Developing and implementing a strategic population monitoring plan for Blanding's turtles

Project description

Blanding's turtles in Nova Scotia are listed as Endangered under both the federal and provincial legislation. They are known to exist in three populations as well as a few other small concentrations. Differences in habitat types, population age structure, genetics, and behaviour have been documented among the three populations. As a result, the recovery team recommends that monitoring and management plans be site-specific. Development a strategic monitoring plan is considered a necessary measure in the Recovery Strategy and high priority in the draft Action Plan.

Monitoring Blanding's turtles to determine population size, trends, age structure, threats, and effectiveness of recovery programs is challenging due to the species' longevity (80+ years) and slow maturation (20 yrs). This is further compounded by varying detectability which is influenced by season, temperature, water levels, habitat type, age class and sex. Though a long-term dataset exists in Nova Scotia, much of the data has been collected opportunistically, with the effort intensity and sites chosen varying based on the needs of specific studies. In 2006, Guillaume Bourque conducted the only detailed analysis of trapping data to date by developing a model that examined factors that affect trapping success. However, this model was based on only data from a single population and focused primarily on the effort required to detect a single Blanding's turtle for presence/absence surveys rather than for monitoring.

This project aimed to analyze existing trapping and visual survey data and develop and implement a strategic long term monitoring plan in Nova Scotia.

Results

The primary deliverables of this project are detailed in the attached reports.

Table 1. Results of activities presented in original proposal

What you will do (activities)?	**Summary of activities**
Proof, map and summarize all past trapping and visual survey data to present to the recovery team	• Historic trapping and visual survey effort data for McGowan Lake, along with data collected in the last two years, were entered into the NS Blanding's Turtle Database, proofed, and mapped. 878 effort lines and 87 trap sessions were added; 764 turtle observations were modified/proofed. • Data were sent to Drs. Ryan Stanley and Trevor Avery for use in their analysis.
Hold a workshop with recovery team members, field researchers, volunteers and other recovery partners to review data	• The monitoring plan was discussed at two recovery team meetings (2014 and 2015) to update the team on objectives and progress of the project.

summary results and to identify specific monitoring goals that can be used in the development of the model.	• Monitoring goals were discussed with Dr. Tom Herman, co-chair of the recovery team, as they were developed. • The grant recipient attended a range-wide Blanding's Turtle Symposium in Massachusetts to see how efforts in Nova Scotia can fit into the monitoring efforts in rest of the range. • A further workshop with members of the recovery team is planned for winter 2016-2017.
Develop a model to identify target trapping and visual survey intensity and conditions to maximize the success of efforts and to increase understanding of factors that affect detectability.	• Meetings were held with Drs. Tom Herman, Ryan Stanley and Trevor Avery to discuss the analysis for the monitoring plan. • Trapping and visual data for McGowan Lake was analyzed by Drs. Stanley and Avery. See attached report.
Develop draft monitoring plan and hold a follow-up meeting with the recovery team members to solicit feedback on the data analysis and draft plan	• Draft monitoring plan has been prepared and is submitted with this report. • This plan will be presented to the Blanding's turtle recovery team during their annual meeting in winter 2016-2017. • Because the modelling analysis did not fully answer the central question of the amount of effort required to assess change in the population, further data analysis. A revised monitoring plan is expected to be in-place for spring 2017. • The monitoring plan includes a two-year intensive sampling period designed to collect additional data that will contribute to future analysis.
Conduct initial year of monitoring	• Monitoring efforts, particularly visual surveys, were ramped up at McGowan Lake in 2015 to provide additional data that were used in the analysis. • These efforts were successful in locating the first juveniles found under age 5 in the population
Develop a final report detailing the results of the analysis, monitoring plan and results from the first year of implementation	• A final report has been developed that includes analysis results, draft plan and timeline for revising the plan. See attached document.

This ambitious project was approved by the Nova Scotia Conservation Fund in 2013 with an expected completion date of 2014. However, it was delayed in 2014 due to unanticipated extended leave of the project recipient (due to parental leave followed by illness in the family) and again in 2015 due to delay in receiving the analysis report. Results listed here present a preliminary draft and further work is anticipated in winter 2016-2017 to refine the monitoring plan, as outlined in the attached report.

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DEVELOPING A MONITORING PLAN FOR BLANDING'S TURTLE IN NOVA SCOTIA, USING MCGOWAN LAKE AS A CASE STUDY

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Developing a monitoring plan for Blanding's turtles in Nova Scotia, using McGowan Lake population as a case study

Introduction

The primary goal of a monitoring plan is to detect change in the population. However, this can be challenging with rare species that occur in small numbers and have low detectability. In the case of Blanding's turtles, this also confounded by the late maturation and longevity of the species.

In Nova Scotia, Blanding's turtles do not mature until they are approximately 20 years old (McNeil 2002, Standing *et al.* 2000). This slow maturation results in a time lag between either recovery actions or catastrophic events that affect juvenile age classes from showing up in the adult population. As such, it is important that monitoring include both juvenile and adult age classes so that changes could be detected on a reasonable time frame to allow recovery programs to adjust.

Blanding's turtles can live over 80 years and naturally have very high adult survivorship (Congdon *et al*. 1993). In Nova Scotia, annual adult survivorship in two populations has been estimated to be approximately 98% (Green and McNeil 2014; Bourque *et al.* 2006). Even a very small sustained increase in mortality can result in population decline (Congdon et al. 1993); however, detecting these small changes can require significant effort. Assessing change in adult survivorship is confounded by the mobility of the species. Individuals may disappear for many years, even from sites with regular monitoring, only to show up again several years later. In Nova Scotia, a few turtles have been re-found after more than two decade's absence. Because of these confounding factors, it may not be practically possible to monitor sufficiently to detect all small changes that may affect the trajectory of the population. However, there is some level of change that could be reasonably detected with a systematic monitoring program. A primary objective of this project is to determine what level of change we can reasonably detect with a feasible, systematic long term monitoring program and how to best implement that program.

A long-term monitoring program must balance several factors in its design, beyond just determining optimal levels of effort. The amount of work and frequency of monitoring must be practically based and economically feasible. Where possible it should also fit in with existing protocols and programs, including those elsewhere in the species' ranges, to allow for detection of trends on a larger geographic scale. Recovery of Blanding's turtles in Nova Scotia relies on a well-established network of volunteers, who have made the success of the program to date possible. The design of the monitoring program must incorporate elements that include retention and training of volunteers, particularly when considering the frequency of monitoring.

This first draft of the monitoring plan focuses on the population at McGowan Lake but is expected to be exportable to the other populations in Nova Scotia. McGowan Lake was selected because it occurs on private and provincial lands and has been the subject of annual surveys since its discovery in 1996 (McNeil 2002). McGowan Lake is likely the smallest of the main populations and may be the most at risk. It is one of the most accessible populations and is influenced by water level control and cottage development. A Population Viability Analysis conducted in 2006 suggests the population is at significant risk of decline and eventual extinction, while genetic analysis suggests that over time the population has gone from being a net exporter to a net importer of genes (Bourque *et al.* 2006, Howes *et al.* 2009).

This report reflects the first steps toward developing a comprehensive monitoring program for Blanding's turtle at McGowan Lake. It includes initial analysis of trapping and visual survey success in the adult population as well as a summary of juvenile monitoring to date. It also ties into monitoring elsewhere in the range. While it does not yet answer how much change can be detected, it will provide additional data that will further the discussions of the recovery team and provide the necessary data to refine the plan within two years.

McGowan Lake overview

Trapping and visual survey efforts have been undertaken in the McGowan Lake population since 1996, nest protection since 2000 and sniffer dog surveys since 2013 (Table 1). Data on observations and effort are compiled in the Nova Scotia Blanding's Turtle Database.

Table 1. Summary of monitoring efforts at McGowan Lake population (* these data do not include Luxton Meadows, which may be part of the McGowan Lake complex).

Category	Summary
Discovered	1996
Monitoring frequency to date	Ongoing since 1996 with varying levels of annual effort
Population estimate	79 (60-116) Schnabel (using data from 1997-2002)
Number of marked adults	75
Adult sex ratio	~1:1 (40 females: 35 males marked)
Estimate adult survivorship	98.8 (based on 2006 Jolly Seber calculations)
Nest protection	Annual since 2000 188 nests protected 707 hatchlings released 2000-2015 >3000 person-hours of effort
Head-starting	14 headstarts released (1 in 2007 and 13 in 2008)
Total number of trap nights	1793 trap nights (1996-2015)
Total hours of visual surveys	>250 person hours (1996-2015)
Total hours of sniffer dog surveys	47 dog-hours (2013-2016)
Number of concentration sites	7-8
Landownership / protection	Provincial crown (much proposed to become Nature Reserve) Nova Scotia Nature Trust (McGowan Lake Turtle Sanctuary) Private (cottage development particularly on Dean's Lake)

Data analysis: Stanley and Avery Report

Visual survey (1996-2015) and trapping data (2005-2015) were analyzed by Drs. Ryan Stanley and Trevor Avery, using the program R, to estimate the average return on sampling effort. Their report in full is provided in Appendix I. They included only adult and older juvenile turtles in their analysis (i.e. those that could have been alive and present for the duration of the sample period).

Stanley and Avery's analysis of visual surveys suggested that a higher likelihood of catching additional turtles occurred for sampling events in which individual observers surveyed more than two hours and when a combined person-effort (number of observers x duration of survey) exceeded 6 hours. However, this analysis did not factor in turtle processing time, which cumulates as each turtle is found. The report also indicated that the number of turtles caught per year reached an asymptote at approximately 23 individuals when sample effort exceeded 100 person hours. They estimate that it would take approximately 880 observational hours to catch all 52 of the turtles included in the dataset.

Trapping analysis by Stanley and Avery showed positive correlations between both the number of traps set and the duration of trapping with the number of individual turtles caught. Data sampling suggests that the number of turtles caught only plateaued in sampling years with more than 150 trap nights. Catch per trap night varied with year and season. On average 0.17 (sd: 0.52) turtles were captured per trap night; this ranged from 0.03 in 2007 to 0.36 in 2013. Adult turtles tend to be captured with higher efficiency in mid-summer (mid July to August).

Stanley and Avery conclude that "Currently the data within a given assessment year is insufficient to simulate the how changes in monitoring effort could influence the ability to accurately census and detect changes in the McGowan's Lake population." Additionally, there are several limitations and assumptions in the analysis conducted. It assumes that all turtles were present during each sampling year and all were equally likely to be caught. Genetic analysis and movement studies support the assumption that most turtles remained within the McGowan Lake population. However, the assumption of equal catchability is likely violated by both uneven sampling across the population and by variation in individual turtle detectability. Unfortunately, Stanley and Avery's analysis treated visual surveys and trapping as separate analyses and thus did not examine any potential relationship between the two. Moving forward with a monitoring plan, it would be useful to understand what combination of the two techniques maximized the number of individuals caught. Additionally, the trapping analysis only examined turtles that were caught in traps, not those who were caught visually near traps and whose presence may have been influenced by the trap.

Stanley and Avery's report represents a first step in determining the factors that influence detectability in the McGowan Lake population. Follow-up analysis is planned for winter 2016-2017 to help finalize monitoring goals prior to spring 2017. These are detailed in Next Steps below.

Data summary: juveniles at McGowan West Bog

Stanley and Avery's report (Appendix I) considered only adult and older juvenile turtles in their analysis of trapping and visual survey success. However, juveniles are also an essential component of any potential monitoring program, particularly in a species that takes 20 years to mature. At the McGowan Lake population, there are several specific monitoring goals that centre around juveniles. These include assessing the success of the ongoing nest protection program, assessing the success of the head-starting program and determining the abundance and age-specific survival rate of the juvenile population. A summary of juvenile data to-date on the McGowan West Bog is presented below. These data are not yet formally analysed but are intended to complement Stanley and Avery's analysis of adults.

