Progress report for the San Joaquin Valley giant garter snake conservation project – 2004

Justin Sloan
Los Banos Wildlife Complex
California Department of Fish and Game
18110 Henry Miller Road
Los Banos, CA 93635

Los Banos Wildlife Area Publication #: 27

Agreement # 114202J069

Table of Contents

Figures

Chapter 1

Chapter 2

Tables

Chapter 1

Chapter 1. Giant garter snake trapping at Volta Wildlife Area

Introduction

The giant garter snake (*Thamnophis gigas*) is endemic to the Central Valley of California. Historically, the range of the giant garter snake extended from Sacramento south to Buena Vista Lake in Kern County (Beam and Menges 1997). Conversion of wetlands for urban development and agriculture has led to extensive habitat loss, reducing the range by approximately one third (Hansen and Brode 1980). The giant garter snake was listed as rare in the state of California in 1971. When the California Endangered Species Act was passed in 1984, the giant garter snake was designated as threatened (California Fish and Game Code §2050-2116) due to habitat loss throughout its range (California Department of fish and Game 2000). In 1993, the giant garter snake was listed as threatened under the Federal Endangered Species Act (US Fish and Wildlife Service 1993).

The giant garter snake is a highly aquatic species found in still or slow moving waterways with mud bottoms, such as freshwater marshes, sloughs and irrigation and drainage canals. They inhabit areas with emergent vegetation which provide cover and foraging habitat (US Fish and Wildlife Service 1991). Historically, the giant garter snake preyed on Sacramento blackfish (*Orthodox microlepidotus*), thick tailed chub (*Gila crassicuda*), and California red-legged frogs (*Rana aurora draytonii*) (Rossman et al. 1996). With the extirpation of these native species, giant garter snakes now prey on introduced species such as mosquito fish (*Gambusia affinis*), carp (*Cyprinus carpi*o), and bullfrogs (*Rana* *catesbeiana*) (Brode 1988). Although sub-adult bullfrogs are an important part of the snake's diet, adult bullfrogs are known to feed on neonate giant garter snakes (Wylie et al. 2003). It is unknown how this interaction affects the overall population of giant garter snakes.

Surveys conducted in 1975-76 by the California Department of Fish & Game found giant garter snakes to be present at several locations in the San Joaquin Valley (Hansen and Brode 1980). However, no giant garter snakes were observed in these same areas during surveys conducted from 1986-1988 (Hansen 1988). Fish and Game biologists, working cooperatively with the Grassland Water District, have trapped areas throughout the San Joaquin Valley from 1997-2003. As a result of these surveys, giant garter snake populations have been located on private land, as well as on the Mendota and Volta Wildlife Areas (Dickert 2003).

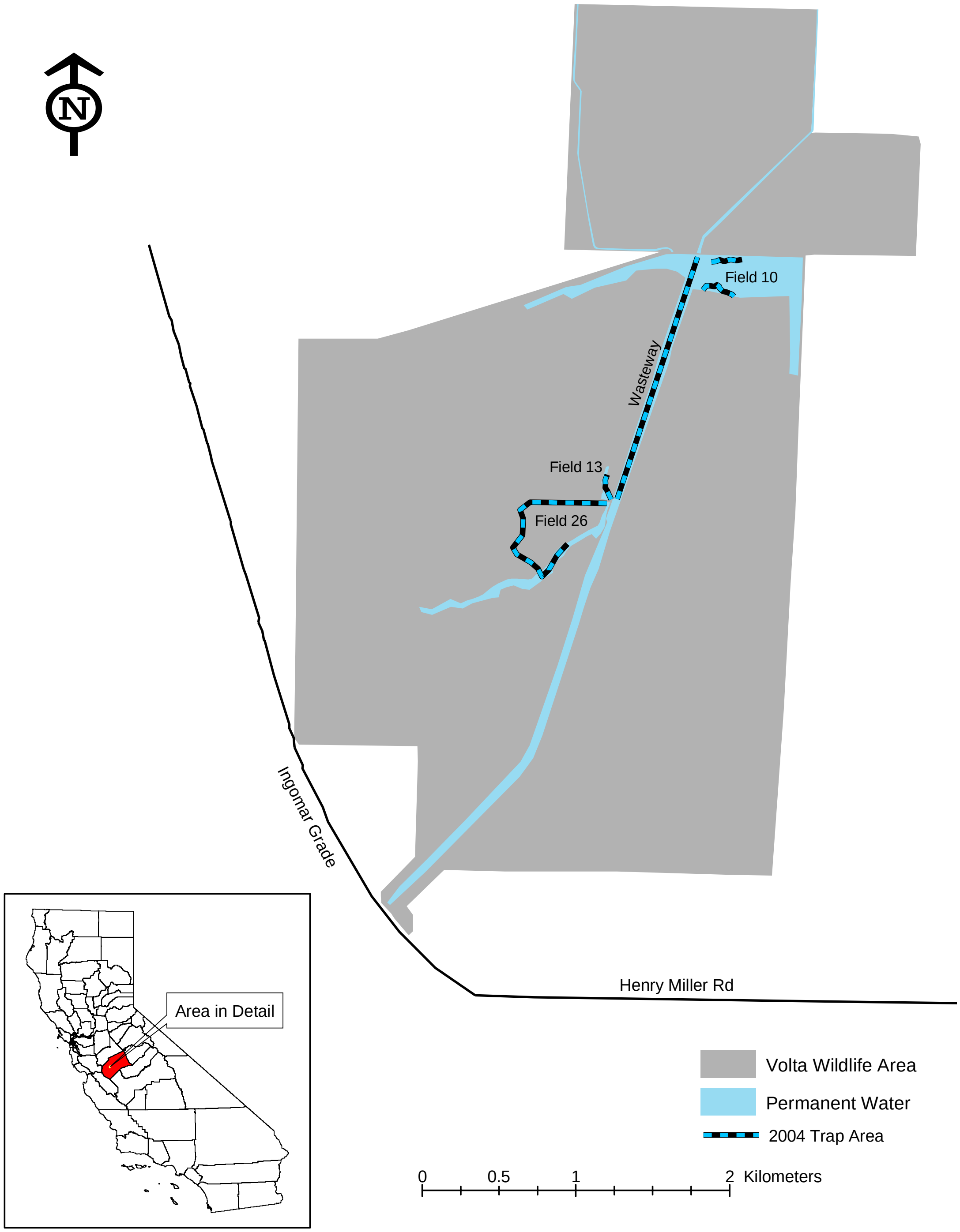
The goals of the 2004 trapping season were to intensively trap the Volta Wildlife Area in order to obtain an estimate of the total population of giant garter snakes and to recapture snakes caught during the 2003 season. In addition to trapping giant garter snakes, we conducted bullfrog count surveys and stomach content analysis of bullfrogs collected from the Volta Wildlife Area to further evaluate the impacts of bullfrog predation on giant garter snakes. We also continued to investigate the feasibility of external radio transmitter attachment on giant garter snakes (Chapter 2).

