

Monitoring of the Rio Grande cooter (*Pseudemys gorzugi*) in a dynamic landscape, Eddy County,
New Mexico

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Testudines are one of the most imperiled groups of vertebrates in the world with approximately 42% considered threatened (Baillie *et al.* 2004). Of North America's 56 native turtle species, at least 35 (63%) are threatened or in decline and require conservation action (Ernst and Lovich 2009). Generalized threats to turtle populations include, habitat modification and fragmentation, road mortality, pollution, collection for the pet and food trade, interactions with invasive species (Gibbons *et al.* 2000), climate change (Mitchell and Janzen 2010), and disease (Goodman *et al.* 2013, Miller *et al.* 2015). As with most threatened species, population declines are driven by additive effects from multiple threats and not a single cause (Böhm *et al.* 2013).

The Rio Grande cooter (*Pseudemys gorzugi*, hereafter RGC) is one of the least studied turtle species in the United States. Little is known about its basic population structure, ecology, reproductive biology, or current population trends and threats (Lovich and Ennen 2013, Bailey *et al.* 2014). This species requires large, clear pools in the river channel with abundant emergent vegetation (Ernst and Lovich 2009). The best available information suggests this species is highly susceptible to certain threats, and has declined throughout its range (Bailey *et al.* 2014). Due to the apparent declines, the RGC is considered threatened by the New Mexico Department of Game and Fish and is classified as a Species of Greatest Conservation Need (NMDGF 2016). Furthermore, the IUCN has categorized the RGC as near-threatened (van Dijk 2013) and the United States Fish and Wildlife Service are currently conducting a status review for the RGC (USFWS 2015). These designations were assigned because of the species' small range, unknown population trends, and multiple threats (van Dijk 2013). The Rio Grande cooter is threatened by water usage in occupied rivers, habitat fragmentation, oil and gas extraction, pet trade, and killing by fisherman (Ward 1984, Bailey *et al.* 2008; Van Dijk 2013). Studies of this species in Texas report troubling population declines, local extirpations, and an apparent lack of recruitment (Bailey *et al.* 2014).

Within the United States, the range of the RGC is comprised of two disjunct populations; a population in the Pecos River drainage of southeastern New Mexico and northwestern Texas, and another in the Rio Grande from Big Bend to Brownsville in Texas. These two populations are separated by an approximately 160 km stretch of the Pecos River in Texas, and it is hypothesized that this fragmentation is caused by impacts from oil and natural gas drilling (Ward 1984). Heavy modification of the Pecos River, especially by the construction of dams, may impede gene flow between populations, while increased sedimentation or pollution from industry can degrade suitable habitat. Populations in New Mexico have been monitored intermittently since the 1990s (Christman and Kamees 2007, Painter 1993, and Painter 2013).

In 2016, we initiated a study to address some of the deficiencies in our knowledge of RGC ecology. We conducted aquatic turtle trapping surveys at sites along the Delaware River and upper Black River in southeastern New Mexico. Additionally, we initiated a study to evaluate the spatial and thermal ecology of the RGC.

Methods

We collected reports, publications, and museum specimen data for the RGC in New Mexico. All distribution records were mapped in ArcGIS and entered in the Natural Heritage New Mexico

database, NMBiotics. As our focal study site, we selected a historic locality on the Delaware River where RGC have been detected in past studies (1993, 2007, and 2012–2013) and an alternative locality in the upper Black River where RGC are readily observed basking (Figure 1).

Trapping

We set baited hoop traps upstream and downstream of a decommissioned dam along the Delaware River in June and July (E 584484, N 3542148, UTM NAD83, zone 13). In August and September we set hoop traps in the upper Black River (E 549405, N 3548515, UTM NAD83, zone 13). We used hoop traps with 2" square mesh and 3 hoops of 2-1/2 ft diameter. Traps were baited with sardines, fresh carp, cat food or mango. Sardines are well documented as effective bait for most turtle species but we experimented with alternatives since RGC are largely vegetarian, though opportunistic omnivores (Degenhardt et al. 1996). We also experimented with the use of smaller crawfish traps to capture juvenile turtles that are more likely to escape the larger mesh of the hoop traps.

Traps were checked twice each day (AM and PM) and rebaited every 24 hours. Captured turtles were identified to species, marked with a unique scute code (Emydids only), photographed, and held briefly to collect morphometric data. We recorded straight-line carapace length (SCL), curved carapace length (CCL), carapace width (CW), carapace height (CH), plastron length (PL), and mass (g). We also collected tail tip tissue samples from all captured RGC to deposit at the Museum of Southwestern Biology for potential future genetic analyses.

