Results of 2006 Monitoring for Giant Garter Snakes (*Thamnophis gigas*)

For the Bank Protection Project on the Left Bank

of the Colusa Basin Drainage Canal in Reclamation District 108,

Sacramento River Bank Protection Project, Phase II

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EXECUTIVE SUMMARY

The USGS surveyed for giant garter snakes (*Thamnophis gigas*, GGS) in Colusa Basin Drainage Canal by conducting walking surveys and trapping from 21 April to 26 September 2006, to determine abundance of GGS in Colusa Drain and to assess potential effects on GGS of three bank stabilization treatment sections: 1) soil planted with native grasses over a rock substrate, 2) soil planted with native grasses without a rock substrate, 3) rock/riprap only, and 4) a control section which had no bank stabilization treatment. We captured 71 GGS, 11 during walking surveys and driving and 60 using 400 traps deployed along the bank treatment areas and in a control area where the bank was not altered. We recaptured four GGS originally marked in 2006, and one each marked in 2003 and 2004. We estimated a GGS population density in Colusa Drain of 20±3 snakes/km (95%CI: 16-31), which falls within 2003 and 2004 95% confidence intervals (95%CI: 12-35). Though we captured approximately the same number of GGS as in 2003 and 2004, the distribution of GGS appears to have changed. More GGS were captured in the control section than in all other sections combined, which may be due to fallowing and conversion of rice fields on the south side of Colusa Drain adjacent to the bank treatment areas.

We surgically implanted radio transmitters into 17 GGS (16 females and 1 male) and attached external transmitters to an additional 6 GGS (5 females and 1 male). We will continue monitoring these snakes through spring 2007. Thus far, minimum convex polygon home range estimates ranged from 3–50 ha and GGS moved up to 17 km over the course of the summer. One GGS used Sections 2 and 3, three GGS used the rock/riprap section. Four GGS stayed mainly in Section 1 of Colusa Drain, while the rest used both the Control Section and adjacent rice fields. Eight snakes originally captured in traps eventually moved into rice fields and as of 17 November 2006, only one male and one female returned to Colusa Drain. Currently, five snakes are in burrows or mud cracks adjacent to rice fields, four snakes are in burrows along the north bank of the control section, two are in burrows along the north bank of section 1, and two are in mud cracks or burrows approximately 100 m south of section 1 of Colusa Drain. As nighttime and water temperatures are now too low for snakes to make extensive movements, likely these will be the locations where the snakes will be during winter.

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Introduction

In October 1998 the U.S. Army Corps of Engineers (Corps) began to place rock revetment (riprap) on the north bank of the Colusa Basin Drainage Canal (Colusa Drain) located in Reclamation District 108, which was damaged by flooding in the winter of 1997-1998. Upon inspection of this repair work by the U.S. Fish and Wildlife Service (Service), the Corps requested a Section 7(a)(2) (Public Law 84-99) consultation from the Service concerning impacts of the bank protection project on giant garter snakes (*Thamnophis gigas*; GGS) (Figure 1), a federally and state listed threatened species. As a result of this consultation, the Corps agreed to apply as bank stabilization measures soil and soil over rock bank reinforcement with native grasses planted to stabilize the soil surface. The Corps also agreed to establish a long-term monitoring program for giant garter snakes to document their use of the bank stabilization design. In 2003, we began monitoring giant garter snakes in and around the project site; here we report our results from the 2006 field season.

Figure 1. Adult female giant garter snake (*Thamnophis gigas*), Colusa Drain 2006.

Methods

Study Site

The project site is a 10.1 km reach of the north bank of the Colusa Drain in Yolo County (Figure 2). About 1.8 km of the bank is covered with Rock/Riprap only (Rock/Riprap Section). To the east (Section 1, 7km) and west (Section 2, 0.8 km) of the Rock/Riprap Section the bank stabilization design consists of a layer of rock riprap no greater than 38 cm in thickness, graded with larger stones to increase spaces between individual rocks. In Sections 1 and 2 the interstitial space between the rocks was filled with a clay soil and more clay was layered over the rock/soil mix to a minimum depth of 30.5 cm, and planted perennial native grasses in the surface soil layer. .To the northwest of Section 2 the bank stabilization consisted of native grasses planted over soil with no underlying rock (Section 3, 0.5 km) For this project we also sampled an unaltered area southeast of Section 1 (Control Section, 3.3 km).

Survey Techniques

From the middle to the end of May we placed 400 modified floating funnel traps (Casazza et al., 2000) to trap GGS in Colusa Drain. We placed one trap line (50 traps) in each of Sections 2 and 3, Rock/Riprap, and Control sections and four trap lines (total of 200 traps) in Section 1. At each trap location we recorded environmental variables (vegetation type and structure, landscape type, and adjacent field conditions) and geospatial coordinates using a handheld global positioning system (GPS). We checked traps five to six times weekly through the monitoring period and collected all GGS for processing (measuring and permanently marking).

In order to find additional snakes for telemetry studies, we searched for GGS on foot (walking surveys) between 21 April and 26 September along the banks of Colusa Drain, adjacent canals, and nearby rice fields. These walking surveys were delineated using GPS and are shown in Figure 2, and totaled 118.1km.

