Columbia River Project Water Use Plan

Lower Columbia River Fish Management Plan

Implementation Year 2

Reference: CLBMON-49

Lower Columbia River Effects on Wintering Great Blue Herons

Study Period: 2014

Okanagan Nation Alliance, Westbank, BC
and
LGL Limited environmental Research Associates, Sidney, BC

November 17, 2015

ARROW LAKES RESERVOIR

CLBMON-49 Lower Columbia River Effects on Wintering Great Blue Herons




CLBMON-49 Year 2 - 2014/2015

Analysis-Summary

Final Report

Prepared for

BC Hydro Generation
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6911 Southpoint Drive
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Prepared by

Okanagan Nation Alliance

and

LGL Limited environmental research associates

Technical Contact: Nathan T. Hentze, M.Sc.

nhentze@lgl.com; 1.250.656.0127

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EXECUTIVE SUMMARY

This report summarizes the findings of the second year (2014/15) of surveys for BC Hydro's Monitoring Program CLBMON-49: *Lower Columbia River Effects on Wintering Great Blue Herons.* Small but variable numbers of Great Blue Heron (*Ardea herodias*) overwinter in the lower Columbia River and often congregate in the area around Waldie Island near Castlegar. Castlegar is about eight kilometers downstream of the Hugh Keenleyside Dam, which impounds the Columbia River to form Arrow Lakes Reservoir.

Concern about the impact of dam operations on herons during winter was triggered by the death of five herons in the vicinity of Waldie Island during January 2000. In the mid-1990s, BC Hydro had initiated a still-active program to stabilize river flows downstream of the dam in winter to minimize impacts on spawning success of Mountain Whitefish (*Prosopium williamsoni*). That program requires variable river flows prior to whitefish spawning, which corresponds with the beginning of the wintering period for Great Blue Heron. Higher flows for Mountain Whitefish during early winter may directly impact the abundance, density, distribution, and habitat use of herons on Waldie Island and the lower Columbia River.

The general approach for this study is, by necessity, opportunistic. BC Hydro cannot alter flow rates and river elevations at specific times specifically to provide a controlled, experimental basis for this study. Rather, heron distribution and abundance, along with physicochemical and other habitat and environmental parameters are used to assess the pattern of heron use in the lower Columbia River. To put our results in context, we have surveyed for herons at a variety of sites throughout the Kootenays during the winter months. Surveys are completed prior to, during, and after flows related to management of Mountain Whitefish (generally November 1 to February 28) in the Castlegar area, encompassing varied water elevations and flow rates resulting from known dam operations.

In the Kootenay Region, herons were observed in Revelstoke, Burton, Castlegar, Creston, Lumberton and Invermere. Herons were fairly widely distributed in November, but during February surveys were only located in Creston, and one bird near Invermere. Typically only one to three herons were present at any locality, except around Waldie Island and Duck Lake where larger congregations occurred (up to 18 individuals). Daily counts from the Waldie Island area indicate that herons begin returning to the Castlegar area in late July and peak in numbers in September. Heron numbers are relatively high in November, but appear to decline throughout December. From January onwards few to no herons are present in Castlegar, a trend that has been consistent for the past two winters. Despite the trend of higher heron numbers pre-whitefish flows, and the virtual absence of herons post-whitefish flows, there is little evidence supporting a linkage between heron numbers and discharge from the Hugh Keenleyside Dam. Rather, heron numbers were statistically better explained by snow cover (weak relationship), survey year (2013/2014 and 2014/2015), and time of year (whitefish flow period). Differences in heron numbers both within a winter period and between survey years indicate strong inter- and intra-annual variation.