Study Area

The Volta Wildlife Area (37 07' 28.53" N, 120 55' 14.40" W) is located in western Merced County, approximately 11 kilometers north-west of the city of Los Banos. The area is owned by the Bureau of Land Reclamation and managed by the California Department of Fish and Game. The terrain is flat and elevation ranges from 29 to 33 meters. The climate is characterized by hot, dry summers, mild falls and springs, and cool, wet winters with an average annual rainfall of 21 centimeters (Los Banos Wildlife Area Unpublished Data 1970-2000).

For the 2004 trapping season we surveyed Field 26, Field 13, the Volta Wasteway (Wasteway) and the permanent water portion of Field 10 (Figure 1). Field 26 is a permanent wetland bordered by tule (*Scirpus* spp.) and cattail (*Typha* spp.). Field 13 is a summer flooded wetland dominated by tule and cattails that was dry throughout the winter and flooded in April. The Wasteway is a permanent waterway that flows south to north through the wildlife area into the permanent water of Field 10 creating a pond-like area. Tule and cattails dominate the edges, with low herbaceous plants found in some areas.

Figure 1. Areas trapped for giant garter snakes at Volta Wildlife Area in 2004.



Methods

We trapped snakes in modified eel pot traps (Casazza et al. 2000) placed 10 meters apart along banks and tied to emergent vegetation or stakes. The distance between traps sometimes varied due to bank structure. We checked traps daily and recorded environmental data, including cloud cover, water temperature, and air temperature every 70 traps. We identified and recorded the contents of each trap and separated the bullfrogs into age classes.

We processed captured giant garter snakes at the office and released them, usually the next day, at the capture site. Processing consisted of recording morphological measurements to positively identify the snake to species. These measurements included counts of supralabial, infralabial, preocular and postocular scales, and dorsal scale rows at mid-body (Rossman et al. 1996). We also measured physical characteristics such as snout to vent length (SVL) and mass. We implanted passive integrated transponder (PIT) tags for individual identification of the snakes in the field. We sketched and photographed each snake to indicate the location of any cysts or lumps on the snake's body. We used global positioning systems (GPS) to record the location of each giant garter snake caught. This information was incorporated into a geographic information system (GIS) that includes giant garter snake captures from 1998 to the present.

We conducted visual surveys along roads in the Volta Wildlife Area and on private land within the Grassland Resources Conservation District (Table 1) in accordance with the US Fish and Wildlife Service protocols for avoidance of take of giant garter snakes during construction activity (US Fish and Wildlife Service

2000). We performed surveys in the morning when snakes were most likely to be basking.

Table 1. Location of visual surveys in the Grasslands Resources Conservation District

Survey Site	*Location in Grassland Resource Conservation District*
Big Water Drain	South Grasslands
Britto Ditch	South Grasslands
Eagle Ditch	North Grasslands
Fremont Canal	North Grasslands
Gun Club Road Ditch	North Grasslands
Helm Canal	South Grasslands
Los Banos Creek	North Grasslands
Mud Slough	North Grasslands Wildlife Area
Poso Drain	South Grasslands
Santa Fe Canal	North Grasslands
Volta Wildlife Area	Volta Wildlife Area
Westside Ditch	North Grasslands

We surveyed the bullfrog population at Volta Wildlife Area by conducting nocturnal count surveys, trap surveys using giant garter snake traps and collection surveys. We collected adult bullfrogs for the purpose of stomach content analysis. We dissected the collected frogs and identified, when possible, the contents of their stomachs.

Results

Visual Survey

We did not capture or see giant garter snakes during visual surveys.

Trapping Survey

A total of 791 traps were set at Volta Wildlife Area covering approximately 7 kilometers. Traps were set a total of 59,860 trap nights. Trap effort at areas within the wildlife area varied due to personnel and funding problems (Table 2).

We captured 13 individual garter snakes (eight males, five females) a total of 18 times (Figure 2). Four snakes were captured more than once during the 2004 season. Captured snakes ranged in size from 372-775 mm SVL with a mean of 570 mm (SD=132.89). The mass of captured snakes ranged from 29-480 grams with a mean of 166.08 grams (SD=129.05) (Figure 3). Of the 13 snakes captured, four had cysts which could indicate a parasitic infection.

