An Investigation of the Abundance and Key Habitat Parameters of the Northern Map Turtle (*Graptemys geographica*) in an Eastern Ontario Bay
- A Baseline Study -

by

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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Environmental Studies
in
Geography

Waterloo, Ontario, Canada, 2007

Author's Declaration for Electronic Submission of a Thesis

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

This study assessed the principles of ecosystem management and utilized the Northern Map Turtle, a species at risk, as a key indicator species to illustrate the importance of preserving riparian habitats and island complexes on an ecosystem scale. Overall, the study explored the population characteristics and use of habitat of the Northern Map turtle (*Graptemys geographica*) within a small bay within the Gananoque River system in South Eastern Ontario. Results from field observations showed that the bay population of Northern Map Turtles appeared to be female biased. Use of habitat features differed by females, males and juveniles at different times throughout the summer (May-August). Females were frequently observed basking within the bay in May and June while males were more frequently observed throughout July and August. Nesting by female Northern Map Turtles appeared to be concentrated atop small islands scattered throughout the bay. Nest sites were located within narrow bands of soils. The most prominent difference between site conditions at the monitored nests was soil moisture; this was likely the result of different soil materials at each site. Air and soil temperature did not differ significantly between sites. Additional research could be pursued on the bay population of Northern Map turtles looking at the following: movement patterns by females out of the bay post-nesting, genetic linkages to other satellite populations of Northern Map Turtles in the Thousand Islands, hatchling success and sex composition, overall species health due to food availability and lastly the effects of anthropogenic stressors.

Acknowledgments

Sarah Michaels
Stephen Murphy
Larry Lamb
Lynn Finch
Mary Kaiser
Michael O'Connor
Raisin Region Conservation Authority
St. Lawrence Island National Park
Craig McCosham
Jane Beehler-field assistant
Sarah Beehler
Ron and Nancy Beehler
Eleanor Allgood
Gananoque Waterways Association
Ryan Steckly
Residents of the bay
Orville Erickson Foundation

Field Volunteers

Erinn Belmore
Lissa Deslandes
David Murphy
Amanda Sills
Matthew Mitrovich
Kari and Josh Puklicz

Dedication

To Mary Kaiser, for teaching me the importance of a peaceful lake for the minds meditation.
May you rest in peace.
1942-2005

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Chapter 1: Introduction

1.1 Problem Statement

Approximately 441 species have been identified as at risk in Canada with more than 40 percent of these occurring in Ontario (COSEWIC 2003; COSSARO 2003). Of those species identified as at risk an alarming 80 per cent are at risk due to habitat loss, fragmentation and degradation the consequences of human activities including, agriculture, forestry, climate change, the introduction of invasive species and wildlife poaching to name a few (Canadian Wildlife Federation 2004). In an attempt to protect the greater landscape and its biological diversity, ecosystem management techniques have been undertaken by land managers.

Overall, ecosystem management aims to improve the quality of habitat and the populations of species inhabiting them through a blend of sound management and science. Management often involves cooperation across political and social sectors involving cross agency collaboration, stewardship and cooperation commitments from private landowners, economic incentives and even the promotion of environmental values (Grumbine 1997; Vogt & Vogt 1997). Sound science in ecosystem management often integrates principles of conservation biology, ecological data on species, as well as the key forces driving the health of the ecosystem (Vogt & Vogt 1997). However, most conservation efforts and habitat research have been restricted to terrestrial systems and species or species of recreational and economic value (Bodie 2001; Sparks 1995). As a result, knowledge on important habitat and species requirements for areas such as riparian ecosystems and nearshore habitat, which represent high biodiversity areas in the aquatic and terrestrial interface, are relatively poorly researched and understood.

Although riparian areas have been identified as diverse habitats, very little ecological information is known about the species that utilize these aquatic – terrestrial interfaces. Much of the current literature on riparian species is limited to fish species or game species such as largemouth bass or mallard ducks (Bodie 2001; Sparks 1995). However, species such as freshwater turtles, which utilize several aspects of riparian ecosystems to complete their lifecycle, have not been adequately recognized within the available literature addressing riparian ecosystem management (Bodie 2001). In particular, research on the Northern Map Turtle's use of habitat is limited due to the challenges of observing such a shy evasive creature. Without information that identifies a species' critical habitat, use patterns and threats to its survival, an ecosystem management plan with viable solutions cannot be prepared. Since, "habitat structure is known to influence amphibian and reptilian community structure" (Rudolph & Dickson 1990, p.475), inadequate riparian zone widths and the removal of snags from waterways that are used by freshwater turtles for basking, can function as major fragments within freshwater turtle habitat for nesting and basking activities (Rudolph & Dickson 1990; Bodie 2001). In addition, since turtles frequent both aquatic and terrestrial systems, baseline data identifying their ecological requirements will hopefully assist in the formulation of an ecosystem management plan that promotes the overall protection of species diversity within riparian zones. Within this study, the Northern Map Turtle will be observed as a key indicator species to illustrate the importance of riparian zone habitat for freshwater turtle species at risk. Within the Frontenac Arch Biosphere Reserve, a tract of land connecting the Canadian shield to the Adirondack Mountains, riparian habitat utilized by the Northern Map Turtle (*Graptemys geographica*) along with other turtle species at risk such as the Stinkpot Turtle (S*ternotherus odoratus*) have been identified as critical habitat features that are threatened by shoreline development, recreation and habitat alteration through controlled waterways (Parks Canada 2003).

This study has been designed to explore the population characteristics, behavior and key habitat parameters of the Northern Map Turtle (*Graptemys geographica*). Overall, research on the Northern Map Turtle has primarily focused on distributional characteristics within Ontario and Quebec. As well, most academic efforts in Ontario herpetology have centered on species such as the Painted Turtle, Spiny Softshell and the Wood Turtle. Thus, research from this project will help fill current gaps in the academic literature as well as provide land use managers with data that not only promote a greater understanding of the current population characteristics of the species but also identify the species key habitat parameters within a northern portion of its range.

1.2 Goals and Objectives

The goal of this study was to explore the population characteristics and use of habitat of the Northern Map Turtle within a small eastern Ontario bay. For a species such as the Northern Map Turtle that prefers large lakes and rivers in the Great Lakes region where recreational activities and development pressures are increasing; public awareness of the threats to the species survival are paramount. Hence, detailed information on the

Northern Map turtle's ecological characteristics will promote effective conservation, protection and education efforts contributing to land use management decisions and aquatic recreation

The specific study objectives were:

I. Review current literature on the principles and approaches of ecosystem management and restoration ecology;

II. Examine population characteristics of the Northern Map Turtle (*Graptemys geographica*) at four capture sites throughout May to August 2005;

III. Assess basking trends of the Northern Map Turtle (Graptemys geographica) based on site characteristics, weather conditions, timing, and turtle size and sex to determine if different size classes of Northern Map turtles and sexes utilize different special habitat features;

IV. Monitor nest site selection and nest characteristics to determine preferred habitat characteristics.

1.3 Thesis Organization

This thesis consists of eight chapters beginning with an introduction of the key problem statement and goals and objectives in Chapter 1. In Chapter 2 a literature review of the principles and approaches to ecosystem management are discussed along with the gaps of knowledge associated with riparian habitats and the species that inhabit them such as freshwater turtles. Chapter 3 provides necessary background information on the Northern Map Turtle (*G. geographica*), site selection and description, and field methods employed. Chapter 4 presents the study site and specific trap sites. Chapter 5 describes the methodologies of the study as well as research limitations. Chapter 6 reviews the results of population characteristics, basking trends and nest selection and monitoring respectively. Chapter 7 is a discussion of the results. Finally Chapter 8 presents conclusions and recommendations for future study.

2.0 Chapter 2: Literature Review

2.1 Introduction

Nearshore habitats such as riparian zones as well as island complexes within the southern Ontario landscape are impacted by numerous pressures such as shoreline development, recreational activities, incompatible landuses, water level fluctuations, and the presence of pollutants. In order to protect areas of key ecological significance, such as riparian zones and the species that utilize them, landuse managers need to identify the direct and indirect threats that are influencing a system. The themes and principles of ecosystem management as outlined in this chapter provide a framework of necessary components that should be explored in order for landuse managers to engage themselves in holistic decision making.

Two important components of ecosystem management is the collection and sharing of ecological data and the importance of integrating science based information into the decision making process for the management of natural systems. However, it is impossible to gather ecological data on every aspect of a natural system, particularly a system as diverse as the nearshore habitat. Thus, the use of specific species as ecological indicators and key habitat features are often used as benchmarks for establishing the necessary habitat conditions of the whole system (Graul and Miller 1984; MacDonald 2003; Noss 1983; Noss 1994). This thesis uses the Northern Map Turtle as an ecological indicator for riparian systems. More specifically, this thesis focuses on data collection, the base work for future monitoring and the identification of key environmental stakeholders in the Thousand Islands area, for the overall ecosystem management process.

2.2 Ecosystem Management

Ecosystem management is based on protecting the landscape as a whole including all organisms, physical and chemical attributes, energy flows, and species relationships and interactions within the constructs of a natural and social system (Vogt & Vogt 1997; Noss 1994, Slocombe 1998).

For ecosystem management to meet its goals of protecting the landscape and the biological diversity of an ecosystem (Sparks 1995), it is important to ensure that complete representation of habitats and species populations is achieved. However, managers undertaking ecosystem management as a natural resource management tool must also recognize that it is impossible to collect data on all of the biological, physical and chemical attributes of a system. Instead, managers will need to understand the overall forces that drive and control ecosystems such as net primary production and species diversity (Vogt & Vogt 1997). By focusing more on the maintenance of the entire ecosystem, managers can avoid recurring situations of crisis management that target individual projects that are already at a critical threshold (Vogt & Vogt 1997). With the foresight gained from employing ecosystem management techniques to conservation, a flexible and sustainable approach to protecting natural areas and the species that interact within these systems can be pursued.

Graul and Miller (1984) suggest four approaches to ecosystem management. The first approach, *Management Indicator Approach,* uses a specific species as an ecological indicator for habitat requirements. This approach may be used to maintain healthy populations of keystone species or umbrella species. The presence or absence of keystone species are important indicators since their presence will often determine the overall productivity, species composition or species diversity of an ecosystem (MacDonald 2003). Likewise, umbrella species are excellent indicators since their, "resource requirements and role in the ecosystem provide evidence of biodiversity, habitat diversity, and healthy ecological functioning" (MacDonald 2003, p. 494). In addition, this approach may focus on identifying the ecological needs of rare or endangered species, since these species are usually the most sensitive to fluctuations in their habitat (Noss 1983; Noss 1994). Under the second approach, *Ecological Indicator Approach,* ecosystem management is based on meeting the ecological requirements of specialist species. Specialist species are species with a narrow range of resource tolerances and a narrow ecological niche (MacDonald 2003). The third approach, *Habitat Diversity Approach,* focuses on providing diverse habitats to meet the requirements of all species within an environment. In this approach, land managers would not only focus on representing high quality examples of habitat but would also focus on the size and spatial arrangement of core protected areas (Graul & Miller 1984; Noss 1983; Noss 1994). Lastly, the *Special Features Approach*, focuses on integrating specific habitat requirements, such as fallen logs or nesting boxes, throughout a landscape to increase its habitat value (Graul & Miller 1984).

Equally as important as the natural requirements for ecosystem management are the social or managerial components that are necessary for practitioners to put ecosystem management into practice. Grumbine (1997) revisits his ten key components of ecosystem management with additional comments and knowledge gained from conservation managers who have applied ecosystem management techniques. Table One outlines some of the key themes and concepts that emerged from this exercise. Similarly, Vogt & Vogt (1997), also identify several key principles that characterize the evolving approach of ecosystem management within conservation (Table One).

Table 1: Themes and Concepts of Ecosystem Management

Grumbine's Ten Dominant Themes of Ecosystem Management			**Vogt's Principles of Ecosystem Management**
Theme	**Key Concepts**	**#**	**Key Principles**
Hierarchical Context	Based on contextual or broad thinking.	*1*	Draft and implement their own formal working definition of ecosystem management that accounts for the specific characteristics of a given management issue and its philosophy.
Ecological Boundaries	Most boundaries are artificial; all parties must be brought together.	*2*	Identify management goals and objectives.
Data Collection	Good relationships are necessary between managers and field staff, scientific and social data are important.	*3*	define management units and boundaries
		4	Develop and implement management plan.
Monitoring	Important to determine whether goals were sustainable, funding a major boundary to monitoring.	*5*	Identify policies, laws and regulations that directly affect management activities.
Interagency Cooperation	All stakeholders must be involved when defining the problem and course of action.	*6*	Carefully select and utilize ecosystem management tools and technologies.
Humans are Imbedded in Nature	Humans and nature cannot be viewed as independent from one another.	*7*	Collect, analyze and integrate economic, social and ecological information and make decisions using this science-based information.
Adaptive Management	Flexibility, change, and constant feedback and increased learning between all participants.	*8*	Clearly identify ecological constraints or limits.
Organizational Change	Institutional structures must change in order to successfully implement ecosystem management.	*9*	Coordinate management activities with adjacent landowners, resource user extractors, and other institutions and agencies that have an interest in jurisdiction over the management unit.
Values	Necessary to accept the role of human values in ecosystem management.	*10*	Enable feedback mechanisms at all levels that promote adaptive management.

(Source: Grumbine 1997, Vogt & Vogt 1997)

A common theme that emerges from both Grumbine's and Vogt & Vogt's, analyses of the key themes and principles of ecosystem management is the notion of human values and activities being embedded throughout the landscape. Basically, when approaching ecosystem management, managers must actively incorporate coordination and cooperation between the various interest groups. In addition, ecosystem management must be approached under the auspices of adaptive management to allow for flexibility, change and feedback to be involved in the ecosystem management plan (Slocombe 1998). This is particularly significant for conservation efforts in Ontario since areas where a high diversity of species at risk are concentrated are also the areas where human settlement and activity are the densest (Parks Canada 2003)

Due to recent criticisms on the scientific value and effectiveness of ecosystem management, Keough & Blahna (2005) re-examined a variety of principles associated with ecosystem management. After analyzing successful cases of collaborative ecosystem management, eight relevant principles were identified. With these eight principles (or factors as Keough & Blahna refer to them) in mind the researchers examined four very different case studies in resource management in which these eight principles played significant roles in the success of the projects. The eight key principles to successful collaborative ecosystem management according to Keough & Blhana (2005) are:

1. Integrated and balanced goals between social, economic and ecological scales.
2. Inclusive public involvement.
3. Stakeholder influence during decision making.

4. A consensus approach where agreement is by majority.
5. Collaborative stewardship where stakeholders are actively participating and developing a sense of ownership.
6. Monitoring
7. Adaptive management
8. Multidisciplinary data involving social, ecological and economic data being analyzed and monitored; and economic incentives.

These eight principles support many of the earlier themes and principles outlined by Grumbine and Vogt & Vogt.. According to Keough & Blahna (2005) the key to the success of collaborative ecosystem management is an integrated balance between each of the principles.

Although participation and collaboration between all interested stakeholders is emphasized for successful ecosystem management, Brody et. al. (2003) caution that it can also lead to increased conflict, reduced chances of action and weakened management plans. They suggest the use of GIS techniques in order to avoid these potential pitfalls. GIS can be used to assess local management capabilities and then identify the specific gaps that can be filled using this information at the ecosystem level (Brody et. al. 2003). Exercises like this can clarify the roles that local jurisdictions play in the greater ecosystem management goals (Brody et. al. 2003). Keough & Blahna (2005) also noted that there were short-term difficulties associated with the four case studies they explored.

However, these were outweighed by the long-term benefits that will be reached from the ecosystem management process that was adopted.

2.2.1 Ecosystem Management and National Parks

Traditionally, Parks Canada has managed visitor satisfaction and natural resource management solely within the park boundaries and independent of one another. However, revisions to the National Parks Act in the last decade have steered park management towards the adoption of a greater ecosystem management approach. In order to achieve greater ecosystem management, park policy statements were developed that mirror the ten Dominant Themes of Ecosystem Management identified by Grumbine (Zorn et. al 2001). One of the policy objectives identified through this exercise involved broadening the scope of ecological knowledge and monitoring for National Parks beyond designated park boundaries. In order to better understand surrounding stressors, specific ecological indicators measuring the structure, composition and function of the greater park ecosystem were pursued. Ontario National Parks turned to Noss's (1995) framework for selecting indicators for monitoring biodiversity (Zorn et. al 2001).

The status of ecosystem management in Ontario National Parks was recently reviewed by the Ecosystem Management Section of Ontario Service Center of Parks Canada. Results from their study indicate that Ontario National Parks ranked low overall in regards to ecosystem management efforts in scientific research and ecological integrity monitoring programs (Zorn et. al 2001). Included in this study is the St. Lawrence Islands National Park (SLINP). Ecosystem management is essential for SLINP. With its small size and fragmented land holdings the ecological integrity of the park is under heightened pressure from surrounding land use activities (SLINP 2007a). On a Canada – wide scale, SLINP was one of four National Parks designated with high levels of impairment to ecological integrity. It is particularly significant that those threats that were identified as causing unfavourable environmental conditions within the park were primarily from external sources and not from activities occurring within the park (SLINP 2007b). To assess the scope of the threats, biological indicators were chosen under three overall categories: species and population level, community level, and landscape level. Under species and population level assessment the monitoring of herpetile species diversity was identified (SLINP 2007b).

Research on the bay population of Northern Map Turtles addresses the need for the SLINP to increase its scientific research and ecological monitoring within the greater St. Lawrence Island National Park ecosystem. Knowledge gained from the bay population can be compared to monitoring efforts of Northern Map turtles within the park to provide a broader understanding of trends in turtle populations, habitat uses and potential impairments for this species at an ecosystem scale. The Northern Map Turtle is a good indicator species for ecosystem health, because they utilize aquatic and terrestrial habitats, utilize variable habitat features and have high environmental requirements for unpolluted waterways to sustain their mollusk diet. In order to develop successful management goals for herpetile species such as the Northern Map Turtle disciplines such as conservation biology and restoration ecology need to be examined as key components of the research and monitoring process.

