NORTH DAKOTA GAME AND FISH DEPARTMENT

Final Report

Population and Status Assessment Strategies Applied to a Management Plan for the Snapping Turtle *Chelydra serpentina* in North Dakota

Project T-29-R-1

February 15, 2011 – December 31, 2013

Terry Steinwand
Director

Submitted by Greg Link
Chief, Conservation and Communications Division
Bismarck, ND

June 2013

Population and Status Assessment of the Snapping Turtle *Chelydra serpentina* in North Dakota

A Thesis

Presented in Fulfillment of the Requirements for the

Degree of Masters of Science

with a

Major in Environmental Sciences

in the

College of Graduate Studies

University of Idaho

By

Christopher D. Dekker

February 2014

Major Professor: Dennis L. Scarnecchia, Ph.D.

Authorization to Submit Thesis

This thesis of Christopher Dekker, submitted for the degree of Master of Science with a Major in Environmental Science and tilted "Population and Status Assessment of Snapping Turtles *Chelydra serpentina* in North Dakota," has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

Major Professor:

______________________________ Date: ____________
Dr. Dennis Scarnecchia

Committee
Members:

______________________________ Date: ____________
Dr. Brian Dennis

______________________________ Date: ____________
Dr. Luke Harmon

______________________________ Date: ____________
Dr. Patrick Wilson

Department
Administrator:

______________________________ Date: ____________
Dr. Jan Boll

College of Liberal
Arts and Social
Sciences
Dean:

______________________________ Date: ____________
Dr. Katherine Aiken

Abstract

Research was conducted on snapping turtles in North Dakota from 2012-2013. State-wide distribution was determined through use of the North Dakota fisheries database, North Dakota Game and Fish personnel, U.S. Fish and Wildlife refuge personnel, and sampling conducted in areas where no information on presence. Population estimates, age structure, and growth models were done for three intensively studied lakes which are Lake LaMoure, Nelson Lake, and Patterson Lake. The population estimate for Lake LaMoure was 48 turtles, 10 turtles for Nelson Lake, and 10.44 for Patterson Lake. The age structure for each lake shows mostly adult turtles with very few juveniles. Growth curves were constructed using Von Bertalanffy growth equations for length and weight at age. Turtles at Lake LaMoure were tracked to overwintering locations. Nesting locations were also located for snapping turtles at Lake LaMoure. Harvest surveys were sent out to 10,000 fishing license holders in North Dakota. 733 individuals responded to the survey with 13 stating they had harvested snapping turtles and harvested 55 turtles. A sampling protocol and management plans were also laid out for North Dakota Game and Fish. They involve steps the state should take to monitor the snapping turtle population and options they can consider to help preserve the existing turtle populations.

Acknowledgments

I would like to thank the state of North Dakota for funding the research project. I would also like to thank Patrick Isakson for his support and help. I would especially like to thank Fred Ryckman for his support whenever called upon. A special thanks to my advisor Dennis Scarnecchia, without whom none of this would have been possible. His support and help was greatly appreciated and made this a memorable experience. I would also like to thank my technician Zach Kjos. Zach was an amazing assistant; he worked through whatever I threw his way. He helped to make this project a success.

Dedication

I would like to thank my wife Mallory for her constant support while I pursued my masters at the University of Idaho. It was not easy being 1,000 miles apart, but she always stood by my side. She also came to North Dakota for both of my field seasons, the first on just days after our wedding, and assisted whenever I needed her help. Thank you to my parents for your support, you helped in so many ways to make this possible. Thank you for always believing in me. To Elliot Reams, thank you for friendship, the many adventures around Idaho and for braving the sub-zero North Dakota winter with me to try and find turtles. I would have probably gotten myself killed had you not been there. Thank you R.J. Hemmingway for your friendship, help, and advice, it was always appreciated and many times needed. I would also like to thank the other graduate students who have been there as friends always willing to help and give advice.

Table of Contents

List of Tables

List of Figures

Introduction

The snapping turtle (*Chelydra serpentina,* Family Chelydridae), is one of the earliest of the chelonians, an ancient survivor, and one of two species in the genus extant in North America. It is characterized by an olive drab color, large body, slightly rounded carapace, large head, powerful jaws, powerful limbs with webbed feet, and forelimbs covered with scales (Pritchard 1979; Ernst et al. 1994). Its distribution extends from southern Canada to the Gulf of Mexico and westward to the Rocky Mountains. Typical snapping turtle habitat consists of sluggish rivers and a variety of various standing waters, including lakes, reservoirs, ponds and marshes (Pritchard 1979). In addition to being an important component of many waters, the snapping turtle also has potential as a useful biomonitor for contaminants in aquatic systems (Bonin et al. 1995; Overman and Krajicek 1995).

Snapping turtle life history is characterized by slow growth, late age at maturity, iteroparity, low adult mortality and a long lifespan (Gibbons 1987). The adaptiveness of this protracted life history strategy is strongly dependent on a consistently low mortality rate among adult turtles (Brooks et al. 1991). Like many long lived species, its life history characteristics make the species vulnerable to overharvest (Pritchard 1980; Brooks et al. 1991). Adequate recruitment is necessary at sufficiently regular intervals to maintain the populations; enough turtles must reach a sufficiently large size to where their natural mortality rate becomes low and remains low (Pritchard 1980; Galbraith and Brooks 1987; Brooks et al. 1991). Any unnatural factors such as highway deaths (Haxton 2000; Gibbs and Steen 2005), pollution, unnaturally-high predator mortality, or overharvest that affect adult turtles can have serious impacts on turtle population sizes, reproductive success and population viability. Habitat destruction or alterations can reduce nesting and rearing success and can reduce juvenile survival, adult survival, and recruitment (Musick 1999). With such a long-lived, slowly-developing species, the negative impacts may be ongoing and not easily detectable until well after populations have begun to decline, even in some cases to eventual extirpation (Congdon, 1994; Musick 1999). Achieving adequate recruitment, maintaining adequate turtles of reproductive age and creating and maintaining overall habitat conditions that result in low adult mortality are thus critical to species survival (Brooks et al. 1991).

Information from various investigations suggests that long-term sustainability of snapping turtles may be less certain for populations in the more northerly portions of their range, such as in Ontario or North Dakota. Abundance and densities of snapping turtles are typically much higher in the southerly areas (Galbraith et al. 1988). In the north, where turtles have a more protracted life history than farther south, age at maturity may be 20 or more years (Congdon et al. 1994; Galbraith et al. 1989) compared to 4-10 years in more southerly populations. In addition, individuals from more northerly populations may not reproduce each year and devote less than maximum energy to each reproductive event, on the basis that they will reproduce numerous times through their life, which may exceed 40 years (Ernst, 1994; Galbraith, 1989). The slow strategy can be adaptive over evolutionary time in northern localities such as North Dakota, but its adaptiveness can be seriously compromised where human development and resulting rapid changes in habitat conditions (Congdon et al. 1994) leadi to increases in adult mortality (Brooks et al. 1991).

The eastern snapping turtle, the subspecies found in North Dakota, is designated a species of conservation priority in that state and is the subject of this study (Johnson 2010). Although snapping turtles had been documented as occurring widely throughout the state (United States Department of the Interior 2006), little was known about the behavior, life history, population size, growth, age structure, and what specific waters they inhabit. The current interpretation of snapping turtle harvest regulations in North Dakota is that if a person is angling and catches a snapping turtle, the angler is permitted to keep two such turtles a year. However, any person can harvest an unlimited number of turtles a year by non-angling methods such as capture by hand, capture by net, bow fishing, harpoon, or firearms (Patrick Isakson, North Dakota Game and Fish Department (NDGF), Personal Communication).

In the past century in North Dakota, reservoir and lakeshore development, stream and river modifications (including channelization, sedimentation, and dewatering), other agricultural impacts, oil and gas production, and other developments have rapidly modified landscapes and aquatic habitats for snapping turtles (Angradi et al. 2004). Oil and gas development are major activities in the western half of the state; agriculture dominates the eastern half. Both activities can negatively affect snapping turtles.

A scientifically-supported management plan is needed for snapping turtles in North Dakota, one based on an understanding of the status of the species and factors affecting reproductive (nesting) success, juvenile survival, growth, recruitment and adult mortality. Important mortality factors affecting turtles include predation, harvest, and being crushed by vehicles on roads (Ernst 1994). Little is known about current harvest rates in North Dakota. In assessing status of snapping turtles in North Dakota, four key ecological aspects where more information is needed are availability suitable habitat for nesting and hatching, habitat requirements for overwintering, growth patterns, and the current age structure. Intensive efforts to identify suitable nesting and hatching sites and characterization of those habitats would make it easier to identify such sites in other localities where intensive studies cannot be done. A major knowledge gap exists on factors affecting overwinter survival and how a combination of North Dakota winters and habitat changes may affect it. Studies show that in general, turtles form groups during winter (Meeks and Ultsch 1990; Steyermark et al. 2008). Growth rates and age structure information can be related to survival and nest success.

For effective management of snapping turtles ion North Dakota, more information is needed on life history, distribution, demographics, and harvest. As a species of great ecological and evolutionary importance but limited direct economic importance, an ongoing status assessment must necessarily be conducted in a cost effective way. The objectives of this study were to: (1) Estimate length weight relationships, age structure, growth and population size in three reservoir systems (2) Determine overwintering locations, and nesting areas; (3) Determine and characterize statewide distribution at the county level; and (4) Estimate snapping turtle harvest by fishing license holders in North Dakota. In meeting these research objectives, it would enable me to better meet the two management-level outcomes of the project I was charged with: (1) developing an assessment protocol for long-term monitoring that could be incorporated into ongoing regional fisheries sampling by NDGF personnel, and (2) assisting NDGF in developing a framework management plan for the species and other turtles.

General Background on Snapping Turtles

This study focused on the common snapping turtle found in North Dakota. The names common snapping turtle (*Chelydra serpentina)* and eastern snapping turtle (*Chelydra serpentina*

serpentina) are used interchangeably in the literature (Steyermark et al. 2008; Ernst 1994). For the purpose of this study all specimens will be referred to as common snapping turtles (*Chelydra serpentina*).

Taxonomy, biogeography, and distribution

Fossil records place some of the early ancestors of the family Chelydridae in the Late Cretaceous period (Steyermark et al. 2008). The common snapping turtle can be traced to the Pliocene and Pleistocene (Devender and Tessman 1975; Hibbard 1960; Holman 1964). Fossil records indicate the turtles were once present west of the Great Divide (Devender and Tessman 1975; Hibbard 1960; Holman 1964), although they were not native there at the time of their scientific descriptions. Possible causes of the extirpation of common snapping turtles west of the Rockies include climate change and the reduction of water on the landscape, because places where fossil records are found east of the Rockies have extant populations (Devender and Tessman 1975; Holman 1964), There are two living subspecies on the North American continent, *Chelydra serpentina serpentina* (the eastern snapping turtle) and *Chelydra serpentina osceola* (the Florida snapping turtle; Steyermark et al. 2008).

Life history and habitat requirements

Snapping turtle reproduction occurs in late spring and early summer, depending on the latitude, with spawning typically occurring later farther north (Obbard, 1987; Ernst, 1994). Female snapping turtles have been documented migrating to nesting sites; males have been documented patrolling their home ranges during the spring and moving to natural migration bottlenecks to intercept females on their way to nesting sites in order to mate with them (Brown, 1993). In some cases the nesting site might be the bank of the water body in which the individual resides, whereas in other cases females may travel up to several kilometers away from their home body of water to find a suitable site (Obbard, 1980). One study conducted in Ontario, Canada showed an average migration of 5.3 km away from a nesting site after eggs were laid (Obbard and Brooks 1980). Most females use waterways as migration corridors to suitable nesting sites. When water corridors are absent, they have been recorded crossing land to get from one body of water to another (0.05 km overland movement; Obbard and Brooks 1980).

Whether courtship occurs, and to what extent, seems to vary widely among snapping turtle populations. In some cases the male may mount the female without any preceding courtship (Ernst, 1994). In other cases they have been documented performing courtship behaviors on the bottom by mirroring each other's neck movements or by inhaling and up-heaving water (Taylor 1933; Legler 1955; Ernst et al. 1994).

Female snapping turtles use many natural and human-created sites for nesting. Females often prefer open areas of loam, loose sand, or vegetative debris with little to no live vegetative cover on the soil surface (Steyermark et al. 2008). Both natural and unnatural sites are used, including sawdust piles at old mills, fire lanes, shoulders on roads, railroad beds, yards, agricultural fields, shorelines, sandbars, muskrat houses, beaver dams and lodges, gardens, and private driveways (Ernst et al. 1994; Steyermark et al. 2008). The large variety of possible nesting locations can make finding nesting sites difficult for researchers. Clutch size varies by latitude and by the size of females, ranging from 6 to 104, getting larger with increasing latitude and body size. The size of the eggs varies from 23-33mm in diameter and round in shape (Ernst et al. 1994; Steyermark et al. 2008).

Once females have oviposited and buried the eggs they migrate from the nesting areas, the newly deposited eggs are left to hatch (Obbard and Brooks 1980; Ernst et al. 1994; Steyermark et al. 2008). The eggs that make it through to hatching have their sex determined through temperature dependent sex determination (TSD). Male snapping turtles are produced at temperatures below 28°C, females are produced at temperatures above 28°C, and it is believed that at 28°C a 1:1 ratio of males to females would be produced (Janzen 1992). With TSD long term warming or cooling trends can impact populations through soil moisture and temperature changes, skewing sex ratios, and thereby future reproductive potential. Eggs hatch in 60 to 90 days depending on incubation temperature (Janzen 1992; Yntema 1978). Studies have not conclusively shown what mechanism hatchlings use to find their way to water. Robinson's (1989) extensive review of other dispersal theories and her research led to the conclusion that movement downhill with gravity may be the main mechanism for finding water.

Habitat preferences change somewhat with age and size. Hatchling and small juvenile snapping turtles are believed to prefer small streams and then move into the lakes and ponds when they are close to maturity (Graves 1987). Both adults and juveniles are commonly found in and around obstructions, buried in mud, and in often times less than one meter of water (Froese 1978; Graves et al. 1987). When confined in such habitat turtles have to use very little energy to carry out basic functions, such as breathing, food acquisition, and hiding from threats. The optimum water temperature for snapping turtles is 28.1^{0}C, with a maximum of 39.5°C (Graves et al. 1987; Hutchison et al. 1966). Adult snapping turtle habitat consists of shallow, still or slow-moving water full of obstructions (Froese 1978; Graves et al. 1987).

Food habits of snapping turtles vary across their range. Studies from more southern localities show a heavy reliance on aquatic vegetation as food (Aresco and Gunzburger 2007). Other studies of turtle diets indicate highly omnivorous and opportunistic feeding habits. These diets have consisted of aquatic vegetation, fish, birds, terrestrial insects, aquatic insects, amphibians, crustaceans, and carrion (Graves et al. 1987; Pritchard 1979; Richmond 1936). The diet that included terrestrial insects was an isolated incident in which a large hatch of cicada (family Cicadidae) had occurred (Richmond 1936), but the result indicates how opportunistic snapping turtles are. Prey acquisition in adult snapping turtles is generally done by ambushing prey; they generally wait without moving until the prey is in range, striking with quick bites (Ernst 1994). Hatchling snapping turtles will pursue their prey whereas adults typically rely on ambush (Steyermark et al. 2008).

In northern localities where ice forms on lakes and they stay frozen for months, finding suitable overwintering habitat is a critical part of survival. The time at which snapping turtles move to their hibernacula sites and entered into a dormant cycle for the winter varies depending on the latitude. In northern parts of their range they may become dormant as early as October while farther south it may be December. They may not come out of dormancy until May in the north and as early as February in the south (Obbard and Brooks 1981). Snapping turtles can often be found overwintering in groups (Meeks and Ultsch 1990). Meeks and Ultsch (1990) suggest that snapping turtles may have limited numbers of overwintering sites throughout their home range and this may be one reason why they tend to overwinter in groups.

Mortality and limiting factors

Effective management of snapping turtles requires knowledge of factors causing juvenile and adult mortality. Snapping turtle eggs, hatchlings, and juveniles less than 2 years of age experience higher mortality rates than older juveniles and adults (Congdon, 1994). Predation on snapping turtle eggs can be extremely high throughout its range. Studies have shown that nest predation can claim as much as 60% or more of nests each year (Hammer, 1969). Nest predators include numerous vertebrates including, skunks (family Mephitidae), raccoons (*Procyon lotor*), foxes (family Canidae), coyotes (*Canis latrans),* crows (*Crovus brachyrhynchos*), mink (*Neovison vison*), and snakes (order Squamata; Ernst, 1994).

Once snapping turtles have hatched they remain vulnerable to predation from more vertebrates including snakes, frogs, alligators (*Alligator mississippiensis*), fish, other snapping turtles, and various birds (Ernst, 1994; Hammer, 1969). Their swimming capability at early ages is limited; a study by Hammer (1969) showed that hatchlings drowned after venturing only a short distance from vegetation in deep water. Adequate prey acquisition for hatchlings younger than four months was also a challenge.

The main mortality threat to adult snapping turtles is humans. Harvest can be a major source of mortality. There are documented cases of boxcar loads of snapping turtles being taken to the east coast to be served in restaurants in the early part of the 1900's (Ernst 1994; Congdon 1994). There are also other vertebrates that prey on adults including bears, coyotes, alligators, and otters (*Lontra Canadensis*) (Ernst, 1994). One Canadian study showed a considerable mortality of snapping turtles in one winter as otters ate the viscera out of hibernating turtles (Brooks, 1991).

Another source of mortality in snapping turtles is being run over by motorized vehicles on the ever expanding road network that crisscrosses the nation (Gibbs, 2005). Gibbs and Steen (2005) suggest that the mortality of turtles on roadways might be skewed more towards females, because of their tendency to undertake nesting migrations. Beaudry (2010) discussed this potential problem with Blanding's turtle (*Emydoidea* blandingii) in Maine, the need to assess when turtles are making these overland migrations, and the need to use that data to determine times when the risk of mortality is greatest. The same approach may be applicable to snapping turtles. Snapping turtles tend to migrate in the spring and early summer during nesting and mating season (Brown, 1993; Ernst, 1994; Obbard, 1980; Obbard, 1987); it is then that they are most vulnerable to mortality from motorized vehicles.

Abnormally high mortality rates at any life stage as a result of human activities can alter the status of turtle populations from increasing or stable to decreasing or even extirpated. However, it is very difficult to assess the consequences of human development or other human impacts on populations of long-lived species such as the snapping turtle. Although assessment of population status and causes of mortality factors are necessary, such as assessment can present challenges. First, assessment of hatchling and juvenile (less than 2 years of age) snapping turtles abundance is often difficult because younger turtles do not recruit well to trap nets, the preferred sampling gear (Congdon, 1994). Losses at hatchling or juvenile life stages may not be detected for years or even decades (Musick, 1999). In northern localities, there are potentially at least 10-15 immature year classes. Difficulties assessing young life stages often leads to management decisions being based on adult life stages that are recorded at places such as nesting grounds (Musick 1999). In general, snapping turtle populations are not sufficiently well known nor are the harvest monitored closely enough for refined, scientifically defensible harvest management approaches.

Study Sites

Site selection in this study was designed to provide two general kinds of information: (1) detailed information on abundance, movements, age structure, and growth from three reservoir systems and (2) presence or absence information (i.e., distribution) based on more cursory sampling statewide from numerous other lakes and reservoirs in various North Dakota counties.

Turtles were intensively sampled from three reservoirs and their inflows in three different regions of the state: Lake LaMoure (southeast), Nelson Lake (central), and Patterson Lake (western). Lake LaMoure (Figures 1,2; hereafter, LaMoure), is situated in LaMoure County at 46°17’58.36” N and 98°16’12.79” W, has a surface area of 165 Ha, a shoreline of 17.2 km, an average depth is 4.4m, and a maximum depth of 10.1m (http://www.gf.nd.gov/fishing/lakedata.html March 2012). The dam was constructed in 1973 to hold back the waters of Cottonwood Creek (United States Environmental Protection Agency 2012). Nelson Lake (Figures 1,3; hereafter Nelson), situated in Oliver County at 47.074565 N, 101.219444W, has a surface area is 231 Ha, a shoreline of 20.43km, an average depth is 4.7m, with a maximum depth of 10.7m (http://www.gf.nd.gov/fishing/lakedata.html March 2012). Nelson was constructed in 1968 to provide cooling water for the Milton R. Young power plant and is fed by Square Butte Creek. Water levels can also be adjusted by Minnkota Power as needed with water from the Missouri River (Minnkota Power Cooperative Inc. 2014). Patterson Lake (Figures 1,4; hereafter, Patterson), situated in Stark County at 46.867233 N and 102.832546 W, has a surface area of 386 Ha, a shoreline of 31.2 km, average depth of 2.74m, and a maximum depth of 8.1m (http://www.gf.nd.gov/fishing/lakedata.html March 2012). Patterson was created in 1950 by impounding the Heart River with Dickinson Dam. Although the primary purpose of the construction was irrigation and flood control. The reservoir also provides recreation opportunities and wildlife habitat (United States Department of the Interior, Bureau of Reclamation 2013).

Methods

Snapping turtles were sampled with baited Wisconsin-type trap nets with leads (9m lead, 1.2mx1.8m frame and 1.09cm mesh) and hoop nets (3 1m diameter hoops, 2.5cm mesh, and 2.1m total length), baited with chopped fish viscera. The bait was placed in coffee cans that had been outfitted with wooden covers with bungee cords to keep the lid in place. Holes were drilled in the coffee cans to allow scent to disperse. The cans were attached inside the net at the cod end. When possible approximately half of the can was left in the water and half outside the water. Trap nets were set in shallow water with at least 7.5 cm above the water line. When possible the leads were fully extended. In areas where the water would have completely submerged the net, the leads were shortened so turtles were able to access the water surface for air. Hoop nets were set in locations that had flowing water. If no flowing water was present they were set in small bays; as with trap nets, at least 7.5 cm of the nets were left above the waterline. LaMoure was sampled first (4 nights, Jun25-29, 2012), followed by Nelson (13 nights, Jul 10-26, 2012) then Patterson (seven nights, Aug 3-10, 2012). The target catch for each lake was at least 15 turtles. Once sampling was completed on the three main study lakes, the state-wide distribution sampling was conducted (May 20-Jun 4, 2012, Jun 15-24, 2012, Jun 31- Jul 03, 2012, and May 27- Jul 15, 2013). To improve the efficiency of this broader scale sampling, prior to site selection, a review was conducted of existing turtle catch records obtained from the NDGF fisheries data base, contacts with NDGF field personnel, and U.S. Fish and Wildlife Refuge personnel at Des Lacs, J. Clark Salyer, and Long Lake National Wildlife Refuges. Counties with records, the oldest dating back to 1993, of snapping turtle capture were not sampled so that coverage could be more efficient for evaluating turtle presence or absence in all of North Dakota's 53 counties. Of the records more than 12 years old only three counties had those as the only reference to turtles in the county, but all of the counties had large rivers running through them that have records of snapping turtle presence less than 12 years old. In counties that did not have any record on snapping turtle presence, multiple lakes were sampled over two to three day periods

Objective 1 – *Estimate length weight relationships, age structure, growth and population size in three reservoir systems*

All turtles captured from the three reservoirs were measured for carapace length, weighed, and their sex determined. After brief cleaning of the carapace using soft bristle brushes, digital photos were taken of the fourth vertebral scute; counting the annuli of this scute has been used in other studies as an effective, non-lethal method for determining the age of snapping turtles (Hammer 1969; Obbard1983; Galbraith and Brooks 1989). As part of population estimation, prior to release, all turtles had ring (disk) tags attached to a marginal scute at the posterior end of the carapace or were marked with notches in the carapace (Congdon et al. 1994). The disk tags were 33mm in diameter, individually numbered, and contained contact information for North Dakota Game and Fish in case the turtle was harvested. Tag retention was assumed to be at or close to 100%. Other studies have shown great success and little tag loss with tags attached to holes drilled through the turtles shell (Hammer 1968). All turtles were released alive as close as possible to the location where they were captured.

Length-weight relationships were developed for turtles base on the expression $W= aL^b$ where W is weight, L is carapace length, and a and b are parameters. An analysis of covariance (ANCOVA) was done on the length and weight data for the study lakes. The analysis was done in SAS and allowed me to compare the populations between lakes. In an effort to assess size selective selectivity of nets, length-frequencies of snapping turtles were compared with length-frequencies of painted turtles (*Chrysemys picta*), which were commonly caught in the same nets at higher frequencies than snapping turtles..

The images of the fourth scute were aged in double-blind results format (Forsberg 2001; Macena et al. 2007) with two independent agers using Image Pro system at the University of Idaho. Once each observer independently completed their aging the primary ager compiled the results. All age discrepancies were re-aged by the primary and secondary agers together. Once annuli were agreed upon, distances from the focus of the scute to each annulus along the vertebral axis and to the edge of the scute were measured using Image Pro software.

The estimated ages and annuli measurements were used to evaluate the growth of turtles. Two approached to growth were used, back calculation and von Bertalanffy growth models. The expression used to back calculate length at age was $L_i = \frac{S_i}{S_c} * L_c$ where L_i is the back calculated carapace length at age, S_i is the distance from the focus to each annulus i, S_c is the distance from the focus to the edge of the scute, and L_c is the carapace length at capture (Le Cren, 1977). The assumption is that the plot goes through the origin, in this case it is close enough to going through the origin to use this model.

Von Bertalanffy growth was expressed as $L_t = L_\infty[1 - e^{-K(t-t_0)}]$ were L_t is the length at a given age t, L_∞ is the length of an infinitely old turtle, K is a curvature parameter, and t_0 is an initial condition parameter. L_∞, K, and t_0 were all found using a SAS/STAT® software nonlinear regression model, Version [9.3] of the SAS System for [Windows based system]. Copyright © [year of copyright] SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA. Growth models were calculated for two sets of turtle data: Lake LaMoure turtles as a group and all turtles captured in the study. Growth was also expressed with the weight-converted von-Bertalanffy equation, expressed as $W_t = W_\infty[1 - e^{-K(t-t_0)}]^3$, where W_t is weight at a given age, W_∞ is the weight of an infinitely old turtle, derived from $W_\infty = aL_\infty{}^b$. An ANCOVA was run on length equations for each sex to determine if there was a significant difference between the growth rates for each sex.

Population estimates and confidence intervals were attempted for each of the three study reservoirs, LaMoure, Nelson, and Patterson, using the program MARK and the closed population full likelihood model (White and Burnham 1999). The model used for all three reservoirs assumed the probability of capture to be the same for all individuals the first time, but that the probability of recapture was differed among reservoirs. This assumption was made because of the scarcity of recaptures at all three reservoirs and the possibility of individuals becoming trap shy. Also, I assumed that the probability of capturing an adult female or male was equal, but that the probability of capturing an adult was different than for a juvenile turtle. This assumption was made because of the scarcity of juveniles trapped and the possibility of trap bias towards older individuals. An assumption for all of the models was that no deaths, tag loss, immigration, emigration occurred during the sampling periods.

Objective 2 -- Determine overwintering locations, nesting areas, and what impact these areas may have on survival.

