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Status of the Island Night Lizard and Two Non-Native Lizards on Outlying Landing Field San Nicolas Island, California

Report Series Open-File Report 2008–1371

U.S. Department of the Interior
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Contents

Figures

Tables

Status of the Island Night Lizard and Two Non-Native Lizards on Outlying Landing Field San Nicolas Island, California

By Gary M. Fellers[1], Charles A. Drost[2], Thomas Murphey[3]

Abstract

More than 900 individually marked island night lizards (*Xantusia riversiana*) were captured on San Nicolas Island, California, between 1984 and 2007 as part of an ongoing study to monitor the status of this threatened species. Our data suggest that at least a few lizards are probably more than 20 years old, and one lizard would be 31.5 years old if it grew at an average rate for the population. Ages of 20 and 30 years seem reasonable given the remarkably slow growth during capture intervals of more than a decade for five of the lizards which we estimated to be 20 or more years old. Like other lizards, island night lizard growth rates vary by size, with larger lizards growing more slowly. In general, growth rates were somewhat greater on San Nicolas Island (compared with Santa Barbara Island), and this increase was sustained through all of the intermediate size classes.

The higher growth rate may account for the somewhat larger lizards present on San Nicolas Island, although we cannot discount the possibility that night lizards on San Nicolas are merely living longer. The high percentage of small lizards in the Eucalyptus habitat might seem to reflect a healthy population in that habitat, but the high proportion of small lizards appears to be caused by good reproduction in the 1900s and substantially poorer reproduction in subsequent years. The Eucalyptus habitat has dried quite a bit in recent years. Night lizards in the Haplopappus/Grassland habitat have shown an increase in the proportion of larger lizards since 2000. There has also been an increase in the proportion of large lizards in the Rock Cobble habitat at Redeye Beach. However, there are has been some change in habitat with more elephant seals occupying the same area just above the high tide as do the night lizards. Southern alligator lizards and side-blotched lizards are both non-native on San Nicolas Island. Neither lizard causes obvious harm to island night lizards, and management time and effort should be directed toward much more pressing problems, such as general habitat restoration, erosion control, and the removal of feral cats.

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The island night lizard (*Xantusia riversiana*) is endemic to three of the California Channel Islands: San Nicolas, San Clemente, and Santa Barbara Islands. Due to its restricted range and apparently small population levels, both the U.S. Fish and Wildlife Service and the California Department of Fish and Game have listed the island night lizard as a threatened species.

Our study was conducted on San Nicolas Island, which lies offshore 120 km southwest of Los Angeles, California. The island is managed by the U.S. Navy who refers to the island as Outlying Landing Field San Nicolas Island. The Navy maintains radar, telemetry, and communications equipment on San Nicolas Island to support its mission of testing and evaluating weapons systems. The Navy has dual requirements for ensuring military readiness and sustainability while complying with the Federal Endangered Species Act. A comprehensive understanding of the status and stability of the species on San Nicolas Island is essential for effective island management and may aid in the eventual delisting of the species.

Previous work on the San Nicolas Island (Fellers and others, 1998) demonstrated that island night lizards were distributed over the eastern half of San Nicolas Island where there is suitable shrubby habitat. On the eastern half of the island, they occur primarily in or near cactus/sage scrub habitats on the north beach terrace, in scattered patches of scrub on the central mesa, and in boulder and cactus habitats on the southern escarpment of the island. Fellers and others (1998) evaluated data from 1984–85 and 1992–95 and estimated that there were 15,300 island night lizards present on San Nicolas Island.

There are two non-native lizards on San Nicolas Island, the side-blotch lizard (*Uta stansburiana*) and the southern alligator lizard (*Elgaria multicarinata*). Both of these lizards are widely distributed species in western North America, and both occur on several of the California Channel Islands (Stebbins, 2003). Although it has been generally been assumed that the island populations were naturally occurring (Savage, 1967; Wilcox, 1980; Stebbins, 2003), Mahoney and others (2003) used genetic data to conclude that these two lizards were non-native on San Nicolas Island.

Study Area

San Nicolas Island is one of the eight Channel Islands located off the coast of southern California; it is the farthest island from the mainland coast. It is approximately 98 km south-southwest of Point Mugu, the nearest point on the mainland, and 155 km south of Santa Barbara. San Nicolas is also the most isolated of the islands; the nearest other island is Santa Barbara Island, 45 km to the northeast. Santa Catalina and San Clemente are both about 80 km distant. San Nicolas is a medium-sized island for the Channel Islands group, with a land area of approximately 57 km^2.

The topography of San Nicolas Island is relatively simple. The island is a long, tilted mesa oriented in an east-west direction, ranging from 120 m above mean sea level on the east and north, to 270 m above sea level on the south and west. The mesa drops off in steep slopes on all sides. Because the southern edge of the escarpment is tilted up, the long, southern face of the island is particularly high and steep. A low terrace ranging from 15 to 60 m above sea level surrounds the base of the mesa, and slopes gently down to the island's shoreline. This low terrace is broadest at the west end, where is tapers out to form Vizcaino Point, the western tip of the island.

Geologically, the island is a broad anticline that rises up from the southeastern end of the island (Vedder and Norris, 1963). There is a series of marine terraces that step up from the northern and western shoreline to the southern ridge and escarpment. San Nicolas Island is composed of sedimentary rock, with alternating layers of marine sandstone and siltstone (Vedder and Norris, 1963). From a biogeographic standpoint, the most significant aspect of the geology of San Nicolas Island and the surrounding Southern California Bight are the deep basins separating San Nicolas from the other islands and from the mainland coast. San Nicolas Island was completely submerged during periods of high ocean levels during the Pleistocene, and there has been no connection between the mainland and the island since submergence (Vedder and Howell, 1980). Hence, the present flora and fauna has colonized the island by over water dispersal (e.g., Savage, 1967).

The climate of San Nicolas Island has a Mediterranean character, with strong influences from the surrounding ocean. Like the surrounding islands and the southern California mainland, most rainfall comes during the winter months. The scant annual precipitation totals (less than 30 cm) suggest quite arid conditions. However, summer temperatures are relatively low, and high relative humidity, frequent fog, and low stratus clouds ameliorate the low rainfall total. For this reason, the island vegetation does not have the character of desert vegetation (Dunkle, 1950). Characteristic of the weather on the island is the consistent high humidity, with the mean relative humidity at noon greater than 60 percent (Dunkle 1950; see also Fellers and Drost, 1991). Dunkle (1950) noted a mean annual temperature of 15.7 ºC (60.3 ºF) for San Nicolas Island, with an annual range in mean temperature of only 3.4 ºC (6.2 ºF). The mean high temperature on neighboring Santa Barbara Island ranged from 16.5 ºC (61.7 ºF) in December to 23.0 ºC (73.4 ºF) in August, and the mean low temperature ranged from 12.0 ºC (53.6 ºF) in December to 17.0 ºC (62.6 ºF) in September (over an 8-year period, from 1981 through 1988; Fellers and Drost, 1991).

Halvorson and others (1996) mapped vegetation communities on San Nicolas Island. They described 12 different communities, ranging from widespread Haplopappus scrub (goldenbush scrub) [*Haplopappus venetus* (= *Isocoma menziesii*)], coreopsis scrub, and grassland, to narrowly distributed vernal pool and *Lupinus* scrub. Of the major communities, grassland is dominated by non-native annual grasses (*Bromus* spp., and *Hordeum murinum* and *Avena barbata*), whereas the other communities have dominant native shrub components. For mapping purposes, they lump Haplopappus scrub, annual iceplant, and minor scrub types into a general "coastal scrub" category. In their vegetation map, coreopsis scrub dominates the northern shore and slope of the island, the broad mesa is covered predominantly by coastal scrub and grassland, and the west slope and terrace is vegetated primarily with coastal scrub and inland dune. Most of the steep southern escarpment and shore is mapped as barren, with patches of coastal scrub.

Fieldwork for this study was conducted across most of the island, but work on island night lizards was concentrated in three areas (fig. 1). The Eucalyptus study site (near building B182) was located just off of the south edge of the main terrace adjacent to a grove of *Eucalyptus globosus* growing at the head of a canyon that ran down to the ocean on the south side of the island. The Haplopappus/Grassland study site (near building B112) was approximately 1.1 km north-northwest of the Eucalyptus site, at the edge of the main terrace. The Rock Cobble site was located at Redeye Beach, right at the edge of the intertidal zone. Each of these sites has been visited at least once a year since 1984 when Tom Murphey began research on the island night lizard.

