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GIANT GARTER SNAKE SURVEYS AT SOME AREAS OF HISTORIC OCCUPATION IN THE GRASSLAND ECOLOGICAL AREA, MERCED CO. AND MENDOTA WILDLIFE AREA, FRESNO CO., CALIFORNIA

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ABSTRACT

The Threatened (California and Federal listings) giant garter snake, *Thamnophis gigas*, is endemic to still and slow-moving waterways of California's Central Valley, such as sloughs, canals, and cattail and tule marshes. Giant garter snakes have experienced substantial habitat loss in the San Joaquin Valley and are seemingly no longer present in some sites where they were documented in the mid-1970's. In 2001 we conducted giant garter snake surveys on both publicly and privately owned lands in the Grassland Ecological Area and at the Volta Wildlife Area, both located in western Merced County, as well as at two sites in Fresno County; Mendota Wildlife Area and Alkali Sink Ecological Reserve. We performed visual surveys for giant garter snakes in early morning when basking snakes were most visible. In addition, at 18 study sites we set floating funnel traps for giant garter snakes along approximately 19 km of wetland edge. We did not encounter any giant garter snakes during our visual surveys. We trapped 15 giant garter snakes; 14 at the Mendota Wildlife Area and 1 in the southern Grassland Ecological Area. We recorded morphological measurements, physical characteristics, and implanted PIT tags into all captured giant garter snakes prior to release at the point of capture. We did not capture any juvenile giant garter snakes nor did we recapture any giant garter snakes; the snake that was captured in the southern Grassland Ecological Area was not a recapture although giant garter snakes were captured at this site in previous surveys. Giant garter snakes were definitively documented on the Mendota Wildlife Area in 2001, the first year since the mid-1970's. However, we have not found giant garter snakes at the Volta Wildlife Area since 1999, despite conducting surveys there in 2000 and 2001. The late summer timing of trapping efforts could explain this result. Giant garter snakes still persist in some San Joaquin Valley locations thus future research efforts should strive to understand their current status, distribution, and the threats to their continued survival. This basic information is needed to protect populations

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of giant garter snakes in the San Joaquin Valley through effective land management decision making on existing giant garter snake habitat and for the restoration of giant garter snake habitat in areas where it is currently absent or degraded.

INTRODUCTION

The giant garter snake, *Thamnophis gigas*, is endemic to the Central Valley of California. Historically, it ranged from near Gridley, Butte County, south to Buena Vista Lake near Bakersfield, Kern County (Hansen and Brode[2] 1980). The Tulare Lake Basin in the southern San Joaquin Valley once constituted a significant portion of giant garter snake habitat. Reclamation of the basin for agricultural purposes was possible upon completion of Pine Flat and Isabella dams on the Kings and Kern rivers, respectively, and thus the range of the giant garter snake was reduced by approximately one-third (Hansen and Brode[2] 1980).

Giant garter snakes are most often drab olive in color, some with black mottling dorsally. In contrast to giant garter snakes found in the Sacramento Valley, giant garter snakes in the San Joaquin Valley may not have any dorsal striping, although striped individuals do occur (Rossman et al. 1996). The snake has a long muzzle, with muzzle length to frontal length ratio averaging approximately 85% in males and approximately 95% in females (Rossman et al. 1996). The valley garter snake, *Thamnophis sirtalis fitchi*, also occurs in the San Joaquin Valley, but the valley garter snake can easily be differentiated from the giant garter snake due to the bright red spots along its lower dorsolateral area (Stebbins 2003). The giant garter snake has 8 supralabials, with the 7th wider than the 6th, as opposed to generally 7 supralabials in valley garter snakes (Rossman et al. 1996). Adult giant garter snakes may grow to be very long, reaching 165 cm total length (Stebbins 2003).

The giant garter snake is highly aquatic, frequenting slow-moving waterways, such as sloughs and other mud-bottomed wetlands (Stebbins 2003). Giant garter snakes prefer wetland habitat where there is screening vegetation in and adjacent to the water. Researchers in the Sacramento Valley found telemetered giant garter snakes associated with vegetative cover in 94% of observations (Wylie et al.[3] 2002). Screening vegetation, such as shrubby willows, Salix sp., is thought to provide protection from predators, while still allowing the snake to thermoregulate (Hansen[4] 1988). Giant garter snakes pursue prey underwater (Hansen[4] 1988). Their historic prey included Sacramento

[2]Hansen, G.E. and J.M. Brode. 1980. Status of the giant garter snake *Thamnophis couchi gigas* (Fitch). California Department of Fish and Game Inland Fisheries Endangered Species Program, Special Publication Report No. 80-5, unpublished. Sacramento, CA.

[3] Wylie, G. D., M.L. Casazza and N.M. Carpenter. 2002. Monitoring giant garter snakes at Colusa National Wildlife Refuge: 2001 progress report. US Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon, CA.

[4]Hansen, G.E. 1988. Review of the status of the giant garter snake (*Thamnophis couchi gigas*) and its supporting habitat during 1986-1987. Final unpublished report to the California

blackfish, *OrthodoN microlepidotus*, thick-tailed chub, *Gila crassicauda*, and red-legged frogs, *Rana aurora draytonii*, none of which are currently available to giant garter snakes. They now take introduced carp, *Cyprinus carpio*, mosquitofish, *Gambusia affinis*, and bullfrogs, *Rana catesbiana* (Rossman et al. 1996).