Radio telemetry was used in an effort to find nesting and overwintering sites in the three reservoirs and their inflows. Turtles were captured in nets as described in Objective 1. With the target number of turtles to be tagged at 15 per reservoir, LaMoure yielded 15 turtles, Nelson and Patterson yielded only 10 each. Similarly, the target of 75 percent females and 25 percent males to be VHF (radio) tagged was not able to be met as turtle catches were sparse. All 35 turtles captured from the three reservoirs had VHF tags attached to the posterior edge of the carapace in accordance to the designs and plans from Advanced Telemetry Systems for attaching them to shells. The VHF tags used weighed 14 grams with the ratio of tag to body weight at its highest percentage of was 1.2%, well below the 5% limit to be avoided (Obbard 1983). The tags had a battery life of 535 days. The duty cycle was 12 hours on 12 hours off with the active period being from approximately 10:00 through 22:00. This duty cycle allowed the turtles to be tracked throughout the year with emphasis on being able to find the hibernacula sites (Meeks and Ultsch 1990) and nesting sites. There were no mortality signals on the tags due to the inactivity of the turtles during the winter.

For winter tracking, observers tried to locate the turtles when the ice on reservoir surfaces was thick enough to support equipment and personnel.. Tracking was conducted by driving or walking along the shoreline with the receiver and loop antenna to detect signals. Once a turtle was detected, its location was pinpointed by turning down the gain until the signal was only detectable when directly over the turtle. A hole was then drilled in the ice 0.5-1.0 meter away from the turtle and an underwater camera (Cabela's Angler Advantage Underwater Camera with a 60' cord and 12 uv led lights, was sent down the ice hole to confirm the exact position of the turtles. Once the turtles were located, I counted the number of turtles associated with the tagged turtle, their arrangement, and if any were previously sampled turtles. Turtles were determined to be previously sampled if they carried a visible radio tag or disk tag. I hypothesized that the turtles would overwinter in groups, consistent with what was described in the literature (Meeks and Ultsch 1990).

Tracking during the spring was conducted by walking the shoreline or from a boat. Females were tracked daily and had their positions recorded if they moved from their previously recorded position. Males had their positions recorded periodically if they moved from previously recorded locations.

Objective 3-- *Determine statewide distribution at the county level.*

I used a combination of existing data and field sampling for verification to determine overall distribution of snapping turtles in North Dakota. Historical data from NDGF records from standard and non-standard fisheries sampling was reviewed to obtain general information on distribution and abundance. Information was also obtained by contacting refuge managers at National Wildlife Refuges located throughout the state. Information was then entered into a geographically-based format to depict distribution and abundance patterns using GIS mapping techniques.

During two field seasons, two-day field surveys were conducted from waters strategically located throughout the state to ascertain if turtles are found statewide. All turtles captured were measured for carapace length, weighed, and identified externally as to sex as in Objective 1.

Objective 4 -- Estimate current statewide harvest

To estimate statewide harvest, a brief (six-question) survey was sent out to 10,000 fishing license holders with the assistance NDGF personnel. From the survey, I attempted to identify areas within the state that received the most harvest, when the most harvest occurs, the most common means for taking snapping turtles. The initial contact was made by email and a link was provided for the individuals to go to Survey Monkey (Copyright © 1999-2014 Survey Monkey), a survey response website, to complete the survey. NDGF uses this website to complete all of their online surveys. As with all survey methods, some biases are associated with email surveys. Not every license holder has access to the internet and response rates may be lower than those found with traditional mail surveys (Sax et al. 2003; Shin et al. 2012). The questions asked of the survey recipients were: (1) Did you harvest any snapping turtles during 2012; (2) If so, how many did you harvest; (3) What body of water did you harvest them from; (4) When did you harvest them; (5) How did you harvest them; (6) Why did you harvest them. The results for harvest location were plotted using GIS to determine the primary locations where turtles were harvested. The total number of turtles harvested in the state was estimated by assuming that the turtle harvest of fishing license holders surveyed was representative of all fishing license holders in the state.

Results

Length weight relationships, age structure, growth and population size in three reservoir systems

All snapping turtles captured had a carapace length ranging from 16cm to 44cm (Figure 5-10). The median length for all snapping turtles was between 32cm and 35cm. The length frequencies show that the size of snapping turtle captured ranged widely but did not include small individuals. In Lamoure there are several length classes with multiple individuals. The mean length for snapping turtles is 34cm and a median length of 35cm.

Length- weight relationships differed among the three lakes (ANCOVA; p=0.0029 at 0.05 significance level) based on the relationships, a turtle of 300-mm carapace length weighed 6.57 kg in LaMoure, 8.47 kg in Nelson, and 8.09 kg in Patterson. The differences in the size of each sex is noticeable and statistically significant (ANCOVA p<0.0001). The growth and size difference of male and females can be seen by back calculating their length at age (Figure 11).

The von Bertalanffy growth equation for all turtles combined was $L_t = 485.8[1 - e^{-0.0707(t+2.6531)}]$ and for LaMoure it was $L_t = 517.8[1 - e^{-0.053(t+6.653)}]$ (Figures 12-14). Based on those equations, for all turtles an individual that is 300mm long would be 11 years old and for LaMoure the individual would be 9 years old. In terms of weight, W_∞ for all turtles was calculated as $W_\infty = 0.001 * 485.8^{2.7647}$ and for LaMoure it was $W_\infty = 0.0005 * 517.8^{2.8859}$. Based on the weight-converted equations, the VBGF for weight at age is $W_t = 26745.4[1 - e^{-0.0707(t+2.6531)}]^3$ for all turtles and $W_t = 34022.815[1 - e^{-0.053(t+6.653)}]^3$ Lake LaMoure (Figure15-16). A turtle weighing 20,000g would be 16 years old for all lakes and 10 years old for Lake LaMoure. At a significance level of 0.05 there is a statistically significant difference between the growth of males and females (ANCOVA; p<0.0001).

LaMoure's adult and male population was estimated at 40 turtles with lower and upper 95% confidence intervals of 34 and 60 respectively. The estimate for juveniles was 8 with lower and upper 95% confidence intervals of 3 and 11. The population estimate for Nelson was 7 adult turtles with lower and upper 95% confidence intervals of 7. The estimate for juveniles was 3 with lower and upper 95% confidence intervals of 3. The population estimate for Patterson is 9 adult snapping turtles with lower and upper 95% confidence intervals of 9and 17 turtles, respectively (Figure 17).

Overwintering locations, nesting areas, and survival.

Telemetry was effectively used to track turtles in Lake LaMoure. Efforts to determine nesting activity were then concentrated on Lake LaMoure where there were more females tagged and a larger population of turtles existed. Approximately a month was spent tracking the turtles at Lake LaMoure.

Tracking for overwintering turtles at LaMoure proved fruitful. Eleven of the 15 tagged turtles were found during the winter sampling (13-20 January, 2013). They were all located in close proximity to each other. The longest distance between any of the tagged turtles was 45 meters (Figures 18-19). I was able to get video of two tagged turtles. Other tagged turtles could not be located due to turbid water or possibly the position of the turtle in the substrate. The turtles that were observed were sitting on top of the substrate facing the shoreline (Figures 20-22). One of the tagged turtles also had an untagged turtle directly behind it. This turtle was also facing the shoreline. Upon returning the following day to make video recordings of turtle locations, the untagged turtle had moved out of view from the hole used to see it the previous day. None of the turtles were observed buried under the substrate or stacked upon each other. They were all located in an area with approximately 43 cm of ice cover and 60 cm of water or less under the ice.

The results of winter tracking on Nelson Lake were similar to those on Patterson Lake. Approximately one third of the lake froze during the winter of 2012-2013. This was due to the coal fired power plant that used the lake as a cooling reservoir (the intended purpose of the lake).

One tag was detected in a cattail portion of the upper end of the lake. The cattails had been partially submerged in water during the summer of 2012. Due to a water level draw down the area was no longer covered with water. The tag was tracked to a dirt portion of the cattail area. An attempt was made to dig down to the tag but the ground was to frozen. During spring tracking the tag was located in the same spot and it was covered with water. It is unknown if the turtle was still there alive, the turtle had died, or if the tag had fallen off some time prior. Attempts were made to locate the other tags but none were found. I traveled as far up the inflow creek as possible and drove around the rest of the shoreline within the range that the tags could be detected.

Winter tracking on Patterson Lake did not result in the location of any of the tagged turtles. Several attempts were made to find the tagged individuals. The entire shoreline the lake proper was covered in an attempt to locate the turtles. I also went as far up the Heart River as ice conditions would allow. The tags were still in working order when the turtles were tracked in the spring so it is unknown where they overwintered or why the tags were not detectable during the winter. In discussion with the tag manufacturer if the tags had become entrained in the ice they would not have been able to transmit. Due to the tags location on the turtles carapace it is likely that if the tag was entrained in the ice the turtle would have also been entrained in the ice. Entrainment in the ice is fatal for snapping turtles so it is unlikely that this happened because the turtles were moving when tracked in the spring.

While at Lake LaMoure the female turtles were tracked daily to try and determine when and where they nested. The average daily movement was minimal until it is believed that they made a move to their nesting site. No tagged individuals were observed nesting, but there movements were tracked to areas in close proximity to where other turtles were observed nesting and areas of habitat similar to habitat at observed nesting sites. The longest distance traveled between locations recordings was 1341 m, by turtle 384. The average longest distance traveled by the turtles was 1942.8 m. I was able to observe one female that traveled from the upper end of the lake, past the dam, and into the tributary below the dam before she lost her tag. She traveled approximately 5,000 meters through the lake and down to where I found her. When I found her she no longer had her radio tag, the radio tag was found approximately 150 meters upstream from where I captured her. Most of the locations turtles were located in consisted of the same area they I trapped the year before. Most females made a migration upstream from the bay at some point (Figures 23-27). Some migrations were short and only lasted a day or two. Other migrations were long and lasted several days. The location for males did not vary as much as the females. The males stayed within the area they were captured the year before and did not show any signs of migrating (Figures 28). Most of the time the turtles were located in the same bay they were captured in, they moved out of that bay for a short period of time and then returned. The males were not observed outside of the bay (Figure 29). The water depth averaged 1 to 2 meters in the bay. The perimeter consisted of cattails and submerged aquatic vegetation grew throughout the bay.

Non tagged individuals were documented nesting in 3 different locations. These locations include a gravel bar located upstream from Lake LaMoure, a gravel road that lead to campers along Lake LaMoure, and a gravel road that ran along the James River (Figures 30-33). At the gravel bar I witnessed a mature female attempt to dig a nest; she was scared off by our presence when I moved in closer to attempt to document her nesting. Once she had left, I examined the gravel bar and noticed other nest attempts or possible nest completions. I did not dig into possible nest because I did not want to disturb them. I was unable to document any other nesting attempts at the gravel bar do to a rain event that brought up creek levels to a point where water covered a majority of the gravel bar. The nesting female that was observed on the gravel road that lead to campers traveled the farthest distance I documented away from water to nest. She had made an overland migration of approximately 214 meters to reach her nesting site. Once there she nested in the middle of the road. I was able to observe most of her nesting. I first noticed her once she had already started digging her nest. During our observation I witnessed her completion of digging, ovipositing, burying of her eggs, and packing the nest. Once she had completed her nesting event I documented the nest and took pictures of the female's scutes for aging purposes. At the third location a series of roads totaling approximately 1861 meters followed or crossed the James River. On these roads multiple nesting attempts, completed nests, and nests that had been preyed upon I observed. Turtles were also witnessed on the roads attempting to nest. The turtles I witnessed were not disturbed by our vehicle on the road and continued to nest. Nests were under approximately 10-15 centimeters of tightly packed dirt. The nest hole was approximately 25 centimeters in circumference, just big enough for my fist to fit in. Nests were packed with a similar hardness to the surrounding road bed. I also documented several attempted nests on the roads surrounding the river; it is likely that the turtles were scared off by vehicles while they were in the early stages of digging the nests. Along with attempted nests I found nests that had been preyed upon. These nests looked similar to attempted nests, but upon closer examination fragments of egg shells could be found in and around the nest. I was unable to determine what type of animal preyed upon the nest.

Statewide turtle distribution by county

I was able to determine the presence of snapping turtles in 41 of 53 counties (Table 1 and Figure 34). Of the 12 counties for which I do not have records of snapping turtles for I was unable to sample 10 of them with existing resources. Twenty-four of the counties with snapping turtles present had records listed in the fisheries database; of the 17 other counties information was gathered from various sources which included four counties of them from USFW service personnel, 11 from NDGF personnel, and two of them were from our turtle surveys. Two of the 12 counties with no snapping turtle records were sampled and no snapping turtles were found. Any overlap in sampling effort and knowledge of snapping turtle presence was due to timing of information becoming available to us. There were a few counties that after I had sampled information became available to us from various sources that snapping turtles were present in the counties.

During the two field seasons I sampled 21 bodies of water in 12 counties across North Dakota in an attempt to find snapping turtles (Table 2). Of the 7 bodies of water that snapping turtles were trapped I only caught more than one in 4 bodies of water, that includes three at Bowman-Haley Dam, 10 at Patterson Lake, 12 at Nelson Lake, and 35 at Lake LaMoure. At all but Bowman-Haley Reservoir and Nelson Lake when snapping turtles were present they were trapped on the first day, at these two lakes they were trapped first on the second day of sampling. Once the presence of snapping turtles was confirmed for a county traps were pulled, dried, and moved to lakes in a county with unknown turtle presence.

Statewide harvest of snapping turtles

Of the 10,000 turtle harvest questionnaires sent out to licensees, 733 responses were received, a 7.33% return rate. Of the responses to the surveys received, 13, or 2%, stated they had harvested turtles in 2012. The average number of turtles harvested by these 13 individuals was 4.5 and the median was 1. The maximum harvested by a single individual was 23 and the minimum harvested by a single individual was 1. A total of 55 turtles were harvested between the 13 individuals. Three individuals accounted for 41 turtles or 74.45% of overall harvest reported. The other 10 individuals harvested one or two turtles each. Harvest occurred in different areas across the state including lakes and rivers; I depicted it at the county level because some rivers run through multiple counties (Figure 35). The area of the state that had the most harvest was Smishek Lake, 23 turtles were harvested. 88.2% of all harvest occurred during the summer, followed by fall at 23.5%, spring at 17.6%, and winter at 5.9%. Five individuals used hook and line to harvest turtles, four used nets, two caught them by hand, one used a shotgun and one used a harpoon. Eight of the individuals the harvested turtles did so for food, one individual for turtle races, one individual for sport, one individual because the turtle was close to death after being reeled in, one individual because the turtle hooked itself and one individual because they were two close to swimming and fishing areas.

Discussion

Length weight relationships, age structure, growth and population size in three reservoir systems

The sexual size dimorphism seen in this study, where males are larger than females, the length vs. weight regressions, and the VBGF are similar to what has been found in other studies. For example, Christiansen and Burken (1979) stated growth of the two sexes was similar until approximately 50mm plastron length, at which point males grew faster ; Ceballos and Valenzuela 2011 found that there was a greater plasticity in the growth of males (the larger sex) then the females. The reason for this consistent pattern could be related to the cost associated with reproduction. Once females start developing ovaries their growth slows and male growth continues (Ceballos and Valenzuela 2011). The turtles in North Dakota seem to follow the same growth trends as turtles from other areas.

The age structure of the populations across the state consisted mostly adults. Only a handful of young snapping turtles were captured. All age estimates are most likely underestimates because there is some research that suggests annuli might not be laid down every year after maturity is reached (Galbraith and Brooks, 1987).

The scarcity of juvenile snapping turtles caught in my nets throughout this study, along with the ease of capture of painted turtles (Figures 5-7) indicted that either young snapping turtles recruit poorly to the nets or that recruitment is low or non-existent in some years. Sporadic recruitment of snapping turtles is well documented in other localities, with predation rates 60% or higher (Hammer, 1969), low hatchling survival rates, and nesting that may not take place every year. For example Hammers work (1969) showed nest predation between 40% and 60% in some areas of LaCreek Refuge in South Dakota. Now there were multiple nesting areas within the refuge which could explain the ability of nests to escape predation. Robinson and Bider (1988) discuss the possibility that clustered nesting sites may increase the chances of nests being preyed upon. At their study site nests within 1m of other nests had a 3% survival rate, compared to nests farther apart that had a survival rate of 39%; which shows that a lack of nesting areas can lead to high nest densities increasing the number of nests preyed upon. These factors can lead to low numbers of young turtles and sporadic recruitment.

Gear bias against juveniles has been cited in other studies as a reason for low numbers in samples (Congdon et al. 1994). This explanation for low juvenile numbers does not coincide with the catch of other small turtles by my sampling gear. I was able to catch painted turtles as small as 9mm in carapace length (Figure 5), but the smallest snapping turtle caught had a carapace length of 16mm. I should have been able to catch small snapping turtles with the gear if they were present. Net locations at the study sites included the inflow streams and shallow areas that are habitat areas small turtles occupy (Graves et al. 1987). It does appear from growth patterns of adults that if young turtles make it through the bottleneck they are able to grow and thrive if not then killed by humans.

Growth rates for our study population were compared to growth rates of other populations throughout North America. Von Bertalanffy growth equations were done for each data set I acquired, graphed, and compared side by side (Figures 36-39). The growth rates appeared to vary across different latitudes and by sex. There was a statistical difference between growth rates at the different latitudes (ANCOVA $p=<0.0001$). This means that growth varies across different latitudes and that North Dakota turtles grow larger than the three other areas examined. This follows what Steyermark et al. (2008) discuss that with increasing latitude comes and increase in the size with the largest turtles being located in Nebraska and South Dakota.

The population sizes vary across our study area, with population estimates ranging from 10 to 48 turtles depending on the lake. Many factors could have led to the varying population sizes. The area around Nelson Lake has been subject to high snapping turtle harvest due to an annual turtle feed. In an area where continual harvest of long lived species occurs one would not expect to see large populations. Patterson Lake was a large area where turtles could be spread out and I would not have been able to sample them effectively. Lake LaMoure contained limited areas where snapping turtle could reside and was close to a large slow moving river that contained another population of turtles. Also the density of snapping turtles varies widely across their range

(Galbraith et al. 1988, Hammer, 1969, Froese, 1975) and could be a contributing factor to the different population estimates.

Determine overwintering locations, nesting areas, and what impact these areas may have on survival.

Snapping turtles overwintered in areas that coincide with ones described Meeks and Ultsch (1990), areas with soft substrate, undercut banks, and flowing water. It is important that I documented this clustering behavior in turtles within the state. Areas where the turtles overwinter need to be protected from disturbances and harvest. Activities such as channelization, dredging, or deepening of areas can destroy areas that are important to turtle survival. Further work needs to be done to determine what other areas are suitable overwintering habitat.

I was able to document several nesting locations at LaMoure and had information passed along to us about nesting locations by the public. The locations all had one similar characteristic; they were soils that were well drained. A common requirement discussed in the literature (Ernst and Lovich, 1994; Steyermark et al. 2008). The various nesting locations included dams, gardens, gravel bars, gravel roads, putting greens, and sand volleyball courts. Most of these areas are places where the turtles could come in contact with humans, the most dangerous for the turtles being the roads.

I was unable to document any of the tagged turtles nesting, but I did track them to areas where I documented other turtles nesting. The study turtles stayed within the stream system flowing into and out of the lake. I did not document any overland migrations of study turtles. I did document one overland migration of an untagged turtle. She moved to an area uphill from the lake to lay her eggs in the middle of a road. With the exception of her nest the rest were within five meters of water. This overland migration is well within the distances discussed in other papers (Obbard and Brooks 1980)

The locations that turtles are nesting need to be protected in order to ensure the continued survival of the species. Some of the areas see high human activity levels. In cases where this happens managers should look at ways to either reduce the activity or offer other suitable nesting habitat for the turtles. In areas where sea turtles nest there are restrictions on activities as well as the restoration of other nesting sites. Snapping turtle populations could benefit from similar management actions in North Dakota. Areas where the only suitable nesting habitat left is roads and other manmade areas the state could place artificial nesting areas in an attempt to have the turtles nest in areas that will not be disturbed. Another step would be to increase public awareness about what to do when turtles nest on their property. This could be as simple as pamphlets or articles in newspapers. The public needs to know not to disturb the area where turtles nest and about how long it will take for the eggs to hatch.

The inability to locate turtles on two of the three study lakes hampered the efforts to understand the overwintering and nesting locations throughout the state. Had I been able to determine the locations of overwintering and nesting at all of the lakes I could have determined if they vary throughout their range in North Dakota. I might have been able to determine nesting sites on Nelson and Patterson but with the relatively low number of females and turtles overall the greatest effort was placed on LaMoure. Lake LaMoure offered us the greatest opportunity to observe snapping turtle life history.

Determine statewide distribution on a county level basis.

Snapping turtles can be found throughout the state of North Dakota, but local populations vary as evident from sampling efforts. Some of the variation could be attributed to variation in densities which can vary widely (Galbraith et al. 1988, Hammer, 1969, Froese, 1975). Although it was difficult to trap the turtles there was a commonality between the lakes that had turtles. That was they all had some sort of inflow and outflow. In some cases it was a river and in others just a stream. The one lake that did not have an inflow but had snapping turtles was close to other flowing water. The reports and information gathered shows a similar pattern of turtles being located in areas where they have access to flowing water.

The areas where we were unable to locate turtles often did not have inflows, outflows, or were not located in proximity to flowing water. The proximity to flowing water seems to be a limiting factor for snapping turtles in North Dakota. The lack of flowing water did not seem to affect painted turtles, as we encountered them in all but one body of water we sampled and they were still present in other waters within that county. McIntosh County and Rolette County do not contain more than a few bodies of flowing water. They were the two counties I sampled and could not find snapping turtles.

One of the possible reasons for turtles not being present in these areas could be because of localized population extirpation. Extirpation at a local level could be brought on by a myriad of factors including harvest, predation of both eggs and juveniles, loss of habitat, and increased mortality do to human factors. Because there are no travel corridors, in the form of rivers and streams, turtles may not be able to repopulate an area after extirpation.

Estimate current harvest rates throughout the state.

The survey sent out to determine harvest rates within the state was a step in the right direction when it comes to managing snapping turtles. Like any other game species exploitation rates need to be known for managers to effectively manage the species. Most long lived game species within the state have a monitoring program. Tags are issued for big game and paddlefish, surveys are sent out for small game and fish. These steps allow managers to determine harvest rates and adjust regulations accordingly.

Current harvest rates within the state would be approximately 18,400 turtles a year if the survey accurately sampled the people who harvest turtles. Even a conservative estimate of yearly harvest would be around 6,500 turtles, that estimate comes from removing individuals who harvested large numbers of turtles from the data set. That level of harvest would average out to about 20 turtles removed from every fishable body of water within the state. But the estimates from the survey may not accurately portray the harvest. In conversations with Patrick Hubert of the Ministry of Natural Resources in Ontario, Canada (Patrick Hubert, Ministry of Natural Resources, Ontario Canada), he stated that their fisheries survey that included questions about turtle harvest did not provide the best view of harvest within the province. A change in regulations and a reporting process have yielded more information. A similar process may need to be developed within North Dakota to better understand harvest within the state.

Harvest regulations were examined for every state that has snapping turtles to see how North Dakota regulations fall within the broader context of snapping turtle management in North America. Regulations for each state and the province of Ontario were listed and include the length of the snapping turtle season, daily limit, possession limit, yearly limit, and any length restrictions that are imposed (Table 3). Only one state does not allow harvest and that is Florida. The reason being is snapping turtles closely resemble other protected species within the state. 12

of the states, including North Dakota, do not have any regulations pertaining to the number of turtles that can be harvested. 23 states have some regulations pertaining to daily limits, with some also having limits on total possession. Only 4 states have a limit on the number of turtles that can be harvested within a season or year. North Dakota regulations or lack thereof are not uncommon for North America, but they are uncommon for the areas that surround the state. The states surrounding have daily limits and possession limits in place for snapping turtles, but no yearly harvest limits.

Sampling protocol and Management objectives

During the research no protocol for monitoring of snapping turtles was found within North Dakota Game and Fish, but protocols have been put in place for fish species. In order to better manage snapping turtles, similar protocols must be established. The sampling we conducted and the data we collected could easily be taken during current fisheries surveys. Basic length frequency data can be useful in determining the current status of the snapping turtle population. The data that should be taken includes carapace length and individual weights. This data could allow managers to look at overall population trends in a similar manner as used with long lived fish species. Our data allowed us to see possible problems with recruitment in snapping turtles throughout the state. By comparing the size structure of painted turtles we caught and comparing them to the size structure of snapping turtles we caught we determined that our nets would be able to catch smaller snapping turtles, but we did not catch small snapping turtles. This could be indicative of recruitment problems. If managers take measurements of all turtles captured during standard fisheries surveys the data can be entered into the fisheries data base and help to establish long term population trends. If managers would also take pictures of scutes for aging purposes the data sets would be strengthened and allow managers to take a closer look at recruitment on a lake by lake basis.

The recording of non-target species during fisheries surveys often does not happen. By not recording this data managers are losing an opportunity to access potential biological indicator species and potential forage species for fish. Along with turtles species managers should at the very least record catch rates for all other species encountered including amphibians, reptiles, crustaceans, and mammals. This data should then be entered into the fisheries database like any other fisheries data. This enables any manager or researcher to access the populations of various species throughout the state. Had more consistent data been entered into the database our project would have been able to better choose lakes to do intensive work on, more easily fill in the statewide distribution map, and access long term trends in snapping turtle populations. As it was data on snapping turtles had to be teased out of various sources including NDGF personnel, USFW personnel, and the NDGF database. A recent search of the fisheries database revealed that managers in some districts have started keeping better records of turtle catches. This even included noting the absence of turtles in nets. The data only included numbers of individuals caught, but it is a step in the right direction.

Along with collecting data managers should work to reduce the effects of fisheries surveys on turtle mortality. This can be done by following two different approaches. One approach is to reduce the mortality of turtles captured in the nets and the other is to reduce the number of turtles captured. To simply reduce the mortality of turtles captured managers need to leave a portion of the net above the water. During my research I left an average of 7-8cm of the net above the water line. This allows the turtles to come up for air. I only experienced net mortality when one net collapsed and the turtle was not able to come up for air. By leaving an area for turtles to come up for air it allows managers to still collect fisheries data and turtle data while decreasing turtle mortality. The second option is to modify the nets to reduce turtle bycatch. By modifying the nets turtles can be kept out or at least the number and size of turtles captured can be reduced. The only problem with reducing the number of turtles captured is the ability to monitor turtles has also been reduced.

I recommend that at the very least a bycatch reduction device (BRD) be placed on all modified fyke nets used for fisheries surveys in deep water. A paper by Fratto et al. describes a BRD that was effectively used in their study to reduce the bycatch of turtles without significantly affecting the capture of fish species. A study would need to be done in North Dakota to ensure that the BRD does not have a negative effect on fish captures. This can be easily done by paring BRD nets with control nets and determining if there is any difference in capture. It can also be done by setting BRD nets in locations where survey nets are typically set and comparing catch rates to recorded catch rates from previous sampling efforts. If the BRD do not statistically affect the fish catch they should be implemented on all nets to reduce the bycatch of turtles. If BRD's are successful in excluding turtles additional nets should be set during fisheries surveys to monitor turtle populations. This would only need to be a few extra trap nets set in shallow water that would allow turtles to come up for air. If nets are already being set in areas where they will have portions above the water that turtles can use to breathe, BRD's do not need to be placed on those nets.