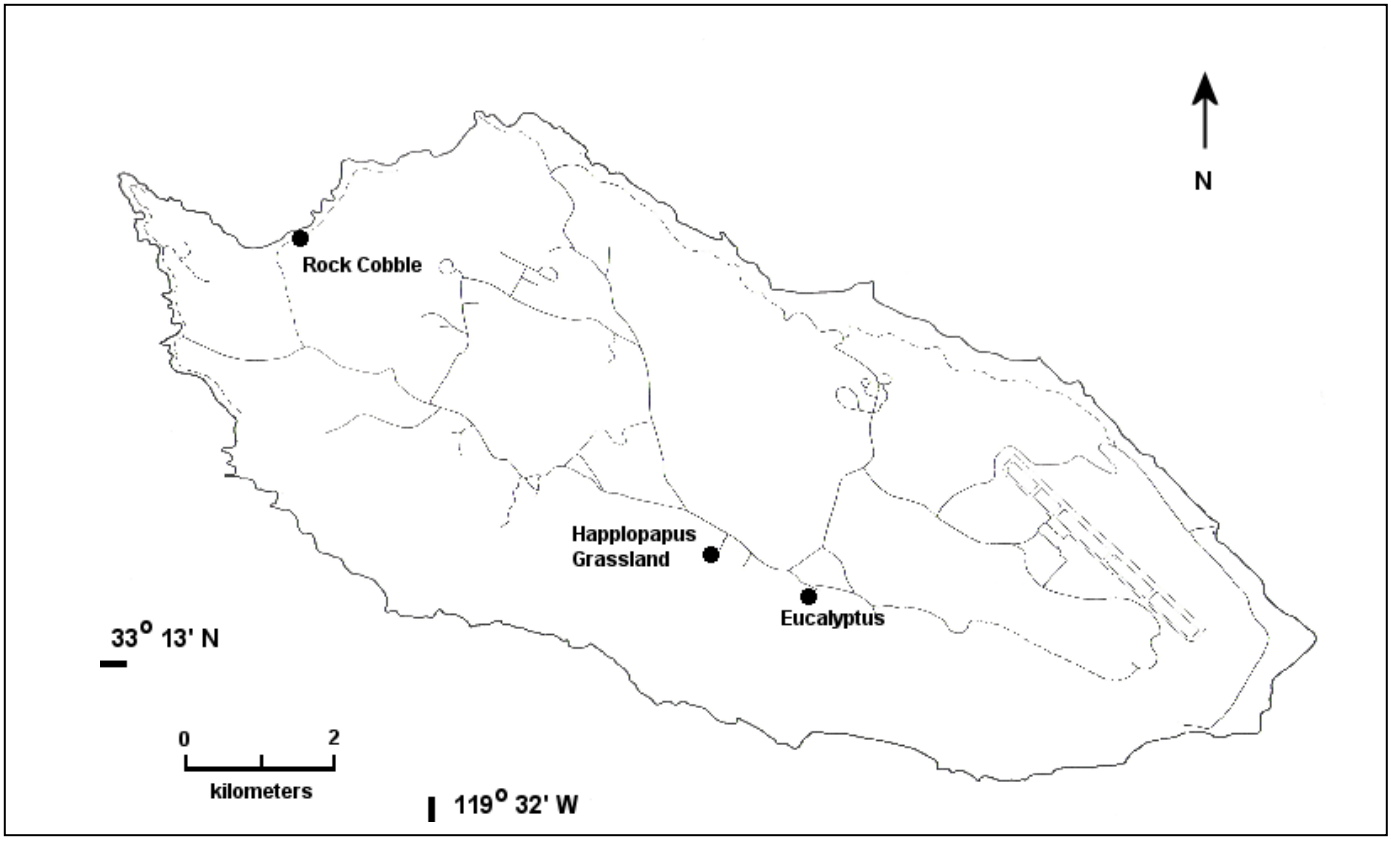

Figure 1. Location of Eucalyptus, Haplopappus/Grassland, and Rock Cobble study sites for the island night lizard on San Nicolas Island, California.

Methods

Methods used for the current study were similar to those used in prior field work on the Channel Islands (Fellers and Drost, 1991; Fellers and others, 1998), although traps were not installed or used to capture lizards. We visited San Nicolas Island on eight occasions during this study (table 1), and also used data from previous work on SNI dating back to June 26, 1984 (Fellers and others, 1998) to evaluate growth, movement, and longevity. All three species of lizards were located by looking under cover boards placed along transects that had been established during prior research and by looking under existing natural (e.g., rocks, small boulders) and artificial (e.g., wood and metal debris) cover objects. For side-blotched lizards, Visual Encounter Surveys were also conducted (Campbell and Christman, 1982; Crump and Scott, 1994). Visual Encounter Surveys are effective for side-blotched lizards because they are often found basking or foraging in the open, unlike the other two species on the island, which are only rarely seen in the open. We looked for lizard sign (droppings, tracks, shed skins, and bones) during our Visual Encounter Surveys and under any cover object that was turned. Not all lizard sign could be identified to species, but lizard skins, some bones, some tracks, and dropping on top of rocks could often be assigned to a particular species.

Table 1. Dates of field work for the island night lizard study on San Nicolas Island, California, 1999–2007.

July 2–6, 1999
October 8– 11, 1999
August 31– September 3, 2001
September 20–23, 2002
October 17–19, 2003
April 21–24, 2005
April 21–33, 2006
May 3–6, 2007

Transect cover boards consisted of 29 × 57 cm pieces of Douglas fir (5 cm thick). The boards were put out in linear transects of 20 boards with a spacing of 5 m between boards for a total length of 95 m. Cover boards were checked once during each visit to the island, though not all transects were visited on each trip. When a cover board was turned, an attempt was made to capture any lizards under the wood.

Lizards were also sampled under existing cover boards, typically plywood sheets (1.2-cm thick) that had been abandoned by the Navy. The size of this cover varied widely, ranging up to full size sheets of plywood, 2.4 × 1.2 m. Most of the cover boards had been in place for more than 20 years, and some of the greatest intervals between captures of marked lizards occurred at these sites. Existing cover boards were checked similarly to cover board transects, though on occasion we would check a few of the boards for a second time after a few days.

Lizards at some of the long-established sites (i.e., eucalyptus, lighthouse, rock cobble) were weighed, measured, and examined to determine their sex and general condition. Lizards 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 lizard. Snout-vent length (SVL), tail length, length of any regenerating part of the tail were measured to the nearest 1 mm. After 1985, nearly all lizards were measured by one person (Drost) to minimize variation in taking measurements. Lizards were marked by clipping a minimum of two toes, but never more than one toe per foot [see Fellers and Drost (1991) for details]. Recapture data were used to calculate size-specific growth rates for 1 mm intervals for lizards with a SVL between 34 and 110 mm. For SVLs greater than 100 mm, data are sparse probably because growth rates slowed down. Hence, the growth rate for 100 mm SVL lizards was used for all sizes at or above 100 mm.

Fieldwork for the current study took place between July 2, 1999, and May 6, 2007 (table 1). However, since much of the data are most meaningful when analyzed as part of a long-term dataset, all data collected since 1984 were used for this report. Details of the earlier work on San Nicolas Island can be found in Fellers and others (1998).

Results

Island Night Lizards

Between 1984 and 2007, we captured and individually marked 997 island night lizards on San Nicolas Island. These lizards ranged from 31 to 117 mm SVL, with the majority of individuals falling into the smallest size class: 248 lizards were <40 mm (fig. 2). The number of lizards in each size class generally declined with increasing size.

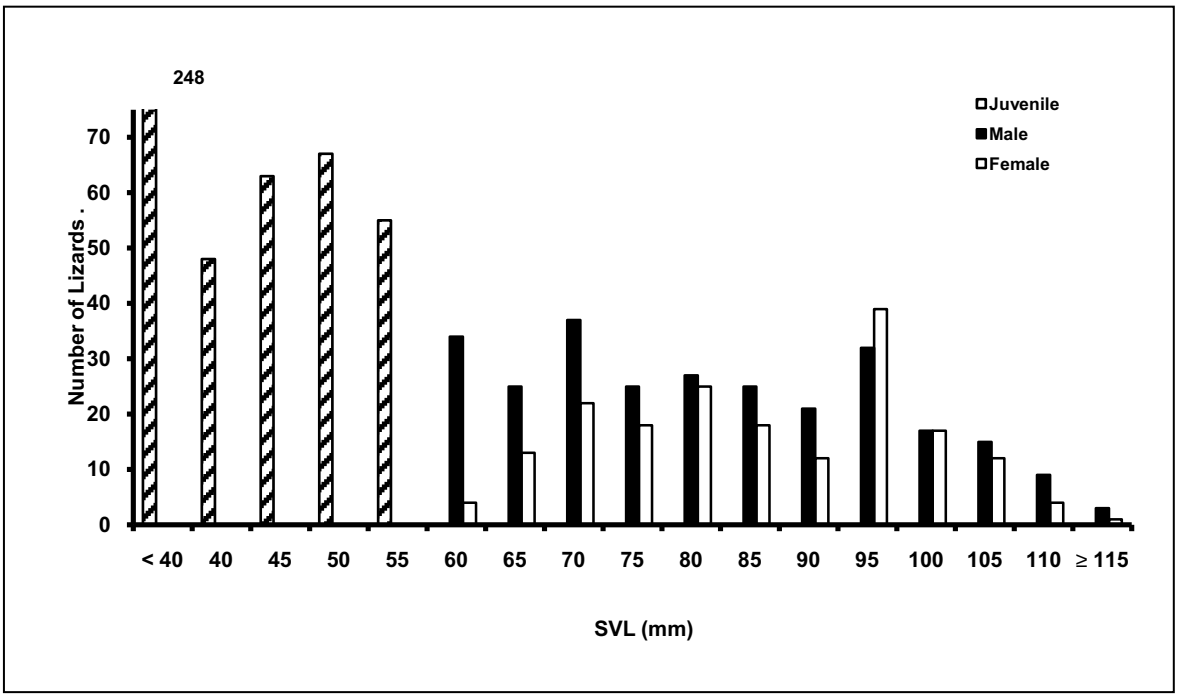

Figure 2. Size distribution by snout-vent length of 997 juvenile, male, and female island night lizards on San Nicolas Island, California, 1984–85 and 1992–2007. Note that the number of 35–40 mm juveniles was 248, a number too large to plot.

The size distribution of island night lizards varied by habitat (fig. 3). The Haplopappus/Grassland and Eucalyptus study sites supported relatively high numbers of large individuals, with all three habitats having at least one lizard that exceeded 100 mm SVL. Of the two largest lizards (117 mm SVL), one was captured at the Eucalyptus site and the other was at the Haplopappus/Grassland site. The largest island night lizard captured at the Rock Cobble site was 114 mm SVL.