Table 2. Trap effort at Volta Wildlife Area in 2004.

Location	*Number of Days Trapped*	*Number of Traps Set*	*Trap Nights*
Wasteway	112	401	38915
Field 26	79	282	17615
Field 13	48	58	2580
Field 10	15	50	750

Figure 2. Giant garter snake capture locations at Volta Wildlife Area in 2004.

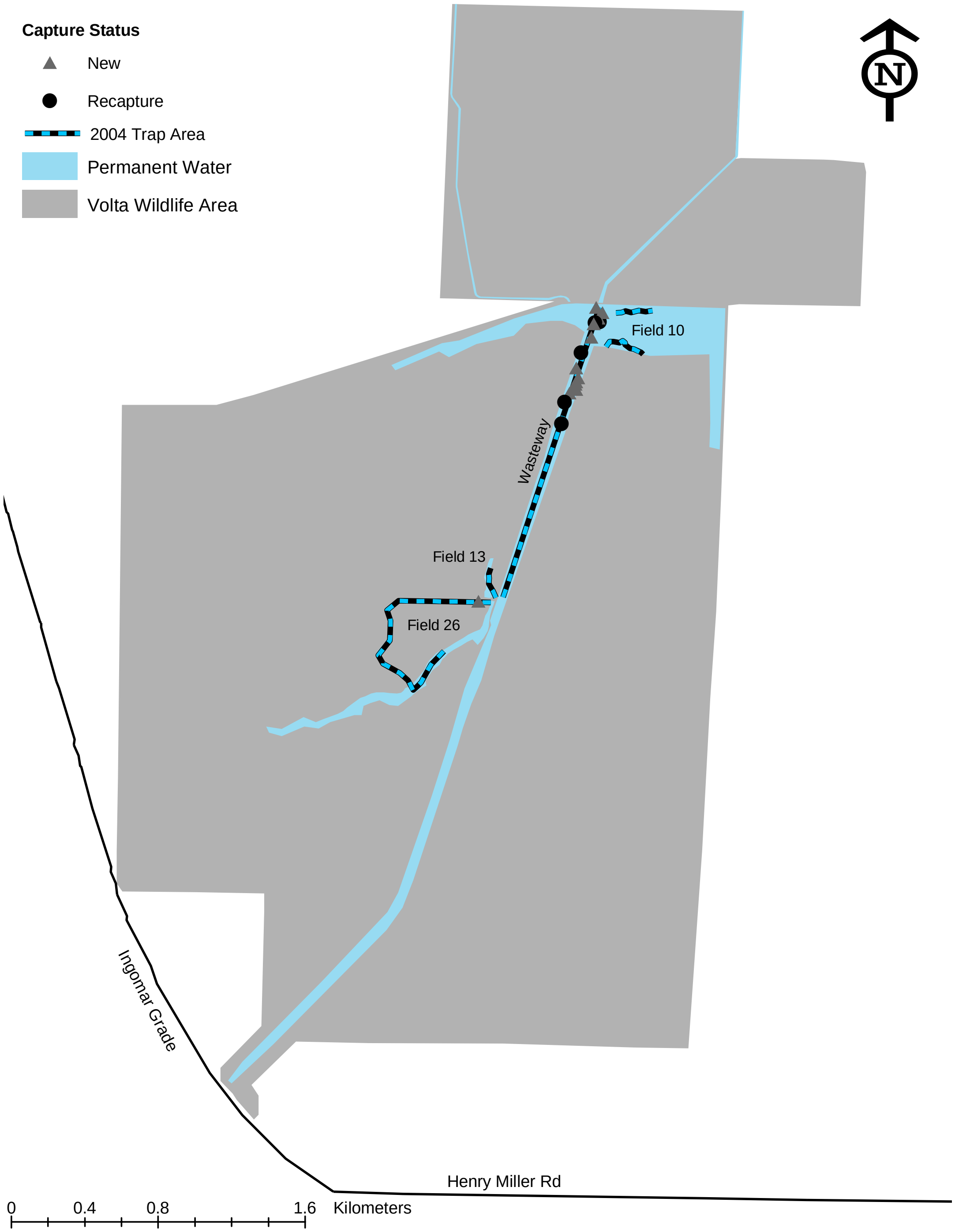
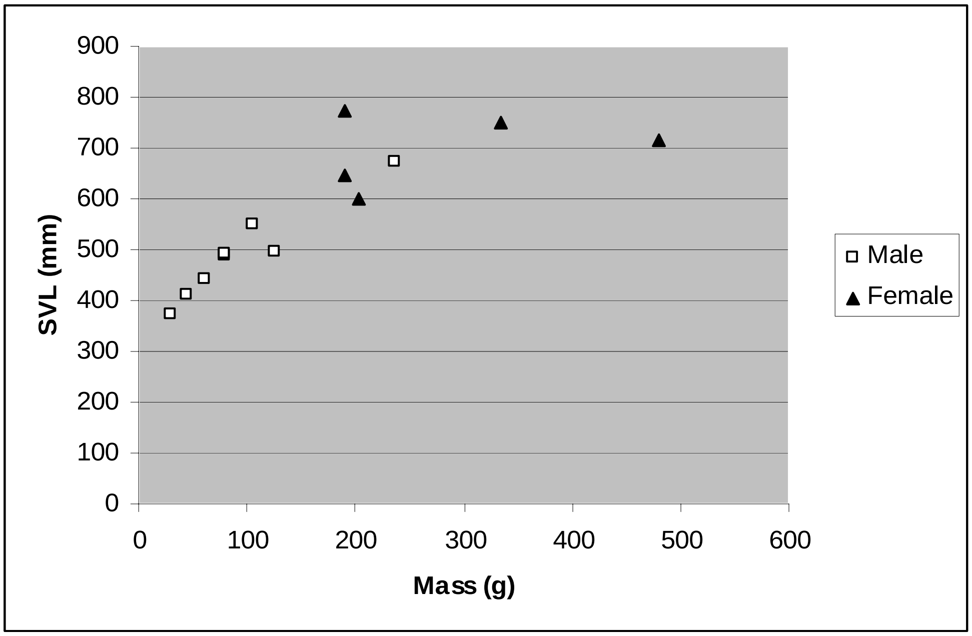


