Columbia River Project Water Use Plan

Kinbasket & Arrow Reservoirs Revegetation Management Plan

Revelstoke Reach Painted Turtle Monitoring Program

Implementation Year 4

Reference: CLBMON-11B3

Monitoring Year 4 -2013 Final Annual Report

Study Period: 2013

Okanagan Nation Alliance &
LGL Limited environmental research associates

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CLBMON-11B3 Revelstoke Reach Western Painted Turtle Monitoring Program




Monitoring Year 4 – 2013
Final Annual Report

Prepared for

BC Hydro Generation

Water Licence Requirements
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Cover Photographs

From left to right: Arrow Lakes Reservoir near Revelstoke; Juvenile Western Painted Turtle (*Chrysemys picta belli*); Adult Western Painted Turtle at 9 mile, Arrow Lakes Reservoir; and Arrow Lakes Reservoir photographed at full pool. Photos © Krysia Tuttle and Virgil C. Hawkes LGL Limited environmental research associates.

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EXECUTIVE SUMMARY

This year marked the fourth year of monitoring under CLBMON-11B3, a 10-year Western Painted Turtle (*Chrysemys picta belli*) life history and habitat use monitoring study in the drawdown zone of Arrow Lakes Reservoir near Revelstoke, BC. Initiated in 2010, this study is intended to address the relative influence of the current reservoir operating regime (i.e., timing, duration and depth of inundation) on the life history (e.g., abundance, distribution and productivity) and habitat use of painted turtles occurring in habitats within Revelstoke Reach. Eight management questions are investigated in this study, with the primary objective being to provide information on how painted turtles are affected by long-term variations in water levels and whether changes to the reservoir's operating regime may be required to maintain or enhance this population or the habitats in which turtles occur.

As in previous years, a variety of survey methods (radiotelemetry, hoop trapping, and visual searches) were used to document the relative abundance, distribution, productivity, and habitat use of Western Painted Turtles in three areas within the drawdown zone of Revelstoke Reach (Airport Marsh, Cartier Bay, and Montana Slough). Observations were also made at two upland reference sites (Williamson Lake and Turtle Pond) in order to assess differences between turtle habitat use and productivity between inundated and non-inundated ponds.

The primary focus of this report is the monitoring that occurred in 2013. Particularly, we began investigating turtle overwintering patterns, which will be continued in 2014. Typical adult Painted Turtles overwintering habitat consists of muddy substrate at the bottom of shallow ponds or other suitable aquatic environments that provide shelter (e.g., in muskrat burrows; Cohen 1992).

Forty-four observations of overwintering turtles were made during the telemetry sessions from January 14 to March 14, 2013. A total of 17 individual turtles were recorded overwintering in January, most which were located at Airport Marsh (eight turtles) and Montana Slough (six turtles). Fewer observations were made through February and March (16 and 11 turtles in each month, respectively), yet hibernation sites were consistent for turtles that were repeatedly located. No turtles were found to overwinter in ponds at Cartier Bay. Hibernating turtles occurred at 429.0 m to 469.5 m elevation, and were found on average at 441.3 m elevation from January through March, 2013. Overwintering ponds in the drawdown zone had an average water depth of 37 cm (min = 5 cm, max = 105 cm), with average ice thickness of 26 cm (min = 10 cm, max = 40 cm). These characters were comparable to nearby reference ponds (Turtle Pond and Williamson Lake). Montana Slough and Airport Marsh are found to be important overwintering sites for turtles in Revelstoke Reach. Characteristics of overwintering sites used by turtles were highly variable in terms of temperature, dissolved oxygen, depth, suggesting tolerance to a wide range of conditions.

Loss and alteration of productive pond habitat has been highlighted as a primary threat to Western Painted Turtles in British Columbia (COSEWIC 2006). We found a direct relationship between reservoir elevation and decreased availability of pond habitat in the drawdown zone. Fluctuating water levels during reservoir operations have been noted to cause reductions in wetland carrying capacity, which can increase predation risk to individual turtles seeking other wetlands and increase nest depredation (COSEWIC 2006). Turtles at Revelstoke Reach experienced an increase in movement and were found at higher elevations later in the year (after inundation). Female turtles in the drawdown zone weighed less than their upland counterparts. Eleven turtle mortalities have been recorded since 2010; all occurred in sites within the drawdown zone. However, there were no observations of deceased turtles in 2013.

Monitoring will continue in 2014 and will follow the same methods used in 2013 (and previously in 2010-2012) along with the development and implementation of a graduate program to investigate the characteristics of overwintering sites in Revelstoke Reach.

Key Words: Western Painted Turtle, reptile, life history, habitat use, reservoir operation, drawdown zone, Arrow Lakes Reservoir

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1.0 INTRODUCTION

The Columbia River Water Use Plan (WUP; BC Hydro 2005) was developed as a result of a multi-stakeholder consultative process to determine how to best operate BC Hydro's Mica, Revelstoke, and Keenleyside facilities to balance environmental values, recreation, power generation, culture/heritage, navigation, and flood control. The goal of the WUP is to accommodate these values through incremental changes on how water control facilities store and release water, or to undertake physical works in lieu of changes to reservoir operations to meet the specific interests. During the WUP, the Consultative Committee (CC) supported the implementation of physical works (revegetation and habitat enhancement) in the mid-Columbia River in lieu of changes to reservoir operations to help mitigate the impact of Arrow Lakes Reservoir operations on wildlife and wildlife habitat. In addition, the CC also recommended monitoring the effectiveness of these physical works at enhancing habitat for wildlife (BC Hydro 2005).

During the Columbia WUP, the Western Painted Turtle (*Chrysemys picta belli*) was identified as a species that may be vulnerable to fluctuating water levels resulting from operations of the Arrow Lakes Reservoir (BC Hydro 2005). It is a provincially blue-listed species and the intermountain population is listed as Special Concern under Schedule 1 of SARA (COSEWIC 2006). The population that occurs near Revelstoke, BC is one of the most northern populations and has regional importance (Schiller and Larsen 2012a and 2012b; Maltby 2000). Furthermore, the Western Painted Turtle was identified as a species that may benefit from habitat enhancement via physical works (Golder Associates 2009a and 2009b).

Western Painted Turtles are small freshwater turtles with smooth, dark carapaces with pronounced red and yellow pigmentation on the limbs and plastron. They are slow to mature sexually (8 to 10 years for males and 12 to 15 years for females) and long-lived, living to 50 years or more. They are found in the shallow water ponds, lakes, sloughs, and slow-moving streams or rivers (e.g., the Columbia River), but like many aquatic reptiles they require three types of habitats corresponding to their life history needs. These include: 1) summer habitat with muddy substrates, an abundance of emergent vegetation, and numerous basking sites; 2) nesting habitat with loose, warm, well-drained soils; and 3), aquatic overwintering habitat that does not freeze and does not become severely hypoxic (COSEWIC 2006).

Western Painted Turtles are found in all provinces in Canada except Prince Edward Island, Nova Scotia, New Brunswick and Québec. The species range appears to be limited by the length of the turtle's active season, mean ambient temperature during egg incubation, and mean winter temperature (COSEWIC 2006). Due to low adult recruitment and delayed maturity, Western Painted Turtles are particularly susceptible to mortality of juveniles and adults (COSEWIC 2006). Factors contributing to low recruitment include road mortality (particularly of females during the nesting season), predation on dispersing turtles, and depredation of nests. Habitat degradation, loss, and fragmentation are also threats (e.g., Maltby 2000). While reservoirs have contributed to the loss of habitat during construction and fluctuating water levels have been linked to increased predation risk (COSEWIC 2006), little is known of the impacts of reservoir operations on western painted turtle populations.

During 2010 and 2011, a pilot project was conducted to collect baseline data on a population of Western Painted Turtles near Revelstoke, BC. The goal of this study was to determine the extent to which painted turtles use the reservoir, provide a preliminary assessment of the population, and develop a long-term monitoring strategy to address the concerns raised during the WUP. This two-year study employed a number of techniques including visual encounter surveys (VES), nesting and hatchling emergence surveys, trapping, mark-recapture, and radiotelemetry to obtain data on painted turtles. A monitoring strategy was developed by Schiller and Larsen (2012b) who identified key information gaps and outlined how to proceed to determine the impacts of reservoir operations on Western Painted Turtles in Arrow Lakes Reservoir near Revelstoke BC and address management questions and hypotheses. Monitoring continued through 2012 (Hawkes et al. 2013) and 2013, providing further insights on painted turtle productivity, habitat use, and overwintering preferences.

This report summarizes work completed in 2013 for BC Hydro's Monitoring Program CLBMON-11B3: *Arrow Lakes Reservoir: Revelstoke Reach Western Painted Turtle Monitoring Program.*

2.0 STUDY OBJECTIVES

2.1 Study Design

A monitoring strategy for Western Painted Turtles in Revelstoke Reach, located at the north end of Arrow Lakes Reservoir, was developed by Schiller and Larsen (2012b) that identified key information gaps and outlined how to address the management questions and hypotheses for this project. The strategy identified several monitoring initiatives and has been adapted into the monitoring framework presented below. This monitoring strategy outlines a two-pronged approach to address the various management questions and hypotheses that can be implemented incrementally over time (Table 2-1Table 2-1).

First, the strategy recommended long-term tracking of population trends through mark-recapture techniques to assess the impacts of reservoir operation on the demographics parameters, requiring summer field sampling from 2012 to 2020. Since nesting locations are known in Revelstoke Reach, monitoring nest success to acquire data on recruitment was also suggested to examine productivity in this population. This initiative will address management questions: Q1, Q3, Q4, and Q5.

Second, a set of initiatives was proposed to address the management questions and hypotheses specific to painted turtle habitat use (Table 2-1). Initiatives 2a to 2d would involve graduate student projects over the ten year study period. With the exception of the initiative 2d, these initiatives are intended to be implemented in two-year sampling windows. Initiative 2d will require a longer sampling period than two years; however, it is likely that data for this initiative can be collected in conjunction with 2a and 2c. Collectively these initiatives will provide more information towards addressing management questions: Q2, Q4, Q6, Q7, and Q8.

Table 2-1: Relationship between the management questions, hypotheses, and the long-term monitoring strategy for Western Painted Turtles in Revelstoke Reach, Arrow Lakes Reservoir. Seasons are grouped into S/S (spring/summer) and F/W (fall/winter)

Initiative		Management Question Addressed	Season		Study Years
			S/S	F/W	
1	Long term tracking of turtle demographics to monitor population trends (abundance, recruitment/productivity, and mortality) and assess the impacts of reservoir operations on these parameters	Q1, Q3, Q4, Q5	X	X	2012-2020
2	Conduct focused studies on the fine scale seasonal habitat use of turtles	Q2, Q4, Q6, Q7, Q8	X	X	2012-2020
2a	Conduct a focused study on the fine-scale habitat use by turtles during spring and summer and investigate potential impacts of reservoir operations on summer habitat use, habitat availability, and turtle movements	Q2, Q4, Q5	X		2014-2016
2b	Conduct a focused study on fine-scale habitat use by turtles during winter and investigate potential impacts of reservoir operations on winter habitat use and habitat availability	Q2, Q4, Q5		X	2012-2014
2c	Conduct a focused study on turtle fine-scale nesting habitat use within and adjacent to the reservoir and identify opportunities for enhancement of nesting sites	Q3, Q6, Q7, Q8	X		2014-2018
2d	Use radiotelemetry, ground surveys, and habitat assessments to assess the effectiveness of the revegetation program (CLBWORKS 2) and wildlife physical works program (CLBWORKS 29A and 30) to enhance painted turtle habitat in Arrow Lakes Reservoir	Q6, Q7, Q8	X		2012-2020

2.2 Management Questions and Hypotheses

As part of BC Hydro's long-term monitoring program CLBMON-11B3, eight management questions were developed to determine the impacts of reservoir operations on Western Painted Turtles that use habitats in the drawdown zone of Arrow Lakes Reservoir near Revelstoke Reach, B.C.:

Theme 1: Life History and Habitat Use

Q1: During what portion of their life history (e.g., nesting, foraging, and overwintering) do painted turtles utilize the drawdown zone in Revelstoke Reach?

Q2: Which habitats do painted turtles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?

Q3: What is the abundance and productivity of painted turtles in Revelstoke Reach and how do these vary across years?

Q4: Does the operation of Arrow Lakes Reservoir negatively impact painted turtles directly or indirectly (e.g., mortality, nest inundation, predation, and habitat change)?

Theme 2: Mitigation – Reservoir Operations and Effects

Q5: Can minor adjustments be made to reservoir operations to minimize the impact on painted turtles?

Q6: Can physical works be design to mitigate the impacts of reservoir operations on painted turtles?

Theme 3: Effectiveness Monitoring

Q7: Does revegetation of the drawdown zone affect the availability and use of habitat by painted turtles?

Q8: Do wildlife physical works (e.g., habitat enhancement) affect the availability and use of habitat in the drawdown zone by painted turtles?

The following hypotheses were developed to address the three themes of management questions:

H1: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir

H2: The operations of Arrow Lakes Reservoir do not affect painted turtle survival or productivity.

H3: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical work and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach.

These questions and hypotheses will be tested directly by this monitoring program, which is aimed at determining the life history and habitat use of Western Painted Turtles in Revelstoke Reach relative to reservoir operational regimes, including changing water levels. The monitoring program is also designed to address whether or not the physical works and/or revegetation programs will enhance habitat suitability for turtles in the drawdown zone.

2.3 Scope of Work 2013

For the period 2012 to 2014, LGL and ONA work is focused on Initiatives 1 and 2b of the monitoring strategy (Table 2-1Table 2-1Table 2-1). During this period, sampling and tracking of Western Painted Turtles will continue to assess the impacts of reservoir operations on turtle abundance and productivity (Initiative #1), and characterise fine-scale habitat associations to assess the potential impacts of reservoir operations on habitat use, habitat availability, and turtle movements in spring, summer, and winter (Initiative #2a,b). Much of the data collected in 2013 are also relevant to Initiatives 2c. Initiative 2d cannot be assessed until habitat enhancement works (physical works) are implemented in Revelstoke Reach.

2.4 Key Water Use Decision

The key operating decisions affected by this monitoring program are the operating regime for Arrow Lakes Reservoir and the implementation of soft constraints for Arrow Lakes Reservoir to balance the requirements of Western Painted Turtles with recreational opportunities, flood control, power generation, and other environmental objectives. Results of this monitoring program will help influence the scope of measures required to minimize or mitigate potential impacts, as well as to evaluate the efficacy of works undertaken to improve habitat for painted turtles. Information on the population demographic requirements of painted turtles will also help inform management decisions regarding the design and location of revegetation efforts and physical works projects within Arrow Lakes Reservoir. Operational changes to be considered will be limited to soft constraints that govern daily operations such as timing, magnitude and flow rate as opposed to hard constraints that include reservoir and turbine capacities, spillway rating, licensing requirements and Columbia River Treaty obligations.

2.5 Program Linkages

CLBMON-11B3 is directly and indirectly linked to other programs being implemented in the Arrow Lakes Reservoir (Figure 2-1). Over time (and following the implementation of physical works in Revelstoke Reach) the monitoring program developed for CLBMON-11B3 will provide an indication of the efficacy of the physical works implemented in Revelstoke Reach at enhancing wildlife habitat. In addition, data collected as part of that monitoring program are related to several long-term monitoring programs—specifically, CLBMON-37, CLBMON-40 and CLBMON-36. Additionally, the protocols for monitoring physical works implemented in Revelstoke Reach could be applied to physical works proposed for mid- and lower Arrow Lakes where wetland enhancement or creation is the objective (i.e., CLBWORKS-29B).

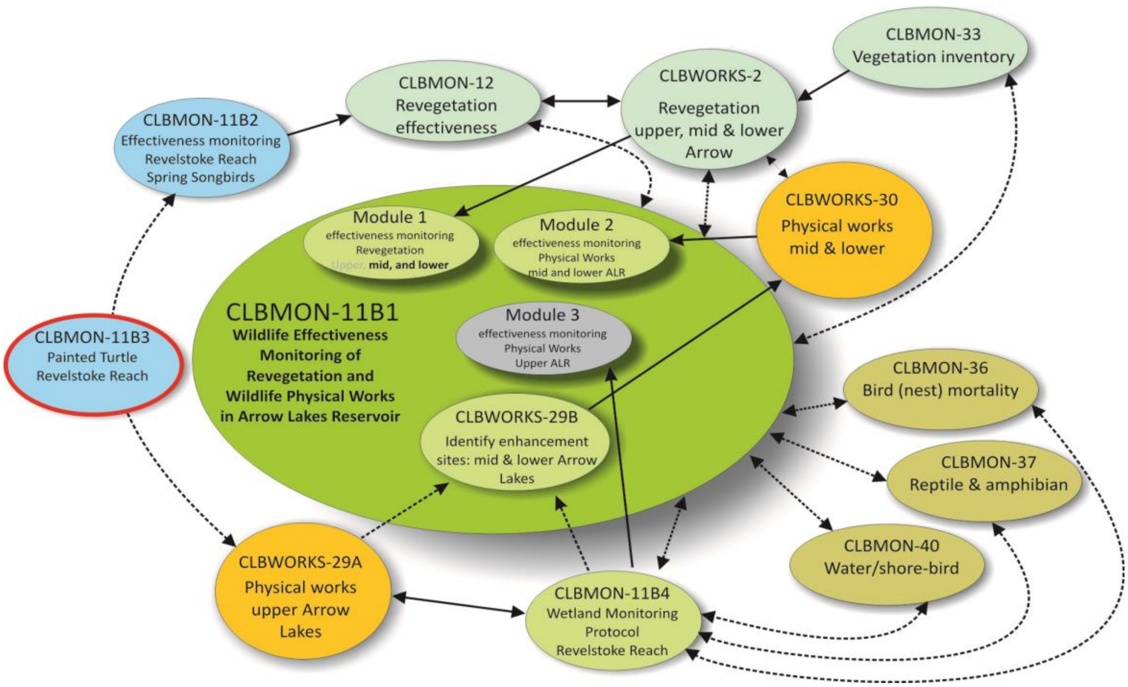


Figure 2-1: The relationship of CLBMON-11B3 (outlined in red) to other physical works and wildlife monitoring projects in Arrow Lakes Reservoir. Direct linkages between relevant projects are shown as solid lines; information flow (e.g., data sharing) is indicated by dashed lines. Module 3 of CLBMON-11B1 has yet to be implemented and Module 1 of CLBMON-11B1 applies only to mid- and lower Arrow Lakes Reservoir

3.0 STUDY AREA

3.1 Arrow Lakes Reservoir

Arrow Lakes Reservoir is a ~230 km long section of the Columbia River drainage between Revelstoke and Castlegar, BC. It has a north-south orientation and is set in the valley between the Monashee Mountains to the west and the Selkirk Range to the east. The Hugh Keenleyside Dam, located 8 km west of Castlegar, spans the Columbia River and impounds Arrow Lakes Reservoir. The reservoir has a licensed storage volume of 7.1 million acre-feet (MAF) (BC Hydro 2007), and the normal operating range of the reservoir is between 440.1 m and 418.64 m ASL. The reservoir is largely operated for downstream power generation and flood control in the United States.