Snake Processing

Immediately following capture, we measured snout-vent length (SVL) and mass, determined sex, and permanently marked all GGS with a passive integrated transponder (PIT) tag or individual ventral scale clip if the snake was too small for PIT tag insertion. Except for individuals chosen for radio telemetry, we returned all snakes to their capture location within a few hours.

Radio Telemetry

We used both surgically-implanted 8 g temperature-sensitive transmitters (Holohil, Inc., Carp, Ontario, Canada) and externally attached 2 g transmitters (Advanced Telemetry Systems, Inc., Isanti, Minnesota, USA). We chose snakes so that these transmitters did not exceed 5% of their mass. Snakes weighing at least 200 g were implanted with the 8 g internal transmitters and snakes weighing at least 100 g had the 2 g transmitters attached to them. Dr. Ray Wack (Sacramento Zoo) performed all transmitter implantation surgeries using a method modified from Reinert and Cundall (1982). After a 2-week recovery period for implanted snakes, we released GGS at their exact capture locations. We attached external transmitters using a taping method (USGS, unpublished data) and released those snakes within 24 hours of their capture. We began radio tracking snakes on 14 June 2006 and will continue through spring 2007.

At each GGS capture location, we recorded geospatial coordinates using a handheld GPS and we recorded behavioral observations and habitat use. We characterized the landscape by treatment type if in or adjacent to the Colusa Drain, or by land use (i.e., rice, fallowed, wetlands). At the microhabitat scale (i.e., one meter around each snake), we recorded substrate type, vegetation type, vegetation structure, and distance to water. We recorded individual movement episodes (movements) as the net linear distance moved since the previous telemetry observation.

Data Analyses

For summarizing data and all statistical analyses, we used JMP™ IN 5.1.2 (SAS Institute, Inc.). Using only GGS caught in traps, we created a monthly capture history for each individual and imported these data into Program MARK, version 4.3 (White and Burnham, 1999) to estimate population density. We chose the model that allows for a behavioral response within the population to capture probability (M_b). We imported geospatial coordinates into Geographic Information System software (ArcView™ 3.3 and ArcGIS™ 9, ESRI, Inc.) and used Animal Movement Analysis (extension obtained online from Alaska Biological Science Center, USGS-Biological Resources Division) to analyze movement and geographic data. Because we only captured two males large enough for transmitter placement, we combined males and females for all spatial analyses. We calculated minimum convex polygon home ranges for GGS with more than 30 locations during the active season (through 30 September) and movement data for all other GGS through 17 November. We report means plus or minus one standard error, unless otherwise indicated.

Results

Surveys

We searched over 118 km during 93 walking surveys for GGS in 2006 (Figure 2). We captured 11 GGS (6 females and 5 males) during walking surveys, driving, and while checking traps and observed 8 more that were not captured (Table 1; Figure 2). In addition to captures and sightings summarized in Table 1, we found two dead GGS.

Figure 2. Locations of GGS found during walking surveys and areas where we conducted walking surveys for GGS at Colusa Drain in 2006.

We maintained traps for 114 – 131 days (8 May – 21 September 2006). Vegetation features were similar among trap lines (Figure 3); most traps were surrounded by dense stands of marsh primrose (*Ludwigia spp.*). A few traps in Section 3 were shaded by trees and some traps in Sections 2 and 3 were set near tules (*Scirpus acutus*).

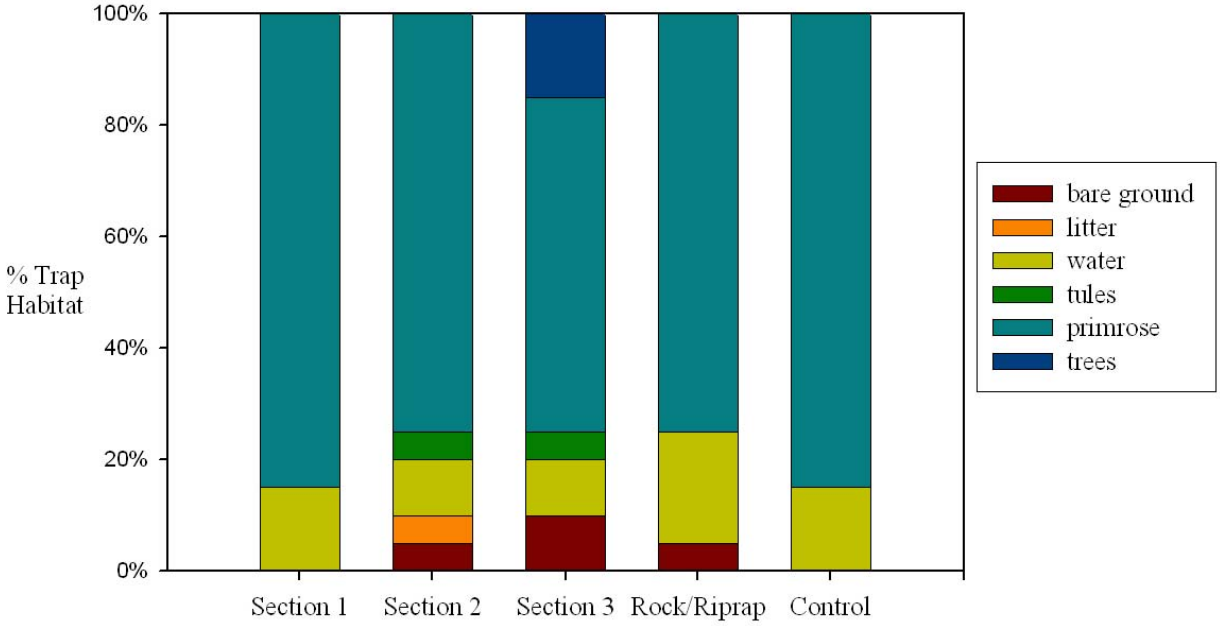

Figure 3. Habitat features of GGS traps at Colusa Drain in 2006. Marsh primrose was the dominant vegetation surrounding all traps.