Radio telemetry and thermal ecology

Four RGC (3 males and 1 female) at the upper Black River were outfitted with radio transmitters and temperature loggers (iButtons). Two RGCs (1 male, 149.371; 1 female, 149.491) were initially captured and fitted with transmitters on August 17, 2016; another two were captured and fitted with transmitters on September 11, 2016 (male, 149.051; male, 149.090). Stationary temperature loggers were placed in the river column and on the shore to develop a baseline temperature profile for both aquatic and terrestrial habitats. Locations of individual turtles were determined using a handheld VHF receiver between 1-2 times per day. For radio telemetry detections, we recorded GPS points at the nearest point on the east bank and recorded general habitat conditions such as canopy cover, bank vegetation, presence of basking structure, etc. When possible, the behavior of each turtle was observed and recorded. We plotted radio telemetry detections for each turtle in ArcMap and recorded the straight-line distance in meters from the previous known location. Occupied area for each turtle was estimated by drawing polygons in ArcMap around the pools in which each turtle was detected. We also downloaded air temperature from the nearest available station in Carlsbad (NCEI 2017) for the period of radio telemetry monitoring.

Other observations

While conducting the trapping and telemetry study, we often conducted informal visual encounter/basking surveys for turtles. These surveys were conducted by walking along the river corridor and scanning for basking or swimming turtles. When possible, observed individuals were identified to species using binoculars. Additionally, both diurnal and nocturnal surveys were conducted at the Delaware River to determine whether the site was occupied by bullfrogs and to record additional herpetofaunal observations.

Results

Trapping at the Delaware River

The Delaware River was trapped upstream and downstream of an old decommissioned dam site (Figure 2). The river was composed of pools separated by relatively short, shallow riffles and runs.

Pool and run substrates were largely sandy whereas riffles consisted of cobble. Riparian vegetation was relatively sparse with grassy banks, occasional hackberry and willow overstory and limited emergent vegetation (Appendix B. photo B3 and B4). Due to the presence of cattle at the site, the banks were typically covered with short, well-grazed grasses. Shallower stretches also showed significant signs of cattle traffic. Downed woody debris in-stream was generally not available due to a flash flood in 2013 that washed most in-stream structure onto the flood plain >10m from the river margin.

We recorded 55 captures of aquatic turtles at the Delaware River. Only two species were captured: red-eared slider (*Trachemys scripta elegans*; N = 14 captures) and spiny softshell turtle (*Apalone spinifera*; N = 41 captures). A single juvenile softshell was captured in a crawfish trap while the remaining turtles were captured in hoop traps. Due to the design of the crawfish traps, we were only able to deploy them in very shallow sections of the river (<20cm depth). No RGC's were captured at the Delaware River during this study despite 171 trap nights of effort. Capture rates were much higher in July (0.38 turtles/trap night) than in June (0.18 turtles/trap night).

Previous work by Painter (2013) at the same site on the Delaware River in August of 2012 documented 3 species: red-eared slider (*Trachemys scripta elegans*), spiny softshell turtle (*Apalone spinifera*), and Rio Grande cooter (*Pseudemys gorzugi*). The combined capture rate was 0.34 turtles/trap night. Species specific capture rates indicate that more softshell turtles were captured in 2016 than in 2012 (Figure 3).

Trapping at the Black River

The Black River study site was characterized by a series of pools separated by riffles and runs with little or no flow. In the upper portions of our study site, river width and depth was similar to sites along the Delaware River. We trapped in pool habitat mostly on the east bank of the river due to access (Figure 4). Overstory cover was more abundant than at the Delaware River and consisted of large mature cottonwoods (*Populus sp.*), willows, juniper and hackberry. Emergent vegetation such as *Carex sp.* was common and often formed dense mats on the banks of the upper portions of the river. RGC were often observed basking on *Carex* mats, often near "escape tunnels" through which they could easily return to the river. There was also an apparent abundance of emergent algae and other aquatic vegetation. Downstream portions of the Black River were significantly wider, deeper, and more devoid of emergent vegetation.

