An Assessment of American Alligators (*Alligator mississippiensis*) on Red Slough Wildlife Management Area in McCurtain County, Oklahoma

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Abstract

A breeding population of American Alligators (*Alligator mississippiensis*) exists at the Red Slough Wildlife Management Area (RSWMA) and Ward Lake in extreme southeastern Oklahoma. To date, few studies exist examining factors affecting alligator populations in Oklahoma. Since 2004, the Oklahoma Department of Wildlife Conservation (ODWC) conducted one spotlight survey per year at RSWMA and Ward Lake as part of population monitoring efforts. My goal was threefold: (1) standardize spotlight survey methodology and perform 6 spotlight surveys during each 2012 and 2013 spring, (2) assess alligator nesting effort, success and overwinter survival of young at RSWMA and Ward Lake, and (3) use historical data collected by the U.S. Forest Service to identify year to year alligator sighting rates and identify sighting hot-spots. Spring surveys for 2012 and 2013 were standardized by using a 6 person crew and restricting surveys to units with previous recorded alligator activity. These 12 surveys resulted in CPUEs between 1.17 – 1.75 alligators seen per hour. Nest searches produced two nests for the first time in RSWMA history in 2012, though both of them produced below the average number of hatchlings (18.2 hatchlings per nest) previously seen at RSWMA. One nest on Bittern Lake yielded 12 young and one nest on Pintail Lake yielded 6 young. No nests were found in 2013. Overwinter survival of young born in 2012 was calculated at 75%. Historical data reveal a large increase in alligator sightings after 2006, and a hot-spot for sightings on Bittern Lake. Historical data reveal Bittern Lake as a hot-spot for sightings, though this is likely due to

biased efforts. With respect to spotlight survey efforts I recommend four changes to ODWC's survey methodology: (1) increase survey frequency, (2) exclude searches of marginal habitat from CPUE calculations, (3) use a consistent number of observers, (4) perform surveys between March 17 – April 30.

Introduction

The Gulf Coastal Plain ecoregion of Southeastern Oklahoma represents the approximate northwestern-most distribution of the American Alligator (*Alligator mississippiensis*) (Heck 2006; Patton et al. 2010). Alligator populations in McCurtain County (the southeastern most county in Oklahoma) are known to occur primarily in the Little River National Wildlife Refuge, and the Red River, along with its associated wetlands, sloughs, and oxbow lakes. Despite the limited useable habitat in Oklahoma, a stable and breeding population of alligators occurs on Red Slough Wildlife Management Area (RSWMA) in the extreme southeastern portion of the state (Arbour and Bastarache 2006). RSWMA is a 3,160 ha restored wetland habitat on the Red River floodplain and is used primarily as a public hunting area and stopover point for migratory birds. Waterfowl management is a primary concern and is achieved through standard moist-soil management techniques (seasonal flooding via water control structures and levees) to encourage optimal forage conditions (Anderson and Smith 2000). The richness of this wetland also produces prime habitat to support a large and diverse herpetological community.

To date, few studies have examined factors affecting alligator distributions in Oklahoma. Hagan et al. (1983) proposed that the limiting factor affecting successful breeding and offspring survival of alligators at the northern extent of their range was prolonged periods of freezing temperatures which caused ice to accumulate over the surface of the water. Brandt and Manzotti

(1990) studied responses of juvenile alligators to freezing weather and proposed that the inability of hatchling alligators to survive even short periods of ice formation was one major factor limiting their northern distribution. However, a more recent study by Lee et al. (1997) observed eight out of nine alligator hatchlings in South Carolina maintaining air holes by holding their snouts just above the water and allowing the ice to freeze around them. This behavior is known as the icing response. Short-term icing is likely not as detrimental to alligators as Brandt and Manzotti (1990) proposed, though it is still likely that long-term periods of freezing weather pose a limit to the northern distribution of alligators. Since 1960 there has been a long-term trend of warmer than average winters (Tran et al. 2007) which has reduced the number of days in which ice forms over the surface of the water. Due to this climatic pattern and recent increases in observations of alligators outside their core Oklahoma distribution (i.e. outside McCurtain County), the general consensus among ODWC personnel and the statewide herpetological community is that the state's population of alligators is increasing.

Alligators are apex predators and can be considered a keystone species due to their impact on the physical environment via creation of "gator holes" that provide refugia for many fish and amphibian species (Campbell and Mazzotti 2004). At RSWMA, alligators are thought to feed primarily on fish but are also capable of feeding on waterfowl, amphibians, and small to medium sized mammals. Prior to 2009, conversations among biologists working at RSWMA anecdotally concluded that limited overwinter survival of juvenile alligators was highly suspect as the limiting factor controlling population size (personal communication, David Arbour, ODWC and Robert Bastarache, USFS). To address this, a radio telemetry study was done to monitor overwinter survival of captive reared one-year-old and two-year-old alligators at RSWMA from September 2009 to April 2011 (Wood and Patton, in preparation). The results of this study suggested that one-year-old alligators had much lower overwinter survival rates than two-year-old alligators. However, inference from this study may be difficult to extend to wild born and raised alligators.

A nocturnal spotlight survey for population monitoring has been a standard method for scientific assessment of many species of crocodilians (Da Silveria et al. 2008). Efficacy of spotlight surveys to detect eye shine in crocodilians has been supported by previous studies (Lutterschmidt and Wasko 2006; Subalusky et al. 2009). All species of crocodilians have a membrane in their eyes known as a tapetum lucidum that reflects the light of the spotlight back towards the observer, allowing the animal's location to be recorded. Starting in 2004, personnel with ODWC, the United States Forest Service (USFS), and Southeastern Oklahoma State University (SOSU) conducted one spotlight survey per year to monitor the alligator population at RSWMA. Analysis of these surveys spanning this six year period (2004-2009) determined that a single survey per year was insufficient in achieving meaningful monitoring goals (Patton et al. 2010).

In summary, though it is the consensus among local wildlife professionals that alligator numbers in southeastern Oklahoma are increasing, we lack basic information on nesting effort, success, and overwinter survival. We believe that addressing these gaps in our understanding is necessary to improve our understanding of the population dynamics affecting alligator distribution in Oklahoma. Accordingly, I developed the following objectives for this study: (1) Standardize and increase the frequency of spring nocturnal spotlight surveys on all wetland units, including privately owned Ward Lake which borders RSWMA to the east. Part of this objective includes creating a map showing locations for all alligators observed during spring spotlight surveys. This map will facilitate biologists in identifying areas with the highest levels of alligator activity. (2) Quantify nesting effort, nesting success, and overwinter survival of young alligators on RSWMA. (3) Compile all past data and observations from ODWC and USFS personnel about alligators to show trends in sightings over the past 12 years, thereby helping to show areas of frequent sightings, or “hot-spots”.

Methods

Study site.— Located approximately 22 km southeast of Idabel, Oklahoma (33°44’45.78”N, 94°38’41.47”W), RSWMA is a complex of levees and water control structures creating both seasonally flooded wetlands and deeper-water lakes which hold water year round. In 1995, the property, previously used as a rice farm, was enrolled in the Wetlands Reserve Program under control of the Natural Resources Conservation Service. Within its 3,160 ha bounds are 162 ha of deep water reservoir units, 1300 ha of moist soil management units, and 850 ha of bottomland hardwood restoration sites. The southern border of RSWMA is 3 km north of the Red River (Fig. 1) and fully within the river’s floodplain creating a soil profile consisting largely of Tuscumbia clay and Wrightsville-Elysian complex (Web Soil Survey 2013). Major vegetation communities include, but are not limited to, the following genera: *Nelumbo* (American lotus), *Cladium* (twig-sedge), *Sabal* (dwarf palmetto), *Quercus* (water and willow oak), *Pinus* (loblolly pine), and *Cephalanthus* (buttonbush). Push Creek runs through RSWMA and is the main water drainage through the area, connecting with Norwood Creek 2.3 km after it leaves RSWMA and running into the Red River 7 km after its confluence with Norwood Creek. Because of its connection with the Red River, it is assumed that alligators present in the river can successfully travel to RSWMA via Norwood-Push Creek or by way of a relatively short 3 km overland walk.

