



Reptile and Amphibian Monitoring

Channel Islands National Park 2010–2015 Annual Report

Natural Resource Report NPS/MEDN/NRR—2021/2266





ON THIS PAGE

Biologist Cathy Schwemm and Ranger Ian Williams check cover boards on San Miguel Island, 1993
NPS

ON THE COVER

Island night lizard, Santa Barbara Island
NPS

Reptile and Amphibian Monitoring

Channel Islands National Park 2010–2015 Annual Report

Natural Resource Report NPS/MEDN/NRR—2021/2266

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Executive Summary

In 2010–2015, staff at Channel Islands National Park monitored reptile and amphibian populations on three of the park’s five islands, using methods developed in the 1980s for the park’s long-term ecological monitoring program. Herpetofauna have been monitored regularly since 1993 by recording lizard and amphibian abundance on cover board transects located in areas of representative native habitat on Santa Barbara, Anacapa, and San Miguel Islands. We collect data on all five herpetofauna species that are present on these three islands. The methods return adequate abundance data for island night lizards (*Xantusia riversiana*), southern alligator lizards (*Elgaria multicarinata*) (Figure 1), and Channel Islands slender salamanders (*Batrochoseps pacificus*), but do not pick up sufficient numbers of island fence lizards (*Sceloporus occidentalis beckii*) or side-blotched lizards (*Uta stansburiana*) to determine their status.

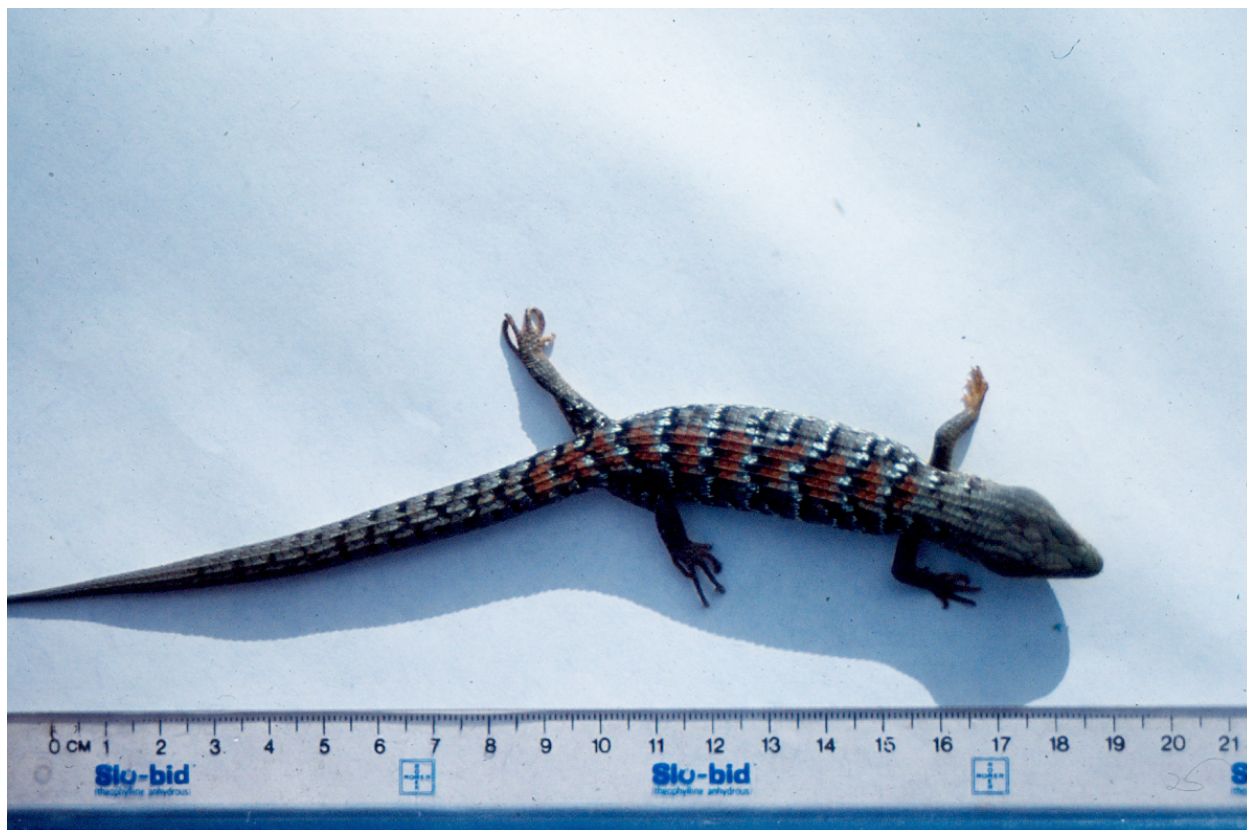


Figure 1. Southern alligator lizard, San Miguel Island.

In the park, island night lizards occur only on Santa Barbara Island, and in 2014 they were removed from the Federal list of endangered and threatened species. They are long-lived and occur at high densities. Our 20-year dataset indicates high recruitment of night lizards in the mid-1990s, after the end of a six-year drought, and then lower but apparently cyclic recruitment following that. The age structure is dominated by older individuals, which may have suffered some mortality in the droughts

of 1986–1992 and 2011–2015. However, overall, night lizards have increased in abundance, and may generally be buffered from the effects of drought by their underground habits.

Channel Islands slender salamander numbers also increased over time on San Miguel Island cover board transects, even throughout the current drought. Like night lizards, they may also be buffered from drought by their proclivity to remain underground unless sufficient precipitation has fallen.

Alligator lizard abundance declined over time on all three San Miguel Island cover board transects and on two Anacapa Island transects. Unlike the other two species analyzed, alligator lizards are active mainly aboveground, and may be more susceptible to the effects of drought.

For the two larger species (night lizards and alligator lizards), we assessed annual body condition, using the slope of the regression line of weight on snout-vent length cubed. The regression slope coefficient varied over time in night lizards, and the species also showed some cyclicity in recruitment. For alligator lizards on East Anacapa, the slope of the weight-length regression generally increased over time.

Acknowledgments

A number of park staff and volunteers conducted herpetofauna monitoring during the study period, and we thank Angela Guglielmino, Helen Fitting, Andy Abate, Robyn Shea, Jen Savage, Renae Sattler, Jim Howard and Nicole LaRoche for turning over those cover boards (and successfully catching almost all the herpetofauna underneath them!). The fieldwork was capably directed and scheduled by Angela Guglielmino. Tom Philippi helped immensely with the R code utilized to investigate slopes of weight-length regressions. The bang-up maps of herpetofauna cover board locations were made by Rocky Rudolph. Thanks to Kate Faulkner for reviewing the draft.

Gary Fellers and Charles Drost developed the herpetofauna monitoring program way back when, and I thank them for coming up with a robust yet simple program that has stood the test of time and returned some interesting data. A number of people kept the vertebrate monitoring program going over the years, despite a lack of funding and appreciation, and for that I thank Paige Martin and, especially, Cathy Schwemm.

We thank Stacey Ostermann-Kelm for thorough and helpful reviews of the draft report. Kasey Rolih provided final edits and layout.

Background

Similar to other vertebrate taxa, the herptile fauna on California's Channel Islands is depauperate compared to that of the nearby mainland. Channel Islands National Park comprises five of the eight Channel Islands (Figure 2), and three of the park islands harbor just 1–3 reptile and amphibian species (Table 1).



Figure 2. Channel Islands National Park comprises San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands.

Table 1. Reptile and amphibian species of Channel Islands National Park (nomenclature is from Collins and Taggart 2009). X = present on island. SB = Santa Barbara Island, AN = Anacapa Island, SC = Santa Cruz Island, SR = Santa Rosa Island, SM = San Miguel Island. *Note:* CHIS only conducts I&M herptile monitoring on Santa Barbara, Anacapa, and San Miguel islands.

Taxonomic Group	Common Name	Scientific Name	SB	AN	SC	SR	SM
Amphibians	Black-bellied slender salamander	<i>Batrachoseps nigriventris</i>	–	–	X	–	–
	Channel Islands slender salamander*	<i>B. pacificus</i>	–	X	X	X	X
	Baja California tree frog	<i>Pseudacris hypochondriaca</i>	–	–	X	X	–
Reptiles	Island night lizard*	<i>Xantusia riversiana</i>	X	–	–	–	–
	Southern alligator lizard	<i>Elgaria multicarinata</i>	–	X	X	X	X
	Island fence lizard*	<i>Sceloporus occidentalis beckii</i>	–	–	X	X	X
	Side-blotched lizard	<i>Uta stansburiana</i>	–	X	X	–	–
	Santa Cruz Island gopher snake*	<i>Pituophis catenifer pumilus</i>	–	–	X	X	–
	Western yellow-bellied racer	<i>Coluber constrictor mormon</i>	–	–	X	–	–
	San Diego nightsnake	<i>Hypsiglena ochrorhyncha klauberi</i>	–	–	X	–	–

* Denotes endemic species

As with other island vertebrates, there is a high degree of endemism among reptiles and amphibians of the Channel Islands. The Santa Cruz Island gopher snake, Channel Islands slender salamander, island fence lizard, and island night lizard occur only on the islands. In the park, the island night lizard occurs only on Santa Barbara Island, and also on San Nicolas and San Clemente Islands (owned by the U.S. Navy). It is perhaps the most unique of the archipelago's herptile fauna. Island night lizards live 20–30 years, bear live young, and have a very slow metabolism, enabling them to live at high densities with very small territories (Fellers and Drost 1991). Concern about the impacts of past grazing practices on island night lizard habitat prompted the U.S. Fish and Wildlife Service to list the island night lizard as threatened in 1977 (U.S. Fish and Wildlife Service 1977), making it one of the first species listed under the Endangered Species Act of 1973. Recent research indicates that the lizard lives at much higher densities, and thus at higher population size, than was previously known; because of this, the species was delisted in 2014 (U.S. Fish and Wildlife Service 2014).

With relatively few species and a high degree of endemism, reptiles and amphibians were a good fit for inclusion in the park's long-term ecological monitoring program (Davis et al. 1994). The park's vertebrate monitoring protocol (Fellers et al. 1988), developed in the 1980s, had the ambitious goal

of monitoring populations of all terrestrial vertebrate species on the three islands under management by the National Park Service (NPS) at that time (Santa Barbara, Anacapa, and San Miguel Islands).

Transects of cover boards were established in representative stands of native vegetation on the three islands. Although methods such as pitfall trapping may have targeted a greater number of species, cover boards had the advantage of being able to be checked just one day per sampling period, and would not require disturbance of island soil (much of which has archeological remains).

Due to funding constraints, herpetological monitoring was never extended to the larger islands (Santa Cruz and Santa Rosa) when ownership of some or all of those islands was transferred to the NPS. Thus, some interesting species, such as the Santa Cruz Island gopher snake, are not monitored, and their population status and trend, as well as distribution, remain relatively unknown. And, as predicted, species such as the island fence lizard and side-blotched lizard are not monitored well by cover boards, which are not well suited for the rocky habitats they inhabit.

However, the herptile cover board transects have been monitored on a mostly regular basis since 1993, despite the vagaries of funding and staffing, and have proved adept at tracking island night lizards, Channel Islands slender salamanders, and alligator lizards. Data have been presented in periodic annual reports (Schwemm 1995; Austin 1996; Schwemm 1996; Austin 1998; Delaney et al. 2010), and the park's island night lizard data were used to support the decision by U.S. Fish and Wildlife Service to delist that species (U.S. Fish and Wildlife Service 2012).