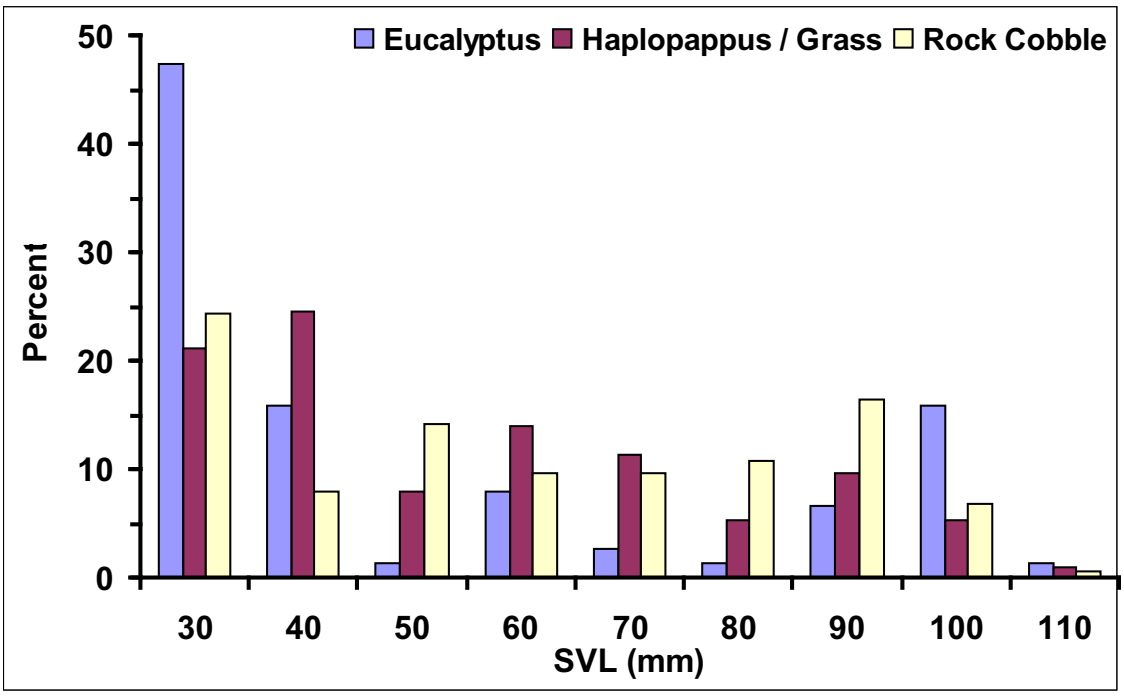

Figure 3. Size distribution of island night lizards for three habitats on San Nicolas Island, California, 1984–2007.

Summarizing the data by juveniles, males, and females and comparing proportions of lizards in each category for the 1900s and 2000s results in significantly different distributions between periods with many fewer juvenile lizards in the 2000s ($X^2 = 51.4$, $p < 0.001$; fig. 4). For the Eucalyptus site, there has been a notable change in size distribution over the last 15 years. A comparison of size distribution using 5 to 6 year intervals shows that the smallest size class (30 mm SVL) has greatly declined since the 1992–96 period (fig. 5). From 1997 to 2001, none of the smallest lizards were found, while this smallest size class accounted for <10% of lizards at the Eucalyptus study site during the 1992–96 period.

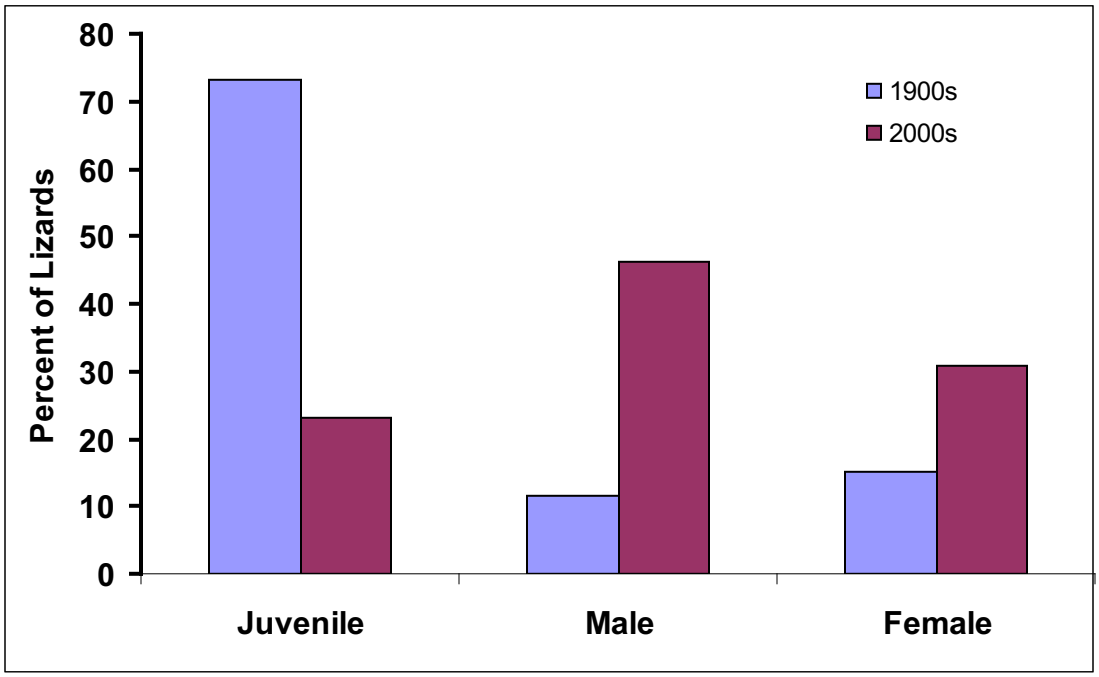

Figure 4. Proportion of juvenile, male, and female island night lizards in Eucalyptus habitat on San Nicolas Island, California, from 1984–2007.

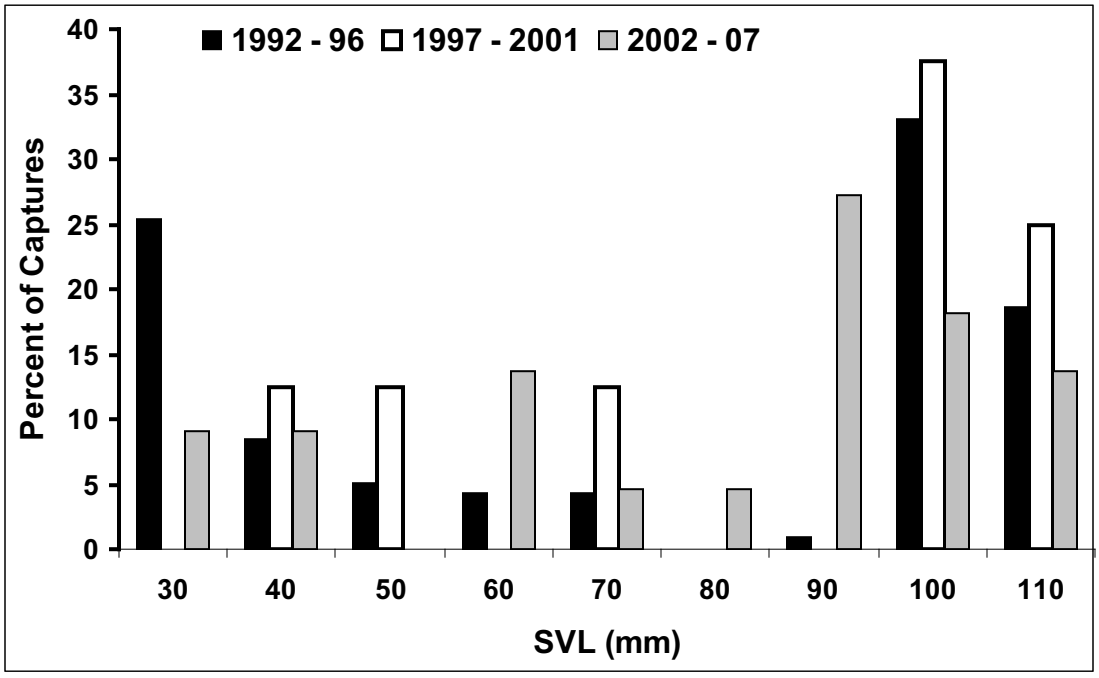

Figure 5. Size distribution of island night lizards in the Eucalyptus habitat over three time periods on San Nicolas Island, California.

Comparisons of size distributions for each of the three study sites also show differences between these time periods. The size distribution of adult island night lizards at the Eucalyptus site was more even in the 2000s (fig. 6). This is because there has been a reduction in the proportion of the large individuals, most notably in the 100–110 mm SVL class. In the 1900s, most of the adult lizards were in that size range; in the 2000s, the largest size classes were more evenly distributed. At the Haplopappus/Grassland site, there has been a loss of the very largest adult size class (>110 mm), but a modest increase in the proportion of island night lizards in the next two smallest classes (fig. 7). The Rock Cobble site has shown an increase in the 90 mm, and to a lesser degree, the 80 mm size class, but a reduction in the largest and smallest classes (fig. 8).