2.3 Conservation Biology

In responding to the increasing biological diversity crisis, Primack (1998, p.5) feels that conservation biology has two primary goals: the investigation of human impacts on species, communities and ecosystems and the development of practical approaches to prevent species extinction and species reintegration into properly functioning ecosystems.

The emergence of conservation biology, drawing from numerous academic disciplines such as ecology, biology, taxonomy, biogeography and genetics, allowed for a broader more comprehensive approach to conservation that focuses on managing multiple landscapes and populations (Primack 1998; Primack 2000; Brussard 1991). Conservation biology also allowes for the development of a reciprocal relationship with those responsible for resource management and ecosystem management (Primack 1998; Primack 2000).

Ecosystem management and protection are essential today in order to counteract the loss of biological diversity that is occurring due to habitat loss, degradation and fragmentation (Pasquarello 1998). However, it is also important to understand the relationships that exist between species, between species and their natural environment, and within individual populations. As such, the essential components of conservation biology serve as key factors for developing informative, successful ecosystem management plans. These essential components include genetic variability, effective population sizes, metapopulations, core area reserve and design and connectivity.

2.3.1 Genetic Variability and Effective Population Sizes

High genetic variability within a species is essential for to ensuring the resiliency of a population to various factors such as long-term changes in the environment, pollution, disease, parasites, predators, and inbreeding and outbreeding depressions (Primack 2000, Frankham 1996). Gene flow within a population is the primary preventative method for maintaining genetic variability (Primack 2000).

A certain population size is required in order to maintain genetic variability. Frankham (1996) assessed ten predictions related to population size and genetic variation, and concluded undoubtedly that small population sizes reduce the evolutionary potential of wildlife species. Therefore, in order to effectively design protected areas for species at risk it is important to understand the population size that is necessary to support healthy reproduction rates. Once the effective population size is determined the size of the protected area can be established (Primack 2000).

Historically, few studies have focused on the population viability of non – charismatic species (Moilanen & Cabeza 2002). For example, research that identifies the life – history stages of freshwater turtles is largely unknown (Litzgus 2006). In order to develop an ecosystem management plan for herpetile species in the greater SLINP ecosystem, data on the life history traits such as estimated population size, recruitment rates, survivorship, mortality rates etc. must be collected and analyzed (Litzgus 2006).

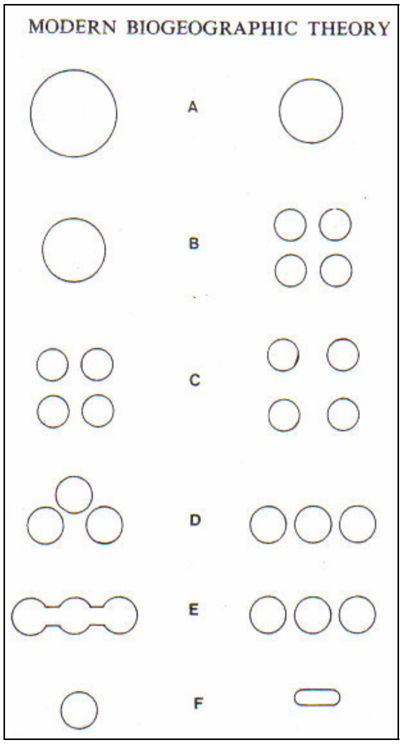
2.3.3 Metapopulation

Defined as a population composed of populations, or subpopulations linked by the dispersal and movements of individuals among them living in a network of spatially distinct habitat patches (Primack 2000; Smith & Smith 1998, Moilanen & Cabeza 2002), the concept of metapopulations is often used to examine the population viability of species in a fragmented landscape. The functionality of metapopulations is important in ensuring that genetic drift occurs between populations and that in the event of a local extinction species from other populations can move in and re-colonize an area (Primack 2000). Unfortunately, minimal research efforts have focused on collecting dispersal data to enhance conservation programs (Fagan & Lutscher 2006). Recent developments in mathematical ecology support the concept of Average Dispersal Success, a model that combines local dispersal data to conservation planning. Building on past ecological practices for determining critical habitat and patch sizes, Average Dispersal Success incorporates data from common field studies involving mark and recapture techniques to determine the dispersal patterns of species within an area, thus allowing for estimations of local metapopulation dynamics (Fagan & Lutscher 2006). Once metapopulation information is available for a species or community of species a clear management plan can be formulated. Akcakaya et. al (1995), suggest linking information from metapopulation modeling with landscape data to determine preferred management options.

2.3.4 Core Areas/Reserve design

Core areas of protected habitat should be selected based on site-specific research (Noss 1994). For example, protected core areas should be spaced close together in large blocks (Noss 1994). According to Noss (1987), planning protected areas in this fashion can reduce mortality due to environmental stochasticity, demographic stochasticity, social dysfunction, and genetic deterioration. In addition, critical habitat and special habitat features that are essential for the long-term viability of species and communities should be targeted in reserve design and selection (Environment Canada 2005). Traditionally, most research addressing reserve design has been based on the theories of island biogeography and species–area relationships. Formulated using principles of balance and equilibrium, species area relations assume that large areas have larger populations and thus less chance for species to become extinct. Particularly, Diamond (1975) proposed a series of six reserve designs based on shape, size and arrangement under what is coined the Modern Biogeographic Theory (Margules et al. 1982) (See Figure 1). Under this theory the designs displayed throughout the left side of the diagram are considered not only to have lower extinction rates but also to support more species at equilibrium than those designs on the right (Diamond 1975; Margules et al. 1982). However, Margules et al. (1982) caution that many of the conclusions presented under the Modern Biogeographic Theory have not been fully substantiated in conservation practice.

Figure 1: J. Diamond's Modern Biogeographic Theory



(Source: Margules et al. 1982, p.119)

Although the procurement of large reserves is ideal, it is not always realistic. This presents conservationists and land use planners with several management considerations. First, lands with the most essential habitat features for species survival could be sought after for protection. Second, buffers around these critical habitats to reduce the effects of edge habitat could be established. Third, the mapping of other areas of preferred habitat and the identification of potential linkages through corridors could be determined. In order for these measures to be successfully implemented at the landscape scale, stewardship initiatives and public support must be established.

2.3.5 Connectivity

Fragmentation, one of the largest threats to biodiversity that can be directly attributed to human activities, has been defined as the isolation of tracts of land from one another, creating increased ratios of edge to interior, thus resulting in an overall reduction in the total usable area of habitat (Mann & Plummer 1993). In the past, solutions for fragmentation were based on creating reserves. Unfortunately, most reserves were allocated based on their lack of value to commercial industry, rather than on levels of biodiversity (Mann & Plummer 1993). More recently, under the US Wildlands Project, the regional wilderness recovery network designed by Reed Noss was proposed. Under this initiative reduced fragmentation would be achieved through the use of buffers and connecting corridors between core reserves (Mann & Plummer 1993).

Species that can freely disperse across their native range are more likely to achieve sustainable, healthy populations (Noss 1994, Tewksbury et.al. 2002). According to Noss (1983), connectivity between protected areas is as important as the initial size of the protected area in ensuring biodiversity within a region. Issues of connectivity are also becoming increasingly important in terms of enhancing long–distance linkages for wildlife movement in response to climate change (Noss 1994). However, several negative implications have also been associated with connectivity through the use of corridors. For one, a homogenous population with reduced genetic variability could occur if separate metapopulations of a species are able to intermix through corridors connecting habitat (Mann & Plummer 1995). Secondly, corridors can also act as conduits for the spread of disease and invasive species between metapopulations. Thirdly, predators have been known to utilize corridors, particularly narrow corridors to trap prey (Mann & Plummer 1993, Mann and Plummer 1995). In these cases, corridors work against the primary goal of corridors which are to promote biodiversity for sustainable, healthy populations (Mann & Plummer 1995; Noss 1994).

2.3.5.1 Aquatic and Terrestrial Connectivity

As previously noted, information gaps on the ecosystem requirements for species such as the Northern Map Turtle often exist due to research efforts being concentrated towards more socially favourable species, such as game species. Similarly, in regards to habitat goals, most academic research and conservation activities focused on maintaining biodiversity and connectivity within the landscape have centered on the reserve design and management activities that are necessary to sustain terrestrial ecosystems, corridors and their large predator species. As a result, a prominent gap regarding issues of aquatic fragmentation, the relationships that exist between the aquatic and terrestrial interface and the species that utilize these environments has developed. Forman (1995) identifies the effects of stream corridor connectivity and continuity as a poorly researched and understood area of stream and riparian ecology. Unfortunately, riparian areas often become fragmented as a result of flood management activities, water diversion, land reclamation, commerce, agriculture, and development purposes (Forman 1995; Wissmar & Beschta 1998). In order to protect the key functions and habitats (i.e. transfer of nutrients and organisms, riparian zones, floodplains, etc.) of these aquatic and terrestrial zones, an increased understanding of the ecosystem responses, ecological processes, and community and population dynamics must be achieved (Molles et al. 1998).

2.3.5.2 Riparian Zones

Riparian zones can be defined as the "interfaces between terrestrial and aquatic ecosystems" that encompass "sharp gradients of environmental factors, ecological processes, and plant communities" (Gregory et al. 1991, p. 540). Although riparian zones do not necessarily encompass large contiguous tracts of landscape, because of the complexity of their landforms and functions, their location as linkages between aquatic and terrestrial systems, and their non–linear interactions with other landscape features, their presence is critical in the overall health of the larger landscape (Gregory et al. 1991; Naiman & Decamps 1997; Wissmar & Beschta 1998). Swanson et al. (1982) view riparian zones from three distinct scales: firstly, as the zone of direct interaction at the water's edge; secondly, as an aquatic and terrestrial interface that includes larger segments of the landscape including the streambed, banks and floodplain; and thirdly, they identify riparian areas on a three dimensional scale that looks at a forested stream as being influenced "biologically, physically and chemically by aboveground and belowground components of stream vegetation" (Swanson et al. 1982, p.268). Functioning under frequent disturbance regimes often based on flood–pulse events, riparian and floodplain landscapes are often more productive and diverse than other upslope or terrestrial ecosystems (Gregory et al. 1991; Sparks 1995; Forman 1995; Cole & Landres 1996, Naiman & Decamps 1997; Molles et al. 1998). Riparian areas are not only responsible for maintaining fluxes such as water and particulate matter within the landscape, but are also responsible for the modification of microclimates and alterations of nutrient and organic inputs between aquatic and terrestrial ecosystems (Gregory et al. 1991).

Within the landscape, riparian zones act as corridors between landscapes as well as conduits for aquatic and terrestrial organisms. For example, riparian zones can connect the headwaters in a watershed to the lowland areas (Gregory et al. 1991). Riparian zones can also serve as conduits for the dispersal and migration of plants and animals in addition to refuges during periods of drought (Gregory et al. 1991; Sparks 1995, Naiman & Decamps 1997). Riparian habitats not only provide habitat for fish and wildlife but also serve as critical wildlife migration corridors (Environment Canada 1998). When allowed to function naturally, riparian zones not only enhance the biological diversity of the ecosystem but also promote connectivity, heterogeneity and increased productivity (Wissmar & Beschta 1998). For example, the frequent disturbance regimes, such as flooding of riparian areas, promote the growth of native plants. In a study conducted by Molles et al. (1998), in the Rio Grande Valley in New Mexico, rivers whose flows were stabilized and therefore did not promote natural aquatic/terrestrial interactions favoured the invasion of non-native tree species. As well, channelization of stream and river corridors can also reduce habitat diversity by limiting the variability of habitat (e.g. pools and shallow areas), that are key habitat features for certain species (Bodie 2001).

However, despite the multitude of functions provided by riparian habitats, little information is available on the appropriate riparian designs required to maintain and restore species composition, interactions between surface and groundwater, stream flow regulation, provision of instream habitat, sediment transport reduction, movement and habitat requirements for terrestrial wildlife and overall biological integrity (Jorgenson et al. 2000).

In order to meet the conservation challenges in areas such as SLINP a clear understanding of the roles connecting corridors (aquatic, terrestrial and riparian) must be pursued. Investigations of the physical, biological and ecological interactions occurring throughout a landscape feature such as riparian habitats can provide insight into keystone sites where disturbances or improvements could have the most significant impacts on a species (Lowe et al. 2006). In the case of freshwater turtles, such as the Northern Map, these may be key nesting sites or rearing areas for young.

Genetic variability, metapopulations, core areas and reserve design and connectivity are all important aspects of a natural area to understand when pursuing ecosystem management. In particular, in order for SLINP to achieve its ecosystem management goals, such as restoring ecological connectivity and gene flow, restoring the natural, physical and biological practices occurring in the park and reducing the impacts of park visitors on the area, threats to the parks ecological integrity such as species isolation, habitat fragmentation, and wildlife impacts, must be examined under the principles of conservation biology.

2.4 Restoration Ecology

The main goals of conservation biology include investigating human impacts on natural systems, preventing the extinction of species through an understanding of population dynamics and reintegrating species into properly functioning ecosystems (Primack 2000). Unfortunately, with continuing development, and the rapid loss of suitable habitat the existence of functioning ecosystems, outside of protected areas, have significantly decreased (Dobson et. al. 1997). For example, in Australia, the effects of urbanization have significantly degraded the ecological integrity of streams in urban settings. In order to restore degraded streams, ecological studies based on ecosystem – level responses, such as the interactions of hydrology, drainage patterns, leaf inputs, biological attributes, and landscape linkages are being conducted (Miller & Boulton 2005). By understanding the greater ecosystem processes affecting urban streams, effective restoration measures that enhance the ecological integrity and biological diversity of urban stream systems can be achieved.

The loss of biodiversity is a significant risk for the Great Lakes in Southern Ontario. With increasing development along the southern border, less and less suitable habitat is available for species, many of which are already at the northern limits of their geographical range. This loss of biodiversity within the landscape creates challenges for effectively applying the principles of conservation biology. Thus, in order to preserve species on the brink of extinction it is necessary to accelerate the naturalization process. This can be achieved through ecological restoration based upon an in – depth understanding of the biological processes of a site (Dobson et. al. 1997).

Where the field of conservation biology aids in the understanding of species interactions and examines the natural connections and biological processes within a system, restoration ecology draws on this information and applies it to the landscape with an understanding of how the variability, abundance and interactions of the species present may affect the successful long term restoration of a site. (Ehrenfeld & Toth 1997,Dobson et al. 1997,Montavlo et al. 1997). For example, the targets for biodiversity are often taxonomic. However approached in conjunction with the perspective of restoration ecology, biodiversity is achieved by seeking a balance between restoring genetic , population, taxonomic and functional diversity of an ecosystem (Naeem 2006).

According to Palmer et al. (2006), "ecological restoration can be viewed as an attempt to recover a natural range of ecosystem composition, structure and dynamics" (p.1). The science of restoration ecology is extremely important in guiding the practice of ecological restoration on the landscape (Hobbs 2006). Overall, the science of restoration ecology is a symbiotic relationship between ecological theories and actual ecological restoration. Palmer lists fourteen areas of ecological theory that are foundational to the science of restoration ecology (Table 2).

Table 2: Broad Areas of Ecological Theory that are Foundational to the Science of Restoration Ecology

Key Areas of Ecological Theory			
#	Ecological Theory	#	Ecological Theory
1	Population and ecological genetics	*8*	Ecological dynamics and trajectories
2	Ecophysical and functional ecology	*9*	Biodiversity and ecosystem functioning
3	Demography, population dynamics and metapopulation ecology	*10*	Invasive species and community invasibility
4	Community ecology	*11*	Modeling and simulations
5	Evolutionary ecology	*12*	Research design and statistical analysis
6	Fine-scale heterogeneity	*13*	Macroecology
7	Food webs	*14*	Paleocology, climate change

(Palmer et. al. 2006 p.4-5)

According to Palmer et al. (2006), the practice of ecological restoration stems from the key areas of ecological theory, for example, food webs. When applying this concept to a restoration project an ecologist would consider which interacting species would need to be introduced to encourage energy movement and self-sustaining interactions within the system (Palmer et. al. 2006). Another excellent example is biodiversity and ecosystem functioning. When applying this concept to a restoration project an ecologist would want to explore whether a single site could actually maximize species richness and ecosystem functions. In order to come to a conclusion, various themes and scientific models could be applied such as, diversity-stability relationships, redundancy, and ecological insurance (Palmer et al 2006).

Davis & Slobodkin (2004) however argue that the basis of restoration ecology is less of a science – based exercise and more of a value – based or social assessment. Their position is based on the belief that ecological rationale cannot be explicitly used to achieve restoration goals. Rather, restoration goals stem from personal values of what constitutes a healthy environment, such as one's social, cultural, economic, health and ethical background, to support the desired ecological goals. Only during implementation does ecology become pertinent (Davis & Slobodkin 2004). Winterhalder et. al. (2004) dispute Davis & Slobodkin's claims. They argue that ecological science has a much broader role in restoration activities and must be presented equally throughout the entire restoration process alongside economic and social goals. Basically, Winterhalder et al. support the concept of ecosystem management.

Without a doubt, ecosystem management is complex and interdisciplinary. Its goal of protecting biodiversity within the landscape through a holistic approach is grandiose. As a result, ecosystem management cannot be effectively pursued unless the social aspects such as public participation and stewardship have been emphasized and the natural sciences such as conservation biology and ecological restoration are fully understood (Carpenter 1996).