Sites within the Castlegar area did not differ from sites elsewhere in the general Kootenay region in regards to physicochemical and other measured habitat variables. Physicochemical and other habitat variables were likewise similar between sites with herons present and sites without herons, though there was a

trend for herons to potentially select sites with characteristics related to lower stream velocities (e.g., lower levels of dissolved oxygen, finer substrates). These results suggest that winter heron habitat is not limited within the Kootenay region, excepting where water freezes completely over and snow depths exceed a tolerable limit for successful foraging. However, the amount of potentially available habitat in the Castlegar region is highly variable owing to changing water elevations related to Keenleyside discharge. At higher elevations, areas with historic heron use, such as Breakwater Island, may lose the majority of their land area, or be completely inundated as water levels rise. Overall, approximately 99.9 per cent and 78.9 per cent of potential shoreline habitat at Breakwater Island and Waldie Island respectively is inundated between the minimum and maximum water elevations recorded during the November to February period.

Comparing climate data for the region, it is clear that the Rocky Mountain Trench is colder and snowier than other areas of the Kootenays, and herons appear to have relatively low use of that area during the winter. In contrast Castlegar retains open water throughout the winter. In Creston, even though much water freezes, open water remains around sluice gates used for water management, and in holes in the ice. Herons were observed foraging from these ice holes around Creston (most notably Duck Lake), which were the only foraging attempts noted during the 2014/15 winter.

Many factors likely influence the abundance and distribution of over-wintering herons in the Castlegar area. As no known nesting occurs in the vicinity, the over-wintering herons must be from other breeding locations and are thus also subject to population influences and habitat conditions elsewhere. As the dynamics influencing over-wintering herons along the Lower Columbia River are likely complex and interconnected, a regional approach to this study is warranted. Flow regime, while not directly linked to heron numbers, greatly affects the amount of potential shoreline habitat available. Confounding our ability to detect linkages are potential annual changes in breeding success and colony structure elsewhere, lack of ability to manipulate river flows experimentally, changes in environmental conditions, and other potential impacts such as human-caused disturbances. These other factors must be considered, and additional data necessary, before firm conclusions may be drawn, especially related to mitigative actions.

The status of CLBMON-49 after Year 2 (2014/15) with respect to the management questions is summarized below.

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
1 – Where are the shoreline areas that are used by Great Blue Herons?	Yes	• Mapped heron locations showing all shoreline areas where herons detected. • Distribution of herons aligns with historical Christmas Bird Count data. • Occupied sites in Castlegar similar to those used in 2013/14.	• Broaden scope of area for desktop data collection (e.g., Christmas Bird Count data) to determine trends in heron numbers in adjacent regions (i.e., Okanagan Valley)	• Natural annual population variation • Variable dam flows among years and throughout the day • Human and other disturbances potentially limiting site utilization • Difficult to observe at night • Lack of experimentation to assess how varying the flows affects herons at different times through the winter period
2 – How does the flow regime affect the area, distribution, and attributes of shoreline areas?	Partially	• Shoreline areas increase with decreasing water elevation and vice versa. • Physicochemical parameters do not seem to be affected.	• Surveys should aim to capture the periods of highest and lowest water elevations taking duration of inundation into account	• Variable dam operations and inter-annual variation. • Uneven site response
3 – Are there physical works that could improve the availability of shoreline areas for Great Blue Herons on Waldie Island and in the Castlegar area?	Not at this time	• Locations where herons occur and knowledge of how water elevations affects the most commonly utilized roosting areas	• Surveys should aim to capture the periods of highest and lowest water elevations taking duration of inundation into account	• Variable dam operations • Natural annual population variation in numbers and site utilization • Lack of physical works to benefit herons already undertaken from which to inform recommendations
4 – How does the suitability of winter habitat on Waldie Island and in the Castlegar area compare to habitat used by wintering Great Blue Herons elsewhere in the surrounding region?	Partially	• Physicochemical parameters do not appear to differ • Water remains ice-free through entire winter period in Castlegar • Security and foraging opportunities present	• Include areas not surveyed previously such as near Nelson • Investigate heron use of habitats in adjacent regions, such as the United States, specifically habitats where high heron numbers are present.	• Only one year of data for areas outside of Castlegar • Unknown distribution, abundance, or site selection attributes of herons from areas with high winter abundances. • Unknown foraging opportunity or how fish presence/density varies among sites • Natural annual population variation
5 – Are there operational changes that could improve habitat availability and suitability for Great Blue Herons on Waldie Island and in the Castlegar area?	Partially	• Available potential shoreline habitat mapped out at different water elevations	• Surveys should aim to capture the periods of highest and lowest water elevations	• Unknown how fish or other aquatic organisms utilize recently inundated areas