This report summarizes reptile and amphibian monitoring data collected from 1993 to 2015.

Methods

Study area

Reptiles and amphibians were monitored on three of the five California islands of Channel Islands National Park: Santa Barbara, Anacapa, and San Miguel Islands.

Data collection

We monitored amphibians and reptiles on transects of cover boards (Table 2 and 3, Figures 3–5), each board being a 35 cm × 35 cm × 5 cm (12 in × 12 in × 2 in) piece of Douglas fir. Most transects had 60 boards, arranged in two rows of 30, with rows approximately 5 m apart and board spacing also approximately 5 m. Cover board transect locations were chosen in the 1980s (Fellers et al. 1988), and were not randomly located, but were sited in areas with representative stands of native vegetation.

Table 2. Herptile cover board transects at Channel Islands National Park.

Island	Site Code	Site Name	Number of Boards	Habitat Type
Santa Barbara Island	CM	Cave-Middle	60	Boxthorn scrub
	MG	Middle-Graveyard	60	Boxthorn scrub
	MC	Middle Canyon	40	Cactus scrub
	TG	Terrace Grass	60	Grassland
	WP	Webster Point	60	Sueda
Anacapa Island	EIIP	EI-Inspiration Point	60	<i>Coreopsis</i> scrub
	EILH	EI-Lighthouse Point	60	Grassland
	EITG	EI-Terrace Grass	60	Grassland
	MIS	MI-Sagebrush	30	Coastal sage scrub
	MIG	MI-Grassland	30	Grassland
	WI	West Islet-Grassland	30	Grassland
San Miguel Island	AS	Airstrip	60	<i>Isocoma</i> scrub
	NC	Nidever Canyon	60	Lupine scrub
	WC	Willow Canyon	60	Grassland

Table 3. Herptile cover board transects monitored in 2010–2015 at Channel Islands National Park. X = present on island.

Island	Site Code	Site Name	2010	2011	2012	2013	2014	2015
Santa Barbara Island	CM	Cave-Middle	X	X	X	–	–	–
	MG	Middle-Graveyard	–	X	–	–	–	–
	MC	Middle Canyon	–	X	–	–	–	–
	TG	Terrace Grass	X	X	X	–	X	–
	WP	Webster Point	X	X	–	–	X	–
Anacapa Island	EIIP	EI-Inspiration Point	X	X	X	X	–	–
	EILH	EI-Lighthouse Point	X	X	X	X	–	–
	EITG	EI-Terrace Grass	–	–	–	–	–	–
	MIS	MI-Sagebrush	–	–	–	–	–	–
	MIG	MI-Grassland	–	–	–	–	–	–
	WI	West Islet-Grassland	–	–	–	–	–	–
San Miguel Island	AS	Airstrip	X	X	X	X	X	X
	NC	Nidever Canyon	X	X	X	–	X	X
	WC	Willow Canyon	X	X	X	–	X	X



Santa Barbara Island Herpetofauna Transects



Figure 3. Location of cover board transects on Santa Barbara Island.



East Anacapa Island Herpetofauna Transects

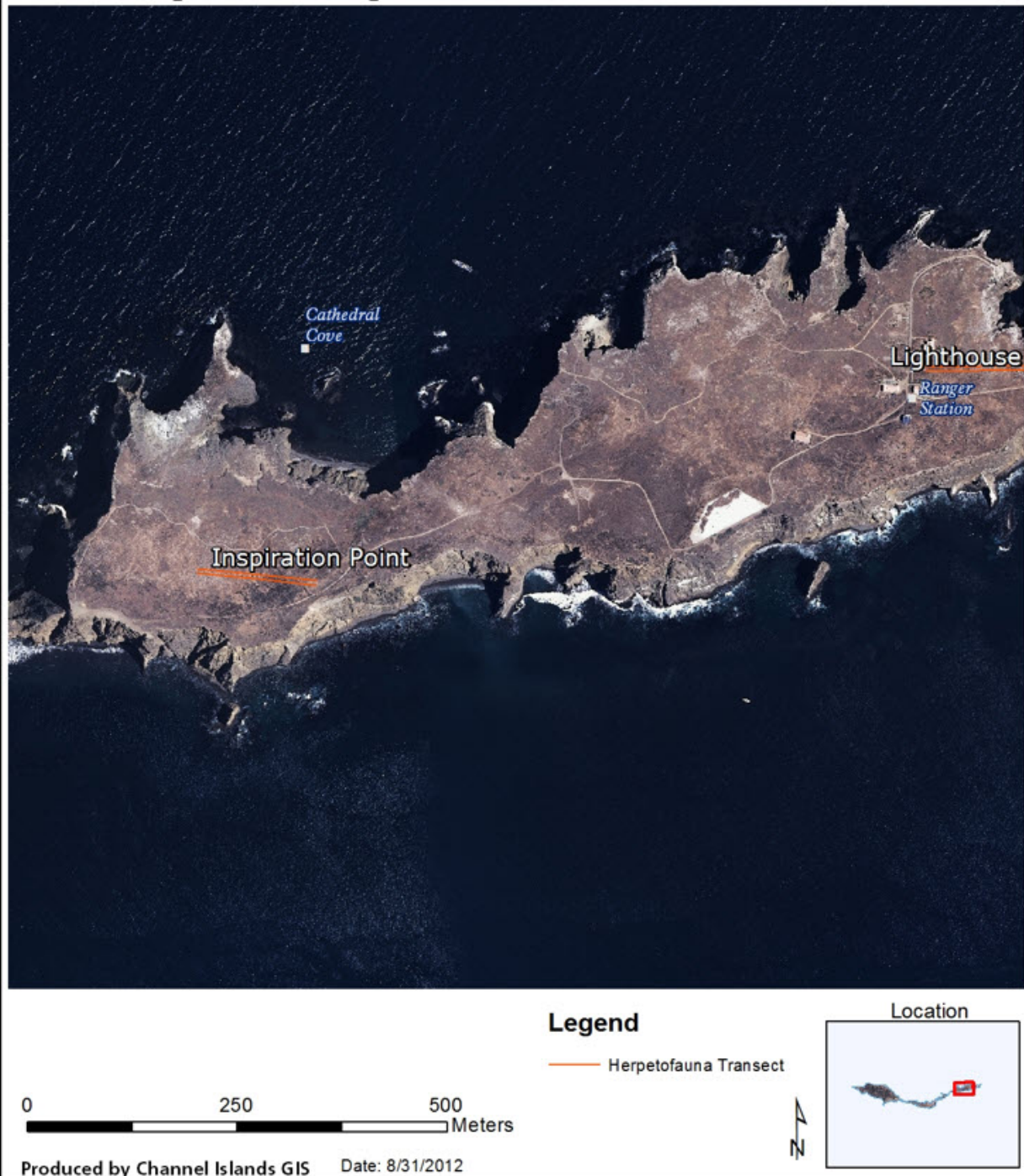


Figure 4. Location of cover board transects on East Anacapa Island that were surveyed between 2010–2013.



San Miguel Island Herpetofauna Transects

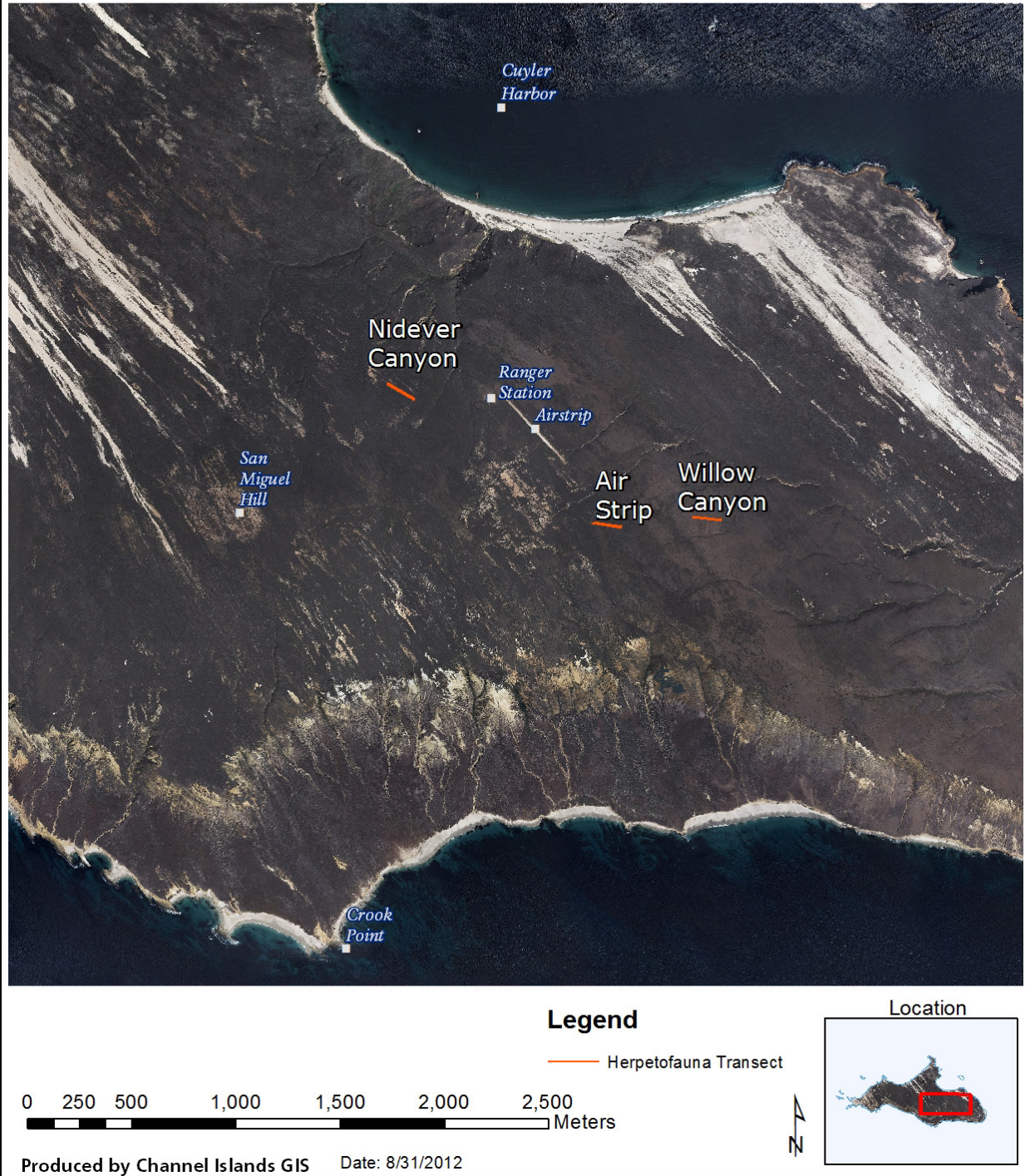


Figure 5. Location of cover board transects on San Miguel Island.

Cover board transects on Anacapa and San Miguel Islands were sampled from October to April, but primarily monitored in December, January, and April, in order to effectively sample salamanders, which only appear aboveground after suitable rainfall. Boards on Santa Barbara Island, where the only herptile is the night lizard, were monitored generally in the spring, when adult night lizards are most active (Fellers et al. 1988; Fellers and Drost 1991), but also in the fall during some years. As in previous years, due to staffing constraints, not all cover board transects (such as those on West and Middle Anacapa Island) were monitored in 2010–2015 (Table 3). However, a number of cover board transects have been monitored consistently since monitoring began in 1993, and we present the results of recent monitoring along with results of previous monitoring.