2.7 Conclusion

The application of ecosystem management tools as outlined by Grumbine (1997) and Vogt et al. (1997) are essential in order to preserve biologically diverse riparian habitats (Gregory et al. 1991; Sparks 1995; Forman 1995; Cole & Landres 1996, Naiman &

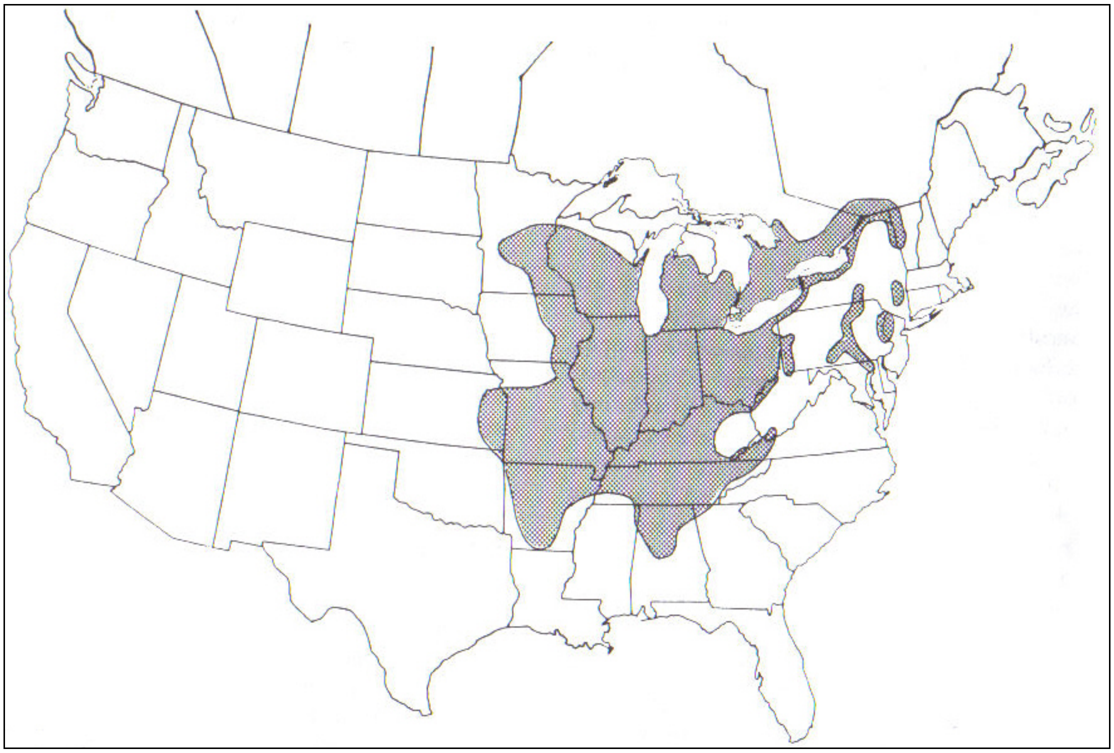
Decamps 1997; Molles et al. 1998). Only through clear management objectives, sound ecological knowledge and public and private support can healthy, ecologically functional, representative riparian ecosystems be achieved. Interacting through various processes and scales across aquatic and terrestrial environments, riparian zones are an integral landscape and habitat feature. Unfortunately, many gaps still exist in riparian management and as a result in comparison to many terrestrial landscape features, riparian areas have been neglected in long–term conservation goals. As well, gaps not only persist in terms of research and knowledge concerning riparian management, connectivity and corridor use but also in the long term monitoring and documentation of species inhabiting riparian zones such as freshwater turtles. Therefore, in order for successful ecosystem management plans to be developed for freshwater turtle species within the bay (See Maps 1 and 2), particularly for species of freshwater turtles that are at risk, the following research will not only collect baseline ecological data on the bay Northern Map Turtle population, but will also explore the turtle's use of key habitat areas.

3.0 Chapter 3: The Northern Map Turtle (*Graptemys geographica*)

3.1 Introduction

Located within large lakes and rivers throughout the Great Lakes – St. Lawrence Watershed and southwestern Quebec, the Northern Map Turtle (See Photo 1 and 2) in its most northern range (See Figure 3) (*Graptemys geographica*) has been identified as a species at risk by the Committee on the Status of Endangered Wildlife (COSEWIC) (Environment Canada 2003a; Environment Canada 2003b). Except for studies centered on Lac des Deux Montagnes in Quebec and more recent studies on the Ottawa River within the St. Lawrence Lowlands natural area, few studies that explore the Northern Map Turtle beyond its distributional characteristics have been conducted in Canada (Gordon & MacCulloch 1980; Daigle et al. 1994). Overall, the Northern Map Turtle's use of habitat is still predominately poorly understood (Fuselier & Edds 1994). Several key threats that have been identified for this particular species of freshwater turtle include: loss of habitat, increased use of recreational waterways, regulated water flows and impoundments, accumulation of heavy metals and toxins and the illegal trade of wildlife (Environment Canada 2003a; Parks Canada 2003).

Figure 2: Distributional Range of the Northern Map Turtle



(Ernst et.al. 1994, p.369)

Photo 1: Adult Female Northern Map Turtle

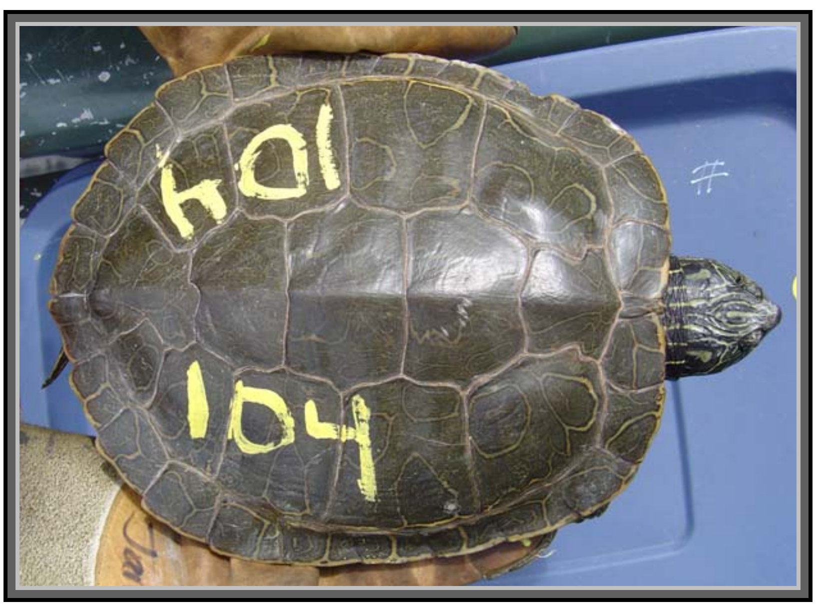
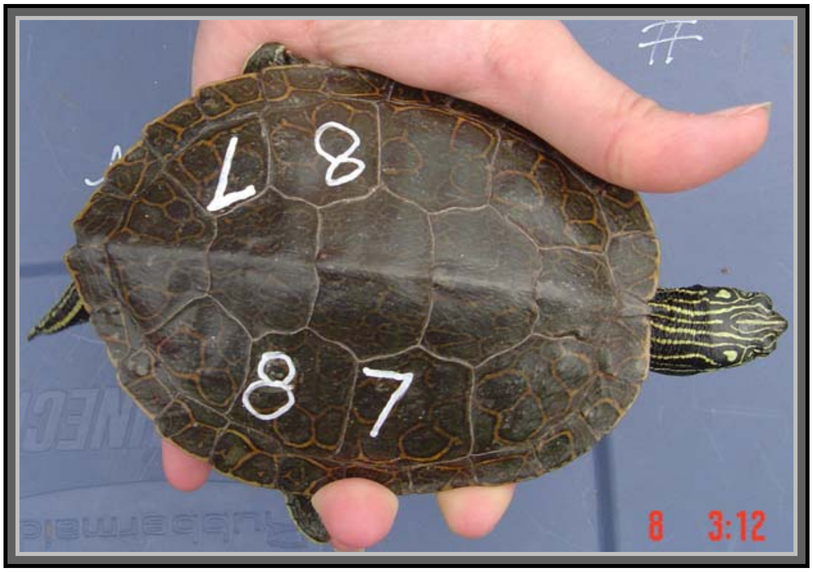


Photo 2: Adult Male Northern Map Turtle



3.2 Physical Description

The Northern Map turtle belongs to the Family of turtles known as Emydidae. There are no sub – species identified for this turtle and very little mitochondrial DNA differences between populations (Ernst et. al. 1994). With a potential life span in the wild of up to 20 years of age, females can reach carapace lengths from 18 to 27 cm in length compared to the males that range between 9 to 14cm in length (Froom 1976, Conant & Collins 1998, Ernst et. al 1994). Several advantages have been suggested for the extreme sexual dimorphism exhibited by this species. For example, sexual dimorphism may reduce competition for certain food sources for the species (Roche 2002). For females, a larger size may increase successfully reproduction by allowing larger clutches of eggs to be developed as well as afford greater protection from predators when maneuvering on land to nest (Roche 2002). For males, the smaller size may allow them to divert more energy to other life cycle functions such as searching for females and sperm production at a younger age (Roche 2002).

The carapace of this turtle is posteriorely serrated and has a distinct, low vertebral keel (Ernst et. al. 1994). The carapace colour is olive green with a pattern of concentric yellow circles that are more evident on males and juveniles of the species. It is this defining feature that led to the naming of this species in 1816 on the shores of Lake Erie when it was observed basking and its markings likened to that of a topographical map (Ernst et. al. 1994, Roche 2002). The head, neck and limbs are a dark olive green with greenish yellow stripes (Roche 2002). Females have a large broad head and a rounded carapace, whereas males have a smaller head, thicker longer tail, larger hind feet and a more oval shaped carapace (Froom 1976, Roche 2002).

3.3 Diet

Feeding on both vertebrates and invertebrates, reptiles, such as the Northern Map Turtle, are a large component of the faunal biomass in North American ecosystems and play an important role in the food chain (Bishop & Gendron 1998). The Northern Map turtle feeds mainly on freshwater molluscs, but will also feed on insects, crayfish, fish carrion and plant material (Gordon & MacCulloch 1980; Environment Canada 2003b).

3.4 Nesting

Accounts of age and size at sexual maturity are widely unknown. To date most observations place nesting females at no less than 17.5-19cm in size and roughly 14 years of age (Conant and Collins 1998, Degraff and Rudis 1983, Gordan and MacCulloch 1980, Ernst et. al 1994). Males will usually begin mate selection while still in hibernacula. Courtship displays involve the males making snout to snout contact with the female and repeated head bobbing before mounting her (Roche 2002). After females emerge from hibernation they will often spend up to six weeks basking, increasing their metabolic rate and egg shell development (Roche 2002).

Nests are usually dug in mid June in soft sand or soil, most commonly early in the day with clutch sizes ranging from 12 to 16 eggs (Froom 1976, Degraff and Rudis 1983). In the Lac des Deux Montagnes population studies by Gordon and MacCulloch (1980), nests were noted to be within 2-3 meters of the shoreline and .5 – 1m elevation from water level.

3.5 Hatchlings

Sex determination is temperature dependent for Northern Map Turtle's with male development under incubation temperatures between 22 - 28°C and female development at temperatures between 30 - 35°C (Bull and Vogt 1979, Bull et al. 1982). Development of both sexes has been observed over a narrow range of temperature of 29°C. Bull et. al. (1982) noted that temperature variations between nest sites reduced the influence of genetic predisposition for a particular sex. Thus nest site selection, yearly summer temperatures, and the zygotes response to temperature play an important role in the sex ratio of young Northern Map turtles (Roche 2002).

Populations of Northern Map Turtle hatchlings that have been monitored in Midwestern North America display a delayed emergence from the nest cavity, oftentimes overwintering and emerging the following spring (Nagle et al. 2004, Baker et al. 2003).

Researchers theorize that hatchlings will overwinter in the nest if hatched late in the season for survival purposes. A spring emergence would offer optimal food source, reduced exposure to predators when resources for growth are minimal, higher water levels would improve downstream movements and aid in the dispersal of hatchlings over a larger habitat area (Nagle et. al. 2004, Baker et. al. 2003). Northern Map turtle hatchlings are able to overwinter in nest sites as a result of their extensive capacity for super cooling and resistance to innoculative freezing (Baker et. al. 2003).

3.6 Habitat Use

Northern Map turtles benefit from riparian areas in several ways. For one, riparian areas are essential to freshwater turtles to complete several aspects of their lifecycle such as nesting, over wintering and feeding areas (Bodie 2001). Adult Northern Map Turtles have been known to travel up to four kilometers along riparian and aquatic corridors for nesting, hibernation and feeding (Environment Canada 2003b). Riparian areas are particularly important for many freshwater turtle species during their juvenile life stage when they prefer to remain close to shallow shore waters (Pluto & Bellis 1986; Naiman & Decamps 1997). Riparian areas are also used in the spring when most basking sites are still submerged. Northern Map turtles will bask on stationary, partially submerged, and low hanging branches above the water level (Gordon & MacCulloch 1980; Environment Canada 2003b, Ernst et.al 1994). Daigle et. al. (1994) noted that the highest concentrations of maps turtles were either in marshy habitats or islands with emergent vegetation or rocky environments with numerous basking sites. The use of basking sites is particularly important in the spring for food digestion in gravid females (Gordon & MacCulloch 1980).

Removing important habitat features, such as basking logs, for populations such as the Northern Map turtle that inhabit the northern reaches of their range could put the species at a greater risk for survival. An example of the importance of basking habitat was observed in Norway Bay in Quebec when a river clean up project removed all snag habitat in the area – the result was the disappearance of all Northern Map's previously using the bay (Roche 2002).

3.6 Conclusion

As noted earlier, the Northern Map turtle in its most northern range is a species of concern. Although detailed information is available on this species' morphological and distributional characteristics, few studies have explored the turtle's use of habitat. An understanding of the Northern Map turtle's general distribution and morphological traits aided in the site selection and field identification for this species and allowed the researcher to examine habitat selection and use patterns by the bay population of Northern Map turtles.

4.0 Chapter 4: Site Description

4.1 Introduction

The inland bay research site was chosen for several reasons. Firstly, local landowners had expressed concern over decreasing numbers of Northern Map Turtles seen basking throughout the previous summer seasons. Secondly, the research site provided an opportunity to assess a Northern Map Turtle population in a smaller bay as opposed to a larger lake or river system where Northern Map Turtles are predominantly found within the Great Lakes. Lastly, the smaller site was also more suitable for a single researcher than a larger site.

4.2 Site Description

The study site was located within a bay in eastern Ontario (See Map 1). The overall area is recognized as being part of the Frontenac Axis that joins the Canadian Shield of Northern Ontario to the Adirondack Mountains in the south. Key natural features of the area include: broad-leafed forests, valleys, wetlands and small farm operations. The geology of the area is rocky rugged shorelines that developed from layers of igneous rock and marble (SLINP 2006, Nature Conservancy of Canada 2001). The area is also designated as a biosphere reserve known as the Frontenac Axis Biosphere Reserve. The reserve includes an area of land between Brockville, Gananoque and Westport within Ontario, and South Frontenac Township in the US. Also captured within the biosphere reserve are several established community and scientific networks working together towards conservation at both the landscape and local scale. Within Canada, these include one national park, three provincial parks, recreational areas and historic sites, Lost Bay

Nature Reserve under the Nature Conservancy of Canada, land trusts with the Canadian Thousand Islands Heritage Conservancy, Conservation Authority lands, provincially significant wetlands, provincially designated areas of Natural and Scientific Interest (ANSI's), Queens University Biology Station and both urban and rural zones (Frontenac Arch Biosphere Reserve 2005).

The bay is identified as an area of high species diversity. For example, on June 17th and 18th 2005, a BioBlitz was organized in the nearby Lost Bay Nature Reserve (43 hectares of land located along the eastern portion of Gananoque Lake) by the Kingston Field Naturalist club. Over the course of two days, volunteers from various environmental agencies, educational institutions, and the general public surveyed the Lost Bay Nature Reserve for everything from mammal, birds, fish and amphibians to mollusks, insects, and plants. Overall, 465 species were identified (Roberston 2005).

The bay was chosen as the focus area for research on the Northern Map Turtle for four reasons. Firstly, discussions with local landowners had shown that there was definitely a Northern Map turtle population utilizing the bay waterbody. Secondly, local landowners had expressed concerns that the numbers seen basking were declining and additional research to help protect the local population was necessary. Thirdly, additional Northern Map turtle research was being conducted in the area along the St. Lawrence River by St. Lawrence Island National Park and University of Ottawa researchers and at Lake Opinicon at the Queen's Biology Station by University of Ottawa researchers. The collection of data from Northern Map turtle populations utilizing a small bay, a larger river system and a larger lake system could prove useful in comparing behavioural similarities or differences. Lastly, the bay was geographically feasible to study for a single researcher with access to a small watercraft. Traps could be checked twice daily as well as nesting sites monitored and basking information collected.

Map 1: Eastern Ontario General Study Location

(Natural Resources Canada 2006)

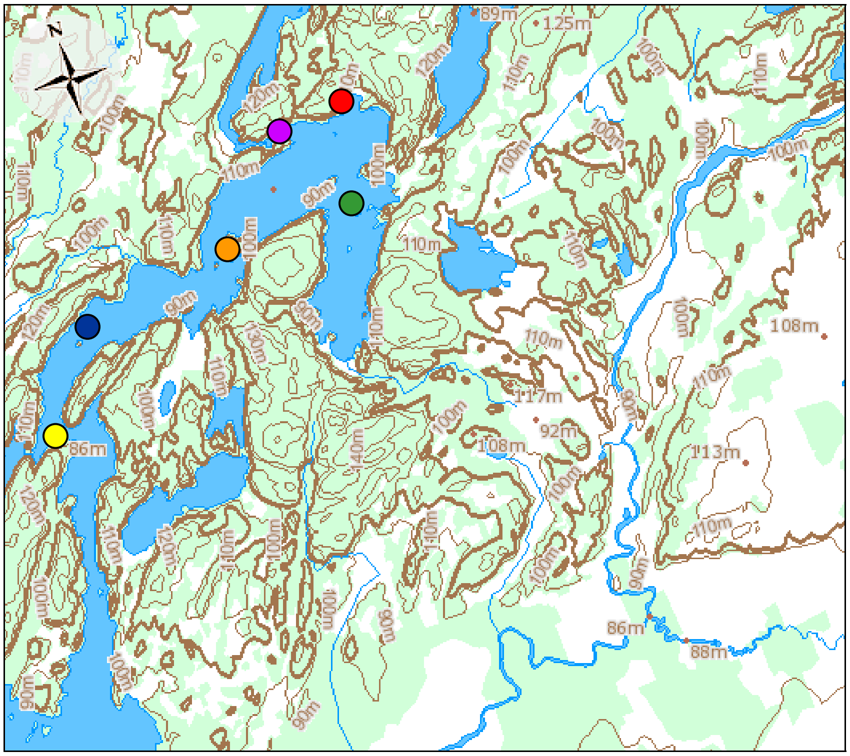
4.3 Capture Site Descriptions

A total of four sites were selected within the bay to capture Northern Map turtles. Two of the traps were located along shoreline areas and the other two traps went adjacent to small islands (See Map 2). Two of the four sites were known basking sites. Northern Map turtle studies conducted in the Lac des Deux Montagnes by Gordon and MacCulloch

(1980) used basking traps that were located either on their own or in conjunction with known basking sites.