Another key component to the research site was Ward Lake. Due to its size (135 ha), proximity to RSWMA, and location within the Gulf Coastal Plain, Ward Lake ostensibly supports one of the largest and most densely populated alligator habitats in Oklahoma and has been included in all previous ODWC annual spotlight surveys. Much of Ward Lake is extremely shallow (< 50 cm) and filled with tree snags that aid in deterring human disturbance of the alligator population. ODWC personnel have long understood this reservoir's importance to RSWMA, and since 1999 it has been included in dozens of wildlife surveys conducted by the agency. Ward Lake was included in my spotlight survey and nest search efforts because it is prime alligator habitat, and it is the largest reservoir south of the Little River in McCurtain County. There is also significant interaction between RSWMA wetlands and Ward Lake, both physically (via common watershed) and biologically.

Spotlight surveys.— The goal for each spring season was to perform six spotlight surveys: one in March, two in April, two in May and one in June. However, after the first spring season the June survey was identified as problematic because aquatic vegetation (primarily American lotus, *Nelumbo lutea*) became a hindrance to boating and restricts the spotlight observers' ability to scan the surface of the water. Accordingly, I eliminated the June survey after the first year in favor of an extra survey in early March, thereby still having six surveys from each spring to compare.

Nocturnal spotlight survey methodology was standardized using three teams comprised of two individuals to sample the 13 wetland units (RSWMA and Ward Lake) determined to be the best alligator habitat (those units with alligator sightings over the past eight years). Each team used a QBeam® three million candela spotlight to perform their survey. Two distinct crew types were used for spotlight assessment: boats on deeper units, and vehicles driving along dikes for all other units. When spotlighting by boat, one person served as boat navigator and secondary observer while the other person served as spotlight operator, primary observer, and data recorder. For surveys by vehicle, one person was the driver and secondary observer and the other person was the primary observer, spotlight operator, and data recorder. After trying a 14-foot aluminum john boat with a five horsepower outboard motor then trying a canoe with paddles, the canoe with paddles was chosen as the preferred method for boat surveys. Major advantages of using a canoe were its quietness in approaching alligators for size estimation and the ease at which it allowed for navigation through extremely shallow water (<15cm) and aquatic vegetation.

Crews were given instructions to begin each survey 30 minutes after the official sunset and survey each unit at a slow and consistent pace. Each two person team was given a printed satellite image of their specified route at RSWMA as part of a data sheet and tasked with recording start and stop time, the point location for each alligator seen, and a visual estimation of total length if possible. If an alligators full body was not visible, visual estimations of alligator length were standardized as being a linear correlation between snout-to-eye length and total length (one unit snout-to-eye roughly equals twelve units total length; Lutterschmidt and Wasko 2006). After the completion of each survey, point locations were identified on GoogleEarth® and corresponding UTM coordinates were recorded. A base layer satellite image from GoogleEarth® was uploaded as a jpeg into ArcGIS® and georeferenced so data could be added to this base layer. Next, alligator locations were added as a layer over the base satellite image creating a map showing all alligator locations recorded during the twelve surveys.

In order to analyze all spotlight survey efforts, both past ODWC surveys and my surveys were compared using a standard catch per unit effort (CPUE) metric (Wiewel et al. 2009). For the purposes of my research I defined "catch" as an alligator observed during the spotlight survey, and "unit effort" was one observer for one hour. Therefore, a 2-hr spotlight survey that yielded 24 alligator detections with a crew of six people would equate to a CPUE of 2.0. Using CPUE calculations and past records, I compared the efficacy of a single annual ODWC survey to multiple annual surveys. A paired t-test was performed to compare the 2012 and 2013 survey results to each other.

Nest searches.— Intensive nest searches were conducted at RSWMA and Ward Lake between August 1 and August 30, 2012, well after the apex of the alligator nesting season in June (Joanen 1969; Goodwin and Marion 1978). Alligator nests are large, dome-like structures made from various species of vegetation (Joanen 1969). Nests are located near permanent water sources and easily distinguished from natural plant formations. At RSWMA twig-sedge (Cladium spp.) is a common and abundant nesting material. Nest searches in most previous studies were done via aerial observation (Woodward et al. 1984; Taylor et al. 1991; Elsey et al. 2008). Due to budget and equipment restrictions it was not possible to use an aerial observation method, therefore all nest searches were done by walking shorelines and looking for indicators of alligator activity (i.e. tracks, slides) to identify active nest sites. Once such alligator activity was identified, the physical location of the nest was easily identified and recorded.

Before nest searches began I set an *a priori* goal of searching >90% of the shorelines at RSWMA and Ward Lake considered to be suitable nesting habitat. Nesting effort was defined as the total number of nests discovered within the study site where eggs had been deposited. Nest success was calculated as the number of nests which produced living offspring that survived through the hatching event. For each alligator nest location found, a Reconyx HC600 Hyperfire® remote sensing camera trap, provided by USFS, was used in an attempt to capture evidence of female nest attendance, defense of young, and any nest predation events. If nests could easily be monitored by ODWC personnel during daily operations, a remote sensing camera was not used. After nests were found, they were monitored (by ODWC personnel or remote sensing photographs evaluated) every 72 hours until the hatching event occurred. After hatching, the hatchlings were monitored throughout the winter months (once per week) for evidence of overwinter survival and any icing response behavior. Beginning April 15 (the date of latest spring freeze for Idabel, Oklahoma; Oklahoma Climatological Survey 2013), the high count of young alligators observed for each nest site would be considered the number of overwinter survivors.

Historical data.— Historical raw data and anecdotal records of alligator observations at RSWMA (not including Ward Lake) were archived by the USFS. The bulk of this data is comprised of the six years of annual ODWC spotlight surveys, weekly ODWC wildlife surveys, and various sightings by other visitors to RSWMA. I thoroughly searched all of these documents for mention of alligators. If there was mention of alligators, the date of the communication, location of the sighting, number of alligators seen, size estimations, and observer name were recorded. At minimum, the date and observer were available for every alligator sighting. I graphed this historical data to show the total number of alligator sightings per year on RSWMA. This data reveals trends in detection rates to compare to annual spotlight survey data. I also used sighting locations from historical data to identify hot-spots for alligator sightings on RSWMA to compare to my spotlight survey results.

Results

Spotlight surveys.— Twelve spring spotlight surveys were performed at RSWMA and Ward Lake between March 2012 and May 2013. A total of 234 alligator detections were recorded (Table 1). Four of the thirteen units searched accounted for 216 (92.3%) of alligator detections including: 107 (45.7%) detections on Ward Lake, 59 (25.2%) detections on Pintail Lake, 29 (12.4%) detections on Lotus Lake and 21 (9.0%) detections on Bittern Lake. The number of alligators detected varied between years. During 2012, a relatively consistent number of alligators were detected during each survey ($\bar{x}$ = 17.5, range = 14-22, SD = 2.26) (Fig. 2). During 2013, detection rates increased, were more variable, and indicated a more bell-shaped curve that peaked in April ($\bar{x}$ = 21.5, range = 3-33, SD = 10.84) (Fig. 2). Using a paired t-test to compare detection rates reveal no significant statistical difference between the 2012 and 2013 spotlight surveys (P = 0.46). One spotlight survey from 8 March 2013 represented an outlier because temperatures were cold (16.7°C average temp; Mesonet 2013) and only two alligators were detected. All combined spotlight surveys yielded a CPUE between 0.11 and 1.75; once the outlier data point was removed, CPUE data was more consistent and ranged between 1.17-1.75.