Assessing the success of nest protection

Nest protection has been ongoing since 2000 at McGowan with most protected nests being from the West Bog females (78% of regularly followed nesters hail from the West Bog). From 2000-2015, 188 nests have been protected at McGowan Lake and 707 hatchlings have been released.

Hatchlings from protected nests are marked with notches that identify them to the nest of birth (Figure 1). These marks are small and fade over time. The rate of fading varies with some notching being very difficult to distinguish at 5-7 years of age (Morrison and McNeil 2003) and other notches apparently lasting up to 13 years at McGowan Lake. It is likely that the persistence of notches depends in part on the depth of the original notch. Because of the high number and annual turnover of volunteers engaged in notching, and their reluctance to notch more deeply, it is safe to assume that persistence of notches for 13 years is anomalous and 5-7 years likely represents the most reliable duration in which to detect a notch. Therefore, any monitoring aimed at measuring survival from protected nests should occur at a maximum periodicity of 5-7-years. Reading these small notches also requires extra training for researchers as the small notches are easily overlooked.

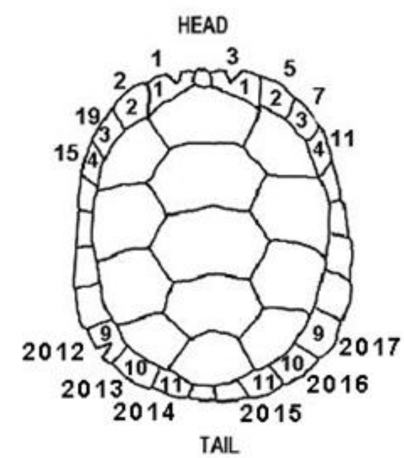

Figure 1. Hatchling notching scheme. Notches on scutes 1-4 represent the nest ID and notches on scutes 9-11 represent the year of hatching.

Assessing the success of headstarting

Although the majority of the headstarting efforts in Nova Scotia have focused on the Kejimkujik population, limited headstarting has also been conducted at McGowan Lake. In 2007 and 2008, 14 headstarted hatchlings were released at McGowan Lake; eleven of these were released into areas around the West Bog. Three of the four radio-tracked headstarts in 2008 eventually made their way into the West Bog and were confirmed to still be there in spring 2015. The remaining seven West Bog headstarts were released without radio transmitters and have not been recaptured in the intervening years. Like hatchlings, notches on headstarted turtles become less prominent over time but are likely still distinguishable for 10 or more years.

Determining age-specific survivorship of wild juveniles

Age specific survivorship of wild juveniles is poorly understood, particularly at McGowan Lake. In fact, the 2006 Population Viability Analysis constructed for the McGowan Lake population used survivorship values from the Kejimkujik population for the juvenile parameters, due to small sample size (Bourque *et al.* 2006). While 23 new juveniles have been found since 2006, more than doubling the sample size used in the PVA (n=18), data remain insufficient, particularly in the younger ages classes. Only two juveniles under 5 years old have been captured at McGowan, both in 2015 (Figure 2). Since 2013, our ability to find younger juveniles has improved with the location of overwintering sites and the addition of a sniffer dog survey. Surveys in 2015 were particularly successful, likely due in part to the increased effort and the presence of a sniffer dog. The delayed winter that year may also have been a factor, perhaps causing more synchronous activity than seen in a typical year.

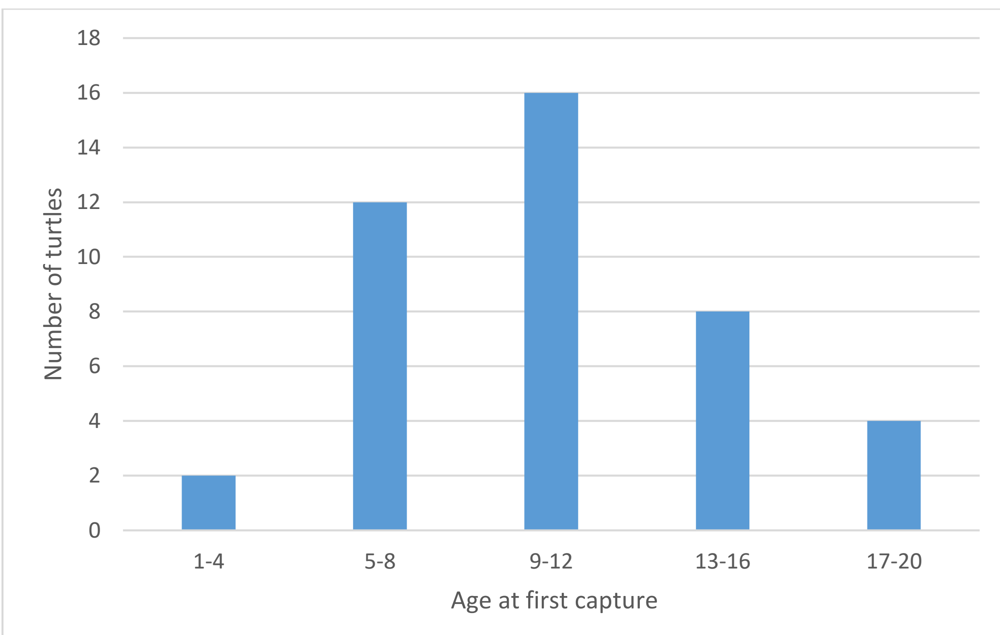

Figure 2. Frequency of age at first capture for juveniles in in McGowan West Bog

A combination of methods appears to be the best approach for capturing juveniles. Individual capture history of West Bog juveniles reveals that 50% of juveniles have only been captured by one method (trapping or visual or sniffer dog survey). The remaining 50% have been captured by two or more methods (Figure 3).

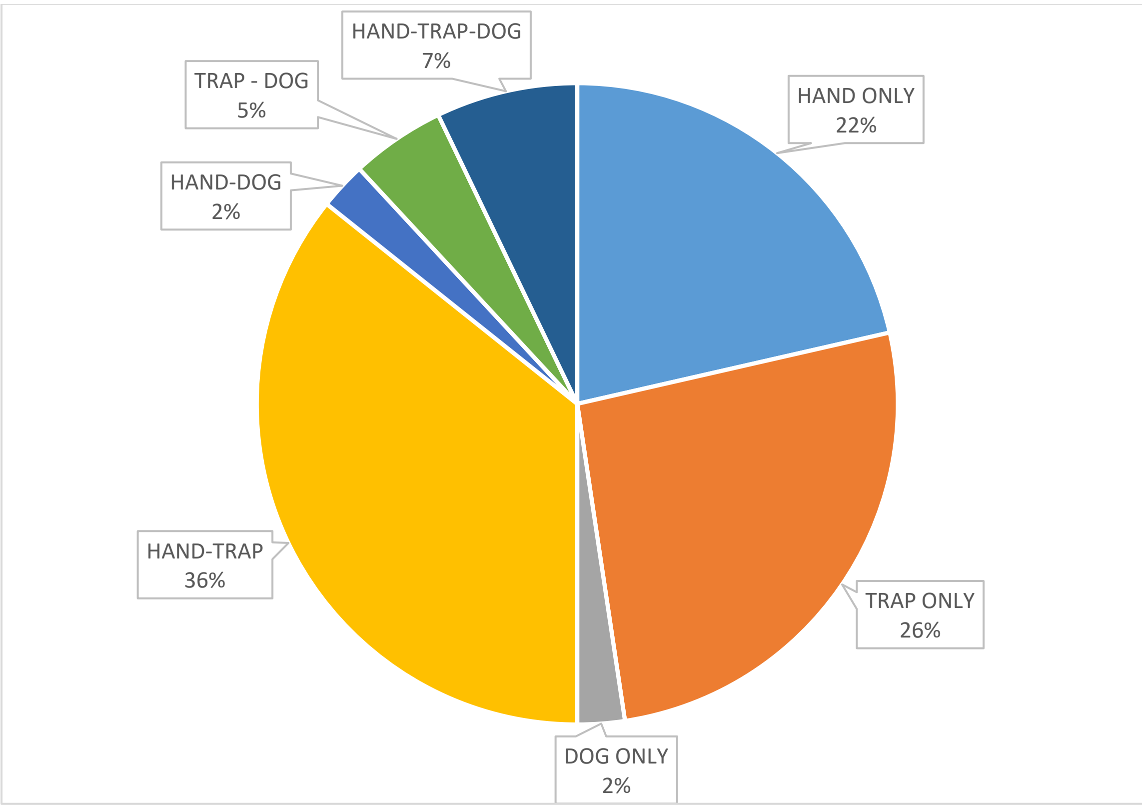

Figure 3. Capture type history for individual juveniles in the McGowan West Bog.

Morrison and McNeil (2003) found that the relative success of trap versus visual surveys varied with habitat and with age. Analysis of juvenile capture success from 2001 and 2002 at Kejimkujik and McGowan revealed that visual surveys were more successful in two brook systems at Kejimkujik, where young juveniles (<10 yrs old) were primarily captured, and trapping was more successful at McGowan West Bog, where older juveniles were more frequently captured (Morrison and McNeil 2003). When examining more recent data, this trend in the West Bog appears to continue though the percent of visual captures of older juveniles has increased (Figure 4). Of the 207 observations of West Bog juveniles, there were a similar number of hand (47%) and trap captures (53%). The number of trapping captures was only higher than the number of visual captures in the 9-12 and 13-16 age groups

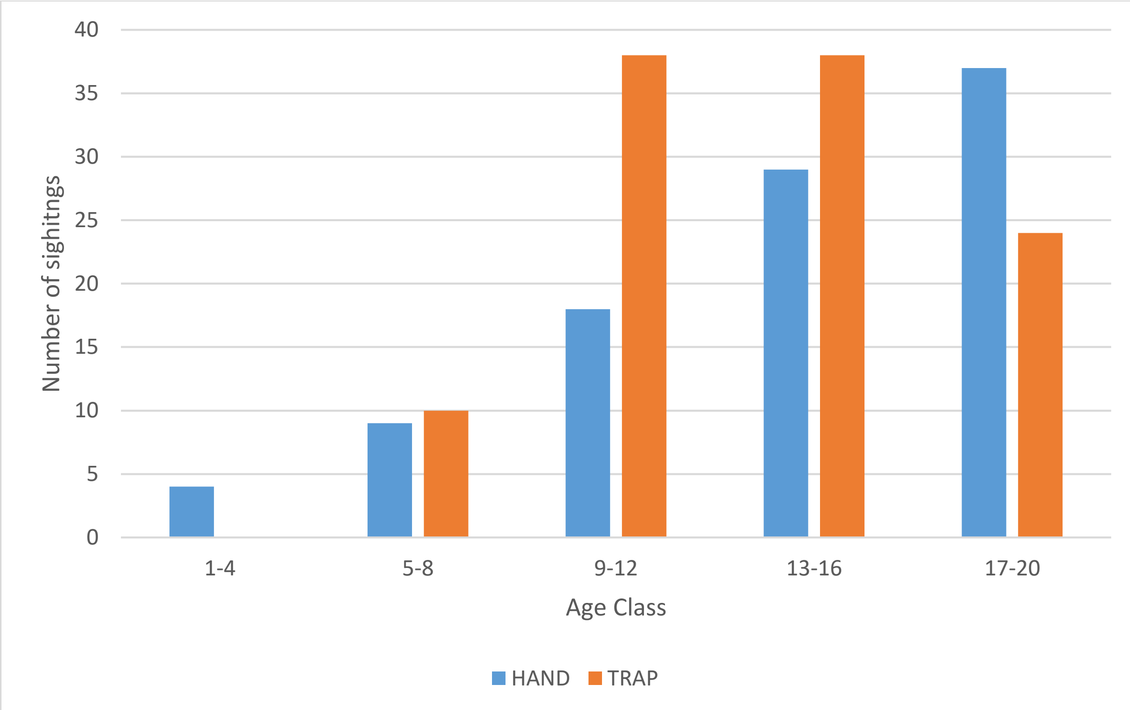

Figure 4. Comparison of in trap captures with hand captures (includes visual surveys, turtles found outside of traps, and incidental sightings but excluded radio tracking and sniffer dog finds). Includes multiple re-captures of individuals. Age at capture estimated based on counts of growth rings; the 17-20 class may include some newly mature adults.