The approximate length of the bay from Trap A to the Crank (term used by locals to identify the sharp bend in the waterway) is 4, 090 meters (4.09 kilometers). Using Trap A as a reference point, Trap B was 737 meters, Trap C was 933 meters and Trap D was 1, 890 meters from Trap A.

Map 2: Map of Trap Sites



Legend			
Feature	Symbol	Feature	Symbol
Flooded Area		Index Contour (interval Varies)	
Lake		Intermediate Contour (interval varies)	
Rivers		Wooded Area	
Slough, Intermittent Lake or Pond		Palsa Bog	
Wetland		String Bog	
Trap A		Tundra Pond	
Trap B		The Crank	
Trap C		Blueberry Island	
Trap D			

(Natural Resources Canada 2006)

Photo 3: Trap A

Trap A was located along the west shoreline (basking facing east) of a small semicircular bay. Only one cottage was located on the east bank of the bay and was mostly concealed by an island situated in the center of the bay. The back portion of the bay was dominated by submergent vegetation such as cattails. Water levels were high throughout May and June 2005 but dropped approximately 0.6 meters by the first week of July 2005. This water drop led to an increase in submerged vegetation around the trap site. Prevailing winds coming into the bay often created high wave action at the site. Boat traffic was limited to the occasional fishing boat trolling slowly through the area. The cottage owner along the opposite bank only used a kayak for water transportation. Conversations with the cottage owner revealed that when he first began using the cottage the turtles were congregating on the center island for basking, but with increased activity at the cottage had relocated further to the opposite shore where trap A was situated.

Photo 4: Trap B

Trap B was located along the north shoreline (basking facing South) in a channel used by boaters to travel between the bay and upstream lakes. The shoreline had a series of large rocks and fallen trees. Although, there were no cottages within the vicinity of the trap, a fire pit and picnic area for fishing groups was situated at the beginning of the channel in the bay.

Water depth increased sharply as you moved away from the shoreline. Although a drop in water levels in July caused increased exposure of aquatic vegetation at the beginning of the channel leading to Trap B, it did not cause an increase in submerged aquatic vegetation at the trap site. Several large fallen trees were evident beneath the water along the shoreline. The channel had low wind velocities and wave action compared to the other three trap sites. Boat traffic increased significantly in July. At times boats were lined up to pass through the channel. Some boats traveled through the narrow channel at high speeds causing large wakes.

Photo 5: Trap C

Photo 6: Trap C Island Location

Trap C was located along the eastern side of a small island. The island is situated approximately 171 meters from the mainland shoreline. There are several cottages or permanent dwellings along the eastern mainland shore. There is no development along the western mainland shoreline, located approximately 246 meters from the island. Drop-off from the island is steep at the eastern tip where most turtles congregated for basking.

As water levels dropped throughout July aquatic vegetation became thick between the island and the mainland on the east. Wind velocities and wave action were often strong at this site and the trap planks had to be constantly tightened. Boat traffic around the island was generally slow due to rocks. A marsh complex was situated along the shoreline northeast of the island.

Photo 7: Trap D

Photo 8: Trap D Island Location (Snake Island)

Trap D was located at the eastern end of a small island was approximately 74 meters from the eastern mainland shoreline and 158 meters from the western mainland shoreline. The island was nicknamed Snake Island (by researcher K. Beehler) due to the presence of water snakes along the rocks and on the trap. Snake Island is situated approximately 74 meters from the eastern mainland shoreline and 158 meters from the western mainland shoreline. Several cottages are located along the western shoreline. Drop-off from the island was generally steep for the entire island. As water levels dropped throughout July aquatic vegetation became thick between the island and the mainland on the east. Most boat traffic kept to the west of the island. Any boats traveling along the eastern edge were mostly trolling for fish. Wind velocities and wave action were often strong at this site compared to the shoreline trap sites. The islands were sometimes used by swimmers and boat parties on weekends. On several occasions the ropes securing the trap at this site were deliberately cut by an unknown party.

4.4 Conclusion

According to previous accounts, the bay displays the unique geological and natural features associated with the Canadian Shield and Frontenac Axis. As a result of surrounding areas of environmental significance numerous community and scientific networks are dedicated to the preservation of the local landscape and species. In particular, several studies focusing on Northern Map Turtles have recently been pursued along the St. Lawrence River and at Lake Opinicon. These ongoing studies were considered important because they contributed to trap design concepts. Collectively, the studies on the St. Lawrence, Lake Opinicon and the bay have the potential to contribute academic literature on large river, large lake and small bay populations of Northern Map Turtles. For the purpose of this research project four capture sites were selected based on either known turtle basking sites or the proximity to specific habitat features. For comparison purposes, two traps were located in nearshore areas (Trap A and B) and while two traps were located alongside small islands out in the bay (Trap C and D). Research methodologies had to be logistically suitable for a single researcher. This included considerations of site access by boat, sampling schedules and durable trap design.

5.0 Chapter 5: Methodology

5.1 Introduction

To develop a research strategy for population and habitat analysis on the bay population of Northern Map turtles a literature review of past research on the species and practical field techniques was first pursued. The literature review provided insight on trapping techniques, habitat usage in other areas of the species range throughout the United States and in the Lac de Deux Montagnes population in Quebec and provided population statistics and habitat utilization for comparison. Practical field techniques when working with freshwater turtles were then conducted throughout 2004 through volunteer work at the St. Lawrence Island National Park. By assisting Park staff in the field I was able to work on capture techniques and investigate potential field sites for my own analysis.

Throughout the 2005 field season information was gathered on a variety of field variables at each of the chosen trap sites. Water and air temperature (°C) were gathered at each site along with wind speed (km/hr) and humidity levels (%). These measurements were taken when turtles were captured within the traps, when they were observed basking and when they weren't observed basking. These site variables were gathered to help assess whether turtles preferred sites with different characteristics and which turtles were utilizing these sites on a regular basis. For example, were juveniles observed using sites with on average higher temperatures and calmer conditions than adult turtles?
When turtles were captured their sex was determined and they were classed as either adults or juveniles based on carapace length. Carapace length, width and depth and the turtle's weight were also recorded. Recaptured turtles were also noted. This was

important to determine whether different turtles remained in the same general area for the duration of the summer season.

5.2 Methods

Preliminary field surveys were conducted by canoe throughout July and August 2004 to identify key basking and nesting sites. Nest sites were located by looking for signs of predation. Residents of the bay often volunteered information on key basking areas and seasonal trends of turtles within the area.

In late April 2005, four basking traps were situated within the bay. The traps consisted of a square frame made from four inch PVC piping with a submerged durable plastic basket and a wooden ramp running across the top of the frame and folding down into the water. (See photos 3-6) Unlike some of the other turtle species in the area, Northern Map turtles are predominantly mollusk eaters and cannot be baited into traps. Researchers in the past have trapped Northern Map Turtles by collecting them from a boat using long dip nets (Chaney and Smith 1950), through snorkeling hand captures, or by appealing to their basking behaviour with the use of basking traps (also referred to as floating pitfall traps) (Gordon and MacCulloch 1980, Pluto and Bellis 1986). Researchers from the St. Lawrence Island National Park and Opinicon Lake utilize basking traps and snorkeling hand captures to gather the turtles. Basking traps and several captures with the use of the dipnet from the boat were the capture methods used for this study. Snorkeling and the use of the dipnet were not always feasible since research was often conducted with only one researcher – thus the basking traps were the most efficient capture method.

Traps were monitored for basking activity and trap captures twice daily from May 6th to August 28th 2005 for a total of 51 sampling days, between 8am and 12pm and then again between 1pm and 6pm. Ethics clearance (AUPP #04-13) was first obtained through the Office of Research Ethics and the Animal Care Committee from the University of Waterloo. The researcher also successfully completed the “Establishing Humane Endpoints” workshop put on by the Office of Research Ethics and the Animal Care Committee prior to working with the turtles. Chaney and Smith (1950) noted in their field studies that the best collecting for Northern Map Turtles was during the day when turtles were basking in groups. They also noted that methods used in one river system to collect turtles were not always successful in another river system when collecting the same species of turtle.

The researcher and a field assistant explored the area in a fourteen foot aluminum motorboat with a six horsepower engine. Turtles are often easily captured following emergence from hibernation but within a week are increasingly more difficult to approach (Gordon and MacCulloch 1980, Daigle et. al. 1994). When approaching trap sites one observed with binoculars while the other steered the boat. The primary observer would take an initial count of basking turtles to determine by size the number of adult females versus males and juveniles and determine whether any were marked with numbers from previous captures. Counts for basking turtles were recorded along with air temperature, water temperature, average and maximum wind speed and relative humidity were documented on each site visit.

Captured turtles were classified as adult male, adult female, juvenile female or juvenile male based on physical characteristics and carapace size, and then weighed using hook weights and a pillow case. Carapace length, width and depth were recorded to the nearest millimeter using calipers weight to the nearest kilogram. A digital photo was taken of each captured turtles. The sexes of the turtles were noted to not only determine whether the population was biased towards a particular sex but to also determine whether males were utilizing different trap sites than females and at different times of the season. General age categories (adult versus juvenile) were also noted to determine whether habitat preferences existed between juveniles and adults and whether juveniles tended to remain in the bay area throughout the summer season.

An identification number was painted on both sides of the carapace on adults and a dot code was placed on the plastron of juveniles for re-identification. The reasoning behind placing the dot on the underside of the smaller turtles was to reduce overhead visibility to raptors such as bald eagles. Gordon and MacCulloch (1980) used paint to identify Northern Map turtles captured from various bays. They found that the paint lasted for one season but had been shed by the second year of their research. Given that only one field season was being conducted this proved to be the least invasive method of marking. Discussions with Elinor Hughes, a PhD candidate studying sexual selection in painted turtles from the Brooks Lab at the University of Guelph, revealed that Automobile touch-up paint was effective for marking turtles for re-identification (Hughes 2005). Although shedding was an issue in mid season with several of the adult females, enough detailed information and photo identification were available to determine the correct identification number for the re-captured females. Unusual scuttelation markings and injuries were noted and an identification picture was taken of the carapace and plastron. Of the 51 sampling days, turtles were caught in the traps on 36 days. A total of 108 turtles and 24 recaptured turtles were collected in the traps.

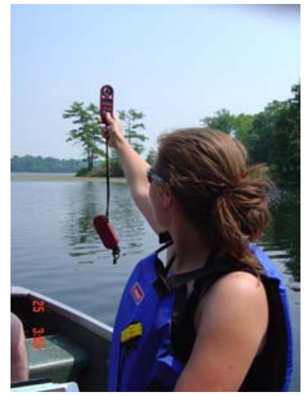
Genetic variability was not assessed in the bay population of the Northern Map Turtle. However, current research is being conducted at the University of Ottawa that tracks the parenting genealogy of map turtles through blood samples. This work will provide insight on mate selection of the Northern Map Turtle. Currently, little is known on the sexual maturity and selection of this species (Ernst et. al. 1994).

Searching for nesting turtles began mid May and lasted until late June 2005. A canoe was used during the early hours of the morning to scout shoreline areas and several islands that had displayed predated nests the previous season. Nesting females were measured for carapace length without moving them from the nesting site. Air and water temperatures were recorded along with soil moisture, soil temperature, average and maximum wind speeds and relative humidity. A Lux reading of light intensity was also taken to compare light conditions on days when turtles were seen nesting. Each site was marked with a Garmin E-Trex Summit GPS unit. Nests sites were then monitored daily between 8am and 11am for above mentioned parameters until late August 2005.

Photo 9

Water Temperature °C

Photo 10

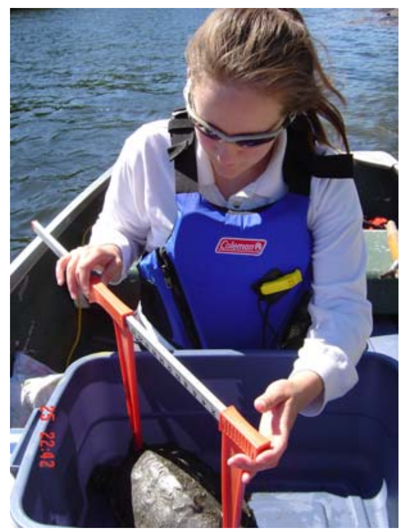


Winds Speeds km/hr and % Humidity

Photo 11

Air Temperature °C

Photo 12



Carapace Measurements cm

Photo 13

Turtle Weight kg

Photo 14

Turtle Identification

Photo 15

Carapace Length (cm) Nesting Female

Photo 16

Nest Monitoring Soil Temperature °C

5.3 Research Limitations

A number of challenges existed in the development and execution of this research project. Some of these include: financial constraints, time constraints, and human disturbance.

Preparations for the 2005 April-August field season were conducted throughout the fall of 2004 and winter 2005. Field surveys were conducted weekly from Thursday to Sunday from April to August (the trap design had a feature that allowed the ramps to be secured out of the water on days that the traps could not be checked to deter turtles from basking on the traps). Had research been able to be pursued 7 days a week for four months a larger sample size of captured and observed turtles could have been collected and additional nesting females might have been observed. This was a particular frustration when sunny warm weather, optimal for basking activity, occurred at the beginning of the week when the researcher was unable to gather data and rain followed for the later part of the week. Not being able to sample into the fall was also a limitation. Basking, particularly by females, was observed by the researcher in late summer. Research in the fall would have provided the opportunity to assess how many females returned to the bay since their absence post-nesting.

Being present on weekends to gather research data was not an issue in the early spring. However, throughout July and August it became more challenging since the level of recreational activity on the water and the islands increased. For example, on several occasions turtles were observed basking on the traps but before a count could be determined and the number of females versus males and juveniles identified, fast recreational boats would cross through the area. This also limited the opportunity to catch any turtles with dipnets through a surprise approach. Monitoring nest temperatures also became more challenging, particularly on Blueberry Island, as it was constantly occupied on weekends by boaters. It would often take more time to monitor since access to the island was difficult with the number of boats moored there. Often, it was necessary to tie the boat at the back of the island and scale the rock face to access the nest sites.

Although collecting data on nest sites was useful in determining the types of habitat being utilized by female Northern Map turtles and the general conditions of the nests throughout the season, it would have been optimal to also install protective caging around the nests to protect them for the entire season and assess the sex composition of hatchlings when they emerged in late summer or early fall. This would only have been feasible if monitoring was conducted on a daily basis. Hatchlings should not be left in the caging for more than a day once they emerge from the nests.

5.4 Conclusion

This chapter explored the process undertaken to determine appropriate methodologies for capture and observation of Northern Map turtles within the bay. Overall, extensive literature review, volunteer work and two field seasons (one pilot and one field/data collection) were necessary. As a result of this work, three different areas of data collection were pursued: capture data, basking data and nesting data. Changes in field collection methods resulting from unforeseen challenges have also been accounted for. Results from the 2005 field season are discussed in the next chapter.

6.0 Chapter 6: Results

6.1 Introduction

Results from the 2005 field season on the bay not only provide baseline data on the population characteristics of the local Northern Map turtle population, but also assess preferred habitat characteristics and preferred nesting sites.

6.2 Population Characteristics

Table 3: Overall Capture Numbers for Northern Map Turtles

Year	Collection Period	No. marked			
		Adult Male	Adult Female	Juvenile Male	Juvenile Female
2005	7 May- 27 August	41	42	7	22

Table 4: Overall Recapture Numbers for Northern Map Turtles

Year	Collection Period	No. recaptured			
		Adult Male	Adult Female	Juvenile Male	Juvenile Female
2005	7 May- 27 August	6	2	8	7

Not counting recaptured turtles, females were the most commonly captured sex with adult and juvenile females representing over half of the captures (57.1%). Adult male captures represented 36.6% of captures, but only 6.2% of captures were juvenile males. Although overall capture numbers were low for male juveniles, compared to adult male and female and juvenile females, they represent the highest recapture rates. Half of the male juveniles were captured at Trap B and the other half at Trap C. Recaptures were all at the same traps that the turtle was first captured at except one juvenile male that originally caught at Trap C then re-caught at Trap A.

Most captures were made in May and June when females were utilizing sunny basking sites for eggshell development. Once the nesting season ended at the beginning of July not only did capture numbers decrease for females but the site of all captures changed from offshore island basking sites (Traps C and D) to a nearshore basking site (Trap B).

In May males were caught basking with females at Trap A, but were not caught at Trap D. In June no males were captured at Trap A. Captures were very few in June with only six captures between Traps B, C and D. In July and August captures of males increased with most captures occurring at Trap B.

Juvenile females were caught more frequently than juvenile males throughout the study at a 3:1 ratio. In May most juvenile females were caught at Traps A and B along the shoreline. In June juvenile females were at all four traps within the Bay and in July in three of the four traps. By August juvenile females were only caught at Trap B. Juvenile males were only captured at Traps B and C throughout the summer. Juvenile males were also the most frequently re-captured turtles.