Agricultural development has impacted giant garter snake populations through habitat destruction and through pesticide and herbicide runoff and drift. Irrigation has increased levels of selenium in some Merced County waterways (Moore et al.[5] 1990) and may impact snake populations. It is interesting to note though, that giant garter snake populations have declined on protected lands such as the Volta and Mendota wildlife areas that have neither received selenium rich agricultural drain water, nor experienced conversion of habitat to agricultural land. More research is needed to understand giant garter snake decline in these areas.

Other threats to giant garter snake populations include urbanization and introduced predators. The Central Valley is rapidly becoming an urbanized environment. For example, the city of Los Banos, located in Merced County, has experienced a 38.7% increase in population between 1990 and 2000 (U.S. Census Bureau, www.census.gov). This city lies between the northern and southern divisions of the Grassland Ecological Area (GEA) and its growth could have direct and indirect impacts on giant garter snake populations.

Introduced predators may reduce the quality of remaining habitat in the San Joaquin Valley. Bullfrogs and introduced predatory fish may prey heavily upon giant garter snake neonates (Carpenter et al. 2002). In addition to becoming prey to introduced species, giant garters snakes may be killed while attempting to ingest introduced bullheads, *Ictalurus* sp., whose sharp spines can become lodged in a snake's throat and prevent ingestion or regurgitation thus killing the snake (G. Wylie, U.S. Geological Survey, personal communication). Both predation by introduced predators and mortality due to ingestion of introduced bullheads have been documented in Sacramento Valley where giant garter snakes appear to be more abundant than in San Joaquin Valley. While introduced species undoubtedly play some role in giant garter snake ecology, more research is needed to ascertain the nature of these impacts. It is possible that the seasonal reduction of available habitat in summer forces aquatic introduced species and giant garter snakes into a greater number of interactions as Joaquin Valley wetlands and canals are drawn down for water saving measures or maintenance purposes.

Based on estimates of habitat loss throughout its range, California Department of Fish and Game (DFG) listed the giant garter snake as Rare in 1971. Surveys conducted in the mid – 1970's suggested the range of the giant garter snake in the San Joaquin Valley was reduced from its historic boundaries, but populations still existed in central and northern parts of the valley (Hansen and Brode[2] 1980). Follow up surveys in 1986 and 1987 failed to find any giant garter snakes in the San Joaquin Valley, altho

[5] Moore, S.; J. Winckel; S. Detwiler; S. Klasing, and P. Gaul. 1990. Fish and wildlife resources and agricultural drainage in the San Joaquin Valley; volume one, section 1. San Joaquin Drainage Program Report, Library Reference #: 6117. Sacramento, CA.

time spent at sites in the San Joaquin Valley was described as "limited" by the researchers (Hansen[4] 1988). When the California Endangered Species Act was passed in 1984, the giant garter snake was designated Threatened (California Fish and Game Code §2050-2116) due primarily to habitat loss throughout its range (California Department of Fish and Game[6] 2000). The giant garter snake was also listed as Threatened under the Federal Endangered Species Act in 1993 (US Fish and Wildlife Service 1993).

In 1998, US Geological Survey Biological Resources Division (USGS) researchers headed a cooperative effort to survey sites in the San Joaquin Valley for giant garter snakes. Through this partnership between the USGS, DFG, U.S. Fish and Wildlife Service, and Grassland Water District (GWD) giant garter snakes were documented on the Volta Wildlife Area, but not on the Mendota Wildlife Area (Table 1). Beginning in 1999, DFG conducted giant garter snake surveys in the San Joaquin Valley, working collaboratively with GWD to gain access to privately owned lands. The goal of DFG's 2001 trapping effort was to document giant garter snake populations in the southern section of the GEA and on the Mendota Wildlife Area, two places where they were known to occur historically.

Table 1. Trap sites, trap-days, and trapping effort per giant garter snake in northern San Joaquin Valley giant garter snake surveys, 1998 – 2001.

1998 (28,238 total trap days)

Trap site[a]	Trap-days	# GGS[b] captured	Trap-days/ GGS captured
Bennet Ditch	1764	0	NA
Canal 1	1581	1	1581
LBWA Fields 37and 27	1598	0	NA
LBWA, Mud Slough Ditch 7/9	1581	0	NA
Mud Slough Site 4	1564	0	NA
Mud Slough Site 5	1746	0	NA
MWA, Ditch 5 3/54	1615	0	NA
MWA, Field 17/18	1513	0	NA
MWA, Hamburger Ditch	1800	0	NA
MWA, Tin Can Slough	2879	0	NA
North GEA	3813	7	545
Salt Slough WA	1547	0	NA
San Joaquin NWR, Riley Slough	1190	0	NA
San Luis NWR, C-Canal	1600	0	NA
Santa Fe Canal	1547	0	NA
VWA Site 3	900	3	300

[6]California Department of Fish and Game. 2000. The status of rare, threatened, and endangered animals and plants of California – Annual report for 2000. Habitat Conservation Planning Branch, California Department of Fish and Game. Sacramento.