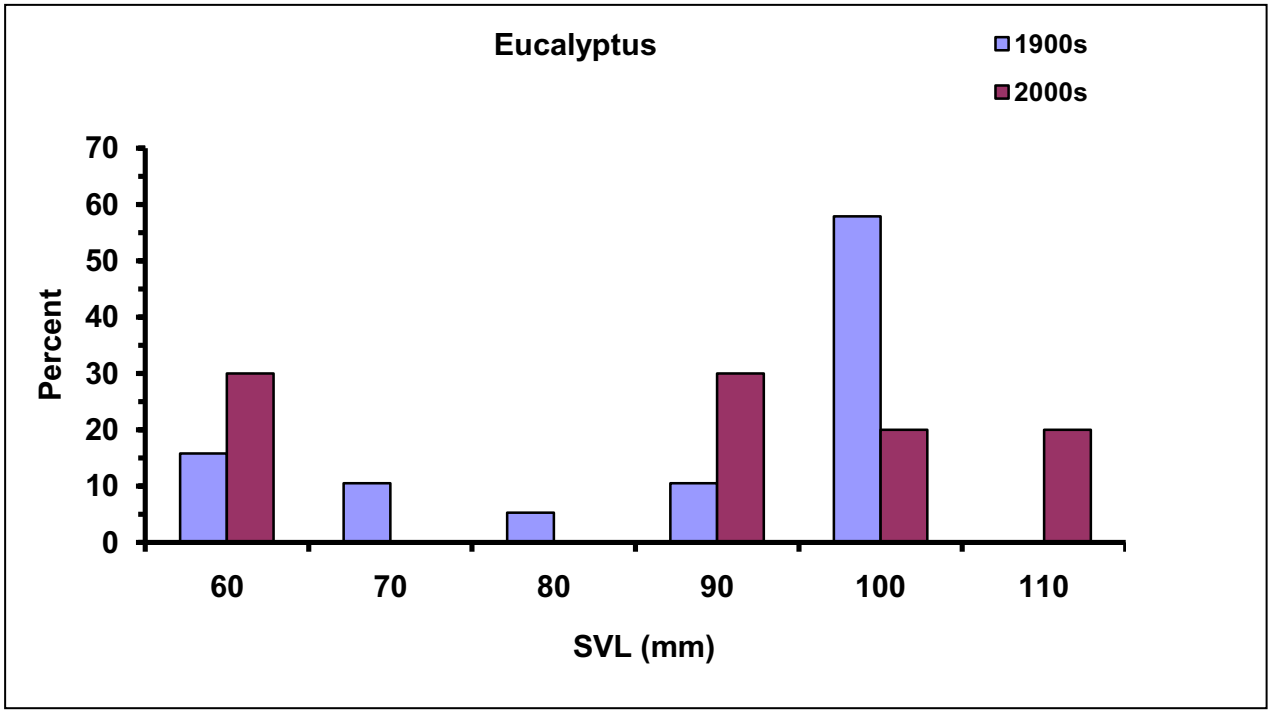

Figure 6. Size distribution of adult island night lizards in the Eucalyptus habitat on San Nicolas Island, California, from 1984–2007. (n = 29 individuals)

The longest interval between captures was 8,306 days (20.8 years) for a female lizard that was first caught July 19, 1984, at 83 mm SVL, and was last captured April 22, 2005, at 107 mm SVL. In addition to that lizard, one night lizard had a recapture interval of more than 18 years, nine lizards had a recapture intervals between 10 to 15 years, and 21 lizards were recaptured at least 5 years after their first capture (table 2). Size-specific growth rates were calculated for every mm of SVL for lizards 34 to 110 mm in size (fig. 9); these rates were compared with growth rates for lizards on Santa Barbara Island (fig. 13 in Fellers and Drost, 1991). Using the SNI data, we plotted estimated age for lizards with at least a 5-year capture interval (fig. 10).

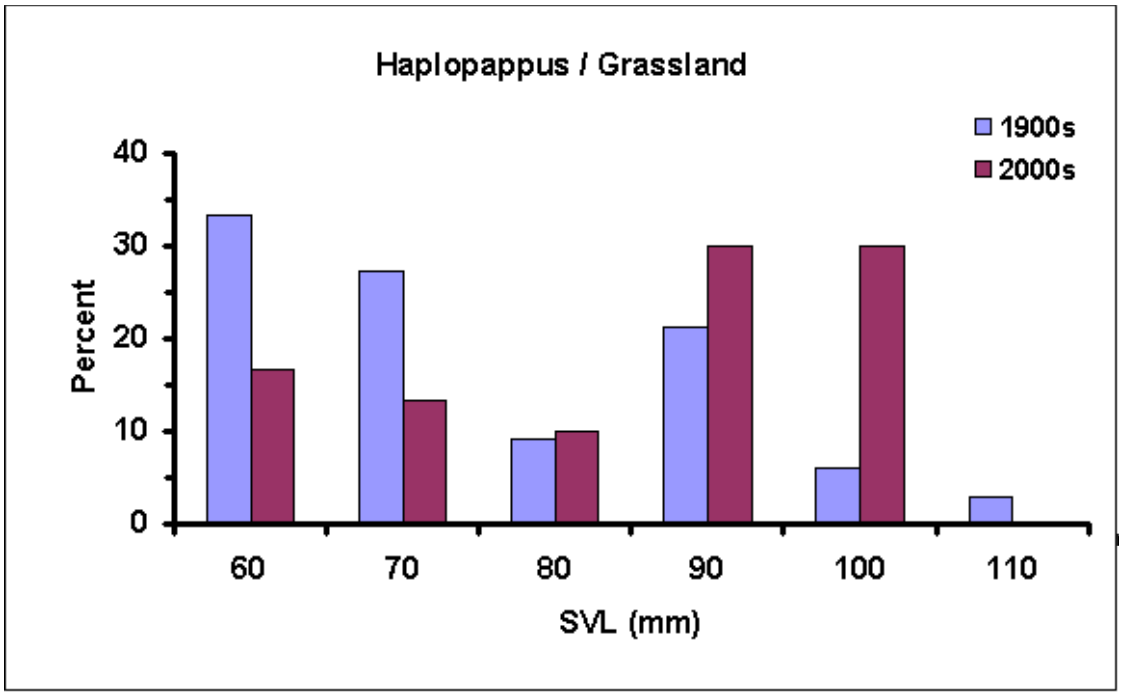

Figure 7. Size distribution of adult island night lizards in the Haplopappus/Grassland habitat on San Nicolas Island, California, from 1984–2007. (n = 63 individuals)

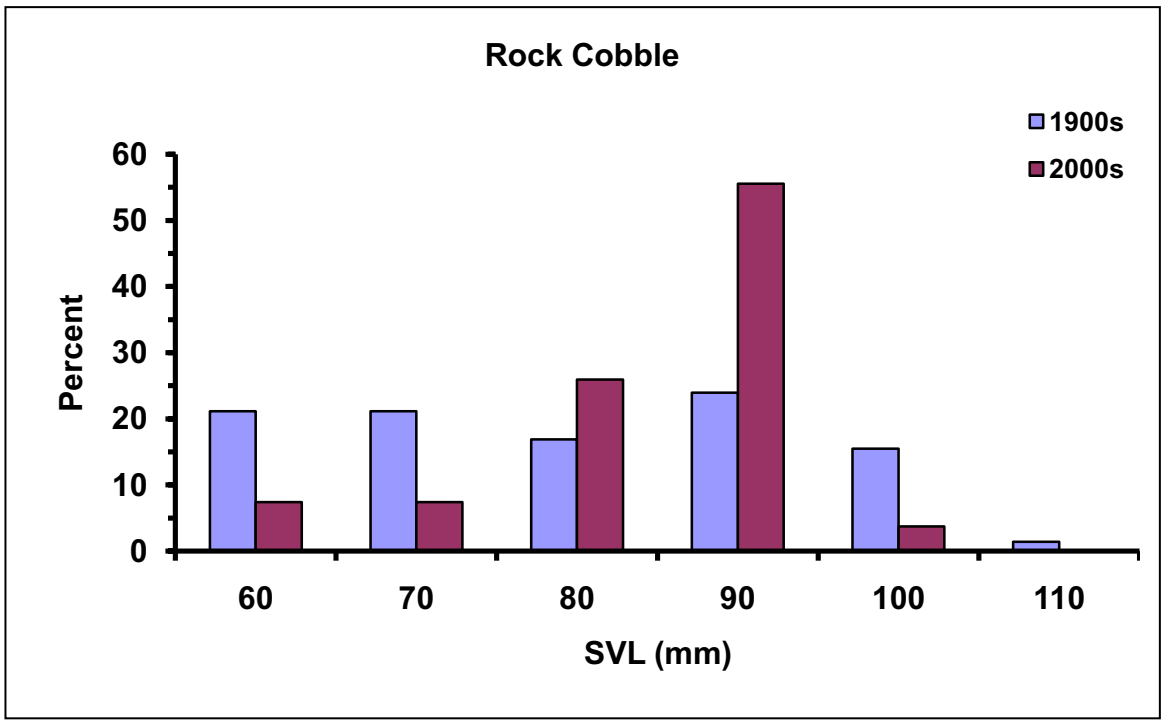

Figure 8. Size distribution of adult island night lizards in the Rock Cobble habitat on San Nicolas Island, California, from 1984–2007. (n = 98 individuals)

Table 2. Interval between first and last capture for island night lizards on San Nicolas Island, California, with capture intervals spanning 5 or more years.