Figure 3: May Trap Captures

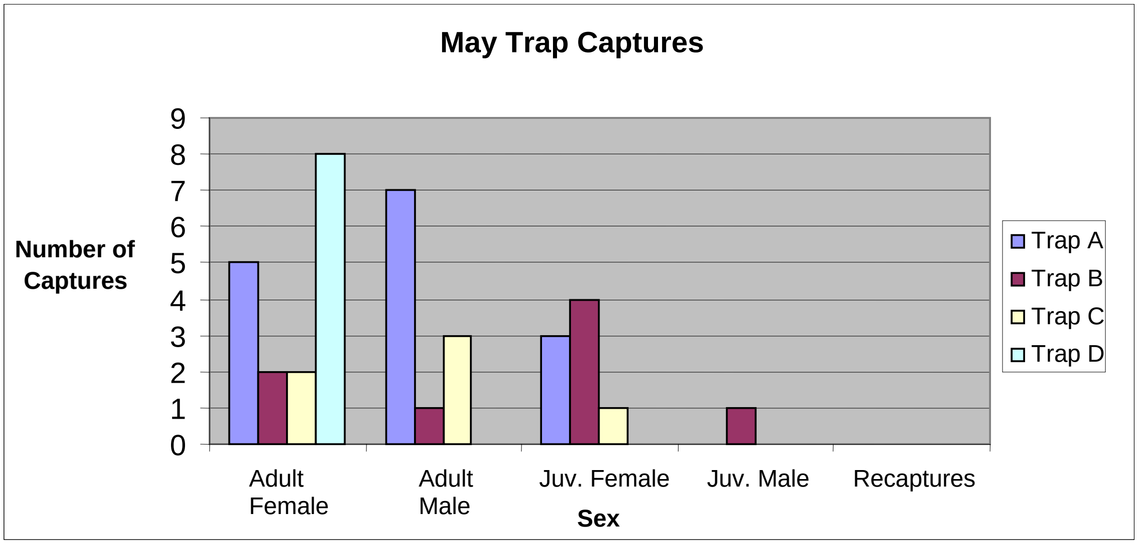


Figure 4: June Trap Captures

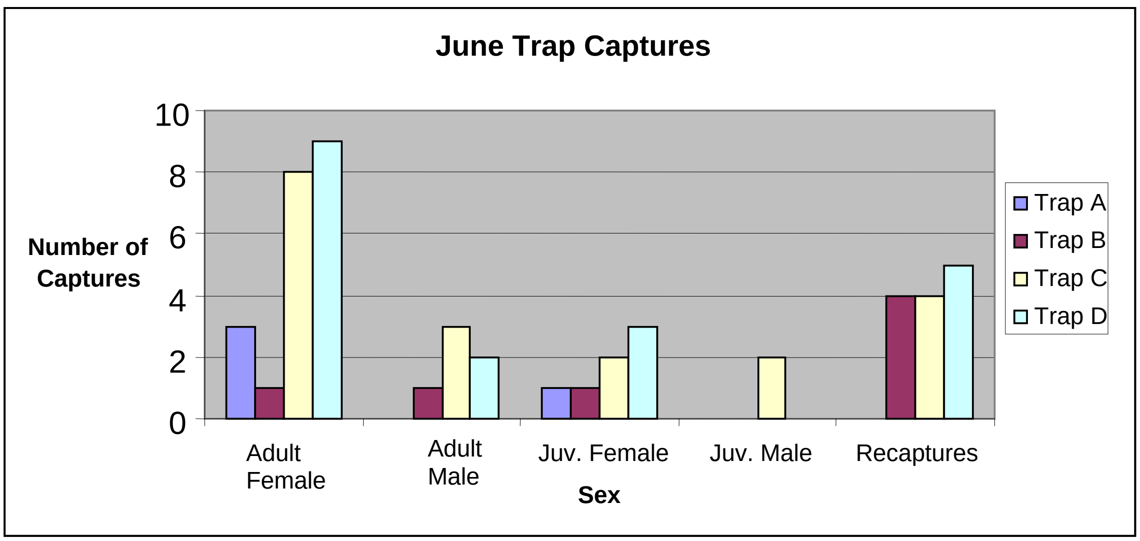


Figure 5: July Trap Captures

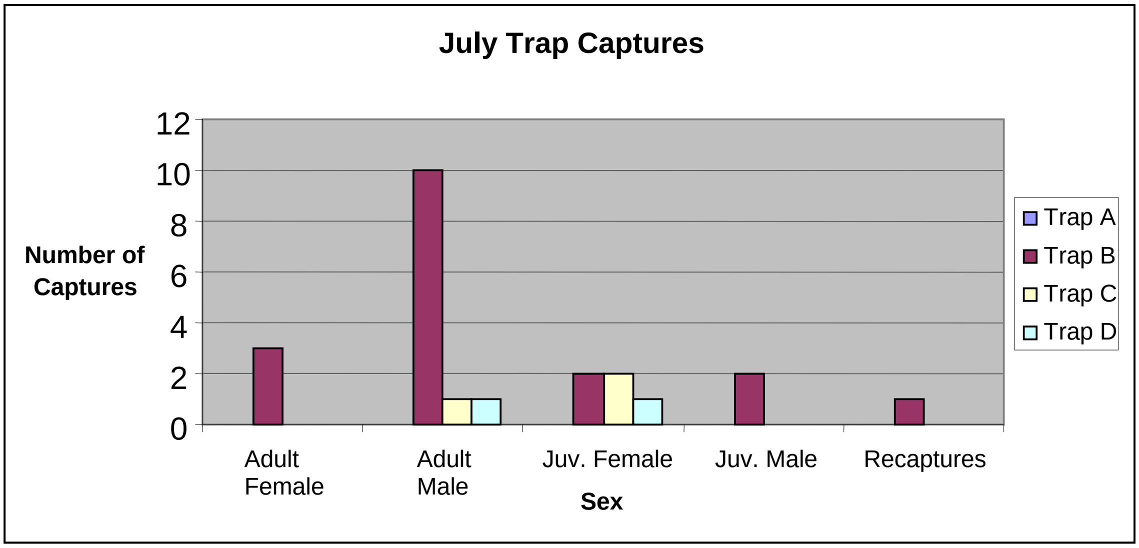


Figure 6: August Trap Captures

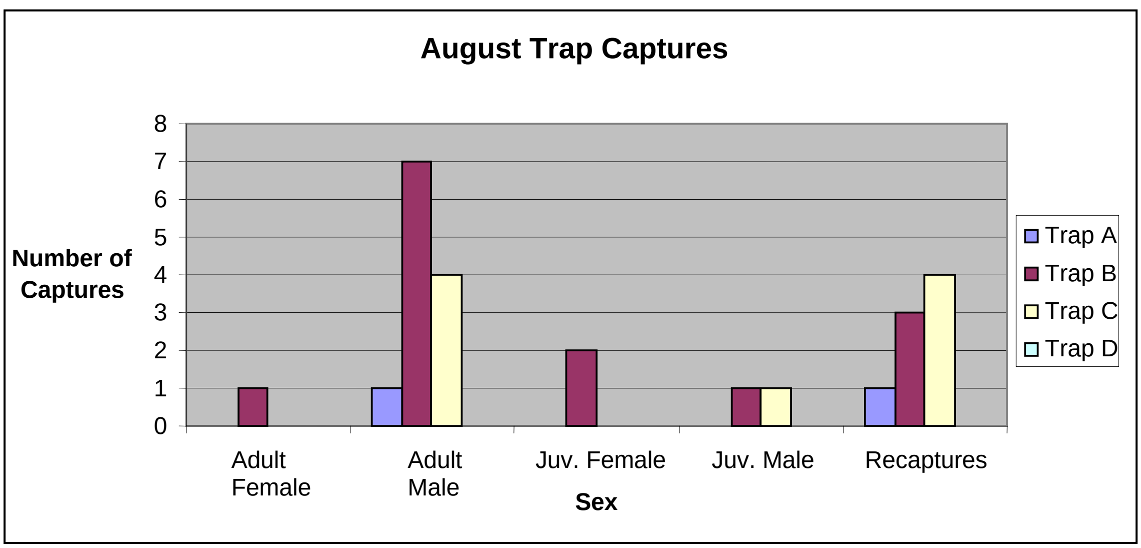


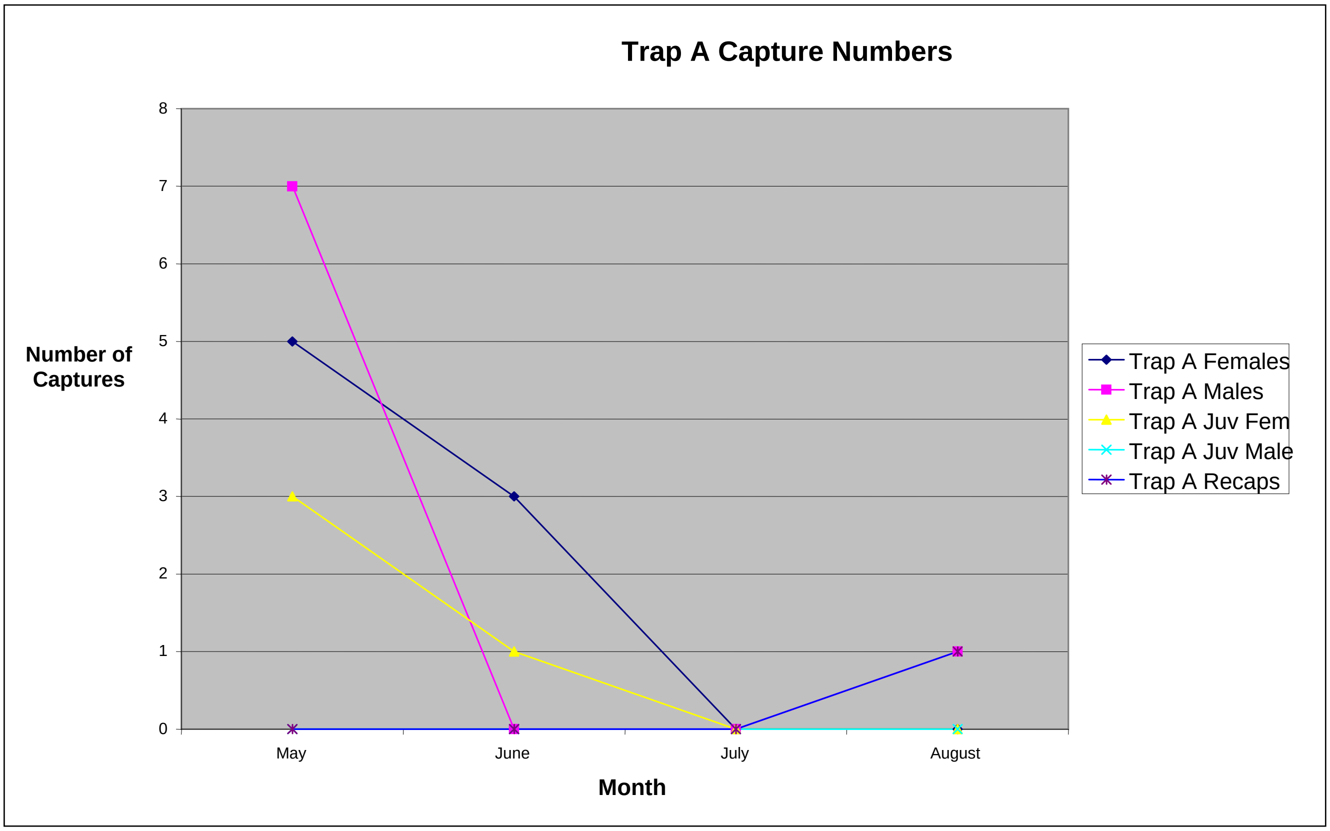
Table 5: Distribution of Northern Map Turtle Trap Captures

Trap Sites	Number Of Captures	Percent
A	21	15.5
B	48	35.5
C	37	27.4
D	29	21.5
Total	135	100.0

Table 6: Turtle Sex and Age Category Captured at Trap Sites

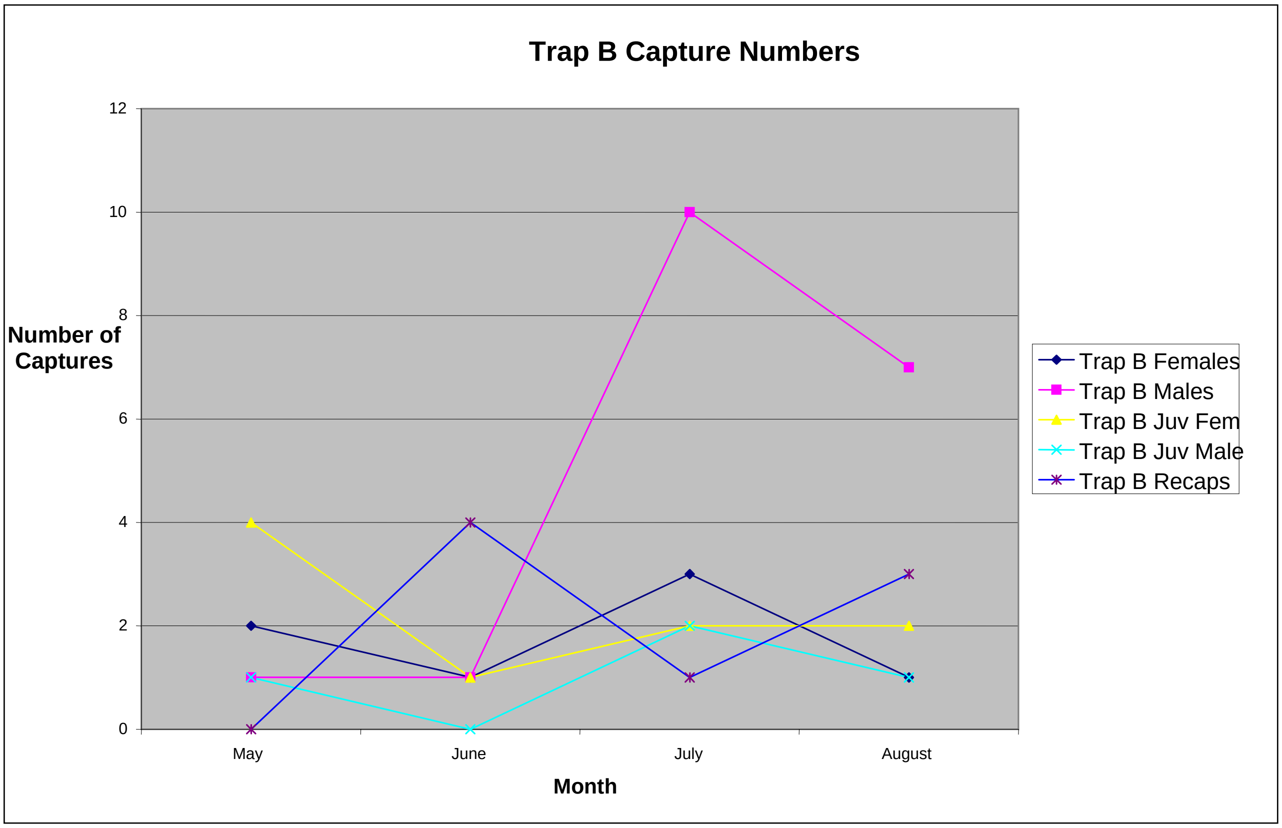
Sex and Age Capture Categories		Trap Identification				Total
		A	B	C	D	
Sex	Adult Female	8	7	10	17	42
	Adult Male	8	19	11	3	41
	Female Juvenile	4	9	5	4	22
	Male Juvenile	0	4	3	0	7
	Adult Female Recapture	0	0	0	2	2
	Adult Male Recapture	1	4	1	0	6
	Juvenile Female Recapture	0	1	3	3	7
	Juvenile Male Recapture	0	4	4	0	8
Total		21	47	37	29	135

Figure 7: Trap A Capture Numbers



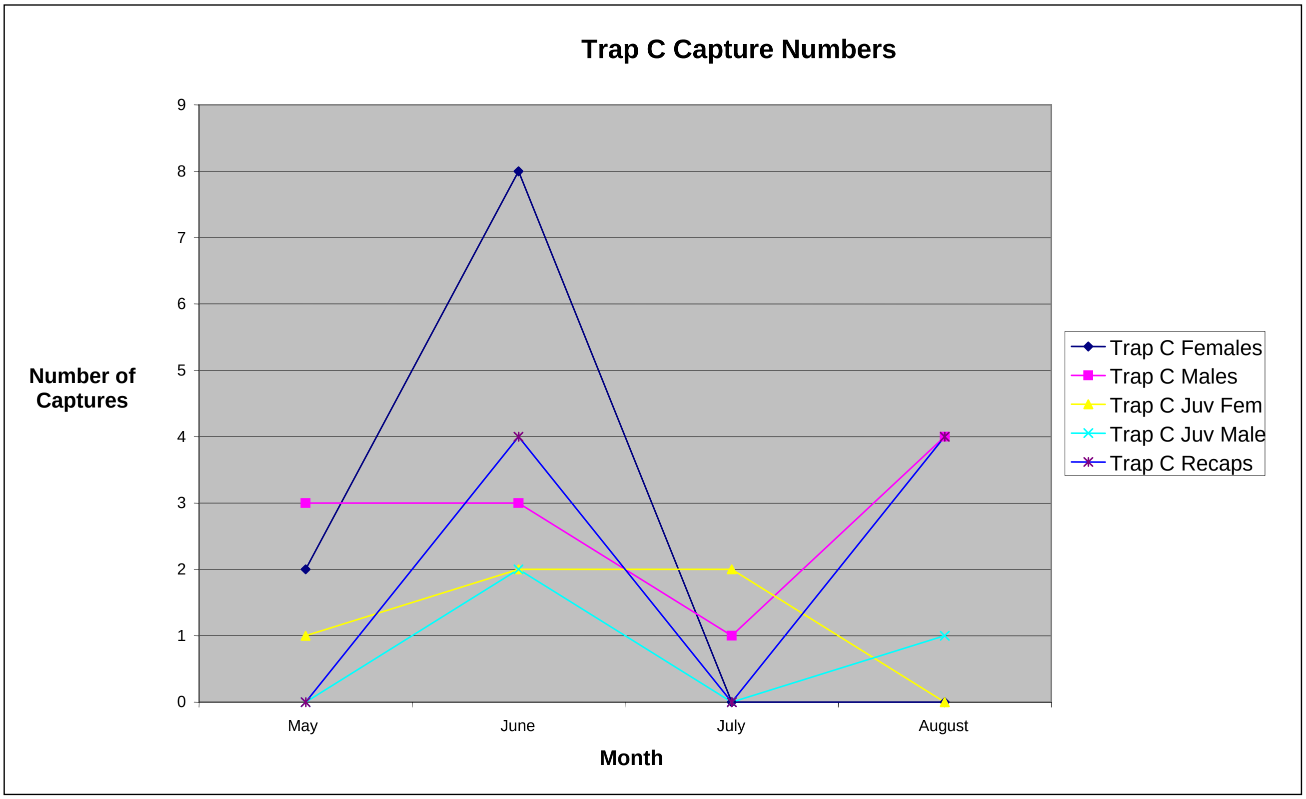
Captures at Trap A were high in May and June but decreased significantly throughout July and August with only a small number of males and recaptures observed in the trap (Figure 7). Although this site had very low boating activity and was often undisturbed, vegetation became extremely dense in the latter part of the summer and this may have influenced its use as a basking site. Overall, Trap A had the lowest capture rate of the four traps in the bay with only 20 turtles being captured at this site. In late August turtles were observed returning to the vicinity of Trap A. However they remained at the opening of the bay where water depths were greater and vegetation less dense than at the trap site