During research no management plan for snapping turtles or other turtles was found within North Dakota Game and Fish archives. The only regulation in place limited the harvest of snapping turtles to two per person per year caught on hook and line if they held a valid North Dakota fishing license. The law is interpreted to mean that if a person is fishing they can keep two turtles a year if they catch them on hook and line, but there is no limit on other means of harvesting snapping turtles. No reporting process for snapping turtle harvest was found within the state regulations either; this lead to an overall lack of knowledge about turtle harvest within the state. Since no knowledge of turtle harvest or populations demographics do not exist, managers could not develop a plan that would manage snapping turtles in a way that coincides with their use by the states populous. Since I only captured a few turtles at any one lake and no turtles at many lakes it is possible that turtle populations throughout the state are low. Accidental mortality of nesting females on roads and high nest mortality leads to sporadic recruitment. Additional mortality on top of unknown rates of mortality should be stopped when possible on long lived species with delayed maturity, sporadic recruitment, and high rates of juvenile mortality.

I recommended that the state suspends all snapping turtle harvest until more data is gathered to determine the status of the turtles in all lakes throughout the state. Some lakes may be able to support limited harvest if closely monitored. But these lakes need to be determined by looking at long term data sets on population trends. These lakes would need to have semi-consistent recruitment, meaning young turtles reaching sexual maturity and reproducing at least once. But with current data it is unlikely that snapping turtles within the state could sustain continued harvest. Knowing that any change in the regulation must first go through public hearings and commission meetings it will give the public an opportunity to voice their opinion on snapping turtles within the state. This process may reveal a strong desire to harvest turtles or it may be met with great indifference towards the turtles. But the process will allow mangers to gauge the public's opinions. Regardless of the feasibility of stopping harvest, a mandatory reporting process should be developed for snapping turtles. This will allow managers to determine when, where, and how many turtles are harvested. If areas are experiencing heavy harvest steps can be taken to protect local populations to prevent local extirpations. Online forms could be developed that have harvesters enter the location of harvest, carapace length, location, and time of harvest for each turtle they keep. There could also be a category for turtles released. Another step that could be taken would be a minimum size limit for turtles. Several states implement a size restriction saying only turtles over a certain carapace length can be harvested. The exact implications for the population would have to be examined to determine what effect this would have. Also closed seasons to protect turtles when they are most vulnerable can be an effective management tool. Nesting females should be protected. Halting the turtle harvest during nesting periods allows them to complete an important life stage. When the females are moving across land they are easily exploited and it is a biased exploitation of the population. Also turtles that are overwintering need to be protected. Once turtles enter hibernation they are slow to react to stimulus that would normally invoke a fight or flight response. Along with slowed movement, they tend to congregate in just a few locations allowing for easy exploitation of large portions of the population. Regardless of which method is used there needs to be some means of control over the population whether it is a halt to all harvest, a reporting process, season closures, or a combination of the last two.

Conclusion

As one of the oldest species in North Dakota, snapping turtles are a species that deserves special attention. Their distribution spans almost the entire state, with the possibility that they do inhabit the counties in which their presence has yet to be confirmed. With continued recording of data by NDGF personnel the knowledge gaps in distribution should be filled in within a few years. Population size varies widely across the state and the exact factors leading to that are yet unknown. But the growth of the turtles is consistent with what would be expected of a population at that latitude. The current age structure of the three populations studied indicates that recruitment is a serious issue. With many older turtles, few young turtles, and varying numbers in each age class recruitment needs to be addressed. Nesting sites were located at Lake LaMoure and all of them were in locations that present potential survival issues, which could be leading to spotty recruitment. Two of the nesting sites were located on roadways and one was located on a gravel bar prone to flooding. The greatest mortality occurs between initial egg laying and about two years of age. Overwintering locations can also be a limiting factor that must be addressed. The overwintering location found at Lake LaMoure was used by numerous turtles. These areas can be limiting factors within a system and destroying them can impact populations. Also overwintering areas can leave multiple turtles exposed to harvest. These areas should be protected by season closures. The ground worked laid out for NDGF will allow for continued monitoring and an expansion of current knowledge of snapping turtles in North Dakota. The simple steps of recording basic information from all turtle catches will allow managers to access long term trends in populations at a lake level and a statewide level. The harvest of snapping turtles in North Dakota does not appear to be sustainable. If stopping harvest is not feasible, steps need to be taken to monitor, regulate, and analyze it throughout the state. The current status of snapping turtles in North Dakota is still not completely clear on the statewide level. But populations at three lakes vary, which may be characteristic of the populations across the state. With simple management steps the status can be better determined. The snapping turtle is a unique and important species in North Dakota. Working to preserve them and all other species for future generations is a top priority.

Literature Cited

Alabama Department of Conservation and Natural Resources. 2013. Alabama hunting and fishing digest. 64 N. Union Street, Suite 468, Montgomery, Alabama 36130.

Angradi, T. R., E. W. Schweiger, D. W. Bolgrien, P. Ismert, and T Selle. 2004. Bank stabilization, riparian land use and the distribution of large woody debris in a regulated reach of the upper Missouri River, North Dakota, USA. River Research and Applications 20: 829-846.

Aresco, M. J., and M. S. Gunzburger. 2007. Ecology and morphology of *Chelydra serpentina* in Northwestern Florida. Southeastern Naturalist 6:435-448.

Beaudry, F., P. G. Demaynadier, and M. L. Hunter, Jr. 2010. Identifying hot moments in road-mortality risk for freshwater turtles. The Journal of Wildlife Management 74:152-159.

Brown, G. P., and R. J. Brooks. 1993. Sexual and seasonal differences in activity in a northern population of snapping turtles, *Chelydra serpentina*. Herpetologica 49:311-318.

Bonin, J., J. L. Des Granges, C. A. Bishop, J. Todrigue, A. Glendron, and J. E. Elliot.1995. Comparative study of contaminants in the mudpuppy (*Amphibia*) and the common snapping turtle (*Reptilia*), St. Lawrence River, Canada. Archives of Environmental Contamination and Toxicology 28:184-194.

Brooks, R. J., G. P. Brown, and D. A. Galbraith. 1991. Effects of a sudden increase in natural mortality of adults on a population of the common snapping turtle. Canadian Journal of Zoology 69: 1314-1320.

Ceballos, C. P. and N. Valenzuela2011. The role of sex-specific plasticity in shaping sexual dimorphism in a long-lived vertebrate, the snapping turtle *Chelydra serpentina*. Evolutionary Biology 38:2:16-181.

Christiansen, J. L. and R. R. Burken, 1979. Growth and maturity of the snapping turtle (*Chelydra serpentina*) in Iowa. Herpetologica 35:261-266.

Colorado Parks and Wildlife. Regulations. 2013. Number 311. 6060 Broadway, Denver, Colorado 80216.

Commonwealth of Massachusetts Department of Fish and Game. 2014. Massachusetts fish and wildlife guide to hunting, freshwater fishing , and trapping. 251 Causeway St, Suite 400, Boston, Massachusetts 02114.

Congdon, J. D., A. E. Dunham, and R. C. v. Loben Sels. 1994. Demographics of common snapping turtles (*Chelydra serpentina):* Implications for conservation and management of long-lived organisms. American Zoologist 347:397-408.

Conneticut Department of Energy and Environmental Protection. Snapping turtle regulations. http://www.ct.gov/deep/cwp/view.asp?a=2700&q=531694&deepNav_GID=1633

Delaware Department of Natural Resources and Environmental Control: Division of Fish and Wildlife. 2013. Delaware huning and trapping. 21.

Van Devender, T. R., and N. T. Tessman. 1975. Late Pleistocene snapping turtles (*Chelydra serpentina*) from Southern Nevada. Copeia (1975):249-253.

Ernst, C. H., R. W. Barbour, and J. E. Lovich. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, D.C.

Florida Fish and Wildlife Conservation Commission. 2013. Florida hunting regulations. 620 S. Meridian St. Tallahassee, Florida 32399

Forsberg, J. E. 2001. Aging manual for Pacific halibut: procedures and methods used at the Inernational Pacific Halibut Commission. Technical Report No. 46

Fratto, Z. W., V. A. Barko, and J. S. Scheibe. 2008. Development and efficiacy of a bycatch reduction device for Wisconsi-type fyke nets. Chelonian Conservation and Biology 7:205-212.

Froese, A. D., G. M. Burghardt. 1975. A dense natural population of the common snapping turtle (*Chelydra s. serpentina*). Herpetologica 31: 204-208.

Froese, A. D. 1978. Habitat preferences of the common snapping turtle, *Chelydra s. serpentina* (Reptilia, Testudines, Chelydridae). Journal of Herpetology 12:53-58.

Galbraith, D. A., and R. J. Brooks. 1987. Addition of annual growth lines in adult snapping turtles *Chelydra serpentina*. Journal of Herpetology 21: 359-363.

Galbraith, D. A., and R. J. Brooks. 1987. Survivorship of adult females in a northern population of common snapping turtles, *Chelydra serpentina*. Canadian Journal of Zoology 65:1581-1586.

Galbraith, D. A., C. A. Bishop, R. J. Brooks, W. L. Simser, and K. P. Lampman. 1988. Factors affecting density dependence of populations of common snapping turtles *Chelydra serpentina serpentina*. Canadian Journal of Zoology 66: 1233-1240.

Galbraith, D. A., and R. J. Brooks. 1989. Age estimates for snapping turtles. The Journal of Wildlife Management 53:502-508.

Galbraith, D. A., R. J. Brooks, and M. E. Obbard. 1989. The influence of growth rate on age and body size at maturity in female snapping turtles. Copeia 1989: 896-904.

Georgia Department of Natural Resources: Wildlife Resources Division. Freshwater turtle regulatoins. http://www.georgiawildlife.com/Turtling

Gibbons, J. W. 1987. Why do turtles live so long. BioScience 37: 262-269.

Gibbs, J. P., and D. A. Steen. 2005. Trends in sex ratios of turtles in the United States: implications of road mortality. Conservation Biology 19:552-556.

Graves, B. M., S. H. Anderson, and C. National Ecology. 1987. Habitat suitability index models, snapping turtle. National Ecology Center, Fish and Wildlife Service, U.S. Department of the Interior, Washington, D. C.

Hammer, D. A. 1968. Snapping turtle life history on LaCreek Refuge, South Dakota. Masters Thesis. South Dakota State University. Brookings.

Hammer, D. A. 1969. Parameters of a marsh snapping turtle population Lacreek Refuge, South Dakota. The Journal of Wildlife Management 33:995-1005.

Haxton, T. 2000. Road mortality of snapping turtles *Chelydra serpentina*, in central Ontarion during their nesting period. Canadian Field-Naturalist 114:106-110.

Hibbard, C. W. and D. W. Taylor. 1960. Two Late Pleistocene faunas from southwestern Kansas. Contributions from The Museum of Paleontology, University of Michigan 16:5-223.

Holman, J. A. 1964. Pleistocene amphibians and reptiles from Texas. Herpetologica 20:73-83.

Hutchison, V. H., A. Vinegar, and R. J. Kosh. 1966. Critical thermal maxima in turtles. Herpetologica 22:32-41.

Illinois Administrative Code (a), section 880.20b. 2013. Springfield.

Illinois Administrative Code (b), section 880.30a. 2013. Springfield.

Indiana Department of Natural Resources. 2013. Indiana fishing regulation guide. 402 W. Washington St. RM W273, Indianapolis, Indiana 46204.

Iowa Department of Natural Resources. 2014. Frogs and turtles. http://www.iowadnr.gov/Fishing/FishingLicensesLaws/AdditionalRegulations/FrogsTurtles.aspx (January 2014).

Janzen, F. J. 1992. Heritable variation for sex ratio under environmental sex determination in the common snapping turtle *(Chelydra serpentina)*. Genetics 131:155-161.

Johnson, S. 2010. Wildlife roll call. North Dakota Outdoors.72:10:4-9.

Kansas Department of Wildlife, Parks and Tourism. 2013. Turtles. http://kdwpt.state.ks.us/news/Fishing/Fishing-Regulations/Turtles

Kentucky Department of Fish and Wildlife Resources. 2014. Fishing regulations. http://fw.ky.gov/Boat/Pages/Fishing-Regulations.aspx

Legler, J.M. 1955. Observations on the sexual behavior of captive turtles. Lloydia 18:95-99.

Le Cren, E. E. 1947. The determination of the age and growth of the perch (*Perca fluviatilis*) from the opercular bone. Journal of Animal Ecology 16:188-204.

Maceina, M. J., J. Boxrucker, D. L. Buckmeier, R. S. Gangl, D. O. Lucchesi, D. A. Isermann, J. R. Jackson, and P. J. Martinez. 2007. Current status and review of freshwater fish aging procedures used by state and provincial fisheries agencies with recommendations for future directions. Fisheries 32:329-340

Maine Department of Inland Fisheries and Wildlife. 2013. Frequently asked questions. http://www.maine.gov/ifw/warden_service/faq.html#snapping (Jan 2014)

Meeks, R. L., and G. R. Ultsch. 1990. Overwintering behavior of snapping turtles. Copeia 1990:19.

Michigan Department of Natural Resources. 2013. Michigan fishing guide. P.O. Box 30028, Lansing, Michigan 48909.

Ministry of Natural Resources. 2013. Hunting regulations. 300 Water St. Peterborough, Ontario K9J 8M5, Canada.

Minnkota Power Cooperative Inc. 2014. Milton R. Young Station: our jewel on the prairie. http://www.wildriceelectric.com/images/2006%20MRY%20brochure.pdf (January 2014).

Missouri Department of Conservatoin. 2014. Turtle regulations. http://mdc.mo.gov/fishing/regulations/non-game-species/turtles (January 2014).

Musick, J. A. 1999. Life in the slow lane : ecology and conservation of long-lived marine animals. American Fisheries Society Symposium 23, Bethesda, Maryland.

Nebraska Game and Parks Commission. 2013. Fishing guide. 2200 N. 33rd St. Lincoln, Nebraska 68503.

New Hampshire Fish and Game Department. 2013. New Hampshire hunting and trapping digest. 11 Hazin Dr. Concord, New Hampshire 03301.

New Jersey Division of Fish and Wildlife. 2013. 2013 New Jersy freshwater fishing digest. P.O. Box 402, Trenton, New Jersey 08625.

New York Department of Environmental Conservation. 2013. Reptile and amphibian hunting seasons. http://www.dec.ny.gov/outdoor/31339.html (January 2014).

North Dakota Game and Fish Department. 2010. Lake contour maps. http://www.gf.nd.gov/fishing/lakedata.html (March 2012).

North Dakota Game and Fish Department. 2010. North Dakota Fishing Guide 2010-2012. http://www.gf.nd.gov/regulations/fish/pdf/fish-guide.pdf (February 2012).

Obbard, M. E. 1983. Population ecology of the common snapping turtle, *Chelydra serpentina*, in north-centeral Ontario. Doctorol Thesis. University of Guelph, Ontario, Canada.

Obbard, M. E., and R. J. Brooks. 1980. Nesting migrations of the snapping turtle (*Chelydra serpentina*). Herpetologica 36:158-162.

Obbard, M. E., and R. J. Brooks. 1981. A radio-telemetry and mark-recapture study of activity in the common snapping turtle, *Chelydra serpentina*. Copeia 1981:630-637.

Obbard, M. E., and R. J. Brooks. 1987. Prediction of the onset of the annual nesting season of the common snapping turtle, *Chelydra serpentina*. Herpetologica 43:324-328.

Ohio Department of Natural Resources Division of Wildlife. 2013. Ohio fishing regulations. 2045 Morse Rd, Columbus, Ohio 43229.

Oklahoma Department of Wildlife Conservation. 2013. Oklahoma fishing. P.O. Box 53465, Oklahoma City, Oklahoma 73152.

Overman, S. R., and J. J. Krajicek. 1995. Snapping turtles (*Chelydra serpentina)* as biomonitors of lead contamination of the Big River in Missouri's old lead belt. Environmental Toxicology and Chemistry 14: 689-695.

Pennsylvania Fish and Boat Commission. 2014. Pennsylvania fishhing summary: Summary of fishing regulation and laws. 1601 Elmerton Ave. P.O. Box 67000, Harrisburg, Pennsylvania 17106.

Pritchard, P. C. H. 1979. Encyclopedia of turtles. T.F.H. Publications, Neptune, New Jersey.

Pritchard, P. C. H. 1980. The conservation of sea turtles: practices and problems. American Zoologist 20:3: 609-617.

Richmond, N. D. 1936. Seventeen-year locust in the diet of the snapping turtle. Herpetologica 1:8.

Robinson, C. 1989. Orientation and survival of hatchlings and reproductive ecology of the common snapping turtle (*Chelydra serpentina*) in southern Quebec. Master of Science Thesis. Macdonald College of McGill University. Montreal, Quebec, Canada.

Robinson, C. and J. R. Bider. 1988. A strategy to decrease predation of snapping turtle (*Chelydra serpentina*) nests. Journal of Herpetology 22: 470-473

Sax, L. J., S. K. Gilmartin, and A. N. Bryant. 2003. Assessing response rates and nonresponse bias in web and paper surveys. Research in Higher Education 44: 409-432.

Shin, E., T. P. Johnson, and K. Rao. 2012. Survey mode effects on data quality: comparison of web and mail modes in a U.S. national panel survey. Social Science Computer Review 30:2: 212-228.

South Dakota Department of Game, Fish and Parks. 2013. 2013 Fishing Handbook. 523 East Capitol Ave, Pierre, South Dakota 57501.

State of Rhode Island and Providence Plantions Department of Environmental Management Division of Fish and Wildlife. 2013. Hunting regulations. 235 Promenade St, Providence, Rhode Island 02908.

Steyermark, A. C., M. S. Finkler, R. J. Brooks, and J. W. Gibbons. 2008. Biology of the snapping turtle. the Johns Hopkins University Press, Baltimore, Maryland.

Taylor, E. H. Observations on the courtship of turtles. University of Kansas Science Bulletin 21:269-271.

Tennessee Wildlife Resources Agency. 2013. Tennessee fishing guide. 440 Hogan Rd, Nashville, Tennessee 37220.

United States Army Corps of Engineers. 2012. Omaha District Lakes and Dams. http://www.nwo.usace.army.mil/lake_proj/garrison/bowman.html (April 2012).

United States Department of the Interior Bureau of Reclamation. 2013. Dickinson unit. http://www.usbr.gov/projects/Project.jsp?proj_Name=Dickinson%20Unit (January 2014).

United States Department of the Interior and United States Geological Survey. 2006. Reptiles and amphibians of North Dakota. http://www.npwrc.usgs.gov/resource/herps/amrepnd/species/chelserp.htm (February 2012).

United States Environmental Protection Agency. 2012. Cottonwood Creek watershed: project is a success in the works. http://water.epa.gov/polwaste/nps/success319/Section319III_ND.cfm (January 2014).

White, G.C. and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46 Supplement, 120-138.

Yntema, C. L. 1978. Incubation times for eggs of the turtle *Chelydra serpentina* (Testudines: Chelydridae) at Various Temperatures. Herpetologica 34:274-277.

County	Present	Information Source
Adams	Yes	Fisheries Database
Barnes	Yes	Fisheries Database
Benson	No	No Data
Billings	No	No Data
Bottineau	Yes	USFW Refuge Personnel
Bowman	Yes	Turtle Research Project
Burke	Yes	Fisheries Database
Burleigh	Yes	Game and Fish Personnel
Cass	Yes	Game and Fish Personnel
Cavalier	No	No Data
Dickey	Yes	Fisheries Database
Divide	No	No Data
Dunn	Yes	Game and Fish Personnel
Eddy	Yes	Game and Fish Personnel
Emmons	Yes	Fisheries Database
Foster	Yes	Game and Fish Personnel
Golden Valley	Yes	Fisheries Database
Grand Forks	No	No Data
Grant	Yes	Fisheries Database
Griggs	Yes	Game and Fish Personnel
Hettinger	Yes	Fisheries Database
Kidder	Yes	USFW Refuge Personnel
La Moure	Yes	Turtle Research Project And Database
Logan	Yes	Fisheries Database
McHenry	Yes	USFW Refuge Personnel
McIntosh	No	No Data
McKenzie	Yes	Fisheries Database
McLean	Yes	Fisheries Database
Mercer	Yes	Turtle Research Project
Morton	Yes	Fisheries Database
Mountrail	Yes	Fisheries Database
Nelson	No	No Data
Oliver	Yes	Turtle Research Project And Database
Pembina	No	No Data
Pierce	Yes	Turtle Research Project
Ramsey	No	No Data
Ransom	Yes	Fisheries Database
Renville	Yes	USFW Refuge Personnel
Richland	Yes	Fisheries Database
Rolette	No	No Data
Sargent	Yes	Game and Fish Personnel
Sheridan	Yes	Game and Fish Personnel
Sioux	Yes	Fisheries Database
Slope	Yes	Fisheries Database
Stark	Yes	Turtle Research Project And Database
Steele	Yes	Game and Fish Personnel
Stutsman	Yes	Fisheries Database
Towner	No	No Data
Traill	Yes	Game and Fish Personnel
Walsh	No	No Data
Ward	Yes	Fisheries Database
Wells	Yes	Game and Fish Personnel
Williams	Yes	Fisheries Database

Table 1. Snapping turtle distribution by county and the sources used for determining presence

1204

Body of Water	County	Sampling Period in Days	Snapping Turtles Trapped
Bowman-Haley Reservoir	Bowman	17	3
Cherry Lake	Kidder	2	0
Frettim Lake	Kidder	2	0
Lake LaMoure	LaMoure	4	35
Mundt Lake	Logan	2	0
Buffalo Lodge Lake	McHenry	2	0
Lehr WMA	McIntosh	2	0
Blumhardt Dam	McIntosh	2	0
Coldwater Lake	McIntosh	2	0
Harmony Lake	Mercer	1	0
The Knife River	Mercer	1	1
Nelson Lake	Oliver	17	11
Oliver County SCP	Oliver	1	1
Balta Dam	Pierce	2	0
Buffalo Lake	Pierce	1	1
Dion Lake	Rolette	2	0
School Section Lake	Rolette	2	0
Willow Lake Creek	Rolette	2	0
Buffalo Lake	Sargent	2	0
Silver Lake	Sargent	2	0
Patterson Lake	Stark	7	10

Table 2. Sampling period and snapping turtles trapped by individual bodies of water.

State	Season length	Daily limit	Possession limit	Yearly limit	Length restrictions
Alabama	Year-round	2	2	None	None
Arkansas	Year-round	None	None	None	None
Colorado	April 1- Oct. 31	None	None	None	None
Connecticut	July 15-Sept. 30	5	30	30	13" min length
Delaware	June15-May15	None	None	None	11" min length
Florida	NO HARVEST				
Georgia	Year-round	10	10	10	None
Illinois	June 15-Aug 31	2	4	None	None
Indiana	Year-round	25	50	None	None
Iowa	Year-round	100 lbs live 50 dressed	100 lbs live 50 dressed	None	None
Kansas	Year-round	8	24	None	None
Kentucky	Year-round	None	None	None	None
Louisiana	Year-round	None	None	None	None
Maine	Year-round	None	None	None	None
Maryland	Year-round except Charles County	1	1	None	4" min length
Massachusetts	Year-round	None	None	None	6" min width
Michigan	July 15-Sept 15	2	4	None	13" min length
Minnesota	Year-round	3	3	None	None
Missouri	Year-round	5	10	None	None
Nebraska	Year-round	5	10	None	None
New Hampshire	July 16-May14	2	4	None	None
New Jersey	June 16-April 30	3	None	None	None
New York	July 15-Sept 30	5	30	30	12" min length
North Carolina	Year-round	10	100	100	None
North Dakota	Year-Round	None	None	None	None
Ohio	July 1-April 30	None	None	None	13" min length
Oklahoma	Year-round	6	None	None	None
Ontario	Year-round	2	5	None	None
Pennsylvania	July 1-Oct31	15	30	None	None
Rhode Island	Year-round	None	None	None	12" min length
South Carolina	Year-round	None	None	None	None
South Dakota	Year-round	2	4	None	None
Tennessee	Year-round	5	10	None	12" min length
Texas	Year-round	None	None	None	None
Virginia	Year-round	5	None	None	None
West Virginia	July 16-May14	10	20	None	None
Wisconsin	July 15-Nov 30	3	3	None	12" min 16" max length

Table 3. Snapping turtle harvest regulations by state (Alabama Department of Conservation and Natural Resources, 2013, Commonwealth of Massachusetts Department of Fish and Game, 2014, Conneticut Department of Energy and Environmental Protection, Illinois Administrative Code (a) 2013, Illinouis Administratvie Code (b), 2013, Delaware Department of Natural Resources and Environmental Control: Division of Fish and Wildlife, 2013, Florida Fish and Wildlife Conservation Commission, 2013, Georgia Department of Natural Resources: Wildlife Resources Division, Indiana Department of Natural Resources, 2013, Ministry of Natural Resources, 2013, Missoui Department of Conservatoin, 2014, Nanjappa, P. and P. M. Conrad, 2011, Nebraska Game and Parks Commission, 2013, New Hampshire Fish and Game Department, 2013, New York Department of Environmental Conservation, 2013, Ohio Department of Natural Resources Division of Wildlife, 2013, Oklahoma Department of Wildlife Conservation, 2013, South Dakota Department of Game, Fish and Parks, 2013, State of Rhode Island and Providence Plantions Department of Environmental Management Division of Fish and Wildlife, 2013, Tennessee Wildlife Resources Agency, 2013, Virginia Department of Game and Inland Fisheries, 2014, West Virginia Division of Natural Resources, 2014, Wisconsin Department of Natural Resources Bureau of Fisheries Management, 2013).

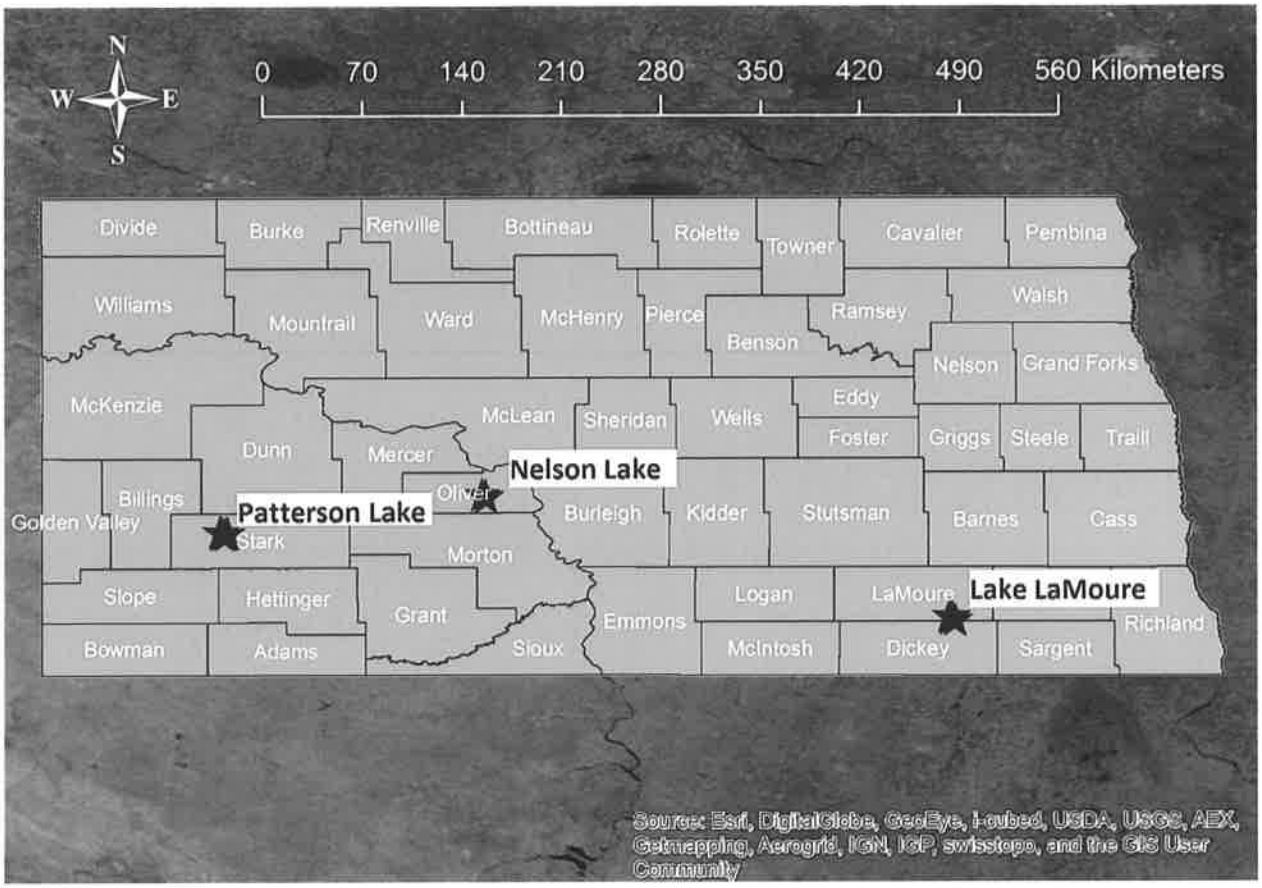


Figure 1. Map showing the locations of the study lakes within the state of North Dakota, stars indicate the locations.