Stewardship

The Blanding's turtle recovery program has been driven by volunteers and students. From 2011-2015, 386 volunteers put in 23673 hours of effort to the Blanding's turtle program. While much of that effort involved the nest protection component, a significant amount of the trapping and visual survey effort in working landscapes has also come from volunteers in recent years. A successful volunteer program requires annual continuity, coordination and training. Even if they might work biologically, multi-year gaps between monitoring events could result in loss of volunteers. This monitoring also proves important training ground for volunteers who trap in search of new populations, another important component of the recovery program. While the focus areas may change from year to year, a program that relies on some level of annual monitoring likely works better for volunteer based monitoring than a program with multi-year gaps. Long gaps can also result in loss of site-based expertise.

Monitoring plan in the Northeast United States

Long term monitoring was a major focus of discussion at the recent Blanding's Turtle and Wood Turtle Symposium held in Westborough Massachusetts on Oct 3rd and 4th 2016, with many Blanding's turtle researchers from across the species range acknowledging the utility of common protocols that could be used to facilitate range-wide data analysis. Researchers in one part of the range, the Northeastern United States, have begun collaborating and have developed a standardized monitoring protocol (Willey and Jones 2014). A summary of the protocol is presented here.

Long-term monitoring

Purpose: *contextualize abundance analysis, evaluate variation in detectability and track change at key sites.*

- 1-4 priority sites selected per state
- Each site trapped for 12 nights at a time, three seasons per year (spring: Apr 15-May 27; nesting season: May 28-July 8 and post nesting: July 9-end of season)
- 20 traps total set in each trapping session. These were separated into four groups of 5 traps each, centered around reference points that are 800-1600 m apart
- Reference points not randomly chosen but rather from high potential use habitats within the site complex.
- 5 traps placed within 400m of each reference point. Traps preferably placed 80m apart in all directions out around the reference point but this can be adjusted based on habitat configuration and biased toward spots likely to catch turtles. Traps at least 20m apart.
- If it was not possible to place all four plots, 1-3 plots were placed in a reduced session (still 5 traps in each).

Trap-Based Rapid Assessment sites

Purpose: Detect regional trend and allow landscape analysis at a regional scale

- >10 per state (including the long-term monitoring sites)
- 20 traps total per trapping session, separated into four groups of 5 traps each.
- The same trap placement protocol as the long-term monitoring but sites only trapped for 4 consecutive nights once a year, in any season.
- Random trap based rapid assessments were also done. These followed the same protocol but only used a single reference plot with 5 traps et for four consecutive nights.

Visual Rapid assessments

Purpose: Detect regional trend and allow landscape analysis at a regional scale

- 5-10 sites per state
- Three site visits within a two-week period during the spring (April 1 – May 27)
- Each site visit consists of eight 10 min surveys distributed throughout site
- If possible turtles not captured until after the survey to keep the 10min standard
- 4 reference points selected 800m apart with two vantage points identified in each. Vantage points focus on habitat likely to contain Blanding's (e.g. cove of a wetland, vernal pool).
- 10 min timed surveys using binoculars and on-foot searches
- Vantage points can remain the same or vary with each site visit.

The monitoring protocol was put in place in 2012 and 2013 and long term sites were sampled in both years, to collect baseline data (Willey and Jones 2014). Analysis of the first two year's results showed that the probability of catching a Blanding's in a trap and the number of individual turtles caught both declined throughout the season, though this only accounted for 3% of the variation in trap success. Air and water temperature negatively affected the probability of catching at least one Blanding's turtle but had no effect on the number of turtles caught. For the 12-night trap runs, relative trap success decreased over time but the effect was minimal. For visual based assessments, detection declined with increasing water temperature, later time of day, reduced quality habitat and reduced basking site availability.

There are advantages to adopting a plan such as the one used in the Northeastern United States (NE Protocol). By using a protocol where one could share data, large data-set analysis could be conducted over a wide geographic area. However, it would only make sense to adopt these protocols if they would work within the Nova Scotia context. The small scale of the Nova Scotia population (only four small populations) precludes some elements of the NE Protocol. For example, the requirement for 800-1600m spacing of reference points would not work at McGowan Lake. The West Bog, a recommended long term monitoring site, is only 500m long, and the other concentration sites are >1600m apart from each other. A scaled down version of the monitoring plan, proposed below, would allow us to monitor at a more appropriate level for Nova Scotia and to still collect data that could be useful for range-scale analysis. The visual survey protocol used in the NE Protocol would be more challenging to implement, given the structure of the Nova Scotia visual surveys and database and does not fit as well with the analysis of Stanley and Avery (2016). Another drawback to the NE Protocol is that it incorporates either visual surveys or trapping but not both in combination.

Proposed Monitoring Plan at McGowan Lake

Site Level 1 (high intensity): West Bog

Monitoring goals:

- Document changes in adult and juvenile population
- Evaluate success of nest protection
- Evaluate success of headstarting
- Refine juvenile survivorship numbers for PVA
- Identify how much change can be detected by intense monitoring

Why here:

- 61% of marked adults at McGowan
- 75% of marked juveniles at McGowan
- Most nest protection and headstarting efforts are from bog female's nests
- One of the largest OW concentrations identified in NS
- Easy to access including overwintering sites
- Proximity to MTRI researchers and volunteers
- Only site where we are likely to be able to statistically detect a change in abundance

Monitoring protocol:

- Trapping for the first two years following a modified version of the NE long term trapping protocol (Willey and Jones 2014):
    - 20 traps for 12 nights in each of 3 seasons: pre-nesting, nesting and post-nesting
    - Four reference points selected, 200-300m apart, in each of sections 1A, 1B, 2A and 2B, corresponding to turtle concentration sites.
    - Five traps set around each reference point, at least 20 m apart and preferably 50-80m apart in a circle around the reference point
    - Traps will be set and checked using existing protocols, checked daily and baited every second day.
- Target 100 person hours of visual survey effort per year in the two high intensity years (Stanley and Avery 2016).
    - At least 3 surveys on 3 separate days in spring at each of two known overwintering sites and two known spring "hot spots"
    - At least 3 survey days on 3 separate days in spring at random/systematically chosen sites on the periphery that have not been surveyed for juveniles
    - Supplement spring surveys with trained conservation canines, where possible
    - Remaining surveys throughout active season
    - Target > 2 hrs per person per survey, after accounting for turtle processing time
    - Surveys will follow existing protocol and data set up.
- Analyse the data following the two years of data collection to determine effectiveness and frequency of repeat intensive surveys (tentative – once per decade)
- In the years between intensive surveys, conduct lower level monitoring annually or biannually to continue to survey for juveniles and adults
    - Target 80 trap nights (1 4-night session with 20 traps)
    - Target 20+ hours of visual surveys with a focus on overwintering and spring basking sites for juveniles
- Continue annual nest protection, which also helps monitor nesting females and mark hatchlings from protected nests.

Site Level 2 (moderate intensity): East Brook, Joe Tom, Dean's Lake

Monitoring goals:

- Document changes in occupancy
- Document changes in adult population
- Document migration between sites
- Identify new threats

Why here:

- Sites have >5 marked adults and known persistence over time
- Sites are part of the McGowan population and have some documented movement among them

Monitoring in a nutshell:

- Trapping for two consecutive years in every decade following a modified version of the NE rapid trap based protocol (Willey and Jones 2014):
    - 20 traps for 4 nights in any season
    - Four reference points selected, 200-500m from their nearest neighbour, in each of four sections
    - Five traps set around each reference point, at least 20 m apart and preferably 50-80m apart in a circle around the reference point
    - Traps will be set and checked using existing protocols, checked daily and baited every second day.
- Target 20 person hours of visual survey in each of the years trapped
    - Emphasis on spring surveys where possible
    - Target > 2 hrs per person per survey, after accounting for turtle processing time
    - Surveys to follow existing protocol and data set up.
- If overwintering sites are known, at least one overwintering site visit to determine continued use of the site and to assess any new threats

Site Level 3 (infrequent): Mt Merritt Brook, Westfield Bog

Monitoring goals:

- Document changes in occupancy
- Document migration between sites
- Identify new threats

Why here:

- Sites with < 5 marked turtles but still considered part of the ML population

Monitoring in a nutshell:

- Follow the tier 2 monitoring but only two in every 20 years, rather than every 10

Next steps

This plan represents the beginning steps toward developing a range wide monitoring plan in Nova Scotia that both meets the species needs in the province and ties into programs elsewhere in the species range. Though the plan is specific to McGowan Lake, it is expected to be exportable to the other populations in the province.

We plan to continue revising this plan throughout the winter 2016-2017 including:

- Using the updated dataset to re-calculate survivorship and abundance estimates and conduct a new Population Viability Analysis.
- Use the R-code provided by Stanley and Avery to re-do their analysis focusing on just the West Bog and, for visual surveys, accounting for the turtle processing time.
- Conduct further analysis to examine the variables affecting trap and visual survey success.
- Contact biologists involved in the development of the NE Protocol for advice on lessons learned.
- Hold discussions with members of the recovery team to brainstorm best approaches.

Based on the analysis by Stanley and Avery (2016), the proposed two years of high intensity surveys at West Bog should be well above levels required for the number of individuals caught to plateau in both trapping and visual surveys. This may result in oversampling but will provide valuable data that could help optimize and reduce future high intensity sampling effort required.

Expected timeline

- Revised plan, March 31, 2017;
- Analysis of first two years of intensive monitoring: March 31, 2019

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Kejimkujik National Park and interior Nova Scotia blanding's turtle (*Emydoidea blandingii*) population monitoring evaluation

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March 2016

Contents

McGowan's Lake

Analysis description

Survey data from McGowan Lake was estimate the average return on sampling effort. We used two indices of visual survey effort for this exercise: 1) elapsed monitoring time · # of observers^{-1}, and 2) the total number of hours spent monitoring ('observational hours') - # of observers * elapsed time sampling. In addition, we used trap survey data to evaluate the utility of trap deployment, aggregated by trap night, for monitoring turtle populations.

We used resampling simulations for each unit of effort (visual and trap surveys) to evaluate variability in our estimates of return on effort (Catch per unit effort: CPUE). For each unit of effort the estimated range of CPUE was based on 1000 simulated sampling surveys drawn from observations among visual and trap survey years (1996-2015 and 2005-2015 for visual and trap surveys, respectively).

In our analyses we made several assumptions. First we only used counts of late juvenile and adult turtles (19+ years) and we assume that all turtles within this age range were available during all sampling events. These assumptions can be modified, but for now they offered a pragmatic first step given the relatively small dataset available for McGowan's lake.