The typical hydrological regime of Arrow Lakes Reservoir is characterized by rapid infill between May through early July followed by a drop in reservoir levels through August. Reservoir levels may continue to decline though the fall but they may also be elevated to near maximum levels to accommodate fall storage. Reservoir levels decline throughout the winter reaching their lowest levels in the late winter/early spring. While levels of Arrow Lakes Reservoir can fluctuate dramatically (upwards of 60 meters) over the course of a year, there are several water bodies that retain water year round, providing possible refuge for the population of Western Painted Turtles near Revelstoke, B.C.

Two biogeoclimatic zones occur at the lower elevations surrounding Arrow Lakes Reservoir: the Interior Cedar Hemlock (ICH) and the Interior Douglas-fir (IDF). Most of the reservoir area occurs within the ICH, with three subzones and four variants represented. The IDF is restricted to the southernmost portion of the area and consists of a single subzone (IDFun); this area is outside of the study area of this project. The subzones are a reflection of increasing precipitation from the dry southern slope of Deer Park to the wet forests near Revelstoke (Enns et al. 2008). The Arrow Lakes Reservoir study is situated primarily within the Arrow Boundary Forest District, but a small portion of its northerly area is in the Columbia Forest District.

A single population of Western Painted Turtles is known to occur in Arrow Lakes, at the northern extent of the reservoir, near Revelstoke, B.C. Thus, the study area for CLBMON-11B3 is restricted to Revelstoke Reach, with all work focused on the east side of the reach. The area hosts several large wetland complexes, large open sedge/grass habitats and several willow-shrub complexes.

3.2 Study Sites

Monitoring occurred at sites known to be used by Western Painted Turtles. Survey locations were consistent with previous study years (Hawkes et al. 2013; Schiller and Larsen 2012b), including three sites within Revelstoke Reach (DDZ: Airport Marsh, Cartier Bay, and Montana Slough) and two upland reference sites (Turtle Pond and Williamson Lake) (Figure 3-1). Upland ponds are unaffected by reservoir operations and can potentially serve as controls for DDZ sites.

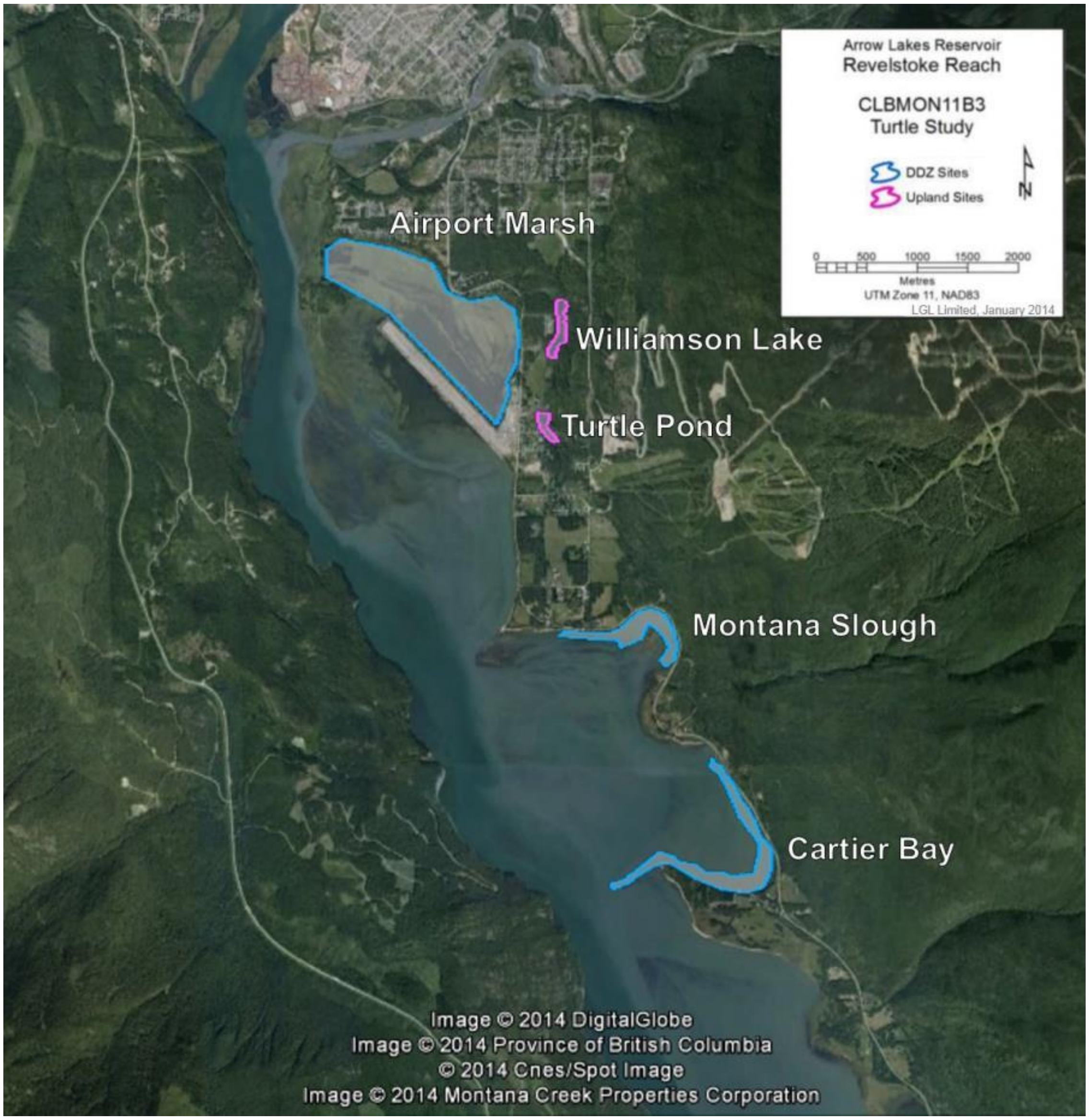


Figure 3-1: Location of Western Painted Turtle study sites in the drawdown zone (DDZ) and upland areas of Revelstoke Reach of Arrow Lakes Reservoir

Vegetation varied considerably between the study locations where turtles were observed. Airport Marsh vegetation is dominated by bulrushes (*Schoenoplectus tabernaemontani*), common cattail (*Typha latifolia*), pondweed (*Potamogeton spp*), and reed canary grass (*Phalaris arundinacea*). The dominant vegetation in Montana Slough is moss (*Sphagnum spp.*), willow (*Salix spp.*), and reed canary grass (*Phalaris arundinacea*). Outside of the drawdown zone, Turtle pond is mainly comprised of Rocky Mountain pond lily (*Nuphar polysepalum*) and Williamson Lake has combination of bulrushes (*Schoenoplectus tabernaemontani*), common cattail (*Typha latifolia*), pondweed (*Potamogeton spp*), and skunk cabbage (*Lysichiton americanus*). Common to all areas of turtle observations was the frequent use of basking logs by turtles, some fixed and some floating, often multiple individuals using the same log. More detail regarding the vegetation of each site within

Revelstoke Reach can be found in Fenneman and Hawkes (2012) and Miller and Hawkes (2013).

4.0 METHODS

As outlined in section 2.1, most management questions necessitate analyses of long-term trends in turtle abundance, productivity, and habitat use/availability. Therefore, the methods and sampling protocols were specifically designed to address the management questions for CLBMON-11B3, and are intended to be comparable in during each year of work. The protocols for 2013 were consistent with previous years and are briefly summarized (see Hawkes et al. 2013).

4.1 Monitoring Methodology

Determining the status of long-lived animal populations such as chelonians is problematic and long-term studies are required to assess population trends (Whitfield et al 2000). As such, it is important to continue to monitor population parameters over time. Monitoring in 2013 followed the methods described by Schiller and Larsen (2011) and RISC (1998a,b,c), and occurred every three to four weeks from January to December. Several sampling methods were used to collect field data including: 1) radiotelemetry, 2) visual encounter surveys (VES), 3) live trapping, and 4) mark/recapture techniques. These methods were used to monitor population trends (abundance, recruitment/productivity, and mortality) and to assess the impact of reservoir operations on these parameters. These data will contribute to addressing management questions: Q1, Q3, Q4, and Q5 over the 10 year study period.

4.1.1 Radiotelemetry

Radiotelemetry provides detailed information on habitat use and selection, home range, mortality and survivorship, migration, dispersal, travel routes, and critical habitat (RISC1998b; Millspaugh and Marzluff 2001). To track turtles, a VHF transmitter was affixed to the carapace of a turtle and a VHF radio receiver was used for the direct location of each animal or an approximate location was obtained through triangulation methods (as in Schiller and Larsen 2012a, b; Hawkes et al. 2013). Transmitters did not exceed 5% of the turtle’s body weight (Millspaugh and Marzluff 2001). The life expectancy of transmitters ranged from 10 to 36 months depending on the size of the unit.

4.1.2 Visual Searching and Hand Capture

Hand/net trapping involved the use of a long-handled dip net while walking, wading or canoeing along the shoreline of a pond or wetland. Searches were conducted when turtles were most likely to be basking (i.e., mid-morning to early evening on either sunny or overcast, but warm days). In shallow water, searches followed a zigzag course parallel to the shoreline. Hand captures were also performed from boat if a turtle was encountered while paddling between locations.

4.1.3 Live-Trapping

In May through October, 2013, hoop traps (Memphis Net and Twine Co., Inc.) were set in drawdown zone and upland reference sites of Revelstoke Reach. The traps were partially submerged in the water and were baited with sardines to attract turtles (bait was refreshed every few days). Baited traps were set and then checked every 12 hours (Gamble 2006). Morphometric data was collected on captured turtles and transmitters were affixed. Efforts were made to minimize stress to the animals, by immediately releasing turtles at the site of capture and equipping handlers with gloves (RISC 1998c).

4.1.4 Mark Recapture

Mark-recapture techniques involve the capturing, marking, releasing and recapturing of individuals through repeated sampling (Krebs 1999). Recapturing of individuals was conducted opportunistically during nesting, VES surveys, and radio-tracking under CLBMON-11B3 and VES under CLBMON-37. Individuals were marked by notching the carapace following the marking technique developed by Cagle (1939) and recommended by the RISC (1998a). Neonates and most juveniles were not notched, as their shells have not fully ossified and are soft. The notching scheme for this project was recorded as per Schiller and Larsen (2012b). Through the use of this marking technique, captured turtles were given unique identifiers in order to track individual turtles for the duration of CLBMON-11B3.

4.2 Habitat Data

Additional data were collected during monitoring surveys to determine turtle habitat associations. These include: location of turtles (using a Garmin® GPSmap60CSx), time, date, water depth, water temperature (taken approximately 10 cm from the surface of the water), air temperature, elevation, precipitation, wind speed, humidity (measured using a Kestrel® 4000), cloud cover, distance to water/shore, activity of the turtle, habitat type (Table 4-1), wetland type (Mackenzie and Moran 2004), and vegetation community (after Enns et al 2008; Fenneman and Hawkes 2012).

Table 4-1: General Habitat Types (Schiller and Larsen 2012b)

Habitat Type	Description
Shoreline	The area within 2 meters along which a body of water meets the land
Dry Land	The area of which is dry and which is greater than 2 meters from any body of water
Marsh	An area of land within the drawdown zone that is flooded during high waters, and typically remains waterlogged at all times.
Floating Island	A portion of the wetland that remains above water as a floating island of vegetation when water levels rise.
Nesting	Dry land characterized by small gravel and sand that is well drained during the months of May to July.
Open Water	An area that is 6 meters or greater from the shoreline
Inundated	An area that was characterized by another habitat but is now submerged by increased water levels
Shoreline Due to Inundation	An area that was characterized by another habitat but is now partly submerged by increased water levels creating an area along a body of water
Pond	A fairly small body of relatively still water.

The physicochemical conditions of ponds and habitats in drawdown areas are likely to be greatly affected by the timing of inundation from the reservoir. Thus, Pond-specific physicochemical data were collected at each site and location of turtle capture/observation. Data loggers (Onset U24-001 and PME MiniDOT) were installed at each of the five monitoring locations and were used to obtain temperature, conductivity, and dissolved oxygen conditions. During winter telemetry surveys, water and ice depth were measured at each location used by turtles. Temperature data were obtained via the Holohil temperature sensitive radio transmitters attached to the turtles. iButtons were also affixed to turtles caught and tagged in the fall of 2012 and 2013. To determine habitat use relative to habitat availability, these parameters were also measured within each water body at randomly selected locations with similar microhabitat characteristics. Comparisons were also be made between inundated ponds in the drawdown zone of Arrow Lakes Reservoir (Airport Marsh, Montana Slough, and Cartier Bay) to natural reference ponds (Williamson Lake and Turtle Pond).

4.3 Data Analyses

All analyses were performed in R version 3.0.1 (R core team 2013) and Microsoft Excel (Microsoft 2013). For interpreting significance tests, we set α at 0.10. Additional emphasis was given to results significant at $\alpha = 0.05$. Standard errors for means and box-and-whisker plots are provided for interpretation of variance (where possible). Statistical significance was not considered in isolation from known species biology. Ecologically meaningful results are presented, based on the current knowledge of Western Painted Turtles and the four years of data collected to date, during CLBMON-11B3.

4.3.1 Occurrence and Relative Abundance

Turtle occurrence patterns were assessed with turtle presence (and non-detection) data. To examine turtle habitat-associations, trap catches, observations and detections were expressed in terms of relative abundance (proportional of observations or proportion of detections) and catch per unit effort (CPUE). For CPUE standardizations, effort related to the number of traps, number of surveys, trap time (hours traps operated), and/or survey time (hours of telemetry or VES). As field sampling in future years will be consistent with 2013 effort, these relative abundance measures will allow for reliable seasonal (i.e., within year) and annual (i.e., among years) comparisons of CPUE and site-specific comparisons over time.

4.3.2 Elevation Distribution

The elevation of radio-tagged turtles was compared by site and by month to identify differences in relation to reservoir elevation and inundation period. A non-parametric alternative to ANOVA was used to identify significant differences in elevation of Western Painted Turtles by month of the year and site, as data failed to meet the assumptions of ANOVA tests. Kruskal-Wallis rank sum tests (Hollander and Wolfe 1973) were performed, such that elevations were transformed to their ranks in the overall data set (i.e., the lowest elevation is assigned a rank of 1, the next smallest is assigned a rank of 2, and so on). Kruskal-Wallis tests and Bonferroni-adjusted post-hoc pairwise comparisons were performed in the R-language package ‘agricolae’ (de Mendiburu 2013).

4.3.3 Water Quality and Overwintering Habitat

Water quality characteristics could be important determinants of turtle distribution and site occupancy patterns, particularly during the overwintering period. Therefore, we compared the water conditions (temperature, dissolved oxygen, and conductivity) associated with radio-transmitter tagged turtles during different life history stages (e.g., foraging vs. overwintering) at each study site. A suite of water quality characteristics were also summarized for ponds where turtles were present and ponds without turtles in winter 2013 (as in Hawkes et al. 2013).

4.3.4 Pond Size and Habitat Availability

The location, elevation, and number of ponds available in the drawdown zone were mapped for Cartier Bay and Montana Slough in Revelstoke Reach as per the CLBMON-37 Arrow Lakes Monitoring Program (Hawkes and Tuttle 2013). The relationship between habitat availability (in terms of pond area) and reservoir elevations was examined for various years (2008-2012).

4.3.5 Growth and Body Condition

A common technique for assessing the condition (health) of animal populations is to: 1) compare the mass of individuals from different environments; 2) compare mass relative to body size; and 3) compare indices of body condition. This is founded on the principle that an animal in good condition is assumed to be heavier because of increased fat and protein stores or because it is structurally larger (Dobson 1992).

We examined turtle growth and body condition for individuals captured across all sites for males, females, and juveniles. Kruskal-Wallis rank sum tests were used to identify significant differences in body mass of Western Painted Turtles by turtle class (adult female, adult male, and juvenile) and also by location.

To further understand relationships between turtle growth and reservoir operations, we examined body condition of turtles. Firstly, a regression of turtle weight (mass) on size (i.e. straight-line carapace length) of turtle was performed. Weight and carapace length data were $\log_e$-transformed, as residual plots of raw data were highly skewed. Secondly, the residuals of this mass-size regression were used as an index of body condition (Schulte-Hostedde et al. 2005) to assess how body condition varied by location. Individuals with positive residuals are heavier than expected by their size, and therefore, these individuals are considered to be in better condition than those with negative residuals (Schulte-Hostedde et al. 2001). Thus, we compared the proportion of residuals that were positive for turtles in each site to examine qualitatively how body condition varies in relation to reservoir position.

A commonly used index of body condition for turtles is that of Bjorndal et al. (2000). We calculated the Body Condition Index (BCI) for female, male, and juvenile Western Painted Turtles by monitoring year (2012 and 2013) and across the five study sites, where:

$$\textbf{BCI} = [\ \textbf{Weight (kg)} / \textbf{Straight Carapace Length (cm)}^{3}\ ] \times 10000$$

Kruskal-Wallis rank sum tests were performed to determine the significance of group differences in BCI.