Point locations for alligators observed during spotlight surveys reveal the western half of both Pintail and Lotus Lake were responsible for 44.4% of observations on RSWMA (Fig. 3). Ward Lake alligator observations were much more widely dispersed than those on RSWMA (Fig 3).

Of the 234 alligator detections, I was able to obtain 147 length estimations. Among the remaining 87 alligator detections, the observer was not confident enough to report an estimation of snout-to-eye length. Size classes ranged from 0.5m – 2.5+m with the majority of detections (60.5%) falling between 1-2m in estimated length.

Nest searches.— A total of 63 hours were spent walking shorelines at RSWMA and Ward Lake, resulting in a search of >90% of the shorelines considered to be suitable alligator nesting habitat. During these searches only two nests were found, one at Bittern Lake (hereafter referred to as “Bittern nest”) and one at Pintail Lake (hereafter referred to as “Pintail nest”). The remote sensing camera at the Pintail nest documented feral swine (*Sus scrofa)* presence at the nest within 12 hours after the hatching event. The Pintail nest yielded 6 young, and the Bittern nest yielded 12 young. Since both known nests were successful in producing young, the nest success rate for the 2012 nesting season was 100%.

During monitoring efforts for the Bittern nest, the mother alligator was observed coming out of the water and performing an open mouth display to discourage my presence on several occasions. The location of this nest meant that overwinter monitoring efforts could be easily achieved by ODWC personnel along their normal observation routes. Throughout the winter months, weekly observations to monitor hatchlings were made by ODWC personnel and on 3 January 2013 icing behavior by hatchlings was documented. Three hatchling alligators were observed submerged underwater along the shoreline with their snouts just above the water with ice freezing around them. Air temperatures during this icing event reached -6.5°C (Mesonet 2013) and created a thin (< 5mm) layer of ice. After the icing event ended and air temperatures began to rise, the juvenile alligators appeared to be active and unharmed.

Twelve alligators successfully hatched from the Bittern nest and the high count of young observed after April 15, 2013 was nine, making the rate of overwinter survival 75%. The Pintail nest was located on an island and could only be monitored via a remote sensing camera. This mother’s den site was unknown, accordingly a remote sensing camera placed at their last known location in an attempt to monitor them. As a result of this camera placement, I was able to obtain several photographic sequences on 21 September 2012 of a mother alligator lunging towards a Great Blue Heron (*Ardea herodias*) in an effort to defend her hatchlings from predation

(Appendix). However, monitoring efforts ultimately were not successful and the whereabouts of the mother and her offspring are unknown. Accordingly, overwinter survival for the Pintail nest could not be calculated.

Historical data.— Analysis of electronic communications regarding historical alligator sightings on RSWMA revealed a total of 209 sightings between 2000-2012 (Appendix B). The data showed a strong upwards trend after the discovery of the first alligator nest on RSWMA in 2005 (Fig. 5). The years 2001 and 2002 had the lowest numbers of sightings with 1 and 2 respectively. Years 2008 and 2011 had the highest number of sightings with 33 and 34 respectively. Of the 209 total sightings, 77 of them mention a wetland unit location where the alligator sighting occurred. From these 77 sightings with a location, the only hot-spot that could be identified was Bittern Lake which provided the most sightings at 38 (49.3%). No other unit provided more than 6 (7.8%) sightings.

Also recorded in the 209 historical sightings were 43 estimates of alligator length ranging from 3 feet to 10 feet in total. All length estimates were converted to meters and consolidated into a length frequency histogram (Fig. 6). This length data followed a similar distribution to the length data obtained in our spotlight survey results, with more than half (53.5%) of alligators observed falling between 1-2m in total length.

Discussion

Spotlight surveys.— Spotlight survey efforts for the 2012 and 2013 spring seasons reveal fairly consistent CPUE values once the 8 March 2013 survey was removed (1.17-1.75). This consistency was likely due in large part to the standardization of the spotlight survey methodology. Though we treated March 8 survey as an outlier in the data set, it is important to know that alligator activity in early March can be unpredictable due to cold weather.

Published assessments regarding six years of ODWC spotlight efforts (Patton et al. 2010) reveal low and highly variable CPUE's, ranging from 0.07-0.49. Traditionally, ODWC spotlight surveys used inconsistent numbers of observers (10-13) and included surveys of many units with little or no alligator habitat value; 13 wetland units surveyed over six years had zero alligator detections (Patton et al. 2010). One way I changed the methodology from previous annual ODWC spotlight efforts was using a consistent number of observers and only surveying units which had previous alligator detections. Many of the units within RSWMA represent little feeding opportunity and frequently go dry during the summer months. Hence, these units represent poor quality habitat for alligators and were removed from our spotlight survey efforts. While inclusion of wetland units that have had no previous alligator detections can be important for determining use of new habitats on RSWMA, they tend to introduce high variability and confound CPUE calculations. In the years 2012 and 2013, ODWC performed a single annual survey, and we performed an additional 5 each year. In comparison of CPUE between ODWC efforts and our own spotlight survey efforts during these two years, ODWC spotlight surveys had a greater year to year deviation in values than the mean value of our efforts. (0.46 for ODWC and 0.08 for our surveys). (Fig.7).

Among all RSWMA units surveyed, Pintail and Lotus lakes had the greatest number of alligator detections, respectively. While these units are considered 'reservoir' units, much of the water is less than 1m in depth, and Pintail in particular has a large central island that makes up between 20-25% of the unit's surface area (depending on water level). The western half of both the Pintail and Lotus Lake units are the deepest part of each respective unit (>3m depth), and is likely the reason they accounted for 44.4% of all RSWMA alligator detections. From my observations during this study, alligators at RSWMA congregated in greatest numbers in areas with the deep water (greater than 1m depth).

A large cohort of alligators in the 1-2m length range represents the approximate size of alligators that were born between the years 2005 – 2007 (Chabreck and Joanen 1979). While it is unlikely that all of these alligators are the result of one female's breeding effort, it is quite possible that the first few breeding events had a major impact on recruitment into this population. After the first recorded nest in 2005, alligator sightings at RSWMA started becoming more frequent. The population at RSWMA is not closed (immigration from Red River and other surrounding habitats is possible) but it is still unlikely that the bulk of this size-class cohort is composed of immigrant individuals. The distance from the Red River to RSWMA is 3km at minimum straight line distance, well within an alligator's ability to cross over dry land (CITE). Immigration from the Red River over land also requires crossing a two lane state highway, barbed wire fencing, and cleared rangeland for cattle production that could pose as obstacles for immigration. Another possible route for immigration from the Red River to RSWMA is the Push creek drainage which bisects the WMA and connects with the Red River 7km after leaving the property.

Nest searches.— Previous studies showed that habitat preferences, nest sites, and hatchling success were valuable parameters to define during implementation of best management practices (Goodwin and Marion 1978). Since discovery of the first alligator nest at RSWMA in 2005, ODWC personnel would search for nests every year, but these searches were opportunistic and restricted mostly to the shoreline of reservoir units of RSWMA that were easily accessible (personal communication, David Arbour, ODWC). For this project I was able to search a much greater percentage of useable nesting habitat than had previously been accomplished on a yearly basis. This extra effort ultimately resulted in the discovery of the Pintail nest. Despite the low number of nests (2), this represents the first time two nests known to be active in a given year were documented on RSWMA. Between 2005 and 2011 the only known nesting alligator at RSWMA had nested in the Bittern Lake unit. Because Pintail Lake ostensibly has an abundance of nesting habitat and was responsible for more alligator detections on RSWMA than any other wetland unit, yearly efforts to search these islands for nests would likely result in increased nest detections.