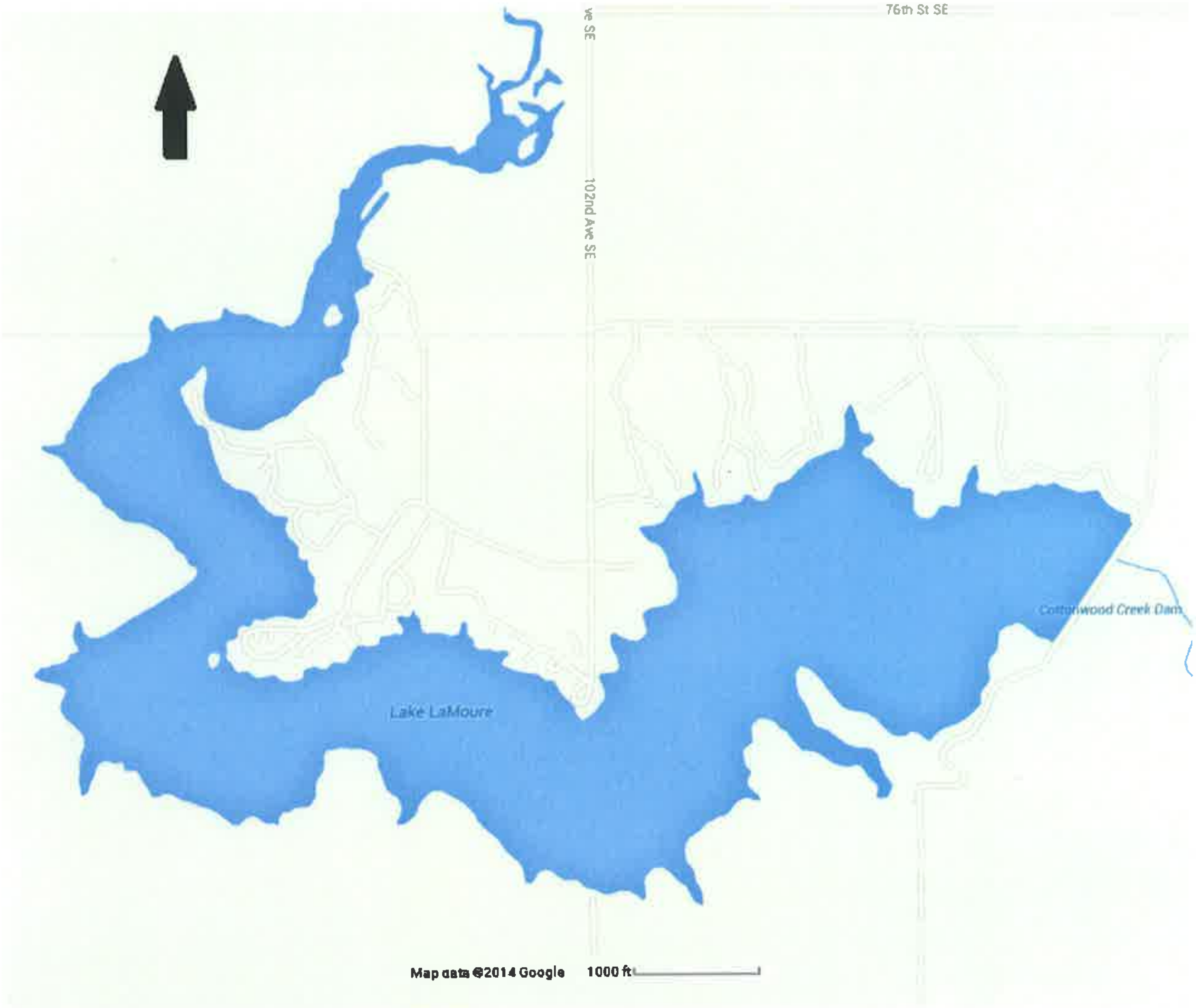


Figure 2. Map of Lake LaMoure.

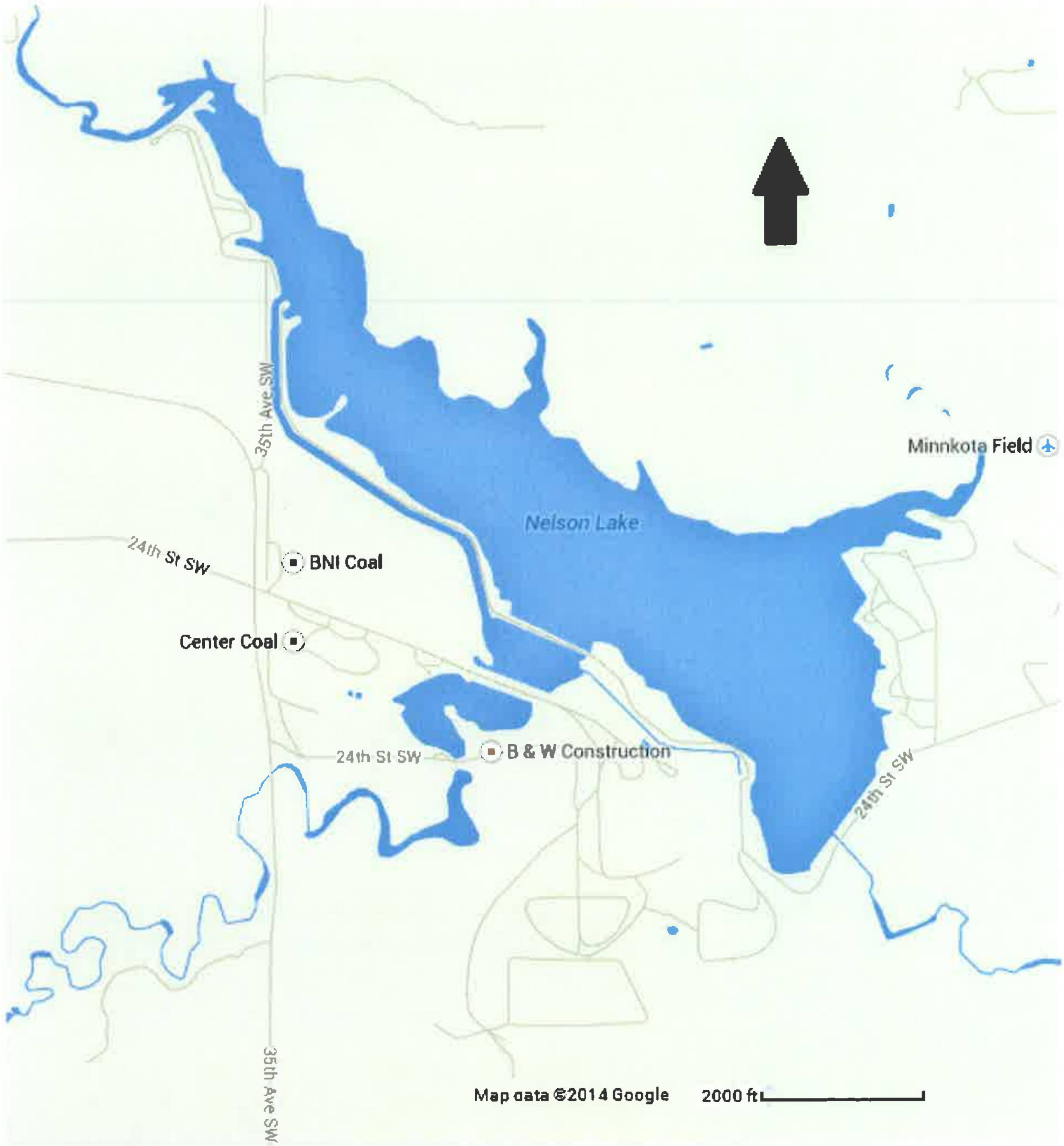


Figure 3. Map of Nelson Lake

Figure 4. Map of Patterson Lake.

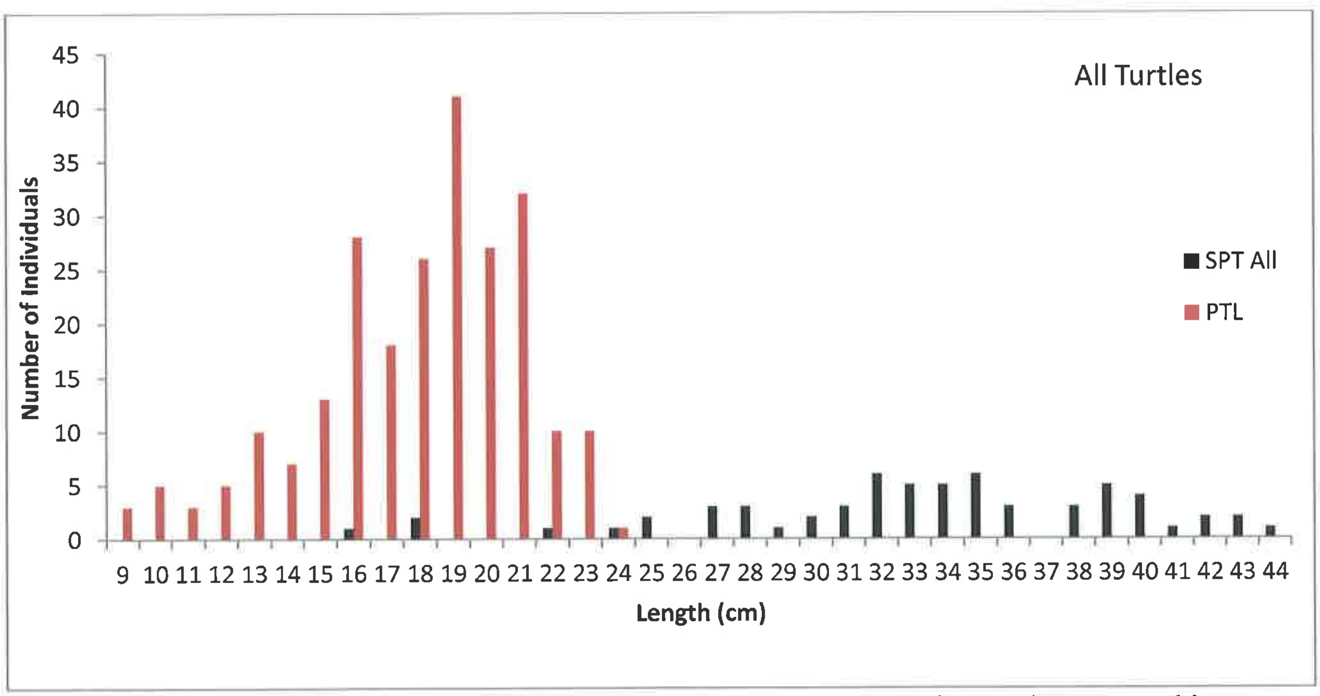


Figure 39. Length frequency histogram for all painted turtles and snapping turtles captured in North Dakota.

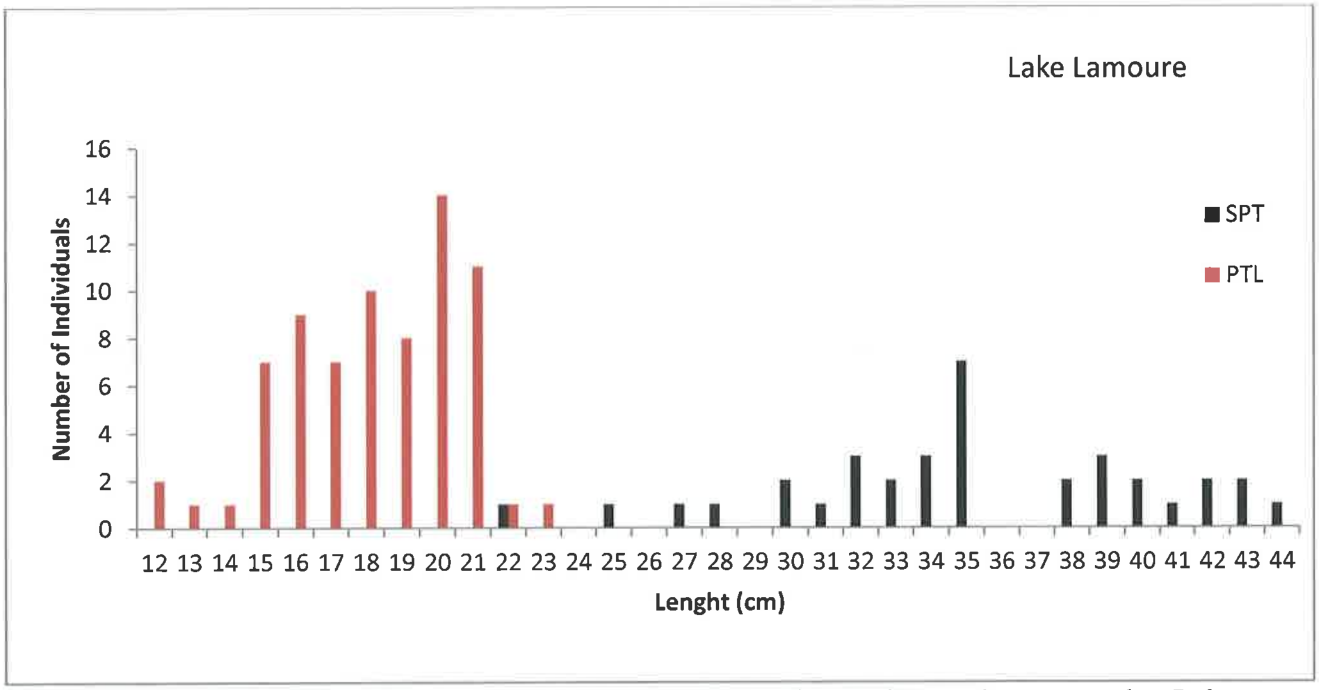


Figure 40. Length frequency histogram for painted turtles and snapping turtles captured at Lake LaMoure.

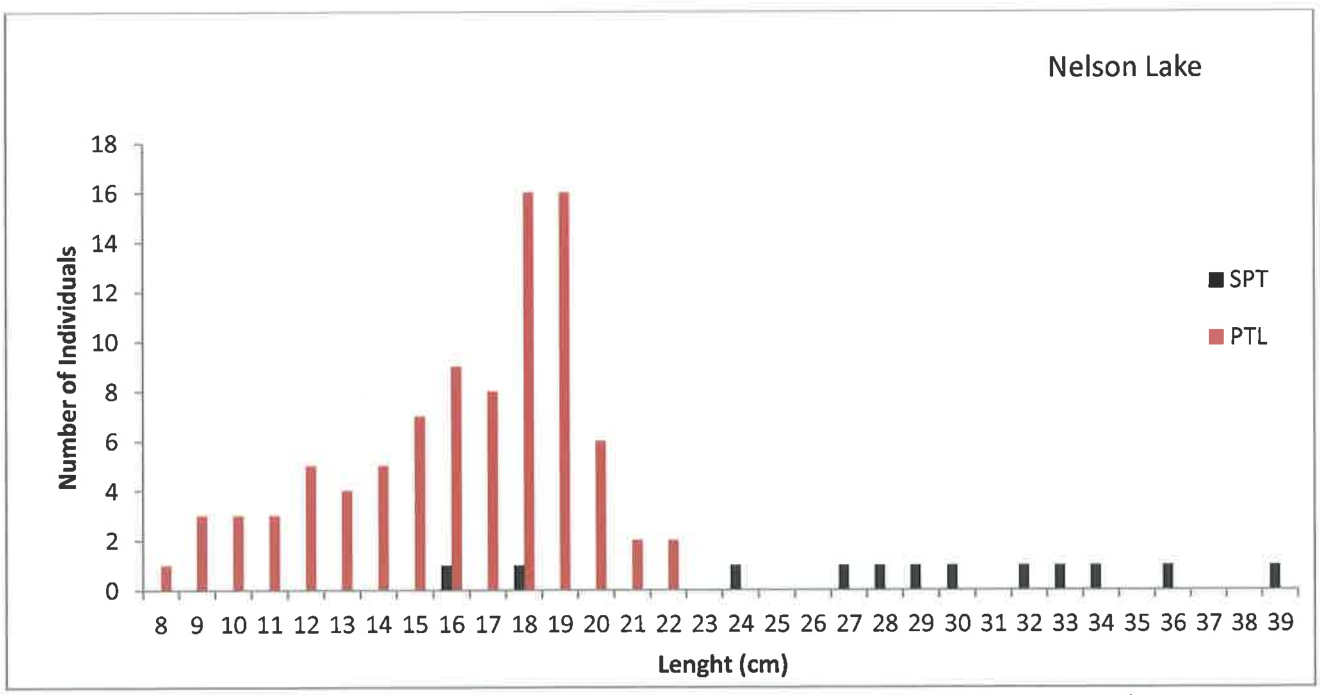


Figure 41. Length frequency histogram for painted turtles and snapping turtles captured at Nelson Lake.

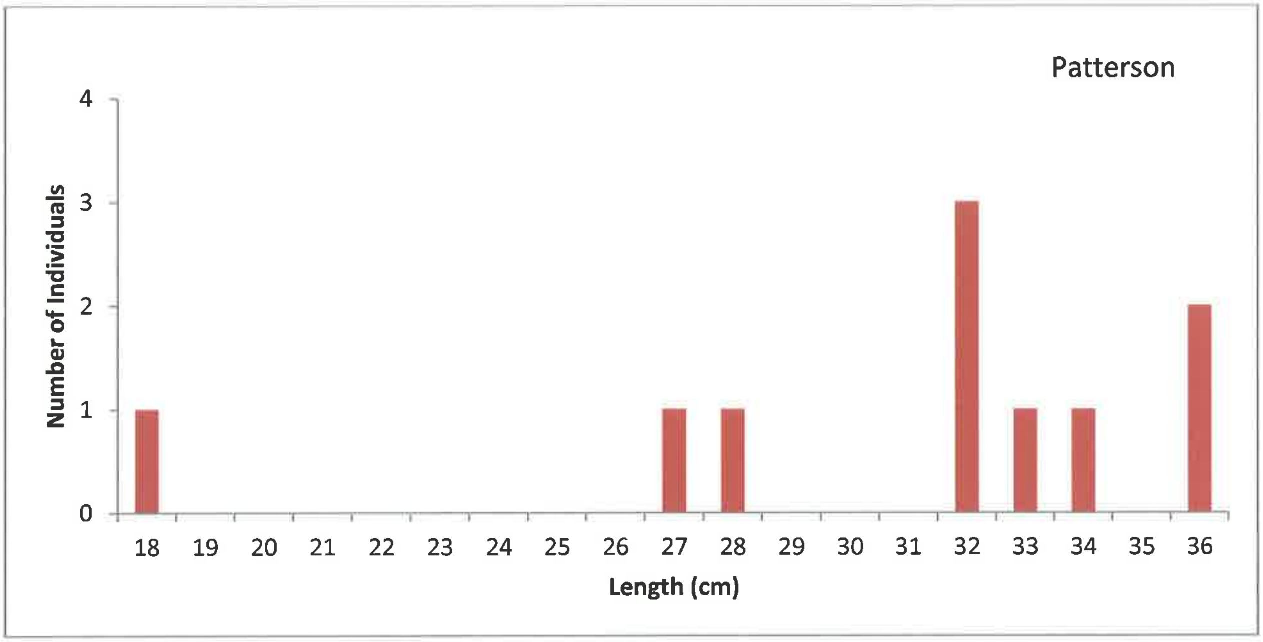


Figure 444. Length frequency histogram for snapping turtles captured at Patterson Lake.

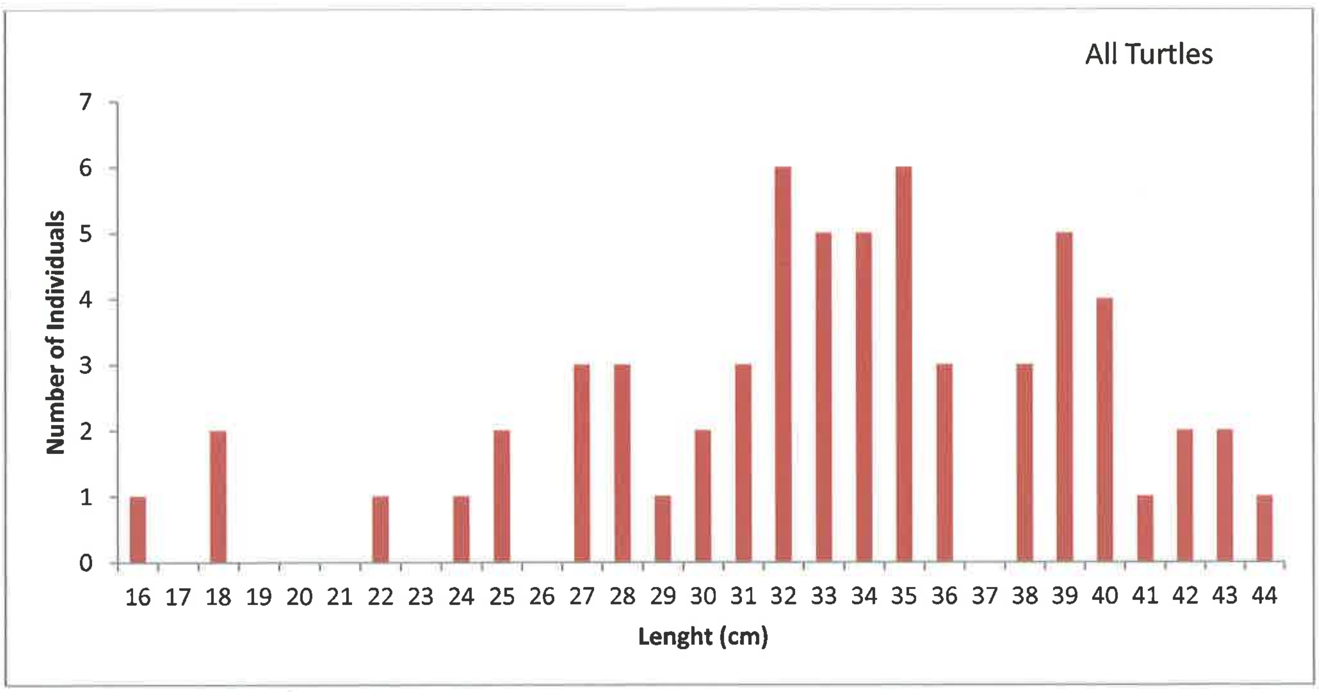


Figure 42. Length frequency histogram for all snapping turtles captured in North Dakota.

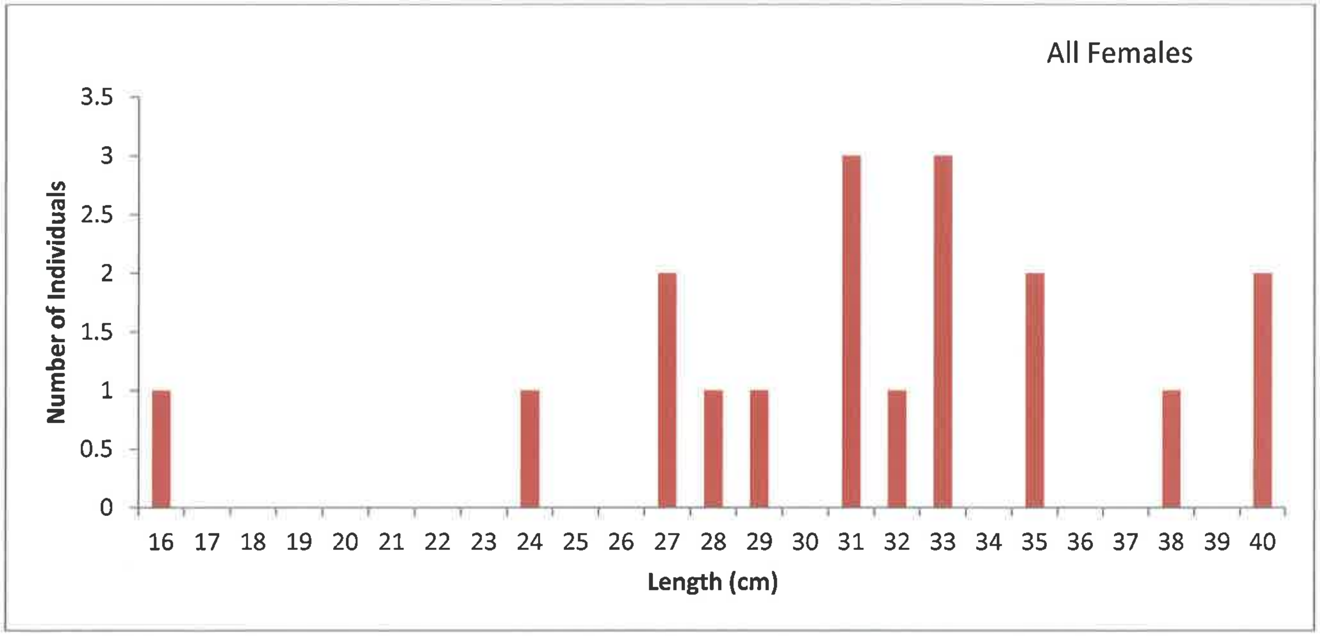


Figure 43. Length frequency histogram for all female snapping turtles captured in North Dakota.