4.3.6 Movement Patterns

We examined the relationship between the daily movements of 79 radio transmitter-tagged turtles by month and inundation period at each site in Arrow

Lakes Reservoir. Turtle movement was expressed as the linear distance (in metres) between telemetry detections of each uniquely identified turtle. Linear distance was calculated using the Pythagorean Theorem and UTM position of turtle locations. The distance between telemetry locations was then standardized by the number of days between subsequent surveys to generate measures of distance traveled (m) per day.

A Two-Factor Analysis of Variance (ANOVA) was used to test for turtle movement differences among sites occurring within the drawdown zone (DDZ) and upland (UPL) areas of Arrow Lakes Reservoir and across months in 2013. Daily distance data was transformed with a power transformation, where $\lambda = 1$ (Box and Cox 1964) to meet the assumptions of ANOVA (Fox and Weisberg 2011).

5.0 RESULTS

5.1 Environmental Data

Weather conditions are known to affect the growth rates and activity of turtles and other reptiles. Warm, sunny summer days are particularly important to turtles for thermoregulation via basking behaviour, and painted turtles are more conspicuous in surveys corresponding to optimal climatic conditions (RISC 1998a). Thus, weather data were obtained from Environment Canada's "Revelstoke Airport" weather station (50°58'00" N, 118°11'00" W; 444.70 m ASL) to evaluate the influence of weather conditions on species detectability and measures of relative abundance among years.

Mean daily temperature varied by month ($F = 711.18$, $p < 0.0001$) and between years ($F = 10.14$, $p < 0.0001$), which is to be expected (Figure 5-1). Similarly, total precipitation varied on a monthly basis ($F = 4.01$; $p < 0.0001$) and between years ($F = 4.09$, $p = 0.017$; Figure 5-1). Environmental conditions were well within the ranges necessary for Western Painted Turtle detection (i.e., spring and summer, temperatures above freezing; RISC 1998a).

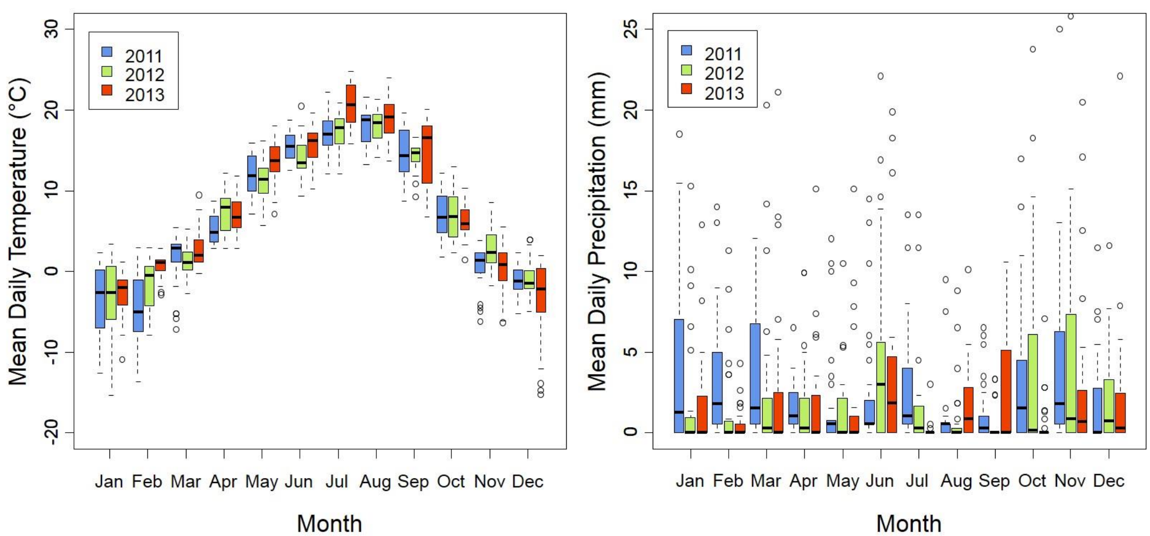


Figure 5-1: Daily temperature (°C, left) and precipitation (mm, right) for January through December, 2011, 2012, and 2013 as measured at Revelstoke Airport. Data source:

Environment Canada (http://climate.weather.gc.ca/index_e.html; accessed January 6, 2014)

Further, 2013 surveys were generally conducted on days with higher mean daily temperatures than average ($F = 43.93$, $p < 0.0001$; Figure 5-2). Survey climatic conditions were quite similar across sites in 2013, except that cloud cover was generally greater in spring and fall at Airport Marsh and Turtle Pond than for other sites (Figure 5-3). The level of variation in climatic conditions is not likely to have influenced detectability between years or sites. Further, the temperature on each survey dates appeared to be optimal for detecting Western Painted Turtles.

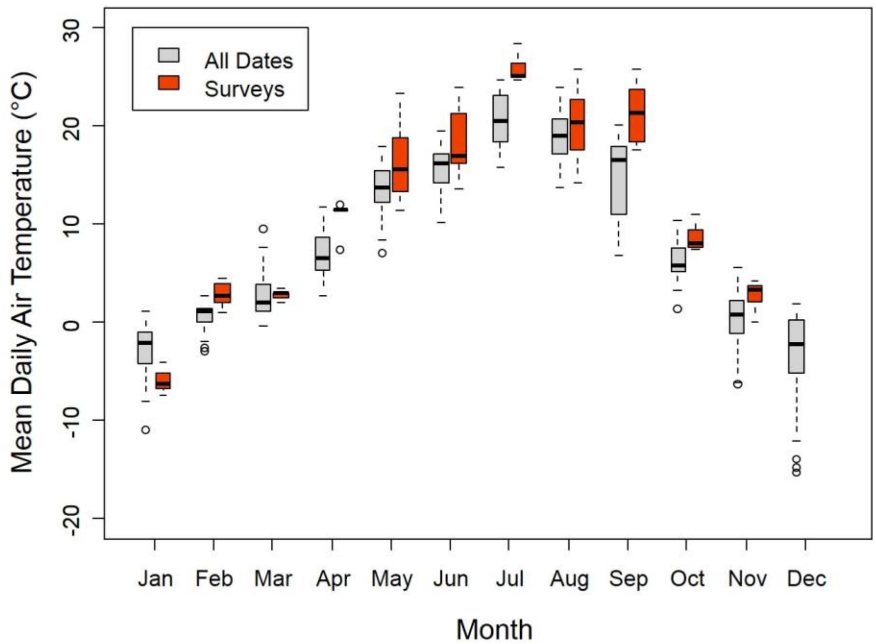


Figure 5-2: Variation in daily temperature (°C) of survey dates in 2013 relative to the average temperature obtained from the Revelstoke Airport weather station

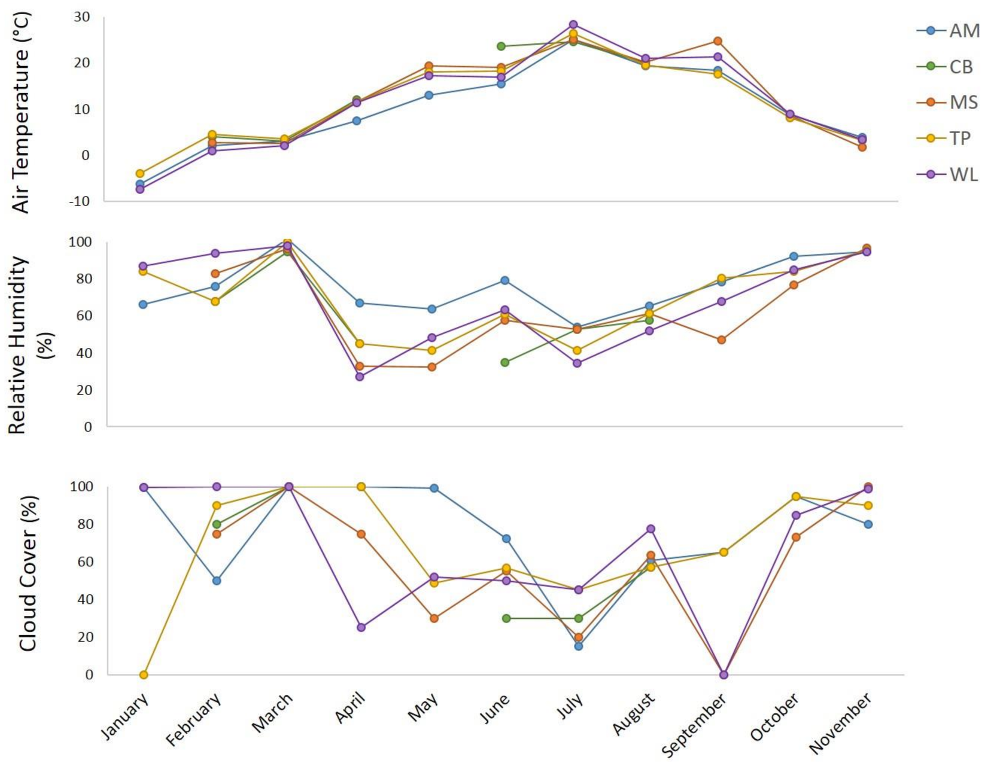


Figure 5-3: Climatic conditions at each site for surveys conducted in 2013 by month. Air temperature (°C), relative humidity (%), and cloud cover (%) measures were averages taken from survey start and survey end to obtain one daily value. AM = airport marsh, CB = Cartier Bay, MS = Montana Slough, TP = Turtle Pond, WL= Williamson Lake

5.2 Reservoir Operations

Reservoir operations directly affect spatial and temporal habitat availability and connectivity of aquatic and terrestrial habitats in the drawdown zone. The Arrow Lakes Reservoir has been operated in a variable manner (Figure 5-4), which will likely make it difficult to assess the implications for Western Painted Turtles habitat use in Revelstoke Reach.

In 2013, reservoir levels increased steadily between February and July, rising a total of twelve meters in elevation (min = 427.9 m, $\bar{x}$ = 432.8 m, max = 439.9 m ASL; Figure 5-5). Sites in the drawdown zone at Revelstoke Reach were inundated as early as the 16th of May, 2013, which was 15 days earlier than in 2012 (Figure 5-5). Reservoir elevations continued to rise, completely inundating sites at Cartier Bay by the 19th of June and Montana Slough by the 7th of July. Airport Marsh was partially inundated by the rise in reservoir elevation through 2013. The maximum reservoir elevation of 439.91 m ASL was achieved on July 4th; after this date, the reservoir receded. Overall, the 2013 operating regime differed from 2012 in the length of inundation period; some drawdown zone sites were inundated for less time compared to the summer of 2012 (Figure 5-5). For example, low elevation ponds (433 m ASL) at Cartier Bay and Montana Slough were inundated for nearly half as long in 2013 (108 days) as in 2012 (215 days). The potential impact of reservoir operations on Western Painted Turtles will be assessed in more detail via longer-term research.

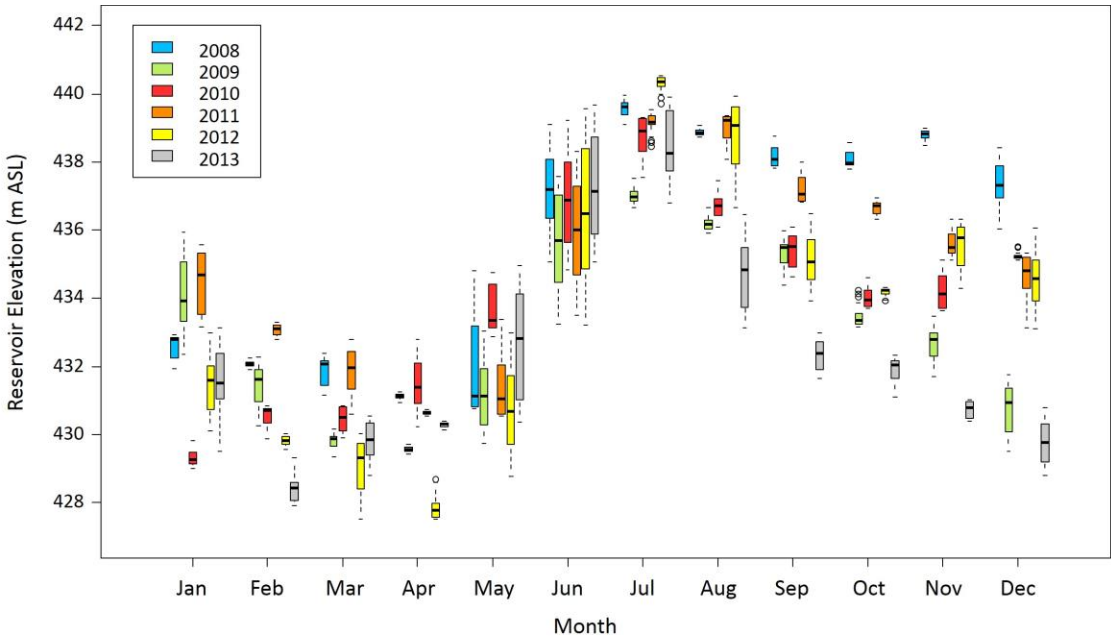


Figure 5-4: **Variation in monthly reservoir elevations recorded for Arrow Lakes Reservoir in the previous six years (2008 to 2013)**

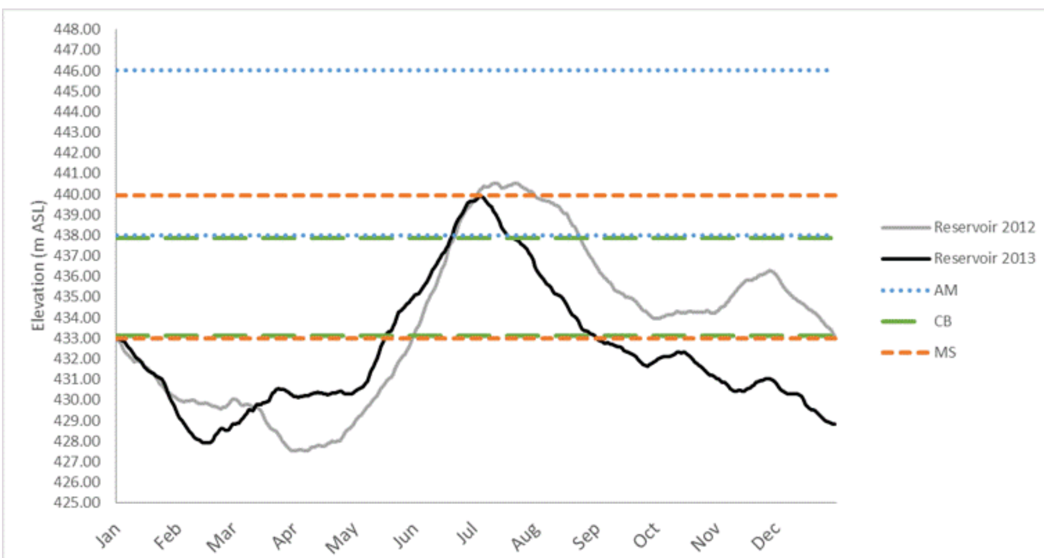


Figure 5-5: **Reservoir elevation (solid lines) and corresponding elevation range for sites in the drawdown zone at Revelstoke Reach (dashed lines) over the past two years. AM= Airport Marsh, CB= Cartier Bay, MS= Montana Slough**

5.3 H1: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir

Western Painted Turtles have been documented using habitats of the drawdown zone (DDZ) of Arrow Lakes Reservoir in each year of monitoring since the initiation of CLBMON-11B3 in 2010 and during the course of CLBMON-37 (Hawkes and Tuttle 2013). Painted turtles appear to use the DDZ to fulfill most of their life history requisites (Table 5-1). Growth, foraging, and overwintering activity has been documented at various sites in the DDZ in previous reports, while reproduction (nesting sites) has only been documented outside of the DDZ (e.g., Red Devil Hill, Williamson Lake, upland areas near Airport Marsh and Montana Slough). The results of telemetry surveys in January and February 2013 confirm that Western Painted Turtles are overwintering at Montana Slough, Airport Marsh, Turtle Pond and Williamson Lake (see Section 5.3.3). Turtles were observed throughout the 2013 summer foraging period at all focal sites (Airport Marsh, Montana Slough, Turtle Pond, Williamson Lake), however very few observations were made at Cartier Bay.

Table 5-1: Summary of observed life history activities of Western Painted Turtles in the drawdown zone and upland sites at Revelstoke Reach of Arrow Lakes Reservoir from 2010 to 2013. Any 'Yes' indicates a direct observation of the life history activity or stage, whereas the rest are inferences

	Life History Activity			
Study Site	**Reproduction***	**Growth**	**Foraging**	**Overwintering**
Airport Marsh (DDZ)	No	Yes	Yes	Yes
Cartier Bay (DDZ)	No	Unknown	Likely	Unlikely
Montana Slough (DDZ)	No	Yes	Yes	Yes
Turtle Pond (REF)	Likely	Yes	Yes	Yes
Williamson Lake (REF)	Yes	Yes	Yes	Yes

*nesting sites

From the past four years of monitoring Western Painted Turtles in Revelstoke Reach, we can conclude that turtles in this population are consistently using sites in the drawdown zone for habitats at different life stages. The extent to which turtles in this system are dependent upon habitats in the drawdown zone will be difficult to assess. Specific results related to this hypothesis are detailed below.

5.3.1 Detection Rates and Turtle Occurrences

Since 2010, 255 turtles have been given individual identities and were followed over time. Of those, 42 were identified as female and 29 as male, suggesting a female bias. Most identified adults were recaptured in subsequent survey years (Table 5-2). In contrast, only 19% of unsexed adults and juveniles were detected in more than one year.