We recorded 19 captures of aquatic turtles at the upper Black River in the months of August and September. Three species were captured: red-eared slider (*Trachemys scripta elegans*; N = 10 captures), common snapping turtle (*Chelydra serpentina*; N = 5 captures), and Rio Grande cooter (*Pseudemys gorzugi*; N = 4 captures). All turtles were captured in baited hoop traps. Overall capture rates were 0.18 turtles/trap night in August and 0.16 turtles/trap night in September with a total of 110 trap nights.

Radio Telemetry

We tracked the movements of 4 RGC (1 female and 3 males) during the months of August through October. On average, we were able to record 12 fixes per turtle (range = 8-18). Due to the aquatic nature of the study species, it was often difficult to determine a clear location for turtles that were not surface or shallowly active.

The distance between each detection was usually less than <200m, but occasional longer distance movements were observed (up to 967m). Three tracked turtles made longer distance movements out of the pool where they were originally captured, while one turtle stayed in the same relatively small

area for the duration. Mean and maximum distances moved for each turtle are listed in Table 1 and dates of detection are shown in the maps below (Figure 5-8). It is noteworthy that one male moved 967m (straight-line distance) between August 19th and September 9th to a much larger section of the river several pools downstream. The other turtles remained upstream where occupied pools were smaller and separated by shallow *Carex* choked riffles that occasionally dry up. Total stream area occupied by each turtle was subsequently small with exception of the turtle noted above (Table 2).

Table 1. Maximum and mean straight-line distances (m) moved between telemetry detections.

| | Female 149.491 | Male 149.371 | Male 149.090 | Male 149.051 |
|---------|-------------------|-----------------|-----------------|-----------------|
| Maximum | 349 | 967 | 86 | 430 |
| Mean | 68.6 | 228.4 | 36.9 | 65.9 |

Table 2. Occupied area per turtle.

| Turtle ID | Occupied area (acres) |
|----------------|-----------------------|
| Male 149.051 | 1.3 |
| Male 149.090 | 0.46 |
| Female 149.491 | 1.2 |
| Male 149.371 | 6.2 |

Thermal Data

Data loggers to record air temperature and water temperature were set up on the upper Black River in August. Only the water temperature logger was recovered in October—the air temperature logger could not be found thus we used climate station data for air temperature (NCEI 2017). Figure 9 shows individual turtle movement distances with minimum and maximum daily air temperature. Figure 10 show the same movements with mean daily water temperature. Temperatures were fairly stable in August (mean water = 72.6°F) and September (mean water = 72.9°F) but minimum air temperature and mean water temperature began decreasing in October (mean = 66.6°F). Similarly, relative movement distances of two turtles decreased in October though surface activity was sufficient to still detect precise locations via telemetry.

Other Observations

We hiked ~2 km along the Delaware River during trapping work, during informal basking surveys for surface active turtles, and during nocturnal hikes. Softshell turtles were frequently observed floating at the surface and occasionally red-eared sliders. At night, we readily found Rio Grande leopard frogs (*Lithobates berlandieri*) and juvenile blotched watersnakes (*Nerodia erythrogaster*; photo B10 in Appendix). Leopard frogs were found adjacent to pool habitats while watersnakes were observed near emergent vegetation in shallow riffle/run habitats.

We hiked ~1.5 km along the Black River during trapping and telemetry work. We easily observed adult RGC basking on available in-stream woody debris and sedge mats. Juvenile and hatchling RGC were less frequently observed but noteworthy for their presence. For a full list of species observed see Appendix A.

Discussion

Trapping

Two previous studies have documented the presence of RGC at our study site on the Delaware River (Christman and Kamees 2007, Painter 2013). Our lack of detection of RGC could be attributed to multiple factors. First, a scouring flood occurred during the monsoon season of 2013, with signs still evident in 2016 (see habitat description). The flood has clearly altered the riparian habitat and may have decreased or eliminated the population of RGC either by direct mortality or through altered habitat suitability. Second, water withdrawals to support oil and gas operations are ongoing and have resulted in periods of low or no flow (John Sherman, BLM, pers. comm.). Third, our observation of higher capture rates for *Apalone spinifera* may be a result of changes in competitive interactions or due to higher rates of recolonization following the flooding. In our experience, the substrate type (silty mud) at the Delaware River is optimal for *Apalone* and could also play a role in their apparent high relative density. It is likely that the lack of RGC observations at the Delaware River is due to an interaction between some or all of the previously mentioned explanations. Whatever the case, the contrast between detection at the Black River versus the Delaware River is stark given that 4 RGC were captured in 110 trap nights at the Black River and 171 trap nights did not produce any RGC at the Delaware.