When the boards were turned over, an attempt was made to capture all lizards and amphibians. Body length was estimated visually for any that escaped, and escapees were included in abundance estimates. Individuals were weighed using a Pesola 10 g scale (with ± 0.05 g accuracy) or a 50 g scale (± 0.25 g), depending on the size of the individual. Snout-vent length (SVL), tail length, and length of any regenerating part of the tail were measured to the nearest 1 mm.

Analysis

For lizards, we used the number of individuals observed on transects as an index of abundance for each species. For salamanders on San Miguel and Anacapa islands, we used the maximum number of individuals recorded on any survey in the winter–spring season as that year’s abundance estimate, since salamanders do not appear consistently aboveground, but require adequate soil moisture from precipitation to become active.

We used program R (R Core Team 2013) to evaluate change in abundance over time by performing Poisson regression for abundance over time (either Julian date or year) for each transect. We incorporated data from previous sampling (1993 to 2009) in this evaluation. R code for this analysis is provided in Appendix A.

We used the relationship between weight and body length to examine relative body condition among years in island night lizards and alligator lizards, following the vertebrate monitoring protocol (Fellers et al. 1988). Body weight is positively correlated with snout-vent length cubed in lizards (Blob 1998), and differences in the slope of that relationship among years may indicate relative differences in body condition, nutritional status, and resource availability. We used program R to perform regressions of weight versus snout-vent length (cubed) for each year to estimate slope coefficients with confidence intervals. Salamanders are too small to make weight–length regressions meaningful, and there were too few data for other lizard species for weight–length analysis.

Results and Discussion

From 2010 to 2015, a total of 1,176 reptiles and amphibians were recorded on cover board transects. The most captures were recorded for salamanders (717) and night lizards (341). A total of 108 alligator lizards were recorded, but only 9 fence lizards and 1 side-blotched lizard were recorded. Due to staffing constraints, cover board transects were not monitored in some years. No transects were monitored on Santa Barbara Island in 2013 or 2014, and on Anacapa in 1999, 2001–2009, and 2014–2015. Appendix B presents total captures for each species on each transect and sampling date. More detailed results for night lizards, salamanders, and alligator lizards are given below.

Island night lizards

Island night lizard captures on individual transects varied over time, with more captures recorded in the latter years of the study period (Figure 6). Results of Poisson regression for maximum lizards observed in spring (Table 4) showed that night lizards increased on two cover board transects (Middle-Graveyard and Terrace Grassland) and showed no trend on two other transects (Cave-Middle and Webster Point). The highest numbers were recorded in 2011–2014, during a deep drought. Poisson regressions were not completed for Middle Canyon due to low sample size over time.

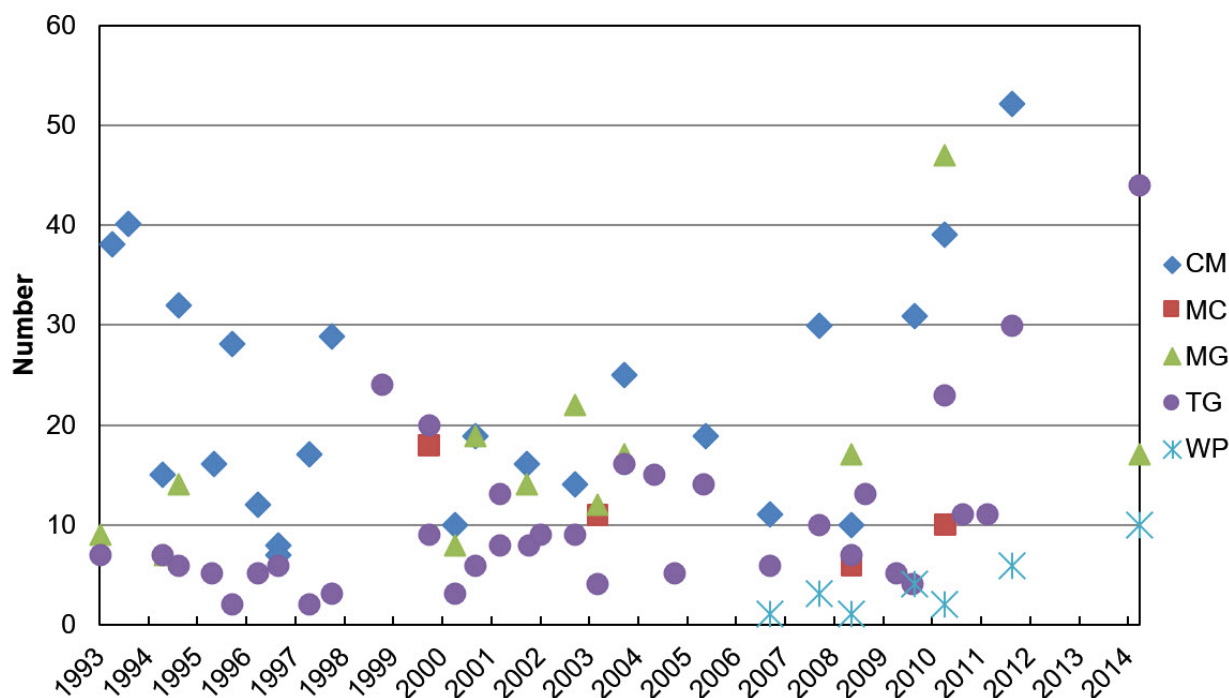


Figure 6. Number of island night lizards recorded on all cover board transects completed on Santa Barbara Island from 1993 to 2015. CM = Cave-Middle, MC = Middle Canyon, MG = Middle-Graveyard, TG = Terrace Grassland, WP = Webster Point.

Table 4. Results of Poisson regression of the maximum number of island night lizards observed in spring over time, Santa Barbara Island.

Site	n	Slope or Coefficient	z-value	p
Cave-Middle	12	0.009453	1.127	0.26
Middle-Graveyard	4	0.03616	0.851	3.95E-01
Terrace Grassland	16	0.0138	2.49	1.28E-02
Webster Point	3	1.819	0.688	0.688

The size distribution of island night lizards for all years (1995–2015), including both spring and fall captures, showed a preponderance of young, small lizards (3–4 cm in length) and an even greater proportion of older, larger lizards (7–10 cm in length) (Figure 7). Size distribution of lizards examined by season (Figure 8) shows a slug of very young and small lizards (3–4 cm in length) in the fall. These individuals are young of the year and represent reproductive effort for that year. In contrast, spring size distributions show fewer young lizards, perhaps due to overwinter mortality. Larger lizards are more apparent in the spring data. Larger lizards are less active in fall (Fellers and Drost 1991) and generally stayed underground, perhaps to conserve energy during the dry season.

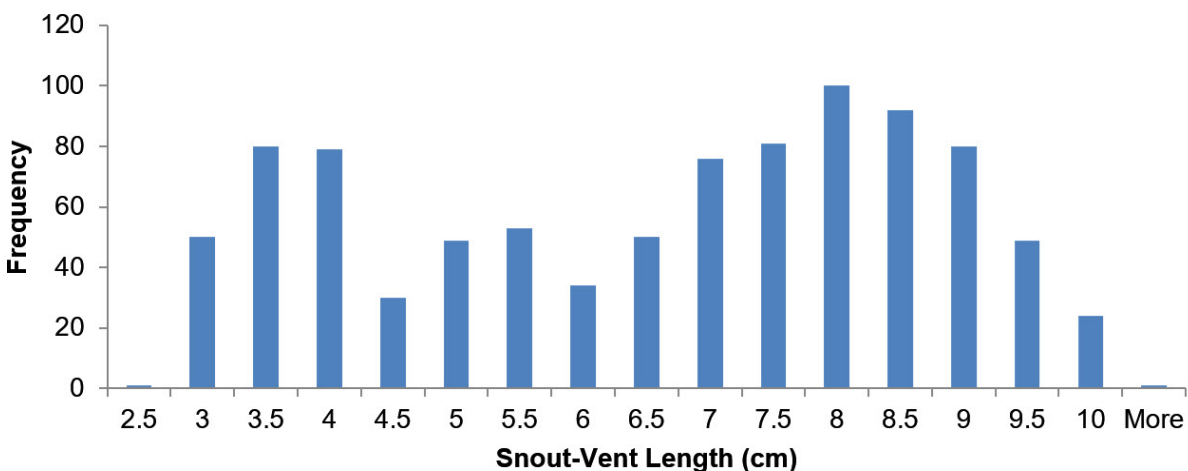


Figure 7. Size distribution of island night lizards (n=929) caught on cover board transects from 1995 to 2015, Santa Barbara Island (no SVL taken 1993–1994, and no sampling occurred in 2013 and 2014).

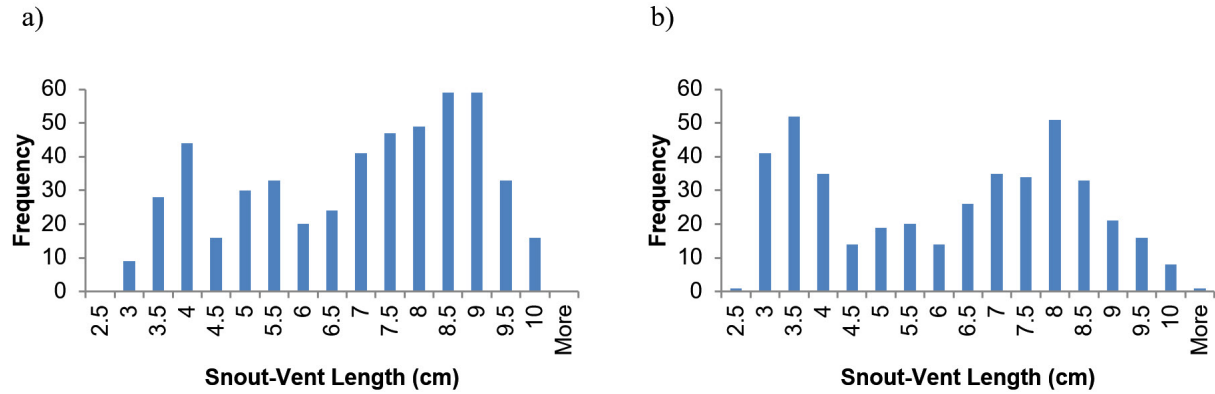


Figure 8. Size distribution of island night lizards caught during (a) spring (n=508) and (b) fall (n=421), Santa Barbara Island, 1995–2015 (no SVL taken 1993–1994, and no sampling occurred in 2013 and 2014).

Dividing the 20-year study period into four 5-year periods (Figure 9) shows that island night lizard reproduction and recruitment is episodic. Larger individuals of this long-lived species predominate in three of the four periods, whereas very young lizards predominate in the first period, 1995–1999. That first period followed the terminus of a six-year drought and may represent more favorable conditions for reproduction. Island night lizards on nearby San Nicolas Island also exhibited higher reproductive success (a greater number of juvenile lizards) during 1992–1996, compared to subsequent years (Fellers et al. 2008). Moreover, the few very large individuals recorded on Santa Barbara Island during 1995–1999 may represent the toll exacted on the population by the drought. Similarly, older, larger individuals are fewer in number during the most recent time period (2010–2015), which encompasses a four-year drought (Appendix C).