Table 5-2: Summary of turtles sexed according to monitoring year. Recapture rate is expressed as a proportion of all individuals that were recorded in more than one year. Recaptures are also expressed as the percent of all individual turtles that were observed in 1, 2, 3, or 4 years

		No. of Individual Marked Turtles				Proportion detected in:			
Sex	No. of Turtles	2010	2011	2012	2013	1 year	2 years	3 years	4 years
Female	42	13	32	17	23	23.8%	50.0%	26.2%	0.0%
Male	29	6	22	13	22	24.1%	41.4%	17.2%	13.8%
Total	71	19	54	30	45	23.9%	46.5%	22.5%	5.6%

Detection rates were calculated in terms of catch-per-unit-effort (CPUE), which varied by survey type, time of year, and site. These are summarized below for the 2013 monitoring period. Temporal patterns were variable. August yielded the highest capture rate per trap, while May yielded the highest capture rate per hour (Table 5-3). Fall trapping was less productive than spring and summer trapping, which is to be expected. In general, approximately 3 turtles were located in each telemetry survey, consisting of about one turtle being located every hour (Table 5-4). The greatest number of turtles detected per survey occurred in the fall (Sept-Nov), while spring and summer detection rates per survey were comparable. Telemetry detections per unit hour were greatest in the spring and fall, with summer yielding approximately half as many detections per hour (Table 5-4).

Table 5-3: Western Painted Turtle trap captures by month for the 2013 trapping session. Catch per unit effort is given per trap ($CPUE_{trap}$) and per hour of trapping ($CPUE_{hour}$)

Month	No. of Turtles	No. of Traps	No. of Trap Hours	$CPUE_{trap}$	$CPUE_{hour}$
May	14	16	791.78	0.875	0.018
August	23	23	1528.98	1.000	0.015
September	5	12	572.37	0.417	0.009
October	1	6	444.73	0.167	0.002
Total	**43**	**57**	**3337.87**	**0.754**	**0.013**

Table 5-4: Western Painted Turtle detections by month for the 2013 telemetry session. Catch per unit effort is given per survey ($CPUE_{survey}$) and per hour of telemetry survey ($CPUE_{hour}$)

Month	No. of Turtles	No. of Surveys	No. of Survey Hours	$CPUE_{survey}$	$CPUE_{hour}$
January	17	5	9.50	3.400	1.789
February	16	4	5.92	4.000	2.704
March	11	5	9.30	2.200	1.183
April	0	4	13.83	0.000	0.000
May	2	2	2.67	1.000	0.750
June	21	7	18.08	3.000	1.161
July	19	5	29.17	3.800	0.651
August	17	8	20.08	2.125	0.846
September	24	5	16.25	4.800	1.477
October	29	7	19.83	4.143	1.462
November	28	4	12.25	7.000	2.286
Grand Total	**184**	**56**	**156.88**	**3.286**	**1.173**

Turtle Pond was the most productive site in terms of turtle catches per trap and per hour (Table 5-5). Turtle Pond also had the most telemetry detections per hour, although Airport Marsh had the greatest detection rate per telemetry survey (Table 5-6). Cartier Bay produced the fewest trap catches and telemetry detections (Table 5-5; Table 5-6). CPUE of the other two drawdown zone sites, Montana Slough and Airport Marsh, were comparable to rates of the Williamson Lake upland reference site.

Table 5-5: Western Painted Turtle trap captures by site for the 2013 trapping session. Catch per unit effort is given per trap ($CPUE_{trap}$) and per hour of trapping ($CPUE_{hour}$)

Site	No. of Turtles	No. of Traps	No. of Trap Hours	$CPUE_{trap}$	$CPUE_{hour}$
Airport Marsh	10	22	1220.02	0.455	0.008
Cartier Bay	0	1	68.10	0.000	0.000
Montana Slough	11	25	1495.12	0.440	0.007
Turtle Pond	21	4	242.03	5.250	0.087
Williamson Lake	1	5	312.60	0.200	0.003
Total	**43**	**57**	**3337.87**	**0.754**	**0.013**

Table 5-6: Western Painted Turtle detections by site for the 2013 telemetry session. Catch per unit effort is given per survey ($CPUE_{survey}$) and per hour of telemetry survey ($CPUE_{hour}$)

Site	No. of Turtles	No. of Surveys	No. of Survey Hours	$CPUE_{survey}$	$CPUE_{hour}$
Airport Marsh	59	12	49.97	4.917	1.181
Cartier Bay	2	5	10.92	0.400	0.183
Montana Slough	47	12	46.23	3.917	1.017
Turtle Pond	64	15	34.43	4.267	1.859
Williamson Lake	12	12	15.33	1.000	0.783
Total	**184**	**56**	**156.88**	**3.286**	**1.173**

Site occupancy was quite similar across years (Figure 5-6). Few turtles use Cartier Bay in any given year. Turtles were most often found at Montana Slough and Airport Marsh, however in 2012 and 2013 Turtle Pond housed a larger proportion of turtle observations than in 2010 and 2011.

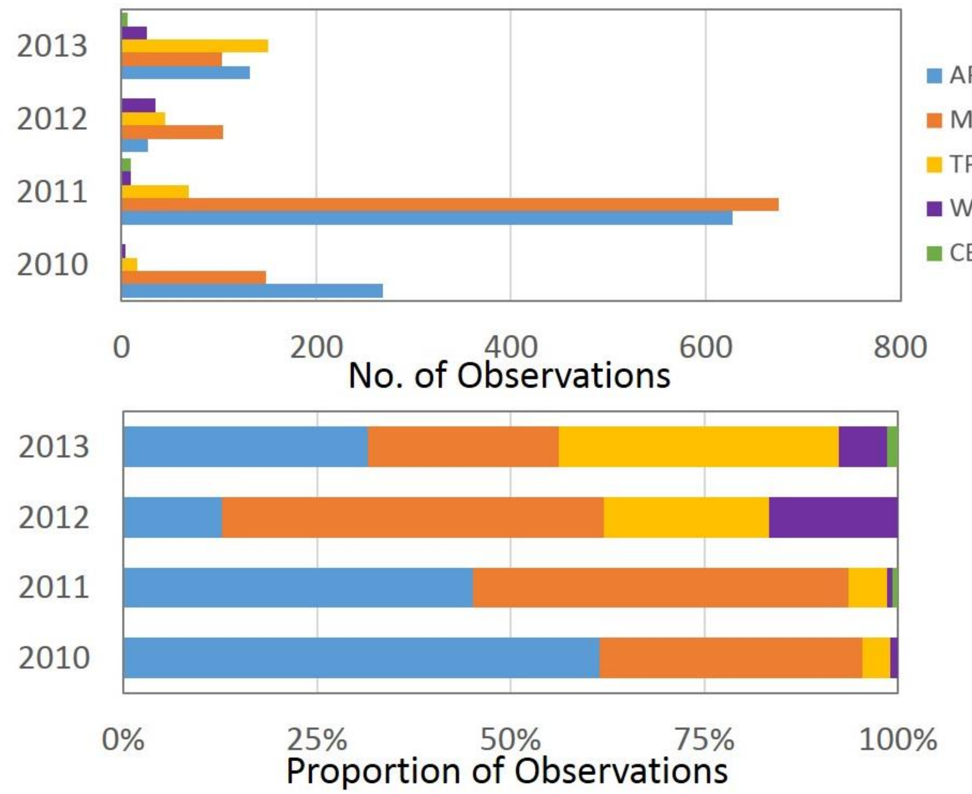


Figure 5-6: Proportion of turtle observations in each year by site (AP= Airport Marsh, MS= Montana Slough, TP = Turtle Pond, WL = Williamson Lake, CB = Cartier Bay). Data from VES, traps, and telemetry combined, not standardized for survey effort

By tracking the proportion of turtle observations in each site by time of year, we can assess the frequency of site usage over time. Turtles site usage did differ considerably throughout the year and across years (Figure 5-7). Turtle Pond hosted the greatest proportion of turtle observations in 2013, particularly in the summer and fall. Prior to 2012, this site comprised a small portion of all turtle observations. Airport Marsh held the second largest proportion of turtle observations in 2013, and housed turtles throughout all months when surveys were conducted. In all years, site occupancy was low at Williamson Lake, which produced only 6.7% of turtle observations in 2013. In all years, few turtles were found at Cartier Bay. Turtle observations at Cartier Bay occurred only in summer months (June and July 2011 and August 2013) and this site accounted for less than 1% of turtle observations in 2013. Airport Marsh and Montana Slough are particularly important sites for turtles in winter months.

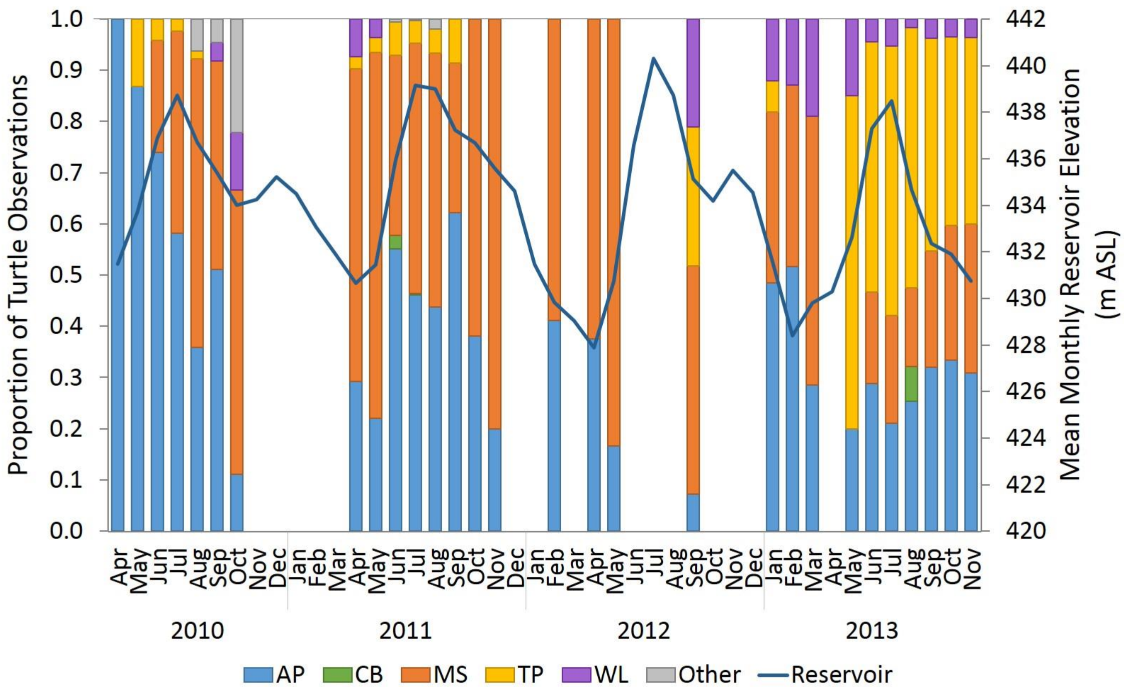


Figure 5-7: Proportion of turtles occupying each site from April 2010 to November 2013 (bars) with corresponding mean monthly reservoir elevation (line). AP= Airport Marsh, MS= Montana Slough, TP = Turtle Pond, WL = Williamson Lake, CB = Cartier Bay, Other = sites not visited in current year (Robs Willow, 9-Mile, 12-Mile, Makay Creek, roads, etc.). Data from VES, traps, and telemetry combined

5.3.2 Elevation Distribution

A total of 84 location records on 27 individual turtles were used to examine turtle elevational distribution. Radio-transmitter tagged of turtle elevations were located at elevations ranging from ~431.5 m to 469.5 m ASL. On average, adult turtles were found at lower elevations early in the year (January – March) when the reservoir elevation was low, than in later months as the reservoir filled (Figure 5-8: A). The mean ranks in elevation of turtles were significantly different among these times of year (Kruskal-Wallis Test: H = 22.36, df = 1, p < 0.0001). However, the elevation of male and female turtles was not significantly different (Figure 5-8: B; $\bar{x}$ = 439.0 m for males and 441.9 m for females).

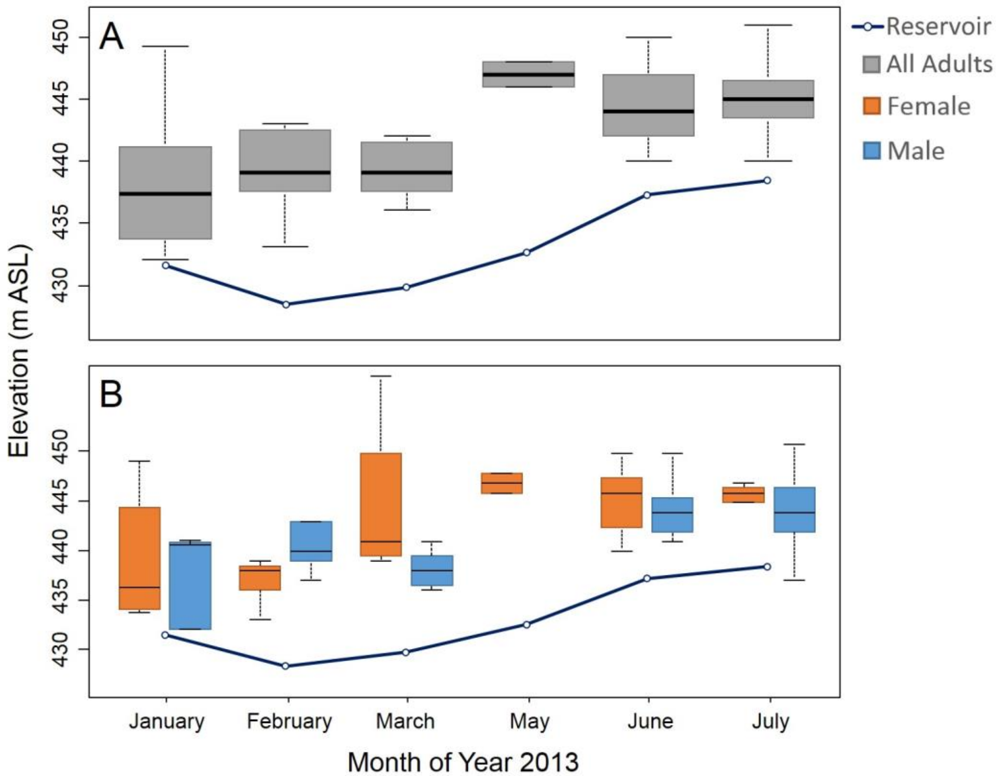


Figure 5-8: Elevation distribution of radio-telemetry located turtles by month in the year 2013 for all adults combined (A) and for males (n=15) and females (n=12) separately (B). Data were not available for April; extreme values not shown (i.e., outliers that lie outside of 1.5 times the interquartile range)

5.3.3 Overwintering Habitat and Water Quality

Due to safety concerns about the depth of the pond and ice condition, the location of overwintering turtles was estimated via triangulation. Forty-four observations of overwintering turtles were made during the telemetry sessions from January 14 to March 14, 2013. A total of 17 individual turtles were recorded overwintering in January, most which were located at Airport Marsh (eight turtles) and Montana Slough (six turtles). Fewer observations were made through February and March (16 and 11 turtles in each month, respectively), yet turtle locations were consistent throughout the winter. No turtles were found to overwinter in ponds at Cartier Bay. With the exception of Montana Slough ("Winter Pond"), most of the turtles overwintered adjacent to a shoreline in shallow water. Habitat data collected for overwintering locations are summarized in Appendix 8-1 and overwintering coordinates are compared to summer locations in Appendix 8-2. Hibernating turtles occurred at 429.0 m to 469.5 m elevation, and were found on average at 441.3 m elevation from January through March, 2013. Overwintering ponds in the drawdown zone had an average water depth of 37 cm (min = 5 cm, max = 105 cm), with average ice thickness of 26 cm (min = 10 cm, max = 40 cm). These characters were comparable to the reference ponds (Turtle Pond and Williamson Lake).

In January through March 2013 the temperature recorded at the bottom of each monitoring location was higher than at the surface. January water temperatures at the bottom of each monitoring location ranged from 0.3 to 1.8°C, with the highest average maximum water temperature associated with Williamson Pond. February water temperatures at the bottom of each monitoring location ranged from 0.3 to 0.9°C. The coldest average bottom temperature recorded in January was 0.3°C at both sites outside of the reservoir (i.e., Turtle Pond and Williamson Lake), and 0.3°C in February at Airport Marsh.

Dissolved oxygen levels were higher at the surface of the water than at the bottom at all sites, which is expected as colder water typically has higher concentrations of dissolved oxygen. Williamson Pond had the highest dissolved oxygen readings of all other monitoring locations. In January, dissolved oxygen levels fluctuated between 2.05 and 7.90 mg/L, with Turtle Pond and Williamson Lake representing the respective extremes. In February, within the reservoir, the dissolved oxygen values ranged between 1.08 and 4.74 mg/L. Montana was the only location to show a pronounced drop in dissolved oxygen at depth between January and February; this is unexpected since the temperature at this location also dropped.

Turtle overwintering locations differed in some abiotic conditions from randomly sampled non-turtle locations, as shown in Figure 5-9 (data is summarized in Table 8-2 of the Appendix). On average water depths at non-turtle locations were deeper than those at known overwintering locations, although ice thickness was similar at all locations. With few exceptions, dissolved oxygen, temperature, and conductivity were lower at turtle overwintering locations than non-turtle locations, for both drawdown zone and reference sites. Samples were also obtained from Cartier Bay, where no turtles are presently known to overwinter. The conductivity values collected from Cartier Bay were higher than at any other location sampled.

Water quality characteristics differ markedly between seasons and by site, which could influence turtle distribution and site occupancy patterns. Thus, we examined the water conditions associated with telemetry-located turtles during different life history stages (e.g., foraging vs. overwintering) at each study site. Although water temperature was variable in each activity period, the range in temperature was similar at each site (Figure 5-10: top). However, dissolved oxygen content was found to be very low during the overwintering period at Montana Slough (Figure 5-10: middle), particularly at the depth of turtle presence, where DO conditions fell to hypoxic levels (i.e., DO < 2.0 mg/L). However, Western Painted Turtles are known to be capable of surviving up to 4 months under conditions of exceptionally low oxygen at near freezing temperatures (Ultsch and Jackson 1982). From current data, it is unlikely that differences in pond water quality between upland reference sites and drawdown zone ponds (or between overwintering turtle locations and unoccupied habitats) produce ecologically meaningful effects on Western Painted Turtles. Painted turtles appear to tolerate a wide range of water physicochemical conditions, which is consistent with the published literature (e.g., Bickler and Buck 2007).