Despite the fact that Ward Lake yielded no nests detected, it still had the highest total number of detections in spotlight surveys, including numerous sightings of juvenile alligators (<1.5m). This suggests that (1) alligators have previously nested successfully at Ward Lake, (2) juvenile alligators have migrated to Ward Lake, or (3) some combination of these two factors. However, 99.15% of the state of Oklahoma was under drought conditions as of July 10, 2012 (U.S. Drought Monitor, 2013) causing water levels to drop an average of 22.4cm (31.0- 13.4cm) across all deep water units surveyed, creating large spans (50-150m) of exposed mudflats (personal observation). This likely reduced the ability of female alligators to access nesting habitat, which is usually much nearer to the water.

The nest success rate on RSWMA for 2012 was 100% but was based on a small sample size (n = 2). Previous work by Woodward et al. (1987) in Florida and Joanen (1969) in Louisiana showed alligator nest success rates to be between 48-72%. Including the previous eight years of known nesting activity on RSWMA, there has still never been a known unsuccessful nesting attempt (based on a small sample size; n = 0.875/year).

Overwinter survival at this northwestern extent of the alligator's range has long been considered a challenging event, more so than in core areas of their range. Overwinter survival rates for nests at RSWMA were 75% for all hatchlings that could be monitored. This high survival rate, combined with the icing behavior documented during a particularly cold period in January 2013, suggests that cold temperatures may not be the limiting factor affecting population dynamics in southeastern Oklahoma. While the effect of extreme cold during winter months still poses a threat to alligator hatchlings throughout a significant portion of their range, the lack of useable habitat and unwanted human interference are more likely the limiting factors affecting the distribution of alligators in Oklahoma. Our results and observations reinforce the idea that alligators are well suited to deal with short periods of extreme cold, even at a very young age. Further studies of wild hatched and raised alligators in Oklahoma are needed to further describe and define the extent of alligator's ability to overwinter at the extremes of their range.

Numbers of successful hatchlings per nesting attempt at RSWMA was low (12 & 9 respectively). Joanen (1969) reported an average clutch size from 315 nests in Louisiana as 38.9 eggs per nest, with a hatchling success rate of 58.2%. Together these numbers show that each successful alligator nest produced an average of 22.6 hatchlings per nest. Goodwin and Marion (1978) reported an average clutch size of 30.3 eggs per nest, with a hatchling success rate of 45% (13.6 successful hatchlings per nest) in North Central Florida. With 12 and 6 successful hatchlings respectively, both nests on RSWMA in 2012 produced below published averages and below the average of 18.2 hatchlings per nest seen previously at RSWMA. It is likely that the primary reason for low production in the Pintail nest was a nest predation event by feral hogs. Previous work by Elsey et al. (2012) showed feral swine predation of alligator nests in Louisiana. The first two pictures taken by my remote sensing camera on September 7, 2012 (i.e., one day post-hatching) were of feral hogs at the nest site. Though none of the images showed active predation, feral hogs are voracious omnivores and not likely to pass up an easy meal such as this. Had a mother alligator attempted to defend the nest from this possible predation event, the activity should have been captured by our remote sensing camera equipment.

In an effort to monitor hatchlings and capture evidence of female defense of young for the Pintail nest, I placed a remote sensing camera near the shoreline facing the open water of the wetlands where the young were observed congregating. The sequences of vigorous hatchling defense that were captured are poorly documented and rarely seen by researchers (Joanen 1969; Goodwin and Marion 1978). The mother of the Bittern nest is also an extremely vigorous nest and hatchling defender. Because these acts of offspring defense are poorly understood, I believe that RSWMA offers an opportunity for further exploration of this behavior.

Historical data.— The historical data showed the Bittern Lake unit was the source of the majority of alligator sightings at RSWMA. To a large degree this is a result of inconsistent search efforts that skewed these sightings to areas where alligators are easiest to see and known to occur. Since discovery of a nest on the Bittern Lake unit in 2005, the area has been a hot spot for tourists and birders to see alligators. Likewise, ODWC personnel heavily monitored this unit more than any other for alligator activity because it was a known nest site and offered relatively easy access. Spotlight survey results indicated Pintail Lake and Lotus Lake as the RSWMA units with the most alligator activity. This is likely to be true despite the large number of historical sightings on the Bittern Lake unit. Areas on Pintail and Lotus Lake where alligator activity was most common were far away from observation towers and not easily accessible by vehicle or on foot. I believe this is the likely reason historical sightings on these units have been so sparse compared to the Bittern Lake unit which has an observation tower on its west levee and is more accessible to visitors. Regardless of bias in the number of sightings per unit, the general trend of increased alligator activity over time is true for the historical data and should still be considered a useful metric.

Management Recommendations.— Based on comparison of spotlight survey data, I propose that ODWC should make alterations to their spotlight survey protocol. When only one survey per year is performed there is an increased probability of conducting a survey on a night with particularly low, unrepresentative alligator activity, as seen in the 8 March 2013 survey. I believe that conducting multiple surveys per year is more likely to result in a reasonably accurate measure of population trends. Recommendations for future spotlight surveys are fourfold: (1) increase survey frequency to more than once per year (5-6 preferred), (2) continue surveying marginal habitat if time permits, however do not include it in CPUE calculations, (3) make a strong effort to use a consistent number of observers, (4) maximize detection probability by conducting spotlight surveys between March 17 – April 30 (correlated with our highest detection rates) when temperatures are warm and before aquatic vegetation becomes a hindrance. These proposed protocol changes represent a move in the right direction towards more accurate and efficient data collection. With a standardized survey protocol agreed upon, year to year population trends can be compared via CPUE and correlated with other variables such as water levels, weather conditions, and vegetative characteristics, which I feel might also be key factors affecting population dynamics and detection rates.

Understanding seasonal movements, area use, population size and structure can greatly affect future management decisions regarding American alligators. Future studies should take a closer look at habitat preferences by using radio telemetry studies, similar to those done by Wood and Patton (in preparation) but with wild born and raised alligators at RSWMA. Further, there has never been a study done to estimate the total number of alligators in Oklahoma or RSWMA to date. A mark/recapture study could be used to begin to reveal these population numbers. Accurately estimating population size and recording movements of adult alligators at RSWMA has never been attempted and I believe that closing this information gap could help further understanding of alligators in southeastern Oklahoma.

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Tables and Figures

Table 1. Numbers of alligators detected and CPUE for each spotlight survey at Red Slough WMA and Ward Lake. Detections for each water body is also shown.

	2012						2013									
Water body	**23-Mar**	**6-Apr**	**26-Apr***	**10-May**	**26-May**	**9-Jun**	**8-Mar**	**29-Mar**	**12-Apr**	**25-Apr***	**17-May**	**31-May**	**SD**	**Mean**	**Total**	**Freq. of occurrence**
Ward Lake	12	4	8	10	10	10	0	10	12	12	12	7	3.7	8.9	107	0.92
Pintail Lake	5	8	4	5	3	5	1	5	8	5	4	6	1.9	4.9	59	1.0
Lotus Lake	2	2	2	0	0	0	0	4	6	7	3	3	2.4	2.4	29	0.67
Ditch 16E	0	0	0	3	0	0	0	0	0	1	0	0	0.9	0.3	4	0.17
Bittern Lake	1	1	2	0	0	0	1	1	2	7	2	4	2.0	1.8	21	0.75
Stork Lake	0	0	0	0	0	0	0	0	1	1	0	0	0.4	0.2	2	0.17
Otter Lake	1	0	1	0	0	1	0	0	0	0	1	0	0.5	0.3	4	0.33
Unit 26	0	0	0	0	0	0	0	1	0	0	0	0	0.3	0.1	1	0.08
Unit 27A	0	1	0	0	1	0	0	0	0	0	0	0	0.4	0.2	2	0.17
Unit 27B	0	0	0	0	0	2	0	1	1	0	0	0	0.7	0.3	4	0.25
Unit 31	0	1	0	0	0	0	0	0	0	0	0	0	0.3	0.1	1	0.17
SD	**3.7**	**2.5**	**2.5**	**3.2**	**3.0**	**3.2**	**0.4**	**3.2**	**4.1**	**4.1**	**3.6**	**2.7**	---	**2.8**	**33.6**	---
Total [mean]	**21**	**17**	**17**	**18**	**14**	**18**	**2**	**22**	**30**	**33**	**22**	**20**	---	**19.4**	**234**	**[0.37]**
CPUE	**1.75**	**1.42**	**0.72***	**1.33**	**1.17**	**1.5**	**0.11**	**1.38**	**1.67**	**1.18***	**1.22**	**1.11**	---	**[1.27]**	---	---