Figure 8: Trap B Capture Numbers



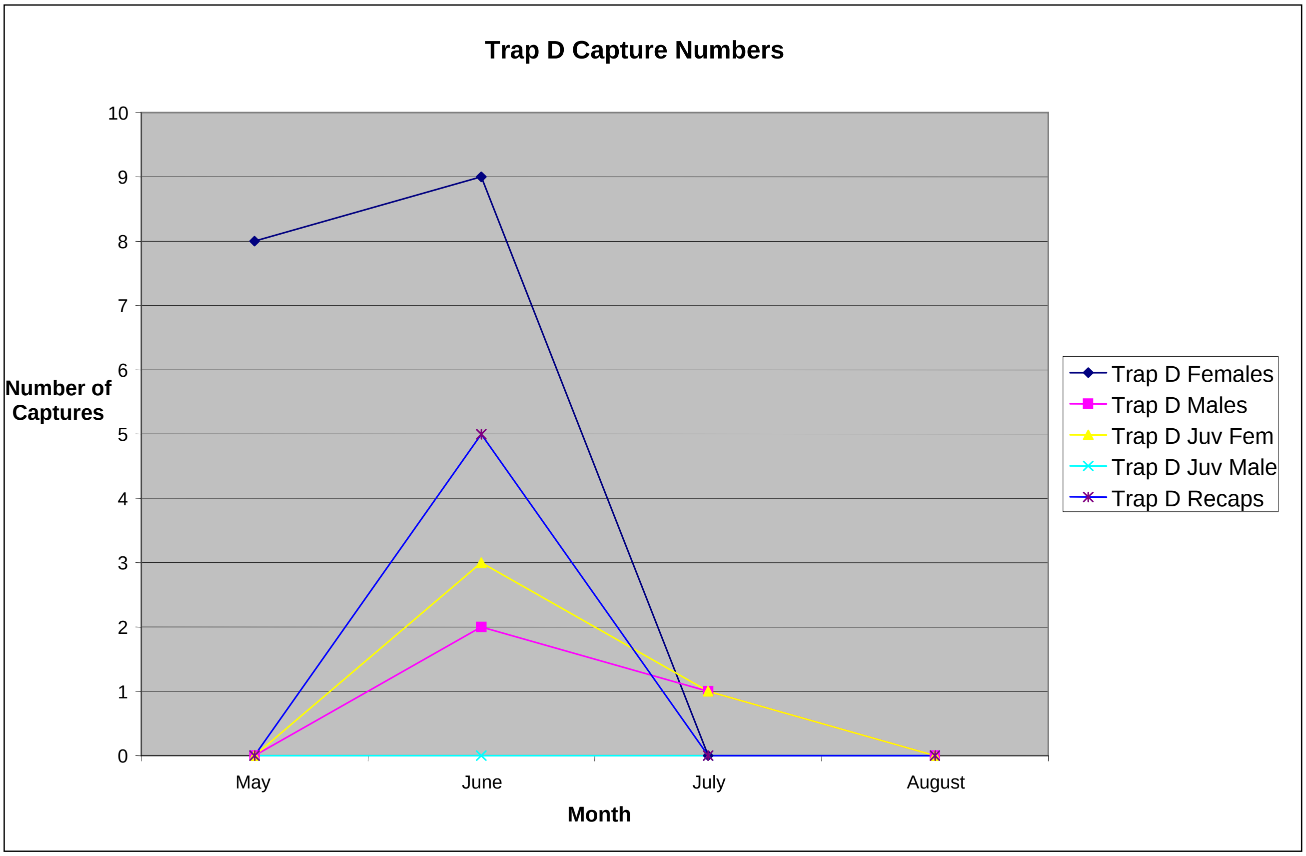
Trap B had lower trap captures of females (7), juvenile females (9) and juvenile males (3) throughout the four months of trapping compared to the 18 adult males that were captured, with numbers peaking in July (Figure 8). Trap B had a high volume of boat traffic during July and August; however boats passed through slowly due to rock hazards and narrowness of passage. Turtles at this site also had access to woody debris and large underwater rocks for camouflage when disturbed. Juveniles and adult males tended to utilize these areas even when disturbed, returning shortly to the basking site. Adult females on the other hand, when disturbed, tended to surface farther from the trap site and did not return to bask. Turtle recaptures peak in June and again in August.

Figure 9: Trap C Capture Numbers



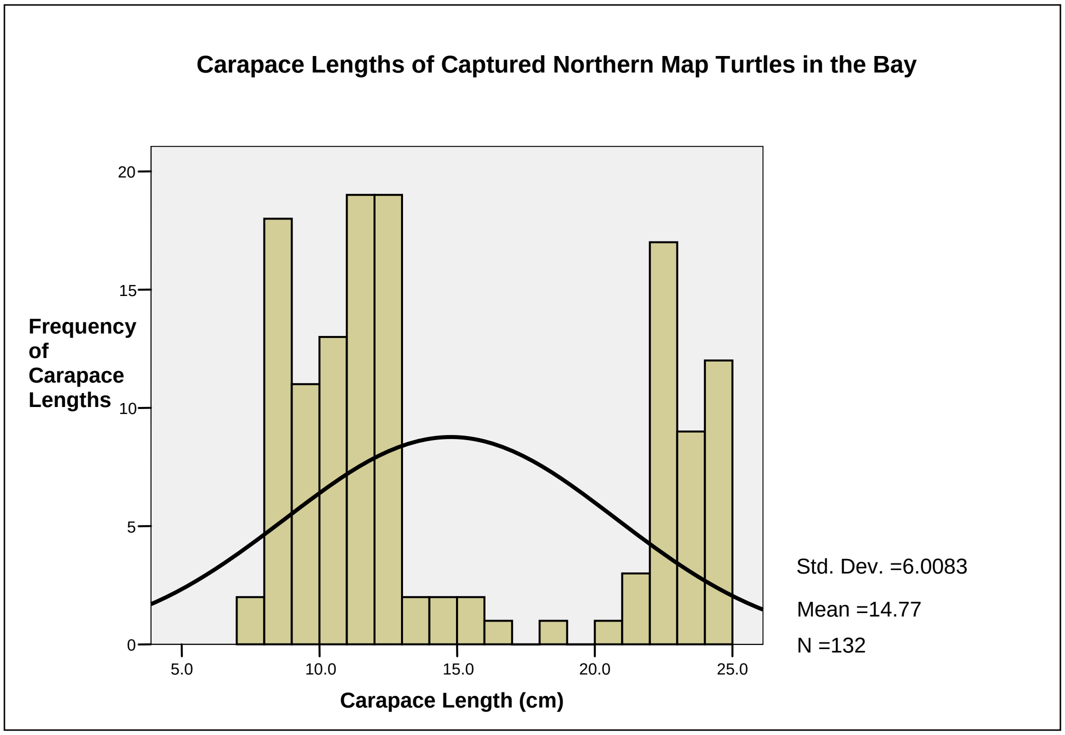
Trap C had consistent turtle captures throughout May and June. Females were particularly prevalent at this site in June. Captures decreased in July with only one adult male and two juvenile females captured (Figure 9). Although Trap C was located off an island site with the greatest distance to the mainland shoreline, it had an equal number of male captures to female captures. In July this site experiences a high volume of boat traffic and nearby cottage activity. Compared to Trap B, boats that pass by Trap C are at much faster speeds. Turtle recaptures peak in June and August.

Figure 10: Trap D Capture Numbers



Capture trends at Trap D are similar to trends observed at Traps A and C. Captures are higher in May and June, particularly for adult females and decrease throughout the latter part of the summer. Recaptures at Trap D peak in June, but unlike Traps B and C do not peak again in August (Figure 10). Trap D had the highest number of adult female captures. Boat traffic and recreational use of the Trap D island site are high throughout July and August. Trap D was also subject to two acts of vandalism throughout August.

Figure 11: Carapace Lengths of Captured Northern Map Turtles



Size ranges as shown in Figure 11 for captured Northern Map turtles are divided into two distinct clusters: the 8-12cm cluster and the 22-25cm cluster. The 22 to 25cm cluster represents the adult females that were captured, while the 8 – 12cm cluster is a mix of adult males (9-14cm), juvenile males (7-9cm) and juvenile females (7-18cm). Most of juvenile females captured were smaller juveniles. Out of 22 captured juvenile females, 14 were under 12cm in carapace length and the remaining 8 were 12 – 14cm in carapace length (Figure 11).

6.3 Trap Captures/Basking Observations

Observations of basking turtles were documented throughout May to August in the vicinity of Traps A, B, C and D (Table 7). Observations were made with binoculars from a distance. Based on size, turtles were identified as either adult females or adult males/juveniles. In May and June a larger number of adult females were captured and observed basking compared to July and August. Captures and observations for adult males and juveniles were higher at Trap B and C then Trap A and D. Throughout May and June observations of basking turtles were made on days with full sun and days with cloud cover; however throughout July and August days with cloud cover resulted in no turtle basking observations. Turtles were never observed basking on days with precipitation.

Table 7: Trap Captures and Basking Observations

Month	**Trap**	**Captures**				**Basking Observations**	
		Female	**Male**	**Juvenile Female**	**Juvenile Male**	**Female**	**Male/ Juvenile**
May	A	5	7	3	0	122	35
	B	2	1	4	0	19	40
	C	2	3	1	0	120	22
	D	8	0	0	0	45	10
June	A	3	0	1	0	27	2
	B	1	1	0	4	2	11
	C	8	3	2	2	42	29
	D	9	2	3	0	24	21
July	A	0	0	0	0	0	1
	B	3	10	2	2	5	24
	C	0	1	2	0	4	8
	D	0	1	1	0	1	7
August	A	0	1	0	0	10	19
	B	1	7	2	1	13	32
	C	0	4	0	1	6	36
	D	0	0	0	0	7	3
Total		42	41	22	7	447	300

*** Please note capture numbers do not include recaptures**

6.4 Trap Site/Basking Site Characteristics

Throughout May to August, daily site conditions were gathered at each trap site in the bay for air temperature, water temperature, % humidity, average wind speed and maximum wind speed (Table 8). According to Environment Canada's (2004a) seasonal forecast temperatures for June, July and August 2005 were considered above normal. Observed precipitation for June, July and August were above normal to normal for 2005 (Environment Canada 2004b). Observations were not available for April or May. Observations for the previous summer saw June, July and August with below normal temperatures and above normal precipitation. All categories (below normal, normal, above normal) are based on 3 equiprobable categories from 1961 to 1990 climatology.

From May to June on average, overall monthly air temperature increased by 9 to 11°C at each site. Between June and August air temperatures at all trap sites fluctuated from approximately 25°C to 31°C. Trap B exhibited slightly higher air temperatures but overall air temperature was not a major difference among traps (See Figure 12). Similarly to air temperatures, water temperatures at the traps increased by 9 to 13°C on average from May to June. Aside from Trap B reaching an average of 27.34°C in August, water temperatures at each site was between 25°C and 26°C for June, July and August (See Figure 13).

The percent humidity fluctuated among all four months and traps. Humidity appears to have been lower on average in May and July. The highest average humidity is seen at

Trap B in August, along with the higher air and water temperatures compared to Traps A, C and D (See Figure 14).

Average and maximum wind speeds were higher in May than any other month at all traps. Traps C and D had the highest average and maximum wind speeds. Winds reached speeds of up to 35.2 to 36.5 km/hr respectively. Trap A exhibited moderate wind speeds and Trap B had the lowest wind speeds. Wave action on windy days at Traps C and D were very strong and maneuvering the boat in such conditions became a challenge. As well, Trap C had to periodically have the planks re-secured throughout the summer due to the roughness of the waves (See Figures 15 and 16).

Table 8: Average Monthly Site Variables for Traps A, B, C and D

Average Monthly Site Variables						
		Temperature °C			Wind Speed km/hr	
Site	Month	Air	Water	% Humidity	Average	Maximum
Trap A	May	17.8	13.1	41.7	5.7	11.8
Range		11.3 to 21.7	9.7 to 16.7	22 to 87	1 to 14.2	6 to 22.5
	June	27.6	26.1	53.7	4.9	7.5
Range		22.2 to 31.4	23.5 to 29.6	36 to 83	2.4 to 11.7	3.2 to 17.6
	July	26.1	26.1	43.7	4.9	7.5
Range		22 to 29.3	25.2 to 29.1	25 to 83	1.3 to 8.9	1.6 to 16.5
	August	26.6	26.3	57.9	5.9	9.5
Range		19 to 32.4	23.2 to 29.9	29 to 84	1.1 to 13.9	3.4 to 17.7
Trap B	May	18.9	16.8	48.6	4.0	8.5
Range		11.3 to 23.6	12.4 to 16.9	22 to 88	1.8 to 6.6	3.1 to 12.4
	June	28.5	25.7	53.7	3.4	6.7
Range		25.5 to 33.7	23.3 to 29	25 to 71	0 to 5.9	1 to 11.1
	July	26.9	26.9	46.6	2.9	7.6
Range		21.5 to 31.2	21.5 to 28.9	28 to 79	0 to 7	0 to 22
	August	28.1	27.3	65.6	2.9	5.4
Range		20.3 to 33.7	23.5 to 29.4	0 to 88	0 to 12.2	0 to 17.3
Trap C	May	16.6	14.4	49.3	9.1	15.9
Range		10.2 to 21.5	12.2 to 16.3	25 to 86	0 to 18.5	0 to 27.7
	June	27.3	25.2	62.5	7.4	10.5
Range		17.1 to 32.7	22.6 to 29.6	41 to 93	1.2 to 26.1	3.2 to 35.2
	July	26.1	26.1	51.5	8.2	12.0
Range		22.2 to 28.5	25.5 to 28.5	32 to 78	2.9 to 18.5	4.5 to 26.2
	August	26.5	26.1	61.4	6.1	9.9
Range		18.5 to 33.6	23.8 to 29.7	35 to83	1.1 to 12.2	1.8 to 26.8
Trap D	May	16.7	14.9	54.6	8.5	12.1
Range		11.4 to 19.5	13.5 to 16.3	36 to 94	1.6 to 14.3	3.6 to 24.6
	June	28.4	24.6	57.6	3.7	7.0
Range		21.6 to 33.1	21.6 to 28.4	33 to 86	0 to7.3	0 to17.4
	July	26.8	26.9	46.8	6.1	10.0
Range		24.4 to 31	25.8 to 28.7	32 to 70	0 to 23.6	0 to 36.5
	August	26.6	25.6	55.0	4.6	8.1
Range		19 to 32.2	24 to 28.1	24 to 87	2 to 9.8	2.8 to17