No	Sex	Date1	Date 2	SVL 1	SVL 2	Estimated Age at 1ST Capture	Years between Captures	Estimated Final Age
324	F	9/26/1984	7/5/1999	109.0	115.5	16.7	14.8	31.5
250	F	9/12/1984	9/21/2002	96.0	109.0	7.6	18.0	25.6
141	F	7/19/1984	4/22/2005	83.0	107.0	4.7	20.8	25.4
2225	F	8/19/1992	5/5/2007	100.0	110.0	8.7	14.7	23.4
4324	F	9/21/1993	4/22/2006	101.0	110.5	8.3	12.6	20.9
5000	F	6/25/1994	5/6/2007	94.0	98.5	6.7	12.9	19.6
305	F	9/13/1984	5/26/1995	102.0	110.0	8.7	10.7	19.4
1534	M	10/28/1995	5/4/2007	99.5	115.0	7.8	11.5	19.3
3043	F	5/4/1993	5/6/2007	43.0	109.0	0.9	14.0	14.9
1053	M	5/28/1989	9/22/1995	108.0	110.5	8.3	6.3	14.6
1344	M	9/22/1995	10/18/2003	100.0	108.0	6.2	8.1	14.3
2050	F	7/4/1999	5/4/2007	101.5	107.0	6.1	7.8	14.0
1341	F	9/22/1995	5/4/2007	57.0	108.5	1.9	11.6	13.5
14	U	6/28/1984	8/23/1994	63.0	102.0	2.3	10.2	12.5
4531	M	4/26/1994	7/5/1999	100.0	110.0	7.3	5.2	12.5
1034	M	9/25/1985	5/28/1994	75.0	111.0	3.3	8.7	12.0
511	U	9/5/1985	8/23/1994	69.0	102.0	2.7	9.0	11.7
2211	F	8/31/2001	5/4/2007	93.0	108.0	5.8	5.7	11.5
1022	M	9/24/1985	9/9/1993	78.0	96.5	3.4	8.0	11.4
2015	M	7/4/1999	5/4/2007	74.0	105.0	3.4	7.8	11.2
354	F	7/16/1985	5/28/1994	61.0	98.0	2.2	8.9	11.1
40	M	5/26/1995	9/21/2002	76.5	97.0	3.6	7.3	10.9
3042	F	5/6/1993	9/3/2001	63.0	105.5	2.4	8.3	10.8
420	F	7/29/1985	6/28/1994	55.0	101.5	1.8	8.9	10.7
502	U	9/4/1985	8/23/1994	49.0	103.0	1.6	9.0	10.6
2051	F	7/4/1999	4/21/2006	78.0	102.0	3.7	6.8	10.5
733	M	9/23/1995	9/20/2002	66.5	98.0	3.0	7.0	10.0
1434	F	9/23/1995	9/20/2002	71.5	99.0	3.0	7.0	10.0
2002	F	7/3/1999	4/21/2006	64.0	106.0	2.5	6.8	9.3
1054	M	2/21/1990	10/27/1995	72.0	99.5	3.2	5.7	8.8
2214	F	8/31/2001	5/4/2007	65.0	98.5	2.3	5.7	8.0
1345	F	9/22/1995	9/3/2001	54.0	97.0	2.0	5.9	8.0

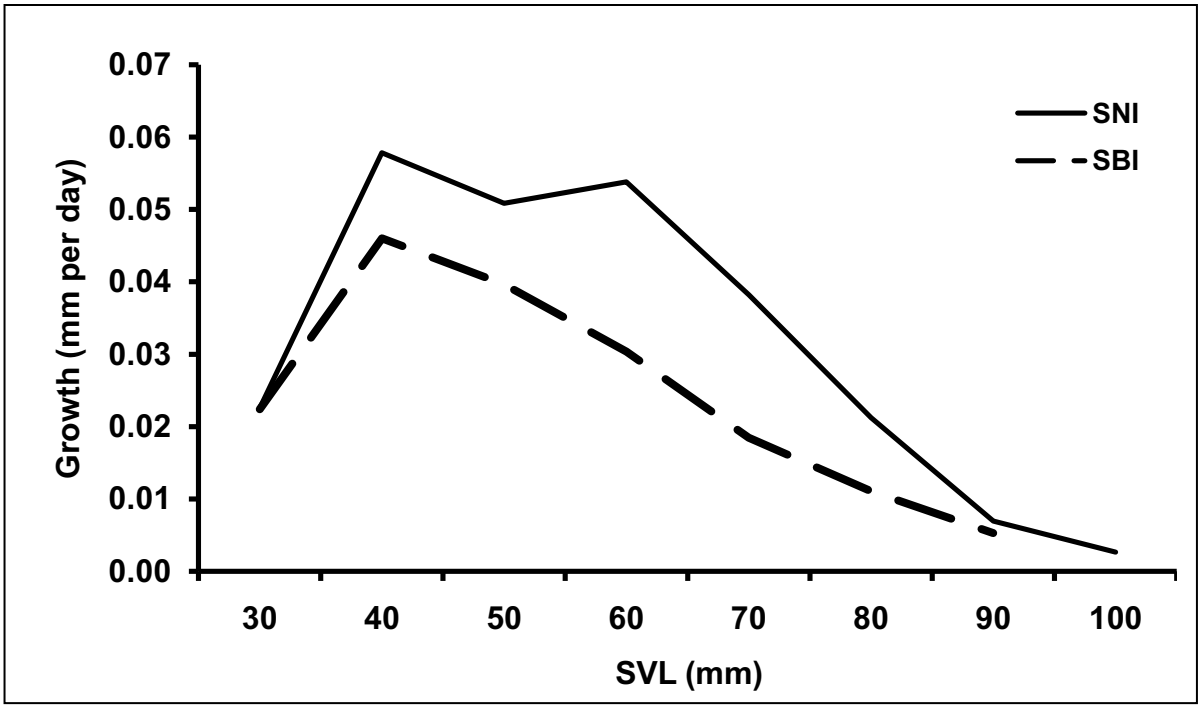

Figure 9. Growth rates for island night lizards on San Nicolas Island (SNI) and Santa Barbara Island (SBI), California.

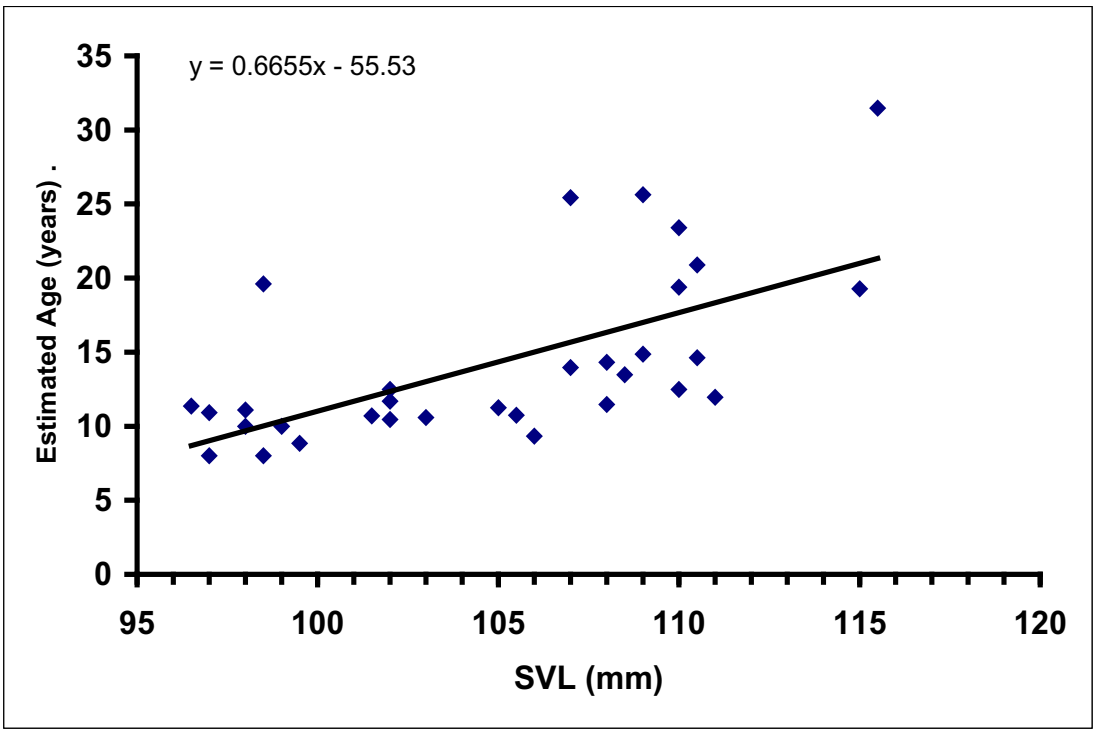

Figure 10. Estimated age of island night lizards on San Nicolas Island, California, for different snout-vent lengths (SVL) from 1984–85 and 1992–2007. Graph includes only lizards with capture intervals of 5 years or more between first and last capture.

Side-Blotched Lizards

The distribution and abundance of side-blotched lizards showed patterns of expansion and contraction, which appear to differ from one part of the island to the other (fig. 11). By 2001, side-blotched lizards had expanded their range to 300 m east of NAVFAC Road on the north terrace, and to the west edge of the residence compound (Public Works bone yard) on the north side of the main plateau. On the main plateau, side-blotched lizards had barely crossed the main north-south road (Owens Road), to the eastern head of Celery Canyon. Along the south ridge, side-blotched lizards reached as far west as the Eucalyptus study site (Building 182) site. On the south beach terrace, side-blotched lizards had advanced from the east to about halfway along Dutch Harbor.