(Table 1 continued)

1999 (19,780 total trap days)

Trap site	Trap-days	# GGS captured	Tr GGS
LBWA, Fields 36 & 39	1530	0	
North GEA	8250	6	
VWA Site 1	7875	5	
VWA Site 3	2125	3	

2000 (27,875 total trap days)

Trap site	Trap-days	# GGS captured	Tr GGS
LBWA, Field 42	5250	0	
Mud Slough Site 2	13875	8	
Mud Slough Site 3	4500	0	
VWA Site 1	4250	0	

2001 (56,689 total trap days)

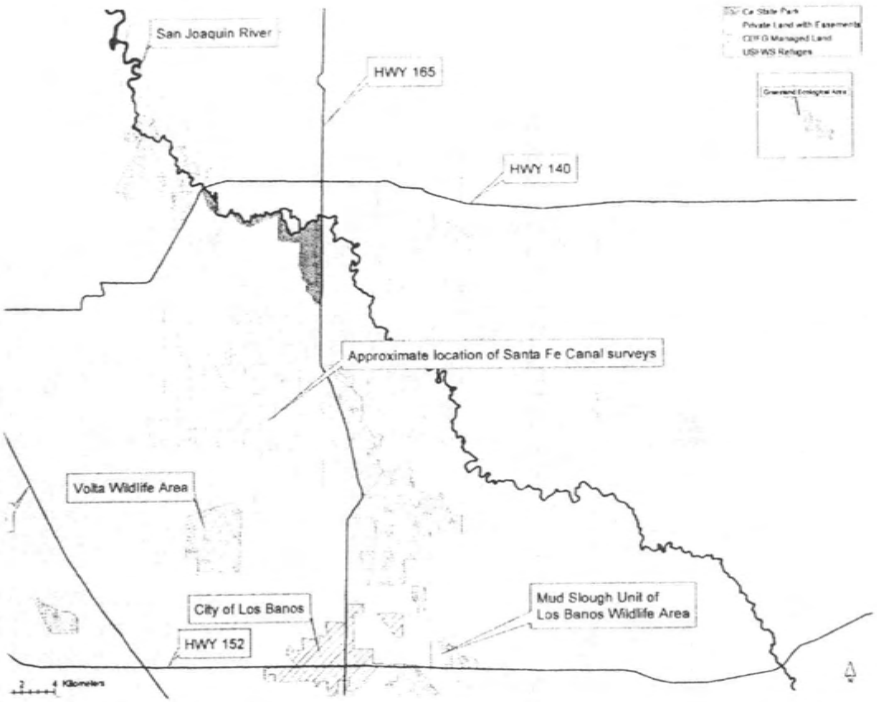
Trap site	Trap-days	# GGS captured	Tra GGS
Canal 1	4074	1	
Mud Slough Site 1	16267	0	
MWA Site 1	11906	18	
MWA Site 2	6400	0	
MWA Site 3 and Alkali Sink ER	4172	0	
MWA, Pump 4	4470	0	
MWA, Tin Can Slough	4000	0	
VWA Site 1	3400	0	
VWA Site 2	2000	0	

[a] Precise locations are available from DFG's California Natural Diversity Datab
[b] Giant garter snake (GGS).

STUDY AREA

We had four study areas in Merced and Fresno counties; northern GEA southern GEA (four sites), Mendota Wildlife Area (six sites) and Alkali Sink Reserve (one site). At approximately 64,752 ha, the GEA of western Mer contains the largest contiguous block of wetlands remaining in the Ce (Fredrickson and Laubhan[7] 1995). In the northern GEA (Fig. 1), we surveyed

[7] Fredrickson, L. H. and M. K. Laubhan 1995. Land use impacts and habitat prese grasslands of western Merced County, California. Unpublished report to Gra District.



ure 1. The northern portion of the Grassland Ecological Area in western Merced County, lifornia.

ction of the Santa Fe Canal that runs through privately owned lands. The canal is rrounded by private duck clubs and agricultural lands, which produce cotton and alfa. The dominant vegetation along the canal was tule, *Scirpus acutus*, and cattail, *pha* sp., although yellow star-thistle, *Centaurea solstitialis*, and pepperweed, *pidium latifolium*, occurred in patches.

The Volta Wildlife Area is owned by the Bureau of Reclamation and managed by G. It is located near the hamlet of Volta, Merced County, approximately 11 km rthwest of the city of Los Banos (Fig. 1). Volta survey areas held water throughout year and were dominated by tule, but had pepperweed in some areas. In 1998 and 99 we captured and PIT (passive integrated transponder) tagged giant garter snakes the Volta Wildlife Area (Table 1). In 1999 we did not capture any snakes that had en captured and PIT tagged in 1998. No giant garter snakes were captured at Volta 2000. We surveyed the Volta Wildlife Area in 2001 in an attempt to recapture snakes m previous years' surveys as well as capture and mark new snakes.

Survey sites in the southern GEA (Fig. 2) included Canal 1, Mud Slough, Britto tch, and Double D Ditch. Canal 1, Britto Ditch, Double D Ditch and part of Mud Slough through privately owned land managed as duck clubs. The remainder of Mud ugh runs through the Gadwall Unit, North Grasslands Wildlife Area. Giant garter

snakes were captured in a stretch of Mud Slough in 2000 (Table 1). We selected a section of Mud Slough downstream of this site with a different vegetation community for our surveys in 2001. Mud Slough, as well as Canal 1, Britto Ditch, and Double D Ditch supported typical marsh vegetation including juncus, *Juncus* sp., and tule, as well as invasive weeds such as yellow star thistle and pepperweed on their banks. The water depth in these waterways was variable, ranging from about 0.3 – 1.5 m, depending on specific location and amount of water moving through them.