***ODWC annual**

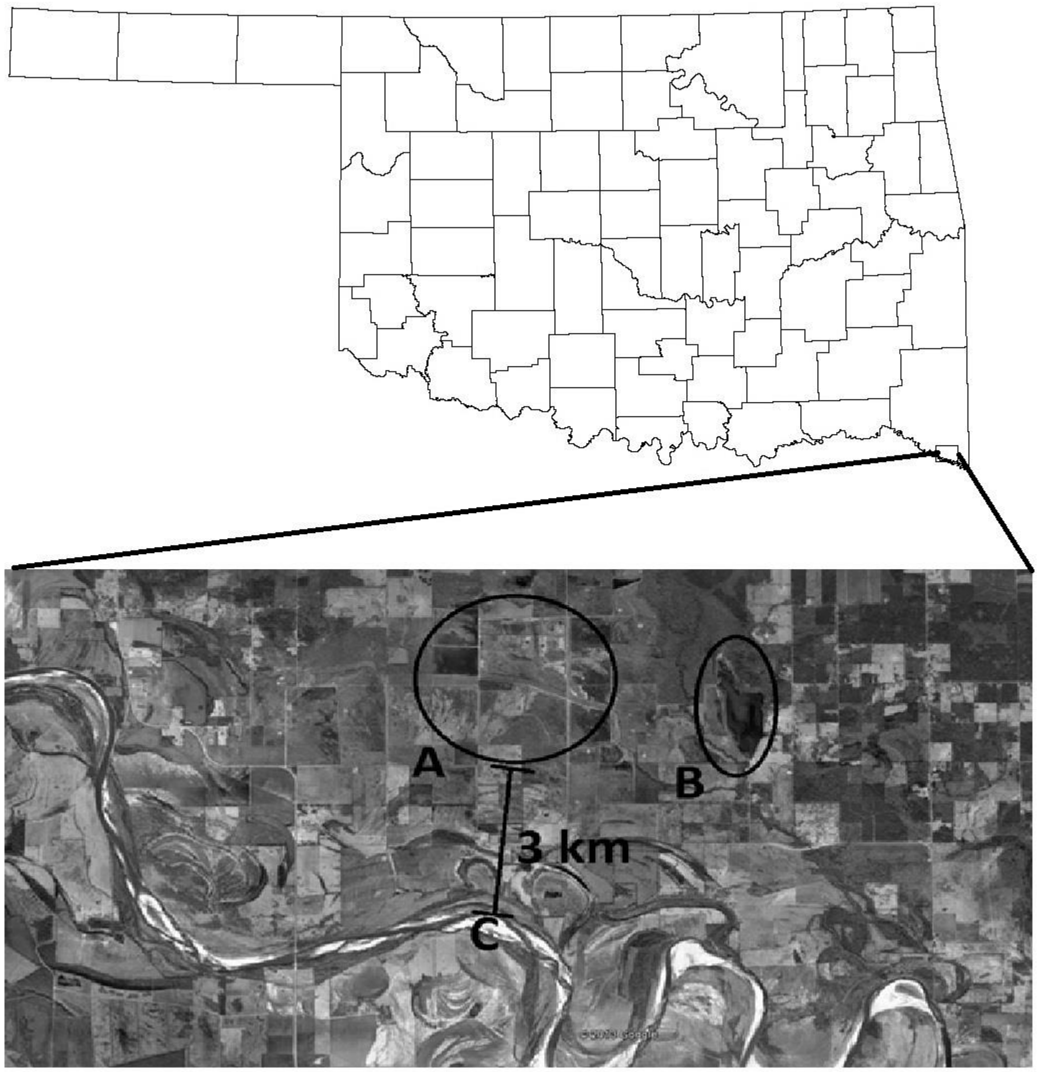

Figure 1. Satellite image from GoogleEarth® showing locations of Red Slough Wildlife Management Area (A) and Ward Lake (B) in relation to the Red River (C).

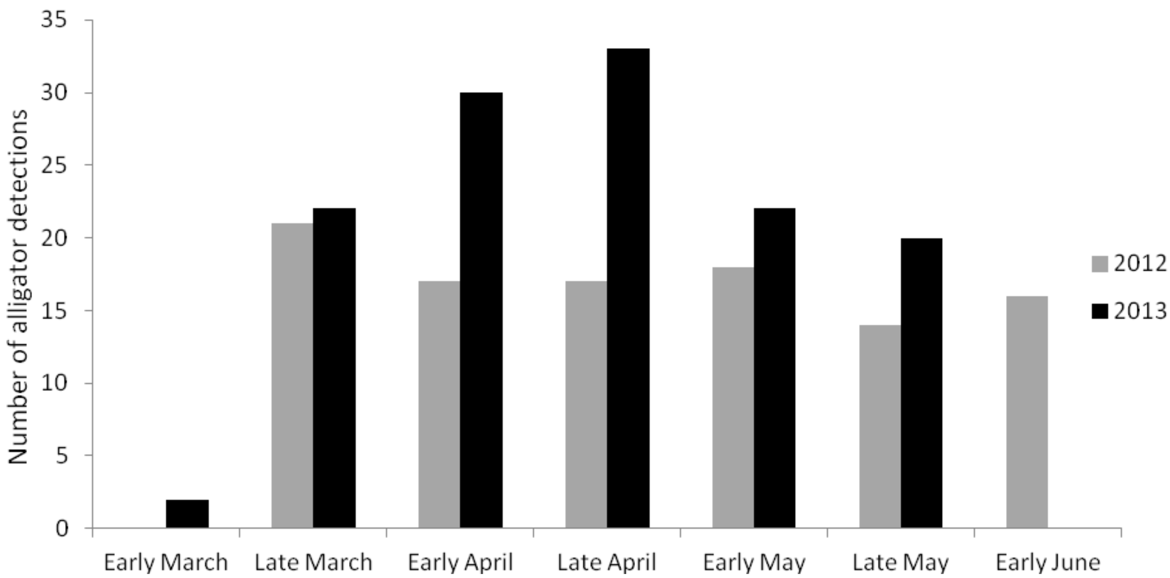

Figure 2. Number of alligator detections for early and late periods of the month (early = <17th and late = >17th of the month) over two years of spring spotlight surveys on Red Slough Wildlife Management Area in McCurtain County, Oklahoma.