We captured 60 GGS (33 females and 27 males) in traps, plus another 11 by hand (Table 1). We captured more GGS per unit length in the Control Section than in all other sections combined (Table 2; Figure 4). In Section 2, we captured nearly twice as many GGS as in Section 1 and the Rock/Riprap section; we only captured one GGS in Section 3 during the 2006 field season. We estimated a population density of 20 GGS/km at Colusa Drain in 2006 (Table 3).

Table 1. Summary of 2006 GGS captures at Colusa Drain by section or capture method.

	Total	**New Snakes**	**Recaptures**	**Males**	**Females**
Section 1	20	19	1	10	10
Section 2	9	9	0	4	5
Section 3	1	1	0	1	0
Rock/Riprap	5	4	1	1	4
Control	25	21	4	11	14
Hand captures	11	11	0	5	6
Sightings	8				
Total	79	65	6	32	39

Table 2. Number of GGS captured in each treatment area of Colusa Drain in 2006. More GGS (per unit length within the survey region) were captured in the Control Section than all other sections combined.

	# Snakes	Length (km)	Snakes/km	# Days
Section 1	19	1.78	11	131
Section 2	9	0.46	20	129
Section 3	1	0.67	1	114
Rock/Riprap	4	0.47	9	125
Control	21	0.46	46	127

Figure 4. Trap locations (yellow) and GGS trap capture locations (red) during the 2006 field season at Colusa Drain.

Table 3. GGS density estimate in Colusa Drain for three field seasons. Density estimate = mean GGS/km ± one standard error; CI = confidence interval.

Year	Density Estimate (±SE)	95% CI
2003	27±3	21-35
2004	16±3	12-23
2006	20±3	16-31

Female GGS averaged 750.8 ± 23.1 mm SVL and were larger than males (613 ± 17.1 mm). Most females were 600-900 mm SVL and weighed 100-400 g; we did not capture any males greater than 200 g or 800 mm SVL (Figures 5 and 6).

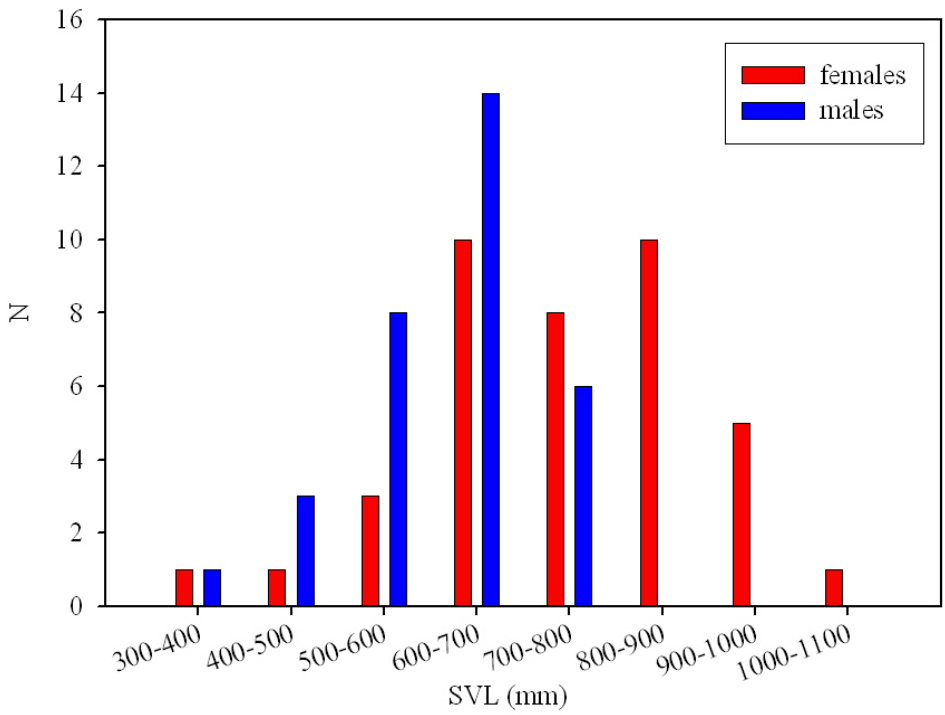

Figure 5. Female and male GGS snout-vent length (SVL) in mm.