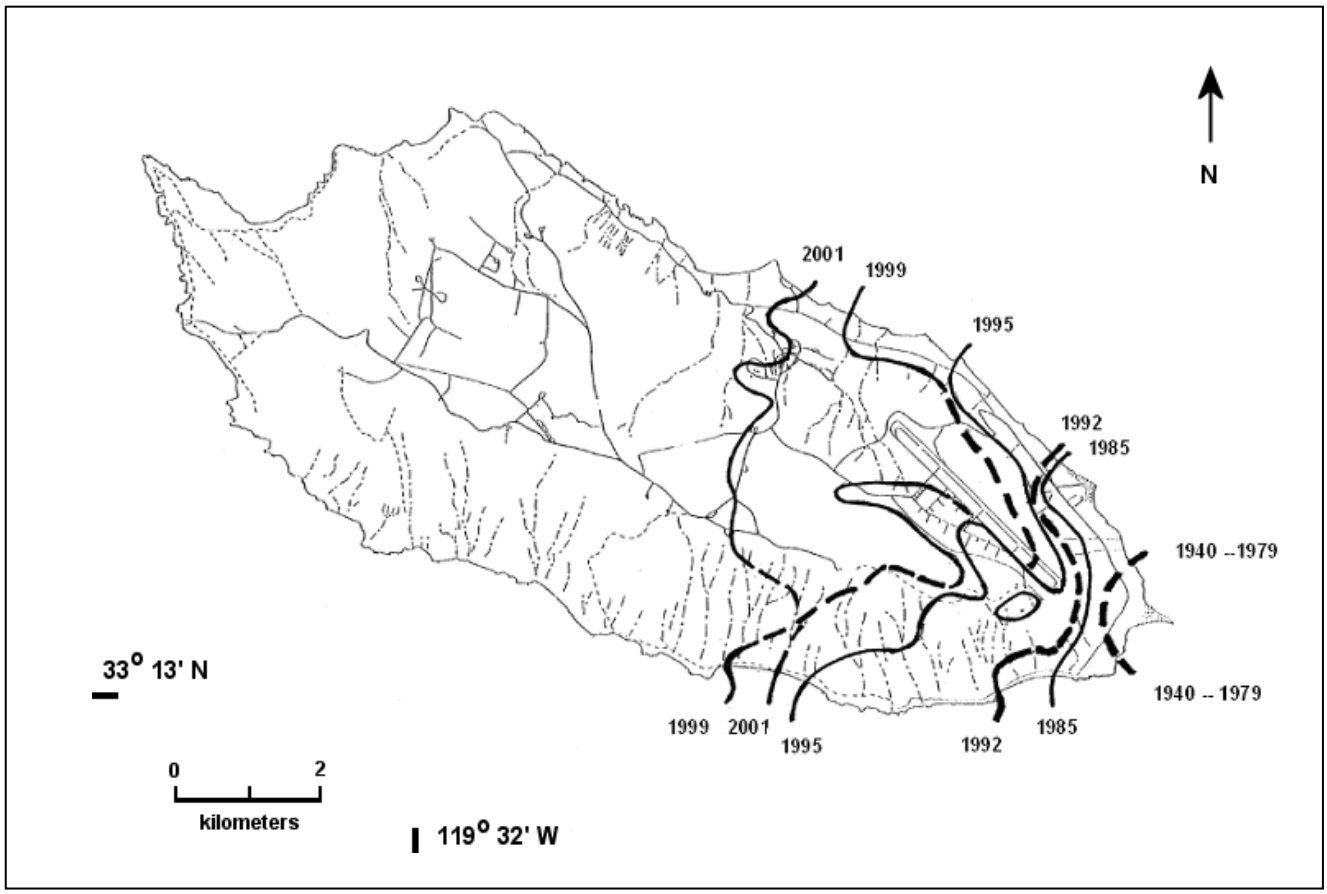

Figure 11. Expansion of side-blotched lizard (*Uta stansburiana*) distribution on San Nicolas Island, California. Successive lines show known range limit to that date. The first record of the species was in the sand spit area at the east end of the island; their range was not known to extend beyond that area until the 1980s. Dashed lines indicate that the range limit in that area was less certain at the time. Note that the known range along the south shore extended farther west in 1999 than in 2001.

Between 2001 and 2005, the distribution of side-blotched lizards appeared to remain stable or even contract in places. On the north beach terrace, lizards were seen no further than 600 m east of NAVFAC Road. In the residence area, only a few lizards were found, and only two of these were west of Owens Road. Distribution in this area appeared to have contracted 400 to 500 m (fig. 12). The south main plateau was not surveyed in 2002 or 2003. However, in 2005, a single lizard was found in the head of the west-most fork of Celery Canyon, a jump of 900 m from the west-most point previously seen in this part of the island. No other lizards were found west of the Monroe Road corridor (the west-most area they had been found in previous years). The west-most point where side-blotched lizards were found along the south ridgeline was virtually the same in 2002, 2003, and 2005 (all locations were within an area of about 100 m). Similarly, no advance was seen in the Dutch Harbor area.

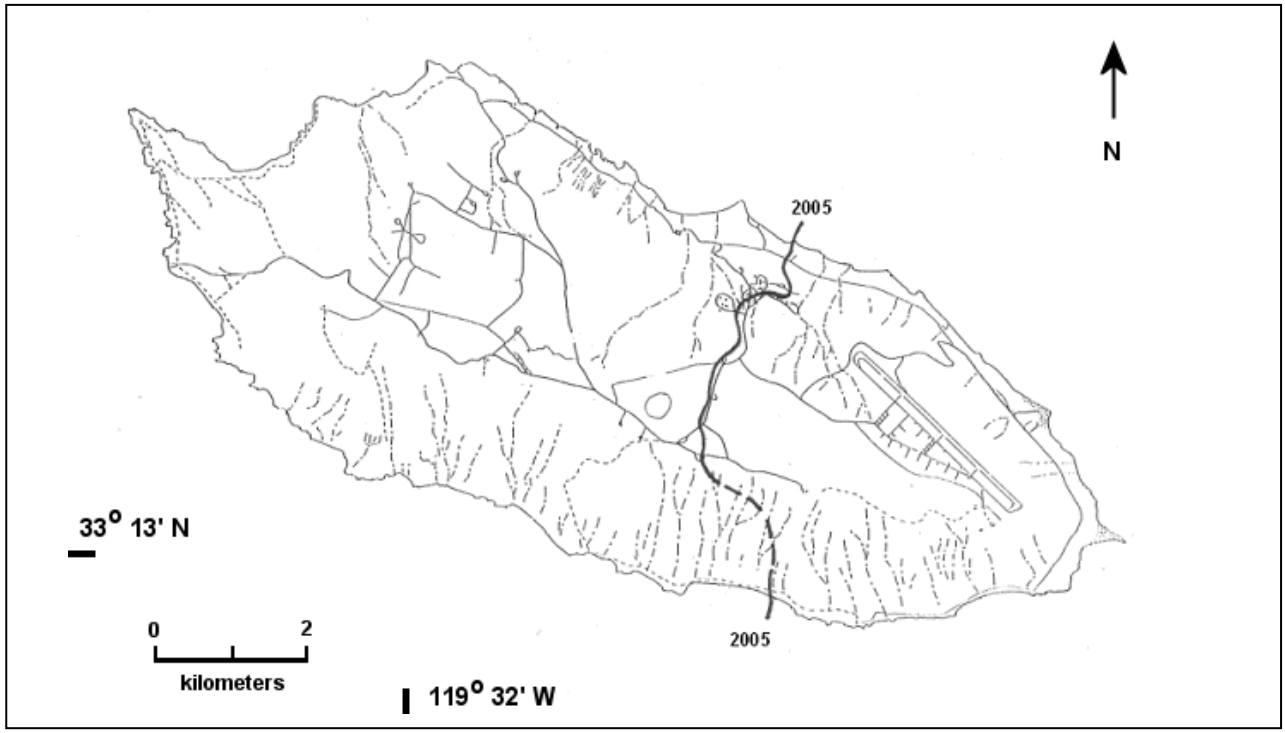

Figure 12. Range limit of side-blotched lizards (*Uta stansburiana*) on San Nicolas Island, California, in 2005. At that time, they occurred throughout suitable habitats east of this line.

In 2006, a range expansion was seen in some areas again. On the north beach terrace, side-blotched lizards were again within 250 m east of NAVFAC Road. They were numerous in the residence area again, and were again found at the west edge of the developed area, near the rim of Celery Canyon. On the south ridgeline, side-blotched lizards had moved past the Owens/Shannon Rd. junction, an advance of close to 400 m. In contrast, on the main terrace, no lizards were found west of the Monroe Rd. corridor, and on the south beach terrace, no lizards were seen as far west as Dutch Harbor.

In 2007, side-blotched lizards were again scarce in the residence area, with no lizards west of Owens Rd (fig. 13). On the north beach terrace, the farthest west that lizards were found was 1,300 m east of NAVFAC Road, over 1,000 m short of where they had been in 2006. On the south main plateau, side-blotched lizards were common in the upper part of Celery Canyon, approximately as far west as they had been in 2005. On the south ridge, side-blotched lizards were found another 600 m west, at the lighthouse site. Dutch Harbor was not surveyed in 2007.

