight-length regression, 1996.



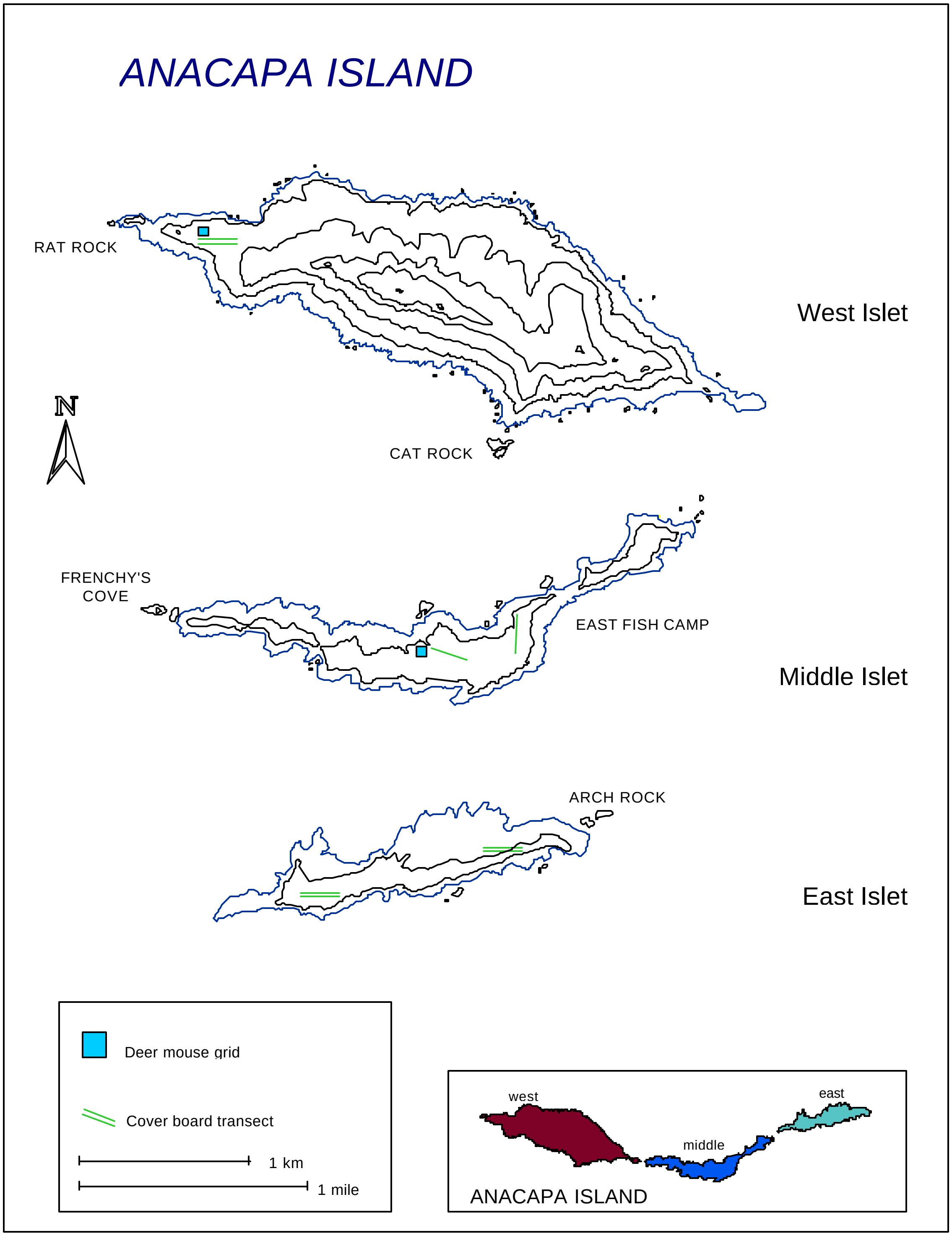


Figure 9. Deer mouse sampling grids and amphibian/reptile sampling transects on Anacapa Island, California.