Key Words: heron, Columbia River, habitat use, Hugh Keenleyside, flow regime, Waldie Island

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1.0 INTRODUCTION

Dams regulate the flow regime in the majority of the world's large river systems and the flooding resulting from dam construction and water storage creates a complex disturbance that can modify entire ecosystems (Nilsson and Berggren 2004). Most major rivers in British Columbia have been dammed and such hydroelectric developments have had numerous upstream and downstream impacts on wetland and shoreline ecosystems (Hawkes 2005). These impacts can be broad, interact in complex ways, and are not only restricted to the direct flooding and loss of riparian and wetland habitats upstream of the dam, but extend downstream of the dam through disturbance of the annual flooding regimes (MacKenzie and Shaw 2000). For wetland-dependent organisms, dam operations can impact all life stages. Furthermore, changes to one component to benefit any given species can have unintentional consequences to other organisms within the reservoir system.

Great Blue Herons are one of the most common, widespread, and adaptable species of wading bird in North America. While they may occur in a variety of habitats, they are typically associated with water at all seasons (Vennesland and Butler 2011). Many prey items (e.g., small mammals, frogs, birds) may be taken, though fish are primarily chosen. Both interior (*A. herodias herodias*) and coastal (*A. h. fannini*) subspecies are blue-listed in the province, owing to disturbance and habitat loss (Gebauer and Moul 2001). While the coastal subspecies is typically resident, interior populations may migrate or remain as environmental conditions dictate (Campbell et al. 1990, Machmer 2002, Vennesland and Butler 2011). In the lower Columbia River, small but variable numbers of herons overwinter (Machmer 2003). A number of these wintering birds congregate in the area around Waldie Island, near Castlegar, BC (Machmer 2003, W. Volovsek pers. comm.). The increased use of Waldie Island by herons may be highest when foraging conditions are limited at other sites due to water elevations, disturbances, or environmental conditions (Machmer 2003).

Mountain Whitefish (*Prosopium williamsoni*) spawn in the Columbia and Kootenay rivers during the winter, with peak spawning in January. To minimize dewatering of eggs due to reservoir operations, flows are stabilized during the peak spawning period. Achieving stabilization requires a period of high and variable flow releases prior to whitefish spawning, which corresponds with the beginning of the wintering period for Great Blue Herons. During the Columbia River Water Use Planning process (WUP), concerns were expressed about potential impacts of the operations of Hugh Keenleyside Dam on the herons of Waldie Island (BC Hydro 2005). Higher flows from the Lower Arrow Lake Reservoir for Mountain Whitefish during early December may directly impact the abundance, density, distribution, and/or habitat use of herons on Waldie Island and the lower Columbia River. This study stems from the need to address the response of herons to flow and stage regime from this dam during the winter period due to its potential impacts on foraging and winter habitat, and to determine feasible mitigative actions.

Monitoring the aggregation of herons at Waldie Island and the lower Columbia River requires understanding the movements and behaviours of herons in the broader Kootenay region. By understanding herons in the region, we are better able to assess the habitat availability and suitability within the Castlegar area during the winter period (November 1 to February 28). We may therefore relate the

Hugh Keenleyside Dam flow and stage regime to heron responses in this period due to the potential effects on availability of shallow-water foraging and winter refuge habitats, and may provide information on habitat use and feasible mitigative actions.