Figure 3. Snout-vent length (SVL) and mass of giant garter snakes captured at Volta Wildlife Area in 2004.



Three snakes captured during the 2003 season were recaptured in 2004 which allowed us record changes in mass and SVL between years. On average, the snakes' mass increased 130% and SVL increased 30% (Figures 4 and 5). Two of the snakes had cysts on their bodies in 2003 that were still present in 2004, however, no new cysts developed during the year. One snake did not have any cysts in 2003 and did not develop new cysts during the year.

Figure 4. Change in mass of three giant garter snakes between 2003 and 2004.

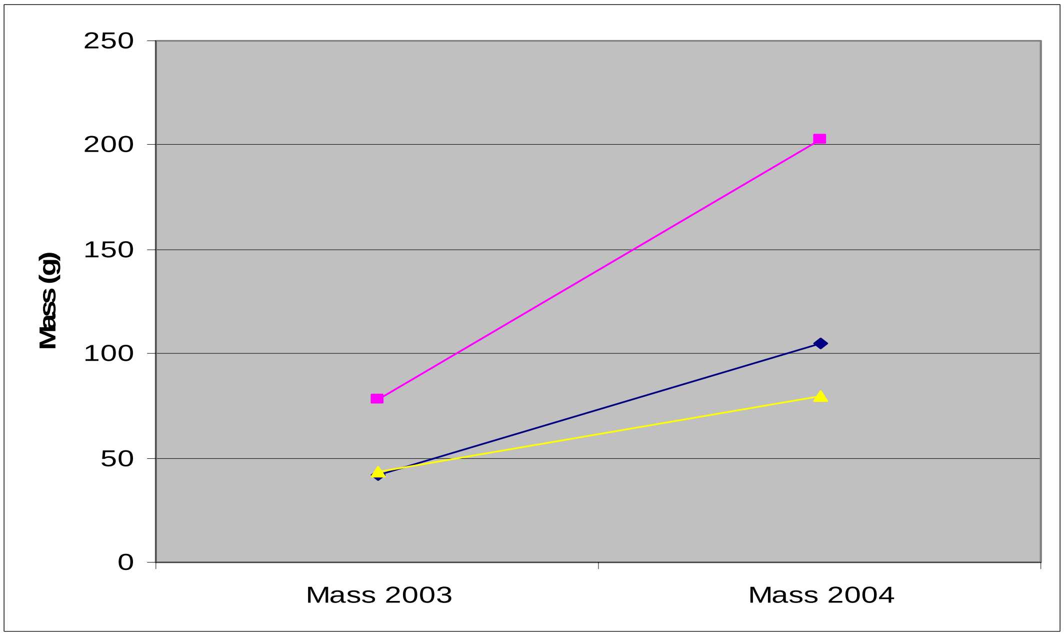
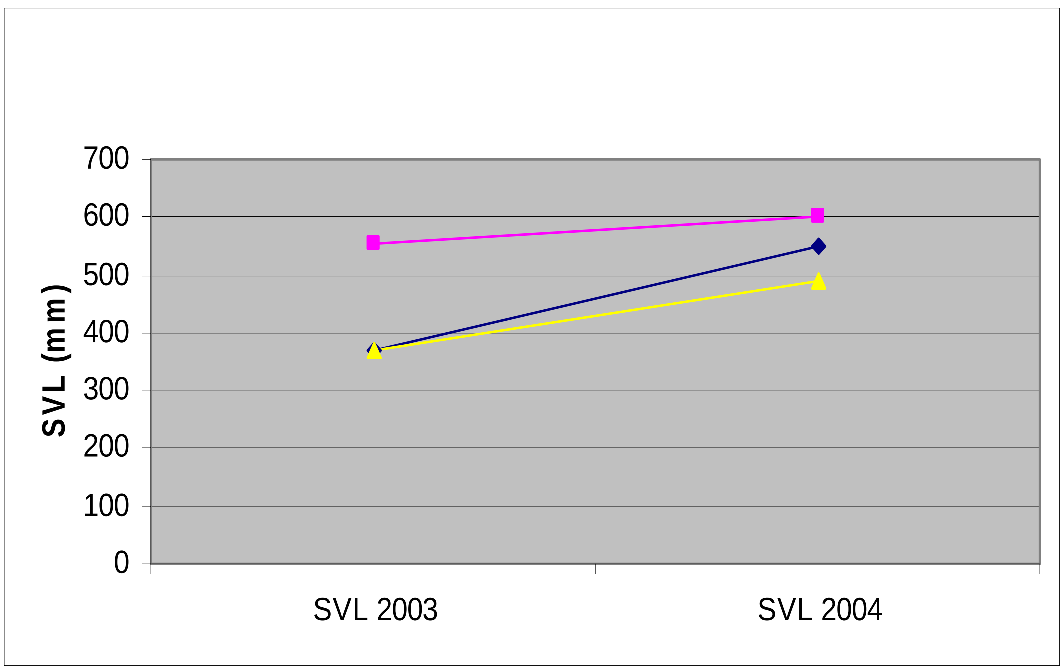


Figure 5. Change in snout-vent length (SVL) of three giant garter snakes between 2003 and 2004.