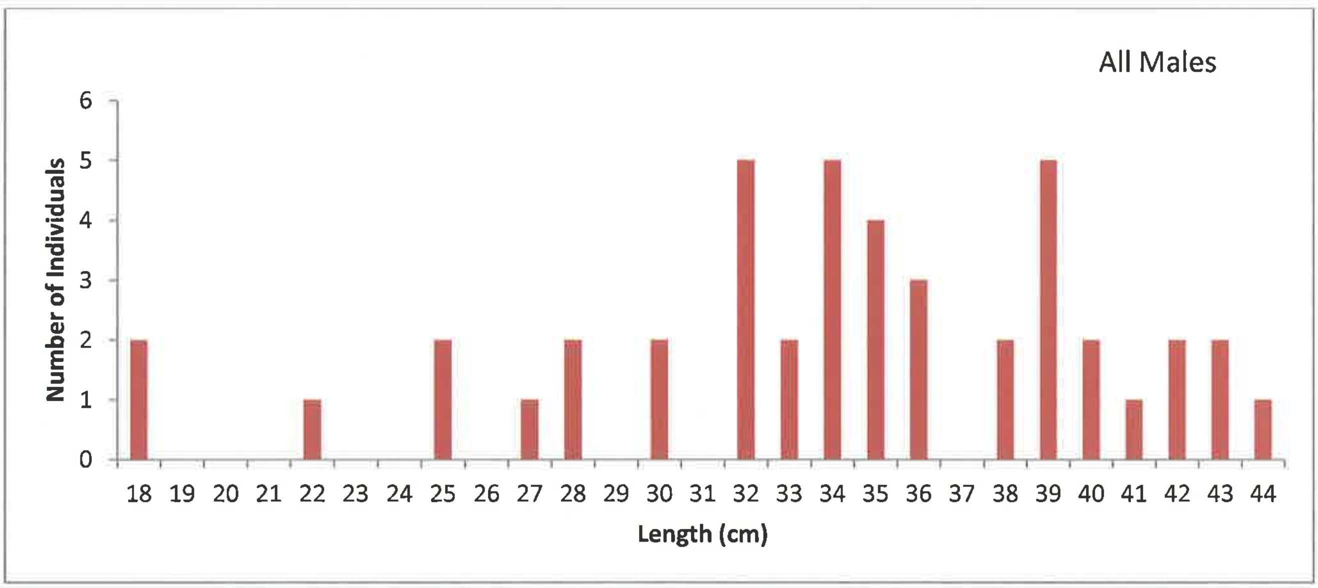


Figure 44. Length frequency histogram for all male snapping turtles caputred in North Dakota.

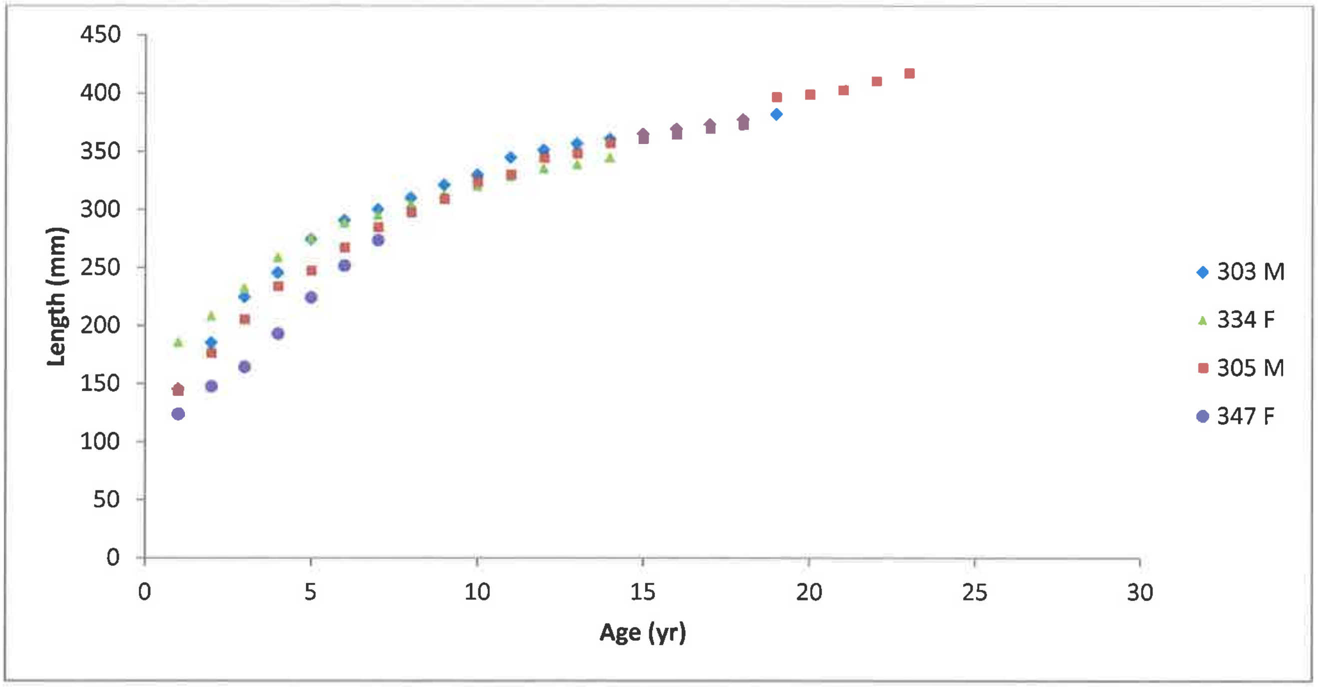


Figure 13. A representation of the back calculated growth patterns of four turtles captured in North Dakota. Along the x axis age is denoted in years and along the y axis length is denoted in millimeters. The equation used to back calculate length at age was $L_i = \frac{S_i}{S_c} * L_c$ where L_i is the back calculated carapace length, S_i is the distance from the focus to the annuli, S_c is the distance from the focus to the edge of the scute, and L_c is the carapace length at capture (Le Cren, 1977).

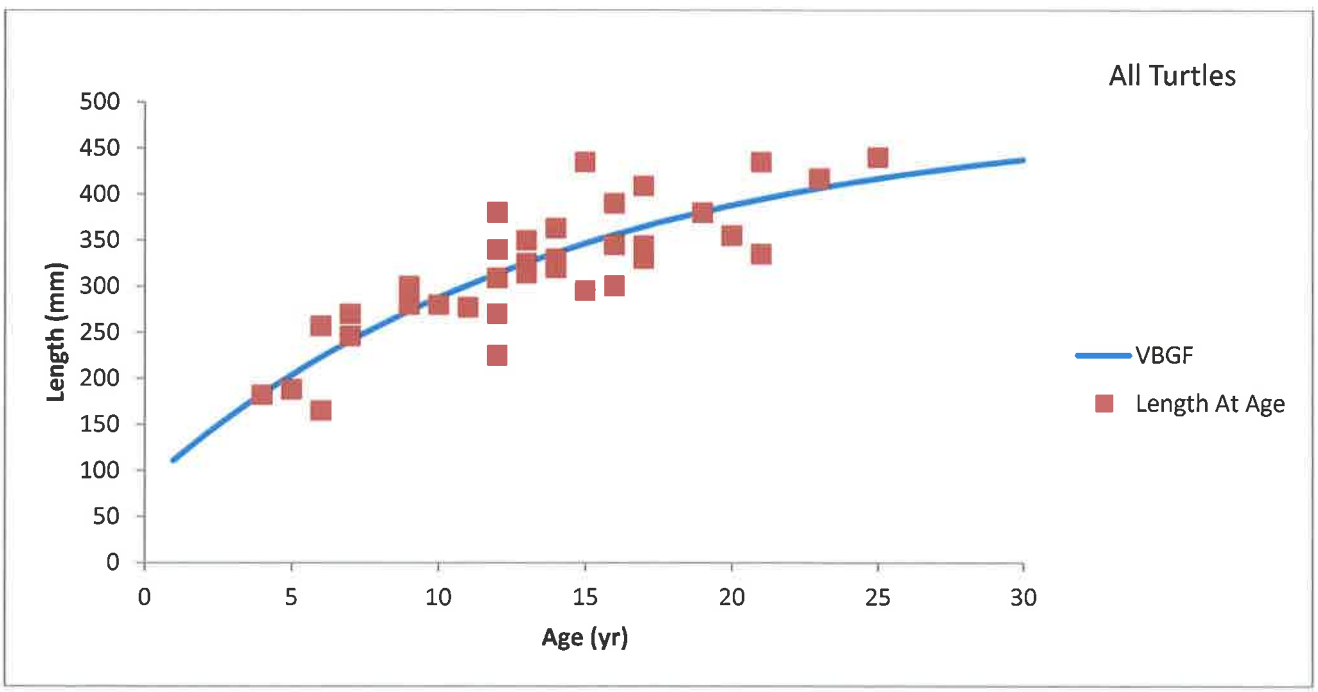


Figure 14. Von Bertalanffy growth function for length at age of snapping turtles captured in North Dakota. Along the x axis age is denoted in years and along the y axis length is denoted in

millimeters. The equation for Von Bertalanffy is $L_t = L_\infty[1 - e^{-K(t-t_0)}]$. The specific equation for all turtles in North Dakota is $L_t = 485.8[1 - e^{-0.0707(t+2.6531)}]$.

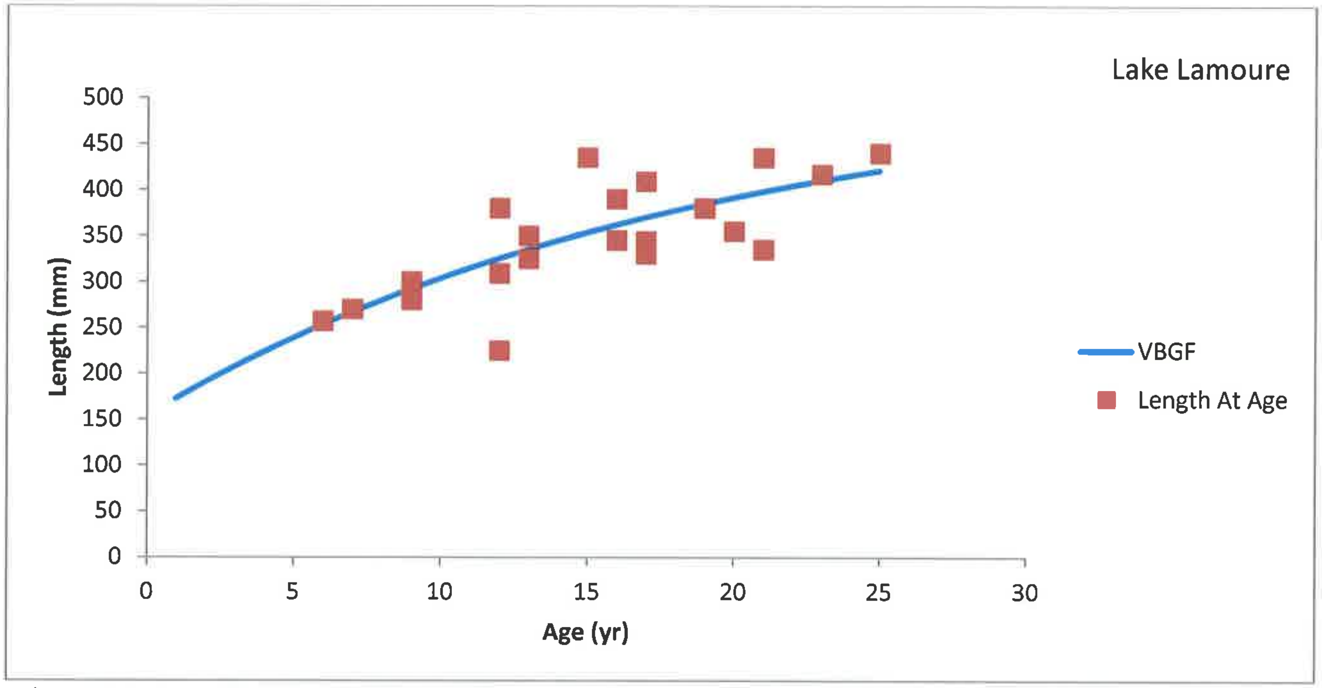


Figure 15. Von Bertalanffy growth function for length at age of snapping turtles captured at Lake LaMoure. The equation used was $L_t = 517.8[1 - e^{-0.053(t+6.653)}]$.

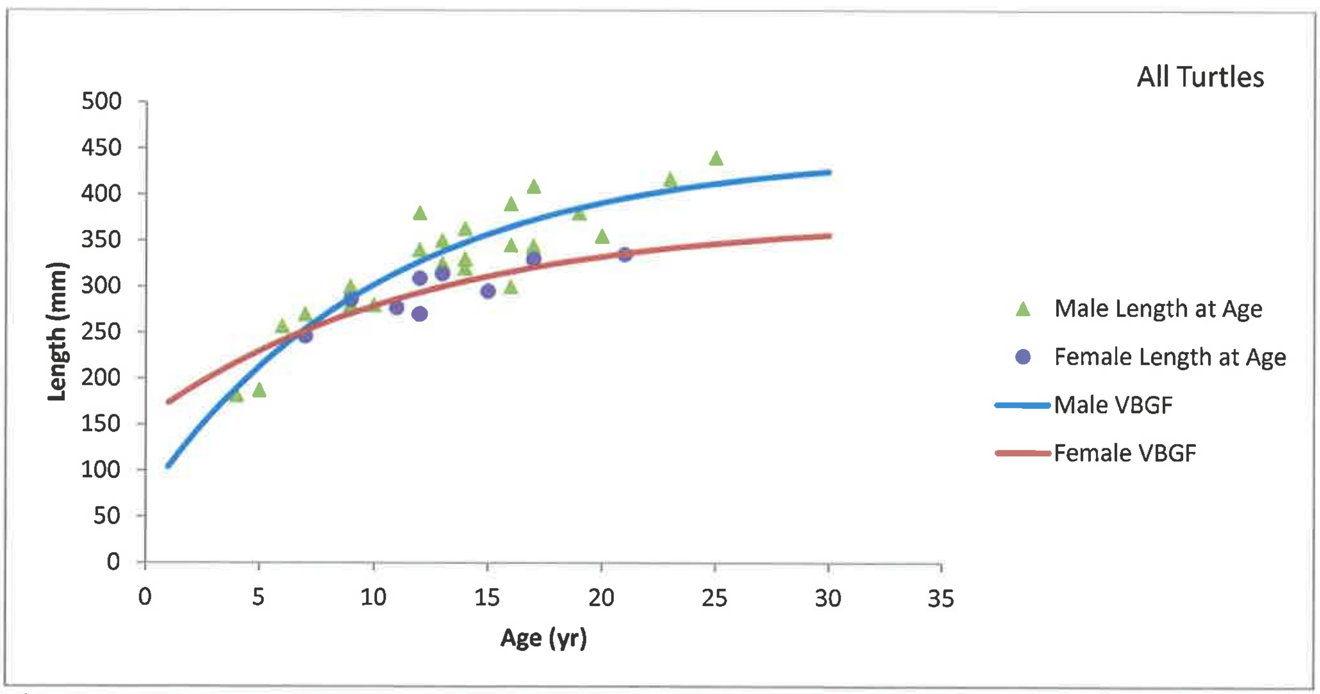


Figure 16. Von Bertalanffy growth function for length at age of male and female snapping turtles captured in North Dakota. The equations used are $L_t = 446.6[1 - e^{-0.0956(t+1.7728)}]$ and $L_t = 374[1 - e^{-0.0826(t+6.5525)}]$ respecively.

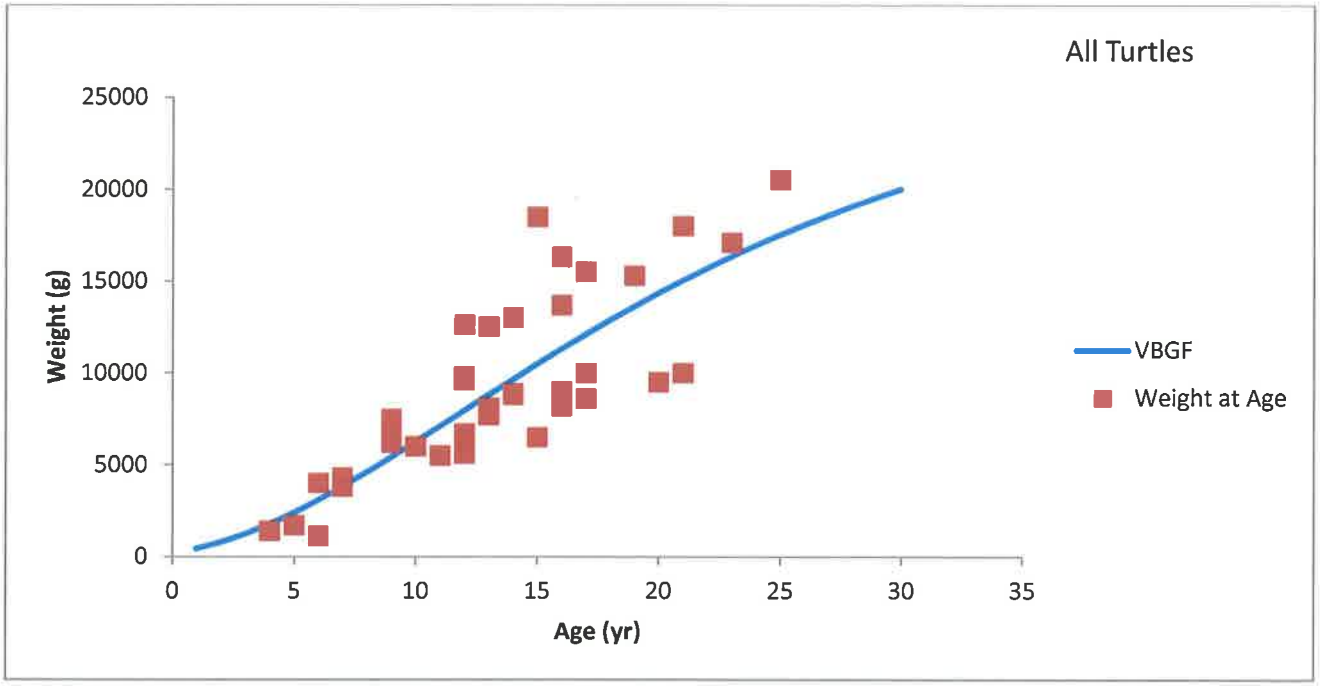


Figure 23. Von Bertalanffy growth function for weight at age of turtles captured in North Dakota. The general equation is used was $W_t = W_\infty[1 - e^{-K(t-t_0)}]^3$ and specifically for this data $W_t = 26745.4[1 - e^{-0.0707(t+2.6531)}]^3$.

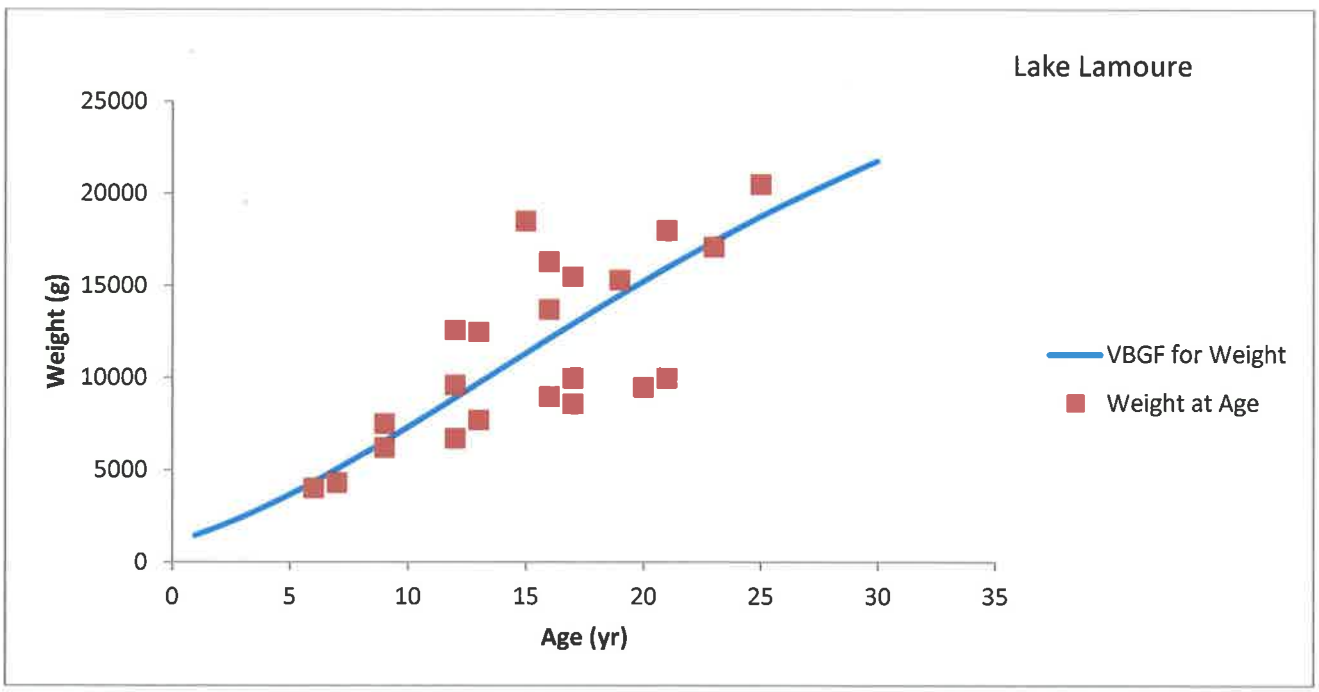


Figure 24. Von Bertalanffy growth function for weight at age of turtles captured at Lake LaMoure. The equation used was $W_t = 34022.815[1 - e^{-0.053(t+6.653)}]^3$.

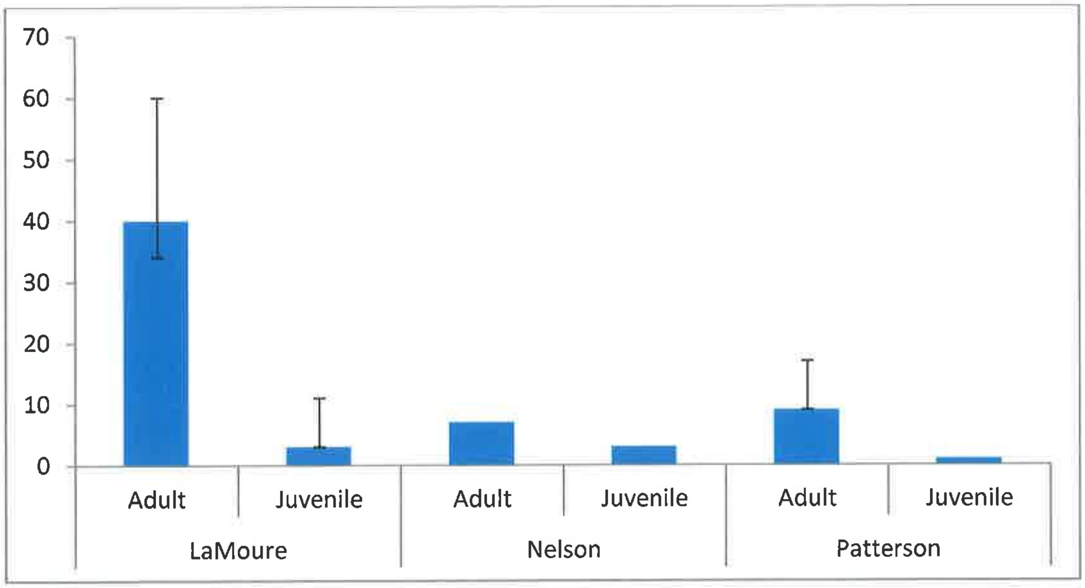


Figure 53. Population estimations from Program Mark with 95% confidence intervals.

Figure 25. Overwintering locations at Lake LaMoure.

Figure 26. Overwintering locations in reference to the entire lake at Lake LaMoure.

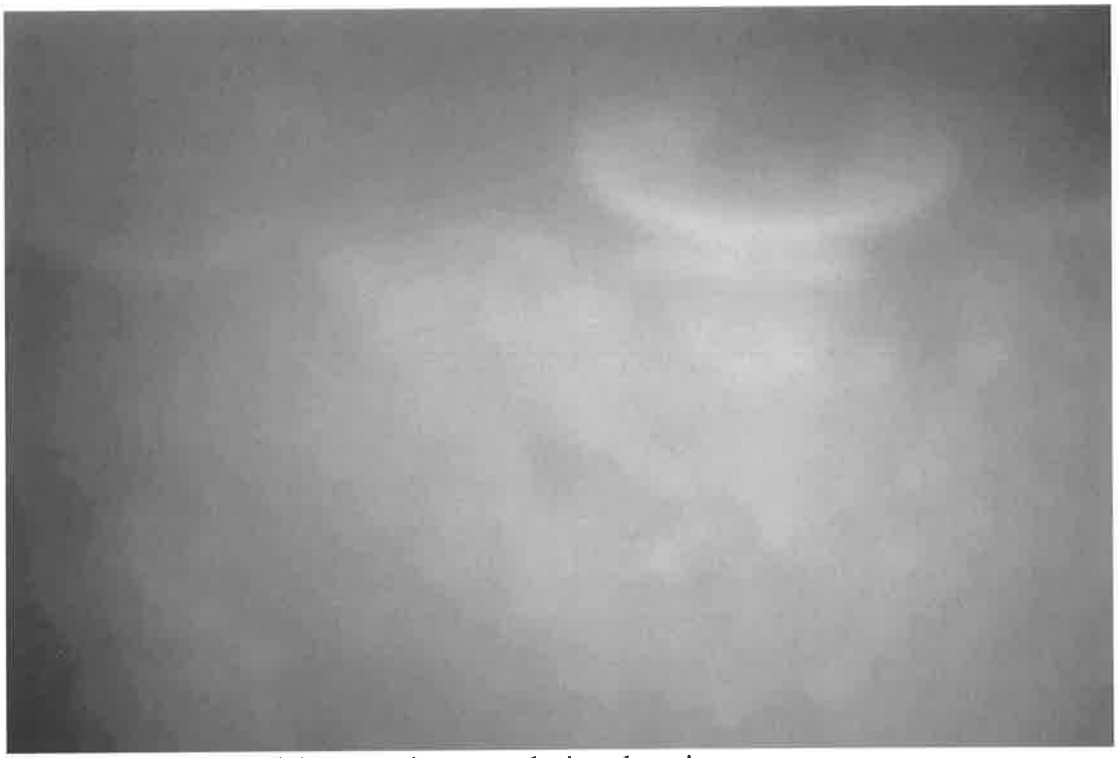


Figure 50. View of disk tag underwater during the winter.

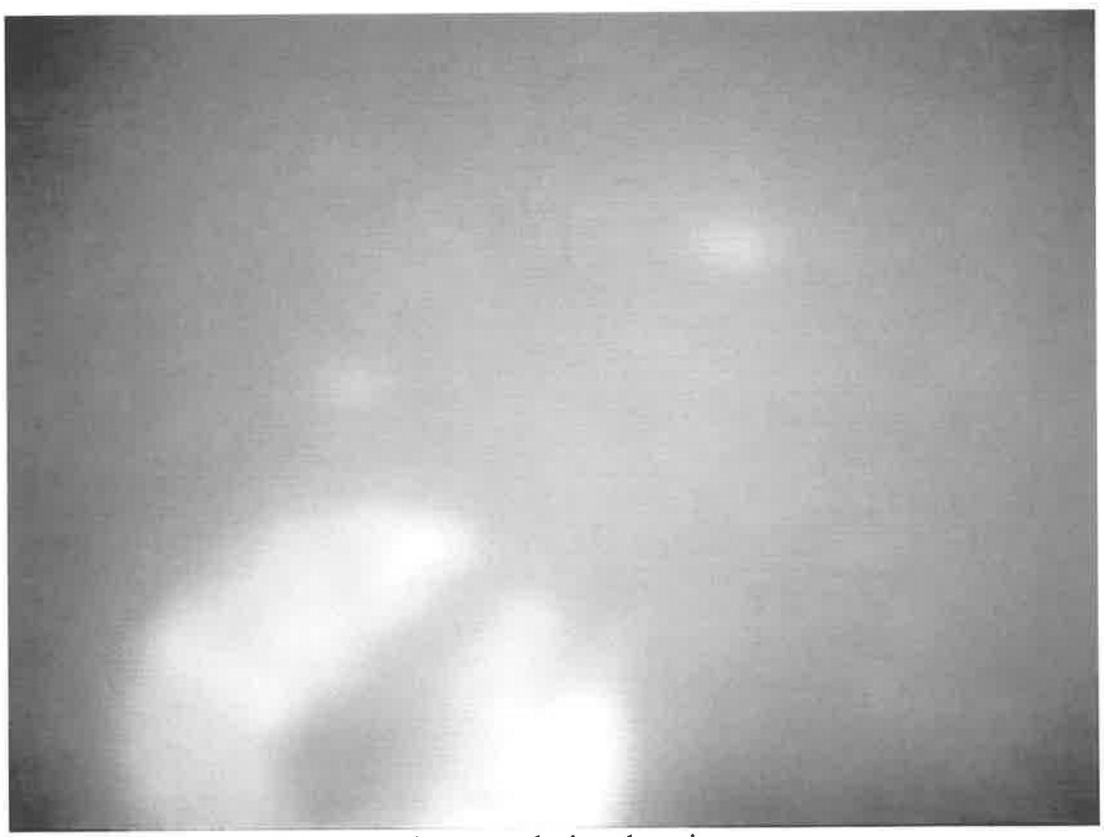


Figure 51. View of disk tag underwater during the winter.