Telemetry and thermal ecology

A previous study in the Black River documented maximum movements by RGC of <300 m (Pierce et al. 2016). Three of the four RGC we tracked had maximum movement distances >300 m. It should also be noted that our estimated movements are straight-line and thus likely underestimate actual distances moved. Movements between pools were observed in 3 RGC.

Degenhardt et al (1996) reported surface activity in December when water temperatures were as low as 12°C (54°F). Our data show water temperatures well above that in October (>60°F) with RGC movements and surface activity only slightly reduced from earlier months. Turtle survival is dependent on ability of individuals to regulate their temperature by basking or selecting sites that are buffered from temperature extremes. A recent study modeled stream temperatures according to projected climate scenarios and predicted a rise in mean August water temperature of 0.5°C (1°F) by 2040 in the upper reaches of the Black River (Isaak et al. 2016). It is difficult to predict what impact this could have on turtles, but ecological effects such as changes in abundance and composition of aquatic vegetation are probable (Bornette and Puijalon 2011). Additionally, soil temperatures and moisture levels are likely to change such that bias in turtle sex ratios and altered probability of nest success could be a concern. The importance of climate related factors is accentuated for this species since southern New Mexico is at the western and northern limit of its range.

Other observations

The presence of juvenile and hatchling RGC at the Upper Black River appears to indicate that reproduction and recruitment are occurring, which again contrasts with our observations at the Delaware River where informal basking surveys failed to detect any age class of RGC. Similarly, overall density of RGC at the Black River was such that adults and juveniles were readily observed floating at the surface or basking on most days. The only turtle species exhibiting such a density at the Delaware River was the spiny softshell turtle which was frequently observed 'snorkeling' near the surface in the pools where we trapped and surveyed.

The relative ease of locating juvenile blotched watersnakes (*Nerodia erythrogaster transversa*) in nocturnal surveys (a NMDGF Endangered species) seems to indicate a reproducing population at the Delaware River. We did not observe adult watersnakes at the Delaware River or observe any

watersnakes at the Upper Black River. Degenhardt et al. (1996) surmised that the deeper pools of the upper Black River may be too cool to support watersnakes. The juveniles we observed at the Delaware River were always in shallow runs with rocky substrates and often with emergent vegetation and large numbers of *Acris crepitans*, a common prey item apparently rare or absent at the upper Black River study site.

Observed threats

The Pecos River originates in northern New Mexico and flow rates are determined by winter snow pack in the mountains there (Gutzler 2013). Occupied tributaries in New Mexico are spring-fed with occasional influx from heavy rain events. Long-term drying trends and decreases in snow pack from climate change are increasing annual and decadal flow variability, but with no long-term changes in annual flow (Salgado and Gutzler 2013). Climate change, combined with water usage demands from agriculture and industry, increased flow variability and water quality have the potential to negatively impact the Rio Grande cooter (Jensen et al. 2006; Cheek and Taylor 2015). River cooters in West Virginia were found to be sensitive to river flows, and may experience disruptions in movement patterns, basking behaviors, and foraging during high flow conditions (Buhlmann and Vaughan 1991). The effects of high flow rates can disproportionately impact juvenile turtles more than adults, and may increase juvenile mortality (Pluto and Bellis 1986). For example, juvenile turtle basking sites may occur in areas with lower flows rates, which may be due to juveniles being poor swimmers (Reese 1996). Additionally, Brodie and Semlitsch (2000) found juvenile turtles occupied slower flowing stream habitats that have more abundant food resources and fewer predators, which can increase survivorship. The absence of juvenile Rio Grande cooters in Texas and areas of New Mexico remains unexplained, but may be due to stream flow variation during periods that may heavily impact juvenile cooters. Flow rates along the Pecos River can be regulated by dam releases, which may minimize impacts to the Rio Grande cooter if done during periods when the species is not vulnerable to flow increases.

Riverbank alteration has also been shown to cause severe declines in turtle populations (Usada et. al 2012). At the Black River a large proportion of the river bank was steeply incised. This creates a potential barrier to females seeking nesting habitat. Nesting habitat selection is crucial to nest success since most species have fairly specific nest temperature requirements. While recent nest success was evident since we observed hatchling RGC, there may be long-term impacts that could limit this population, especially if current or future conditions increase the proportion of incised banks.