Bullfrog Surveys

For the purpose of analysis, we will include bullfrogs recorded and collected in Field 10 with those from the Wasteway. We collected 46 bullfrogs from the Wasteway and Field 26 during July and August. We collected thirteen frogs from Field 26 (seven male, five female, one undetermined) with an average mass of 165.8 g (SD=51.1) and an average snout to urostyle length (SUL) of 127.5 mm (SD=14.4). We collected thirty-three frogs from the Wasteway (10 male, 21 female, two undetermined) with an average mass of 143.6 g (SD=68.7) and an average SUL of 120.5 mm (SD=68.7). No giant garter snake remains were found in the stomachs of the frogs from either area. The stomach of one frog from the Wasteway did contain two neonate valley garter snakes (*Thamnophis sirtalis fitchi*), however. Overall, odonates (dragonflies and damselflies) were the most commonly found prey item (Table 3).

Table 3. Count of identifiable prey remains found in 46 bullfrog stomachs collected from the Volta Wildlife Area in July and August of 2004.

Prey Items	*Total Number Present*
Odonata	47
Hemiptera	34
Isopoda	32
Coleoptera	29
Araneae	25
Crayfish	10
Diptera	10
Hymenoptera	4
Gambusia	2
Dermaptera	2
Valley Garter Snake	2
Trichoptera	1
Lepidoptera	1
Snail	1

The abundance of adult bullfrogs was greater in Field 26 than in the Wasteway during the nocturnal count surveys and the trapping surveys. During the collection surveys, more frogs were collected from the Wasteway than in Field 26 (Table 4).

Table 4. Relative abundance of adult bullfrogs per 100 meters at the Volta Wildlife Area in 2004.

Area	*Count Surveys*	*Trapping Surveys*	*Collection Surveys*
Field 26	3.13	20.51	0.65
Wasteway	0.58	10.24	1.68

Discussion

Thirteen snakes were captured this season while 31 snakes were captured in 2003. One possible reason for this decline is a change in the amount of habitat available due to water depth fluctuations. The water depth in the Wasteway in 2003 was unusually low due to construction near the wildlife area. Low water levels decreased the amount of available habitat by drying up areas that could have been used by the snakes, leading to a concentration of snakes in the Wasteway. In 2004, there was no construction and the water level was approximately a foot deeper than the previous year. This increase in depth led to areas at the northern end of the Wasteway and Field 10 being flooded, allowing snakes to disperse from the Wasteway to un-trapped areas and possibly leading to the decrease in trap success.

Three snakes trapped at Volta in 2003 were recaptured in 2004. This is the first time in the project's history that recaptures between years have occurred. The recapture of these snakes along with the presence of neonate snakes in 2003, are signs that a viable, breeding population of giant garter snakes is present at Volta Wildlife Area.

We were unable to calculate a population size estimate for Volta. We could not find a population model to use for continuous trapping of an open population. The Craig-du Fue method, used in 2003, is based on continuous trapping of a closed population (Greenwood 1996). The giant garter snake population at Volta is an open population because we can not rule out the possibility of genetic movement into and out of the population during the trapping period. Using the Craig-du Fue method on an open population would bias the population estimate. In some cases, short sampling periods can be used to limit or remove the effects of genetic movement into and out of a population; however, it requires a certain number of recaptures. Because our capture success at Volta was so low, we were not able to use short sampling periods to estimate population size.

Two of the three survey methods for adult bullfrogs at Volta yielded a relative density that was higher in Field 26 than in the Wasteway. The trapping survey might be biased towards smaller bullfrogs since bullfrogs have to be small enough to fit in the opening of the giant garter snake traps. Bullfrogs that are too large to enter the traps are not counted. The collection survey is biased towards the larger bullfrogs because the observers targeted bullfrogs that were thought to be large enough to prey upon neonate snakes. Bullfrogs that were too small were not collected. The nocturnal count survey was probably the least biased survey method used. Observers counted the number of pairs of eyes seen regardless of the size of the frog. Using data from the count surveys, the relative density of bullfrogs in Field 26 was five times that of the Wasteway (3.13 vs 0.58 frogs per 100 meters). The frogs might prefer Field 26 because of its still water and greater vegetative cover. Frogs that breed in the Wasteway may be dispersed over larger areas because of the water that flows through the Wasteway.

Giant garter snakes are known to prey upon bullfrog tadpoles and metamorphs (Rossman et al. 1996). Based on results from 2003, adult bullfrogs are known to prey upon neonate giant garter snakes. The degree to which these interactions take place is unknown. Management of the bullfrog population might seem like a logical step to increase the chances of survival of neonate giant garter snakes but it is difficult due to the prolific nature of bullfrogs. It is also unclear what effects bullfrog management might have on adult giant garter snakes.

Future Research

Future research should continue to focus on the Volta Wildlife Area population of giant garter snakes. In addition to large-scale trapping at Volta, trapping efforts should be extended to include areas around Volta that could be used as dispersal corridors for giant garter snakes. Trapping areas around Volta will allow the opportunity to determine if snakes marked in previous years at Volta have dispersed to areas outside of Volta.