Visual surveys (1996-2015)

We show that when observers are sampling for over two hours there is a large jump in the likelihood they will observe more turtles (Figure 1). Similarly, we show that sampling events of over 6 hours shows a higher likelihood that more turtles will be observed (Figure 2). Extending this analysis, we calculated the number of unique turtles observed in each year respective to the sampling effort. Year after year it appeared that the number of turtles observed asymptoted at ~23 unique turtles. This observation was only made when sampling effort exceeded 100 people hours (Figures 2-5).

Next we combined the sampling effort among all years to see how the accumulated effort year to year resulted in the detection of unique turtle IDs. We ran a segmented regression to identify the breakpoint where the return on sampling effort begins to plateau. We show that after 100 observational hours (2006-2007) the observation of new turtles begins to plateau adding only a few turtles' year to year, presumably new recruits. This suggests that it could take up to 2.5 years to observe the majority of adults in the population based on the average sampling effort of ~75 observational hours (Figure 6). We estimate that it would take ~880 observational hours to observe all 52 unique turtles of the specified age range in the population. This could represent approximately a decade of sampling based on the average observational period from 1996-2014 (Figure 7). However, this result does not take into account the fact that new turtles are emigrating into the population and were therefore not available for sampling in years previous.

Trap surveys (2005-2015)

We show that the there is a positive correlation between the number of traps set and the number of unique turtles censused (Figure 8). Similarly, the longer the trap set the increased likelihood more turtles will be observed (Figure 9). Overall, 0.17 (sd: 0.52) turtles were captured on average per trap night ranging 0.03 to 0.36 in 2007 and 2013 respectively (Figure 10). Since 2011 the number of turtles captured per night has remained relatively stable (Figures 10 and 11). West bog had the highest number of turtles on average per trap night (Figure 12), with the highest catch rates observed in the McGowan's Lake survey overall (CPUE=4; Figure 11). No turtles were captured in any sampling year in the Albany New and Mount Merrit Brook sampling areas (Figure 12).

In total 64 unique adult turtles were captured in McGowan's Lake between 2005 and 2015. When the cumulative number of unique turtles are calculated from 2005 through 2015, aggregated sequentially by date, it can be demonstrated clearly that the number of traps deployed (as inferred by trap nights) scales positively with the number of unique turtles observed (Figure 13) agreeing with aggregate estimates (Figure 8). Only in 2015 did the trap survey appear to plateau (Figure 14). Data sampling suggests that only in sampling years where the number of trap nights exceed ~150 did the estimate of turtles within McGowan's Lake appear to plateau (Figure 14). Overall, turtles tend to be captured with higher efficiency in mid-summer (mid July to August; Figures 14 and 15).

Summary

This analysis presents a first look at the how sampling effort is related to population assessment. Currently the data within a given assessment year is insufficient to simulate the how changes in monitoring effort could influence the ability to accurately census and detect changes in the McGowan's Lake population. Currently, the analyses are based on the assumption that the turtles observed between 2005 and 2015 were equally available/probable to be sampled during each sampling year. This assumption does not account for the fact that new turtles emigrate to, and migrate from, the McGowan's Lake population. Estimates of population size, potentially varying per year, and integration of turtle age, and thus catchability, would be needed to build this work into a predictive modelling framework.

Results

Visual survey

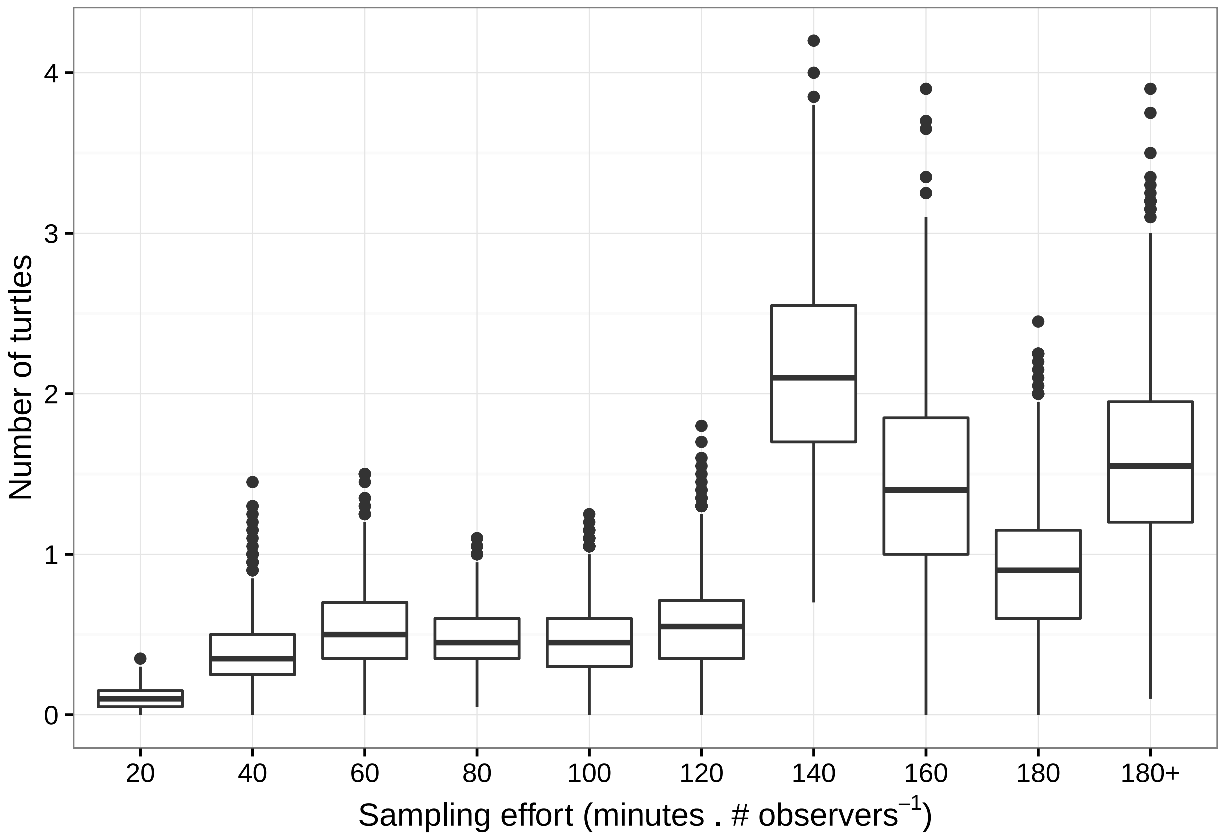

Figure 1: Number of Blanding's turtles(*Emydoidea blandingii*) observed as a function of sampling effort (total time . number of observers^-1). Data derived from 1000 simulated sampling events based on observations between 1995 and 2015

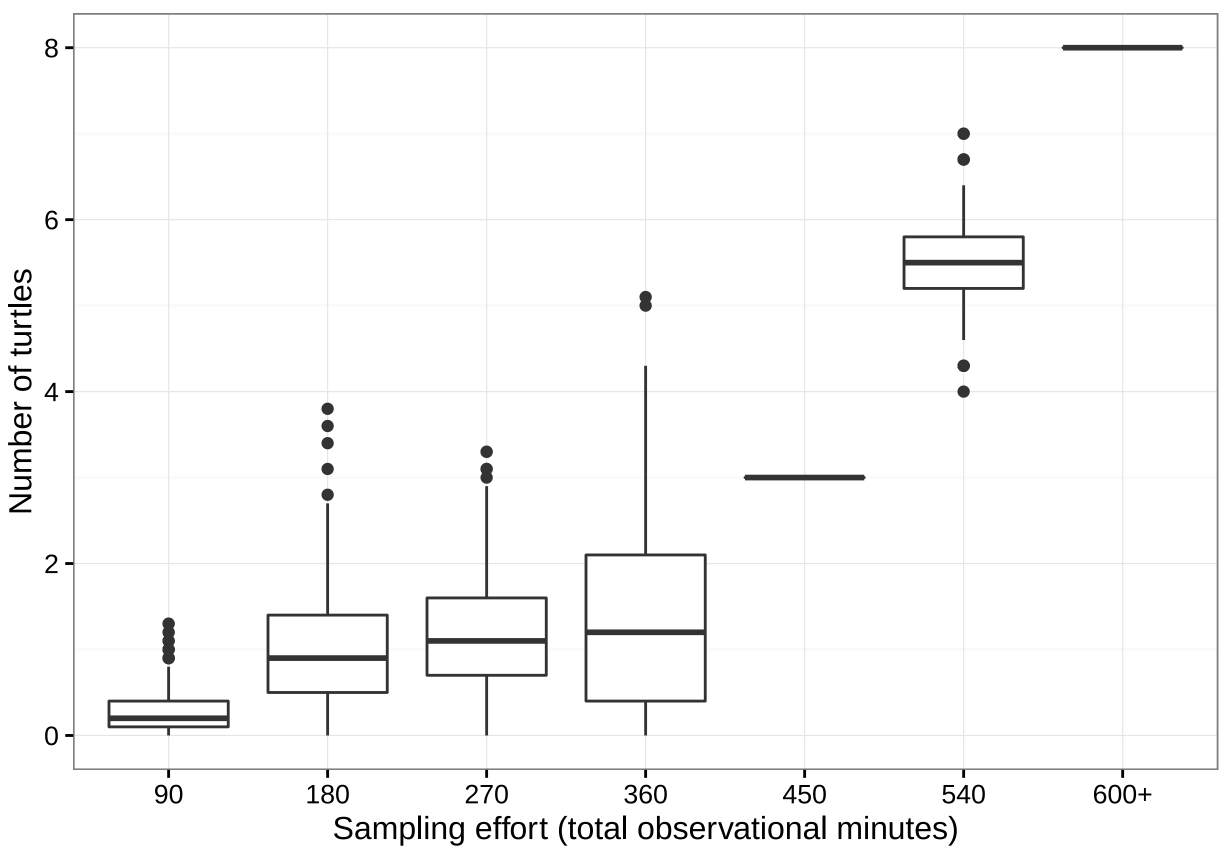

Figure 2: Number of Blanding's turtles (*Emydoidea blandingii*) observed as a function of sampling effort (total # of people minutes). Data derived from 1000 simulated sampling events based on observations between 1995 and 2015