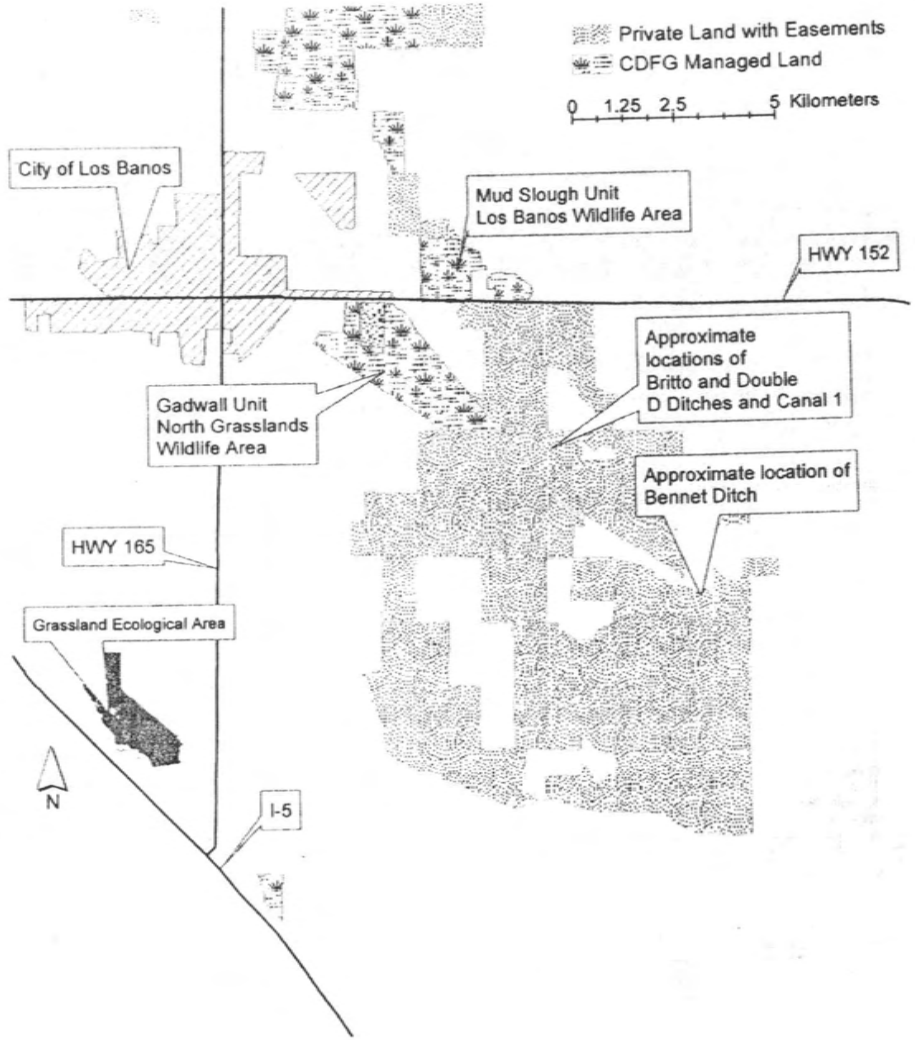
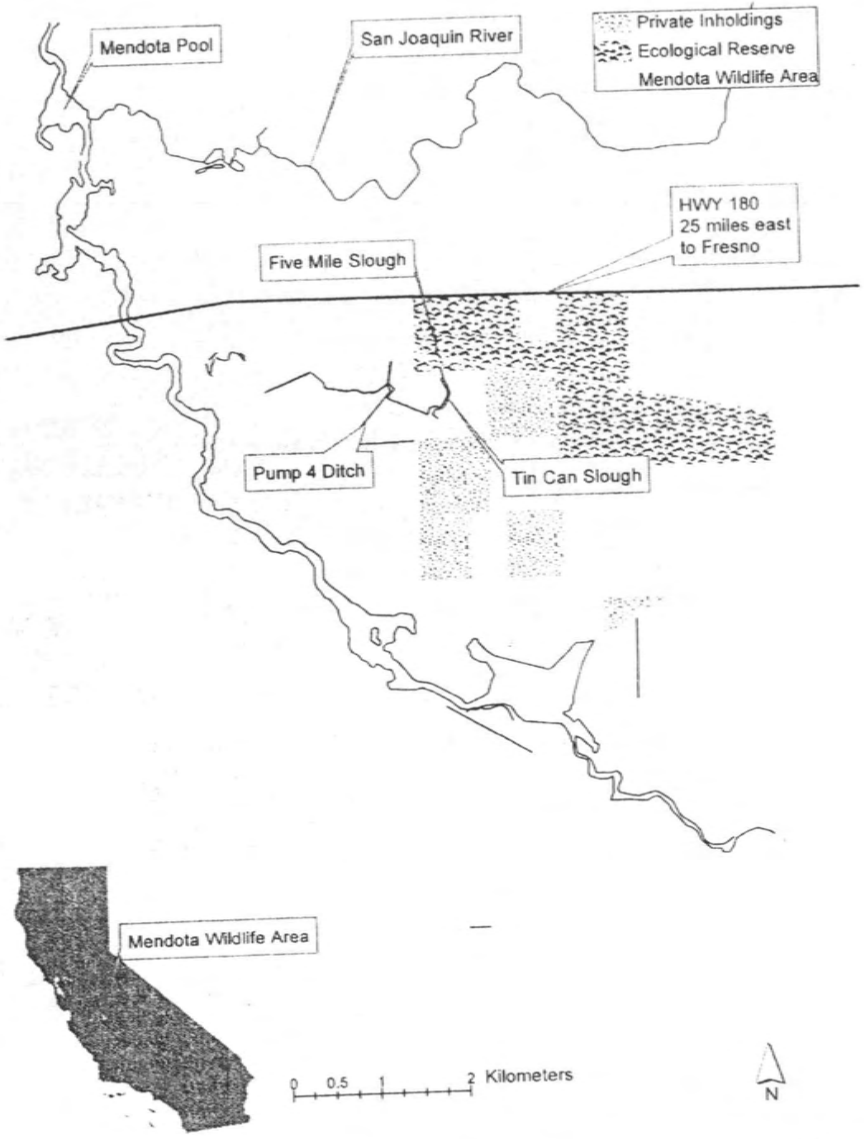