Due to the rarity and elusive nature of giant garter snakes, we believe radio-telemetry has the potential to provide extremely valuable information about habitat use and natural history. The use of external radio transmitters has been evaluated for the last two years (see Chapter 2). We do not believe that externally attached radio transmitters would provide us with enough information about giant garter snake movement and habitat use. Internal radio transmitters should be used to track giant garter snakes because they remain active for over a year, allowing for continuous tracking of snakes. Year-round tracking of giant garter snakes will provide an opportunity to learn more about movement, dispersal, activity periods and winter den site selection. This information is not known about giant garter snakes in the San Joaquin Valley and is vital to their conservation. Currently, management decisions concerning giant garter snakes in the San Joaquin Valley are being made using data obtained from snakes in the Sacramento Valley. Because of the difference in land use between the Sacramento and San Joaquin Valleys, it could be detrimental to the snake to base management decisions for one population on data obtained from another. Implantation of transmitters in snakes in the San Joaquin Valley would allow managers to make more informed decisions about the management of areas where giant garter snakes are located by providing valuable information about their ecology.

Acknowledgements

Amy Howard-Houk was project leader during the planning and data collection periods of this project. Field work was conducted by J. Gross, J. Henkins, M. Olsen, and J. Stegmeier. B.Cook provided support for all phases of this project. This project was supported by the Department of Interior's Habitat

Restoration Program under the authority of the Central Valley Project Improvement Act. Additional support was provided by Grassland Water District and the Los Banos Wildlife Area.

Literature Cited

Beam, J., and T. Menges. 1997. Evaluation of management practices on state-owned wildlife areas and private duck clubs in the grasslands basin of the San Joaquin Valley relative to the giant garter snake (*Thamnophis gigas*). Unpublished report to the Department of Fish and Game.

Brode, J.M. 1988. Natural history of the giant garter snake (*Thamnophis couchi gigas*). Proceedings of the Conference on California Herpetology. Southwestern Herpetologists Society.

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.

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.

Dickert, C. 2003. Progress report for the San Joaquin Valley giant garter snake conservation project-2003. California Department of Fish and Game.

Greenwood, J. 1996. Basic Techniques. In *Ecological Census Techniques*, W. J. Sutherland ed., pp 11-110. Cambridge University Press, Cambridge.

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 for California Department of Fish and Game Standard Agreement No. C-2060

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.

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

U.S. Fish and Wildlife Service. 1991. Endangered and threatened wildlife and plants; proposed endangered status for the giant garter snake. Federal Register 56, Number 249, 67046-67052.

U. S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants, status for the giant garter snake. Federal Register 58, Number 201, 54053-54066.

U.S. Fish and Wildlife Service. 2000. Biological opinion for the Central Valley Project Improvement Acts programmatic environmental impact statement/report. Unpublished report to the U.S. Fish and Wildlife Service.

Wylie, G., M. Casazza, and M. Carpenter. 2003. Diet of Bullfrogs in relation to predation on giant garter snakes at Colusa National Wildlife Refuge. California Fish and Game 89: 139-145.

Appendix

Items captured in giant garter snake traps at Volta Wildlife Area in 2004.

Item	***Count***
Mosquito Fish	23935
Sunfish	4243
Crayfish	4230
Catfish	820
Bullfrog juvenile/adult	424
Silverside	259
Minnow	197
Bullfrog tadpole-no hind limbs	195
Sculpin	143
Bullfrog tadpole-hind limbs	120
Shrimp	56
Bullfrog metamorph	46
Valley Garter Snake	44
Giant Garter Snake	18
California Kingsnake	8
Western Pond Turtle	8
Bass	1
Chorus Frog adult	1
Gopher Snake	1
Western Yellow-Bellied Racer	1
Non-Targets	
Wren	22
Duckling	13
Vole	10
Mouse	1

Chapter 2. Further evaluation of external radio transmitter use on the valley garter snake

Prepared by Melissa Olsen and Justin Sloan

Introduction

Using radio telemetry to track snakes can provide valuable information about habitat preferences, hibernation sites, home range, and the frequency and distance of movement. However, the use of radio transmitters on snakes is problematic because of their body shape. One solution is for the snake to carry the transmitter internally by means of forced ingestion, implantation into the abdominal cavity, or subcutaneous implantation (Ujvari and Korsos 2000). Body cavity implantation techniques involve invasive surgical procedures that can negatively impact the behavior as well as survival of the snakes being studied. Forced ingestion can lead to changes in behavior as a result of the added bulk in the stomach (Ujvari and Korsos 2000). Subcutaneous transmitter attachment is effective for long-term biological monitoring but drawbacks include injury to the snake during surgery and the possibility of bias because the process is most feasible with larger snakes, whose body size allows for implantation (Ujvari and Korsos 2000).

External attachment is favored in studies that focus on species of special status, where individual mortality must be avoided. Several forms of external attachment can be used. Gent and Spellerberg (1993) used a combination of glue and tape to attach transmitters to smooth snakes (*Coronella austriaca*) in England. Alternatively, Ciofi and Chelazzi (1991) used a backpack system of attachment involving subcutaneous implantation of rubber tubes on the dark green snake (*Coluber viridiflavus*). Rathbun et al. (1993), used bands of tape to attach transmitters to the tails of two-striped garter snakes (*Thamnophis hammondi*), a species of Special Concern in California. External attachment techniques have the disadvantage of requiring constant surveillance to ensure that the extra bulk of the transmitter does not cause the snake to become entangled in vegetation. External transmitters also have a much shorter lifespan than those that are internally implanted, and are either lost at the end of their lifespan or must be replaced by recapturing the snake.