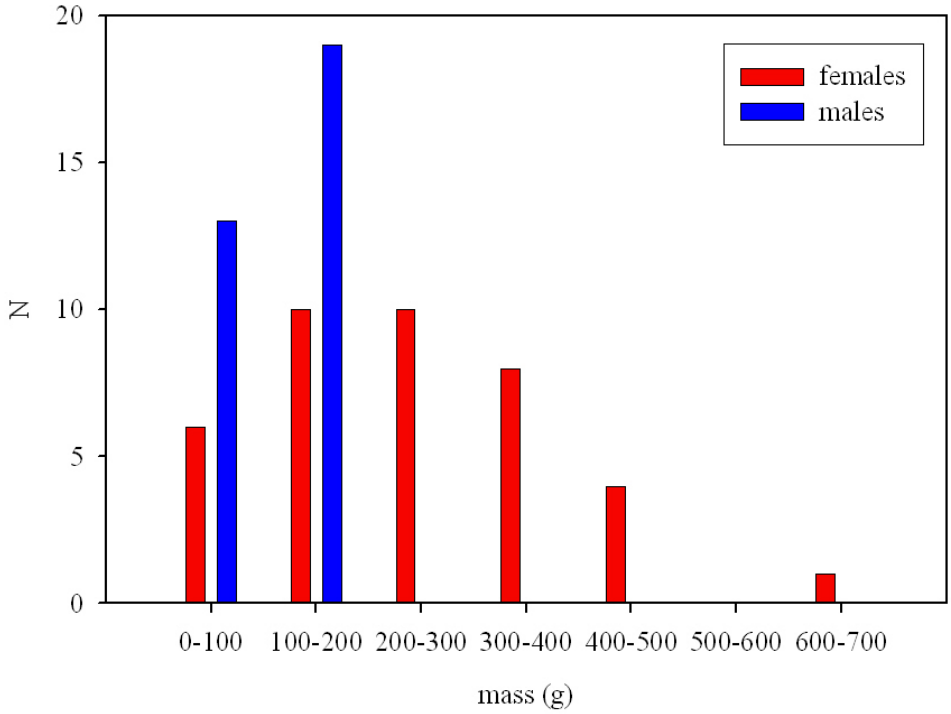

Figure 6. Female and male GGS mass (g).

We captured the most GGS in traps early in the season (35 out of 60 GGS in May and June) and our capture rate decreased by half in July and August and even lower in September (Figure 7).

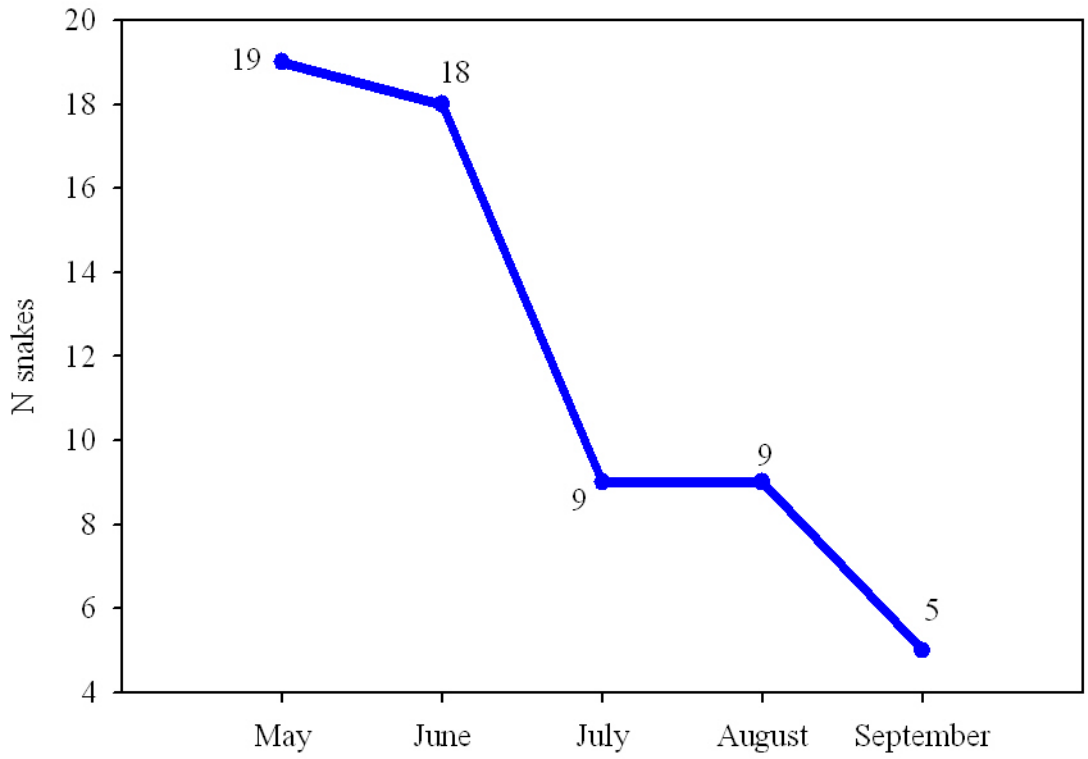

Figure 7. Number of GGS captured in traps each month.