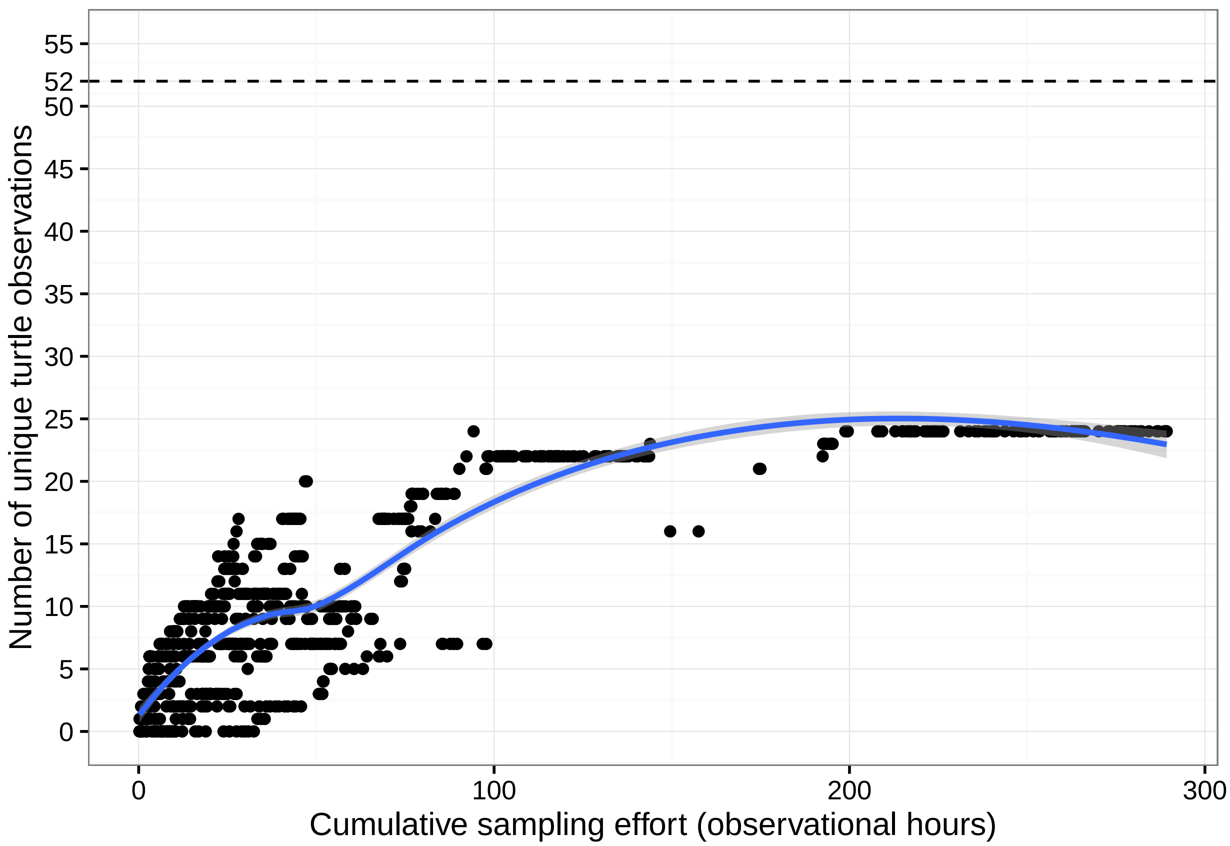

Figure 3: Number of unique turtles versus the total cumulative sample time within each sample year (1996:2014). Dashed line represents the total number of unique turtles observed throughout the sampling period (1996:2015). Note effort is cumulative in chronological order from the beginning of monitoring in 1996. 2015 excluded because of extended sampling season.

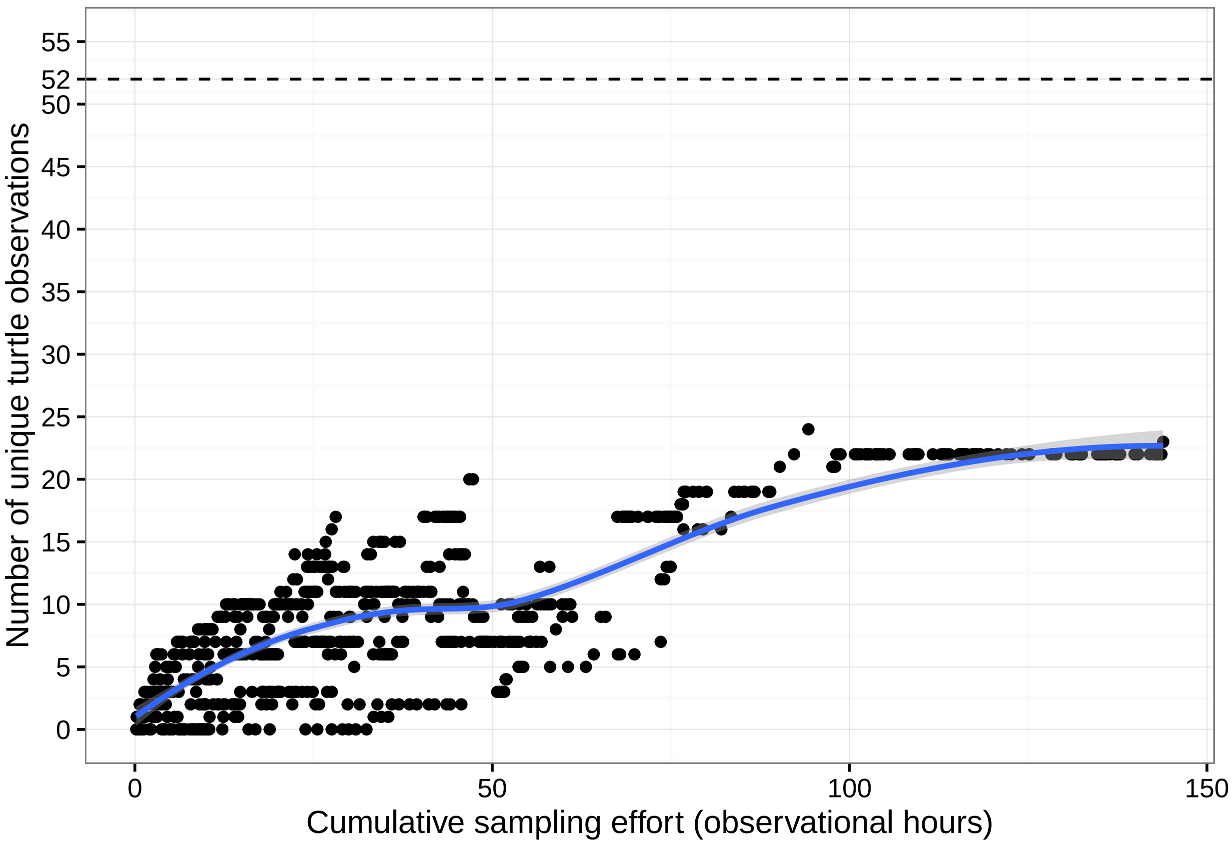

Figure 4: Number of unique turtles versus the total cumulative sample time within each sample year (1996:2015). Dashed line represents the total number of unique turtles observed throughout the sampling period. Note effort is cumulative in chronological order from the beginning of monitoring in 1996.

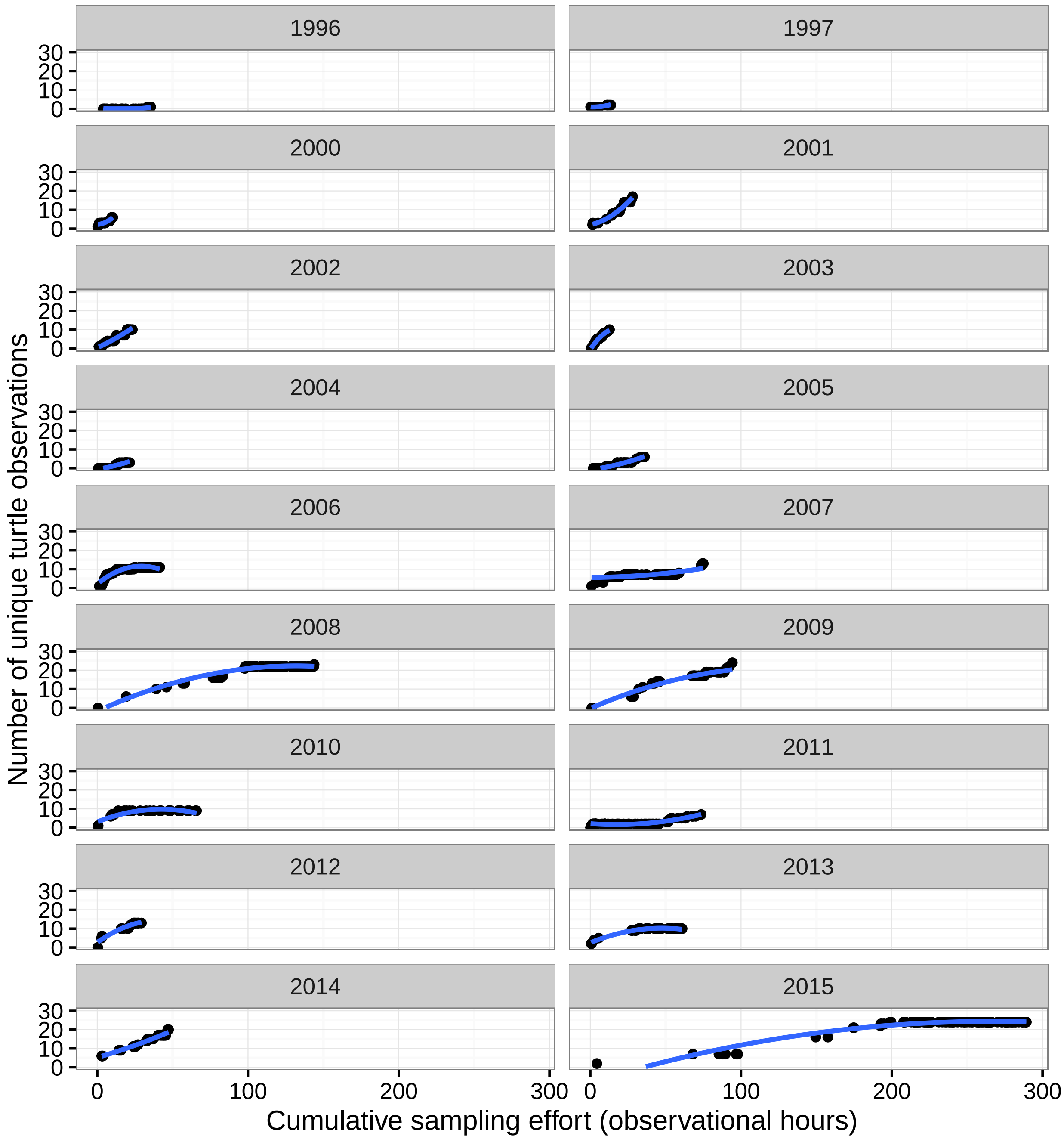

Figure 5: Number of unique turtles versus the total cumulative sample time within each sampling year (1996:2015).