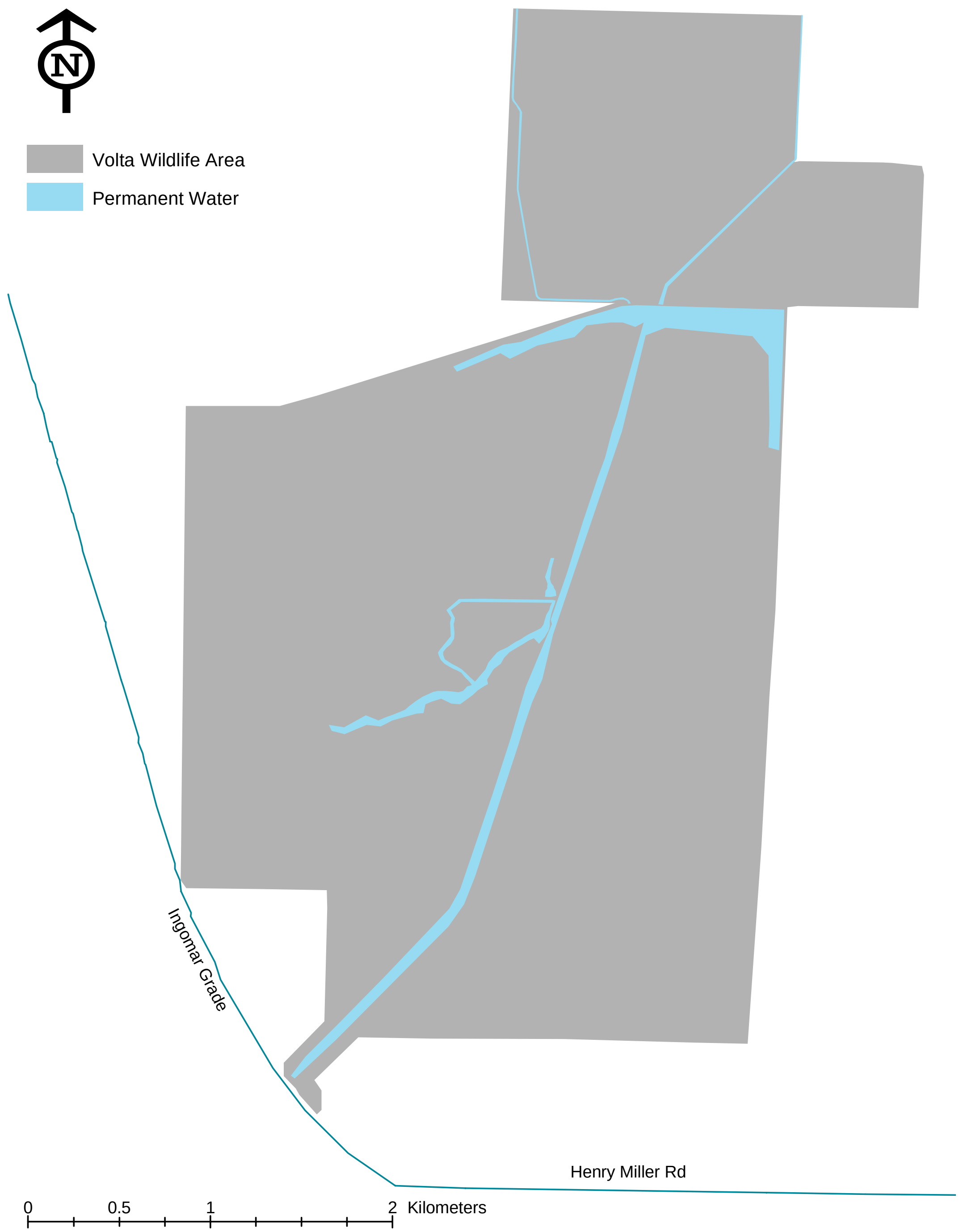
This is the second year of a study to evaluate external attachment of radio transmitters on the valley garter snake (*Thamnophis sirtalis fitchi*). The valley garter snake was chosen as a surrogate for the giant garter snake because the latter species is listed as threatened under both the California and federal Endangered Species Acts, and occurs in low numbers in the San Joaquin Valley of California. Valley garter snakes are of comparable size and occupy habitats similar to that of the giant garter snake, but are common in the northern San Joaquin Valley.

The goal of the 2004 research season was to continue to refine external attachment techniques on valley garter snakes by using smaller transmitters and altering the attachment method in preparation for use on giant garter snakes.

Study Area

The Volta Wildlife Area (37 07' 28.53" N, 120 55' 14.40" W) is located in western Merced County, approximately 11 kilometers north-west of the city of Los Banos. The area is owned by the Bureau of Land Reclamation and managed by the California Department of Fish and Game. The terrain is flat and elevation ranges from 29 to 33 meters. The climate is characterized by hot, dry summers, mild falls and springs, and cool, wet winters with an average annual rainfall of 21 centimeters (Los Banos Wildlife Area Unpublished Data 1970-2000).

Figure 1. Volta Wildlife Area.



Methods

The valley garter snakes used in this study were caught incidentally in modified eel pot traps (Casazza et al. 2000) set for giant garter snakes, with the exception of one snake that was hand captured. We weighed, determined the sex and implanted each captured snake with a passive integrated transponder (PIT) tag, for future identification in the field. We attached a transmitter to the snake as far below the vent as possible to decrease any negative impact on the snake's movement (Figure 2). We placed the transmitter against the side of the snake with the antenna extending beyond the tip of the tail (Figure 3). The transmitters were model BD-2N, manufactured by Holohil Systems, Ltd, and weighed 0.51 g. We attached transmitters using one of two brands of tape, Blenderm (3M) (Figure 3) and Micropore (3M) (Figure 2). We added Super Glue (Loctite) to the edges of the tape to prevent the tape from peeling.