Radio Telemetry

We surgically implanted radio transmitters into 17 GGS (16 females and 1 male) and attached external transmitters to an additional 6 snakes (5 females and 1 male; Table 4). One female died with 24 hours of her implantation surgery, likely from complications related to that surgery, so that a net of 15 females and one male had internal transmitters for our study. Two of the snakes with external transmitters shed or lost their transmitters within a day or two of release, so we obtained no usable data from these individuals. We relocated the remaining 20 snakes once or twice daily beginning in mid-June 2006, five days per week and obtained 1409 usable locations.

Table 4. Movement statistics for GGS at Colusa Drain in 2006. ID: snake identification; Sex: F = female, M = male; N: number of locations used to calculate movement statistics; Dist/mv: distance per movement (meters); Dist/d: distance moved per day; Max: longest movement; Sum: total distance moved; Type: transmitter type (E = external, I = internal); D: (disposition) S = shed transmitter, V = killed by farm vehicle, A = alive, P = predation, U = unknown cause of death; SE: one standard error.

ID	Dates Tracked	Sex	N	m/mv	m/d	Max	Sum	SVL (mm)	Mass (g)	Type	D
P	09/13 – 09/19	F						657	120	E	S
SK	08/25 – 08/31	F						826	250	E	S
LW	07/06 – 08/07	F	12	154.5	103	539.5	1236.3	894	362	I	V
C	10/19 – 11/17	F	13	141.1	43.8	388.3	1269.6	851	344	I	A
TI	10/19 – 11/17	F	14	24.4	5.1	83.5	146.6	770	206	I	A
JC	08/28 – 09/08	F	15	286.5	130.2	947.7	1432.4	681	141	E	S
V	10/12 – 11/17	F	16	11.9	3	34.1	106.7	726	226	E	A
K	10/10 – 11/17	F	18	14.9	3.9	114	148.9	669	197	E	A
NJ	06/14 – 08/08	F	18	112.3	34.7	418.1	1909.5	864	364	I	P
TU	09/18 – 11/17	M	39	56.4	22.5	332.9	1352.6	641	134	E	A
B	09/11 – 11/17	F	54	118.7	30.1	1800.7	2017.4	893	416	I	A
D	08/30 – 10/19	F	58	161.8	80.9	1265.3	4045.5	957	460	I	P
S	08/22 – 11/17	F	77	121.2	65.5	1035.4	5697.1	800	209	I	A
Y	06/14 – 08/21	F	81	168.1	173.4	2022.1	10926.8	841	300	I	U
E	08/22 – 11/17	F	83	56.4	41.5	1019.1	3611.3	823	226	I	A
J	08/02 – 11/17	F	110	65.4	39.1	586.3	4186.5	1030	600	I	A
A	07/28 – 11/17	F	111	127.2	63.6	1214.1	7124.3	968	378	I	A
Q	07/28 – 11/17	F	115	65.7	54.6	445	6111.9	790	365	I	A
G	07/06 – 10/13	F	123	180.8	171.7	2791.3	16995.4	797	219	I	P
R	07/06 – 11/17	M	140	58.7	52.2	678.7	6989	750	192	I	A
N	06/14 – 10/13	F	149	68	70.8	643.1	8564.7	911	385	I	U
M	06/14 – 11/17	F	163	93	72.8	884	11349.2	923	396	I	A
	mean			**104.4**	**63.1**	**862.2**	**4761.1**	**829**	**306**		
	SE			**15.0**	**11.0**	**156.3**	**1010.7**	**23**	**27**		
	minimum			**11.9**	**3.0**	**34.1**	**106.7**	**641**	**134**		
	maximum			**286.5**	**173.4**	**2791.3**	**16995.4**	**1030**	**600**		

We calculated movement statistics for 20 snakes with at least 12 locations each and minimum convex polygon home range estimates for 11 snakes with more than 30 locations each (Tables 4 and 5). GGS moved an average of 63 m/day and 104 m/movement during the active season (time of release – 30 September; Table 4). A female snake made the largest single movement, moved the greatest distance overall, and had the largest home range (Tables 4 and 5; Figure 8).

Table 5. Minimum convex polygon home range estimates for 11 GGS at Colusa Drain in 2006. Sex: F = female, M = male; N = number of locations used to estimate MCP; MCP = minimum convex polygon home range estimate (ha).

ID	Dates Tracked	Sex	N	MCP (ha)	SVL (mm)	Mass (g)
D	08/30 – 10/19	F	41	11.59	957	460
S	08/22 – 11/17	F	50	15.76	800	209
Y	06/14 – 08/21	F	81	13.98	841	300
E	08/22 – 11/17	F	54	13.52	823	226
J	08/02 – 11/17	F	82	3.02	1030	600
A	07/28 – 11/17	F	83	20.29	968	378
Q	07/28 – 11/17	F	87	6.13	790	365
G	07/06 – 10/13	F	109	239.01	797	219
R	07/06 – 11/17	M	115	12.75	750	192
N	06/14 – 10/13	F	135	18.16	911	385
M	06/14 – 11/17	F	134	58.15	923	396
	Mean ± SE			**37.48 ± 20.62**	**829 ± 23**	**306 ± 27**
	Range			**3.02 – 239.01**	**641 - 1030**	**134 - 600**

All snakes were originally captured in the Colusa Drain, but used various habitats during summer. Snake G primarily used Colusa Drain and adjacent canals in Section 3, but also spent some time in Sections 2 and the Rock/Riprap section (Figure 8). Snake D stayed in Colusa Drain in the Rock/Riprap section for the entire active season (Figure 8). Four female GGS (E, J, S, Y) stayed in Section 1 of Colusa Drain (Figure 9). Snakes M and N, though originally captured in Colusa Drain, primarily used the rice fields during the summer, snakes Q and A mostly stayed in the Control section, and the only male GGS (R), used both the Control section and adjacent rice fields (Figure 10).