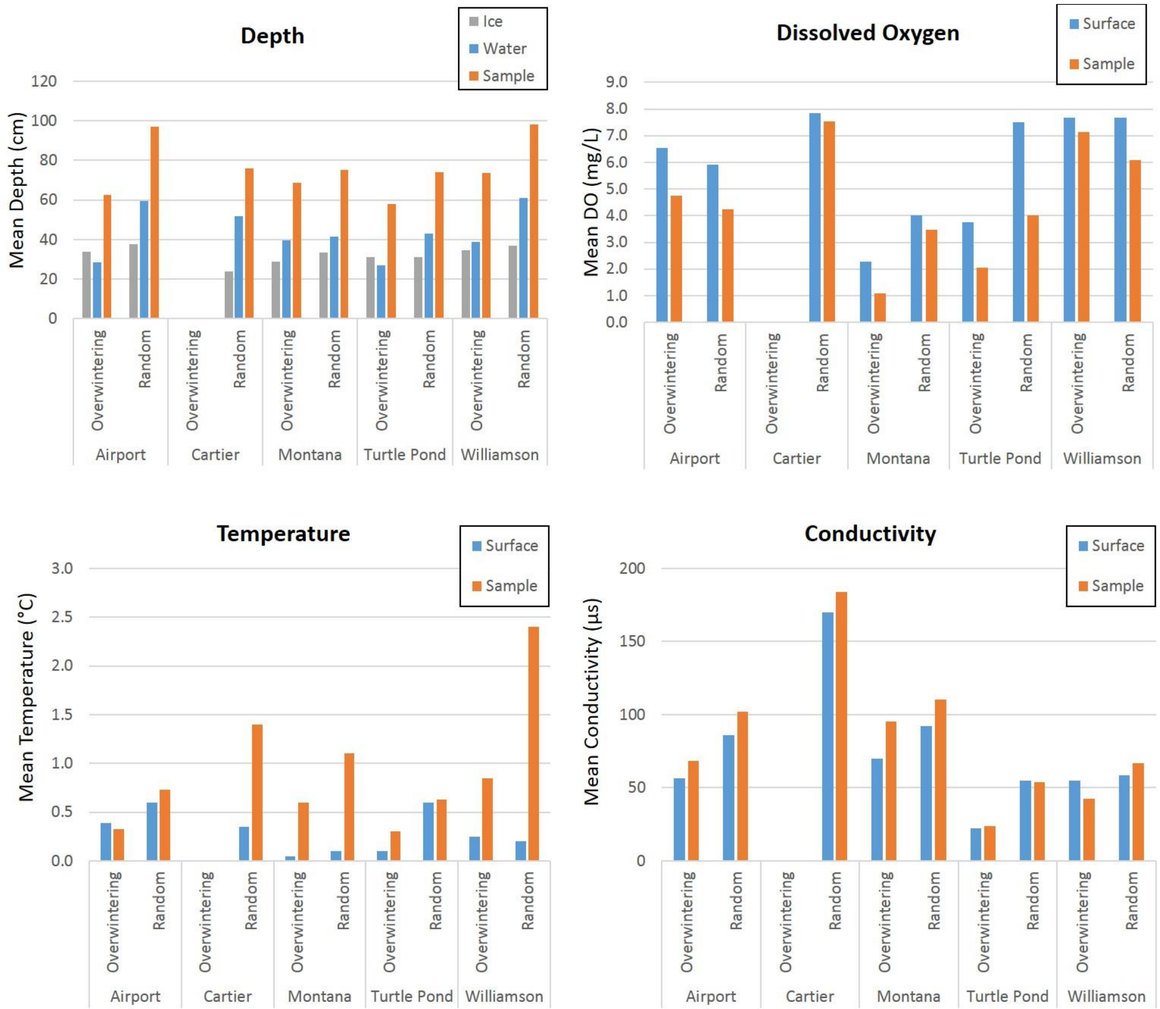


Figure 5-9: Average water conditions of locations containing overwintering turtles ("overwintering") and nearby locations that did not contain turtles ("random") in February 2013 winter telemetry surveys. For most metrics, measurements were taken at the water surface and at the depth of the sample (turtle depth or pond bottom). Note: Data for Turtle Pond was collected in January, as no turtles were detected in February surveys

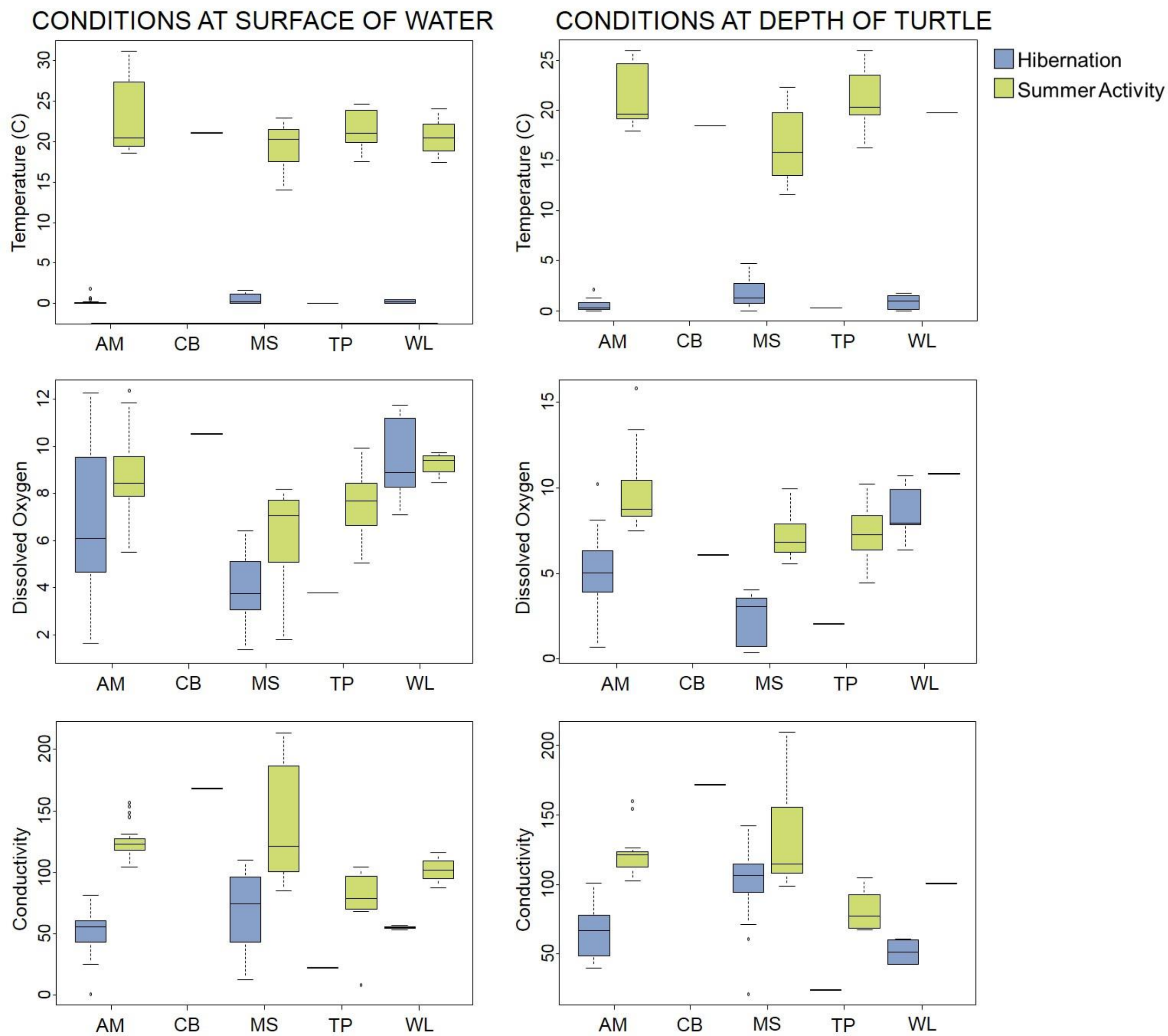
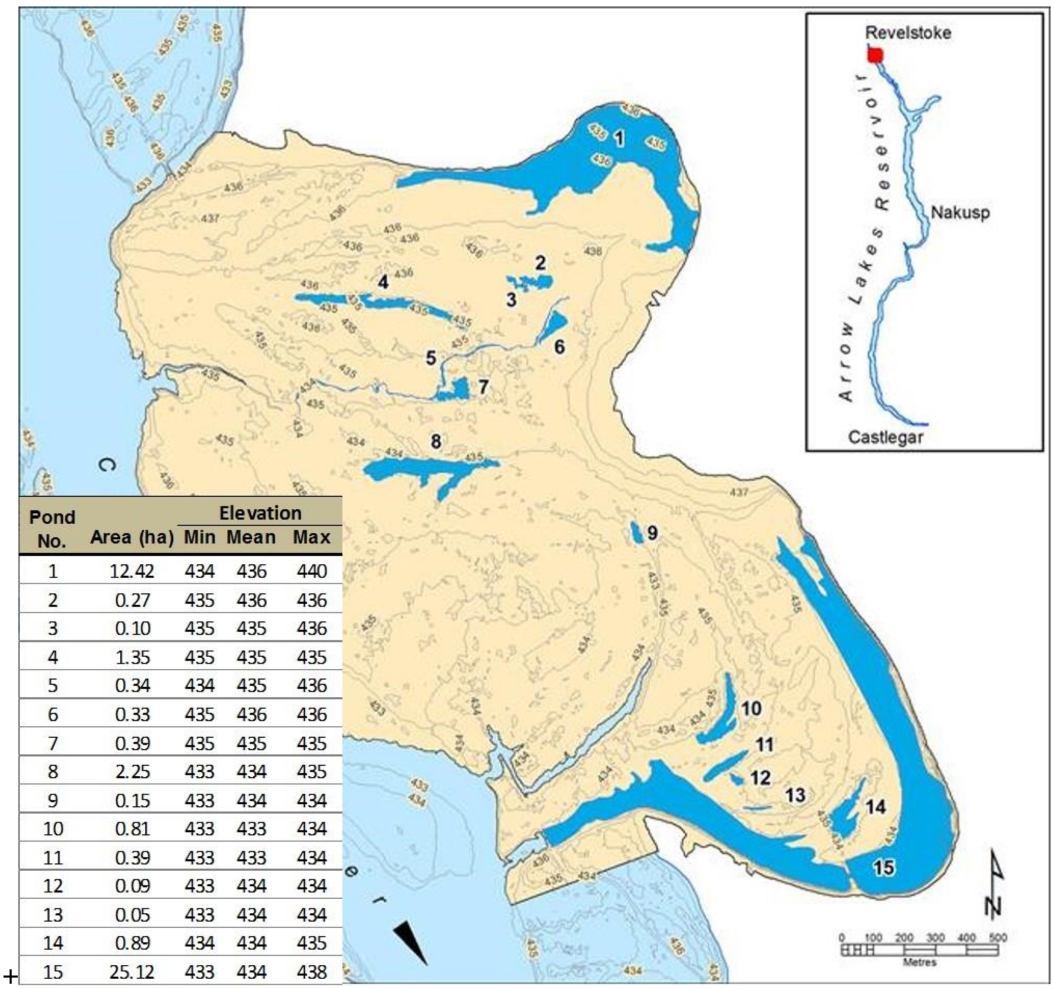


Figure 5-10: Variation in water physicochemical conditions at locations of radio-tagged turtles by site and turtle activity period. Turtle hibernation period included data from January to March 2013 (n= 17 turtles, 44 observations). Summer activity period included data from June to September 2013 (n= 30 turtles, 80 observations). AM= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake

5.3.4 Pond Size

The location, elevation, and number of ponds available in the drawdown zone have been mapped for Cartier Bay and Montana Slough in Revelstoke Reach (Figure 5-11). The ponds mapped in these sites range in size from 0.05 ha to 25.1 ha ($\bar{x}$ = 2.99; SD = 6.86 ha). Most of the pond area (~64 per cent, 28.8 ha) is situated at ~433 m ASL, an additional 30 per cent (13.6 ha) at 434 m ASL and ~ 5 per cent (~2.5 ha) at 435 m ASL. Turtle associations with each pond, pond size, and elevation of pond will be explored in more detail in future iterations of the CLBMON-11B3 study. At present, we know that both Montana Slough and Cartier Bay possess a variety of pond sizes, however few turtles have been observed at Cartier Bay. Schiller and Larsen (2012a) indicated that 'Winter Pond' at Montana Slough, adjacent to Pond No. 1, provided important overwintering habitat to turtles. Pond No. 1 covers a large area (12.42 ha) and occurs at a higher elevation than any other ponds available in Montana Slough/Cartier Bay (range: 434 to 440 m ASL, c.f. 433 to 438 m ASL).



Pond No.	Area (ha)	Elevation Min	Elevation Mean	Elevation Max
1	12.42	434	436	440
2	0.27	435	436	436
3	0.10	435	435	436
4	1.35	435	435	435
5	0.34	434	435	436
6	0.33	435	436	436
7	0.39	435	435	435
8	2.25	433	434	435
9	0.15	433	434	434
10	0.81	433	433	434
11	0.39	433	433	434
12	0.09	433	434	434
13	0.05	433	434	434
14	0.89	434	434	435
15	25.12	433	434	438

Figure 5-11: Delineation of 15 ponds in the drawdown zone at Cartier Bay and Montana Slough (pond 1= "Winter Pond"). The ponds delineated are based on 2011 imagery. Image from Hawkes and Tuttle 2013)

5.4 H2: The operations of Arrow Lakes Reservoir do not affect painted turtle survival or productivity

Survival and productivity were not directly measured in the study. However, through mark-recapture data, relevant inferences can be made. The high rate of recapture (or re-detection) of marked turtles in the study since 2010 (Table 5-2), and few incidences of mortality (no mortality was observed in 2013), suggest that turtle populations are being maintained across years. Nineteen of the 31 turtles recorded in 2012 were also found in 2013 (per cent = 61.3). However, reservoir operations could indirectly affect turtles through changes in habitat availability. As well, direct effects can be examined in greater detail though relationships with indicators of turtle fitness. It is generally held that animals in good condition are heavier (increased fat and protein stores) and/or structurally larger (Dobson 1992). Turtles that travel greater distances for foraging, locating nesting sites, and overwintering may also bear additional energy costs for locomotion. We discuss relationships between reservoir operations and habitat availability, turtle growth parameters, and turtle movement in relation to this hypothesis.

5.4.1 Habitat Availability

Reservoir operations affect the availability of both terrestrial and aquatic habitat. The degree to which specific areas in the drawdown zone are affected depends on reservoir elevations in any given year and month. To demonstrate the relationship between reservoir elevation and habitat availability, data for Cartier Bay and Montana Slough from 2008 to 2013 were used. This location provides important habitat for Western Painted Turtles, as well as Western Toads (Hawkes and Tuttle 2013). Fifteen ponds were delineated in the drawdown zone in this location ranging in size from 0.05 ha to 25.1 ha ($\bar{x}$ = 2.99; SD = 6.86 ha). Most of the pond area (~64 per cent, 28.8 ha) is situated at ~433 m ASL, an additional 30 per cent (13.6 ha) at 434 m ASL and ~ 5 per cent (~2.5 ha) at 435 m ASL. The majority of these ponds were inundated by May 3, (2009) or May 28 (2012). Following the inundation of the 433 m ASL elevation band (and 28.8 ha of breeding habitat), the 434 elevation band (or 13.6 ha) was inundated between May 19 (2010) and June 4 (2009, 2012). The remaining 2.5 ha was inundated between May 31 (2008) and June 11 (2009) (Figure 5-12). The reduction in habitat availability could pose energetic costs to turtles in these areas, such as reduced availability of forage and increased energy costs to relocate to more suitable habitats during inundation. These will be assessed in turn.

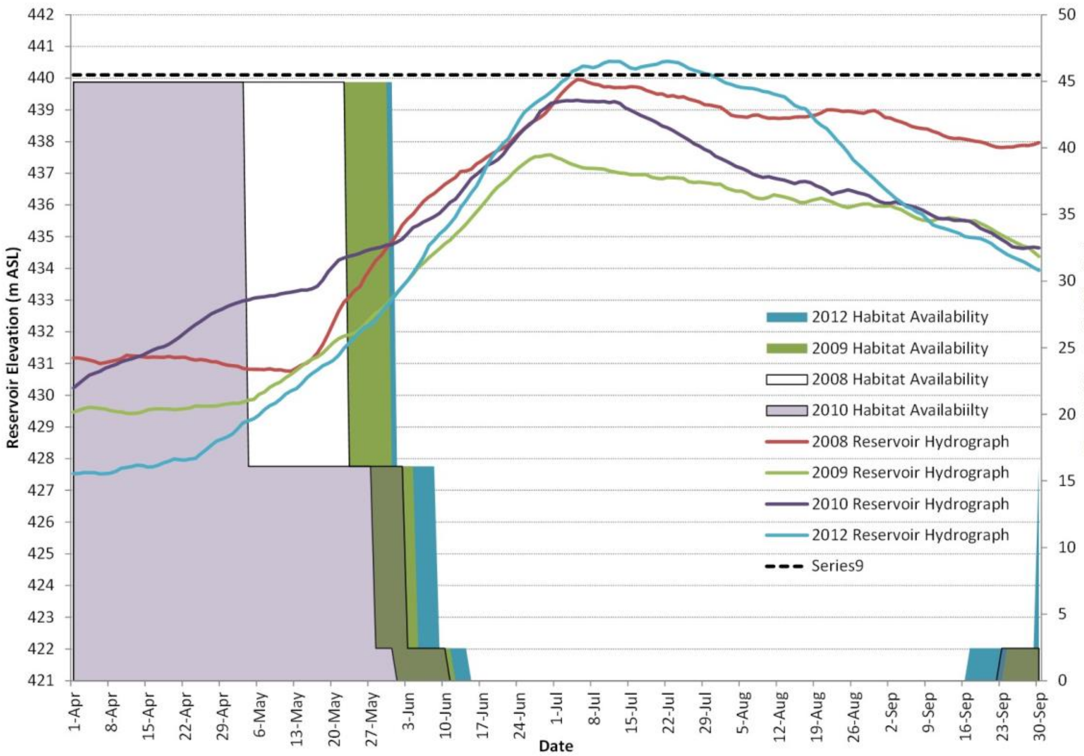


Figure 5-12: Relationship between pond habitat availability (pond area) and reservoir elevations for the period April 1 through September 30 (2008, 2009, 2010, and 2012). The dashed line represents the normal operating maximum of Arrow Lakes Reservoir

5.4.2 Mass and Body Condition

Non-parametric ANOVA (Kruskal-Wallis) tests were used to determine differences in body mass of Western Painted Turtles by turtle class (adult female, adult male, and juvenile) and also by reservoir location. Body mass differed significantly between turtles (Kruskal-Wallis: $H = 45.7$, $df = 2$, $p < 0.0001$), with the greatest weights found among female turtles (*median* = 970 g, *min* = 382.7 g, *max* = 1360 g), followed by males (*median* = 530 g, *min* = 253 g, *max* = 870 g) and juveniles (*median* = 155 g, *min* = 34 g, *max* = 315 g) (Figure 5-13).