Turtles in general are vulnerable to predation in early life stages. Large-mouth bass (*Micropterus salmoides*) are common in the upper Black River and a likely predator of hatchlings. Raccoons and skunks also commonly predate upon turtle nests and may decrease nesting success where they are present (Kolbe and Janzen 2002).

Future work/actions

Due to the lack of RGC captures at the Delaware River, it was necessary to switch study sites to the Black River in order to conduct telemetry studies. For this reason we were limited in our ability to collect early season telemetry data. In order to gain a better understanding of the spatial ecology of the RGC at the Black River we will need to continue to collect telemetry data in the spring and summer months of 2017. The collection of additional telemetry data will allow for more robust analyses (i.e. kernel density and MCP analyses) of RGC spatial ecology. We will also need to focus trapping efforts in order to retrieve the iButtons and replace any expired transmitters. This may require additional trapping effort or focused snorkeling after pinpointing the location of each study turtle. Upon retrieval of the iButtons we will be able to better evaluate the thermal ecology of the RGC.

While trapping in May we can conduct standardized shoreline surveys for basking turtles and nest detection. Future work could include trapping and basking surveys at other locations along the Delaware River where pool habitat persists to detect presence/absence of RGC.

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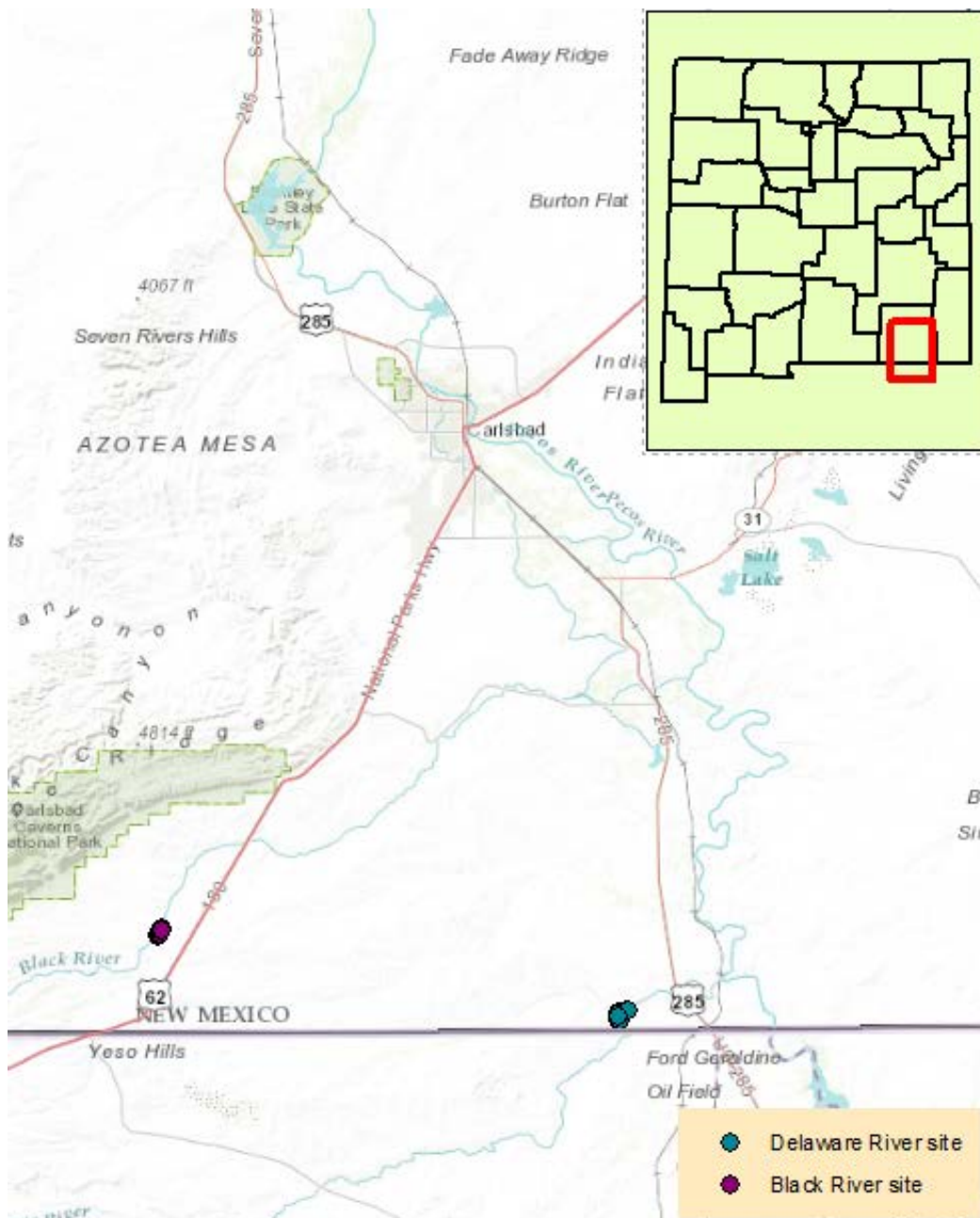