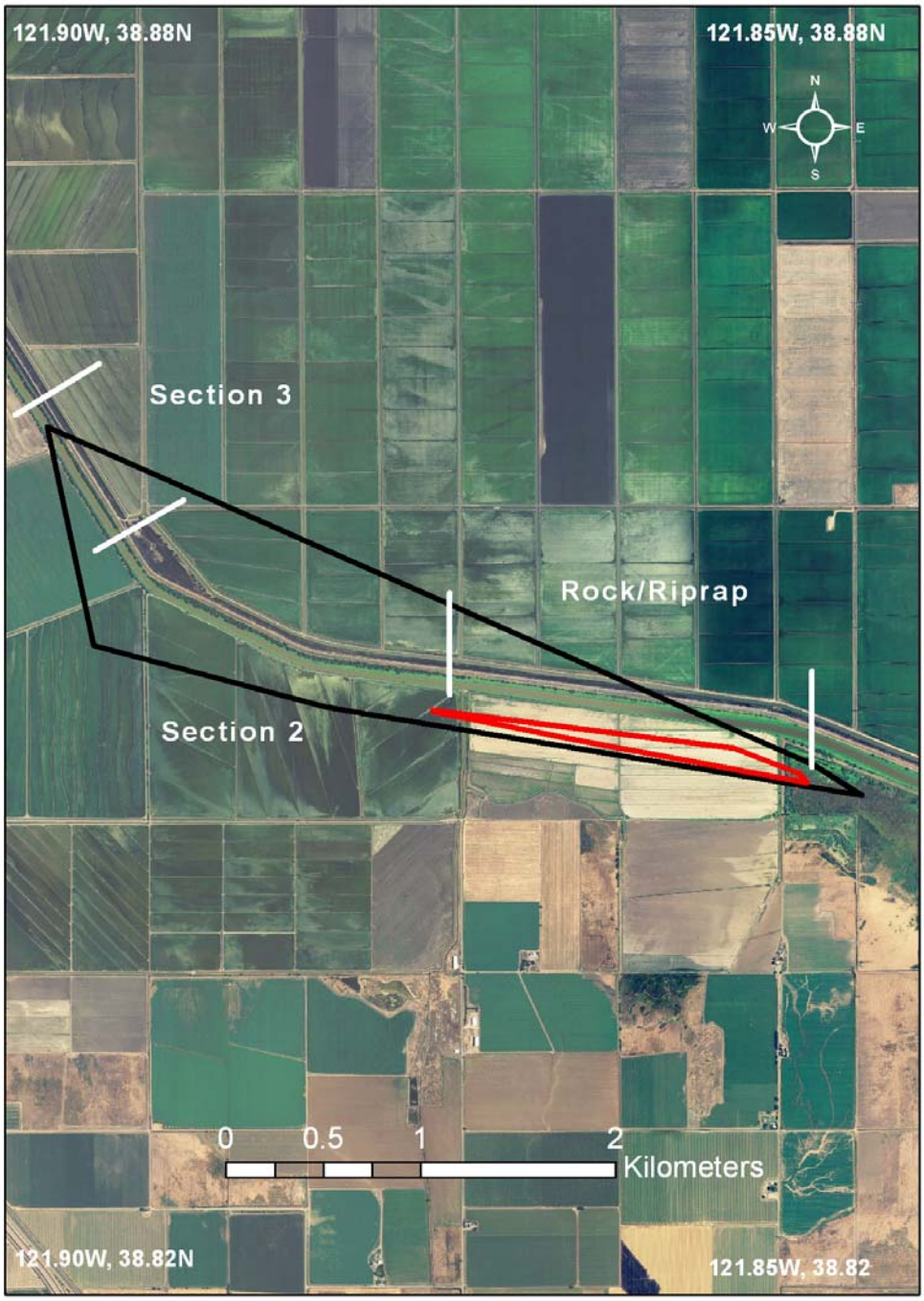

Figure 8. Minimum convex polygon home range estimates for two female GGS (D and G) that used Sections 2, 3, and Rock/Riprap of Colusa Drain in 2006.