Figure 2. Attachment of external radio transmitter on valley garter snake using Micropore tape

Figure 3. Antenna extending beyond the end of the tail of valley garter snake; transmitter attached using Blenderm tape

We released the radio-tagged snakes near the location we caught them, generally the following day. We located snakes using walk-in telemetry each day, until the signal was lost or the transmitter recovered. An effort was made to gain visual confirmation of the snake and the transmitter as often as possible. If a snake remained in its burrow for more than three days, we attempted to dig the snake out and confirm its condition and the condition of the transmitter.

Results

We conducted 15 trials from June 2 to August 16, 2004. Four snakes had transmitters attached using Blenderm tape, with an average attachment time of 16 days. Of these transmitters, one remained attached for 34 days, until the snake was captured in a trap and the transmitter, no longer emitting a signal, was removed. One transmitter fell off after four days. Another snake was recaptured after nine days, and the tape was found to have cut under the scales of the snake (Figures 4a and 4b). To prevent further injury to the snake, the transmitter was removed. The signal of the fourth transmitter was lost, and the transmitter could not be recovered.

Figure 4a. Damage to tail caused by Blenderm tape.

Figure 4b. Damage to tail caused by Blenderm tape.

Eleven snakes had transmitters attached using Micropore tape. The transmitters remained attached for an average of 11 days, with a range of six to 20 days. Of these transmitters, four could not be recovered; two transmitters stopped emitting signals before the snake could be recaptured, one was lost in water and one was located near a partially eaten snake but could not be recovered. Six transmitters were found after they had fallen off of snakes. One remained attached for 20 days until the snake was dug out of its burrow and the transmitter removed at the end of the field season.

Discussion

We began attaching transmitters using Blenderm tape because it is a waterproof and durable surgical tape. The tape adhered well to the snakes, however it was stiff and caused injury to one snake. We were also concerned that the non-breathable nature of this tape could result in tissue necrosis (E. Hansen, personal communication). Because of injuries to the snake and concern for tissue necrosis, we switched to Micropore cloth medical tape, which was more flexible and breathable. The average attachment time using Micropore tape was less than with the Blenderm tape, 11 days compared to 16 days, but the Micropore tape did not cause noticeable injuries. Although the Blenderm tape was more effective in terms of attachment time, we felt that the risk of injury to the snake was too great to continue using it. This risk would be particularly unacceptable when working with a threatened species like the giant garter snake.

During the 2003 field season, the size of transmitter and the techniques used for attachment resulted in the snakes becoming entangled in vegetation or burrow entrances, and five of the 14 snakes lost part of their tails trying to free themselves. Using the 0.51 gram transmitters, we did not see the tail loss that occurred with the 1.8 gram transmitters used in 2003. Using a smaller transmitter did not, however, increase the amount of time the transmitters stayed attached. The average duration of attachment using the on-tail technique during the 2003 field season was 16 days. We achieved the same result with the Blenderm tape, and an even shorter attachment period, 11 days, with the Micropore tape.

The primary goals of conducting telemetry on giant garter snakes in the San Joaquin Valley are to determine habitat use, movement and activity periods. These goals require continuous, long-term monitoring of radio tagged snakes. The transmitters used in this study have a life expectancy of only three weeks and are not practical for a program requiring prolonged tracking. It could be detrimental to the snake to be captured every two or three weeks in order to change the transmitter. It would be impossible to catch the snakes while they are hibernating and not negatively affect them.

Future Research

Because of the restricted amount of tracking time granted by the battery life and attachment technique, it is unlikely that adequate data could be gathered on giant garter snakes using externally attached transmitters. It is our belief that, for future research to yield constructive results that can be used to make informed management decisions regarding giant garter snakes, implantation of transmitters is necessary. Implanted transmitters would remain active for a longer period of time, and give us the opportunity to track snakes throughout the year. The benefits of year-round tracking would greatly outweigh the potential drawbacks of internal radio transmitters.

Acknowledgements

Amy Howard-Houk was project leader during the planning and data collection periods of this project. Field work was conducted by J. Gross, J. Henkins, M. Olsen, and J. Stegmeier. This project was supported by the Department of Interior's Habitat Restoration Program under the authority of the Central Valley Project Improvement Act. Additional support was provided by Grassland Water District and the Los Banos Wildlife Area.

Literature Cited

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.

Ciofi, C. and G. Chelazzi. 1991. Radiotracking of *Coluber viridiflavus* using external transmitters. Journal of Herpetology 25(1): 37-40

Gent, A.H. and I. F. Spellerberg. 1993. Movement rates of the smooth snake *Coronella austriaca* (Colubridae): a radio-telemetric study. Herpetological Journal. 3: 140-146

Rathbun, G.B., M.R. Jennings, T.G. Murphey, and N.R. Siepel. 1993. Status and ecology of sensitive aquatic vertebrates in lower San Simeo and Pico Creeks, San Luis Obispo County, California. Final Report under cooperative agreement 14-16-0009-91-1909 between U.S. FWS and CA Dept. of Parks and Recreation. Publication No. PB93-230779, National Technical Information Service, Springfield, VA, ix 103pp.

Újvári, B and Z. Korsós. 2000. Use of radiotelemetry of snakes; a review. Acta Zoologica Hungary. 46 (2): 115-146.