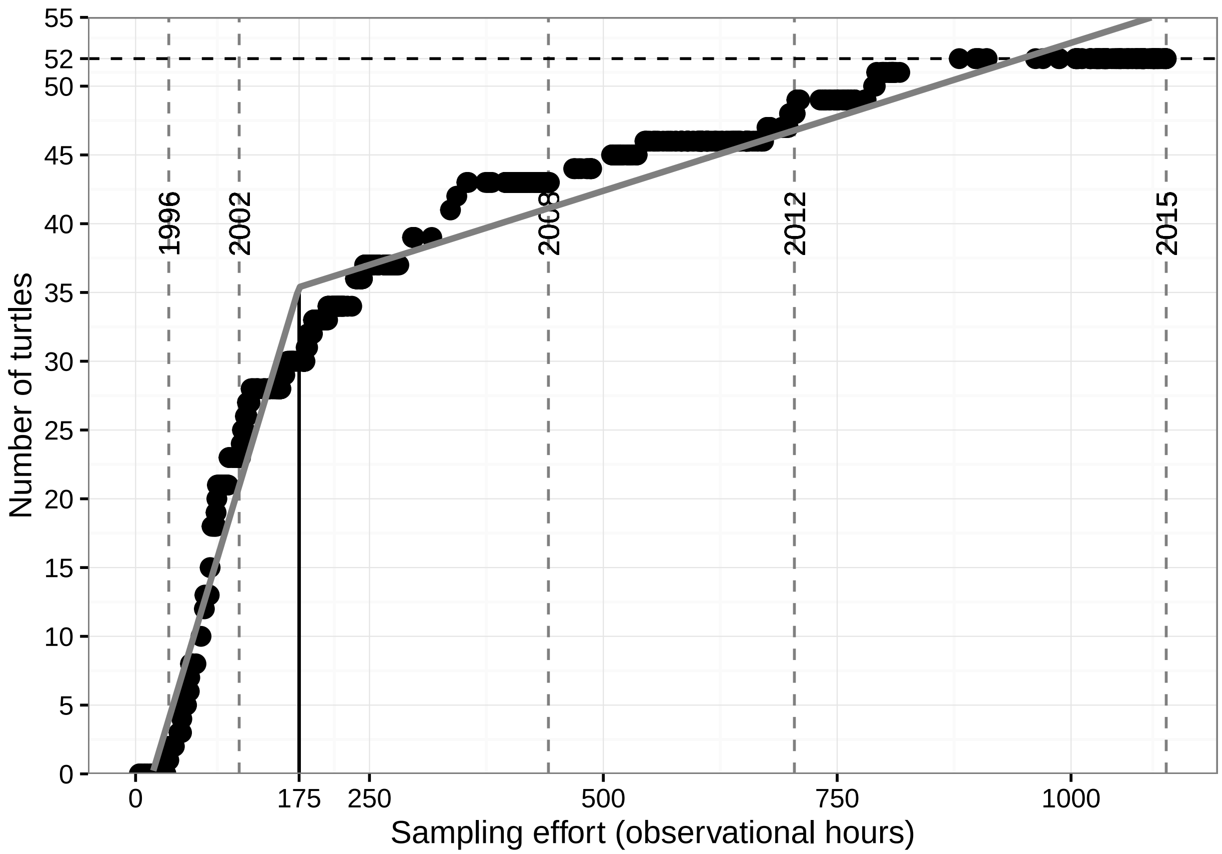

Figure 6: Number of unique turtle captures versus sampling effort (total people hours) for each sample event. Horizontal dashed line represents the total number of unique turtles observed in McGowan's lake. Vertical solid line represents the point of inflection as estimated by a segmented regression analysis (grey line). Dashed grey vertical lines represent the cumulative sampling effort on the respective year. Note effort is cumulative in chronological order from the beginning of monitoring in 1996.

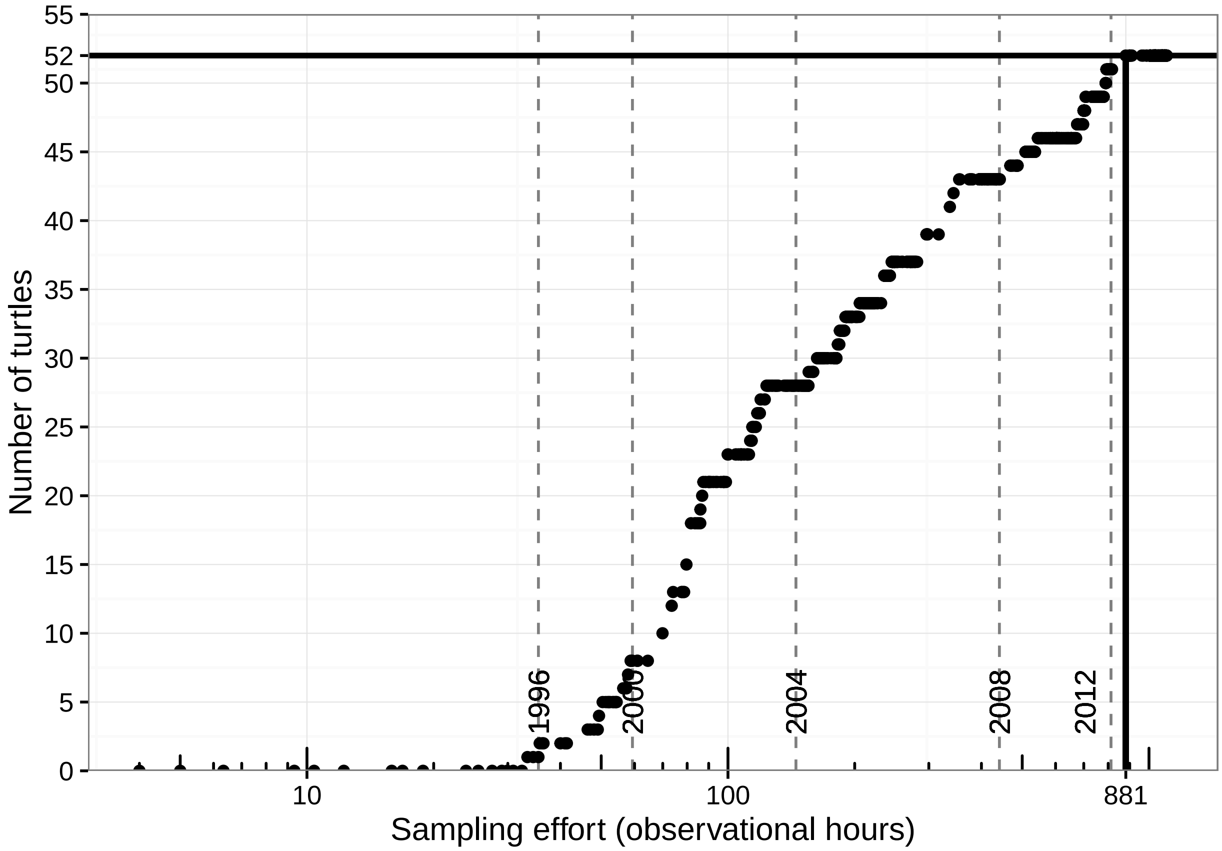

Figure 7: Number of unique turtle captures vs. sampling effort (total people hours) for each sample event. Vertical solid line represents the point where all turtles have been observed (n=52; horizontal solid line). Dashed grey vertical lines represent the cumulative sampling effort on the respective year. Note effort is cumulative in chronological order from the beginning of monitoring in 1996.

Trap survey

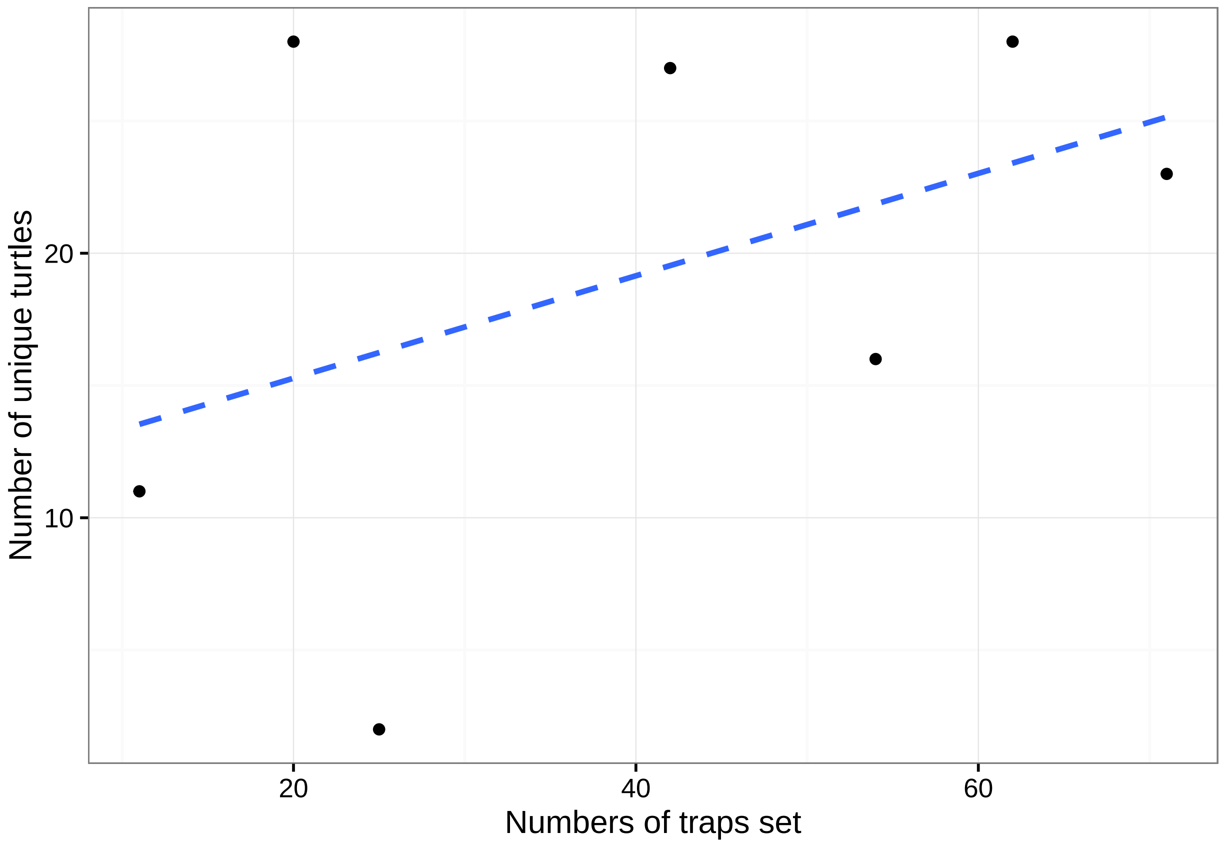

Figure 8: Number of unique Blanding's turtles(*Emydoidea blandingii*) observervations as a function of sampling effort (# traps*year^-1). Data derived from 1000 simulated sampling events based on observations between 1995 and 2015

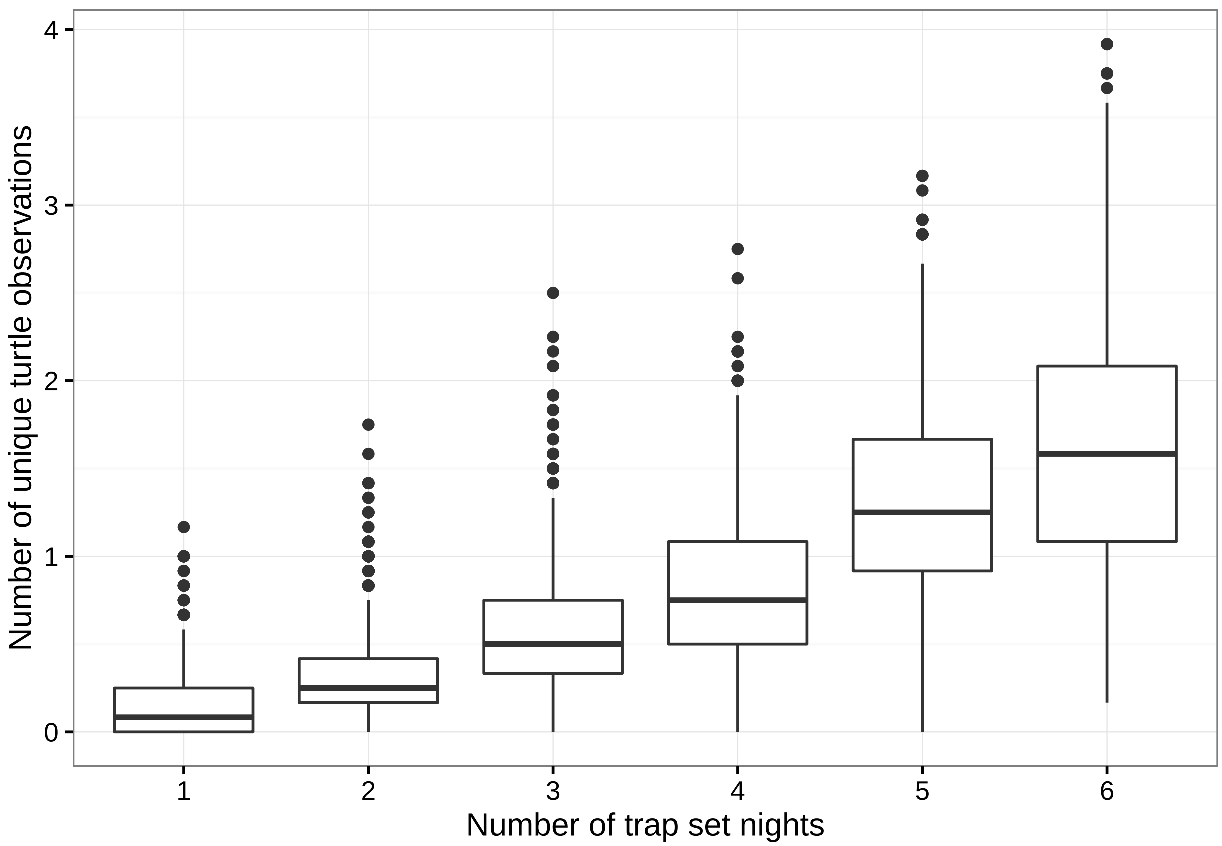

Figure 9: Number of unique Blanding's turtles (*Emydoidea blandingii*) observervations as a function of the number of traps set. Data generated through 1000 simulations cumulative unique turtles per day and trap set among all yeears asampled (2005:2015)