Figure 2. The southern portion of the Grassland Ecological Area in western Merced County, California.

The Mendota Wildlife Area and Alkali Sink Ecological Reserve are adjacent to one ther in Fresno County (Fig. 3). DFG manages the Mendota Wildlife Area primarily wintering waterfowl. It is located approximately 5 km southeast of the city of ndota in Fresno County (Fig. 3). We focused on areas where biologists found kes when they were more common in that vicinity (Hansen and Brode, unpublished



gure 3. The Mendota Wildlife Area and Alkali Sink Ecological Reserve located in Fresno County, alifornia

data, S. Brueggemann, California Department of Fish and Game, personal communication). The banks of surveyed waterways at the Mendota Wildlife Area had primarily tule and cattail edges, although at some trap sites juncus, iodine bush, *Allenrolfea occidentalis*, and saltgrass, *Distichlis spicata*, were common.

Finally, we surveyed Five Mile Slough at the Alkali Sink Ecological Reserve. This ecological reserve is located in Fresno County, adjacent to the Mendota Wildlife Area (Fig. 3). It is managed by DFG primarily for threatened and endangered species protection. Juncus was the dominant vegetation along Five Mile Slough.

METHODS

We visually searched for giant garter snakes by walking areas that were slated for habitat maintenance, habitat where snakes had been found historically, and in wetlands where traps were set. We performed visual surveys at all trap sites, as well as at the Santa Fe Canal, Britto Ditch, and Double D Ditch. We conducted visual giant garter snake surveys in accordance with U.S. Fish and Wildlife Service protocols for avoidance of take of giant garter snakes during construction activity (U.S. Fish and Wildlife Service[8] 2000). This survey protocol was developed in order to prevent incidental take of giant garter snakes during construction activities in snake habitat. The visual surveys were not developed to determine presence or absence of giant garter snakes at specific sites. Failure to find giant garter snakes using visual surveys does not indicate the species' absence at that location, especially at San Joaquin Valley sites with low population density. Visual surveys took place in early morning when snakes were likely to be basking and most visible.

We set traps for giant garter snakes at Canal 1, Mud Slough, Alkali Sink Ecological Reserve, and the Volta and Mendota wildlife areas. We trapped giant garter snakes in modified eel pot traps placed approximately 10 m apart along banks or attached to emergent vegetation of study sites, although bank conditions often caused this spacing to vary. Total number of traps per site varied according to site conditions. Modifications to traps included widening openings to allow snakes to enter and attachment of Styrofoam floats that kept part of the trap above water level (Casazza et al. 2000). Traps remained at each site for at least 14 days before being relocated. We checked traps daily either by boating or walking the trap line. At each trap, we recorded the vegetation directly next to it. We recorded the air temperature at the beginning and end of each trap line each day. We recorded all potential prey that we captured in traps.

We recorded morphological measurements to positively identify captured snakes to species. These measurements included counts of supralabials, infralabials, preoculars, postoculars, and dorsal scale rows at mid-body. We also measured physical characteristics such as snout to vent length (SVL) and mass, and we implanted PIT tags. Finally, we sketched each snake and indicated the location of any cysts or lumps we

[8] US Fish and Wildlife Service 2000. Biological opinion for the Central Valley Project Improvement Act's programmatic environmental impact statement/report. Unpublished report by the US Fish and Wildlife Service

oticed on the snakes' bodies. We used global positioning system (GPS) to digitally ecord capture locations and incorporated all 2001 giant garter snake capture locations nto a geographic information system (GIS) that includes capture locations for trap ears 1998 through 2001. All giant garter snake capture locations were made available or inclusion in the California Natural Diversity Database. We released captured giant arter snakes at the capture site, usually on the day following their capture.

I used NCSS 2000 software (Hintz° 2001) for statistical analysis. I compared means sing two-sample t-tests. For comparison of mean air temperature on days when snakes ere captured to days when no snakes were captured I used the Wilcoxon Rank-Sum st due to lack of normal distribution of these data. I used the Aspin-Welch t-test for ll other tests due to unequal variance of samples.

RESULTS

DFG personnel used the same trap design and trapping protocol while conducting urveys in the San Joaquin Valley from 1998-2001. Trap effort has varied from year to ear (Table 1). I have presented the results from surveys DFG conducted from 1998 rough 2000 for comparison to the results of surveys we conducted in 2001.