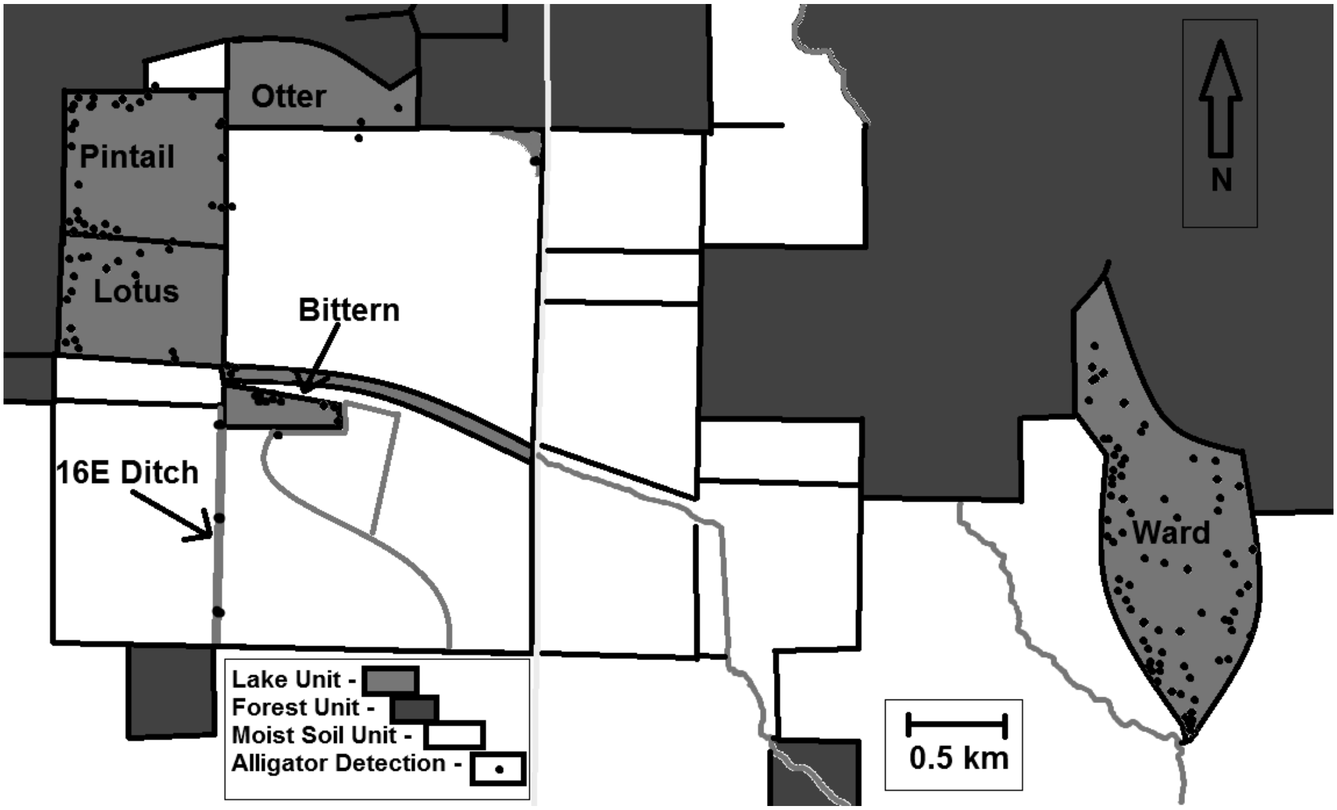

Figure 3. Alligator locations observed on Red Slough WMA and Ward Lake during our 2012-2013 spotlight surveys.

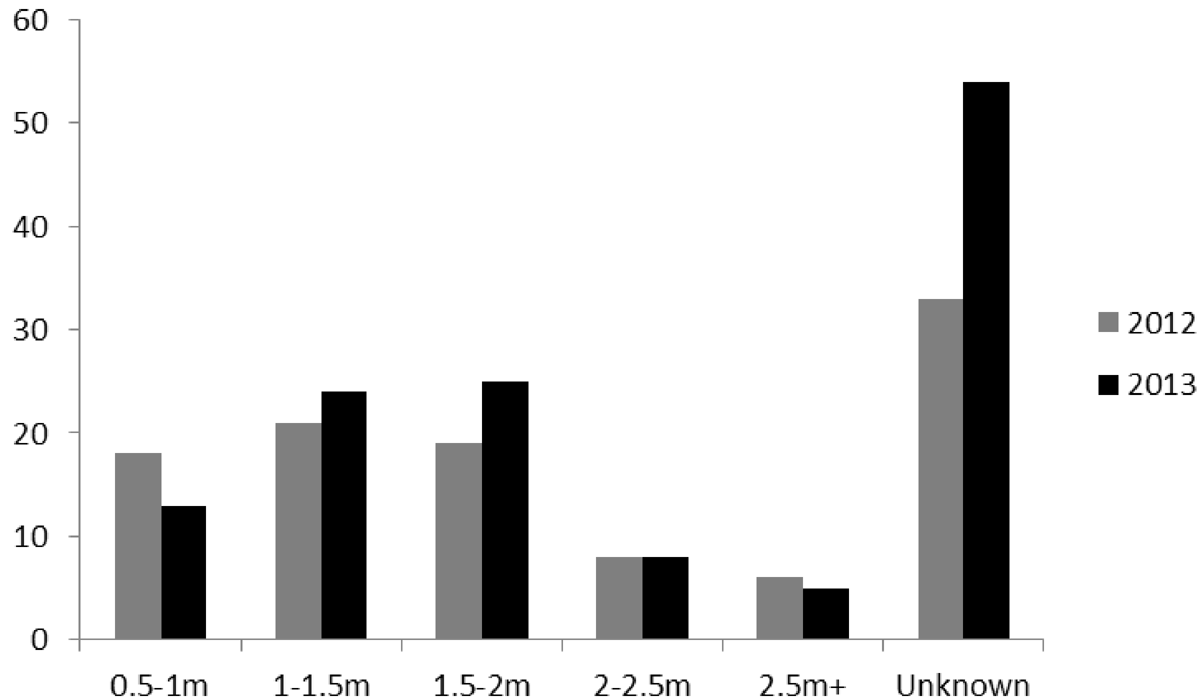

Figure 4. Length-frequency histogram for alligator detections on Red Slough Wildlife Management Area during 2012 and 2013 spring spotlight surveys.

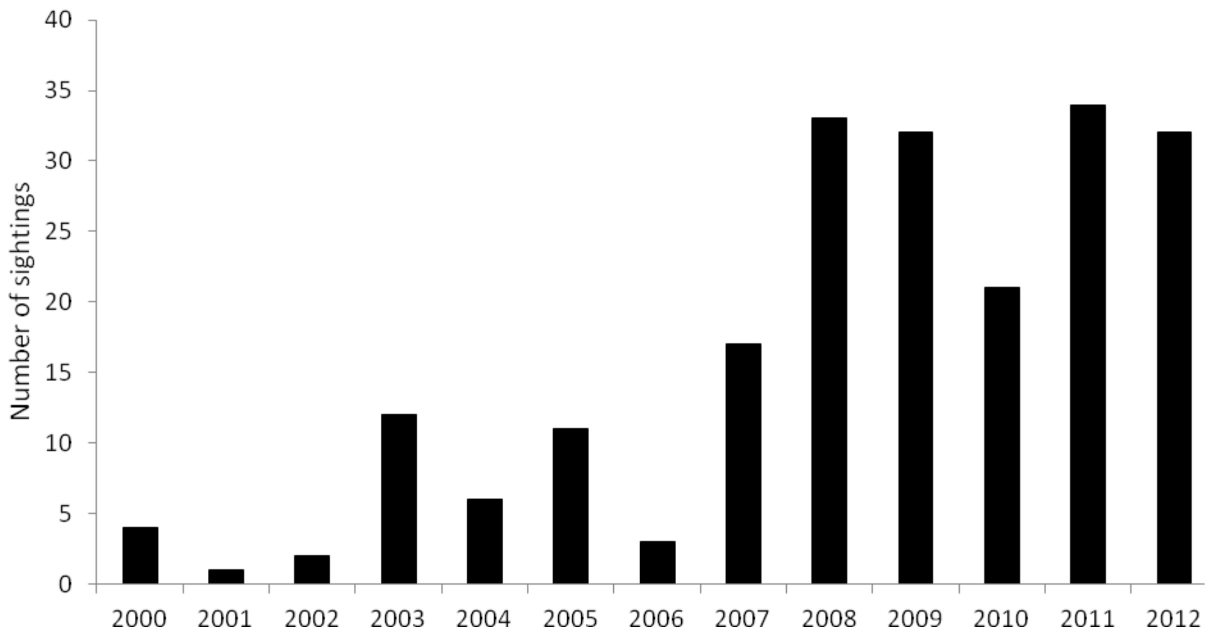

Figure 5. Historical alligator sightings at Red Slough Wildlife Management Area and Ward Lake (2000-2012) from archived United States Forest Service data.