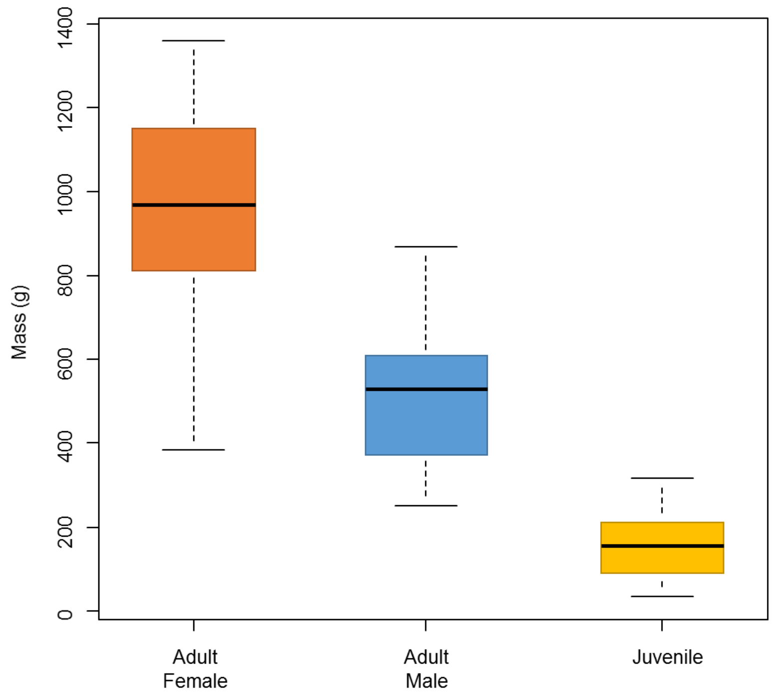


Figure 5-13: Turtle body weight (g) for adult female (*n* = 33), adult male (*n* = 30), and juvenile (*n* = 9) Western Painted Turtles. Data shown are from trap captures in 2012 and 2013 surveys

Body mass of adults differed significantly by reservoir location (Kruskal-Wallis: H = 16.5, df = 4, p = 0.002), with lower mass turtles occurring in drawdown zone sites (Airport Marsh, Montana Slough, and Cartier Bay). This relationship was found not to be significant for juveniles (H = 3.3, df = 2, p = 0.19; Figure 5-14). Female body weight was greater at Turtle Pond (*median* = 1150 g) and Williamson Lake (*median* = 1135 g) than at drawdown zone sites (*median* = 827 g). Although male weight was more similar between the drawdown zone and reference sites, the lightest males were located at Montana Slough (median = 373 g; min= 253 g; max= 607 g). Female turtle mass was more variable at Airport Marsh and Montana Slough than at other sites perhaps indicating the presence of both gravid and non-gravid females at those sites.

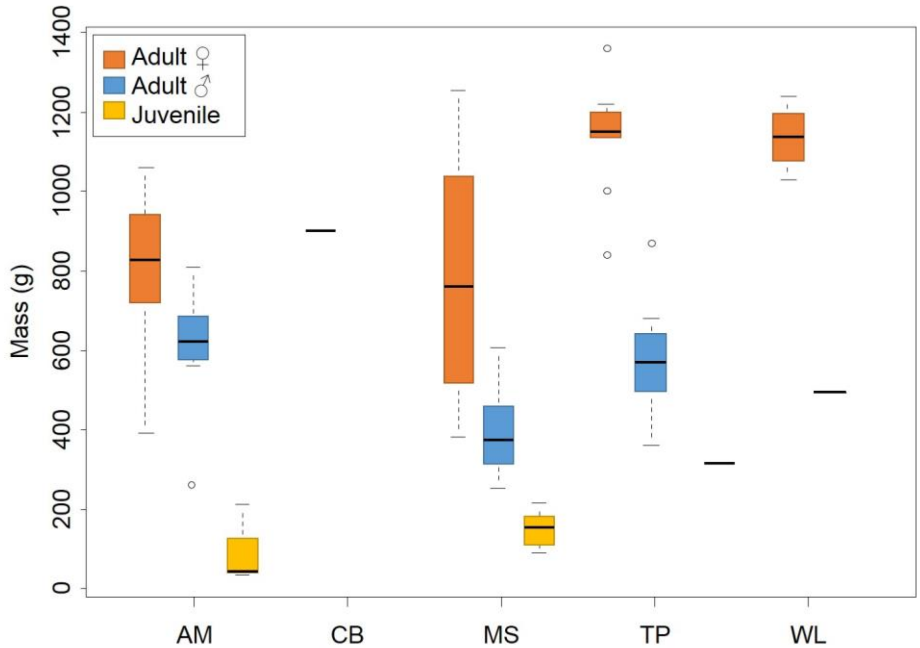


Figure 5-14: Body weight (g) by site for male, female, and juvenile Western Painted Turtles. Data shown is from trap captures during 2012 and 2013 surveys. Sites are abbreviated as follows: Airport Marsh (AM), Cartier Bay (CB), Montana Slough (MS), Turtle Pond (TP), and Williamson Lake (WL)

To further understand turtle fitness, we examined body condition of turtles. We regressed turtle weight (mass) by size (i.e., straight-line carapace length). For all turtles, there was a strong, positive relationship between body mass and carapace length (R^2 >0.87; Figure 5-15). The residuals of this mass-size regression were then used as an index of body condition (Schulte-Hostedde et al. 2005) to assess qualitatively how body condition varied by location. Body condition (derived by residuals) of adult male and juvenile turtles was lowest at Montana Slough (Figure 5-16). Female turtle body condition was also low at Montana Slough, but was lowest at Turtle Pond, where only three of the nine turtles scored heavier than expected by their carapace length. For females, this may not be an accurate depiction of condition, however, as we cannot rule out the possibility that female weights were confounded by differential reproductive status (gravid vs. virgin) across sites.

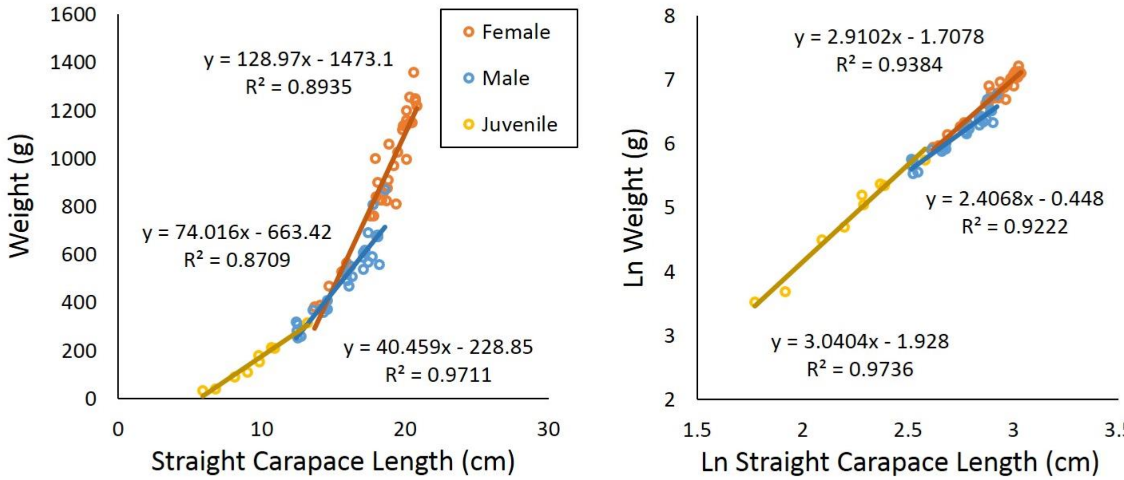


Figure 5-15: Relationship between body weight and size for adult female, adult male, and juvenile Western Painted turtles. Regressed raw data plots (left) and log-transformed data plots (right) are both shown to illustrate improved linearity and fit of the model

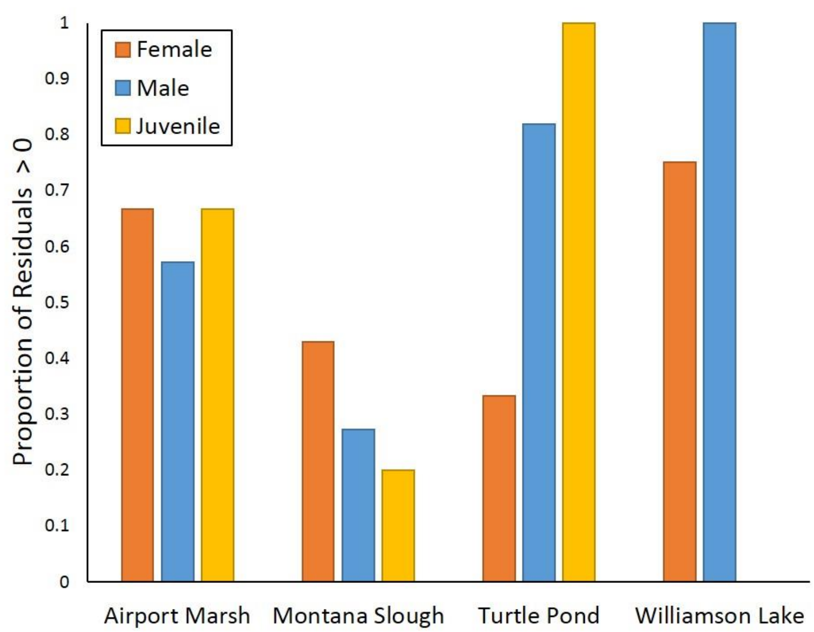


Figure 5-16: Proportion of Least Squares Regression residuals that are positive for female, male, and juvenile Western Painted Turtles, as a proxy for body condition. Positive residuals indicate a higher mass-to-body size ratio than expected by the linear fit of the regression of $\log_e$ Mass (g) by $\log_e$ Carapace Length (cm) (see Figure 5-15).

The Body Condition Index (BCI) derived by Bjorndal et al. (2000) was also examined for female, male, and juvenile Western Painted Turtles by monitoring year (2012 and 2013) and across the five sites. Generally, the Body Condition Index results were not consistent with the results obtained by examining residuals of regressed turtle mass-size. Turtle BCI was fairly similar for males and females across years, with the observed difference between the sexes larger in 2013 (Figure 5-17, top panel). Although turtle BCI varied between females, males, and juveniles, there were no observed trends in body condition index across sites, suggesting that turtle health and energy stores are similar in all locations they were captured.

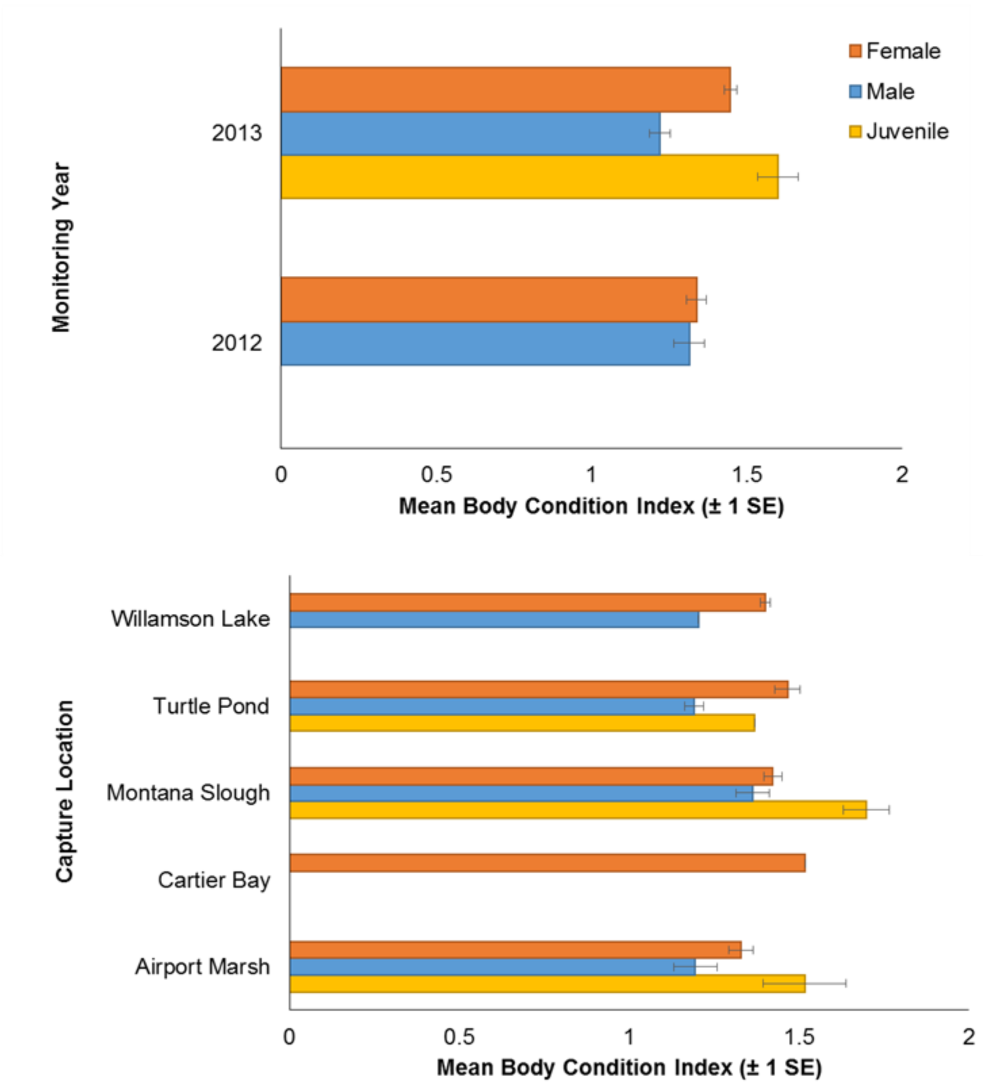


Figure 5-17: Body Condition Index (mean ± S.E.) calculated for Western Painted Turtles captured in different study years (top) and locations (bottom)

5.4.3 Movement Patterns

Turtle movements varied throughout the year of 2013 and were examined to assess whether turtles of the drawdown zone sites incur increased energy costs for locomotion. Two-Factor Analysis of Variance (ANOVA) was used to test for turtle movement differences among sites occurring within the drawdown zone (DDZ) and upland (UPL) of Arrow Lakes Reservoir and across months in 2013 (power-transformed data as described by Box and Cox 1964).There was a significant difference between travel distance per day by month ($F_{8,123}$= 14.53, $p < 0.0001$). Turtles at all sites exhibited greater movement during and after inundation than prior to inundation ($F_{2,128}$= 46.69, $p < 0.0001$). Interestingly, there is also greater turtle movement in DDZ sites compared to upland reference sites ($F_{1,123}$= 2.93, $p = 0.09$). The interaction between reservoir position and month was not significant ($F_{7,123}$= 1.48, $p = 0.18$).