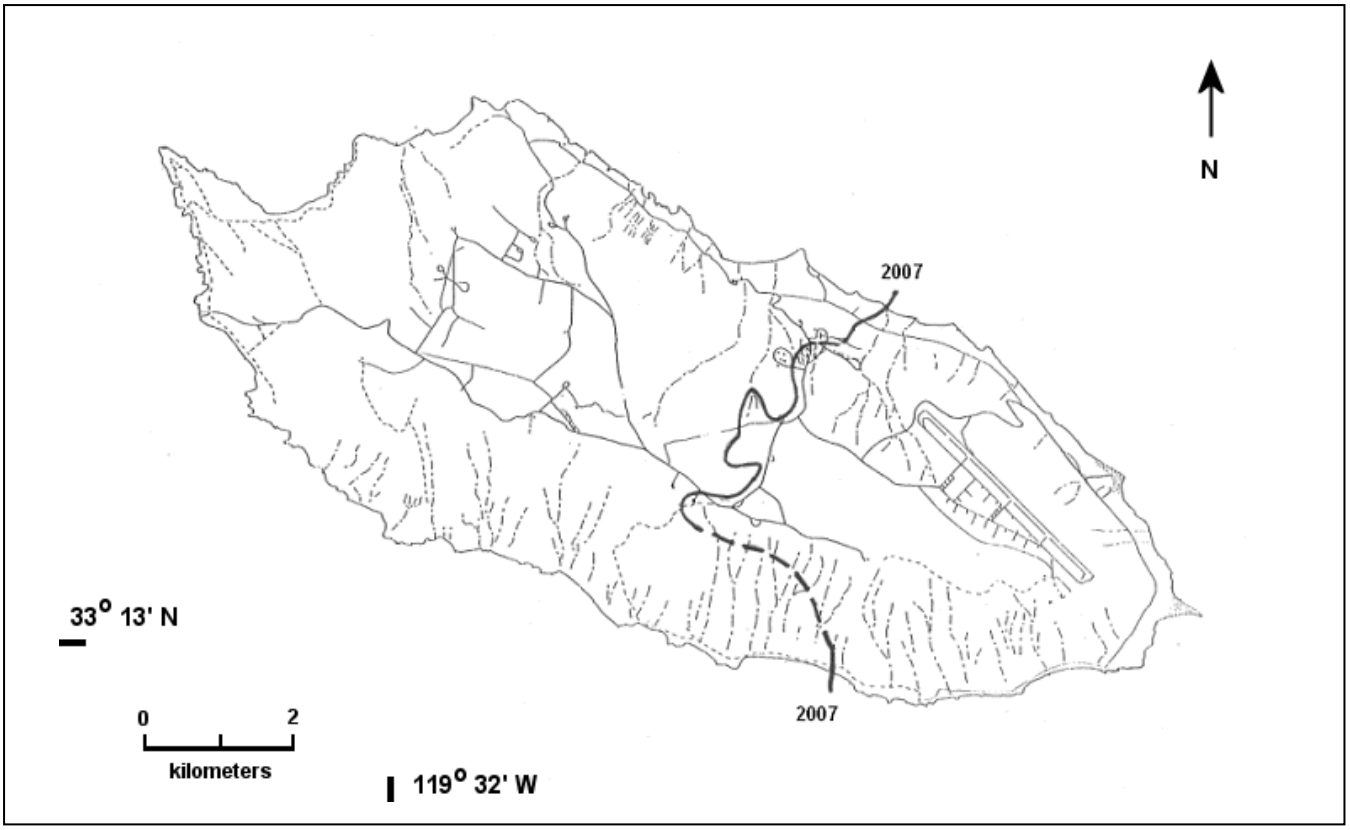

Figure 13. Range limit of side-blotched lizards (*Uta stansburiana*) on San Nicolas Island, California, 2007. At that time, they occurred throughout suitable habitat east of the line. Dashed portion of line indicates the range limit in that area is less certain. Dashed lines are used in areas were we are less certain about the limits of distribution.

Southern Alligator Lizards

The earliest records of alligator lizards on San Nicolas Island are from a museum specimen (collected by E.D. Mitchell, Jr., April 9, 1960) and a shed skin (collected by R.L. Bezy, July 8, 1972) (Banta and Wilson, 1976). Both of these records were from the southeast side of the island, away from Navy facilities. In 1985, the only known locations of the southern alligator lizards were under debris around the Eucalyptus (Building 182) site, and in gullies leading down the steep south slope to the west end of Dutch Harbor, plus an isolated location a few hundred meters west of Building 182, at the top of the Theodolite Road. This was in spite of extensive pitfall trapping around the island and widespread searches by Tom Murphey during 1984–85. By 1995, we found southern alligator lizards under cover boards in the grassland south of the junction of Monroe Road and Beach Road, around the Owens Road fire station, and along a board transect near the junction of Jackson Highway and Shannon Road (fig. 14). Over the next few years (up to 2003), we found alligator lizards in the grassland west of Shannon

Road, in and around the residence area, around buildings south of the west end of the airfield, and a single individual in a gully leading down to the north beach terrace. By 2007, alligator lizards had spread to points along the north beach terrace, east of the NAVFAC Road and west of Beach Road.

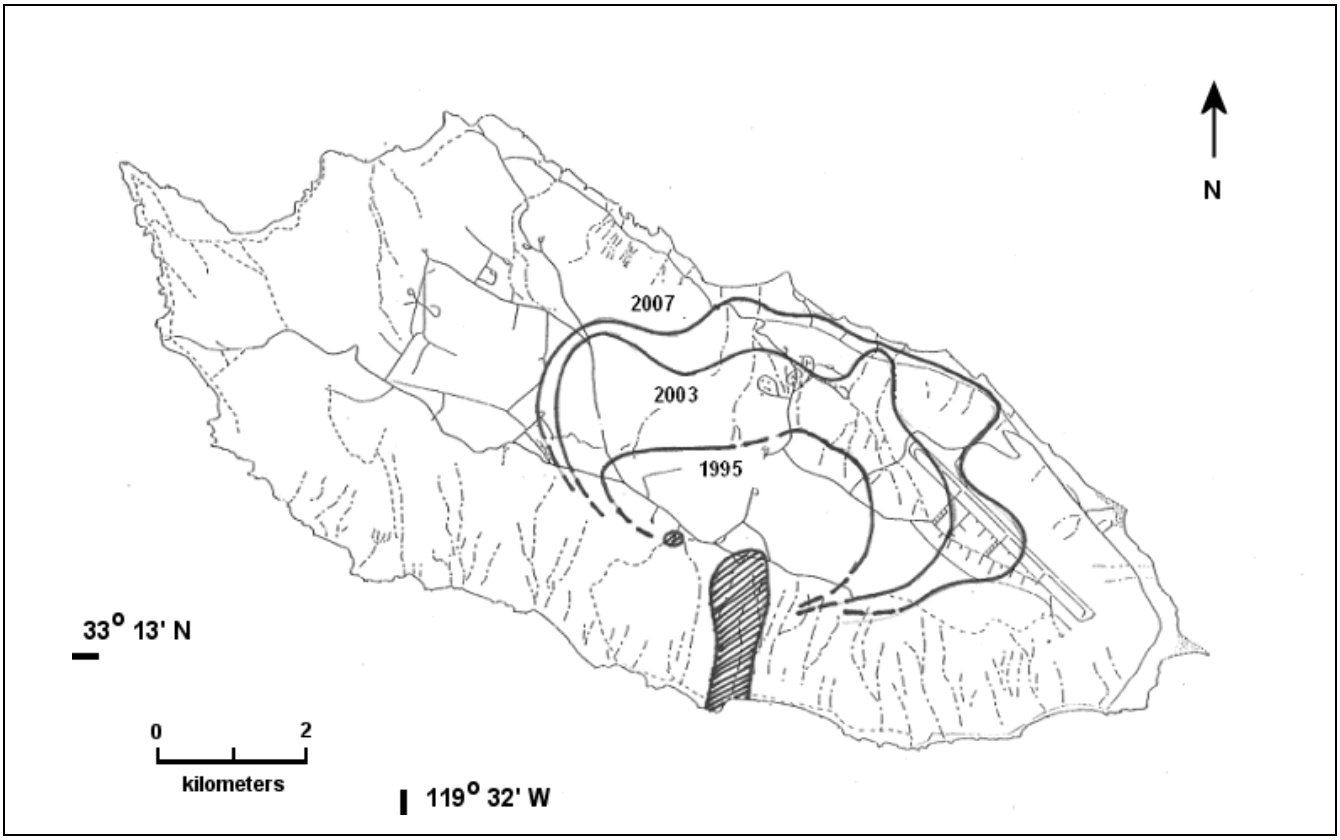

Figure 14. Expansion of southern alligator lizards (*Elgaria multicarinata*) on San Nicolas Island, California from 1985– 2007. Hatched area is the extent of the known range in 1985. Dashed portion of line indicates the range limit in that area is less certain.

Discussion

Island Night Lizards

A substantial dataset has been accumulated for lizards on San Nicolas Island, including over 1,800 captures of more than 900 individually marked island night lizards since 1984, when Tom Murphey first began studying lizards on the island. This has allowed us to look at changes in size distribution, compare lizard size distributions in different habitats, and develop estimates of both growth and longevity for a long-lived, slow-growing, secretive lizard. In combination with the 8-year study of island night lizards by Fellers and Drost (1991) on Santa Barbara Island, this is one of the most detailed studies of a reptile species.

Island night lizards on Santa Barbara Island rarely attain a SVL of more than 100 mm. The largest lizard captured by Fellers and Drost (1991) over an 8-year period (1981–1988) was 102.5 mm. The largest island night lizard reported in the literature is a 109 mm individual from San Nicolas Island (Goldberg and Bezy, 1974). We reported an island night lizard at 117 mm in our 1998 report (Fellers and others, 1998), and that remains the largest island night lizard on record.

Fellers and Drost (1991) presented data from Santa Barbara Island, which suggested that the largest island night lizard they captured (102.5 mm, SVL) could be as old as 13.4 years. Other lizards ranging up to 96 mm were estimated to be nearly 10 years of age. Mautz (1993) suggested that the oldest island night lizards he captured on San Clemente Island were 12 and 13 years old. Our data from San Nicolas Island suggest that at least a few lizards are probably more than 20 years old, and one lizard would be 31.5 years old if it grew at an average rate for the population. This estimated age is slightly less than the age we estimate for this same lizard in the 1998 report due to better age-specific growth rate data that we now have. Ages of 20 and 30 years seem reasonable given the remarkably slow growth during capture intervals of more than a decade for five of the lizards used in these calculations.

Our island-wide size data for island night lizards on San Nicolas Island are similar to that for island night lizards on Santa Barbara Island (Fellers and Drost, 1991), with the most abundant size class represented by the young of the year. On San Nicolas Island, female lizards were less common than males in 11 of 12 size classes, suggesting that there might be somewhat higher survivorship in male lizards. We are currently investigating this trend with several statistical models.

The high percentage of small lizards in the Eucalyptus habitat might seem to reflect a healthy population in that habitat, but the high proportion of small lizards appears to be caused by good reproduction in the 1900s and substantially poorer reproduction in subsequent years. Comparison of 1990s with 2000s (fig. 4) shows that there was only limited reproduction in the 2000s. At times we have wondered if someone on the island might be collecting large lizards from the Eucalyptus site, but we have not been able to acquire any evidence of such activity, so we have considered other hypotheses. The Eucalyptus habitat has dried quite a bit in recent years. What effect this might have on night lizards is uncertain, but it is possible that there has been a reduction in both invertebrate prey and succulent plants that were present in greater abundance when the habitat was wetter. Also, there has been an increase in southern alligator lizards in the vicinity of the Eucalyptus. The increase in alligator lizards is most likely related to an island-wide increase in distribution of this non-native species. With the observational data we have, it is probably not possible to sort out the relative influence of a drying habitat and the increased number of alligator lizards on the island night lizard population.