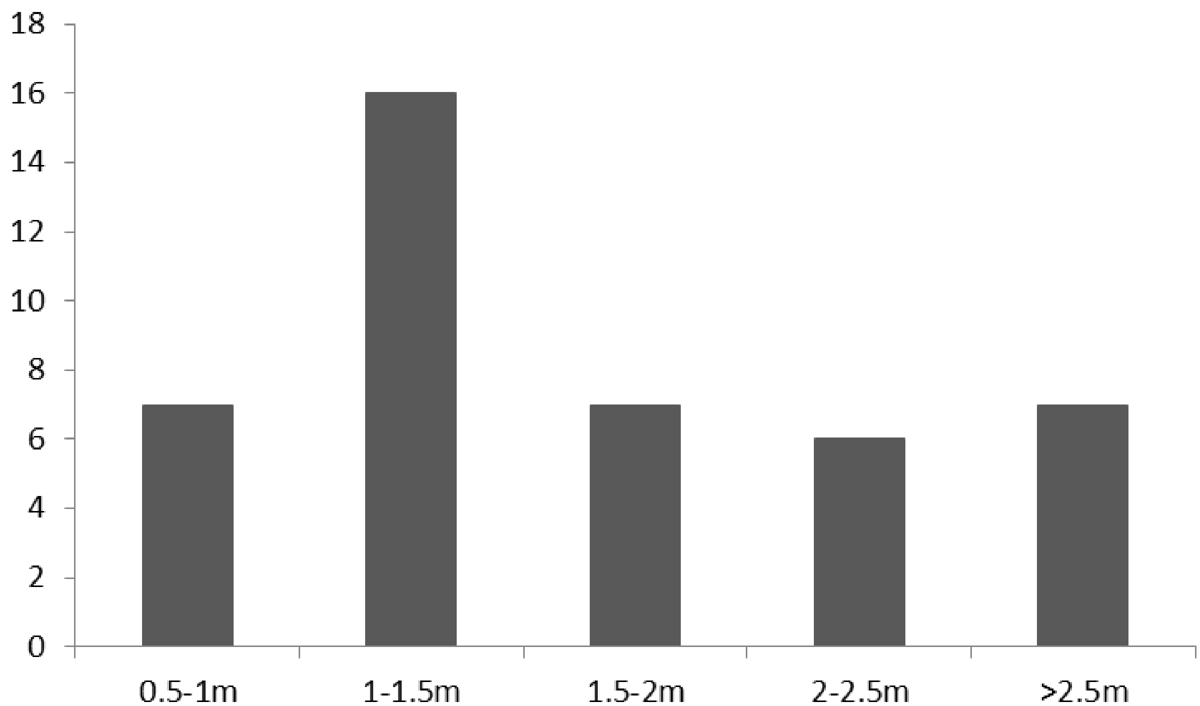

Figure 6. Length-frequency histogram showing size estimate distribution from historical (2000-2012) alligator sightings at Red Slough WMA and Ward Lake United States Forest Service data.

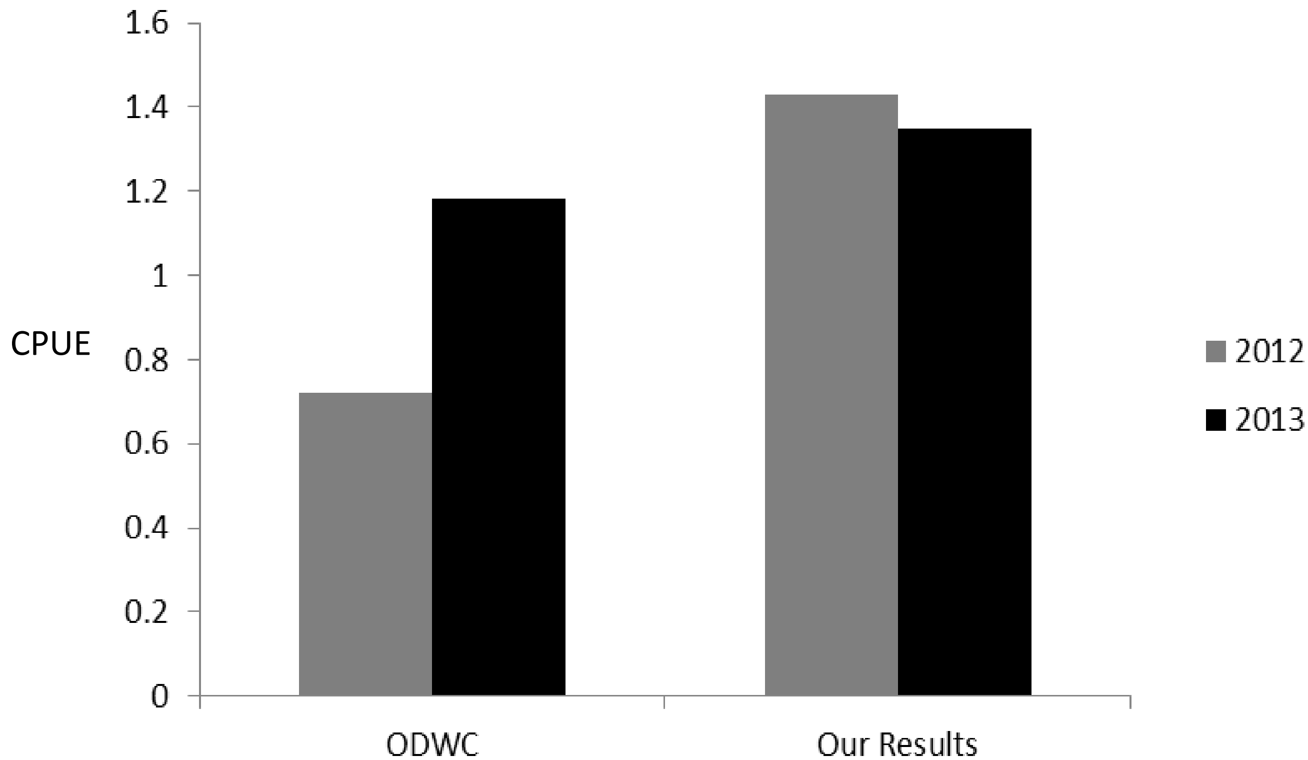

Figure 6. CPUE comparison between ODWC annual spotlight survey and the mean CPUE values of our spotlight survey efforts during corresponding years.

Appendix A

A photographic sequence showing a hidden mother alligator, lunging towards a Great Blue Heron (*Ardea herodias*) in an effort to defend her young. In several pictures before this sequence, hatchling alligators could be seen attempting to flee from the Great Blue Heron. Notice that the pictures were taken exactly one second apart according to the time signature recorded in the top left corner of each photograph. This sequence was recorded at Red Slough Wildlife Management Area in extreme southeastern Oklahoma.

Appendix B

Table showing historical data regarding alligator sightings at Red Slough WMA and Ward Lake. Archived material and communications provided by U.S. Forest Service, Broken Bow, Oklahoma.