Figure 12: Average Daily Air Temperatures °C for Traps A, B, C and D

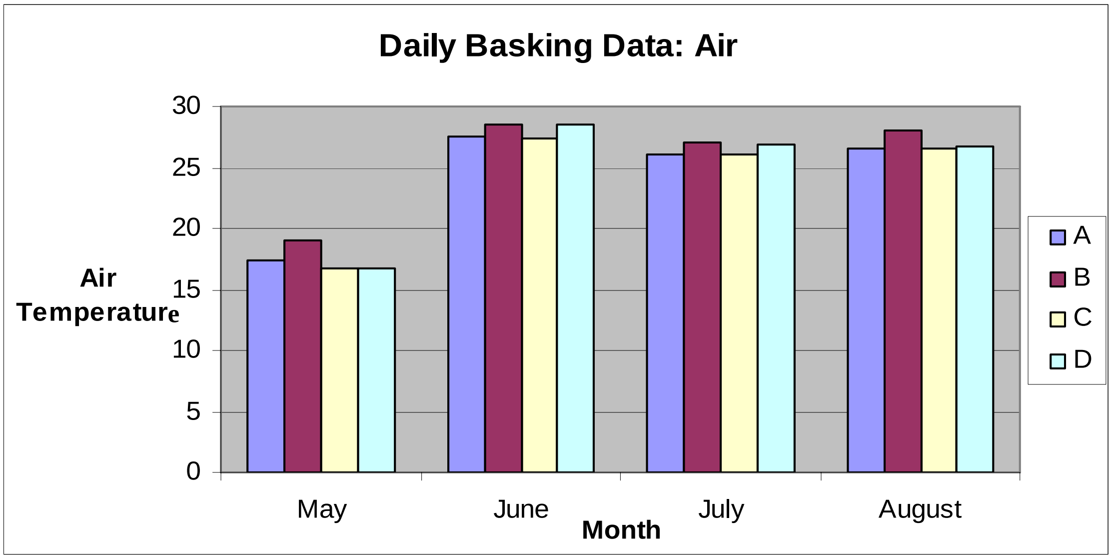


Figure 13: Average Daily Water Temperatures °C for Traps A, B, C and D

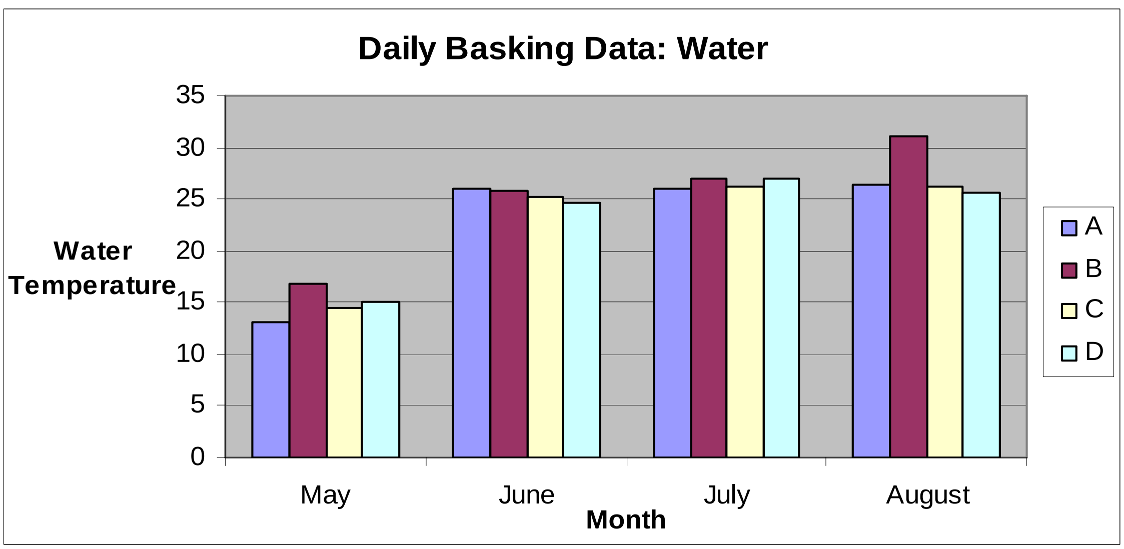


Figure 14: Average Daily % Humidity for Traps A, B, C and D

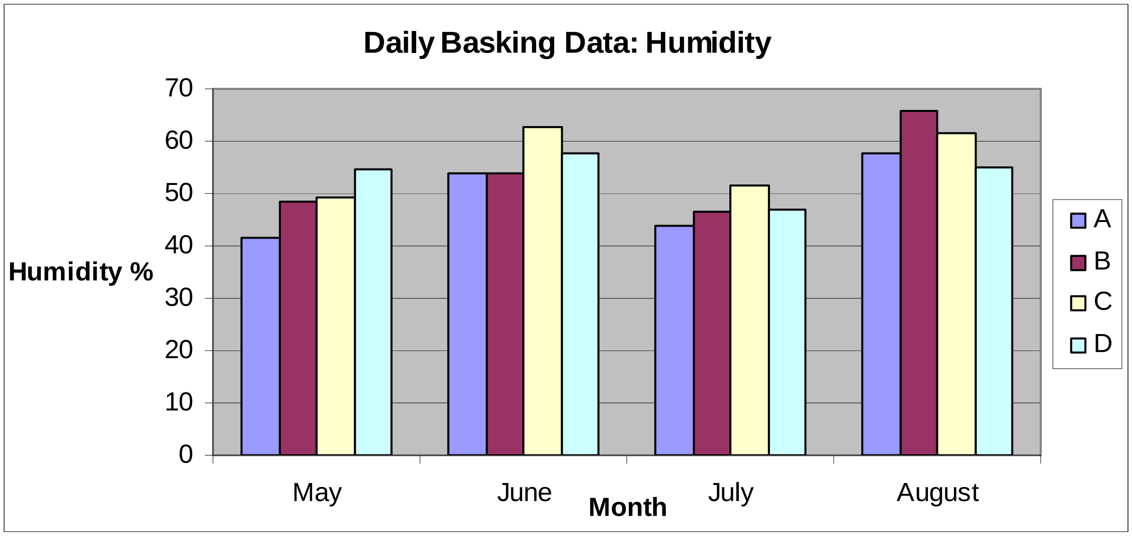


Figure 15: Average Daily Wind Speed km/hr for Traps A, B, C and D

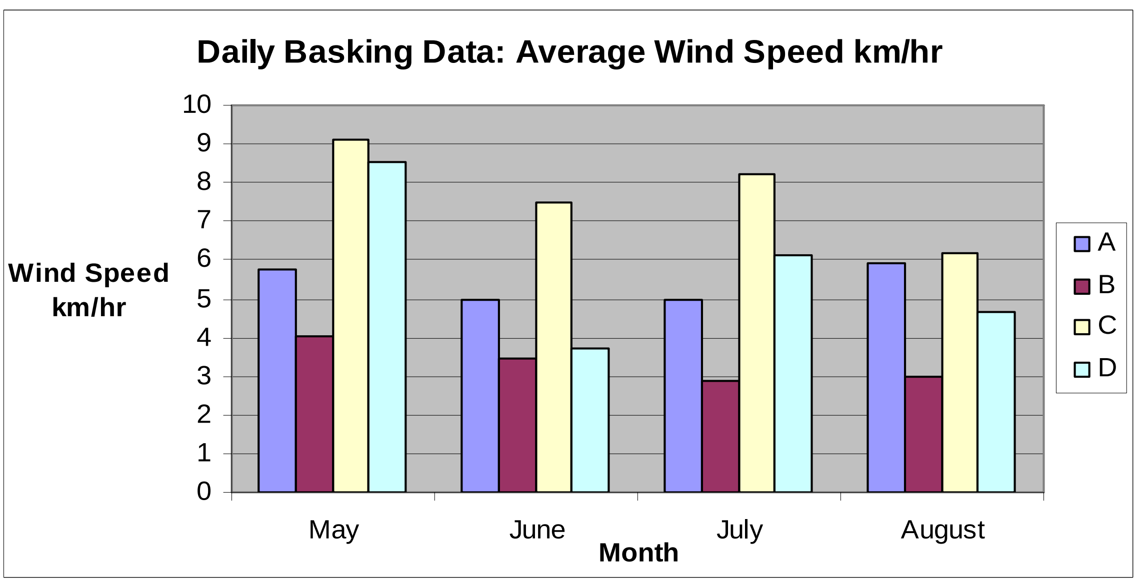


Figure 16: Average Daily Maximum Wind Speed km/hr for Trap A, B, C and D

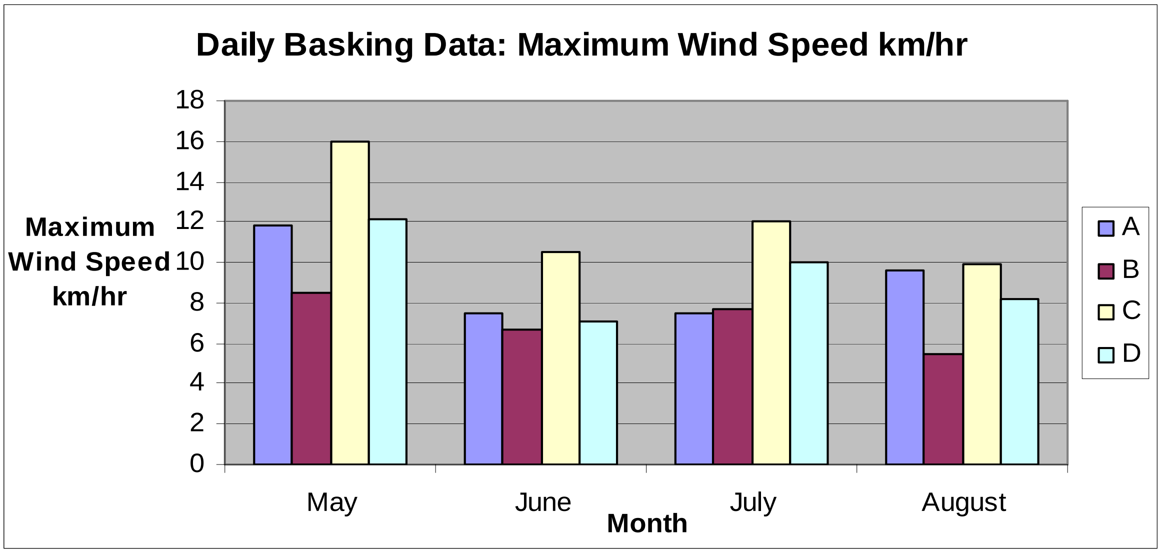
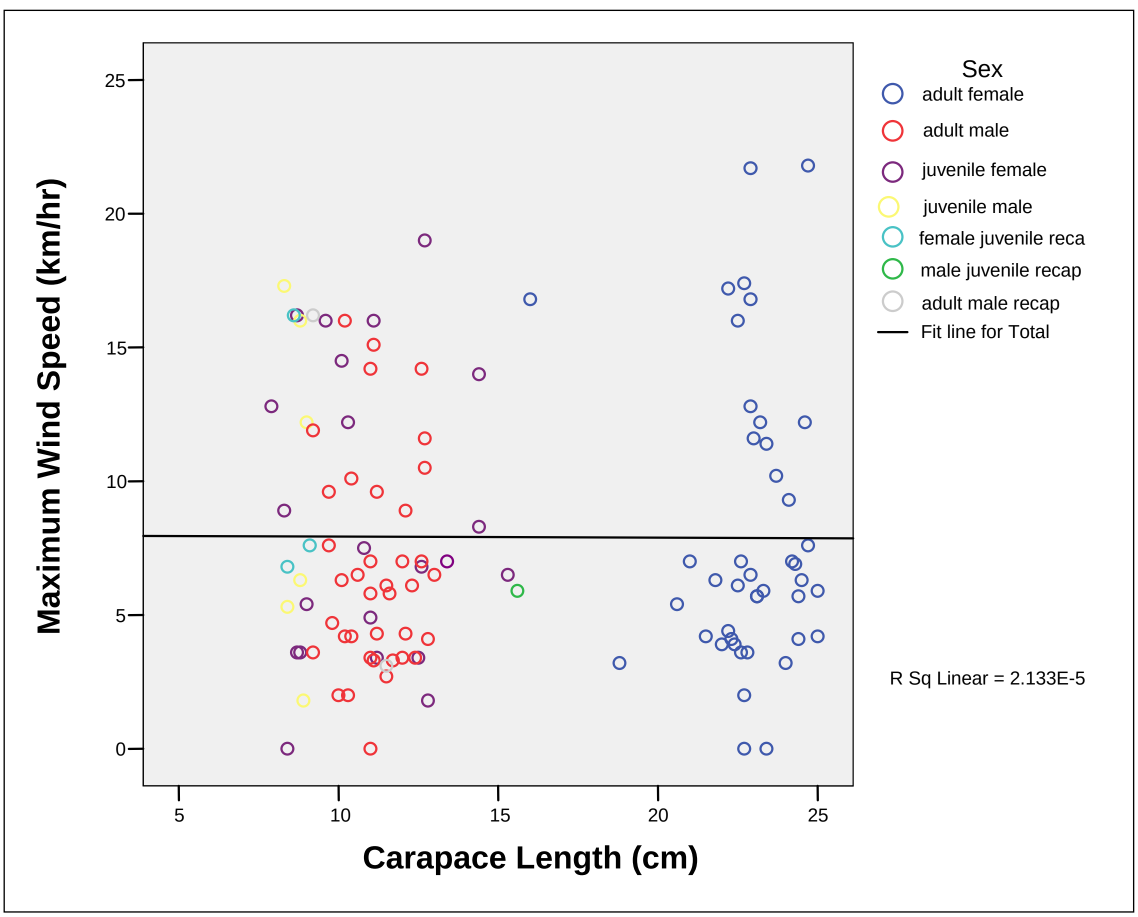


Figure 17: Carapace Length of Captured Turtles as a Function of Onsite Wind Conditions



There appeared to be no positive relationship between larger turtles, in particular adult females, being captured more frequently during higher wind conditions than smaller males and juveniles. However, overall more turtles appear to have been captured on days where winds remained below 7 km/hr. Fewer turtles were caught on days where winds were in exceeded of 15 km/hr (See Figure 17).

6.5 Nesting Females

Table 9: Nesting Activity Observations

Date	Time	Location	Temperature °C		Humidity %	Wind Speed km/hr		Light Intensity Lux 3	Distance to Water (m)	Carapace Length (cm)
			Air	Water		Average	Maximum			
June 10th	7:45 AM	Blueberry Isl.	23.8	24.1	78	2.5	5.7	323	16.3	28.7
June 11th	8:15 AM	Snake Isl.	27.2	25	82	2.6	6.3	387	3.3	24.5
June 11th	8:40 AM	Blueberry Isl.	25.1	25.7	91	1.0	2.1	477	27.4	24.5
June 25th	9:15 AM	Blueberry Isl.	27	23.3	52	9.2	14.1	662	2.7	26.1
July 3rd	9:00 AM	Blueberry Isl.	25	24.7	52	2.9	4.0	603	28.9	22.1

- Northern Map turtles were observed by cottage owners nesting along Hickory Lane. Therefore, this site will be included in the nest monitoring data

Searching for nesting turtles along the shorelines of the bay and on seven small islands within the Bay was conducted from May 26th till June 30th. The July 3rd nesting observation was made while monitoring nest sites on Blueberry Island. Nest searches were conducted between the hours of 5:00 am and 10:00 am. All observations of nesting turtles occurred between the hours of 8:00 am and 9:30 am. Aside from two observations of Snapping Turtles nesting along the main shorelines, and one observation of Northern

Map Turtles nesting along Hickory Lane (runs adjacent to shoreline) by a cottage owner all turtle nesting observations for Northern Map Turtles were made on two of the seven small islands scattered throughout the Bay. Air temperatures on all observed nesting days were high considering the early morning hour. Nest site and distance to water varied greatly between nesting females. Soil material for nest site selection also varied between females. For example, 4 of the 5 nesting females were observed nesting on Blueberry Island. Soil material on Blueberry Island varied between gravel, some sand to sand and mostly organics. Due to the rocky topography of the islands, nest sites were located on small areas of soil situated between rocky outcrops. All of the nest sites were located in full sun. Turtles had to climb rocky ledges to reach all nest sites located on the top of the islands.

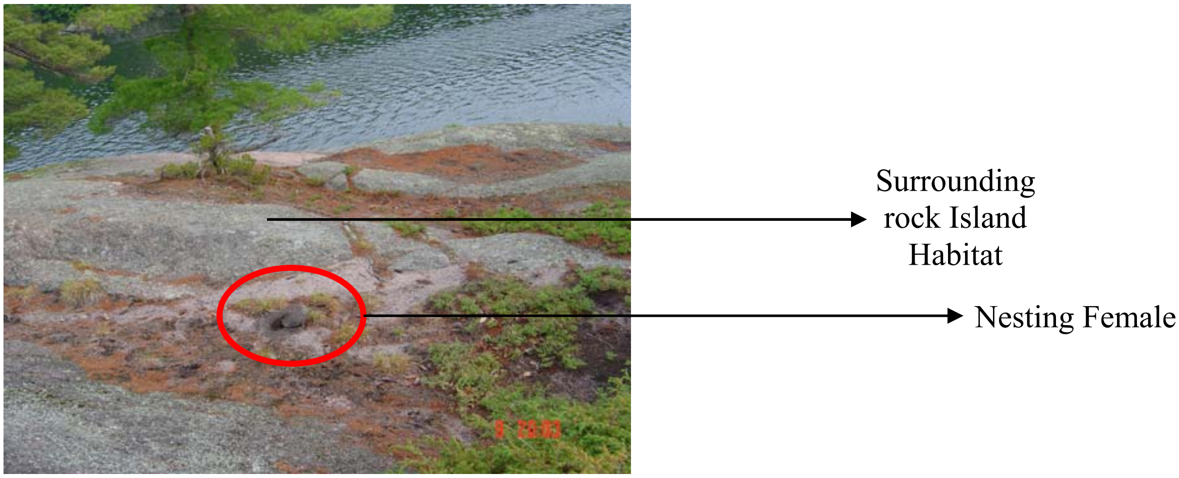
Carapace lengths for nesting females ranged from 22.1 to 28.7 cm.

Despite being located on small islands, nest predation was visible throughout May and June.

Photo 17

June 10th Blueberry Island Nesting

Photo 18



June 10th Blueberry Island Nesting Habitat

Photo 19

June 11th Snake Island Nesting

Photo 20

June 11th Snake Island Nesting Habitat

Photo 21

June 11th Blueberry Island Nesting

Photo 22

June 11th Blueberry Island Nesting Habitat

Photo 23

June 25th Blueberry Island Nesting

Photo 24

June 25th Blueberry Island Nesting Habitat

Photo 25

July 3rd Blueberry Island Nesting

Photo 26

June 11th Blueberry Island Nesting Habitat

Photo 27

June 2006 Hickory Lane Nesting
Photo provided by: M. O'Connor

Photo 28

Hickory Lane Nesting Habitat

6.6 Nest Monitoring

Table 10: Average Site Conditions between June 30th and August 27th 2005

Nest Location	Site #	Air	Soil	Soil Moisture %	pH
Blueberry Isl	1	23.9	23.7	0.3	7.0
	2	23.9	23.4	9.6	6.8
	3	23.9	24.2	7.1	6.8
	4	23.9	22.3	16.9	6.5
Hickory Lane	1	22.3	21.8	3.3	6.9
Snake Isl	1	24.5	25.8	4.5	6.8
	2	24.5	24.5	2.8	6.8

Air and soil temperature and soil pH were similar at all monitored nest sites. Soil moisture however differed greatly between each site. Even though all nests were located in full sun, soil temperatures remained in the 23°C to 25°C range.