We captured 15 giant garter snakes in 2001. Four of these snakes were recaptured at season, for a total of 19 captures. The average mass of these snakes was 170.3 g .E. = 22.4) and the average snout to vent length (SVL) was 652.3 mm (S. E. = 24.8) (Fig.). Male and female giant garter snake mass and SVL did not differ significantly (t = .21, df = 1, P ≈ 0.833 and t = 0.97, df = 1, P ≈ 0.348 respectively), although there was reater variation in mass and SVL within females than within males. One giant garter nake female, captured at the Mendota Wildlife Area accounted for much of that ariation. Her mass was 410 g and SVL was 850 mm. Average mass for all females ptured in 2001 was 165 g (S. E. = 42.7). Average SVL for all females was 626.4 mm (S. . = 46.1). Male mass averaged 175 g (S. E. = 22.5) and SVL averaged 675 mm (S. E. = 3.8). We captured 8 males and 7 females in total.

We captured only one giant garter snake in the southern GEA, at Canal 1. This was 125 g male, which was afflicted with several unidentified cyst-like lumps. In Canal 1, e dominant vegetation next to our traps was the invasive aquatic weed, parrot's ather (*Myriophyllum aquaticum*). There were areas that supported juncus and tule well.

We captured 14 giant garter snakes in one waterway on the Mendota Wildlife Area here most traps were attached to tule and cattail. We caught 7 males ranging in size om 500-772 mm SVL (95-295 g) and 7 females ranging from 500-850 mm SVL (75-410). Five of the 14 snakes had cyst-like lumps on their bodies, similar to those seen on e snake captured in Canal 1. We did not capture giant garter snakes at any other sites Mendota, although valley garter snakes, *Thamnophis sirtalis fitchi*, were abundant several of these waterways.

°Hintze, J. 2001. NCSS and PASS. Number Cruncher Statistical Systems. Kaysville, Utah.

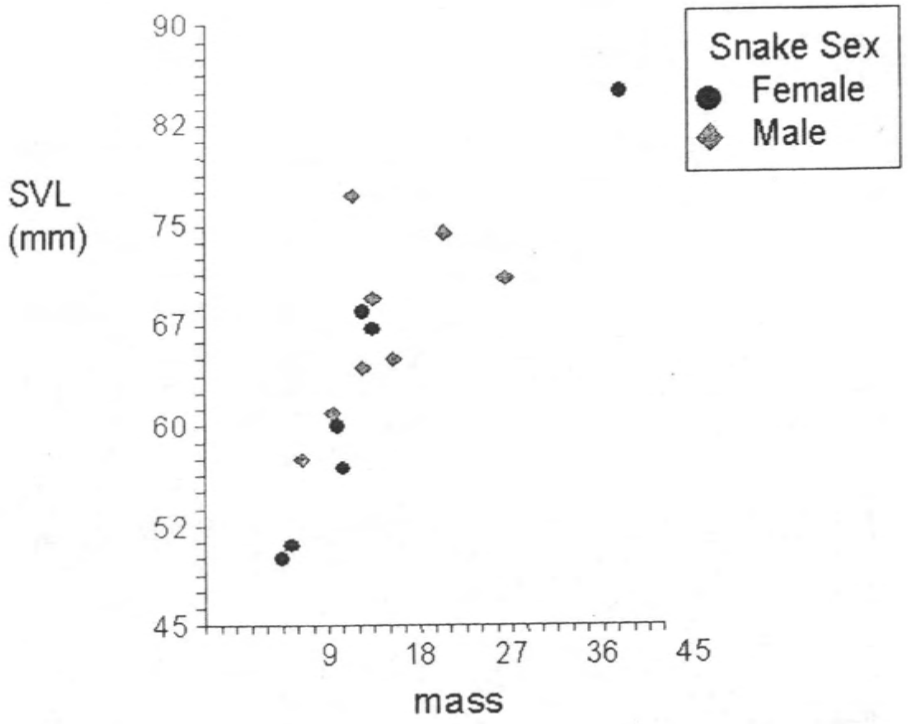


Figure 4. Mass and SVL of giant garter snakes captured in northern San Joaquin Valley surveys in 2001.

No giant garter snakes were captured in Mud Slough. The traps here were surrounded by invasive pepperweed. Exotic poison hemlock, *Conium maculatum*, was also present.

We did not capture any giant garter snakes at the Volta Wildlife Area. Tule and cattail were the dominant vegetation at trap sites, although there was pepperweed mixed in with these plants in some areas. Valley garter snakes were commonly captured in traps set for giant garter snakes at Volta Wildlife Area sites.

No giant garter snakes were seen or captured in visual surveys conducted at any location. This includes visual surveys performed at sites where snakes were captured in traps in 2001.

The average air temperature on days when giant garter snakes were captured (29.0 °C) was slightly higher than the average air temperature on non-capture days (27.0°C) though not significantly so.