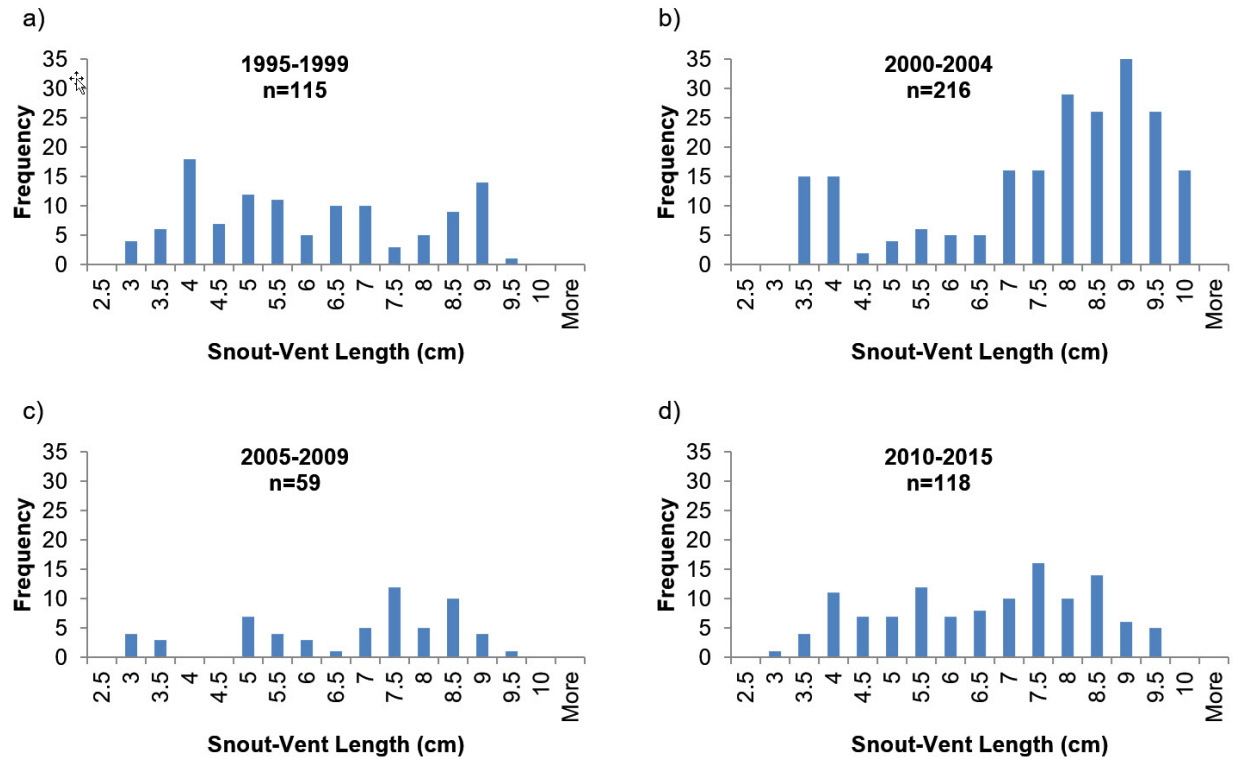


Figure 9. Size distribution of island night lizards in spring, Santa Barbara Island, during four 5-year time periods (*Note: no sampling occurred in 2013 and 2014*).

Island night lizards on Santa Barbara Island reach sexual maturity at 2.5–3 years, corresponding to a snout-vent length of 6.5–7.0 cm (Fellers and Drost 1991); thus, juvenile night lizards are those with a snout-vent length of <6.5 cm. Young are born in September, and so appear in fall sampling (when adults are less active; Fellers and Drost 1991). The ratio of juveniles to adults in spring sampling can thus be considered an estimate of recruitment, and it varied over the study period, likely due to varying precipitation (Figure 10). Recruitment was very high in the mid-1990s, after a six-year drought ended, and appeared to be cyclic during the remaining years of the study period.

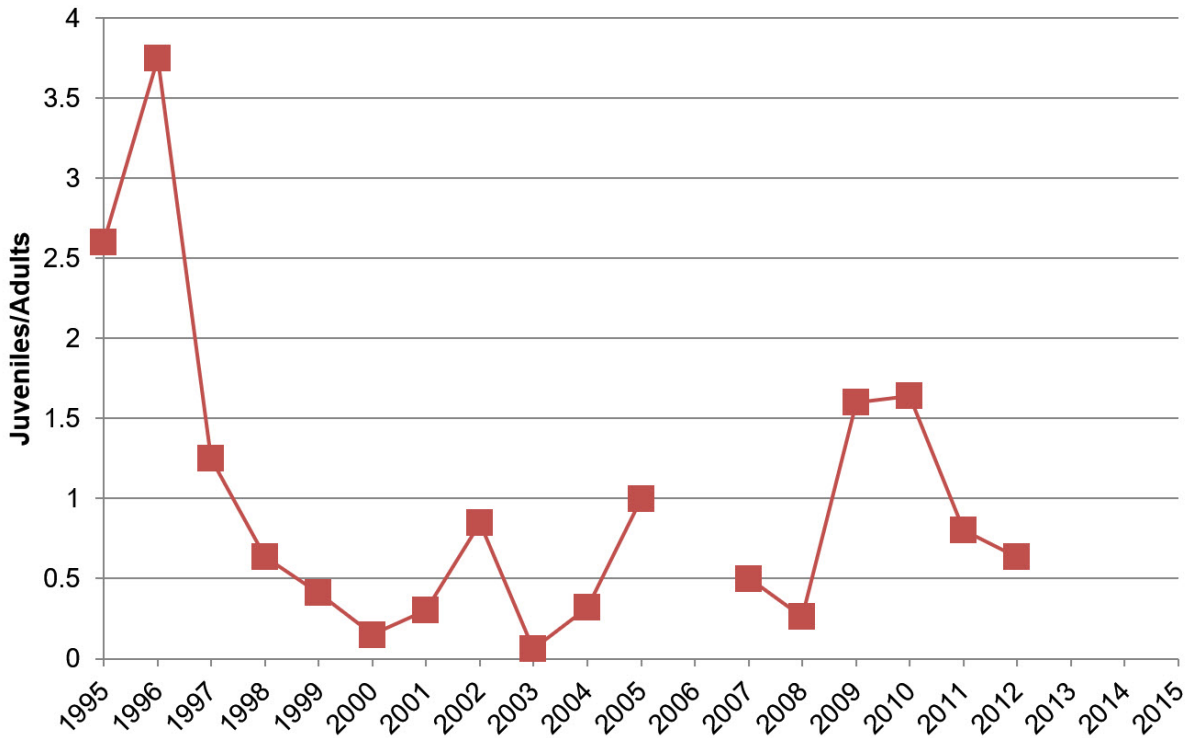


Figure 10. Recruitment (juveniles/adults) of island night lizards in spring sampling 1995–2015, Santa Barbara Island (*Note:* no sampling occurred in 2006, 2013–2015).

Island night lizard weights (using only spring data) were positively and significantly related to cubed snout-vent length in each year (Appendix D), and the slopes of the regression lines differed (Figure 11). Higher slopes indicate higher lizard weights. There appeared to be some cyclicity in body condition, as there was in recruitment.

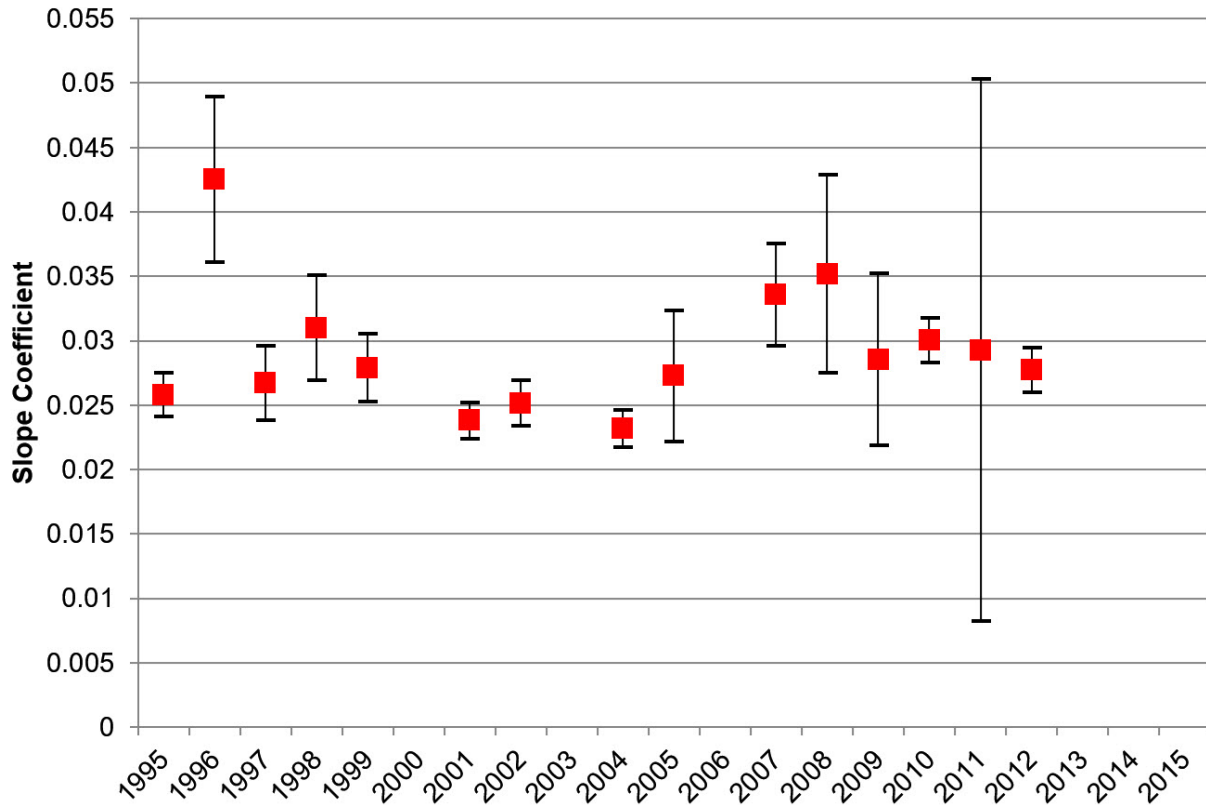
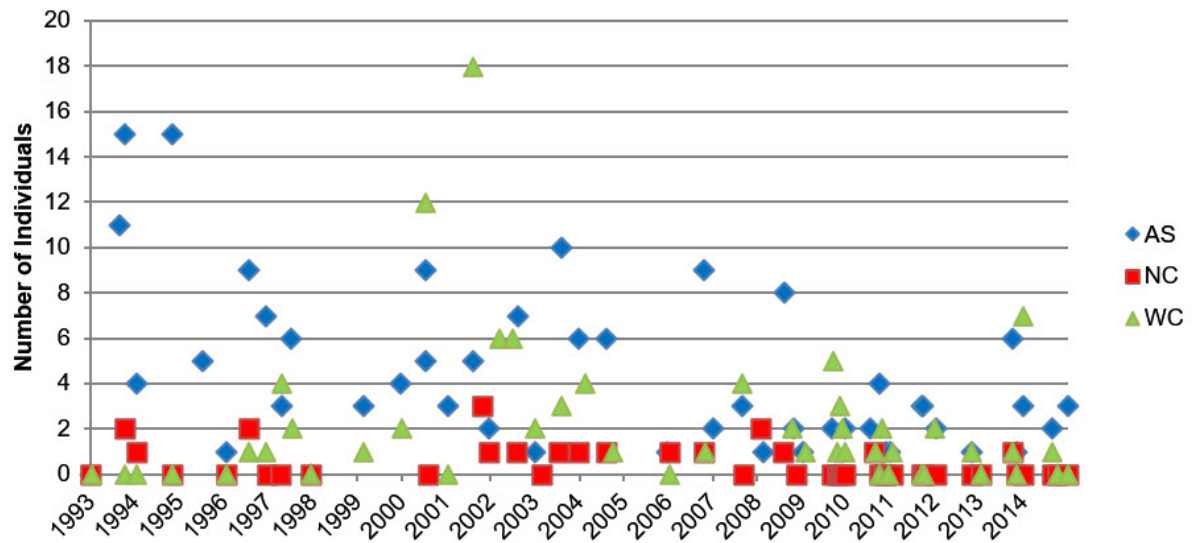


Figure 11. Annual slope coefficients for regression of weight on cubed snout-vent length in island night lizards, 1995–2015, Santa Barbara Island. *Note:* no sampling occurred in 2000, 2003, 2006, 2013, 2014 or 2015.