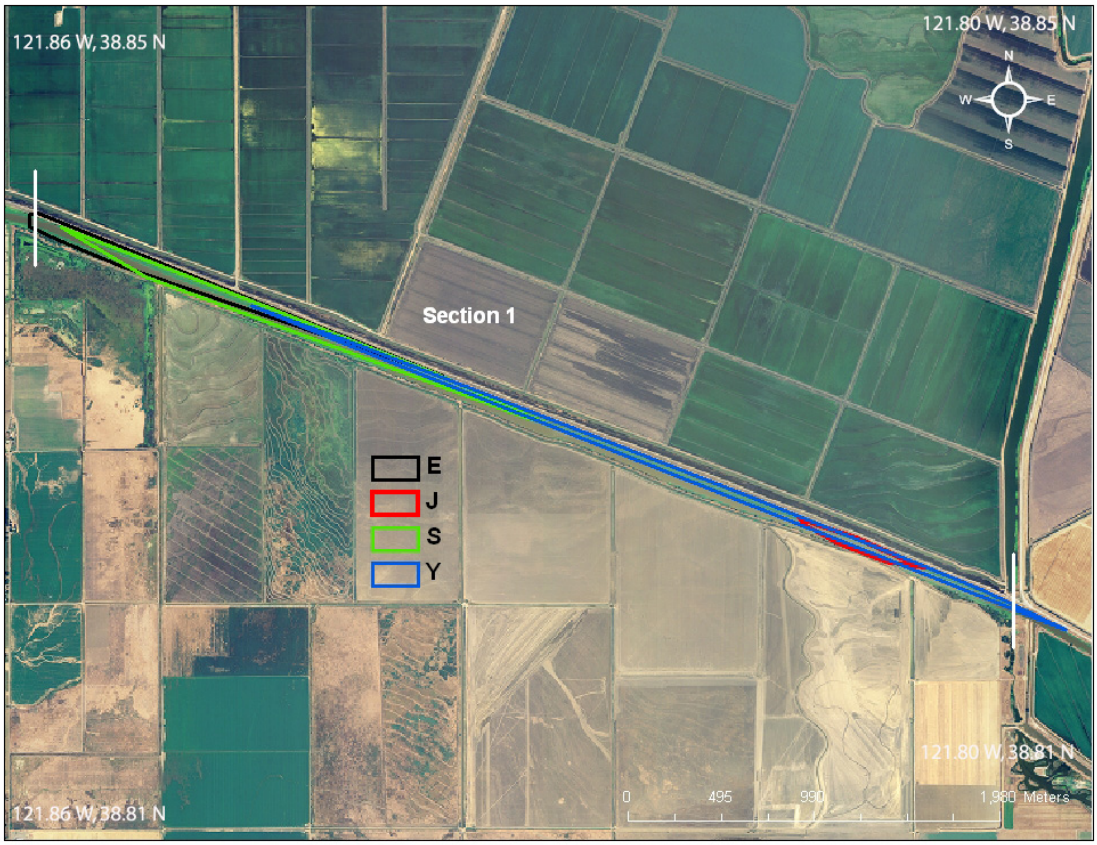

Figure 9. Minimum convex polygon home range estimates for four female GGS (E, J, S, and Y) that used Section 1 of Colusa Drain in 2006.