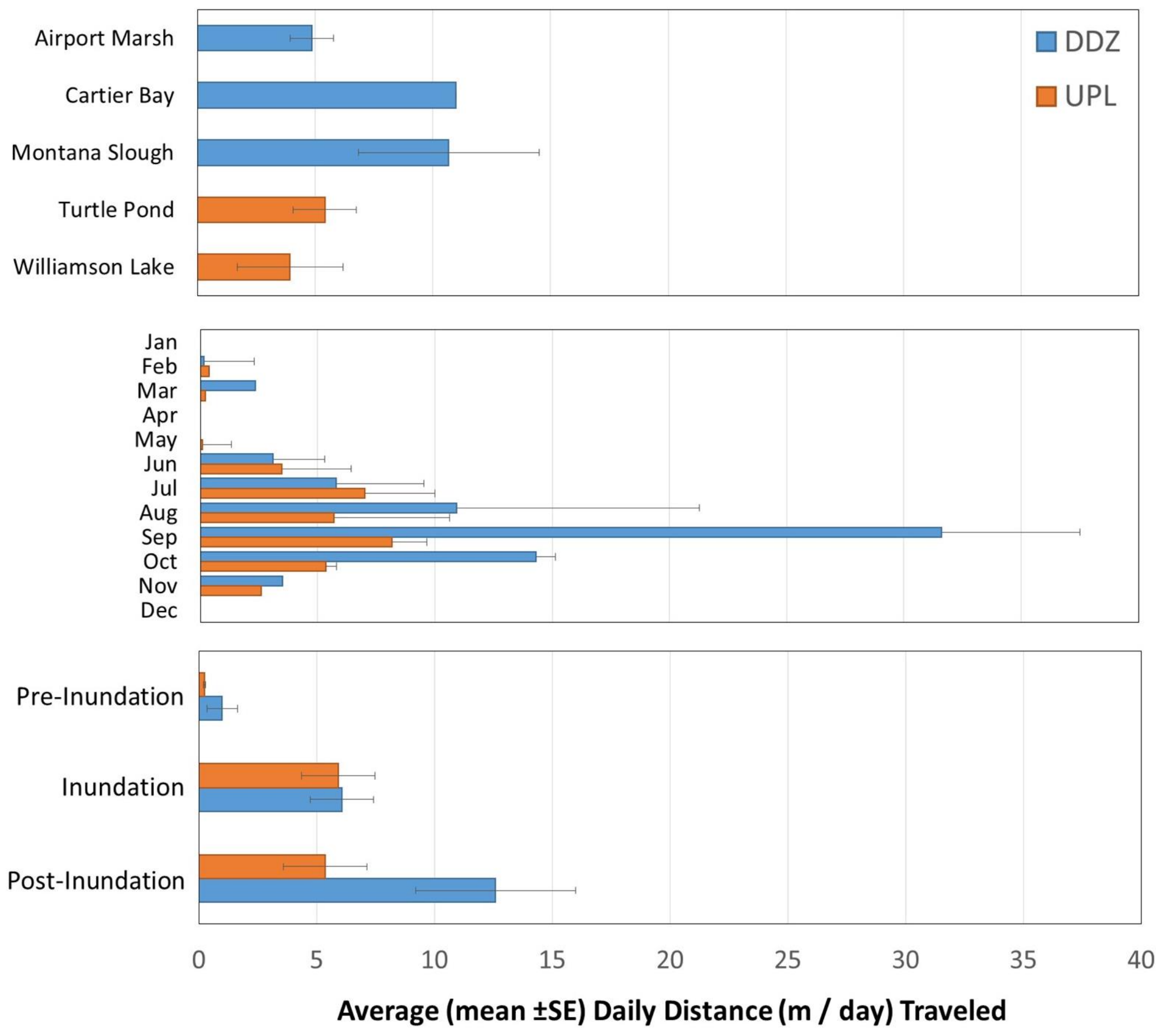


Figure 5-18: Average distance (m) traveled per day for turtles in each site of the drawdown zone (DDZ) and upland reference sites (UPL) of Revelstoke Reach (top), by month of 2013 (middle), and by reservoir inundation period (bottom)

Average distance traveled per day was also examined by turtle sex to determine if females and males exhibit similar movement behaviours. Average distance traveled was highly variable between study years (Table 5-7). Although it appears that there is a strong difference between drawdown zone and upland sites, due to unbalanced sampling between years, differences cannot be interpreted. The implementation of more balanced survey efforts in 2013 and future years will help to elucidate this relationship.

Table 5-7: Summary of movements (daily distance traveled in meters) from telemetry surveys per year by site and sex of turtle

Turtle Sex	Site	Mean (± S.E.) Distance Traveled (m per day)			
		2010	2011	2013	All Years
Female	Airport Marsh	84.12 (20.7)	68.57 (7.9)	4.23 (.9)	62.96 (6.7)
	Montana Slough	95.41 (26.3)	49.05 (8.4)	14.98 (9.3)	60.05 (9.1)
	Turtle Pond	-	-	6.09 (1.9)	6.09 (1.9)
	Williamson Lake	-	41.25 (12.7)	4.84 (2.6)	14.77 (6)
Male	Airport Marsh	55.5 (28.2)	87.67 (18.6)	5.38 (1.3)	58.37 (11.7)
	Montana Slough	-	55.1 (8.1)	9.8 (3.7)	42.46 (6.1)
	Turtle Pond	-	-	-	-
	Williamson Lake	-	-	.36 (.1)	.36 (.1)
All Turtles		90.77 (19.9)	61.41 (4.7)	6.84 (1.2)	53.82 (4)

5.5 H3: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical work and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach

5.5.1 Revegetation

The revegetation prescriptions applied in Revelstoke Reach of Arrow Lakes Reservoir are not considered relevant or beneficial to reptiles. The relationship between revegetation prescriptions and Western Painted Turtles habitat utilization will not be assessed in the present study. Relationships between revegetation prescriptions and other taxa (e.g., invertebrates and small mammals) and productivity are being studied as part of the Arrow Lakes Wildlife Effectiveness study (CLBMON-11B1). However, that study is constrained to mid- and lower-Arrow Lakes Reservoir.

5.5.2 Physical Works

Several wildlife physical works have been proposed for implementation in select areas of in Revelstoke Reach (Golder 2009a and 2009b), however, these projects have not yet been implemented. Proposed physical works have been designed to specifically address the loss of shallow valley bottom and wetland habitat, which would have been flooded when Arrow Lakes Reservoir was created. The creation / enhancement of habitats in the drawdown zone of Arrow Lakes Reservoir is intended to improve habitat suitability and increase the amount of shallow water habitat to benefit reptiles, amphibians and waterfowl.

6.0 DISCUSSION

The occurrence, life history, habitat use, and productivity of Western Painted Turtles in the drawdown zone of Arrow Lakes Reservoir have been studied since 2010. This long-term study focuses primarily on the demographics and habitat use of a population of Western Painted Turtles in Revelstoke Reach, on how reservoir operations may affect the population and/or the habitats they use, and whether physical works can be implemented to mitigate any potentially adverse effects of reservoir operations on this population or its habitats. Monitoring painted turtles in the drawdown zone over a ten year period will provide the necessary information to address the management questions outlined in the terms of reference for CLBMON-11B3.

The current study focuses on two key initiatives (#1 and 2b, Table 6-1; see Table 2-1Table 2-1

for the ten-year initiatives). As well, we performed some initial investigation of initiative 2a (see Sections 5.4.1 and 5.4.3), which will be studied in more detail in future years. The majority of the work in 2014 will be to support these key initiatives, whilst also initiating a detailed study of turtle nesting habitats in Revelstoke Reach.

Table 6-1: Relationship between management questions, hypotheses, and long-term monitoring strategy for Western Painted Turtles in Revelstoke Reach, Arrow Lakes Reservoir. Seasons are grouped into S/S (spring /summer) and F/W (fall/winter)

Initiative		Management Question Addressed	Season		Study Years
			S/S	F/W	
1	Long term tracking of turtle demographics to monitor population trends (abundance, recruitment/productivity, and mortality) and assess the impacts of reservoir operations on these parameters	Q1, Q3, Q4, Q5	X	X	2012-2020
2	Conduct focused studies on the fine scale seasonal habitat use of turtles	Q2, Q4, Q6, Q7, Q8	X	X	2012-2020
2a	Conduct a focused study on the fine-scale habitat use by turtles during spring and summer and investigate potential impacts of reservoir operations on summer habitat use, habitat availability, and turtle movements	Q2, Q4, Q5	X		2014-2016
2b	Conduct a focused study on fine-scale habitat use by turtles during winter and investigate potential impacts of reservoir operations on winter habitat use and habitat availability	Q2, Q4, Q5		X	2012-2014

6.1 Management Questions and Hypotheses

Several management questions (Q#1 – #6; Section 2.2) focus on the effect of reservoir operations on turtle occurrence, habitat use, and productivity in the drawdown zone of Arrow Lakes Reservoir. Concurrent with the assessment of population characteristics and habitat use, certain components seek to determine whether revegetation prescriptions (Q#7) and/or future physical works projects (Q#8) could affect habitat quality or turtles use of the drawdown zone. The ability to address each of the management questions with is discussed below. The methods we have used with Initiatives #1 and #2b appear to have been appropriate for collecting data adequate to address the questions. It is expected that the future completion of Initiatives #2a, 2c and 2d and use of a time-series approach to data analyses will provide the means necessary to address each management question.

6.1.1 Theme 1: Life History and Habitat Use

Q1: During what portion of their life history (e.g., nesting, foraging, and overwintering) do painted turtles utilize the drawdown zone in Revelstoke Reach?

Our current understanding of the use of the drawdown zone by Western Painted Turtles in Revelstoke Reach is that turtles use the DDZ to fulfill most of their life history requirements (Table 5-1). Western Painted Turtles typically nest in late June, finding suitable habitat usually within 150 m of water (Matsuda et al. 2006). Summer telemetry surveys detected adult females in Airport Marsh, Turtle Pond, and Williamson Lake between June 21 and June 23, 2013. Unfortunately information on female reproductive status is quite limited. In future years, it would be helpful to examine whether captured females are gravid. Neonates hatch by late summer and generally overwinter in the nest. Juvenile turtles were found in August 2013, using habitats in the drawdown zone at Airport Marsh and Montana Slough, as well as Turtle Pond, which is consistent with previous years. Several neonate turtles have been observed in Airport Marsh (as part of CLBMON-11B4). Unfortunately, observations of neonates are limited and we do not have sufficient data to confirm overwintering sites. No observations of nesting sites or breeding were made during the 2013 monitoring year. However, nesting sites are known to occur at Red Devil Hill and Williamson Lake. This component was not examined extensively in 2012 and 2013, as it will be addressed by Initiative #2c in future years (i.e., 2014 to 2018).

Standardized telemetry detection rates are useful in comparing turtle use of drawdown zone and upland sites by season (Figure 6-1). The results of the telemetry in January and February 2013 confirm that Montana Slough, Airport Marsh, Turtle Pond and Williamson Lake are all used by adult Western Painted Turtles during their overwintering period (Figure 6-1: A). Further, the drawdown zone sites at Airport Marsh and Montana Slough had three times the number of turtle detections per survey in the overwintering season; thus the drawdown zone provides important overwintering habitat for a significant portion of the turtle population at Revelstoke Reach. Across all seasons, detection rates were much lower at Williamson Lake and Cartier Bay than at other sites. Turtles were only found at Cartier Bay in August telemetry surveys, whereas turtles were found using Williamson Lake throughout the year. Airport Marsh, Montana Slough, and Turtle Pond all yielded numerous turtle detections per survey in the summer and fall. Data collected in subsequent monitoring years of the CLBMON-11B3 study will be similarly examined to determine if the current pattern in turtle use of the drawdown zone at Revelstoke Reach is consistent long-term.

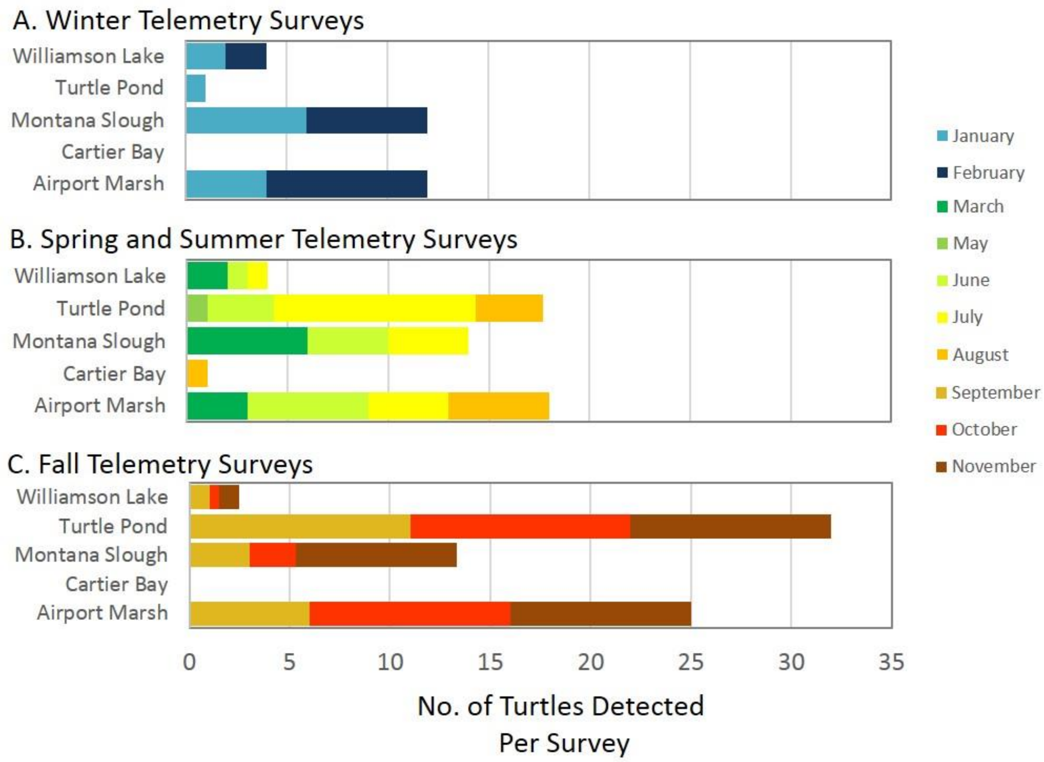


Figure 6-1: Seasonal patterns in site occupancy (number of turtles per survey) for 2013 telemetry surveys. The horizontal axes are scaled equally between plots

Q2: Which habitats do painted turtles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?

Western Painted Turtles in and adjacent to the drawdown zone in Revelstoke Reach depend on aquatic habitats to fulfill their life history requisites (e.g., foraging, basking, and overwintering). In the summer, turtles were dispersed in wetland areas with an abundance of vegetation (emergent and submergent) and basking capabilities (e.g., logs, lily pads, floating mats of vegetation). During the winter, turtles were clustered at winter pond in Montana Slough and along the shoreline areas of Airport Marsh, Williamson Lake, and Turtle Pond.

Ponds within Montana Slough and Cartier Bay (*n* = 15) have been mapped and their areas have been calculated (Figure 5-11). 'Winter Pond' (Pond No. 1) at Montana Slough is consistently productive for turtle detections and is the largest pond in that location (12.42 ha c.f. $\bar{x}$ = 2.99; SD = 6.86 ha). Coincidently, Winter Pond also occurs at the highest elevation band in that system ($\bar{x}$ = 436 m).

Reservoir elevation influences habitat availability and likely affects habitat suitability of sites in the drawdown zone of Arrow Lakes Reservoir. We have shown that there is a strong negative relationship between pond area in Montana Slough/Cartier Bay and reservoir elevation (Figure 5-12). As well, turtle elevational distribution is markedly altered in summer months, raising by approximately 7 m following the onset of inundation (Figure 5-8). The impact of recurrent annual loss in habitat during reservoir inundation is not yet known.

Consistent with previous years, water physicochemical conditions in ponds suggest little evidence of an effect of dissolved oxygen, water temperature, or conductivity on turtle habitat use (see Section 5.3.3). Rollinson et al. (2008) classified temperature and dissolved oxygen levels as important factors that may contribute to overwintering site selection by Western Painted Turtles. However, painted turtles have the ability to depress their metabolic activity and limit dissolved oxygen uptake while overwintering, allowing them to survive in near-freezing, anoxic conditions for long periods of time. Thus, there was no detectable pattern in habitat suitability based on water conditions for ponds where turtles were present (Table 8-1) and random pond conditions where turtles were absent (Table 8-2).

Currently, turtles tend to overwinter in sites where water depth ranges from 0.5 to 0.75 m and that are close to shore (with the exception of Montana Slough). These two parameters require further investigation, but suggest that fluctuating reservoir elevations could negatively affect current overwintering sites, particularly if water depth (relative to elevation) exceeds 0.75 m during winter. Fluctuating water levels have the potential to not only influence temperature and dissolved oxygen levels at the hibernation sites, but may also present the potential for beaching hibernating turtles or possibly crushing turtles by ice left by receding water. These hypotheses will be investigated in future years as we collect more data on turtle overwintering locations and conditions.

Q3: What is the abundance and productivity of painted turtles in Revelstoke Reach and how do these vary across years?

We have calculated various measures of relative abundance to allow for comparisons between sites at Revelstoke Reach, among months, and with data from future years of monitoring (see Section 5.3.1). All sites monitored at Revelstoke Reach supported turtles, but Airport Marsh, Montana Slough, and Turtle Pond generated the highest number of trap catches (Table 5-5) and telemetry detections (Table 5-6). Montana Slough and Airport Marsh were also identified as important overwintering sites during winter telemetry surveys in January and February, 2013 (Figure 6-1).

Productivity (nest and egg counts) has not yet been measured; however this component of the long-term turtle monitoring study will be addressed as part of Initiative #2c in future years. Additional years of data collection will allow for comparisons between years and capture of any potential variability in relative abundance or productivity due to reservoir operations.

Q4: Does the operation of the Arrow Lakes Reservoir negatively impact painted turtles directly or indirectly (e.g., mortality, nest inundation, predation, and habitat change)?

Currently, there is little evidence of increased turtle mortality, nest inundation, or predation that could be linked to the operations of Arrow Lakes Reservoir. However, reservoir operations are influencing pond habitat availability (Figure 5-12) and are related to shifts in the elevation distribution of turtles (Figure 5-8) and movement patterns (Figure 5-18). Reservoir elevation and turtle movements are compiled in Figure 6-2. Turtles travelled greater distances during (and immediately following) reservoir inundation periods. Increased movements during inundation were expected for turtles in the drawdown zone, because the flooding of ponds may displace individual turtles. However, increased travel distances were also observed throughout the post-inundation period in September through November. This could partly be explained by increased turtle activity to locate overwintering sites. We found evidence that turtles in the drawdown zone are traveling greater distances than those in upland sites ($F_{1,123}$= 2.93, p = 0.09), and this suggests that turtles in the drawdown zone are utilising more energy during and after inundation. Only one turtle was recorded moving back-and-forth between the drawdown zone and upland sites in 2013 (Female #091; Airport Marsh to Turtle Pond to Montana Slough), so this trend could not be explained by travel between upper and lower reservoir sites.

Eleven turtle mortalities have been recorded since 2010; all occurred in sites within the drawdown zone (nine turtles at Airport Marsh, two turtles at Montana Slough). Evidence of predation was noted for three of the mortalities. Cause of death was unknown. Deceased turtles have not been found in upland reference sites. There were no observations of dead turtles in 2013.