Southern alligator lizards

Southern alligator lizard abundance was variable over time (Figure 12). It declined over time on all three San Miguel Island cover board transects and on the two Anacapa Island cover board transects for which we had recent data (East Anacapa Inspiration Point and East Anacapa Lighthouse) (Table 5). Alligator lizards do not use soil cracks and crevices as much as salamanders or night lizards do, and so they may not be as buffered from drought as those other species.

a)



b)

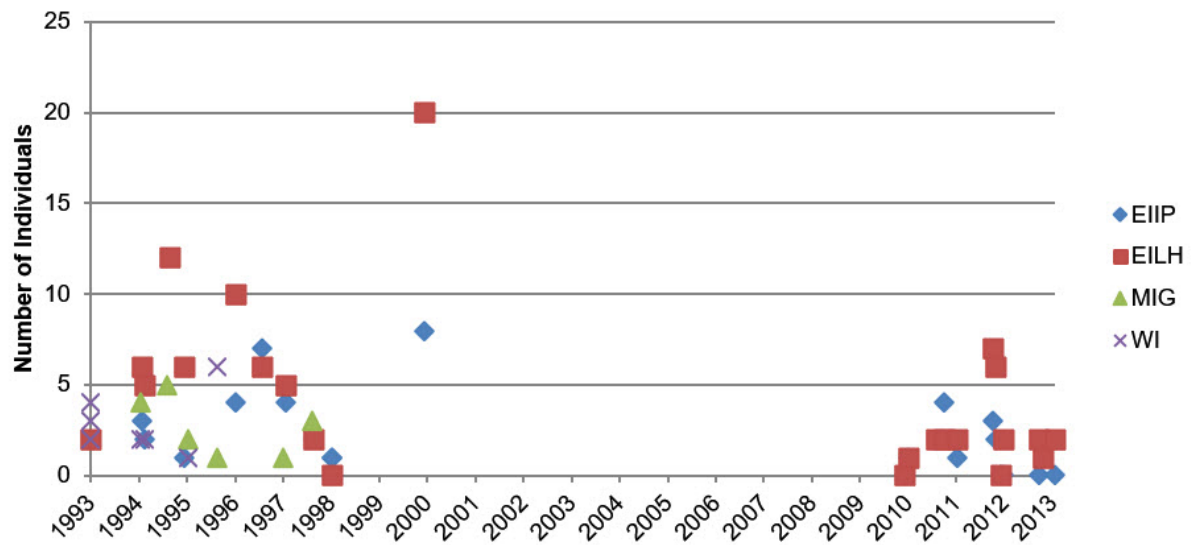


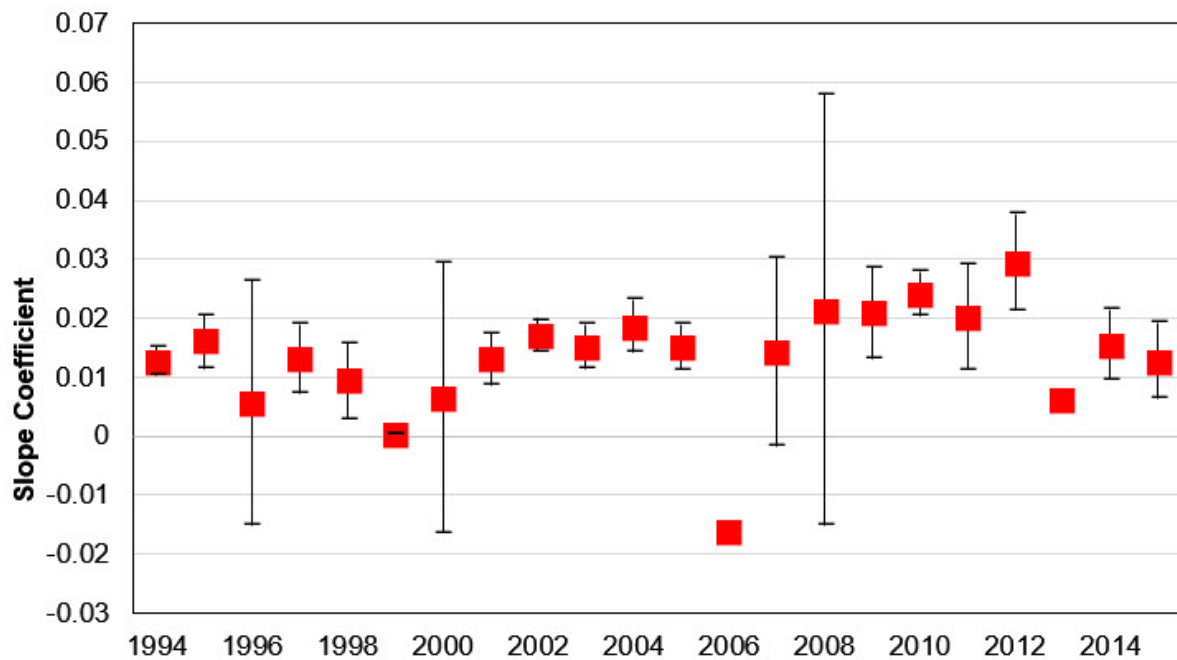
Figure 12. Number of southern alligator lizards recorded on cover board transects, 1993–2015, on a) San Miguel and b) Anacapa Islands. *Note:* Anacapa was not sampled in 1999, 2001–2009, or 2014–2015. AS=Airstrip, NC=Nidever Canyon, WC=Willow Canyon, EIIP=El-Inspiration Point, EILH=El-Lighthouse Point, MIG=MI-Grassland, WI=West Islet Grassland.

Table 5. Results of Poisson regression of number of southern alligator lizards recorded versus time, San Miguel Island and Anacapa Island.

Island	Site	n	Slope or Coefficient	z-value	p
San Miguel Island	Airstrip	53	-1.65E-04	-5.969	2.38E-09
	Nidever Canyon	44	-2.03E-04	-2.353	1.86E-02
	Willow Canyon	47	-5.92E-05	-1.499	1.34E-01
Anacapa Island	East Island Inspiration Point	19	-1.74E-04	-2.1914	0.003568
	East Island Lighthouse	21	-1.65E-04	-4.583	4.59E-06

Weight-length regressions indicate that alligator lizard body condition, as estimated by the slope of the regression of weight on snout-vent length cubed, fluctuated mildly over time on San Miguel Island (Figure 13). Slope coefficients, and thus body condition, appear to have increased slightly over time on Anacapa, although sufficient lizard data was unavailable from 1999 to 2010 on that island (Appendix D).

a)



b)

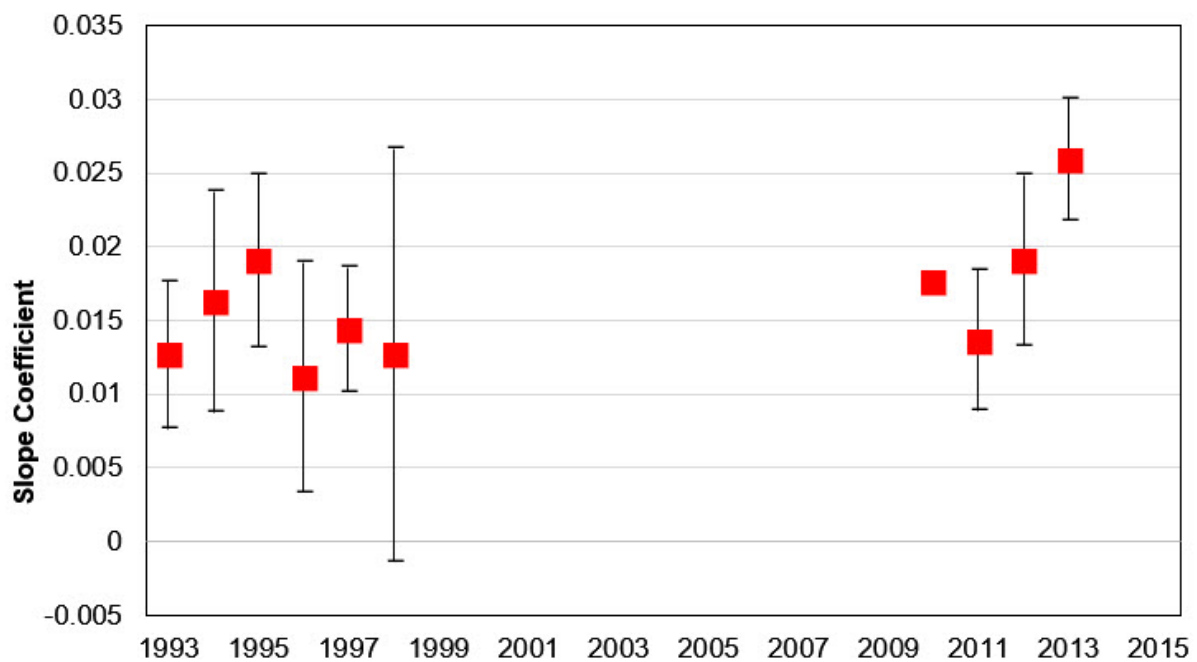


Figure 13. Slope coefficients for regression of weight on snout-vent length cubed in southern alligator lizards on a) San Miguel Island, and b) Anacapa Island. There was only one alligator lizard captured in both 2006 and 2013 on San Miguel Island, and only one alligator lizard captured in 2010 on Anacapa Island and therefore error bars are not necessary.

Channel Islands slender salamanders

Counts of Channel Islands slender salamanders on San Miguel Island cover board transects (Appendix B) varied considerably within a season (winter–spring; October–May), likely due to varying soil moisture levels. Graphing the maximum number recorded in a season on each transect suggests a recent increase in slender salamanders on San Miguel Island transects, despite the drought, as well as single or multi-year cycles (Figures 14a, 14b, and 14c). Poisson regressions of maximum number of salamanders per season (Table 6) for each site were significant. Data were sparser on Anacapa Island (Figure 14d), but the two cover board transects with adequate data for analysis (East Island Inspiration Point and East Island Lighthouse) showed a decline over time. The salamander decline on Anacapa Island is curious because salamanders on San Miguel Island seem rather immune to the current drought, even increasing in numbers. Perhaps salamanders can generally withstand periodic drought due to their underground habits, and San Miguel Island may be more equable, even during a drought, due to the persistent marine layer that often blankets the island.