6.7 Conclusion

A sample size of 135 captured turtles as well as 52 days of field observations allowed for an analysis of Northern Map turtles within the bay. In addition, two months of nest site selection data provided a large quantity of preliminary data on habitat usage. These observations are discussed in greater detail in the next chapter.

7.0 Chapter 7: Discussion

7.1 Introduction

Through field investigations, the ecological and biological uncertainties of a species and its use of surrounding habitat can be attained. This reduction of uncertainties aids land-use planners to establish fundamental steps in the development of ecosystem management plans for an area (Ehrenfeld & Toth 1997, Carpenter 1996).

Thus, in the case of the Northern Map turtle, knowledge gained on the species' population characteristics, its use of habitat features for basking and dispersion, and its key habitat preferences for essential life cycle stages such as nesting, will aid in the formulation of ecosystem management plans that incorporate the conservation needs of not only the Northern Map turtle but also other native species that utilize the bay, the surrounding riparian habitat and the small island complexes within the Thousand Islands area.

7.2 Population and Basking Characteristics

Most North American populations of turtles are weighted in favour of females (Ernst & Barbour 1972). However, research by Ernst et al. (1994) and Gordon & MacCulloch (1980) suggest that Northern Map turtle populations are generally male biased. Although some researchers speculate that this reversal of sex ratios could be the function of temperature dependent sex determination (Gordon & MacCulloch 1980), other researchers speculate that it is more likely a behavioural bias since females are often more difficult to capture (Pluto & Bellis 1986). Females tend to be more wary than males and when startled dive deeper and swim further distances to escape. Connor et. al (2005) hypothesized that the male-biased population in their study on turtle assemblages may be the result of road fatalities of adult female Northern Map turtles. Although road mortality was observed for snapping turtles within the bay, no Northern Map Turtle fatalities were observed. In the bay study area, females (adult and juvenile) made up approximately 60% of the sample and males approximately 40%. Unfortunately, since sampling was only conducted over one field season it is difficult to determine whether the bay population is indeed female biased. For example, Gordon & MacCulloch studied the Lac Des Deux Montagnes Northern Map turtle population over the course of three field seasons (1977, 1978 and 1979). The first field season had a slightly larger female population than male. However, the following two years had significantly higher numbers of male captures to female. Their final conclusions were a 3:2 ratio of males to females.

Northern Map turtles inhabit both lakes and rivers and are commonly observed basking along shorelines on rocks or fallen trees with unobstructed views of their surroundings (Roche 2002, Daigle et.al 1994). According to research conducted by Gordon & MacCulloch (1980), the preferred basking locations for Northern Map Turtles are offshore locations that are adjacent to deep water and receive sun exposure for part of the day. Turtles will often change their basking sites during the season as water levels drop, moving further away from shoreline basking sites (Roche 2002, Gordon & MacCulloch 1980). In the bay study, basking traps were located at four sites; two adjacent to the shoreline (A and B) and two adjacent to rocky islands (C and D). Use of the traps by turtles changed during the season, particularly use patterns and captures between May-June and July-August. In May and June, captures were higher at Traps A and D compared to captures at Traps B and C. Most captures were of adult females. However, after nesting season in late June, female captures and females observed basking throughout the Bay decreased significantly.

Although adult males were observed basking during all four months of the study, males were most frequently caught throughout July and August at Trap B and Trap C compared to captures at Trap A and D. Observations by Flaherty (1982) along the Ottawa River indicate that male Northern Map turtles tend to begin feeding in May after ice break-up and will then disperse from the area in late June once females begin to feed. In the bay, male captures increased in the post-nesting period indicating that males were not leaving the area but remaining within the Bay for the greater part of the season. Males were also frequently caught at Trap B, a nearshore shoreline site surrounded by numerous underwater rock outcrops and submerged dead wood. Thus, one of two patterns may be occurring within the bay. Assuming that the study population of Northern Map turtles is emerging from hibernation from within the bay, two scenarios may be occurring. First, males may be emerging from hibernation, remaining in the Bay and concentrating their feeding activities throughout May and June while females are predominantly basking, then utilizing basking structures throughout the later part of the season, remaining within the bay for the entire season. Or, alternatively, males may be moving out of the bay throughout May and June, feeding and basking in either the connecting channels between lakes or one of the larger lake systems, then returning to the Bay in July and August to bask and return to hibernation in the fall.

Few females were seen at the trap sites or other basking locations in June but were observed basking in the Bay by late August. Thus, it would seem that female adult Northern Map Turtle's utilize the bay from after ice break-up until egg laying but move to other areas to feed in July and August. Gordon & MacCulloch (1980) theorized that post-nesting dispersal could be associated with either feeding behaviour or a lack of tolerance to human recreational activities. In their comparison of two bays with similar habitat features, turtle numbers utilizing the area remained the same in the one bay but decreased in the other bay. The only difference in the bay whose population decreased was the intensity of cottage use and recreational activities. In the bay, male captures did not appear to be influenced by the increase in recreational boating activities throughout July and August. Trap B, the site of the most frequent male captures, was located in a high volume boat area. Boats however passed by slowly due to narrowness of passage and navigational hazards. Flaherty & Bider (1984) tested the key stimulus for habitat selection in a northeastern population of Northern Map turtles in Quebec. After analyzing food resources, nest site characteristics and basking characterizations for unused and used habitat sites by turtles, they concluded that habitat choice was not based on the available physical structures of an area but a result of social factors within the population.

Recent studies on Northern Map Turtles indicate available food sources as the determining factor for habitat selection and movement patterns. For example, the study by Connor et al. (2005) study of turtle assemblages within a canal and a lake in an urban setting in Indiana, Northern Map Turtles were more abundant in the canal where several mollusk species were identified than in the lake where mollusk availability was less.

Lindemann (2006) looked exclusively at the diet of Northern Map turtles in Lake Erie. His results showed a difference in diet selection between male and female turtles. Males fed mostly on snail and trichopteran larvae while females (including juveniles) fed almost exclusively on mollusks. In areas where invasive zebra and quagga mussel were predominant, the usually diversified mollusk diets of females were composed entirely of invasives. In captive experimental settings females demonstrated a preference for native mussels over invasive mussel species (Connor et. al 2005). In the bay zebra mussels were evident. It's possible that females may be moving into more inland lakes such as Red Horse Lake and Charleston Lake where native mussels may still predominate.

Female juveniles were caught at all four traps over the course of the field season, with the largest number of captures occurring at Trap B. On the other hand, juvenile males were only captured at Traps B and C. Surprisingly, Trap A, the other nearshore site, was not used for basking by juveniles. This may have been due to the dense submerged aquatic vegetation that surrounded the trap by mid July. At Trap B submerged aquatic vegetation was sparse. Overall wind conditions and wave action were calmer at Trap B than the other trap sites. Juvenile Northern Map turtles are known to have slower swimming speeds and poorer diving abilities than adults (Pluto & Bellis 1986). Thus, a calmer site would allow juveniles to conserve energy as less effort would be necessary during swimming activities for feeding. Trap B also had several rock outcrops and submerged fallen trees that created accessible hiding and camouflage opportunities. Therefore, turtles did not have to dive as deep or swim as far to escape potential threats.

7.3 Nesting

Nesting by Northern Map turtles usually occurs in soft sand or soil and at a distance from the water's edge to protect nests from flooding (Gordon & MacCulloch 1980, DeGraff & Rudis 1983). In the Lac des Deux Montagnes study by Gordon & MacCulloch (1980) nests were approximately 2-3m from the water and no more than 1m above water level. Aside from Hickory Lane that was located along the shoreline on the mainland, observed nesting sites in the bay were located on the top of rocky islands with distances from the water's edge ranging from 2.75m to 28.5m. Nests were dug in narrow bands of soil between exposed rock areas. From the edge of the islands there was anywhere from a 1.54 to 4.59m steep rocky drop to the water (Table 9). The use of the islands as key nesting sites could have a significant impact on local turtle populations. With numerous nests concentrated in small areas, if changes occur in the landuse of the islands entire nesting grounds could be destroyed.

In a very early study by Newman (published 1906) nesting females never had a carapace length of less than 19cm in length (Roche 2002). In the Lac des Deux Montagnes study by Gordon & MacCulloch (1980), it was estimated that female Map Turtles reached sexual maturity around 17.5 cm in carapace length. The smallest nesting turtle observed at the bay was 22.1 cm in length and the largest was 28.7 cm in length. Whether the larger sized turtles observed nesting is related to the further offshore sites being selected, remains undetermined.

The sex determination of Northern Map turtles is a result of the incubation temperature of the nest and the embryo's genetic responsiveness. According to Bull & Vogt (1979), a constant incubation temperature of 25°C will produce mainly males whereas females will be produced at a constant incubation temperature of 30.5°C and higher. Thus nest selection by Northern Map Turtles and the environmental effects of temperature on the nesting area can affect sex ratios (Bull & Vogt 1984). In Bull & Vogt's 1984 study in Wisconsin on the Mississippi River, nests that were incubated in open sand produced females and nests that were incubated with vegetation surrounding a beach produced males. In the bay, nest sites on Blueberry Island and Snake Island were chosen in full sun with little surrounding vegetation. One site was mainly gravel with some sand, one site was predominantly sand and three sites were mostly organic soil. The sites with higher organic content also had higher moisture percentages. The site on Hickory Lane received partial shade and was surrounded by grass. Consequently, Hickory Lane had an average soil temperature one degree lower than all other nest sites. Snake Island had the highest average soil temperature with 25.9°C.

7.4 Conclusion

Based on information from the field season, capture patterns fluctuated both spatially and temporally between traps throughout the months of May to August. These fluctuations indicate that adult female, adult male and juvenile Northern Map Turtles have different habitat preferences and use patterns from one another. In addition to the availability of diverse habitat features, the type and intensity of recreational activities appear to be limiting factors for habitat use. Recommendations for the successful management and the need for additional research are presented in the next chapter.

8.0 Conclusion

8.1 Ecosystem Management

Loss of biodiversity and habitat is a growing threat. In order to reduce these threats, a landscape approach to land use planning must be adopted. This landscape approach will be extremely important in areas with concentrated human activities such as housing settlements, industrial expansions and agricultural practices. Human pressures are of particular concern in southern Ontario along the Great Lakes. The concept of ecosystem management aims to improve habitat quality and the populations of species inhabiting them through sound management and science. Unfortunately, not all natural systems have received the same research efforts as others, making ecosystem management difficult to apply. This can be said for riparian ecosystems which represent highly diverse landscapes between the aquatic and terrestrial interface but have been low priority for conservation and research efforts. As a result, knowledge gaps have developed for numerous species that inhabit these areas. The freshwater turtles are excellent examples of species that has been inadequately researched. In particular, data on the impacts of human activities on populations of freshwater turtles and what management options are necessary to mitigate or reverse these impacts are important (Connor et. al 2005). In the greater SLINP ecosystem, monitoring programs have been established to ensure the long –term ecological integrity of the park. Monitoring of ecological indictors is particularly important for SLINP due to the parks' small size and the propensity for impacts from human activities in the surrounding landscape. One of the biological features used as an ecosystem monitoring tool by SLINP is the assessment of potential threats to species and population levels; herpetiles are identified as key species under this monitoring objective (SLINP 2007b).

Herpetiles, or in the case of this research paper, Northern Map Turtles, are not common indicator species. However, in the case of the greater SLINP ecosystem, this species can provide useful information for ecological assessments. Several populations of Northern Map Turtles exist throughout the greater ecosystem Analysis of potential genetic linkages between these groups, viable population numbers and movement patterns could provide information on the linkages between habitats and need for corridor protection and enhancement. As an indicator species, the Northern Map Turtle can also provide information on the stress of invasives throughout the region. An example is the influence of quagga and zebra mussels which are overtaking native mussels throughout the Great Lakes and altering the traditional diet of Northern Map Turtles, in particular, female Northern Map Turtles (Lindeman 2006). The persistence of populations of Northern Map Turtles can also be used for monitoring the effects of increased anthropogenic influences. These may include loss of critical habitat, effects of increased recreational boating, and decreases in water quality. However, due to the long – term lifespans of Northern Map Turtles long term monitoring programs must be established in order to truly capture human induced changes to the species aquatic and terrestrial habitats (Smith et al. 2006). Observations and reporting from local organizations and landowners could play a key role in the success of long – term monitoring of the Northern Map turtle.

8.2 Field Observations of Northern Map turtle Population in the Bay

Outcomes from this study suggest that males, females and juvenile Northern Map turtles utilize different habitat features at different times throughout the spring and summer season. Thus, variability within the landscape is important to capture all the habitat requirements of this species. For example, basking opportunities offshore surrounded by deeper water for female basking turtles and nearshore basking areas with underwater features such as rocks and fallen woody debris for males and juveniles. Small islands also play an important role for female Northern Map turtle's nesting and basking. Movement out of the bay into surrounding water systems such as Charleston Lake or the St. Lawrence, particularly by adult females post nesting, is possible but has not been documented. Research using radio telemetry would be necessary to determine the movement of females in and out of the Bay.

8.4 Future Research

Although this study collected valuable baseline data on the population dynamics and preferred habitat characteristics of the Northern Map turtle in the bay, the opportunity to explore additional research questions exist. These can be divided into six different areas of possible research: movement patterns, genetic linkages, hatchling composition/ success rates, species health and anthropogenic stressors and stewardship and public participation.

First, radio telemetry tracking of adult females and adult males throughout the entire season would strengthen observations made from trap captures from May to August of

2005. For example, adult female map turtles were seldom captured in traps or observed basking throughout the bay in late July and August. Whether females were traveling out of the bay after post nesting to feed in either the adjoining lake systems or south toward the St. Lawrence through the Gananoque River system is unknown. In addition, although basking activities of males and females appeared to be increasing at the very end of the season, where the turtles are hibernating within the bay is currently unknown. Knowledge of habitat areas used for critical life functions such as nesting, feeding, hibernating, and basking will help target specific areas for protection and enhancement.

Second, with a longer field season and additional resources, more in-depth monitoring of the sex composition and success of hatchlings from nest sites could be pursued. Interestingly from data gathered throughout 2005, soil temperature between sites did not vary greatly. Soil moisture content however, did vary greatly between sites. It would be interesting to investigate whether sites with higher moisture contents had lower success rates than those with less moisture content. With weather patterns producing more extreme events(extreme heat, hard rains, cold snaps) as a result of global climate change, the effects on species such as Northern Map Turtles, whose eggs are vulnerable to the abiotic influences of a site, are currently unknown.

Third, research that investigates whether genetic relationships exist between the population of Northern Map Turtles in the bay and other known populations of Northern Map turtles in the Thousand Islands could be pursued. Knowledge on whether Northern Map turtle populations within the St. Lawrence, Gananoque River, the bay and surrounding inland lakes exist and the role these interactions play in the persistence of the species in the area could have important implications for protecting conduits between metapopulations.

Fourth, future research could investigate whether the increasing pressures of invasive species have a negative effect on the overall health of Northern Map turtles. This could be assessed by comparing turtles from the St. Lawrence whose mollusk diets have been altered by the presence of zebra mussels compared to populations of Northern Map turtles in inland lakes that still have a predominantly native mollusk diet available. This information could help forecast the long-term implications of invasives on native turtles in the northern most reaches of their geographical range.

Fifth, tolerance levels of Northern Map turtles to human disturbance either on land through development or on the water through recreational activities before they abandon a site have not been fully explored. For instance, within the Lake Ontario system potential repercussions could occur with the proposed changes to lake levels which are currently under review. If water fluctuations allow for prolonged boating seasons, species such as Northern Map Turtles could be at greater risk of disturbance. How this might affect known populations of Northern Map Turtles is not know. For example, will they migrate to areas with fewer disturbances and if they do, will this create pressures on the food source if they become crowded? Will basking time decrease due to disturbance and would this have an effect on eggshell development in gravid females? According to Litzgus (2006, p.285), “adult survivorship is the most important factor contributing to population growth rate and stability in turtles”.

Finally, future research investigating the roles of stewardship and public participation within the greater St. Lawrence Islands National Park ecosystem to help achieve the Park's goals for ecological integrity would be beneficial. Protected areas and reserves do not have solid boundaries. Therefore, it is essential to establish cross-boundary participation and support in order to promote habitat and species enhancement throughout the working landscape (Sample 1994). Partnerships with various stakeholders and government agencies that are based on equality will provide the most effective ecosystem management results (Zorn et. al 2001). According to Pasquarello (1998, p.290), stewardship should be fostered through "education and participation in a democratic process", which can be achieved by including several core elements throughout the planning process, such as; access to information, open decision making, public accountability, recognition of different values, communication, coordination, and collaboration among stakeholders to name a few (Landres 1998; Pasquarello 1998; Yaffee 1998).

Herman et al. (1998) in their article on the recovery of the threatened Blanding's Turtle in a protected and working landscape in Nova Scotia, stress the importance of not only creating networks within a community to foster awareness regarding the Blanding's Turtle but also to gather additional information regarding the species distribution, habitat requirements and behaviour. In the case of the greater SLINP ecosystem, public participation and stewardship are fundamental components to achieving park ecosystem management goals. With specific respect to this thesis, public input on observed impacts to local populations of Northern Map turtles in relation to numbers observed basking and nesting, road mortalities and changes to the environment i.e. increases in recreational boating, disturbance to habitat etc, will provide a broader picture of the dynamics occurring within local freshwater turtle populations.

Currently, freshwater turtle populations are under pressure from human activity and loss of critical habitat (Smith et. al 2006, Connor et. al 2005). Most available information regarding freshwater turtles are short term studies that don't capture the longer term responses to environmental pressures being experienced throughout their lifetime (Smith et al. 2006). Data collected from this study will hopefully set the groundwork for continued monitoring to develop from and ultimately strengthen the ecological data collected for assessment of the greater SLINP ecosystem. With support from various partners, ecosystem management in the greater SLINP will hopefully reach the ultimate goals of long-term improved and protected habitat quality for all species and communities inhabiting the area.

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