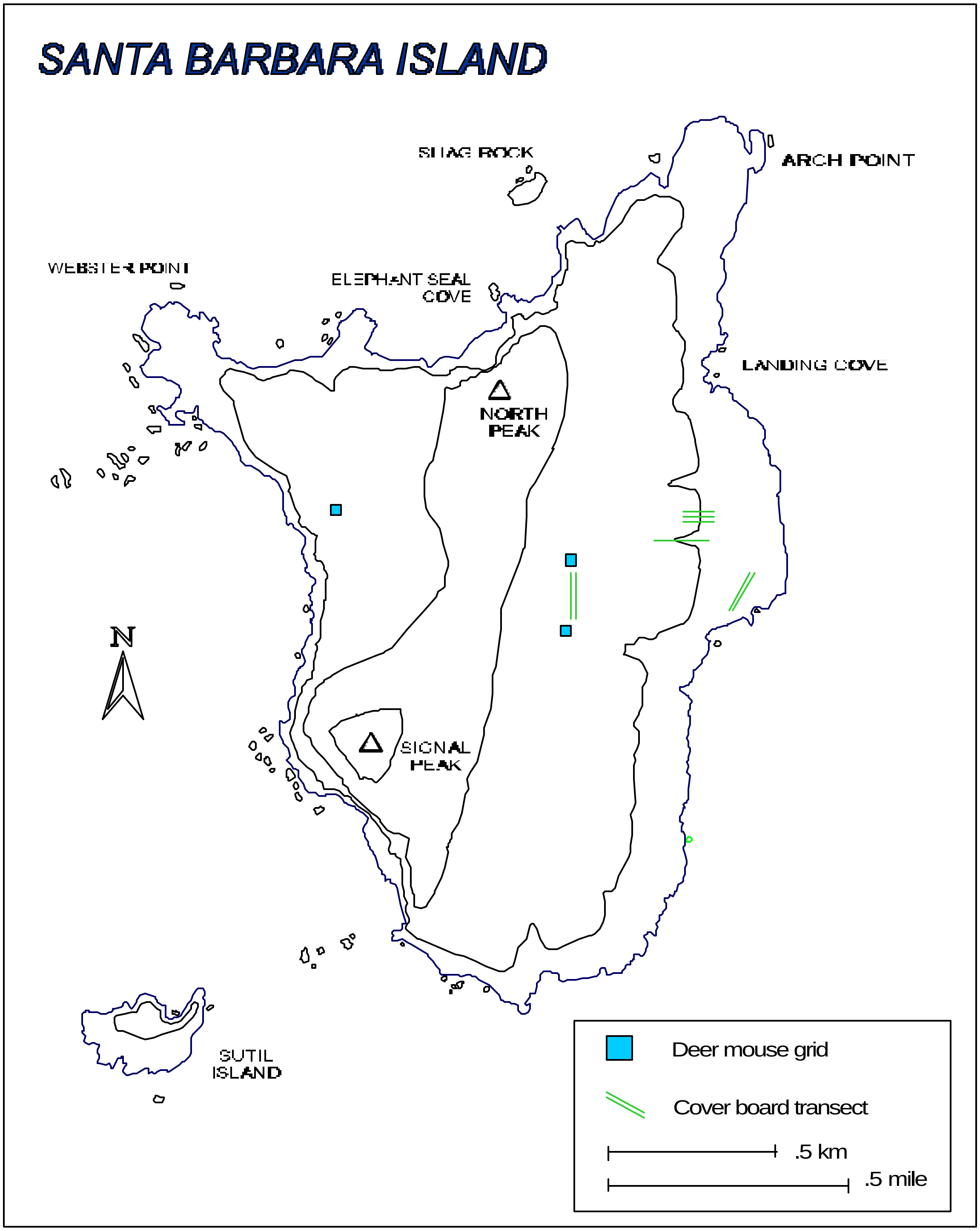


Figure 10. Deer mouse sampling grids and reptile sampling transects on Santa Barbara Island, California.