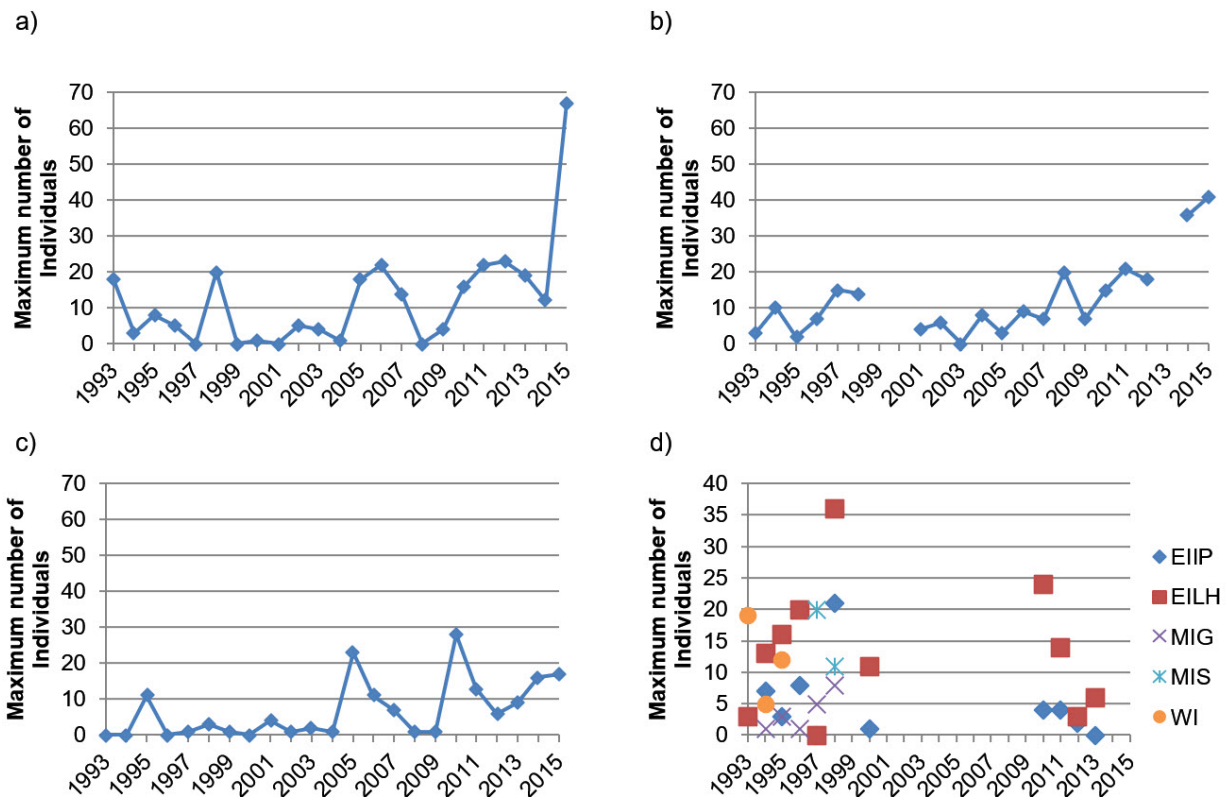


Figure 14. Maximum number of slender salamanders recorded during winter spring sampling on a) Airstrip, b) Nidever Canyon, and c) Willow Canyon cover board transects on San Miguel Island, and d) cover board transects on Anacapa Island. EIIP=EI-Inspiration Point, EILH=EI-Lighthouse Point, MIG=MI-Grassland, WI=West Islet Grassland.

Table 6. Results of Poisson regression of the maximum number of slender salamanders recorded versus time, San Miguel Island and Anacapa Island.

Island	Site	n	Slope or Coefficient	z-value	p
San Miguel	Airstrip	22	0.09638	9.571	<2E-16
	Nidever Canyon	20	0.08124	7.612	2.69E-14
	Willow Canyon	22	0.10614	7.665	1.79E-14
Anacapa Island	East Island Inspiration Point	7	-1.45E-04	-2.349	0.0188
	East Island Lighthouse	9	-7.56E-05	-2.391	1.68E-02

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Appendix A: R Code for Analyses

Analysis of change in abundance over time

Note: This example is for slender salamanders (BP) on San Miguel Airstrip (AS).

```
####This script will analyze herp count data for change over time,
using Poisson regression.####
#Set the working directory. Use "/" to separate directories.
setwd("T://Im/LandVert//Herpetofauna//Analysis//2010-2015
analysis//BP//AS")
####send output to a text file and to the screen####
sink("SMAS_BP_regression.txt", append=TRUE, split=TRUE)
#Read csv file
bpas <- read.csv("SM_AS_BP_max_1993-2015.csv", header = T)
#Print bpas
bpas
#Attach bpas to the search path
attach (bpas)
#summarize
summary (modelbpas <- glm(NCount~SamplingYear, family = "poisson"))
####If you want to plot the data:####
#install.package (ggplot2)
#library (ggplot2)
ggplot(bpas, aes(x = SamplingYear, y = NCount)) +
geom_point(shape=1) + geom_smooth(method=lm, se=FALSE)
####If you want to save the graph as a jpeg:####
dev.copy(jpeg, 'bpas_20190320.jpg')
dev.off()
####stop output to a text file####
sink ()
```

Note: This R script requires a data input file similar to the following:

SM_AS_BP.csv

<i>SamplingYear</i>	<i>NCount</i>
1993	18
1994	3
1995	8
1996	5
1997	0
1998	20
1999	0
2000	1
2001	0

```

2002 5
2003 4
2004 1
2005 18
2006 22
2007 14
2008 0
2009 4
2010 16
2011 22
2012 23
2013 19
2014 12
2015 67

```

Estimation of coefficients for snout-vent length regressions

Note: This example is for island night lizards (XR) on Santa Barbara Island.

```

setwd("T:\\Im\\LandVert\\Herpetofauna\\Analysis\\2010-2015
analysis\\XR\\WeightLength")
setWindowTitle('CHIS Santa Barbara Island Night Lizard Condition')
library(lattice)
library(ggplot2)
library(reshape2)
library(plyr)
##open a window to view plots
windows(record=TRUE)
##load the dataset and assign it to svl
svl <- read.csv('SB_XR_WL.csv',as.is=TRUE)
str(svl)
svl$Yr <- factor(svl$Sampling_Year)
##the following is for a plot of weight on SVLen3 (cubed)##
fig <- ggplot(svl,aes(x=SVLen3,y=Weight_g))
fig + geom_point()
# separate panels per year
fig + geom_point() + facet_wrap(~Sampling_Year)
##the following is for a plot of weight on SVLen_cm (not cubed)##
fig2 <- ggplot(svl,aes(x=SVLen_cm,y=Weight_g))
fig2 + geom_point()
# separate panels per year
fig2 + geom_point() + facet_wrap(~Sampling_Year)
##create a new dataset named svl3m with mean of SVLen3
svl3m <- mean(svl$SVLen3)

```

```

# create new column in svl named SVLen3n with a value that is
SVLen3-svl3m
svl$SVLen3n <- svl$SVLen3 - svl3m
##the following is for a plot of weight on SVLen3 (cubed)##
fig <- ggplot(svl,aes(x=SVLen3,y=Weight_g))
fig + geom_point()
# separate panels per year
fig + geom_point() + facet_wrap(~Sampling_Year)
# one figure, colorized
fig + geom_point(aes(color=Sampling_Year))
fig + geom_point(aes(color=Yr))
# Using 0 svl for intercept
mod1 <- lm(Weight_g~SVLen3*Yr,data=svl)
mod0 <- lm(Weight_g~0+SVLen3*Yr,data=svl)
summary(mod1)
anova(mod1)
#get lm coefficients for each sampling year using split-apply-
combine dply (data to list)
byYear <- dply(svl,. (Yr),lm,formula=Weight_g~SVLen3)
#put list of coefficients results into a dataframe (coeffs)
coeffs <- ldply(byYear, coef)
#assign column names
names(coeffs) <- c('Yr','Intercept','Slope')
#make into long format with value in new 'Estimate' column
coeffsL <- melt(coeffs,value.name='Estimate')
#rename variable column to 'term'
names(coeffsL)[2] <- 'term'
#put list of confidence intervals into a dataframe (ci)
ci <- ldply(byYear, confint)
#assign column names
names(ci) <- c('Yr','lci','uci')
#add new column 'term'; populate with Intercept, Slope, etc.
##the number at the end of the next line has to be the number
of years
ci$term <- rep(c('Intercept','Slope'),15)
#create new dataset (Params) joining on 'Yr' and 'term'
Params <- merge(coeffsL,ci,by=c('Yr','term'))
#make Params into long format
ParamsL <- melt(Params)
#show structure of ParamsL
str(ParamsL)
#add Var column combining term and variable values
ParamsL$Var <- paste(ParamsL$term, ParamsL$variable, sep='_')

```

```

#make into wide format by Yr and Var
ParamsW <- dcast(ParamsL,Yr~Var,value.var='value')
#write to csv file
write.csv(ParamsW,'Estimates0ByYear.csv',row.names=FALSE)
##how about a graph of parameters with 95% c.i.s?
fig3 <- ggplot(Params,aes(x=Yr))
fig3a <- fig3 + geom_point(aes(y=Estimate)) +
geom_errorbar(aes(x=Yr,ymax=uci,ymin=lci)) +
facet_grid(term~.,scales='free_y') +
xlab('Year') + ylab('Estimate and 95% C.I.') +
ggtitle('Lizard Condition Estimates Regressing Mass on
SVL^3\nIntercepts at SVL=0')
plot(fig3a)
ggsave('Figure3a_ParameterEstimates0ByYear.png',fig3a,width=6,height=4,units='in',dpi=600)
#####
# Using Mean svl^3 for intercept
mod1n <- lm(Weight_g~SVLen3n*Yr,data=svl)
mod0n <- lm(Weight_g~0+SVLen3n*Yr,data=svl)
summary(mod1n)
anova(mod1n)
byYear <- dlply(svl,.(Yr),lm,formula=Weight_g~SVLen3n)
coffs <- ldply(byYear,coef)
names(coffs) <- c('Yr','Intercept','Slope')
coffsL <- melt(coffs,value.name='Estimate')
names(coffsL)[2] <- 'term'
ci <- ldply(byYear,confint)
names(ci) <- c('Yr','lci','uci')
ci$term <- rep(c('Intercept','Slope'),15)
Params <- merge(coffsL,ci,by=c('Yr','term'))
ParamsL <- melt(Params)
str(ParamsL)
ParamsL$Var <- paste(ParamsL$term,ParamsL$variable,sep='_')
ParamsW <- dcast(ParamsL,Yr~Var,value.var='value')
write.csv(ParamsW,'EstimatesMeanSVLByYear.csv',row.names=FALSE)
)

# how about a graph of parameters with 95% c.i.s?
fig3n <- ggplot(Params,aes(x=Yr))
fig3an <- fig3n + geom_point(aes(y=Estimate)) +
geom_errorbar(aes(x=Yr,ymax=uci,ymin=lci)) +
facet_grid(term~.,scales='free_y') +
xlab('Sampling_Year') + ylab('Estimate and 95% C.I.') +