Figure 1. Location of Black River and Delaware River sites in Eddy County, New Mexico.



Figure 2. Trap locations along the Delaware River, June and July 2016.

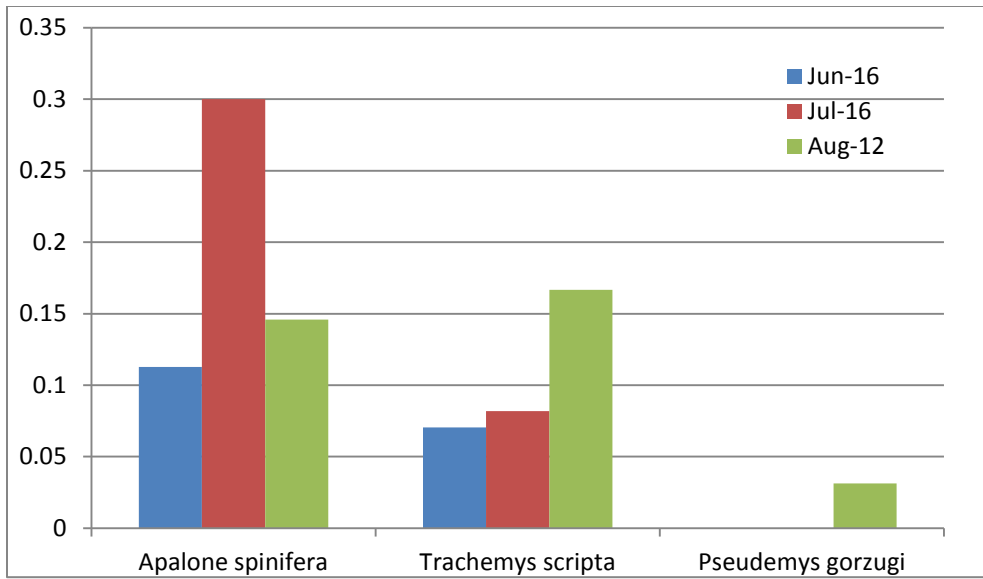


Figure 3. Capture rates at decommissioned dam on the Delaware River from this study and Painter (2013).



Figure 4. Trap location on the upper Black River, August and September 2016.



Figure 5. Locations of female turtle bearing transmitter 149.491.



Figure 6. Locations of male turtle bearing transmitter 149.371.



Figure 7. Locations of male turtle bearing transmitter 149.090.



Figure 8. Locations of male turtle bearing transmitter 149.051.