This report summarizes the findings of Year 2 (2014/15) surveys for BC Hydro's Monitoring Program CLBMON-49: *Lower Columbia River Effects on Wintering Great Blue Herons.* This project is being delivered collaboratively between the Okanagan Nation Alliance (ONA) and LGL Limited environmental research associates.

1.1 Key Water Use Decision Affected

The key operating decisions that might be affected by this monitoring program are the following:

1) Should the early winter flow releases from Arrow Lakes Reservoir be altered to mitigate potential impacts of high river elevations on overwintering Great Blue Herons in the vicinity of Waldie Island?
   - The monitoring project will provide information on how the current flow regime in the lower Columbia River affects the foraging ecology and overwinter survival of Great Blue Herons.
   - The monitoring project might suggest changes to the flow regime that would improve the availability of shoreline winter foraging areas for Great Blue Herons.
2) Are there physical-works projects that would enhance or create suitable shallow-water foraging areas for the over-wintering Great Blue Herons?

Water flow from the Hugh Keenleyside Dam must balance the needs of fish and spawning habitat with that of water-dependent terrestrial animals (i.e., Great Blue Herons), power generation and environmental objectives while simultaneously addressing requirements under the Columbia River Treaty, such as increased downstream power generation and flood control benefits. Results of this monitoring program will help clarify the relative importance of Waldie Island and surrounding shorelines and shallow water habitat for wintering Great Blue Herons, and provide recommendations on how and if water flow changes can be implemented to minimize or mitigate potential impacts to Great Blue Herons while addressing the aforementioned concerns. Information on the life history requirements of Great Blue Herons in this local context combined with monitoring results will also help inform management decisions regarding the design and location of any potential physical works projects within this study area.

2.0 OBJECTIVES AND MANAGEMENT QUESTIONS

Eight management questions (MQs) were originally developed to address the intent of CLBMON-49 as outlined by the Consultative Committee to (1) address "*whether there was an operational link between the mountain whitefish flows and impacts to herons on Waldie Island*"; (2) *"assess the response of herons to flow and stage regime from the Hugh Keenleyside Dam during the winter period due to its potential effects on availability of shallow-water foraging and winter refuge habitats*"; and (3) "*provide information on habitat use and feasible mitigative actions*." However, over the course of Year 1 of CLBMON-49, it became evident that some revision to the management questions was required. The management questions were revised for Year 2 (BC Hydro 2014).

MQ: Where are the shoreline areas that are used by Great Blue Herons?

MQ: How does the flow regime affect the area, distribution, and attributes of shoreline areas?

MQ: Are there physical works that could improve the availability of shoreline areas for Great Blue Herons on Waldie Island and in the Castlegar area?

MQ: How does the suitability of winter habitat on Waldie Island and in the Castlegar area compare to habitat used by wintering Great Blue Herons elsewhere in the surrounding region?

MQ: Are there operational changes that could improve habitat availability and suitability for Great Blue Herons on Waldie Island and in the Castlegar area?

2.1 Management Hypotheses

Hypotheses were originally presented in the Terms of Reference (BC Hydro 2012) that were designed to test specific relationships between the variation in the number of Great Blue Herons (count data) and water elevations. The original proposal laid out reasons why using a simple linear regression and strict cut-off values for the result was nonsensical in this project. The original management hypotheses were related to management questions that were subsequently dropped. As a result, these management hypotheses were likewise removed (BC Hydro 2014). Instead, we shift the focus of CLBMON-49 to address the quality and availability of wintering habitat in a regional context and how habitat availability is altered in the Castlegar area at different water (flow) regimes.