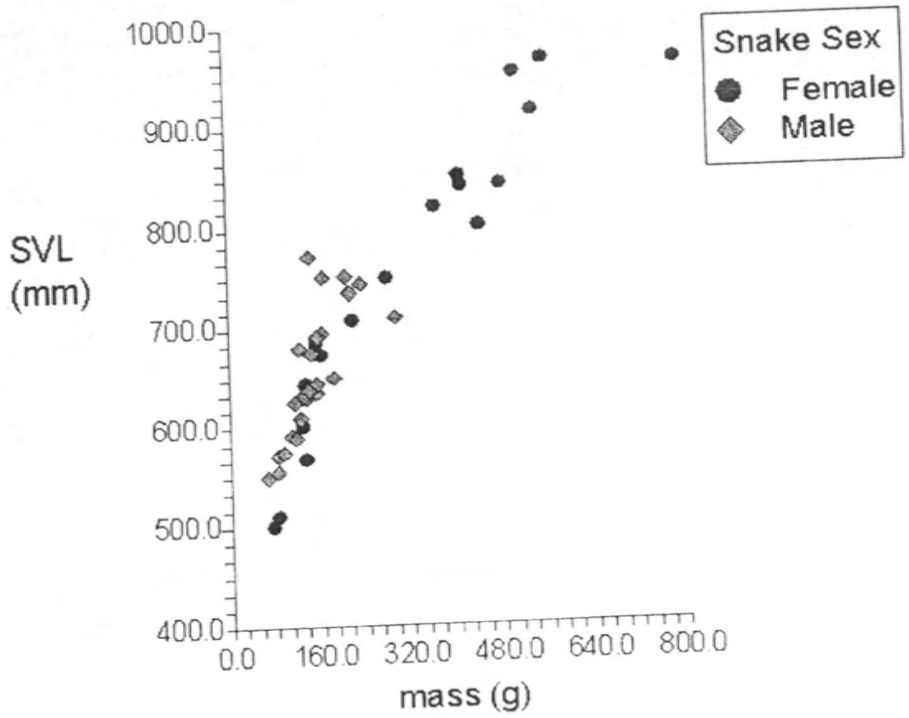
I calculated the average percentage of traps at each site that captured potential prey items. At trap sites where giant garter snakes were captured, the percentage of traps that also contained potential prey items was not among the highest or lowest when all trap sites were considered. From 18%-25% of the traps set in sites where giant garter

snakes were captured contained potential prey, while 7.3% - 60.9% contained potential prey items where no giant garter snakes were captured. The most common potential prey items included fish such as mosquito fish, cyprinids, and centrarchids.

DISCUSSION

Our trapping efforts resulted in capture of 15 giant garter snakes from two populations in 2001. Since surveys began in 1998, five populations have been located in the northern San Joaquin Valley (Table 1). The population located on the Mendota Wildlife Area in 2001 was the first in Fresno County since surveys began in 1998. The remaining populations are located in western Merced County.

Although there were no significant differences between males and females in average SVL or mass for snakes captured in 2001, when all data collected between 1998 and 2001 are pooled, females have significantly greater mass ($t = 3.6$, $df = 1$, $P = 0.001$) and longer SVL ($t = 2.83$, $df = 1$, $P = 0.005$) than males (Fig. 5). The small sample size collected in 2001 is the most likely cause for the lack of significance in difference between males and females in terms of mass and length.



The smallest snake captured in 2001 was 500 mm in length, well above the m neonatal length of 206.4 mm (Rossman et al. 1996). This could reflect a true scarci neonates in San Joaquin Valley populations or it could be reflective of trap design b Young snakes may be able to escape from the modified funnel traps more easily t adults. An investigation into alternative trap designs might lead to discovery of a n efficient trap design.

Knowledge of temperature and seasonal effects on our ability to catch snakes c improve our capture rates for giant garter snakes. While average air temperatures v slightly warmer on days that giant garter snakes were captured than on non-cap days, there were essentially only two capture sites, Canal 1 and Mendota Wildlife A and only one snake was captured in Canal 1. Since most snakes were captured in one location, over a short time period, this result probably indicates the site condit at Mendota Wildlife Area in June and may have little applicability to giant garter s habitat in general.

Because we had only two capture locations, we cannot generalize about w vegetation communities are preferred giant garter snake habitat. The Mendota Wil Area site was bordered by tule and cattail, but at Canal 1 parrot's feather was a n component of the wetland edge plant community. We also trapped sites o Mendota Wildlife Area that supported atriplex, *Atriplex* sp., and saltgrass commun but did not capture giant garter snakes at these sites. Conversely, there were s sites at both the Mendota and Volta Wildlife Areas that supported tule and c vegetation where no snakes were found.

Some sites that we trapped in 2001 supported populations of valley garter sn but no giant garter snakes were captured. Valley garter snakes were seen in and ar waterways and were also captured in floating funnel traps set for giant garter sn Sites at the Volta and Mendota wildlife areas supported what appeared to be numbers of valley garter snakes in some wetlands. Valley garter snake densities not be determined since these snakes were not marked prior to release. Understa niche use and life history differences between valley and giant garter snakes may determine why no giant garter snakes were found in waterways where valley g snakes appeared to be successful.