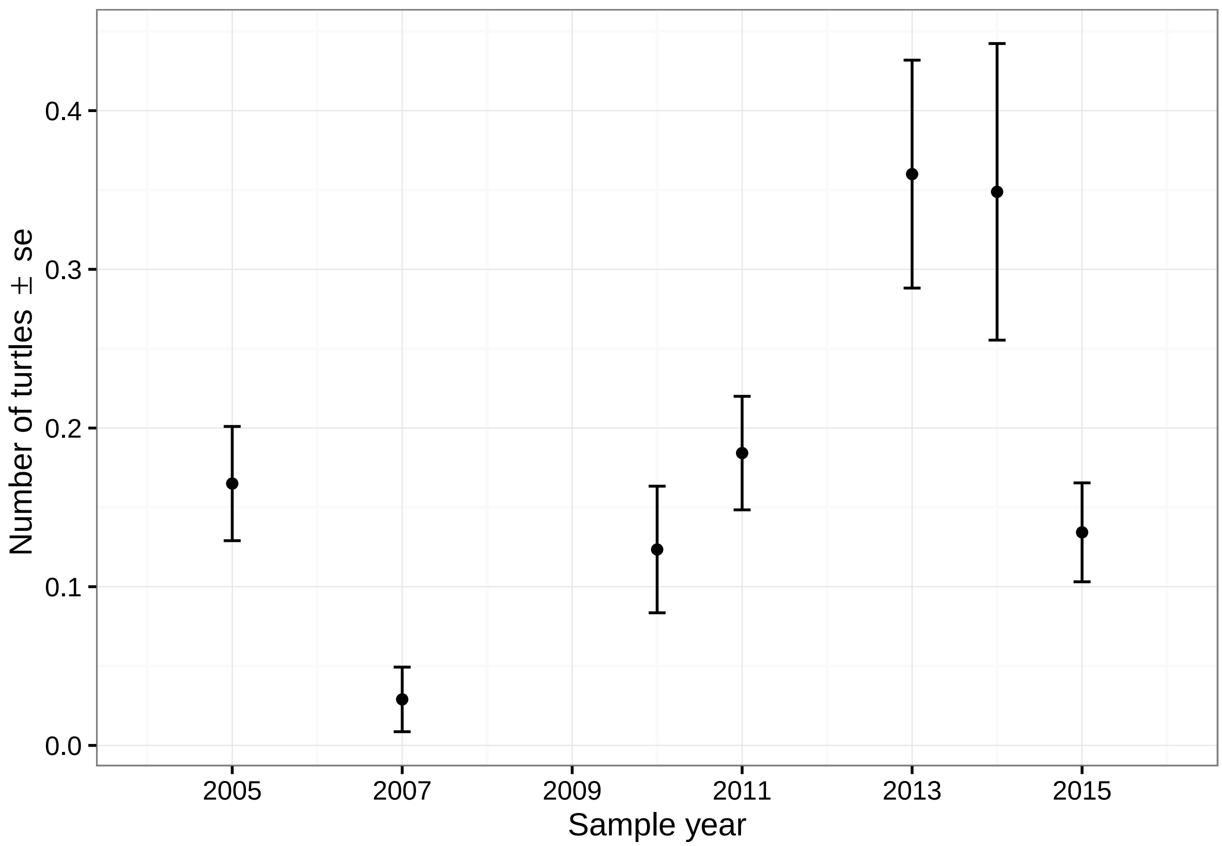

Figure 10: Average CPUE as a function of the sample year within McGowan's Lake assessment area

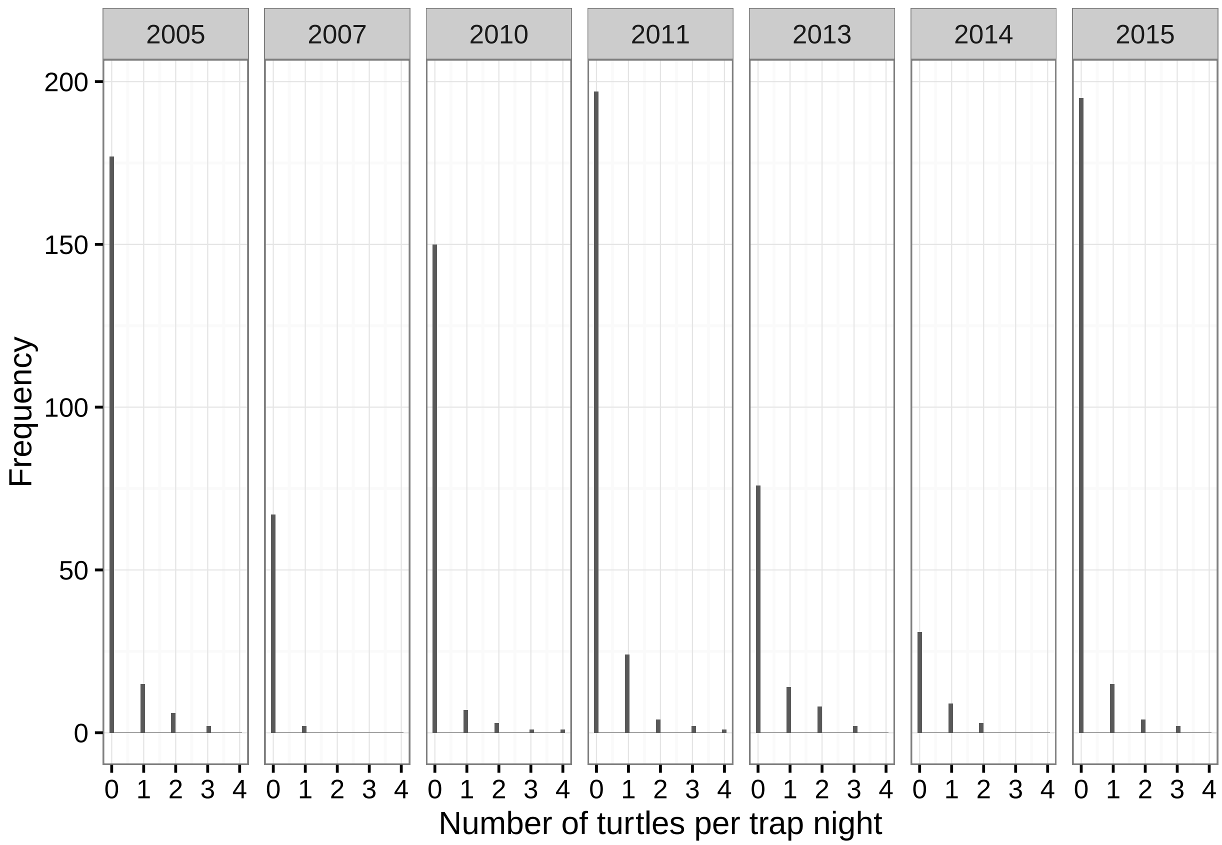

Figure 11: Frequency of turtle CPUE as a function of the sample year within McGowan's Lake assessment area

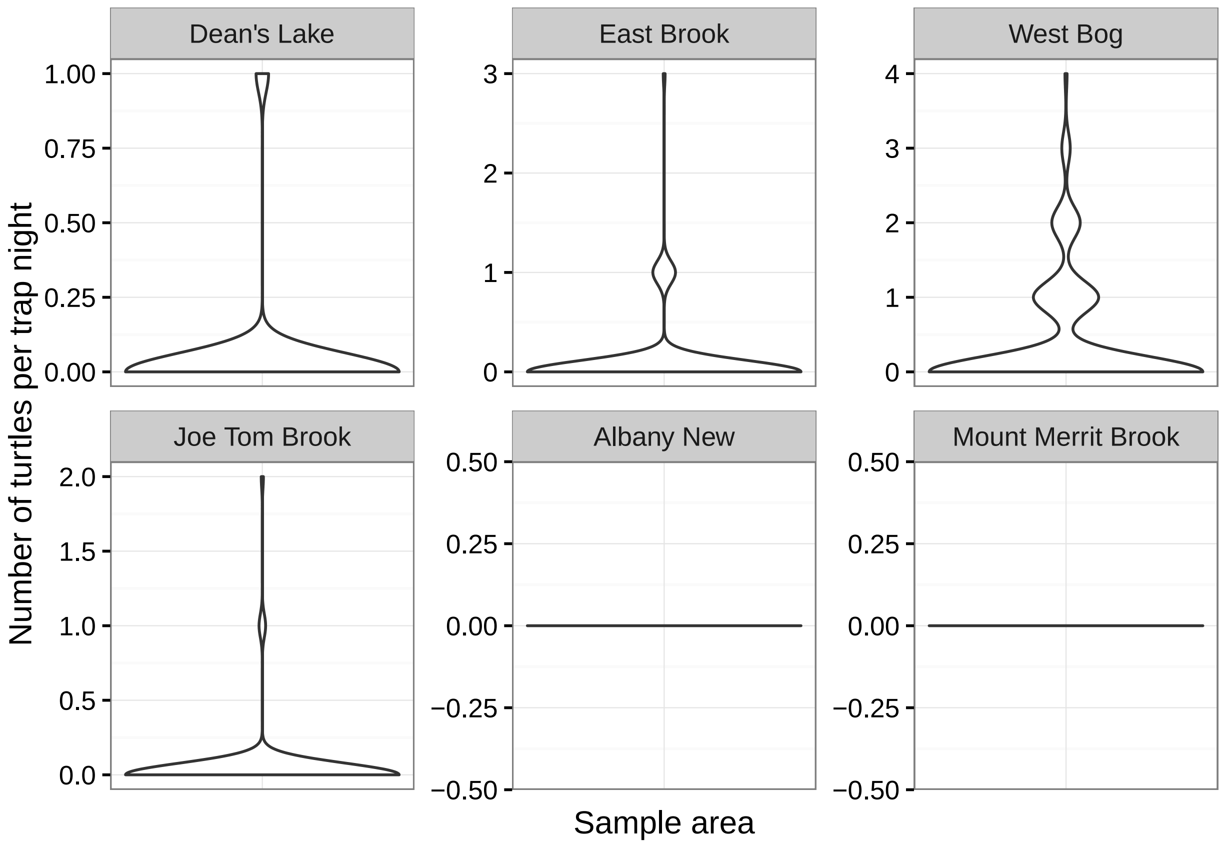

Figure 12: Turtle CPUE as a function of sample area within McGowan's Lake.Data presented as a violin plot with the width of the polygon scaling with the relative density of the observed CPUE.