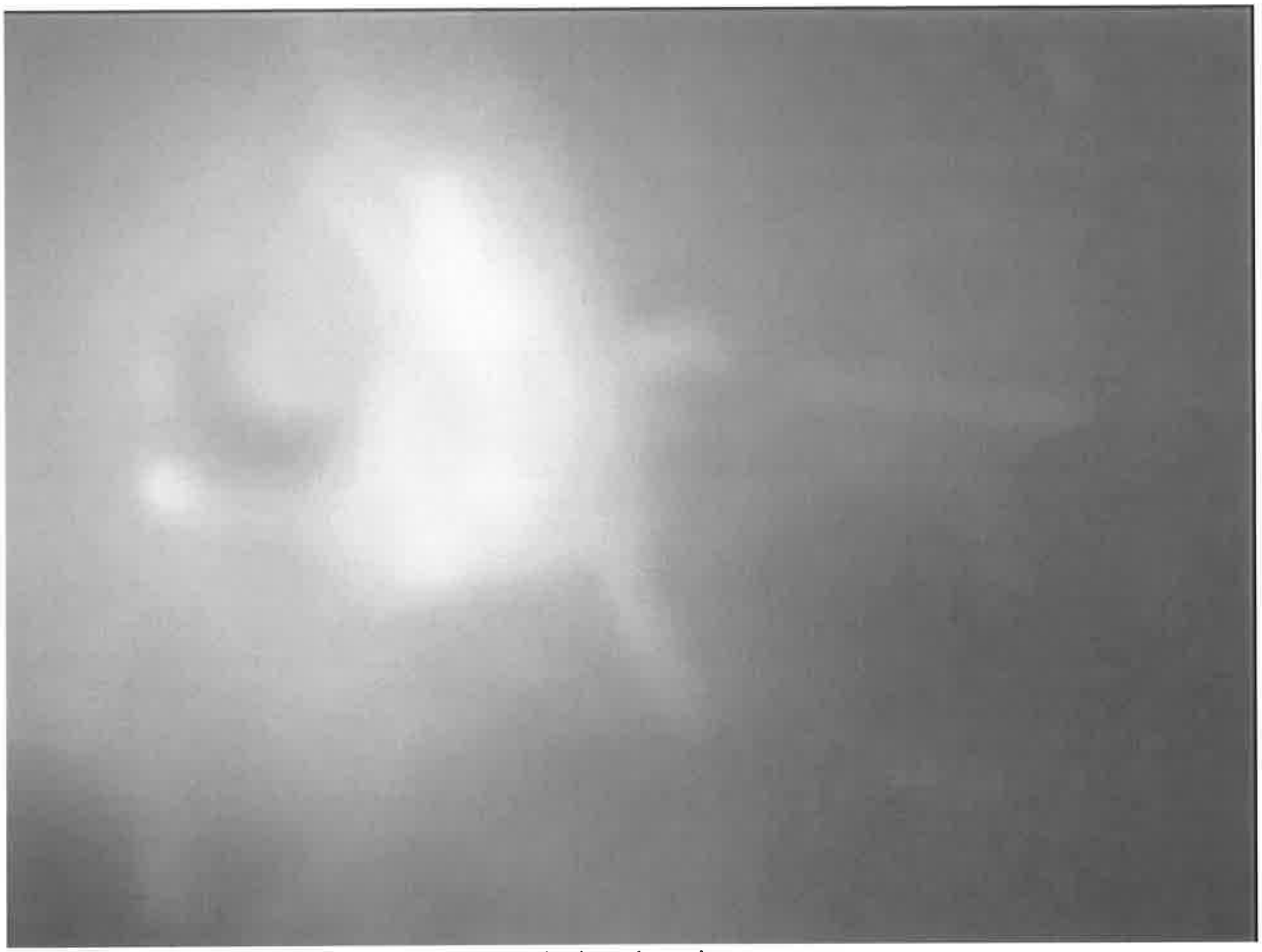


Figure 52. View of radio tag underwater during the winter.

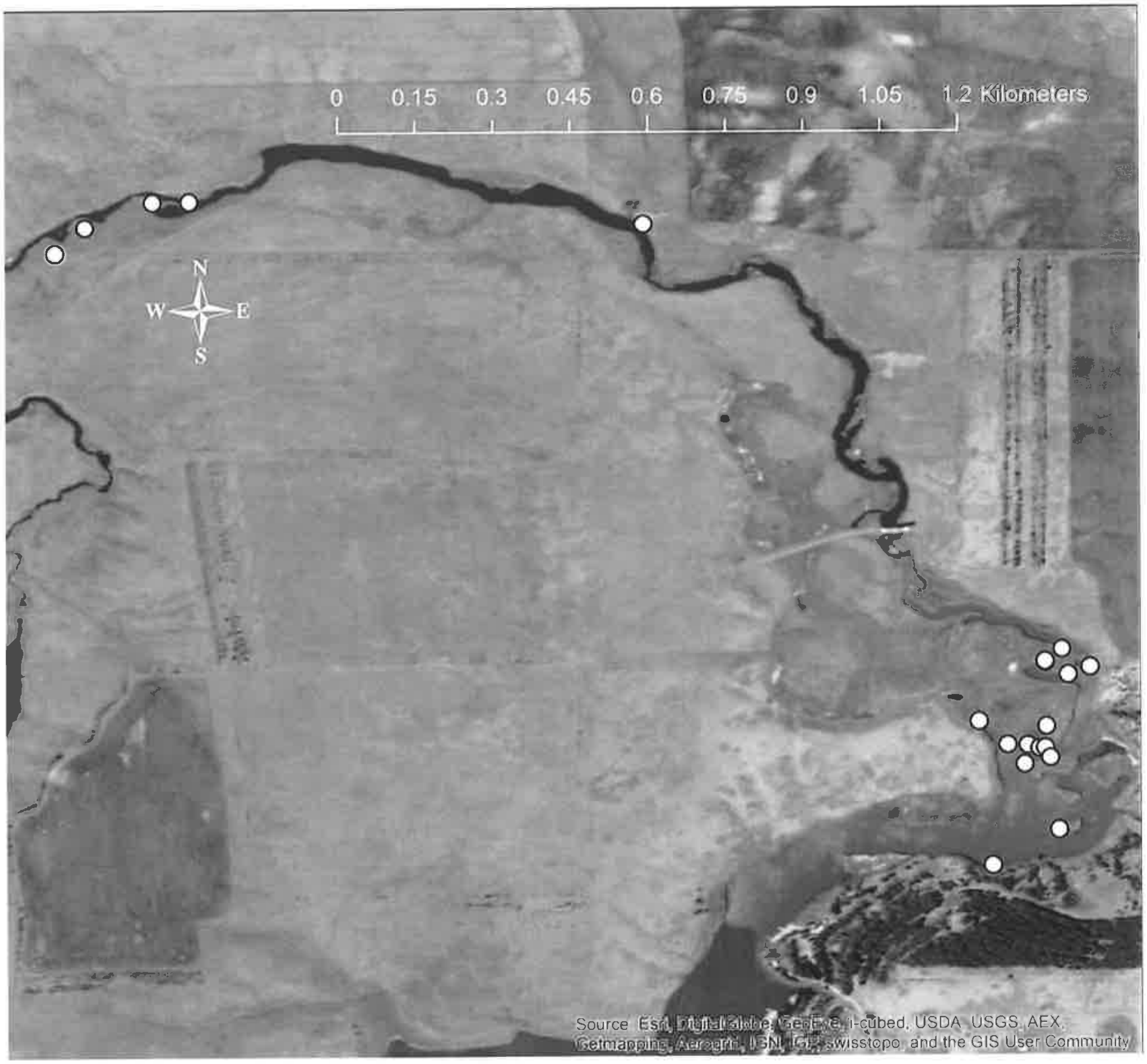


Figure 27. Movements for female turtle 384.

Figure 28. Movements for female turtle 454.

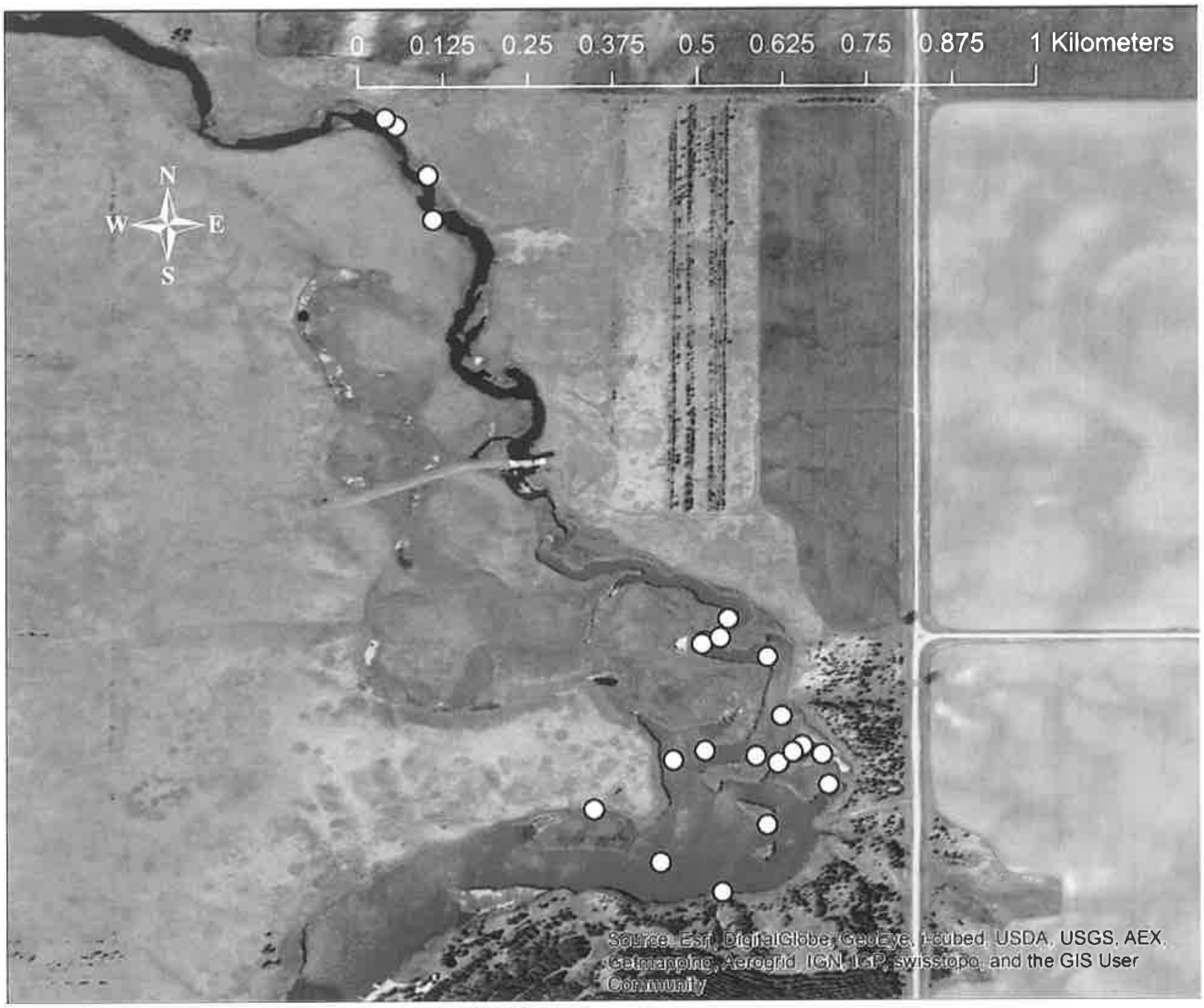


Figure 29. Movements for female turtle 484.

Figure 30. Movements for female turtle 494.

Figure 31. Movements for female turtle 495.

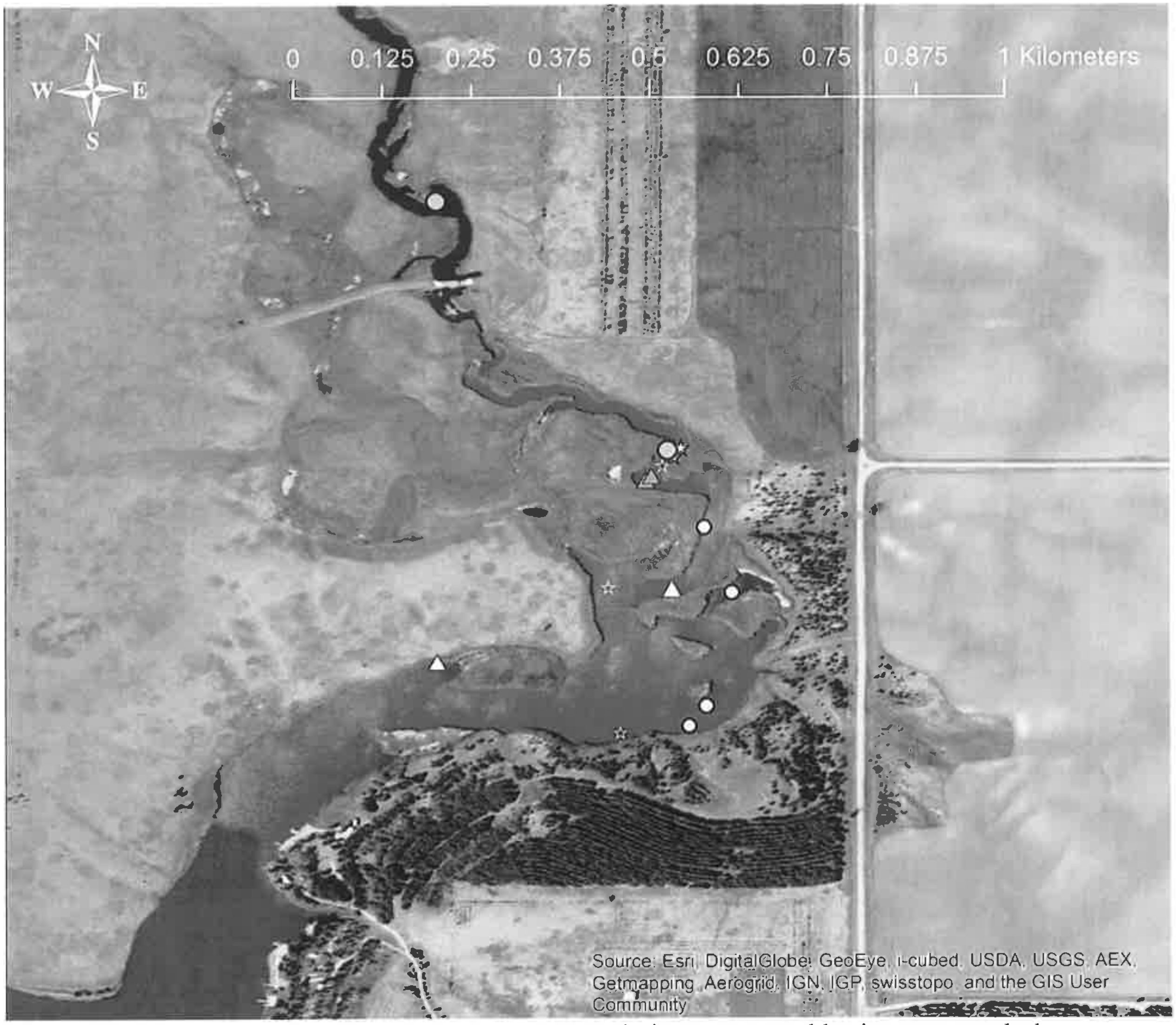


Figure 32. Movements for all male turtles, each male is represented by its own symbol.

Figure 33. All nesting locations found at Lake LaMoure.

Figure 34. Nesting locations along the James River by Lake LaMoure.

Figure 35. Nesting location on a gravel bar located on Cottonwood Creek, Lake LaMoure's inflow.

Figure 36. Nest location on a gravel road surrounding Lake LaMoure.

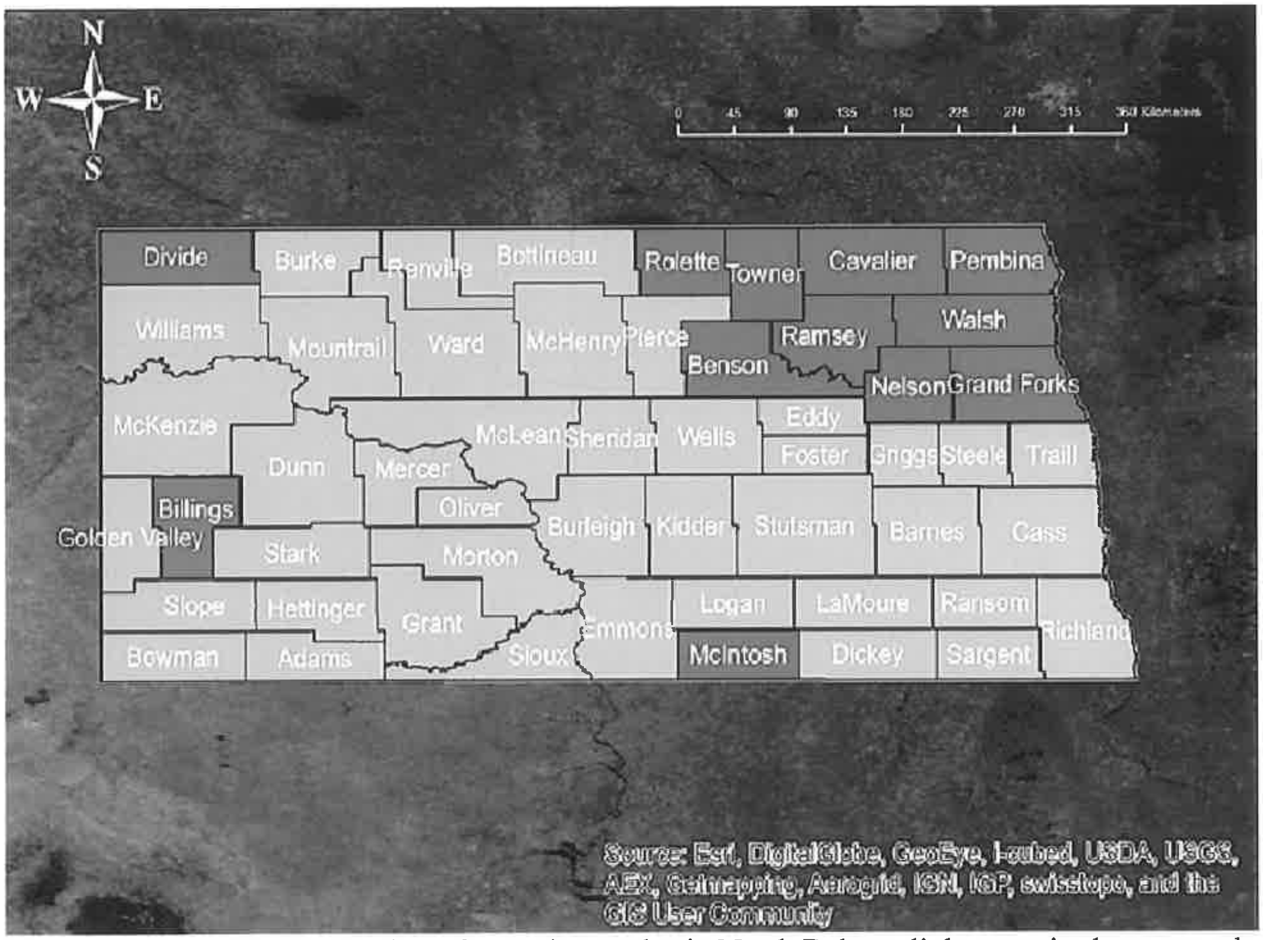


Figure 37. Statewide distribution of snapping turtles in North Dakota, light counties have records of snapping turtle presence and dark counties have no records.

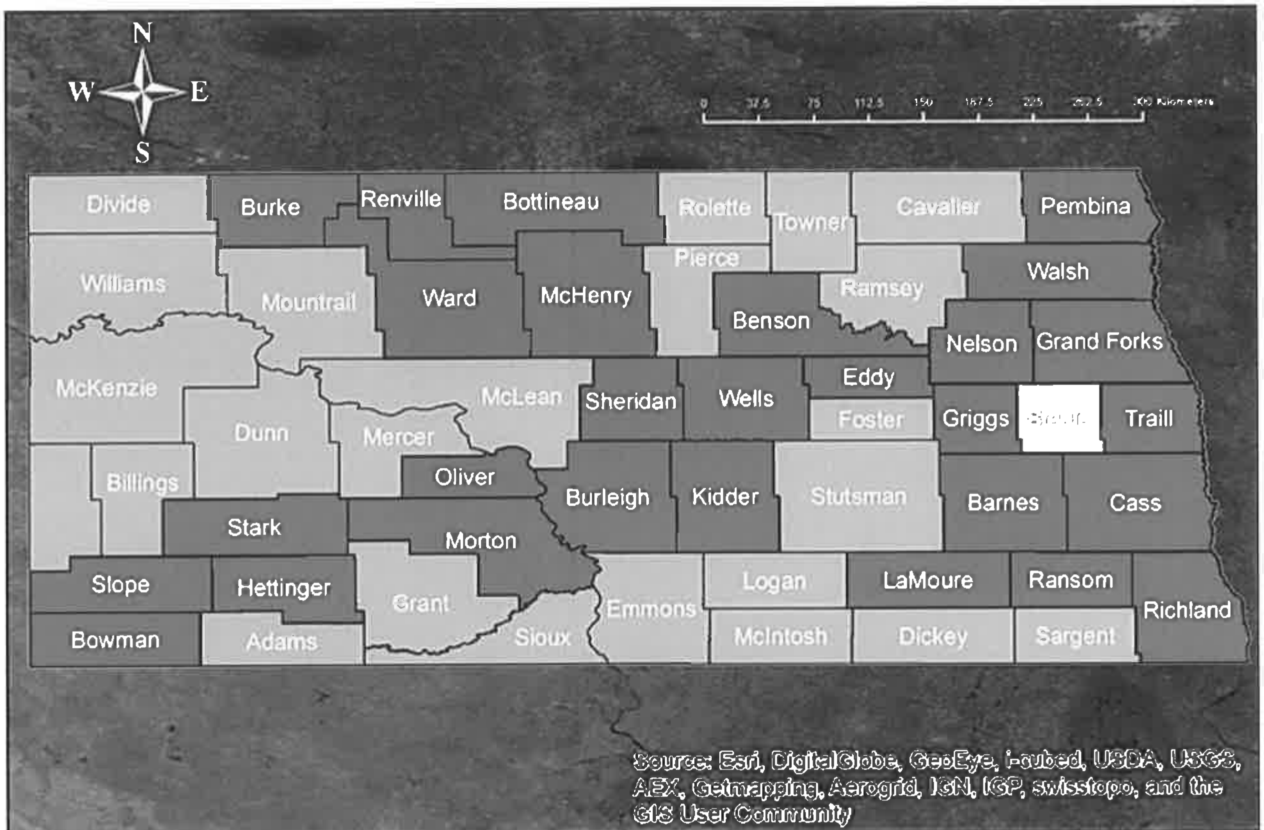


Figure 38. Snapping turtle harvest map from harvest survey, where dark counties represent counties with harvest and dark counties did not have harvest.

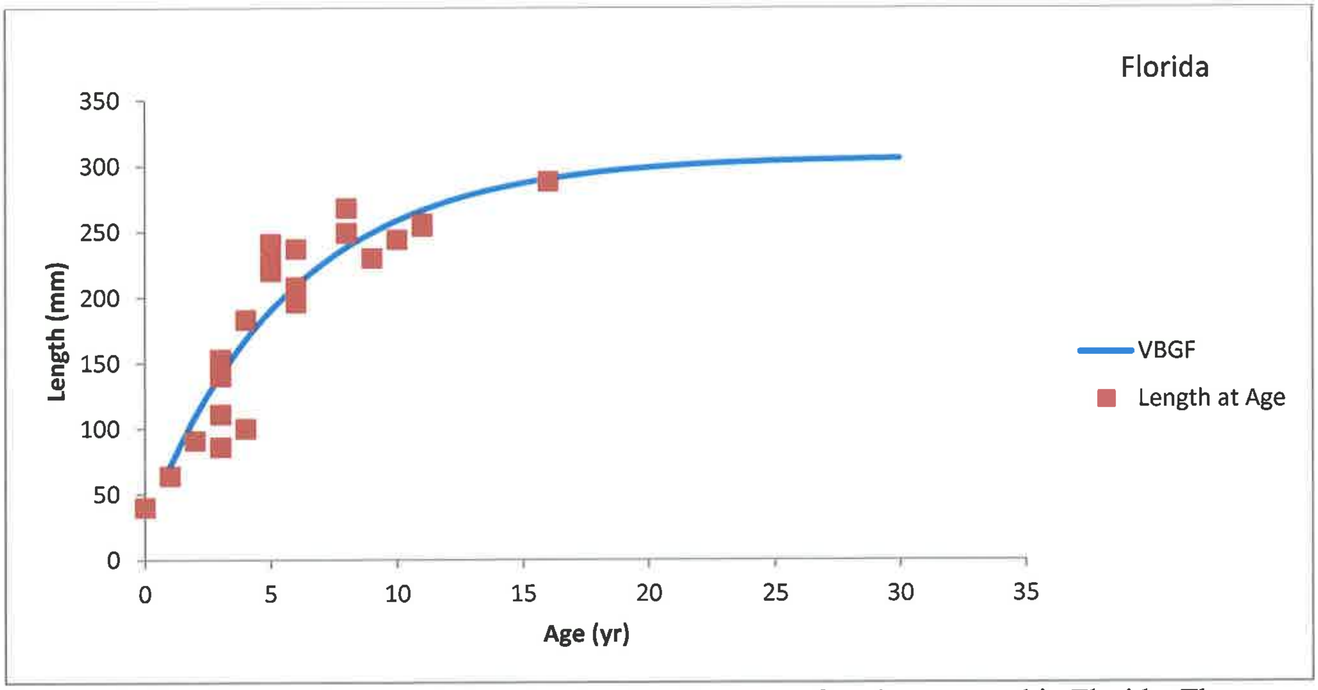


Figure 45. Von Bertalanffy growth function for length at age of turtles captured in Florida. The equation used was $L_t = 307.1[1 - e^{-0.1757(t+0.4757)}]$ (Aresco, unpublished).