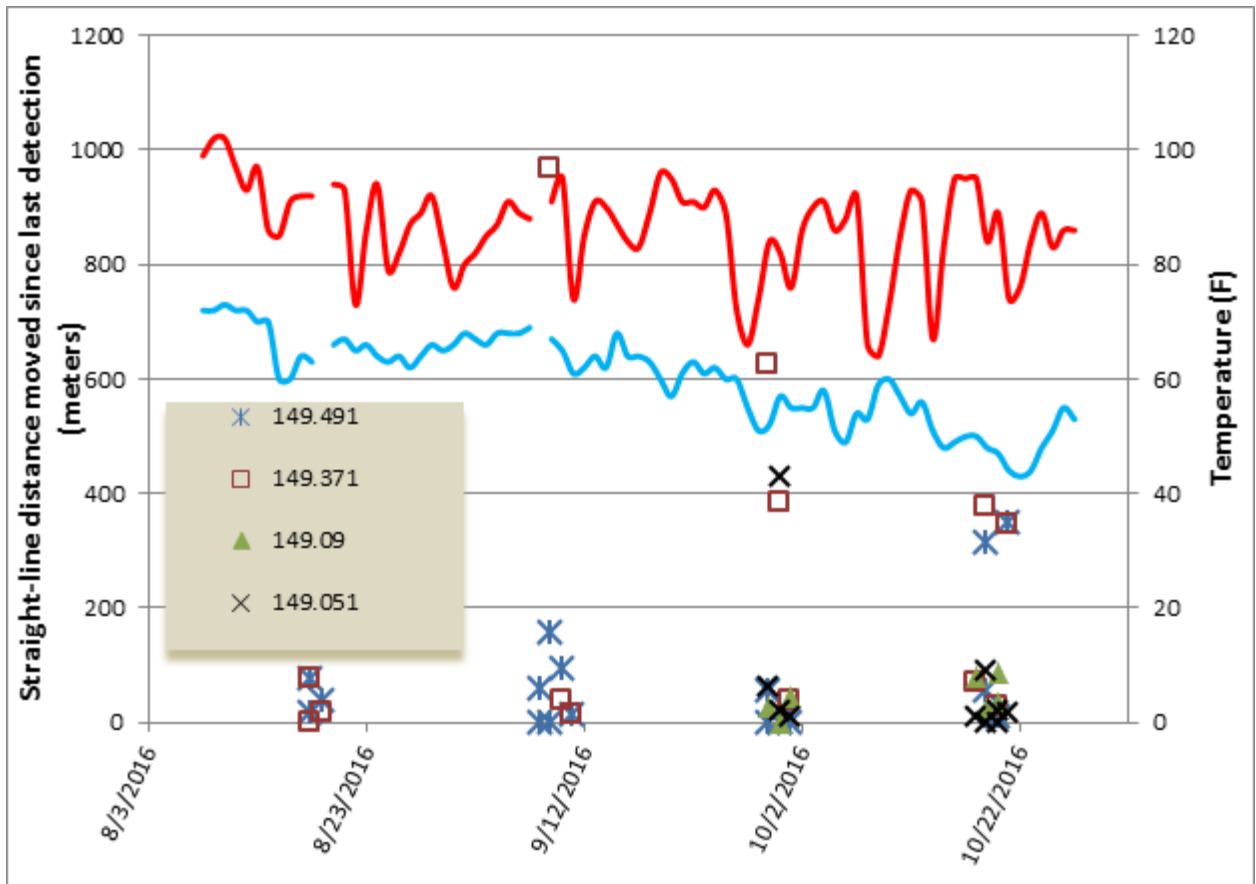


Figure 9. Distances moved by monitored RGC between subsequent detections and air temperature (daily minimum = blue line, daily maximum = red line).