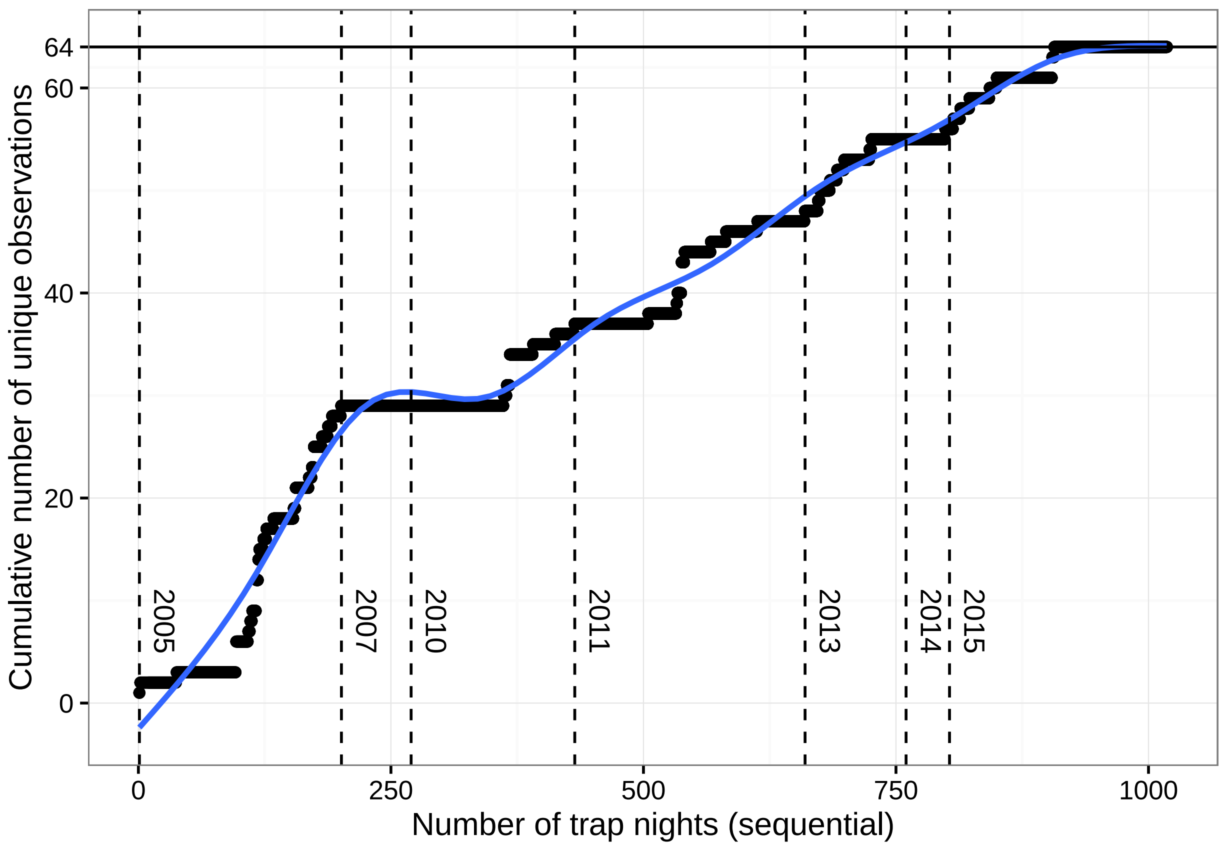

Figure 13: Cumulative number of unique Blanding's turtles (*Emydoidea blandingii*) observervations as a function of the number of trap nights. Dashed lines represent the start of sampling for each sample year and the solid horizontal line represents the total unique turtles observed over the entire monitoring period. Blue line fitted as loess regression

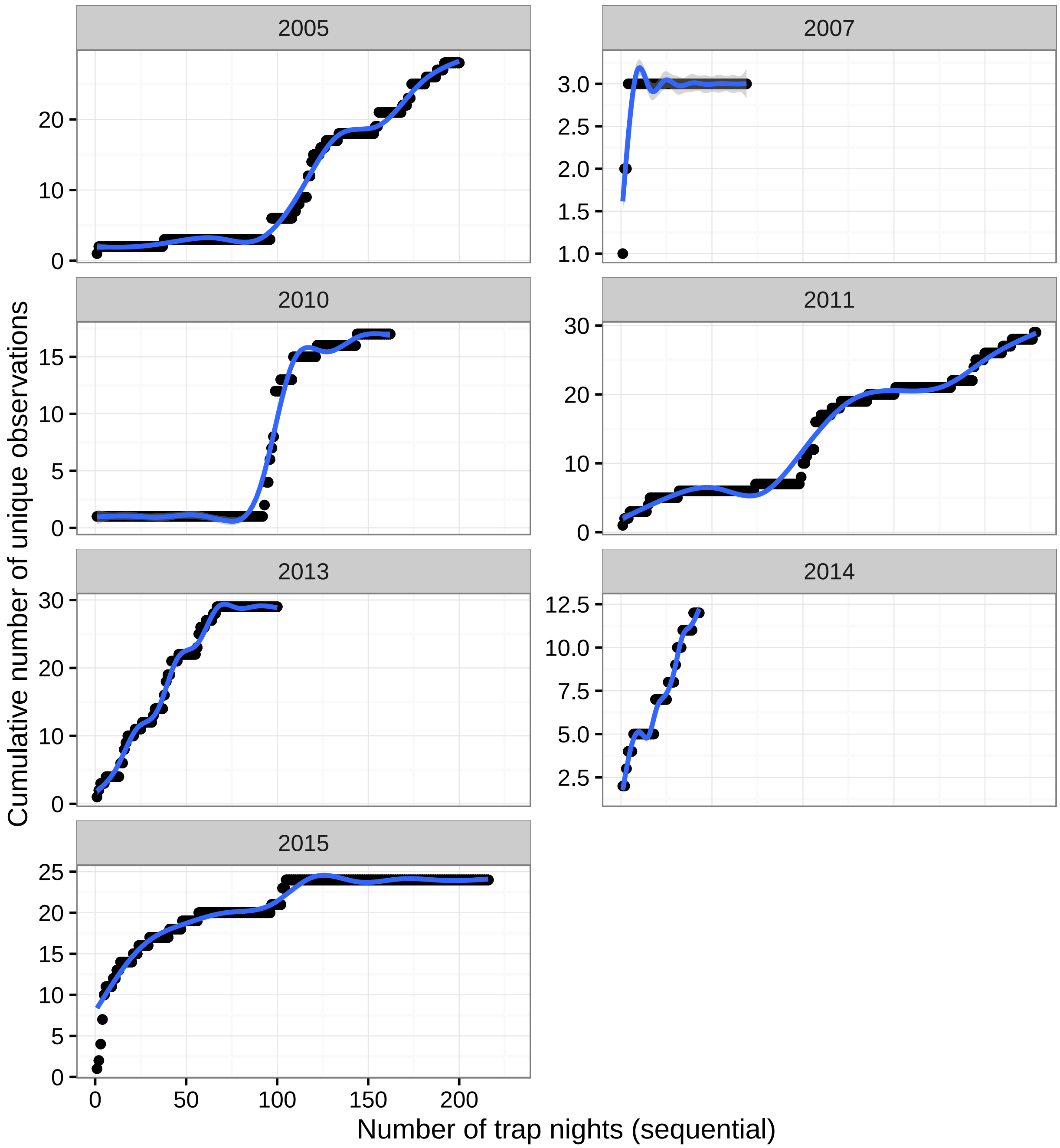

Figure 14: Cumulative number of unique Blanding's turtles (*Emydoidea blandingii*) observervations as a function of the number of trap nights within a year. Dashed lines represent the start of sampling for each sample year and the solid horizontal line represents the total unique turtles observed over the entire monitoring period. Blue lines fitted as loess regressions within each year

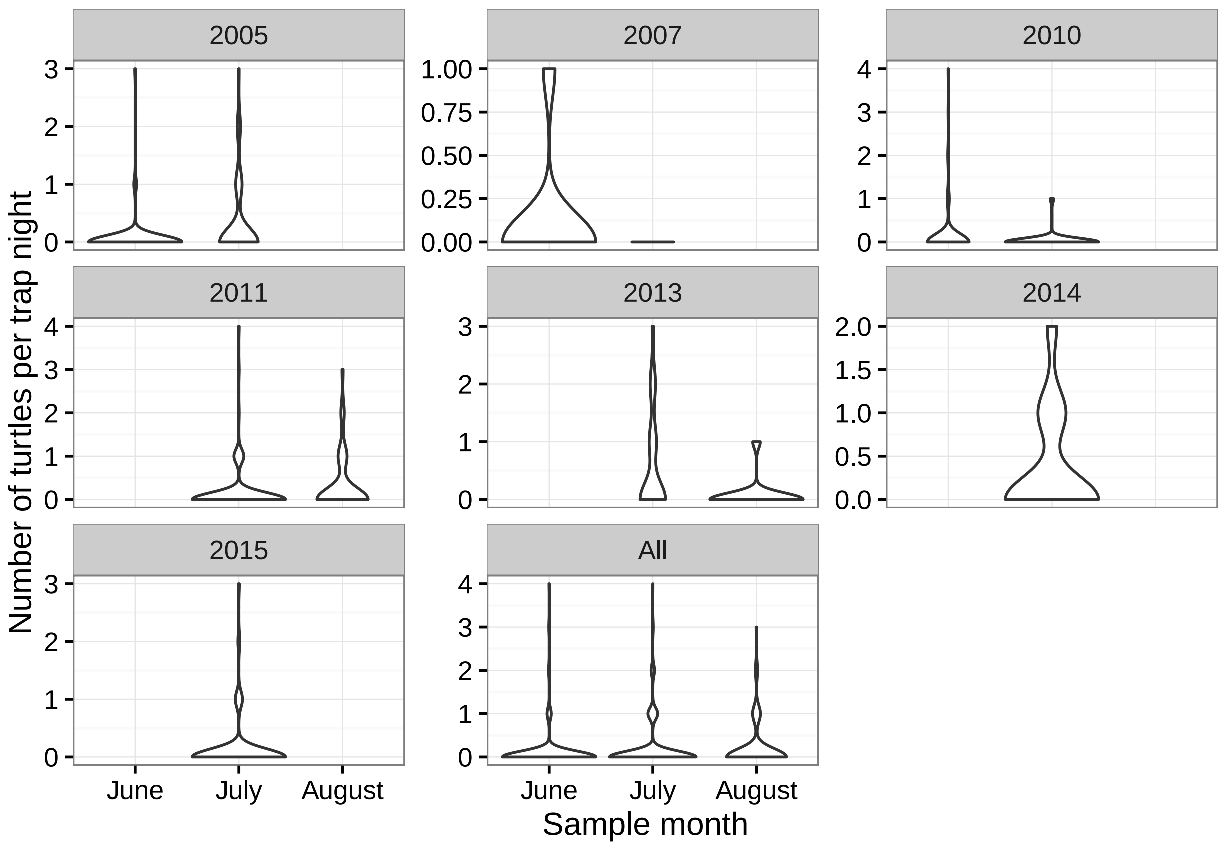

Figure 15: Turtle CPUE as a function of the sample year and month within McGowan's Lake assessment area. Data presented as a violin plot with the width of the polygon scaling with the relative density of the observed CPUE.