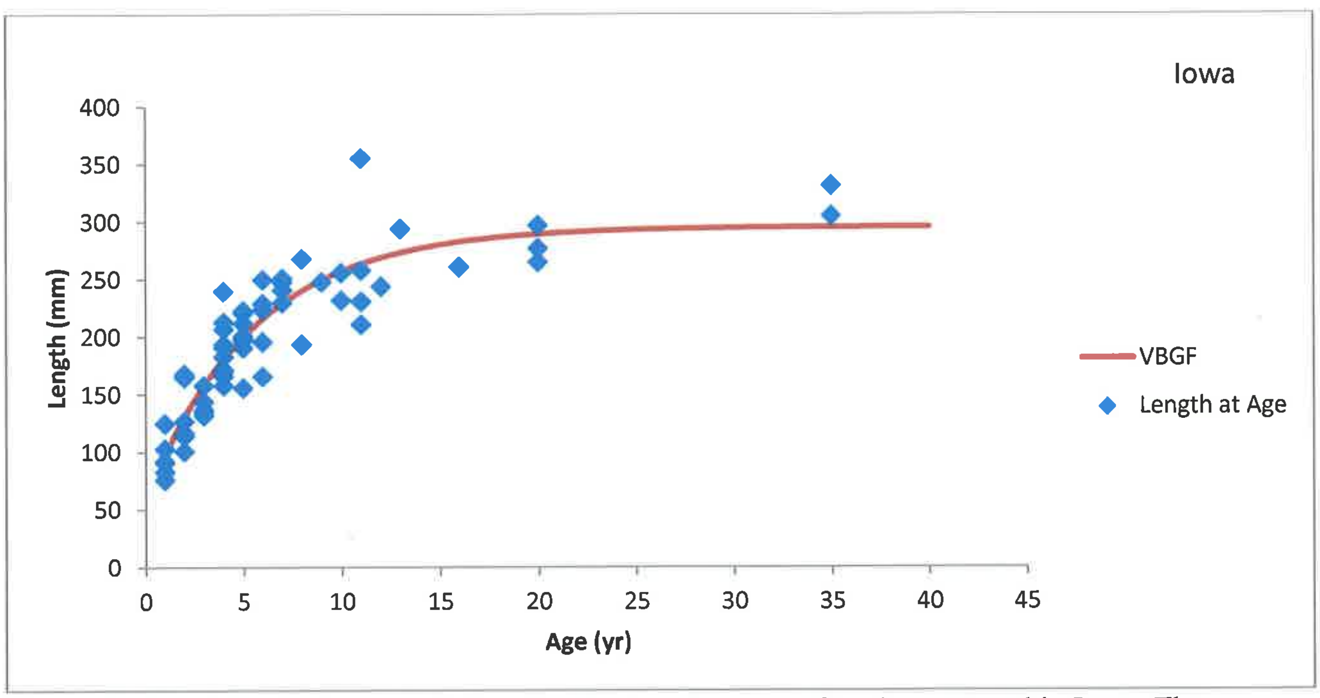


Figure 46. Von Bertalanffy growth function for length at age of turtles captured in Iowa. The equation used was $L_t = 307.1[1 - e^{-0.1757(t+0.4757)}]$ (Christiansen, 1979)

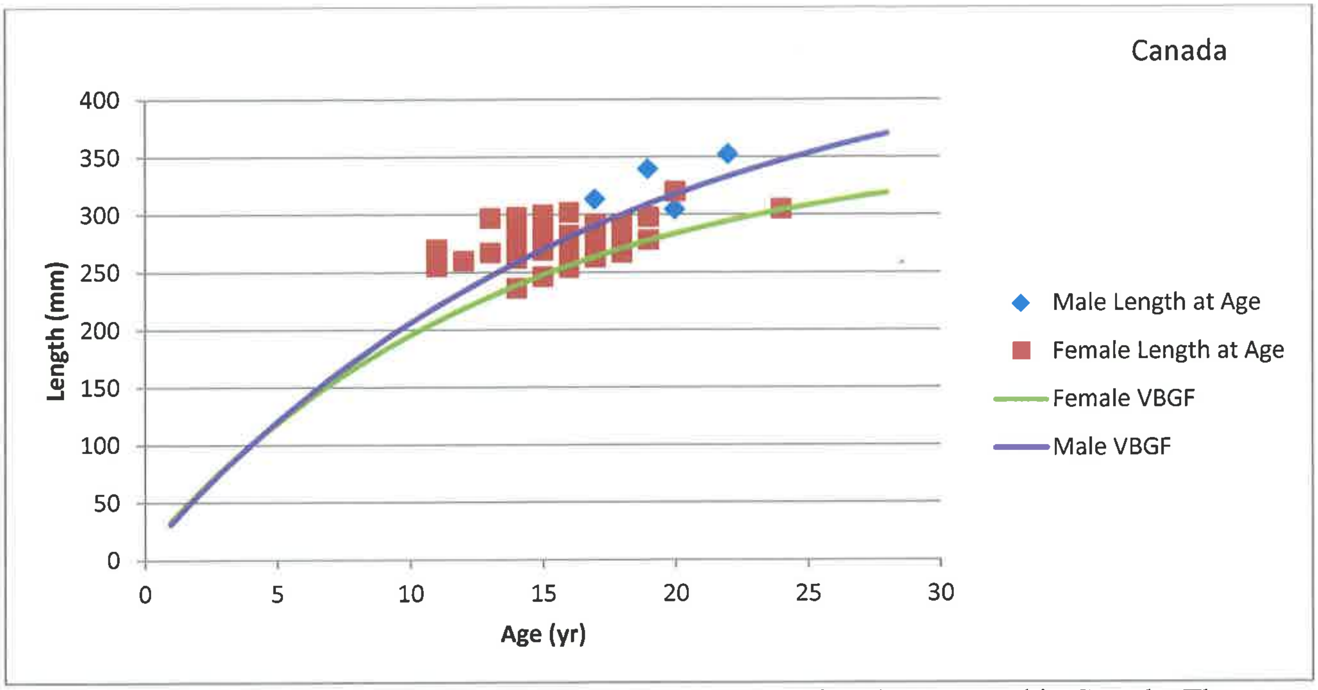


Figure 47. Von Bertalanffy growth function for length at age of turtles captured in Canada. The equation used was $L_t = 307.1[1 - e^{-0.1757(t+0.4757)}]$ (Obbard, 1983).

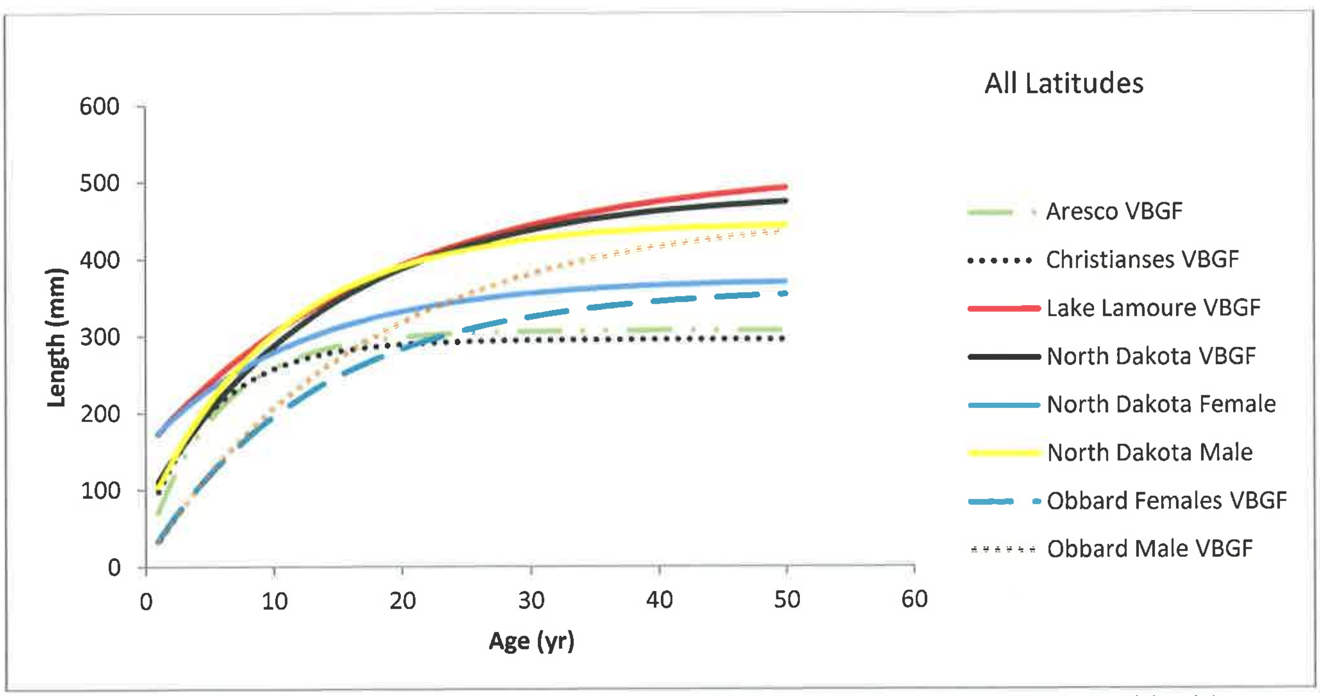
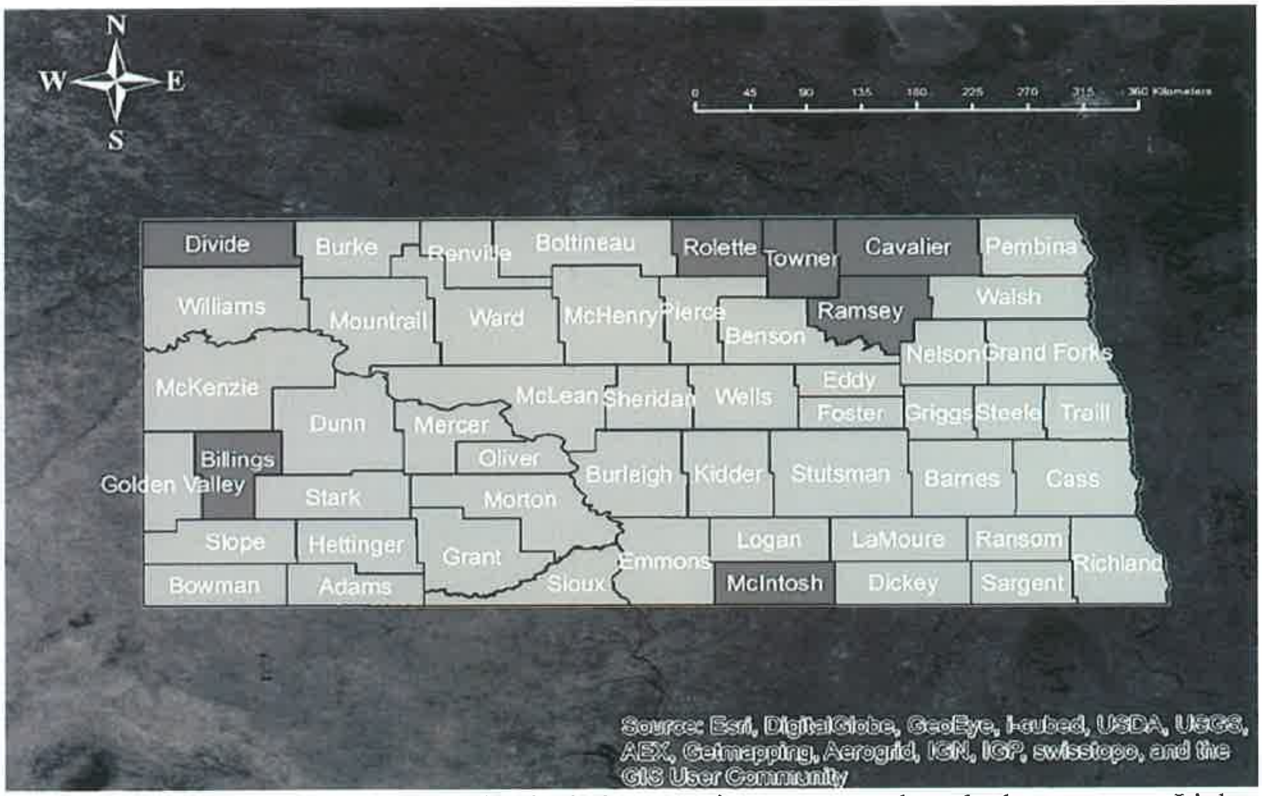
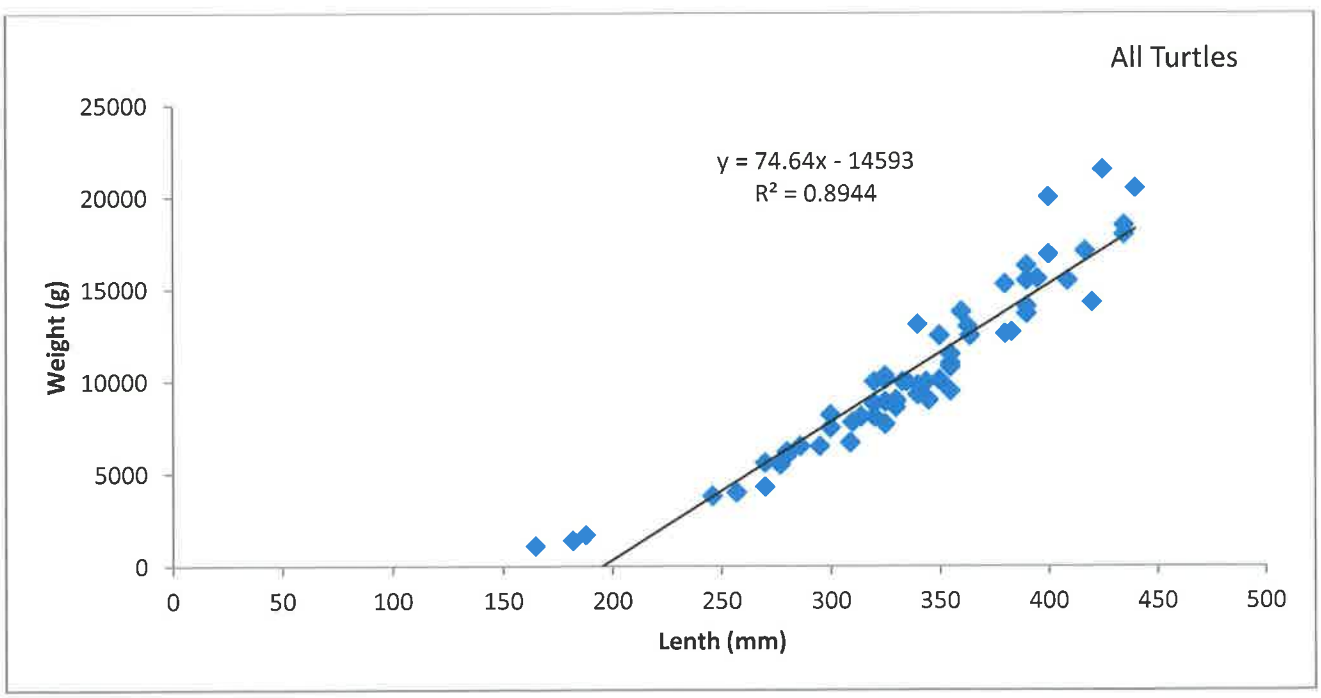


Figure 48. Von Bertalanffy growth functions for Ontario, North Dakota, Iowa, and Florida side by side for comparison (Christiansen 1979, Obbard, 1983, Aresco, unpublished data).

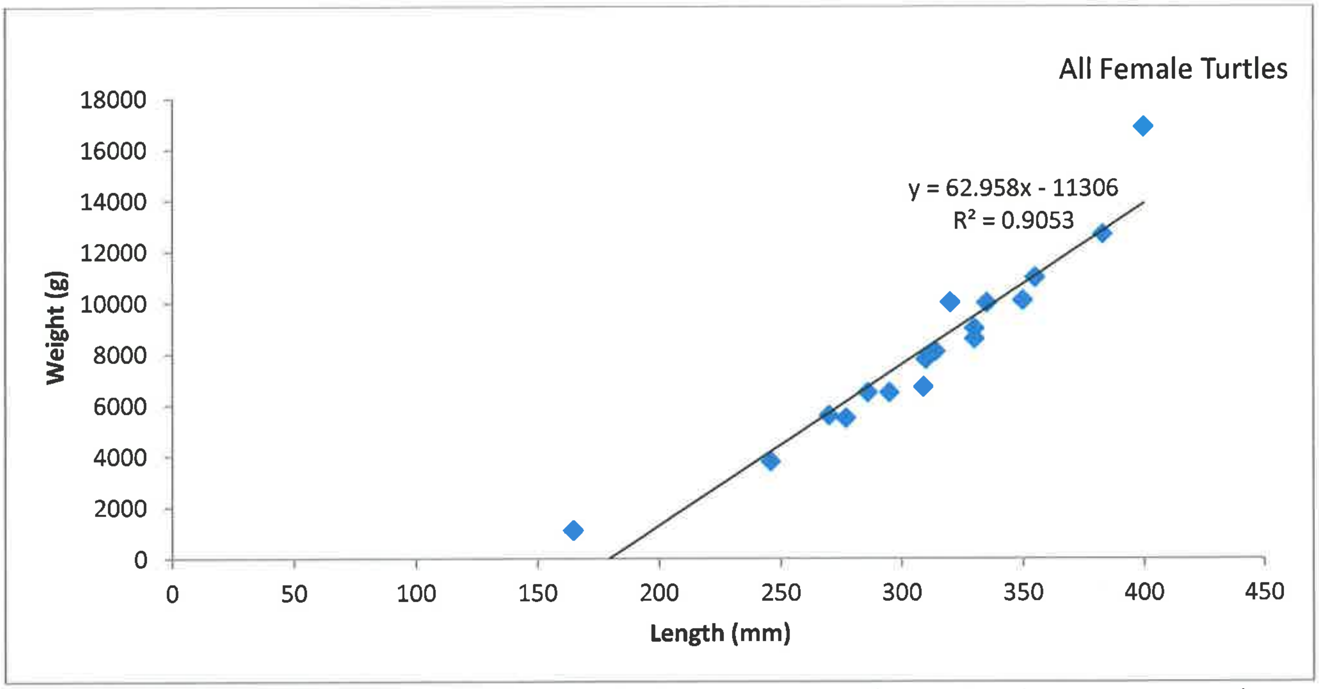
Appendix 1



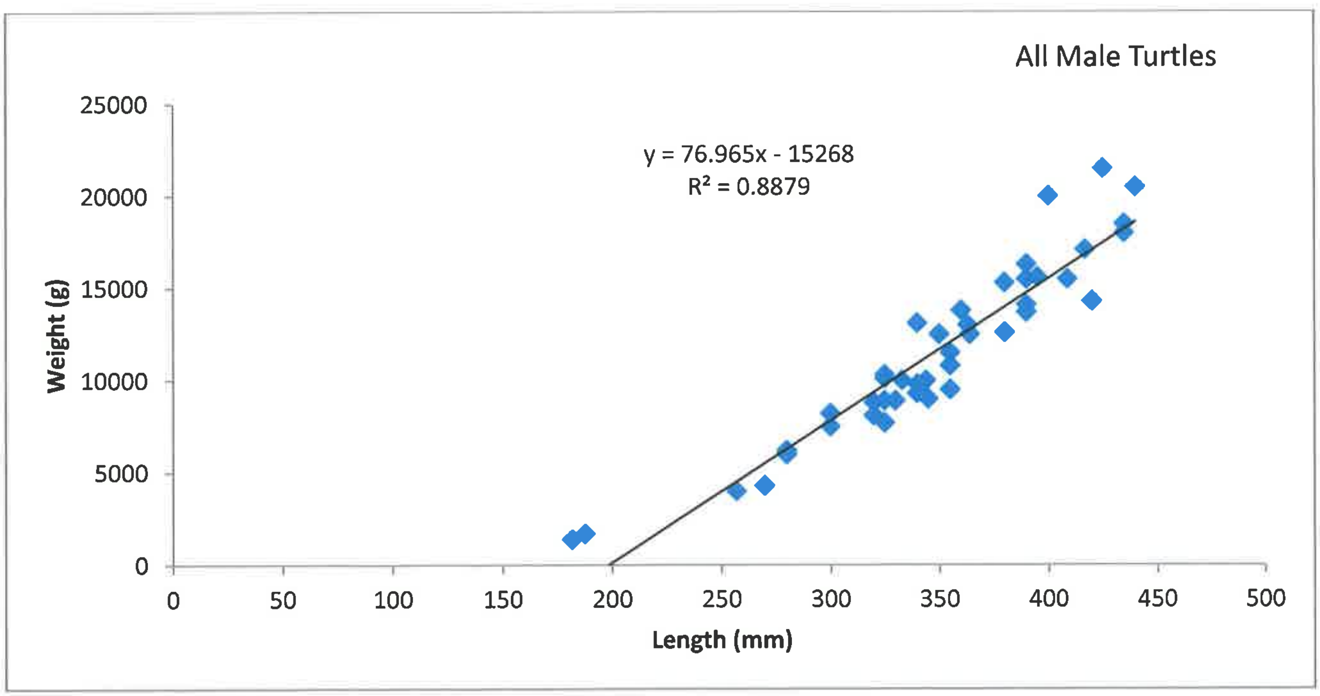
Updated statewide distribution map that includes counties represented on the harvest map. Light counties represent counties with records of snapping turtles and dark counties have no record.



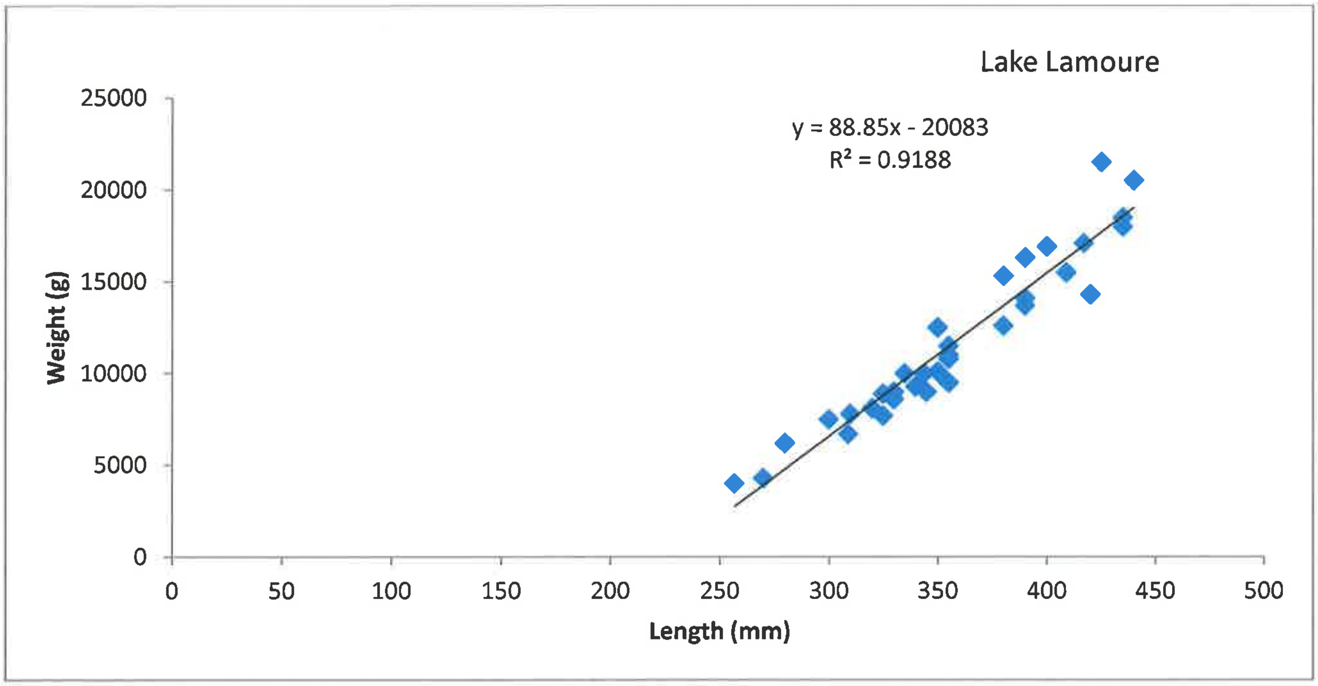
Length (L) vs. weight (W) linear regression for all snapping turtles that were captured in North Dakota. Length is along the x axis in millimeters and weight is along the y axis in grams. A linear trend line was fitted to the data and the resulting equation is shown.



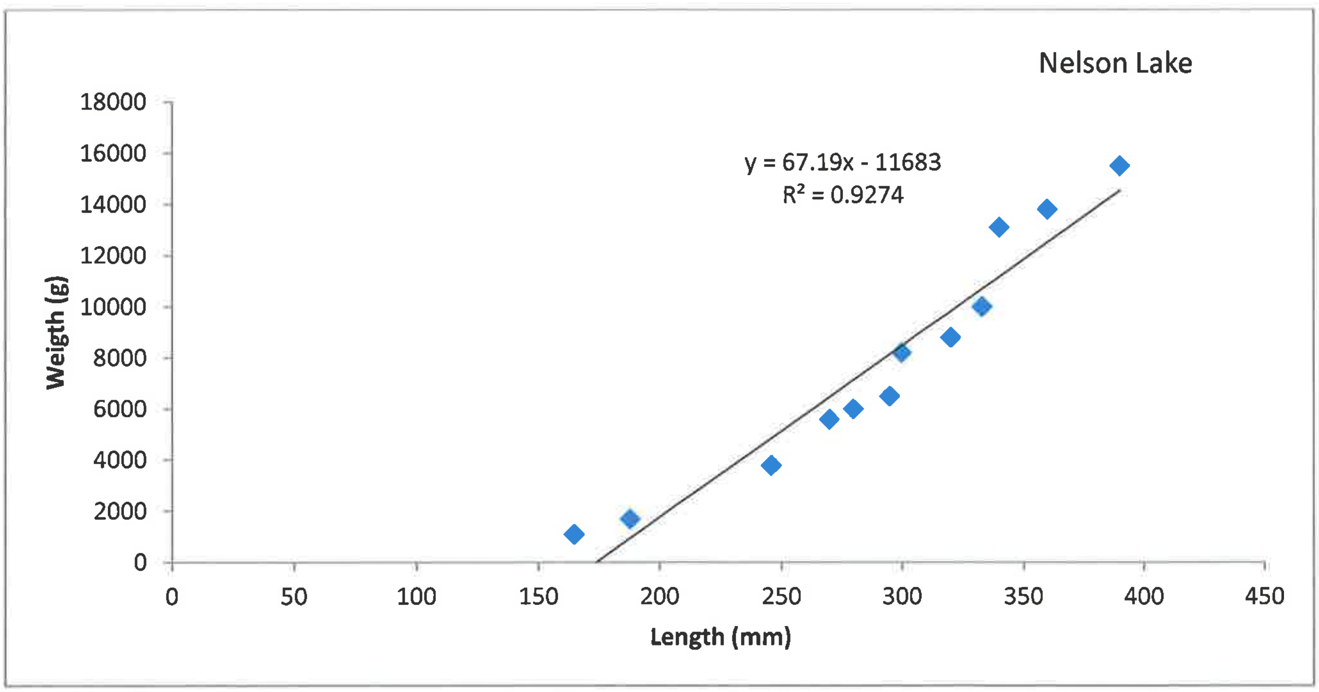
Length (L) vs. weight (W) regression function for the female snapping turtles that were captured in North Dakota.