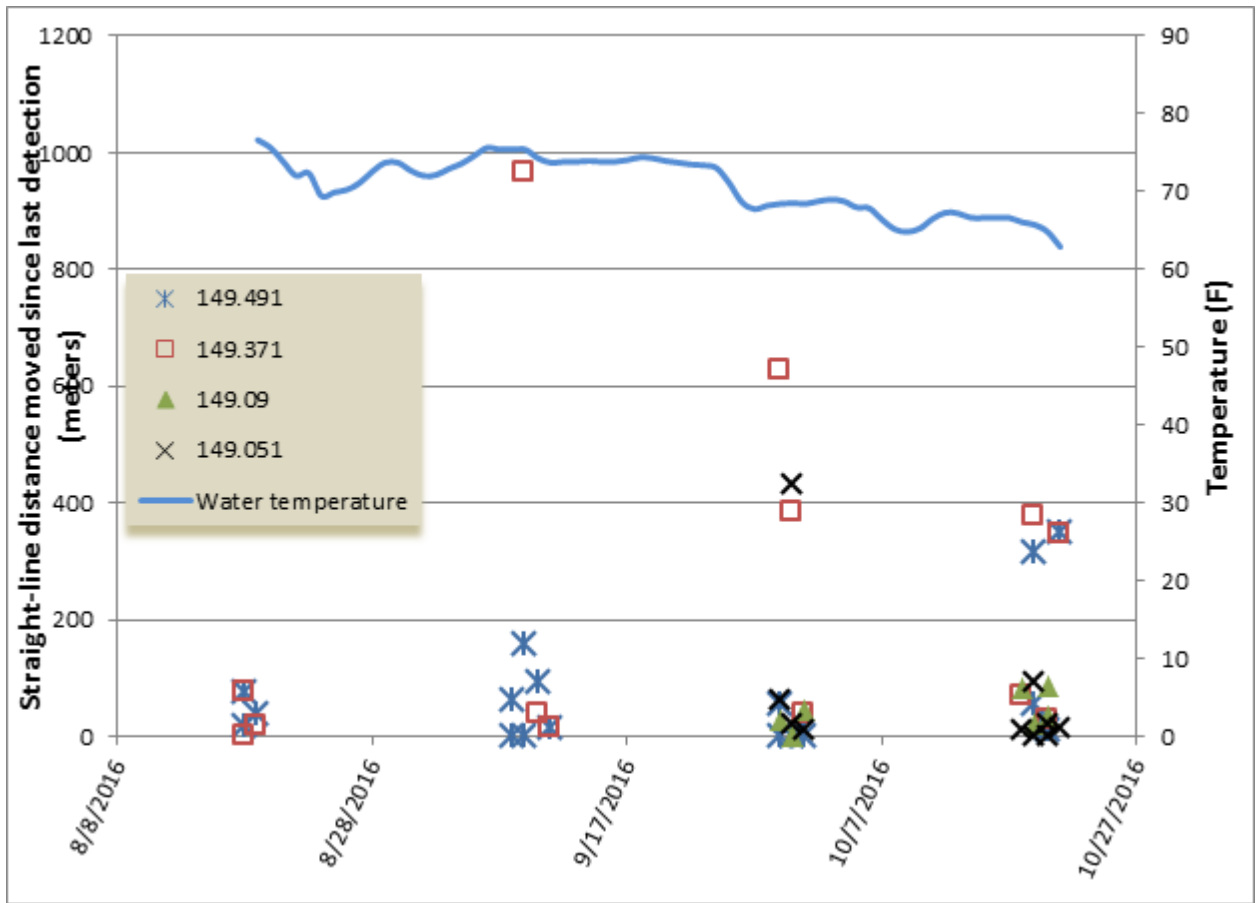


Figure 10. Distances moved by monitored RGC between subsequent detections and mean daily water temperature (blue line).

Appendix A. Other species observed at the Delaware River and Black River

| Group | Species | Delaware River | Black River |
|-----------|---|----------------|-------------|
| Plant | <i>Anulocaulis leiosolenus</i> var. <i>gypsogenus</i> | - | + |
| Plant | <i>Astragalus gypsodes</i> | - | + |
| Plant | <i>Echinocactus horizonthalonius</i> | + | - |
| Plant | <i>Echinocactus texensis</i> | + | + |
| Plant | <i>Ibervillea tenuisecta</i> | - | + |
| Mammal | <i>Tadarida brasiliensis</i> | - | + |
| Amphibian | <i>Acris crepitans</i> | + | - |
| Amphibian | <i>Lithobates berlandieri</i> | + | + |
| Reptile | <i>Crotalus atrox</i> | + | + |
| Reptile | <i>Masticophis flagellum</i> | + | - |
| Reptile | <i>Aspidoscelis gularis</i> | + | - |
| Reptile | <i>Aspidoscelis marmorata</i> | + | - |
| Reptile | <i>Sceloporus tristichus</i> | + | + |
| Reptile | <i>Uta stansburiana</i> | + | + |
| Reptile | <i>Nerodia erythrogaster</i> | + | - |
| Reptile | <i>Sceloporus bimaculosus</i> | + | - |
| Reptile | <i>Crotaphytus collaris</i> | + | - |
| Cultural | Huecos at Delaware River | + | - |

Appendix B. Photos



B1. Delaware River, view downstream at decommissioned dam.



B2. Delaware River, view upstream from decommissioned dam. Note the shallow riffle and upstream pool which is the general pattern for this river.



B3. Upper Black River habitat.



B4. Female Rio Grande cooter (*Pseudemys gorzugi*), Black River, August 2016.



B5. Male Rio Grande cooter (*Pseudemys gorzugi*), Black River, September 2016. (Photo credit: Chris Anderson)



B6. Male Rio Grande cooter (*Pseudemys gorzugi*) with reticulate melanism, Black River, September 2016 (photo credit: Chris Anderson).



B7. Smooth softshell (*Apalone spinifera*) female with tumor on front limb, Delaware River.



B8. Red-eared slider (*Trachemys scripta*) melanistic male, Delaware River.



B9. Red eared slider (*Trachemys scripta*), upper Black River.



B10. Juvenile blotched watersnake (*Nerodia erythrogaster*) at Delaware River.