```

```

    ggtitle('Lizard Condition Estimates Regressing Mass on
SVL^3\nIntercepts at mean(SVL^3)')
    plot(fig3an)
ggsave('Figure3an_ParameterEstimatesmeanSVLByYear.png',fig3an,width
=6,height=4,units='in',dpi=600)
#####
## Cubed Snout-Vent Length
fig <- ggplot(svl,aes(x=SVLen3,y=Weight_g))
# separate panels per year
fig1a <- fig + geom_point() + facet_wrap(~Sampling_Year) +
    xlab('Cubed Snout-Vent Length') +
    ggtitle('Lizard Condition Estimates')
plot(fig1a)
ggsave('Figure1a_MassSVLf.png',fig1a,width=6,height=6,units='in',d
pi=600)
## Snout-Vent Length (not cubed)
fig2 <- ggplot(svl,aes(x=SVLen_cm,y=Weight_g))
# separate panels per year
fig2a <- fig2 + geom_point() + facet_wrap(~Sampling_Year) +
    xlab('Snout-Vent Length') +
    ggtitle('Lizard Condition Estimates')
plot(fig2a)
ggsave('Figure2a_MassSVL2f.png',fig2a,width=6,height=6,units='in',d
pi=600)
#create new dataframe (FitLines) by making Params into wide format
on Yr and term
FitLines <- dcast(Params,Yr~term,value.var='Estimate')
#add new column (Int0) that is the intercept-(slope*meanSVL)
FitLines$Int0 <- FitLines$Intercept - (FitLines$Slope*svl3m)
fig4 <- ggplot(svl,aes(x=SVLen3,y=Weight_g))
# separate panels per year
fig4a <- fig4 + geom_point(aes(color=Yr)) +
    xlab('Cubed Snout-Vent Length') +
    ggtitle('Lizard Condition Estimates') +
geom_abline(aes(intercept=Int0,slope=Slope,color=Yr),data=FitLines)
+
    geom_vline(aes(xintercept=svl3m))
plot(fig4a)
ggsave('Figure4a_MassSVL4lf.png',fig4a,width=6,height=6,units='in',
dpi=600)
##Is there any difference with this figure than with figure 4??
fig5 <- ggplot(svl,aes(x=SVLen3,y=Weight_g))
# separate panels per year

```

```

fig5a <- fig5 + geom_point(aes(color=Yr)) +
  xlab('Cubed Snout-Vent Length') +
  ggtitle('Lizard Condition Estimates') +
geom_abline(aes(intercept=Int0,slope=Slope,color=Yr),data=FitLines)
+
  geom_vline(aes(xintercept=svl3m))
plot(fig5a)
ggsave('Figure5a_MassSVL5lf.png',fig5a,width=6,height=6,units='in',
dpi=600)
# separate panels per year
fig6a <- fig5 + geom_point() +
  geom_smooth(method='lm') +
  xlab('Cubed Snout-Vent Length') +
  ggtitle('Lizard Condition Estimates') +
  facet_wrap(~Sampling_Year) +
  geom_vline(aes(xintercept=svl3m))
plot(fig6a)
ggsave('Figure6a_MassSVL6lf.png',fig6a,width=6,height=6,units='in',
dpi=600)
#same plot but without confidence intervals
fig6b <- fig5 + geom_point() +
  geom_smooth(method='lm',se=FALSE) +
  xlab('Cubed Snout-Vent Length') +
  ggtitle('Lizard Condition Estimates') +
  facet_wrap(~Sampling_Year) +
  geom_vline(aes(xintercept=svl3m))
plot(fig6b)
ggsave('Figure6b_MassSVL6lfbw.png',fig6b,width=6,height=6,units='in',
',dpi=600)
# So the figures I think are informative are:
fig1a# MassSVLlf.png
fig3a# ParameterEstimates0ByYear.png
fig3an      # ParameterEstimatesmeanSVLByYear.png
fig6a# MassSVL6lf.png
# or
fig6b# MassSVL6lfbw.png

```

Appendix B: Total Herpetofauna Captures on Cover Board Transects

Table B-1. Santa Barbara Island – Total Captures.

Site	Date	Island Night Lizard
Cave-Middle	3/10/2010	31
	10/22/2010	39
	3/5/2012	52
Middle Canyon	10/26/2010	10
Middle Graveyard	10/25/2010	47
	4/14/2014	17
Terrace Grassland	2/26/2010	4
	10/21/2010	23
	3/5/2011	11
	9/6/2011	11
	3/3/2012	30
	4/12/2014	44
Webster Point	3/8/2010	4
	10/24/2010	2
	3/2/2012	6
	4/13/2014	10

Table B-2. Anacapa Island – Total Captures. “–” = species not seen for that date; “X” = no species detected.

Site	Date	Slender Salamander	Alligator Lizard	Side-blotched Lizard	No species detected
Inspiration Point	2/24/2010	4	–	–	–
	3/23/2010	–	1	–	–
	12/15/2010	–	4	–	–
	3/26/2011	4	1	–	–
	12/21/2011	–	3	–	–
	1/11/2012	2	2	–	–
	2/22/2012	1	–	–	–
	3/15/2012	–	–	–	X
	12/6/2012	–	–	–	X
	4/3/2013	–	–	–	X
Lighthouse	2/24/2010	10	–	–	–
	3/21/2010	14	1	–	–
	10/21/2010	–	2	–	–
	12/15/2010	2	2	–	–
	3/25/2011	14	2	–	–
	12/14/2011	2	7	–	–
	1/11/2012	3	6	–	–
	2/22/2012	–	–	–	X
	3/15/2012	–	2	–	–
	12/5/2012	4	2	–	–
	1/9/2013	6	1	1	–
	4/2/2013	4	2	–	–

Table B-3. San Miguel Island – Total Captures. “–” = species not seen for that date; “X” = no species detected.

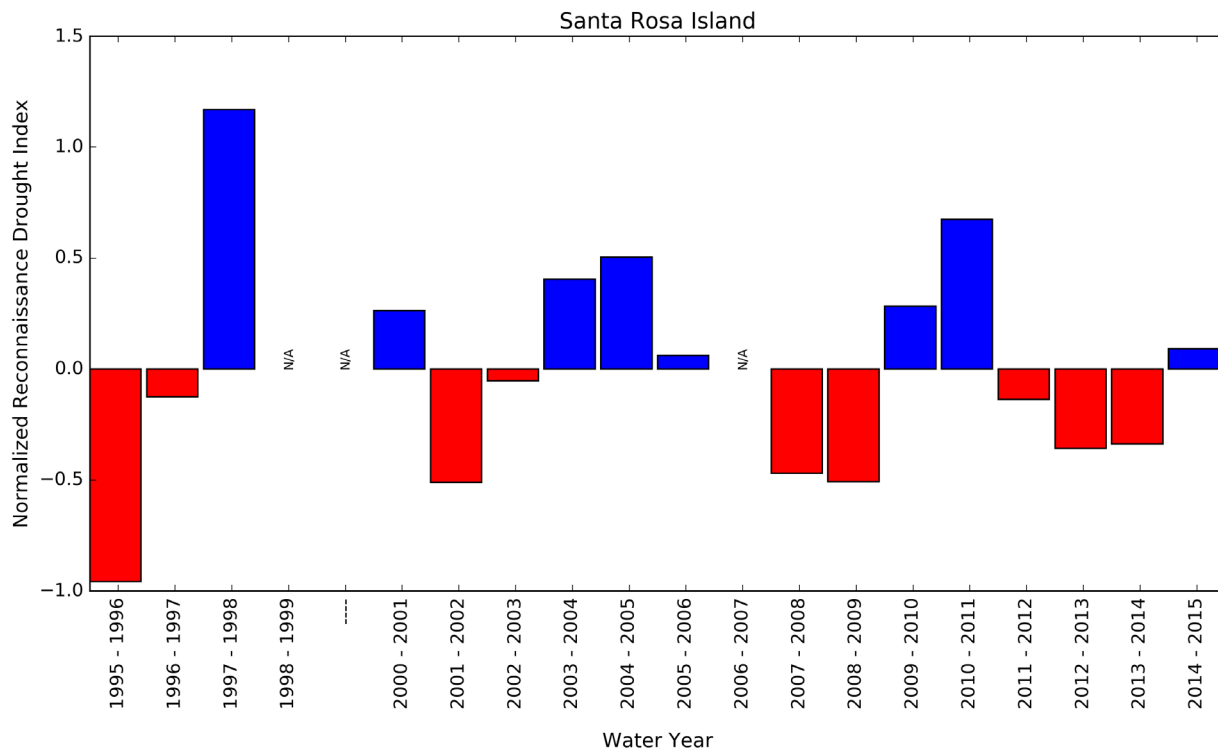
Site	Date	Slender Salamander	Alligator Lizard	Side-blotched Lizard	No species detected
Airstrip	1/21/2010	15	–	–	–
	2/20/2010	11	–	–	–
	3/4/2010	16	–	–	–
	4/3/2010	5	2	–	–
	10/31/2010	12	2	–	–
	1/7/2011	14	4	2	–
	2/7/2011	22	–	–	–
	3/4/2011	10	1	1	–
	4/4/2011	4	1	1	–
	12/15/2011	10	3	1	–
	1/2/2012	23	2	–	–
	4/21/2012	2	2	–	–
	2/9/2013	19	1	1	–
	4/26/2013	–	–	–	X
	1/8/2014	1	6	–	–
	2/6/2014	12	1	–	–
	4/6/2014	–	3	–	–
	11/28/2014	4	2	–	–
	1/9/2015	67	–	–	–
	4/3/2015	–	3	–	–
	12/10/2015	–	9	–	–
Nidever Canyon	1/23/2010	8	–	–	–
	2/18/2010	15	–	–	–
	3/8/2010	11	–	–	–
	4/5/2010	5	–	–	–
	11/24/2010	21	1	–	–
	1/6/2011	8	–	–	–
	2/6/2011	16	–	–	–
	3/5/2011	5	–	–	–

Site	Date	Slender Salamander	Alligator Lizard	Side-blotched Lizard	No species detected
Nidever Canyon (continued)	4/24/2011	2	—	—	—
	12/17/2011	2	—	—	—
	1/14/2012	8	—	—	—
	4/19/2012	5	—	—	—
	2/10/2013	10	—	—	—
	4/28/2013	—	—	—	X
	12/30/2013	36	1	—	—
	2/7/2014	13	—	—	—
	4/7/2014	2	—	—	—
	11/29/2014	25	—	—	—
	1/8/2015	41	—	—	—
	4/4/2015	2	—	—	—
	12/12/2015	23	—	—	—
Willow Canyon	1/25/2010	28	1	—	—
	2/21/2010	15	3	—	—
	3/6/2010	18	2	—	—
	4/1/2010	2	1	—	—
	12/11/2010	5	1	—	—
	1/10/2011	2	—	—	—
	2/4/2011	2	2	—	—
	3/21/2011	13	—	—	—
	4/21/2011	1	1	—	—
	12/16/2011	6	—	—	—
	1/15/2012	2	—	—	—
	4/6/2012	—	2	—	—
	2/11/2013	9	1	—	—
	4/26/2013	—	—	—	X
	1/9/2014	—	1	1	—
	2/8/2014	16	—	1	—
	4/7/2014	—	7	—	—
	11/27/2014	—	1	1	—

Site	Date	Slender Salamander	Alligator Lizard	Side-blotched Lizard	No species detected
Willow Canyon (continued)	1/11/2015	17	–	–	–
	4/2/2015	–	–	–	X
	12/11/2015	–	2	–	–