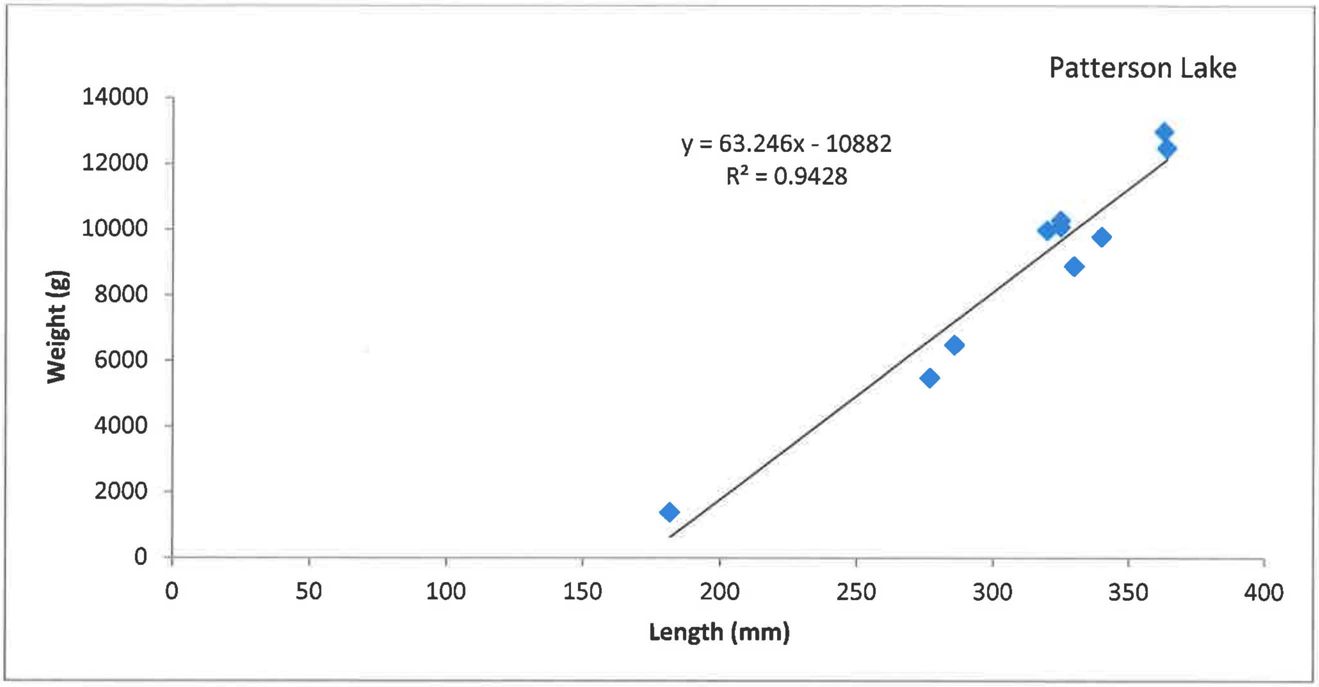
Lengths (L) vs. weight (W) regression function for all male snapping turtles that were captured in North Dakota.



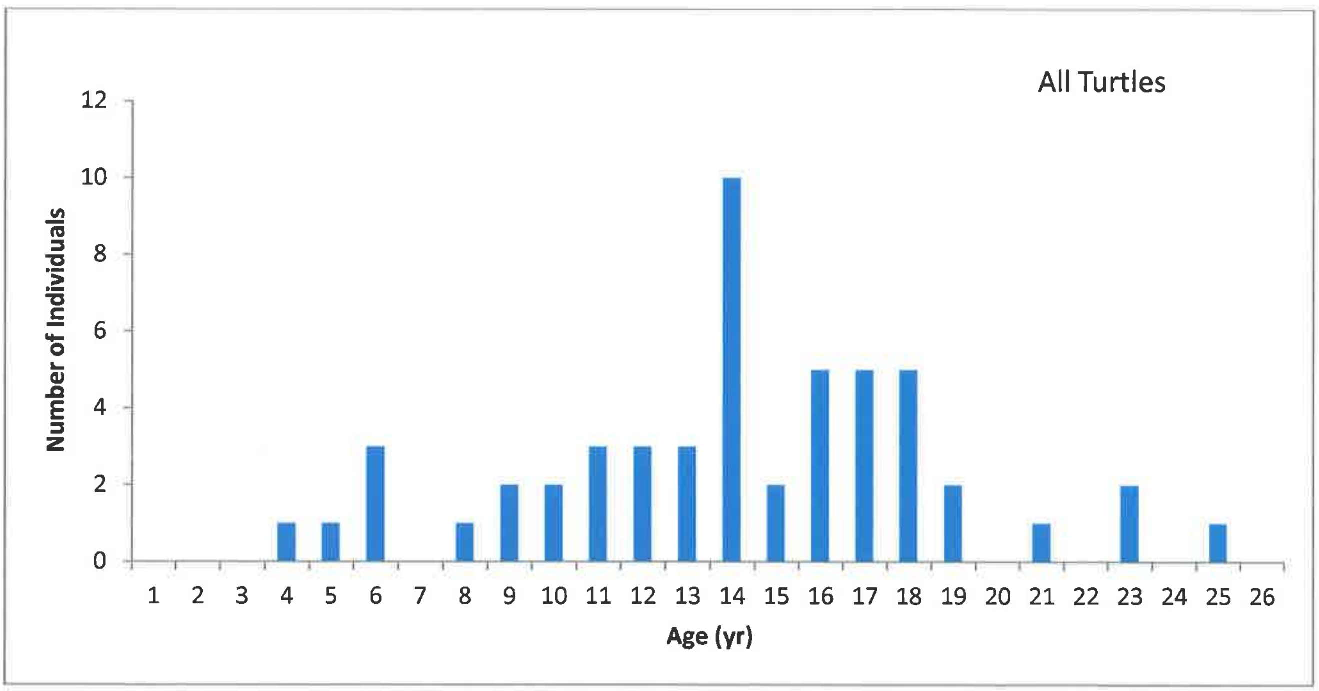
Length (L) vs. weight (W) regression function for snapping turtles captured at Lake LaMoure.



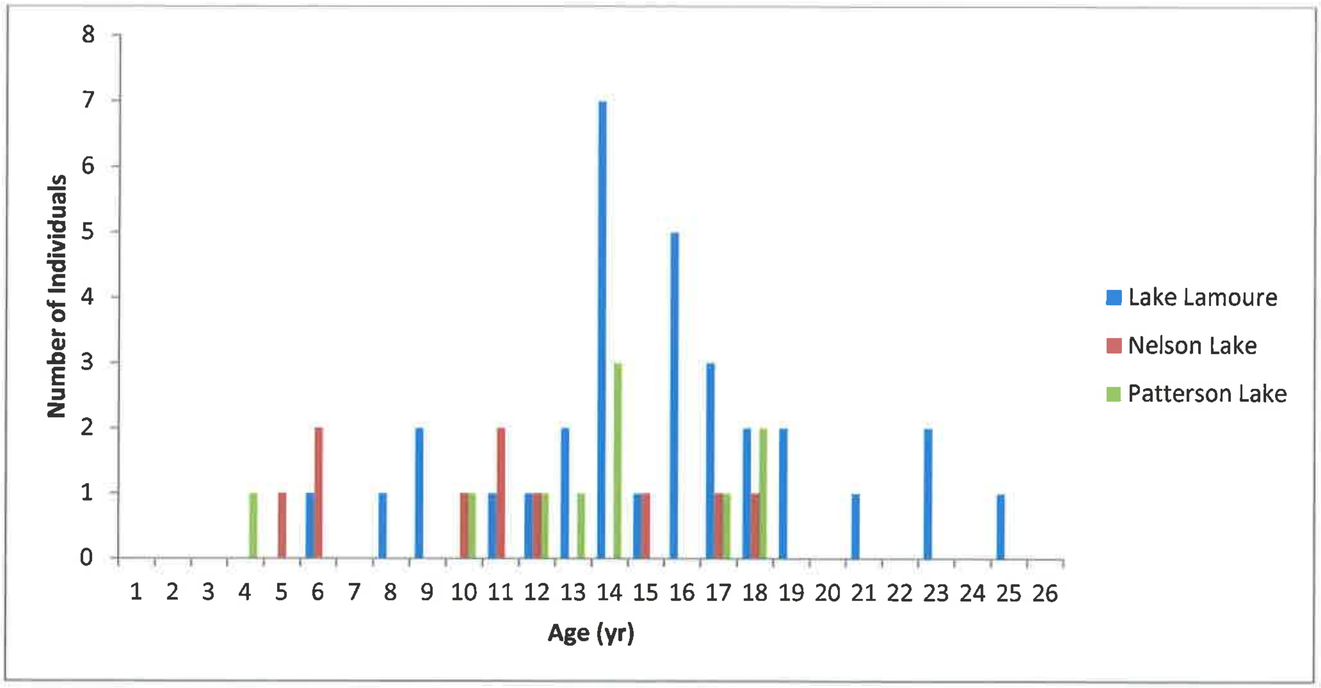
Length (L) vs. weight (W) regression function for snapping turtles captured at Nelson Lake.



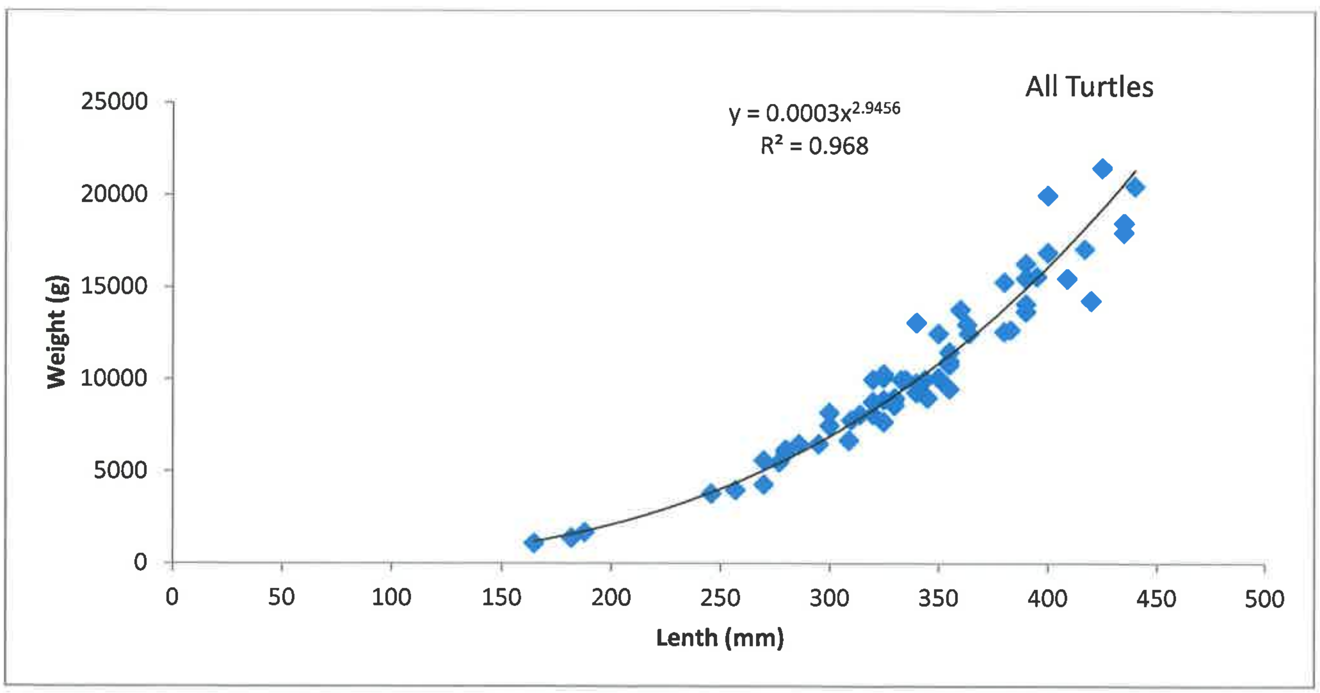
Length (L) vs. weight (W) regression function for snapping turtles captured at Patterson Lake.



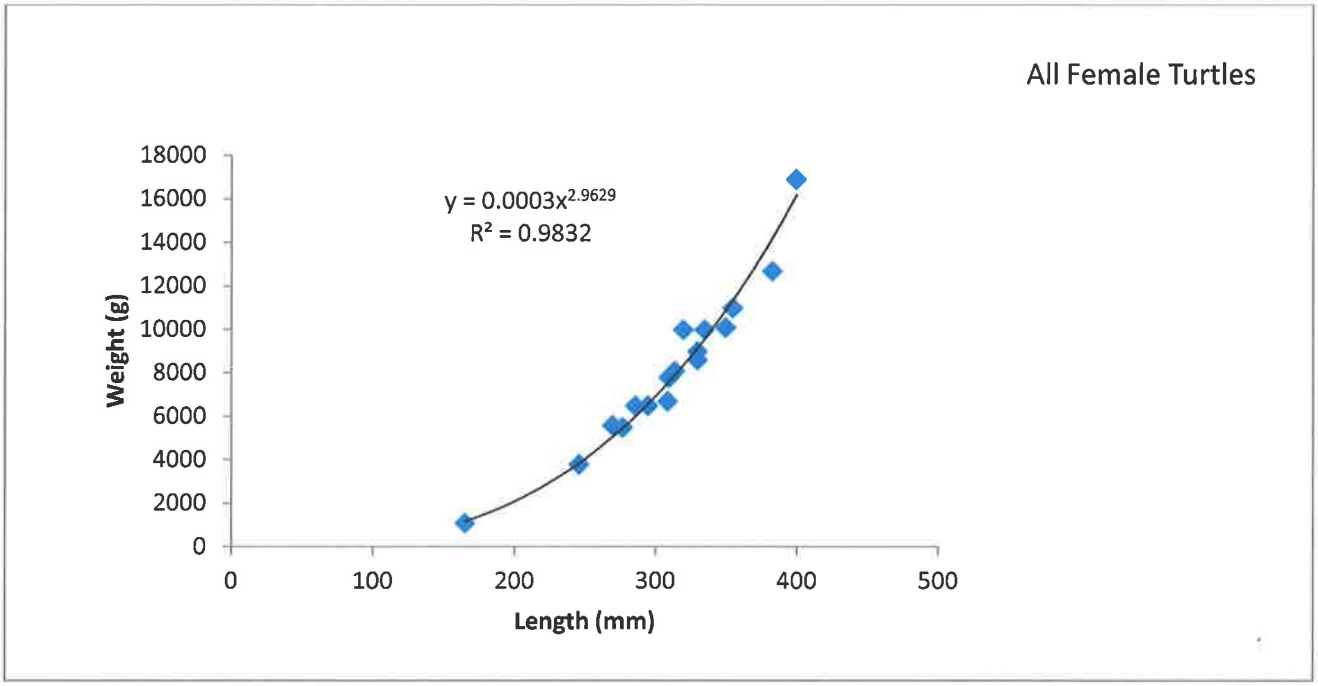
Age frequency histogram showing the number of individual in each age class. Along the x axis age is denoted and along the y axis the number of individuals in each age class is denoted.



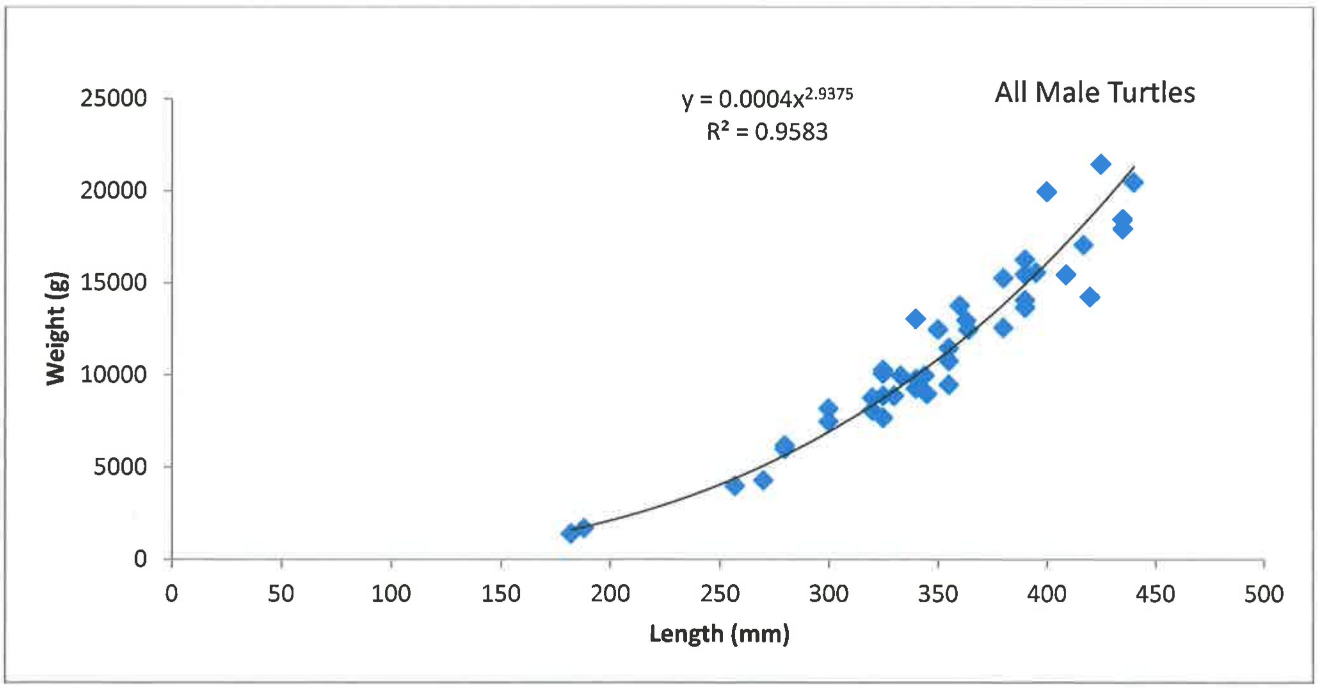
Age frequency histogram showing the number of individuals in each age class and the lake they were captured in.



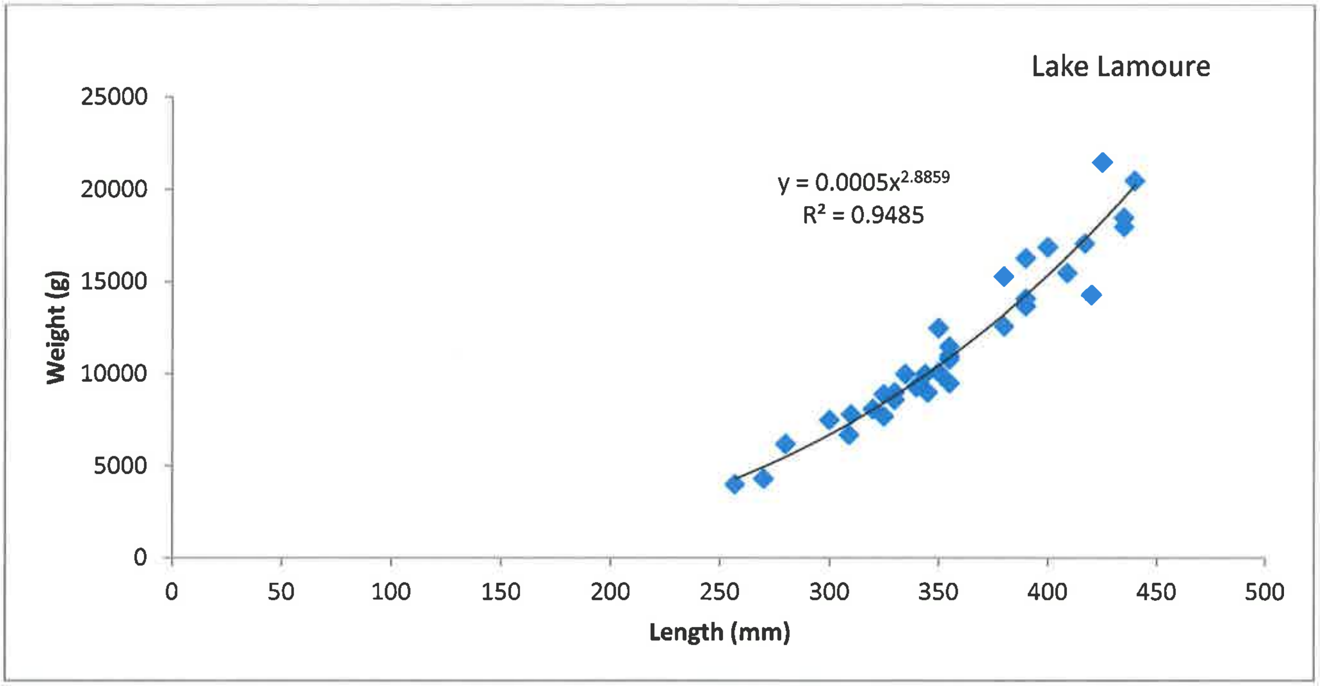
Length (L) vs. weight (W) power regression for all snapping turtles captured in North Dakota. The equation for the regression line is on the graph.



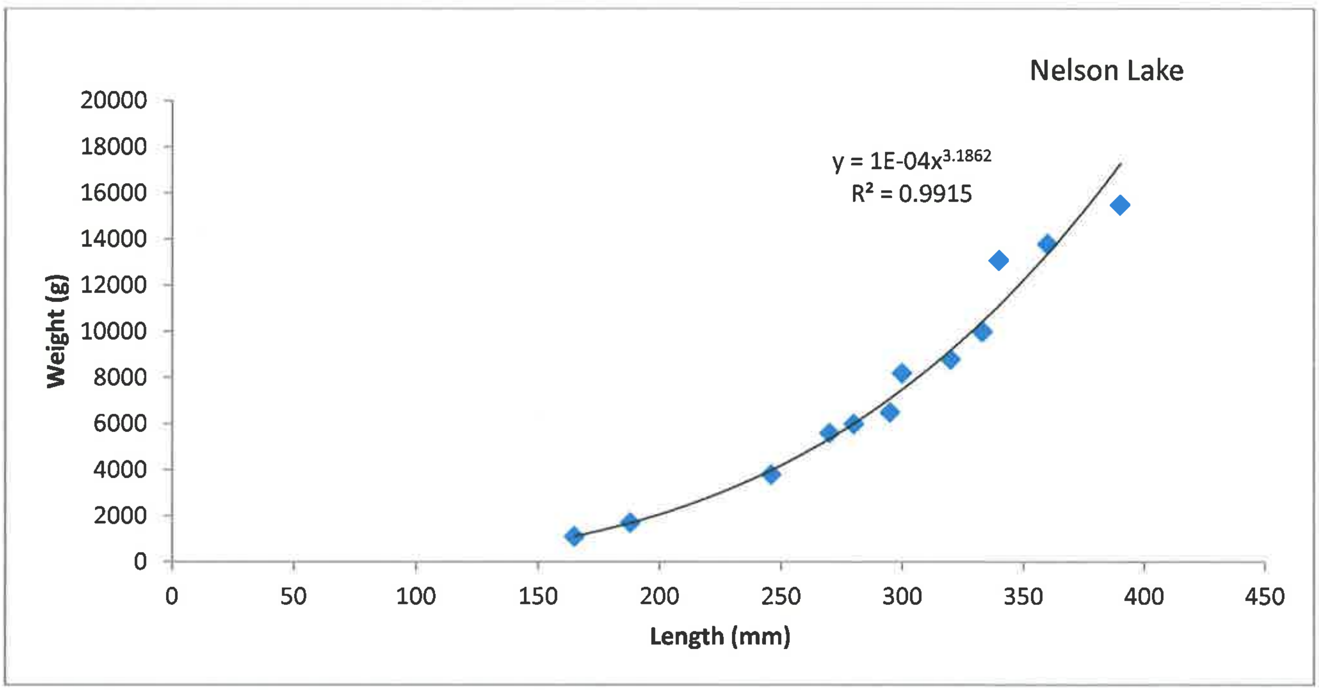
Length (L) vs. weight (W) power regression for all female snapping turtles captured in North Dakota.



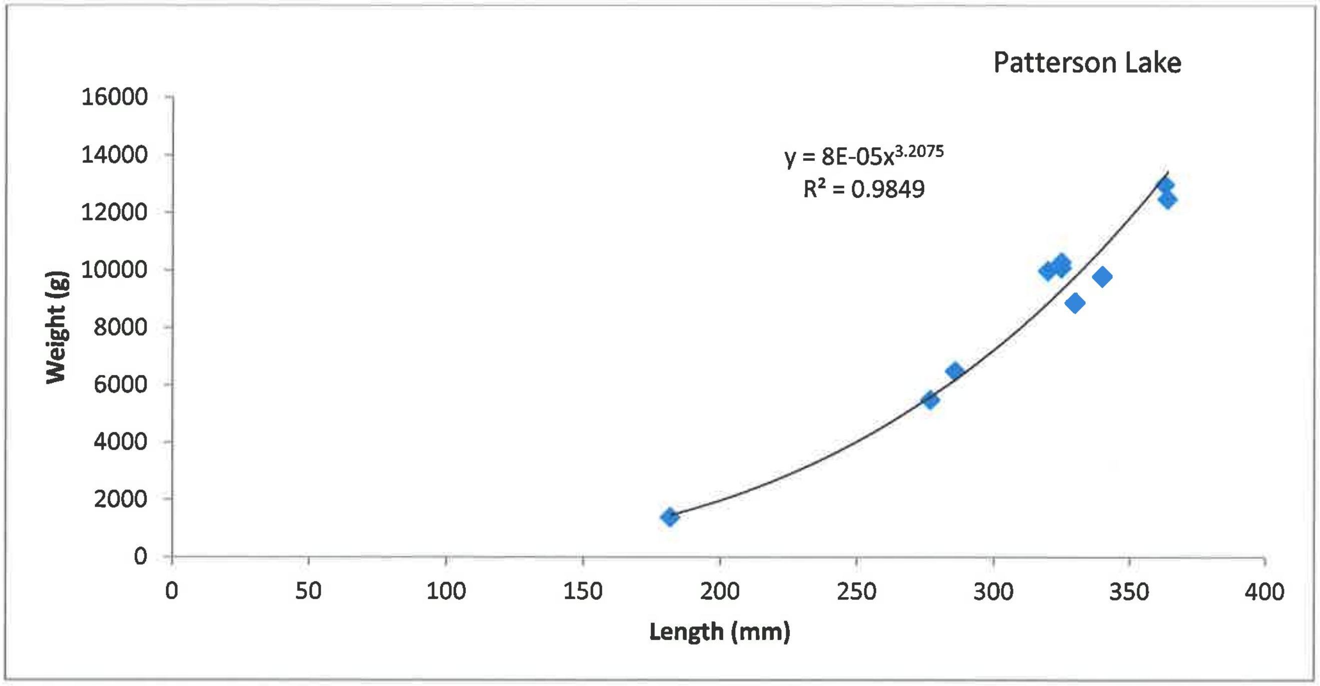
Length (L) vs. weight (W) power regression for all male snapping turtles captured in North Dakota.



Length (L) vs. weight (W) power regression for snapping turtles captured at Lake LaMoure.



Length (L) vs. weight (W) power regression for snapping turtles captured at Nelson Lake.



Length (L) vs. weight (W) power regression for snapping turtles captured at Patterson Lake.