Date	Number of Alligators	Location	Size	Observer
1990	10	Ward Lake	babies	Dennis Ward
7/13/2000	1	Ward Lake		DA*
7/20/2000	1	Ward Lake	8’	DA
7/20/2000	1	Ward Lake	9.5’	DA
9/27/2000	1		6’	DA
4/30/2001	1		7-8’	DA
8/1/2002	1			DA
8/14/2002	1			DA
3/9/2003	1	Bittern	5-6’	Berlin Heck
3/17/2003	1			DA
3/27/2003	2			DA
4/7/2003	2			DA
4/29/2003	1			DA
5/1/2003	1			DA
5/16/2003	2	16E ditch, Bittern	4’, 5’	DA
7/8/2003	1			DA
9/23/2003	1			DA
10/6/2003	1			DA
10/14/2003	1			DA
10/28/2003	1			DA
3/28/2004	1		8-10’	DA
4/16/2004	1			DA
5/1/2004	1			DA
5/8/2004	1			DA
9/3/2004	1			DA
10/10/2004	1			DA
1/4/2005	1	Bittern	4.5’	DA
2/22/2005	4	Bittern	4.5’, 4’, 4’, 3’	DA
3/1/2005	3	16E ditch		DA
4/27/2005	10			DA + CREW
4/18/2005	5			Tim Patton
5/19/2005	1			Tim Patton
9/26/2005	12	Bittern	babies	DA
10/24/2005	18	Bittern	babies	DA
10/25/2005	2	Bittern		DA

11/8/2005	1			DA
11/9/2005	1	Bittern		DA
4/6/2006	1			DA
4/13/2006	1			DA
10/3/2006	2			DA
3/7/2007	1			DA
3/13/2007	2			DA
3/20/2007	2			DA
3/21/2007	3			DA
3/27/2007	1			DA
4/3/2007	3			DA
4/27/2007	9			DA + CREW
5/8/2007	5			DA
6/21/2007	1			DA
7/1/2007	1			DA
7/11/2007	1			DA
7/18/2007	1			DA
7/24/2007	1			DA
8/7/2007	2			DA
8/27/2007	2			A.F. Hendershot Jr.
8/30/2007	31	Bittern	babies, 7’	DA
8/31/2007	many	Bittern	babies	Debbie Butler
2/11/2008	1	NE Bittern		Berlin Heck
2/28/2008	1			DA
3/5/2008	1			DA
3/13/2008	1	NE Bittern		DA
3/17/2008	2			DA
3/20/2008	3			DA
3/26/2008	1			DA
4/8/2008	1			DA
4/10/2008	1			John Wilson
4/17/2008	1		6’	DA
4/22/2008	1			DA
4/26/2008	1			Dan Moore
5/6/2008	1			DA
5/11/2008	2	Bittern		Berlin Heck
5/14/2008	3			DA
5/20/2008	2			DA
5/23/2008	3	NE Bittern		DA
5/24/2008	1			Berlin Heck
5/25/2008	1			Mary and Lou Truex

5/27/2008	3			DA
6/3/2008	1			DA
6/24/2008	1			DA
6/27/2008	1	16E ditch	9-10’	DA
7/15/2008	1			DA
7/16/2008	1	N Bittern		DA
7/24/2008	1			DA
8/7/2008	1	Unit 21	small	DA
8/13/2008	1			DA
9/22/2008	1	Bittern	7’	DA
9/23/2008	1			DA
10/8/2008	1			DA
10/22/2008	1			Bill Adams
10/30/2008	1			DA
2/10/2009	2			DA
2/19/2009	1			DA
3/10/2009	1			DA
3/17/2009	1			DA
3/26/2009	1			DA
4/7/2009	1			DA
4/14/2009	1			DA
4/20/2009	1			Berlin Heck
4/21/2009	1			DA
4/28/2009	1			DA
5/4/2009	1			DA
5/14/2009	1			DA
5/19/2009	1			DA
6/1/2009	1			DA
6/8/2009	1	16E ditch		DA
7/9/2009	1			DA
7/14/2009	1			DA
7/15/2009	1	Stork	4.5’	DA
8/4/2009	1			DA
8/11/2009	1			DA
9/8/2009	1			DA
9/10/2009	16			DA
9/15/2009	1			DA
9/22/2009	1			DA
10/7/2009	1			DA
10/12/2009	9			Tim Patton
10/17/2009	1	Unit 21	3’	DA
10/28/2009	1	Stork	6-7’	DA

11/3/2009	1			DA
11/4/2009	9			Tim Patton
11/10/2009	1			DA
11/25/2009	1			DA
1/13/2010	3			Jared Wood
3/12/2010	1			Tim Colston
4/6/2010	3			DA
4/20/2010	1			DA
4/22/2010	1			Tim Patton
5/3/2010	5	E Otter + Bittern	6.5’, big, babies	DA
5/4/2010	1			DA
5/12/2010	1	Stork, Otter, Pintail, Lotus, Unit		DA
6/25/2010	8	21		DA
6/28/2010	1			DA
7/13/2010	2			DA
7/19/2010	1	Unit 26	3’	DA
7/28/2010	2	Bittern, Otter	big	DA
8/2/2010	1			Tim Roberts
8/2/2010	1	Bittern		Berlin Heck
8/5/2010	1			DA
8/11/2010	1			DA
8/17/2010	1			DA
8/23/2010	1			DA
8/25/2010	1	Bittern		DA
9/17/2010	2	NW Bittern, NW 27B		DA
2/8/2011	1			DA
2/23/2011	2	NW Pintail	big	DA
3/2/2011	1	Bittern		DA
3/22/2011	3		9’, 8’, 6’	DA
4/5/2011	1			DA
4/26/2011	1			DA
4/26/2011	14	RSWMA		Tim Patton
5/30/2011	1	Otter		DA
6/15/2011	1	Otter		DA
6/29/2011	2			DA
7/5/2011	1			DA
7/12/2011	1			DA
7/13/2011	1	Bittern		DA
7/22/2011	1	Pintail		Terry and Jack
7/25/2011	1			DA
8/2/2011	1	Unit 21	3’	DA
8/23/2011	1			DA

8/29/2011	15	Bittern		DA
8/30/2011	18	Bittern		DA
8/31/2011	4	Ward Lake	3-4’	DA
9/6/2011	1			DA
9/9/2011	1	SE Lotus	3.5’	DA
10/17/2011	6		babies	DA
10/25/2011	1			DA
11/2/2011	14	SW Pintail, Stork, Bittern	9’, 4.5’, babies	DA
11/8/2011	1			DA
11/9/2011		Ward Lake	4’, 10’	DA
11/15/2011	1			DA
11/21/2011	1			DA
12/6/2011	1			DA
12/13/2011	1			DA
12/20/2011	1			DA
12/28/2011	1			DA
12/29/2011	10	Bittern	babies	DA
1/23/2012	1			DA
1/31/2012	1			DA
2/1/2012	14	Bittern	babies	DA
2/6/2012	1			DA
2/14/2012	1			DA
2/21/2012	1			DA
2/22/2012	16	Bittern, Pintail		DA
3/5/2012	1			DA
3/12/2012	1			DA
3/19/2012	1			DA
3/26/2012	1			DA
3/29/2012	17			DA
3/31/2012	1			DA
4/3/2012	1			DA
4/22/2012	1	Bittern		DA
5/14/2012	1			DA
5/15/2012	3			DA
5/16/2012	1	NW Unit 27B	4’	DA
5/21/2012	1			DA
5/30/2012	1			DA
6/13/2012	2	Otter, 16 E ditch	4’	DA
6/18/2012	1	SW Unit 27B	3’	DA
6/19/2012	1			DA
7/8/2012	1	Push Creek	4’	DA
7/11/2012	1		4’	DA

8/30/2012	1			DA
10/31/2012	17	Bittern, SE Lotus	4’, babies	DA
11/13/2012	6	Bittern	babies	DA
11/19/2012	7	Bittern	babies	DA
12/3/2012	6	Bittern, Pintail	10’, 5’, babies	DA
12/18/2012	2		young	DA
12/31/2012	3	Bittern	babies	DA
1/3/2013	8	Bittern	babies	DA
1/14/2013	7	Bittern	babies	DA
2/4/2013	3	Bittern	babies	DA

DA= David Arbour*