Island night lizards in the Haplopappus/Grassland habitat in the vicinity of the lighthouse (fig. 1) have shown an increase in the proportion of larger lizards since 2000. This is an area where the habitat has not noticeably changed since we began working on the island in 1984. There has also been an increase in the proportion of large lizards (especially those in the 80 and 90 mm SVL range) in the Rock Cobble habitat at Redeye Beach. However, in this area, there are has been some change in habitat with more elephant seals occupying the same area just above the high tide line as do the night lizards. Although these marine mammals are not necessarily a detriment to night lizards, they do change the habitat by lying on the rock cobble that harbors island night lizards. Nonetheless, island night lizards occupying the rock cobble must be accustomed to frequent habitat changes since winter storms would certainly wash over the area we normally sample. Presumably island night lizards move higher up the slope and use the suboptimal microhabitat provided by the low bushes during winter storms. Another important factor with long-term monitoring of lizards in this unusual habitat is that it is difficult to capture lizards in the combination of rocks and sand. In such a complex microhabitat, we cannot assume that we capture all size classes equally well. Also, in years where there is a lot of sand, it might be more

difficult for lizards to escape as we lift up rocks, whereas in years when winter storms deposit less sand on the beach, there are more interstitices between rocks, making it easier for lizards to elude capture.

Like other lizards, the island night lizard growth rates vary by size of lizard. The pattern of growth is similar for lizards on Santa Barbara and San Nicolas Islands, although there are minor differences, especially in the 40 to 60 mm size classes. In general, growth was somewhat greater on San Nicolas Island than on Santa Barbara Island, and this increase was sustained through all the intermediate size classes. The higher growth rate may account for the somewhat larger lizards present on San Nicolas Island, although we cannot discount the possibility that night lizards on San Nicolas are merely living longer.

Non-Native Lizards

Southern alligator lizards are more difficult to find than side-blotched lizards, thus we have not been able to track changes in their distribution. Most of our locations of this species are from established board transects, and from looking under rocks, scrap wood, and other debris. In areas where we do not have established board transects and where there is little natural or artificial cover, we have few records of southern alligator lizards and the limits of its distribution are imprecisely known. In areas where we have cover boards, they are regularly used by southern alligator lizards. Cover boards seem to provide a reliable indication of when alligator lizards are present in an area. Hence, the cover boards provide some of our best data on the increasing distribution of southern alligator lizards on San Nicolas Island.

In our 1998 report, we noted that southern alligator lizards were slowly increasing their distribution on San Nicolas Island. This was of concern in part because alligator lizards are as large or larger than most island night lizards and prey on a variety of invertebrates and small vertebrates (Nussbaum and others, 1983) which might result in competition with island night lizards. However, our data indicated that the two species tend to occur in different habitats, both general habitat types, and microhabitat preferences within a local area. We found six alligator lizards in grassland habitats where night lizards rarely occur, and then probably only as transients. At the Eucalyptus site, where moderate numbers of alligator lizards and high numbers of night lizards occur, the two species typically occurred under different boards. Alligator lizards were found more frequently in the cooler sites in and near the shade of *Lavatera* and *Eucalyptus*, and night lizards were more numerous in areas away from dense shade.

We see no indication of negative impacts of alligator lizards on island night lizards and hence we do not recommend any management effort to control or eradicate alligator lizards on San Nicolas Island. Even though the species is apparently an accidental introduction, it causes no obvious harm to the native island night lizard, and management time and effort should be directed toward much more pressing problems, such as general habitat restoration, erosion control, and the removal of feral cats.

The other non-native lizard on San Nicolas Island is the side-blotched lizard. We did not discuss this species in our 1998 report, but this lizard is another introduced species on the island. Mahoney and others (2003) reported that side-blotched lizards on San Nicolas Island are genetically identical to mainland relatives from Point Mugu Naval Air Station. Both sites are U.S. Navy installations, and there is regular transport of cargo between the two installations by boat and aircraft. Historical records for side-blotched lizards on San Nicolas Island are nonexistent, and as recently as 1980, the species was not included on a list of reptiles occurring there (Wilcox, 1980). Genetic data suggest recent colonization and inadvertent transport in naval shipments as the mechanism for their arrival on San Nicolas Island (Mahoney and others, 2003).

Our data on the distribution of side-blotched lizards on the island date back to 1985. Since then, we have visited the island during 14 years and have data on the distribution of side-blotched lizards for most of those years (fig. 11–13). During the 1980s and 1990s, side-blotched lizards increased their range on San Nicolas Island, with their distribution expanding nearly every year. More recently, the distribution has been fairly stable with side-blotched lizard distribution expanding in some years and contracting in others, with little net change over the 6–8 years prior to 2007. The reason for this is unclear. The distribution is similar to that of island night lizards, with night lizards occupying roughly the eastern half of the island (plus a few isolated sites to the west) and side-blotched lizards occupying the eastern 40 percent of the island. Thus, side-blotched lizards have never expanded their range as far west as night lizards. Similar to our recommendation regarding northern alligator lizards, we see no reason to control or eliminate side-blotched lizards from San Nicolas Island. It would probably be impossible to do so, and there are much more pressing needs for the time and money that would be expended.

Management Recommendations

Based on the results of our research on San Nicolas Island since 1984, we make several recommendations for the protection and management of the island night lizard on San Nicolas Island. These recommendations are similar to those included in Fellers and others (1998).

1. Because of the restricted distribution and specific habitat needs of island night lizards on San Nicolas Island, any new projects that might alter or damage night lizard habitat should be carefully reviewed and monitored. Habitats of concern include beach cobble/driftwood, prickly pear, cholla cactus, boxthorn, and mixed shrub habitats that contain prickly pear, cholla, island morning glory, Catalina tarweed, and Haplopappus. Fellers and others (1998, figures 11 and 12) showed the distribution of the prime lizard habitat (as of 1995) and the areas that range from moderate to low to no lizard habitat present. Those figures remain accurate today.

2. Habitat stabilization and restoration projects, including erosion control and revegetation, are needed in a number of areas around the island. These projects would be benefit both plant and animal species native to San Nicolas Island. Halvorson and others (1996) also noted the need for active erosion control and vegetation restoration work in barren, eroding areas such as the south bluffs, and areas of the north bluffs. Consideration should be given to using prickly pear and boxthorn as components of the revegetation. Both species provide very good habitat for island night lizards, but are largely neglected in propagation and restoration efforts. Boxthorn has suffered general decline on the Channel Islands (Philbrick, 1972), so revegetating with boxthorn would benefit the shrub as well as providing lizard habitat.

3. Non-native cats and rats could be a serious threat to island night lizards. Rats are generalist predators known to prey on lizards in other island situations. Rats prefer the same dense, shrubby habitats that are best for island night lizards. On Anacapa Island in the northern Channel Islands, rats have reached high numbers between periods of active control. Rats prey on endemic island snails, lizards, and a wide variety of other native species. They may have been responsible for the extirpation of the endemic subspecies of deer mouse on East Anacapa Island, which disappeared sometime during the last 40 years, subsequent to the introduction of rats. A concerted effort should be made to monitor rats and to eradicate them if and when they are found.

Cats are known predators of island night lizards. Animal Damage Control (ADC) personnel who worked on a cat control/eradication program on San Nicolas Island during the 1990s found the remains of island night lizards in the stomachs of several cats. While the current cat population is not likely to be a significant factor in reducing island night lizard populations, there is that potential if the cat population were left unchecked. A continued, concerted effort should be made to control cats and to eradicate them if at all possible.

Although we do not have detailed information on when cats were introduced to San Nicolas Island, we know that cats have been present during all years that we have conducted fieldwork on the island. Although cats seem to be somewhat more abundant near human habitation, we have observed cats in nearly all parts of the island, including some of the best habitats for island night lizards.

4. Monitoring of lizard populations should be continued on an intermittent basis. We recommend sampling every 3 to 4 years, using existing cover board sites and the three study areas (Eucalyptus, Haplopappus/Grassland, Rock Cobble) used in the work reported here. This should provide adequate data for assessing changes in lizard numbers at individual sampling sites and for tracking changes in distribution that may occur with continuing vegetation recovery on the island.
5. Avoid creating artificial habitat for island night lizards with lumber, concrete, wooden pallets, boxes, sheet metal, and other materials. Subsequent removal of such materials would disrupt the local population of lizards that take up residence and could constitute "take" as defined by the U.S. Fish and Wildlife Service, and hence require a formal consultation. To reduce the likelihood that lizards will occupy areas where materials are stored, we make the following recommendations for storage and handling of materials:
    a) avoid storing materials on or near shrubby vegetation, particularly cactus and other low shrubs. Where possible, store material on bare asphalt, ground, or sand.
    b) use pallets or other means of keeping lumber and other flat material up off of the ground.
    c) avoid driving over or otherwise disturbing natural shrubby vegetation when using heavy equipment to handle and place materials.
    d) avoid using rock riprap on slopes or in culverts since it can become night lizard habitat. If such materials are used, they should be made as permanent as possible, so that it is not necessary to disturb the rock and associated vegetation later.
    e) where there is extensive artificial cover that harbors night lizards, consideration should be given to leaving the cover in place if it does not present a safety concern or other serious problem. If that is not possible or desirable, a survey of the cover and the immediate surrounding area (by someone knowledgeable about night lizards and their habitat) may be sufficient to ensure that it is safe to remove the material.

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