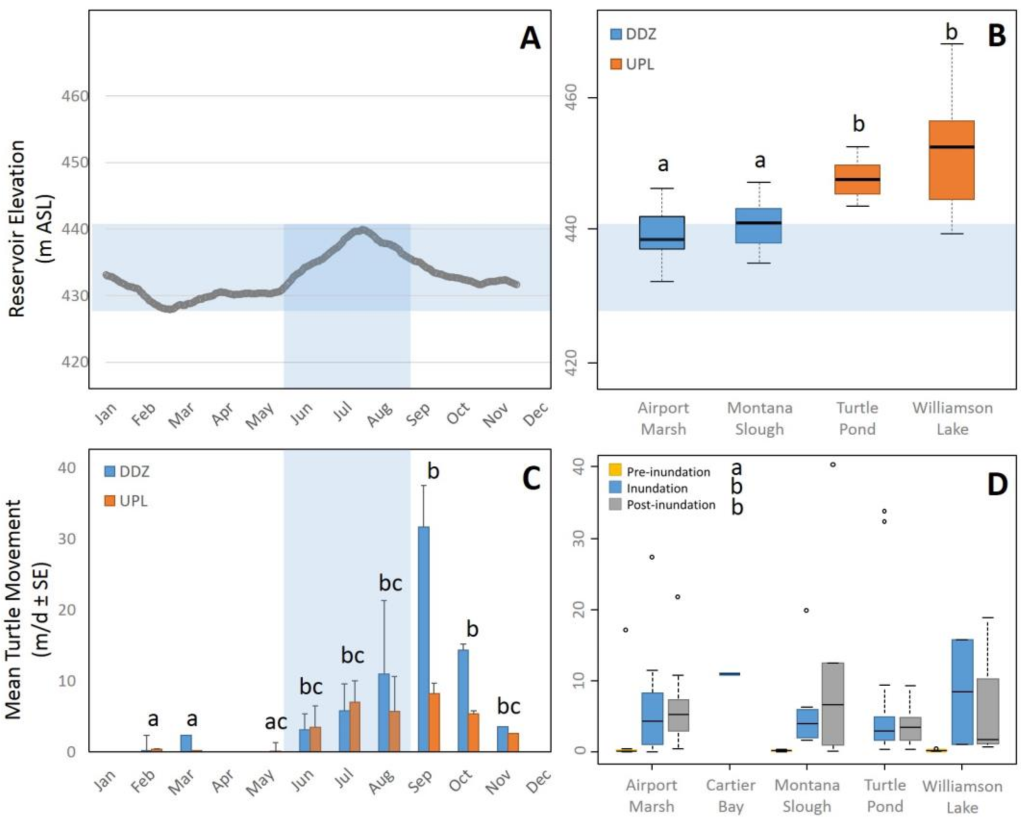


Figure 6-2: Relationships between reservoir elevations (upper panels) and daily movements of turtles (lower panels) for 2013. Reservoir hydrograph, indicating operational elevations and inundation period with blue shading (A); elevation distribution of Western Painted Turtle observations by site and reservoir position (B); daily turtle movements for sites in the drawdown zone (DDZ) and upland (UPL) by month (C); and boxplots (± 95% CI) of daily turtle movements by site and reservoir inundation period (D). Significance of post-hoc multiple comparisons (Bonferroni corrected p-values) are given by lower case letters at α = 0.05; patterns are interpreted for α = 0.1

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Additionally, body condition can have important fitness consequences. We found evidence that turtles occupying the drawdown zone may have reduced weights and body condition relative to turtles in upland reference sites. Females caught in the drawdown sites have lower body weight (*median* = 827 g) than those at Turtle Pond (*median* = 1150 g) and Williamson Lake (*median* = 1135 g) (Figure 5-14). Males and juveniles were lighter than expected for their carapace length in Montana Slough and Airport Marsh compared to upland reference sites (Figure 5-16). Body weight is generally considered a sign of energy reserves, and thus, low body weight indicates poorer condition. For females, energy reserves also relate to reproductive output and thus, can have consequences on productivity. Body size, mass, and condition indices should be evaluated throughout time to further investigate this relationship over time.

A list of potential direct and indirect negative impacts from reservoir operations on turtles of Revelstoke Reach was also produced in the 2012 study year, including a discussion of nest flooding and predation risk (Hawkes et al. 2013).

6.1.2 Theme 2: Mitigation – Reservoir Operations and Effects

Q5: Can minor adjustments be made to reservoir operations to minimize the impact on painted turtles?

This management question is related to H_2 and the discussion associated with this hypothesis relates to Qs 1 to 6 (Section 2.2). Several additional years of documenting the presence of the various life stages and their related habitat use in the DDZ will help determine how the timing of reservoir inundation potentially affects turtles. Based on these data, we will be able to provide recommendations on managing reservoir elevations to benefit the Western Painted Turtle population in Revelstoke Reach.

Currently, we know that cold water can significantly slow movements, alter foraging behaviours, or affect overwintering habits in ectothermic animals, which in turn can delay growth, decrease survival, and reduce reproductive output (e.g., Rollinson et al. 2008). The rapid inundation of ponds, wetlands and shallow drawdown zone areas with cold reservoir water, could have an effect on painted turtles, especially if active season basking locations are submerged or displaced during inundation. Basking logs (or other equivalent forms of floating basking material) are important to a turtles' thermoregulatory system, as well as offering a certain measure of protection from predators (as opposed to shoreline basking). Additionally, during the winter, stable aquatic habitat with appropriate water temperatures, dissolved oxygen levels, and substrates may be most desired by overwintering turtles. We have yet to find evidence for particular water quality associations, though it is likely that significant changes to reservoir levels during winter would affect the overwintering survival of turtles in the drawdown zone.

To address this management question, turtle presence and relative abundance will be correlated with various microhabitat characters and related to reservoir elevations. For example, number and availability of basking logs (e.g., fixed logs, floating logs, etc.), water physicochemistry metrics, vegetation communities, and pond area will be used to evaluate the effect of changing reservoir elevations on turtle habitat use. We will also continue to assess differences in seasonal patterns in turtle locations and morphometrics in turtles from the drawdown zone compared to turtles from nearby reference sites. With the addition of data from future initiatives of the CLBMON-11B3 study, we will understand more fully how reservoir operations influence the population of Western Painted Turtles at Revelstoke Reach, and how the operations might be altered to mitigate impacts.

Q6: Can physical works be designed to mitigate the impacts of reservoir operations on painted turtles?

Certain physical works, such as the addition of floating islands in Montana Slough and Airport Marsh could potentially mitigate any effects of reservoir operations as they would partially mitigate the loss of available habitat in the spring and summer due to reservoir inundation. Montana Slough generally supports a large portion of the Western Painted Turtles at Revelstoke Reach. In 2013, turtles inhabiting the drawdown zone exhibited increased mobility during and after inundation (see Section 5.4.3). The addition of anchored floating islands would provide refuge to turtles during inundation, increased availability of basking habitat during summer months, and add to habitat heterogeneity as this feature is currently lacking in the reservoir. Additional physical works have been proposed to improve the suitability of Revelstoke Reach to painted turtles, such enhancement of known nesting locations (e.g., Red Devil Hill) and other important upland sites. Enhancing or managing existing upland nesting habitat is essential to ensure the long-term viability of this population.

6.1.3 Theme 3: Effectiveness Monitoring

Q7: Does revegetation of the drawdown zone affect the availability and use of habitat by painted turtles?

Q8: Do wildlife physical works (e.g., habitat enhancement) affect the availability and use of habitat in the drawdown zone by painted turtles?

Management questions #7 and #8 are difficult to address at this point, because neither projects (revegetation, physical works) have been implemented in Revelstoke Reach. Several wildlife physical works have been proposed for implementation in select areas of at Revelstoke Reach (Golder 2009a and 2009b). These physical works have been designed to specifically address the loss of shallow valley bottom and wetland habitat, which would have been flooded when Arrow Lakes Reservoir was created. The creation or enhancement of habitats in the drawdown zone of Arrow Lakes Reservoir is intended to improve habitat suitability for several species groups including painted turtles, pond-breeding amphibians, and birds (waterfowl).

6.2 Recommendations

The objective of CLBMON-11B3 is to monitor trends in the Western Painted Turtle population (relative abundance, productivity), determine whether reservoir operations impact these turtles, determine their habitat use, and assess the impacts of any revegetation and physical works on species that use habitats within the drawdown zone of Revelstoke Reach, Arrow Lakes Reservoir.

Monitoring of painted turtles in Revelstoke Reach in 2014 should continue using similar methods applied during previous years. MSc. student Amy Leeming (under the supervision of Dr. Karl Larsen at Thompson Rivers University) is investigating overwintering habitat use by Western Painted Turtles in Revelstoke Reach and will assess how fluctuating reservoir elevations might impact this population, particularly during winter.

Additional recommendations for consideration in future years include the following:

1. Assess turtle hibernating location (e.g., in or on substrate) using temperature profiles of the water column and substrate and correlate with the temperature data from the transmitters. A similar approach was used by Rollinson et al (2008). If turtles are hibernating on the substrate and not it in, they are more likely to be exposed to predation, which needs to be considered as possible limiting factor. This will be investigated in more detail via the graduate research currently being conducted.
2. Year-round surveys are recommended to obtain data of seasonal and annual movements of turtles.
3. Continue to compare the water physicochemistry characteristics between used and unused but suitable habitat during the winter with other studies on Western Painted Turtles. Additional water characteristics should be taken in the shallow water areas of the reservoir; these data can be used to compare what the conditions are like for turtles as the water recedes during winter.
4. Assess the reproductive status of all females captured, particularly during months when females are likely to be gravid. These data will contribute to a more informed assessments of body condition while controlling for reproductive status in females.
5. Several morphometric measurements may not be necessary. We have used standard measures (e.g., straight length carapace length, plastron length, mass) to assess turtle condition, but not others (e.g., tail length). Although tail length has been found to correlate with age of males, we found no strong relationship between mass or size and tail length.
6. GIS should be used to track turtle locations and distances moved during monthly telemetry sessions. In particular, the methods used to assess the likely position of a turtle via telemetry should be refined to include on-the-ground mapping of turtle locations relative to known (used) habitats such as Airport March, Montana Slough, and Turtle Pond. Refining these methods in the field will increase the accuracy of the telemetry data used to assess movement patterns.
7. Graduate research should continue on the turtle population in Revelstoke Reach. The current focus of over-wintering strategies and success has been assessed and the focus of future research should shift to juvenile turtle survival. Discussions with Dr. Karl Larsen are ongoing and a proposed study will be presented to BC Hydro for consideration prior to spring 2014.

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8.0 APPENDICES

Appendix 8-1: Overwintering habitat water quality measurements recorded for 2013 in locations where turtles were present (Table 8-1) and not detected (Table 8-2).

Table 8-1: Average water depths and measurements associated with turtle locations at each study site for January, February, and March 2013

Location	No. Turtles	No. Surveys	Mean Elevation (m ASL)	Total Depth (cm)	Ice Depth (cm)	Water Depth (cm)	Surface Temp (°C)	Surface DO (mg/L)	Surface Conductivity (µs)	Sample Depth (cm)	Depth Temp (°C)	Depth DO (mg/L)	Depth Conductivity (µs)
January													
Airport	8	2	429.1	57.0	24.1	32.9	0.1	5.7	46.8	55.9	0.6	3.7	66.7
Montana	6	1	423.0	72.7	22.0	50.7	0.5	4.6	85.9	72.7	1.8	3.0	114.9
Turtle Pond	1	1	449.3	58.0	31.0	27.0	0.1	3.8	22.4	58.0	0.3	2.1	24.0
Williamson	2	1	461.7	48.5	13.0	35.5	0.0	8.9	-	48.5	0.3	7.9	-
February													
Airport	8	1	437.5	62.5	34.0	28.5	0.4	6.5	56.6	62.5	0.3	4.7	68.6
Montana	6	1	440.3	68.5	29.0	39.5	0.1	2.3	70.0	68.5	0.6	1.1	95.1
Williamson	2	1	458.0	73.5	34.5	39.0	0.3	7.7	55.1	73.5	0.9	7.1	42.5
March													
Airport	3	1	441.0	52.0	28.7	23.3	0.0	11.4	38.0	52.0	0.8	8.1	51.6
Montana	6	1	436.2	58.0	14.3	43.7	1.2	4.8	51.2	58.0	2.7	3.2	93.8
Williamson	2	1	456.0	52.0	15.5	36.5	0.6	11.5	55.3	52.0	1.5	10.3	60.0
Total	**44**	**11**	**437.6**	**61.8**	**25.0**	**36.7**	**0.4**	**5.9**	**58.9**	**61.6**	**1.1**	**4.3**	**80.2**

Table 8-2: Average water depths and measurements associated with non-turtle locations for each study site in February 2013

Location	No. Surveys	Total Depth (cm)	Ice Depth (cm)	Water Depth (cm)	Surface Temp (°C)	Surface DO (mg/L)	Surface Conductivity (µs)	Sample Depth (cm)	Depth Temp (°C)	Depth DO (mg/L)	Depth Conductivity (µs)
Airport	1	97	37.7	59.3	0.6	5.9	85.73	97	0.73	4.23	102
Montana	1	75	33.5	41.5	0.1	4.01	92.4	75	1.1	3.46	110.15
Cartier	1	76	24	52	0.35	7.85	169.9	76	1.4	7.53	183.85
Turtle Pond	1	74	31	43	0.6	7.5	55	74	0.63	4	53.73
Williamson	1	98	37	61	0.2	7.66	58.4	98	2.4	6.09	66.7
Total	**5**	**84.0**	**32.6**	**51.4**	**0.4**	**6.6**	**92.3**	**84.0**	**1.3**	**5.1**	**103.3**

Appendix 8-2: Telemetry locations of western painted turtles made in the winter (January – March) and summer (June – August) of 2013 at Revelstoke Reach.

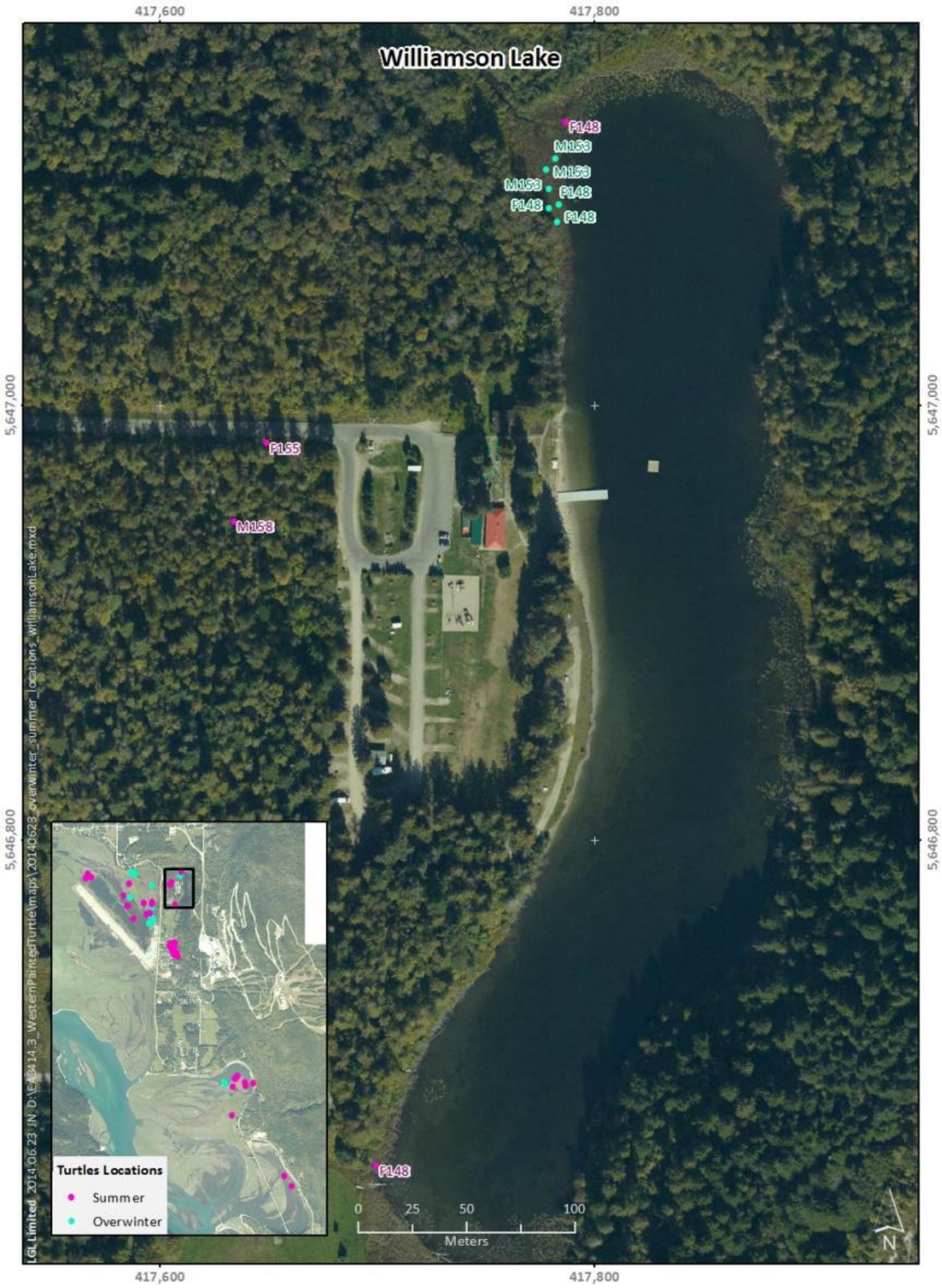
The following maps identify the locations of individual turtle observations (marked with turtle IDs) in each study area

Map 8-1: Western painted turtle locations at Airport Marsh in winter (January – March) and summer (June – August) surveys in 2013. Point labels identify individual turtles (F= female, M= male)

Map 8-2: Western painted turtle locations at Cartier Bay in winter (January – March) and summer (June – August) surveys in 2013. Point labels identify individual turtles (F= female, M= male)

Map 8-3: Western painted turtle locations at Montana Slough in winter (January – March) and summer (June – August) surveys in 2013. Point labels identify individual turtles (F= female, M= male)

Map 8-4: Western painted turtle locations at Turtle Pond in winter (January – March) and summer (June – August) surveys in 2013. Point labels identify individual turtles (F= female, M= male)



Map 8-5: Western painted turtle locations at Williamson Lake in winter (January – March) and summer (June – August) surveys in 2013. Point labels identify individual turtles (F= female, M= male)