3.0 STUDY AREA

3.1 Physiography

The Columbia Basin in southeastern British Columbia is bordered by the Rocky, Selkirk, Columbia, and Monashee Mountains. The headwaters of the Columbia River begin at Columbia Lake in the Rocky Mountain Trench and the river flows northwest along the trench for about 250 km before it empties into Kinbasket Reservoir behind Mica Dam (BC Hydro 2007). From Mica Dam, the river continues southward for about 130 km to Revelstoke Dam. The river then flows almost immediately into Arrow Lakes Reservoir behind Hugh Keenleyside Dam. The entire drainage area upstream of Hugh Keenleyside Dam is approximately 36,500 km^2.

The Kootenay River has its headwaters in the Rocky Mountains, just north of Kootenay National Park. From there it flows south through the Rocky Mountain Trench and into Lake Koocanusa, which is impounded by the Libby Dam in Montana. Past the dam it again re-enters British Columbia south of Creston, eventually flowing into Kootenay Lake. From the west arm of Kootenay Lake the river flows west to join the Columbia River in Castlegar. The entire Kootenay Basin encompasses about 46,620 km^2 in both Canada and the U.S.A., and is the second largest tributary of the Columbia River by runoff volume. The Kootenay River flows for about 780 km from the headwaters to its terminus in the Columbia River.

Both the Columbia and Kootenay basins are characterized by steep valley side slopes and short tributary streams that flow into the respective rivers from all directions. The Columbia River valley floor elevation falls from approximately 800m near Columbia Lake to 420m near Castlegar. Over the course of its length, the Kootenay River drops about 1,805 m in elevation, though the majority of that drop occurs near between the headwaters and the Rocky Mountain Trench, with the river dropping less than 305 m between Canal Flats and Kootenay Lake. Approximately 40 per cent of the drainage area within the Columbia River Basin is above 2000 m elevation. Permanent snowfields and glaciers predominate in the northern high mountain areas above 2500 m elevation.

3.1.1 Climatology

Precipitation in the basin occurs from the flow of moist low-pressure weather systems that move eastward through the region from the Pacific Ocean. More than two-thirds of the precipitation in the basin falls as winter snow. Snow packs often accumulate above 2000m in elevation through the month of May and continue to contribute runoff long after the snow pack has depleted at lower elevations. Summer snowmelt is reinforced by rain from frontal storm systems and local convective storms. Runoff begins to increase in April or May and usually peaks in June to early July, when approximately 45 per cent of the runoff occurs. The mean annual local inflow from upstream of the Hugh Keenleyside project is 355 m^3/s.

Air temperatures across the basin tend to be more uniform than precipitation. The winter climate is usually cool and wet. The Environment Canada climate normals between 1981 and 2010 show median snow depths of 0 to 7 cm at the Hugh Keenleyside Dam between the months of November and March. The daily maximum temperature for the same time period ranged from 0.5 to 4.8˚ C.

3.2 Arrow Lakes Reservoir

Arrow Lakes Reservoir is an approximately 230 km long section of the Columbia River drainage between Revelstoke and Castlegar, BC (Figure 3-1). It has a north-south orientation, set in the valley between the Monashee Mountains in the west and Selkirk Mountains in the east.

Two biogeoclimatic zones occur at lower elevations surrounding Arrow Lakes Reservoir: the Interior Cedar Hemlock (ICH) and the Interior Douglas-fir (IDF) (Figure 3-1). The majority is ICH, with IDF restricted to the southernmost portion of the area. The Arrow Lakes Reservoir is situated within the province's Selkirk Resource District.

Most of the Columbia Basin watershed is forested. Dense forest vegetation thins above 1500 m elevation and tree-line occurs at ~2000 m elevation. The forested lands around Arrow Lakes Reservoir have been and continue to be logged, with recent logging occurring on both the east and west sides of the reservoirs. The area around Castlegar is urbanized with a population of approximately 8,000. Commercial, industrial, residential and recreational developments all exist along the Columbia River in the vicinity of Castlegar.