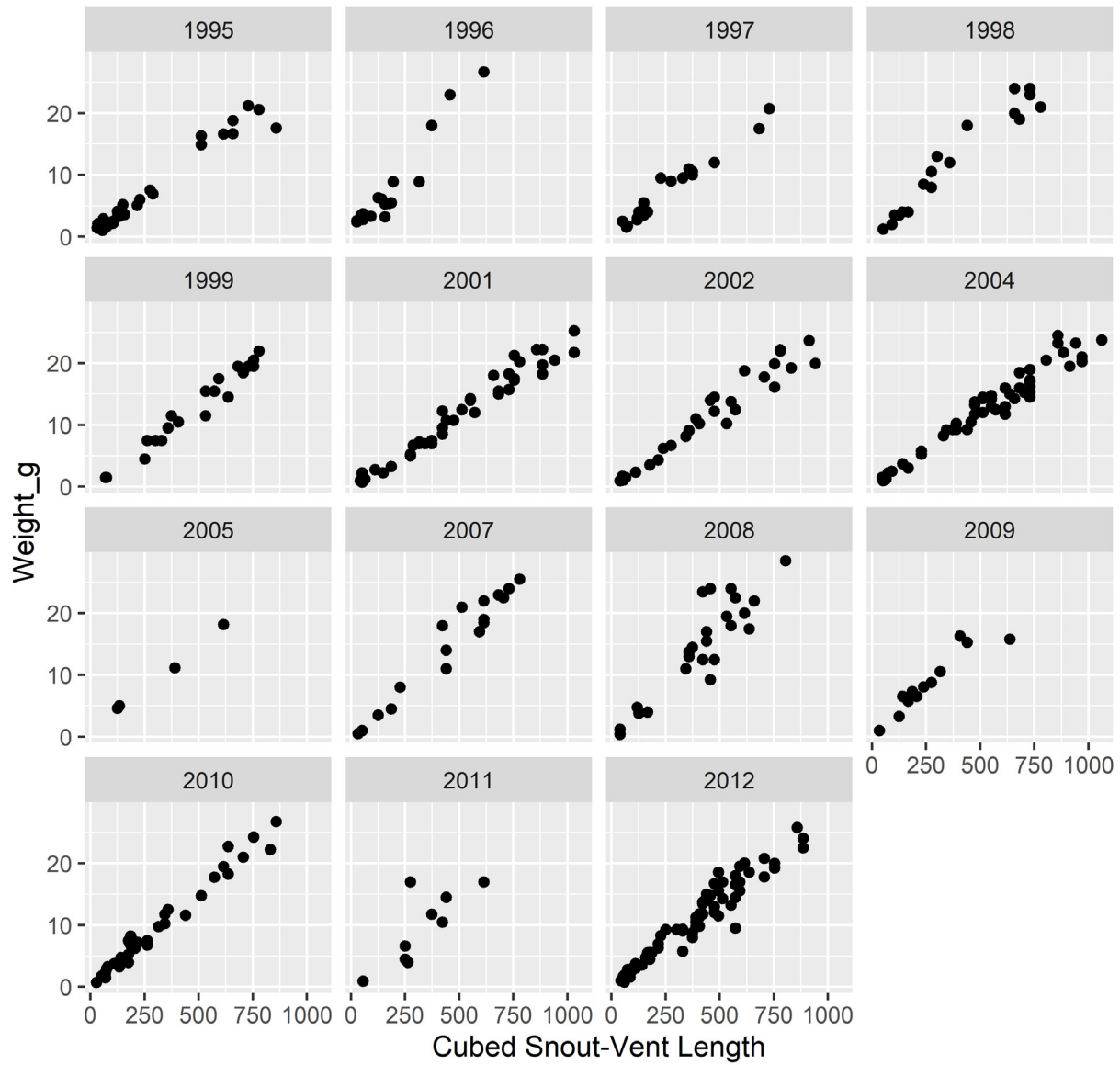
Appendix C: Climatic Data

The following graph presents the annual Normalized Reconnaissance Drought Index for Santa Rosa Island (1995–2014) in Channel Islands National Park. Climate records for Santa Rosa Island are more complete than those for other islands within the park and are provided here to generally characterize climate at the Channel Islands during the study period. Data are from www.ClimateAnalyzer.org (accessed November 27, 2017), with this note: *Drought index calculations are relative to the time period selected: 1995–2015. Choosing a different set of start/end points may produce different results. The zero horizontal line is the average for the time period considered. Red bars = years that were drier than average. Blue = years that were wetter than average. N/A = insufficient data for an accurate calculation. Dashes = groups of years with insufficient data.*

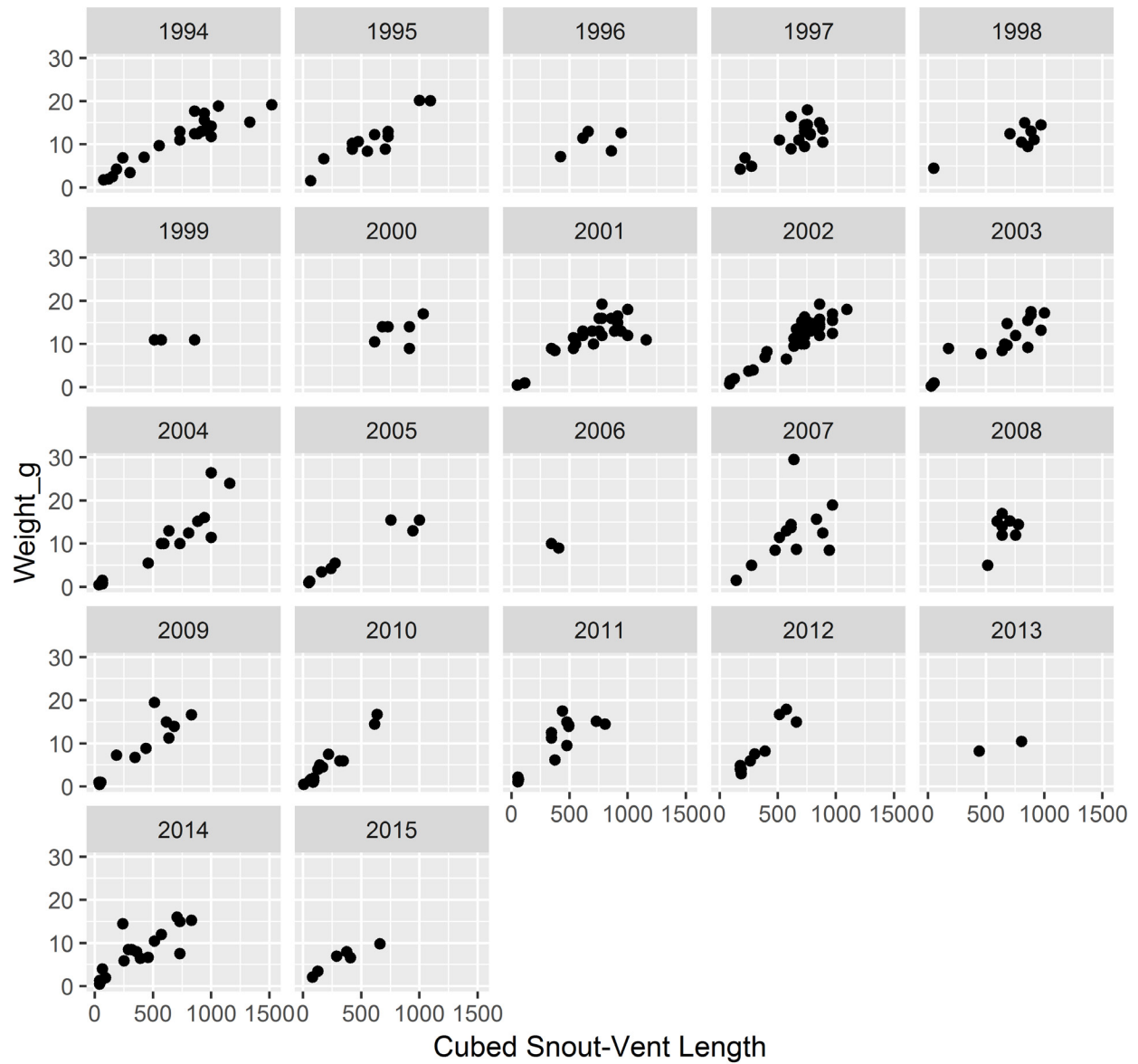


Appendix D: Annual Regressions of Weight versus Snout-vent Length

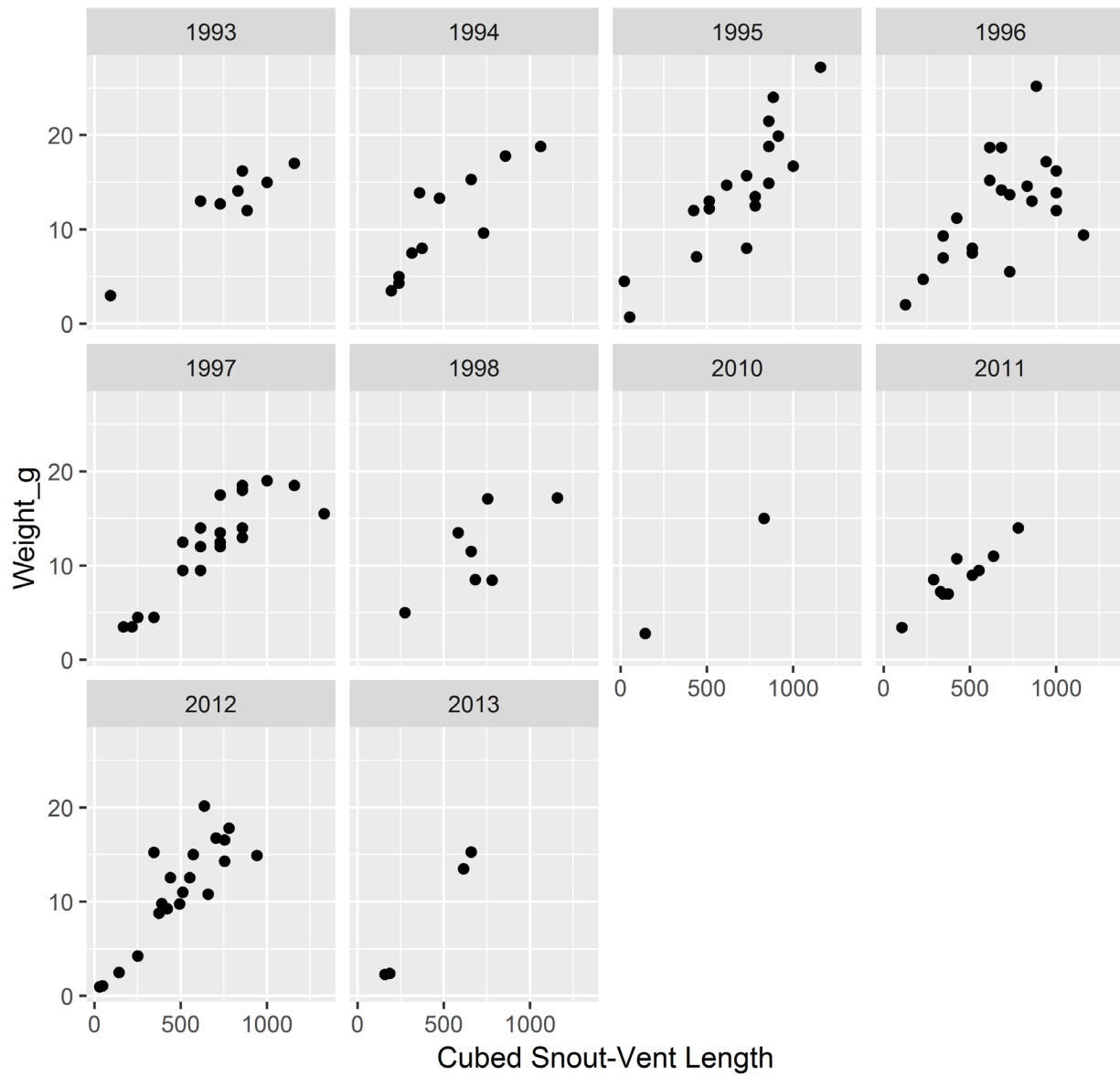
Island Night Lizards



Southern Alligator Lizards – San Miguel Island



Southern Alligator Lizards – Anacapa Island



The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 159/176594, June 2021

National Park Service
U.S. Department of the Interior



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