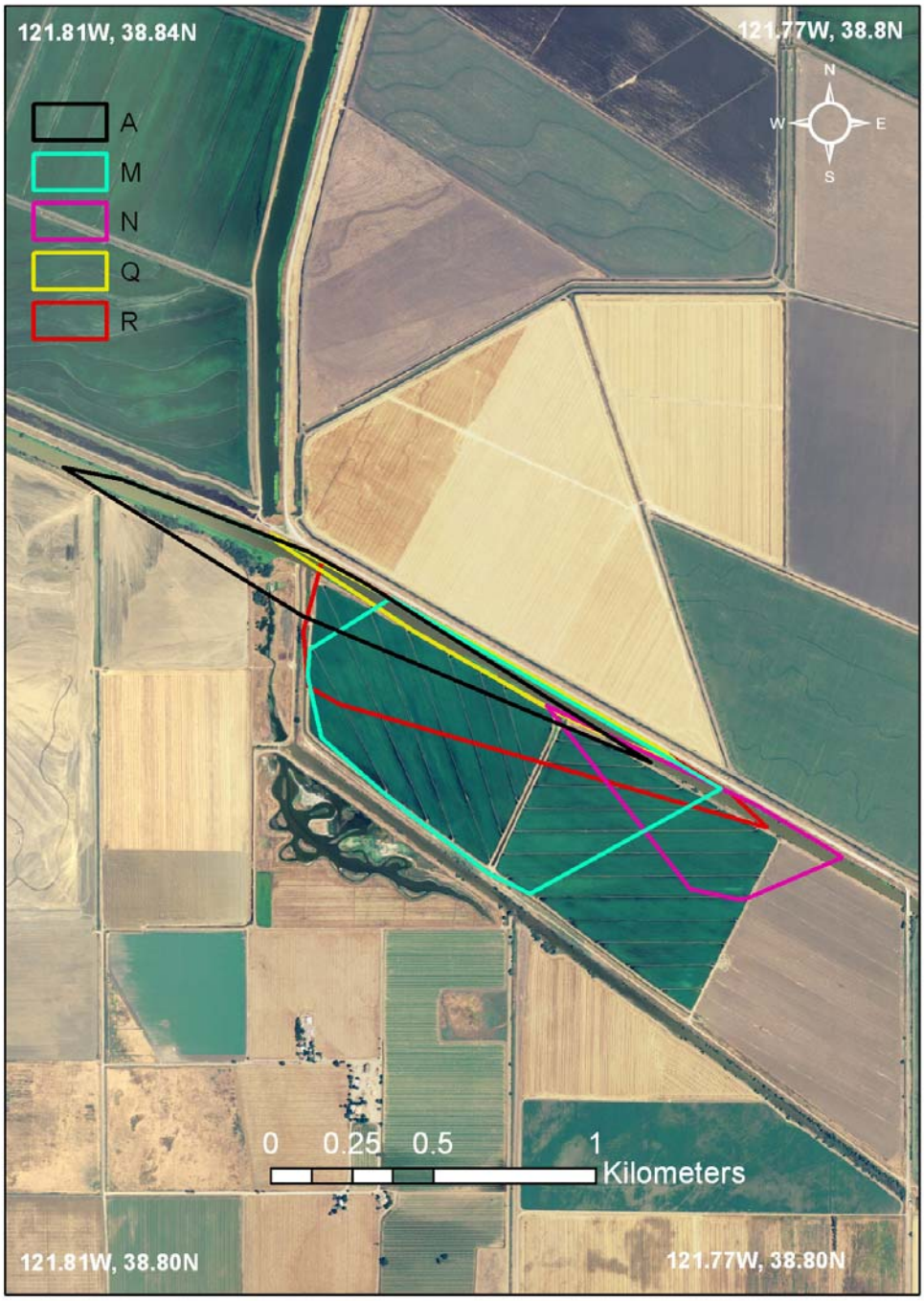

Figure 10. Minimum convex polygon home range estimates for five GGS, A, M, N, Q (females), and R (male) that used the control section and adjacent rice fields at Colusa Drain in 2006.

We captured 18 snakes in or near traps in Colusa Drain and 2 adjacent to rice fields south of the Control section. Eight GGS originally captured in traps eventually moved into rice fields and as of 17 November, only one male and one female returned to Colusa Drain. All GGS stopped making extensive movements in October and will likely overwinter in their present locations. Five snakes are in burrows or mud cracks adjacent to rice fields, four snakes are in burrows along the north bank of the control section, two are in burrows along the north bank of Section 1, and two are in mud cracks or burrows approximately 100 m south of Section 1.

Six GGS with radio transmitters died in the field at Colusa Drain in 2006. Two females died of unknown causes and we are waiting for necropsy results on one of these individuals. Predatory birds likely killed three other females, based on the location and condition of their remains. The sixth female was run over by agricultural equipment in a rice field early in the season. Though anthropogenic mortality is a factor at Colusa Drain, based on our limited number of snakes outfitted with transmitters, the most common cause of death for GGS at Colusa Drain appears to be from predatory birds, since we witnessed raptors perched above the places where we recovered dead snakes.

Discussion

The unusually wet winter and spring of 2006 delayed our trap installation by two weeks. GGS are most active in late spring and early summer and this is when most snakes were captured in 2003 and 2004 at Colusa Drain (Wylie et al., 2003; Wylie et al., 2004). Therefore, it is difficult to make direct comparisons between 2006 and other field seasons. Although the overall population has remained stable from 16-27 snakes/ km (12-35 snakes/km, 95% CI), the relative density between sections of the drain has shifted. The number of GGS found in the Rock/Riprap and Section 1 has decreased since 2003, from 22 and 31 (respectively) to only 4 and 19 in 2006. However, we found more GGS in the Control section in 2006 (21) than in 2003 (11) or 2004 (16).

When we started this project in 2003, all adjacent fields on the south bank of the study site were used to grow rice. While many other wetland areas are drained during the summer, when snakes are active, rice fields remain flooded during this important time for GGS. In 2004 and 2006, many GGS captured in the drain eventually moved to the rice fields. In 2006, most of the fields on the south bank of Colusa Drain were dry or being converted to seasonal wetlands and the only remaining rice fields were south of the Control area. The decrease in rice fields as suitable summer habitat adjacent to the drain could account for increased density of snakes in the Control area and a decrease in snake density elsewhere.

Reclamation District 108 uses fire as a management technique to control weeds and allow for visual inspection of levee integrity. Fire on the north bank left the ground charred and black, which likely increased the surface temperature relative to unburned areas as well as removing vegetative cover. GGS never used the treatment areas on the north bank during summer. The effect of fire may overwhelm any effects of the north bank stabilization treatments on GGS habitat use. By late fall, vegetation had started to grow on the north bank and one snake started to use Section 1 for wintering habitat. Four other GGS, however, were using the Control section as wintering habitat in grassy areas which were near the water and unaffected by the burn.

Future Monitoring and Management Recommendations

We will continue monitoring GGS in Colusa Drain through early summer 2007. Terrestrial areas are most important to GGS over the winter, so continued monitoring will provide more information on GGS use of different stabilization treatments on the north bank of Colusa Drain. Particularly if the land to the south and west of the Colusa Drain floods this winter, as it typically does, we should be able to document the use of the main levee as refuge habitat from the flooding. Perhaps more important than stabilization treatments for management of GGS is the use of fire as a management tool on the north bank. Burning the north bank allows visual monitoring of levee integrity, but burning also overwhelms habitat attributes of the various bank stabilization procedures. Burning removes the vegetative cover and increases ground temperatures, and likely inhibits use of the burned area of the levee by GGS during the summer. The relatively high surface temperatures of burned sections of the levee may increase snake use of the levee in the fall and winter, because snakes can more easily warm themselves on the burned surface; however, they are exposed to predation by the lack of cover. Changing the

season and the intensity of the burn, or alternative weed removal methods, should be considered for greater benefits for GGS.

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