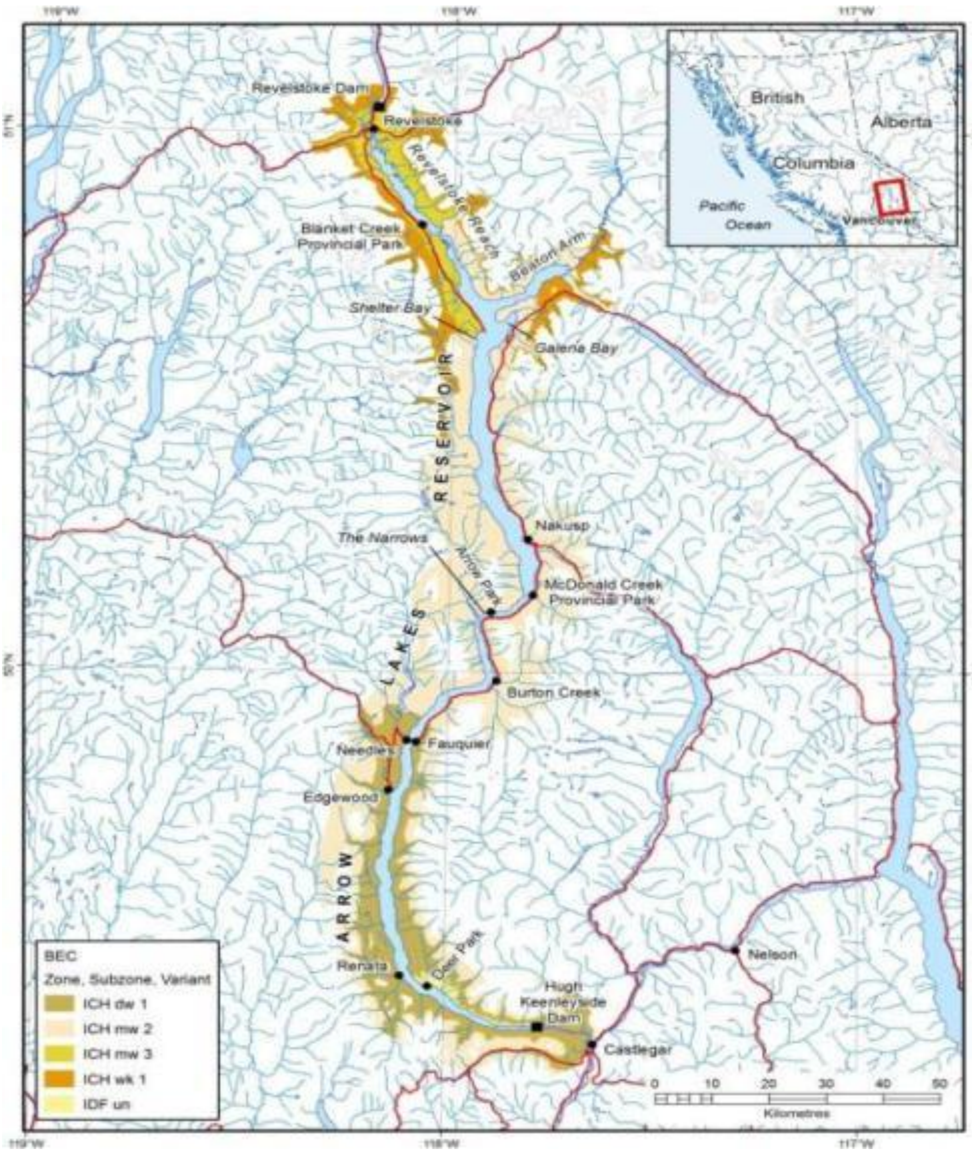

Figure 3-1: Location of Hugh Keenleyside Dam and its relation to Castlegar and the Arrow Lakes Reservoir in British Columbia

The Hugh Keenleyside Dam, located 8 km west of Castlegar, spans the Columbia River and impounds Arrow Lakes Reservoir. Arrow Lakes Reservoir has a licensed storage volume of 7.1 MAF[1] (BC Hydro 2007). The normal operating range of the reservoir is between El. 418.64 m and 440.1 m ASL. Reservoir elevations are determined by flows through Hugh Keenleyside Dam, which in turn determines the elevation of the Columbia River downstream of the dam. Flow rates vary throughout the year, typically reaching peaks in early winter and mid-summer (Figure 3-2).