The most important outcome of this survey was the location of a population of garter snakes at the Mendota Wildlife Area. This area was surveyed in the late 1 (Hansen and Brode[2] 1980), mid 1980's (Hansen[4] 1988) and in 1995 (Hansen[10]). surveys relied primarily on visual observation of giant garter snakes inste trapping. Giant garter snakes were found on the Mendota Wildlife Area in th 1970's, but were not seen in the later surveys. Visual observation may be a less re method of detecting giant garter snake presence than trapping. For example, i study a giant garter snake was trapped at Canal 1 where visual surveys conducted to and after the capture date failed to find any giant garter snakes. In 2001, we fo

[10] Hansen, G. E. 1995. Status of the giant garter snake (*Thamnophis gigas*) in the San J unpublished report to the California Department of Fish and

ur trapping efforts on Mendota Wildlife Area waterways where giant garter snakes ad been encountered previous to 1980, but found snakes at only one of these ocations. This population is now the southern-most recently documented population f this species that once ranged into Kern County. While most of the giant garter snake abitat in the Tulare Lake Basin, including Tulare and Buena Vista lakes, no longer xists, there is a small possibility that giant garter snakes are extant in remnant habitats. ormal surveys for giant garter snakes in remaining suitable habitat fragments could etermine their status there.

Another interesting outcome of this work is our failure to capture giant garter snakes om the Volta Wildlife Area population. Three giant garter snakes were captured in id-August at the Volta Wildlife Area in 1998 (Table 1). Eleven snakes were captured nd marked at Volta from the end of March through the end of June in 1999 (Table 1). rapping took place in September of 2000 at Volta Wildlife Area and August 2001, but o giant garter snakes were captured there either year. It is unclear whether we have imply failed to locate this population of giant garter snakes or if it has been extirpated. rapping in both 2000 and 2001 occurred late in the trapping season and the timing of apping could explain the failure to capture snakes these years. An expanded trapping ffort over a longer time frame may enable us to locate this population.

Several giant garter snakes that we found had unidentified lumps on their bodies. ive of the 14 snakes captured at Mendota Wildlife Area, and the snake captured in anal 1 had these abnormalities. The cause of these lumps should be identified in the ear future in order to determine if a parasite or other disease is attacking giant garter nakes. Giant garter snakes have experienced declines in areas of the San Joaquin alley such as state-managed wildlife areas and other protected areas. Factors such s disease could be in part responsible for giant garter snake decline in areas where bvious factors such as habitat destruction and contaminated water can be ruled out.

In order to best manage areas for giant garter snake conservation, it is necessary o understand the habitat requirements of giant garter snakes in the San Joaquin Valley, ow habitat requirements might differ from general habitat requirements documented n the Sacramento Valley, and the factors that are limiting giant garter snake recovery n the San Joaquin Valley. Successful restoration and repatriation efforts on state and ederally managed lands will depend on accurate habitat characterization, determination nd removal of threats to species recovery, and understanding of the current status nd distribution of this species. This information is also essential for understanding he management impacts on giant garter snake populations. Private land owners also enefit from this knowledge since it allows them to manage their duck clubs while inimizing impact to giant garter snakes. Implantation of radio-transmitters in giant arter snakes would be an excellent method to discover many details of giant garter nake habitat requirements. Studies of giant garter snake habitat use in the San Joaquin alley would complement those currently being conducted by the USGS in the acramento Valley. Differences in habitat use by snakes in the two valleys are possible ecause of differences in soil type and vegetation composition between these two ioregions. Climate and water availability differ between these two areas and may nfluence giant garter snake habitat use. For example, not only does less rain fall in the

San Joaquin Valley annually (Western Regional Climate Center http://www.wrcc.sage.dri.edu/narratives/CALIFORNIA.htm), but its warmer climate promotes rapid moist soil plant growth in spring allowing wetland managers to draw wetlands down 2-4 weeks earlier in the San Joaquin Valley (Reid 1995). Interaction of these factors may affect giant garter snake habitat use and survival. Unfortunately, due to the low numbers of giant garter snakes present in northern San Joaquin Valley populations, and mortality associated with radio implantation, U.S. Fish and Wildlife Service could not permit this action (K. Hornaday, U.S. Fish and Wildlife Service, personal communication 2001). Another obstacle to use of this method is that most of the snakes we captured in the 2001 trapping season were too small to have radio-transmitters surgically implanted (G. Wylie, U.S. Geological Survey, personal communication). Research into new trap design, intended to capture larger snakes, or use of a less invasive methodology for transmitter deployment, may make radio tracking of giant garter snakes feasible in the San Joaquin Valley.

Information gleaned from trapping surveys is valuable however for learning general habitat characteristics and giant garter snake population locations. This knowledge of giant garter snake distribution and habitat requirements could lessen impact to snakes and habitat during maintenance of water delivery systems and aid land managers in balancing the goals for waterfowl management with giant garter snake conservation.

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LITERATURE CITED

Carpenter, Neil M., Michael L. Casazza, and Glen D. Wylie. 2002. *Rana catesbeiana* (American Bullfrog). Diet. Herpetological Review 33: 130.

Casazza, M. L., G. D. Wylie, and C. J. Gregory. 2000. A funnel trap modification for surface collection of aquatic amphibians and reptiles. Herpetological Review 31: 91-92.

Reid, Frederick A. 1995. Managing seasonally flooded wetlands in California's Central Valley. Valley Habitats, No. 9: 1-4. Ducks Unlimited, Inc. Sacramento, CA.

Rossman, D. A., N. B. Ford, and R. A. Seigel. 1996. The garter snakes: evolution and ecology. University of Oklahoma Press, Norman, OK. 332 pp.

Stebbins, R. C. 2003. A field guide to western reptiles and amphibians. Houghton Mifflin Co., Boston. 533 pp.

U. S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants, determination of threatened status for the giant garter snake. Federal Register 58, 54053-54066.

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