[1] One acre-foot is the volume of one acre of surface area to a depth of one foot. One million acre-feet (MAF) is equivalent to approximately 1.2 trillion litres.

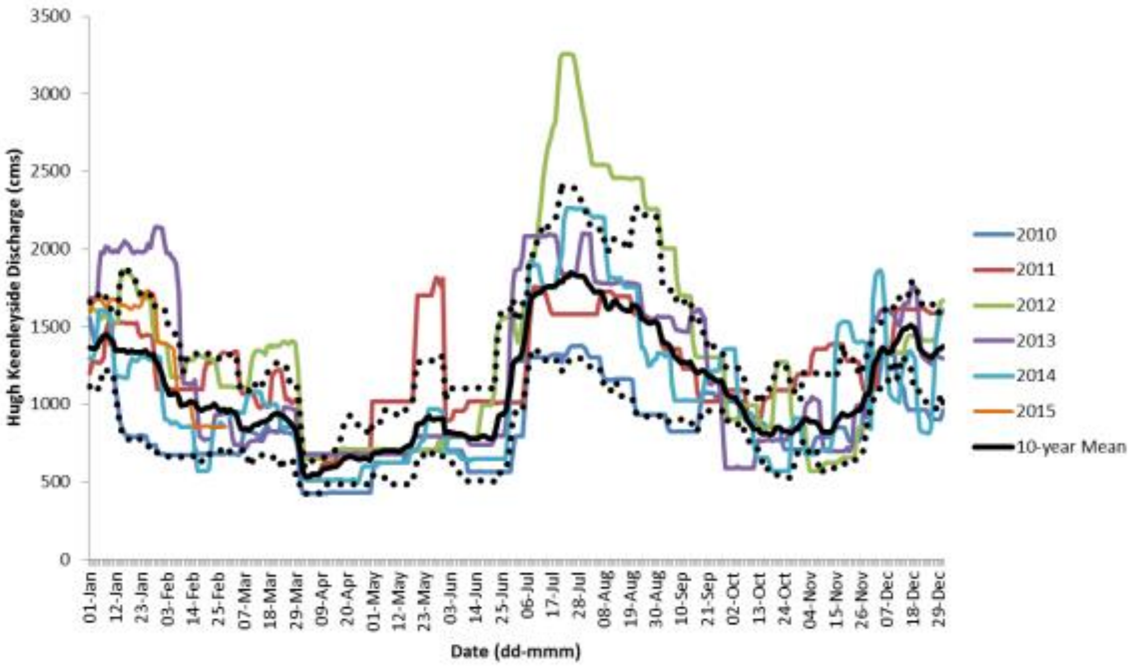

Figure 3-2: Hugh Keenleyside Discharge rates (cubic metres per second) from 2010 to 2015. Dotted lines represent the 10th and 90th percentiles. The 10 year mean (2005 through 2014) is provided to indicate the general timing of high and low flow rates

3.3 Study Location

The study area for CLBMON-49 was expanded during the second year to encompass a broad area of potential habitat for Great Blue Herons wintering in the Kootenay region. The regional area extends from Revelstoke in the northwest and follows the Arrow Lakes Reservoir south through to Castlegar in the southwest. The study area then extends eastward to include Creston and as far south as the Canada-United States border and over to Cranbrook and Fort Steele. From there the study area followed the Kootenay River northwards including Columbia Lake before terminating in the Kimberley/Invermere area. This resulted in a roughly horseshoe-shaped study area (Figure 3-3).

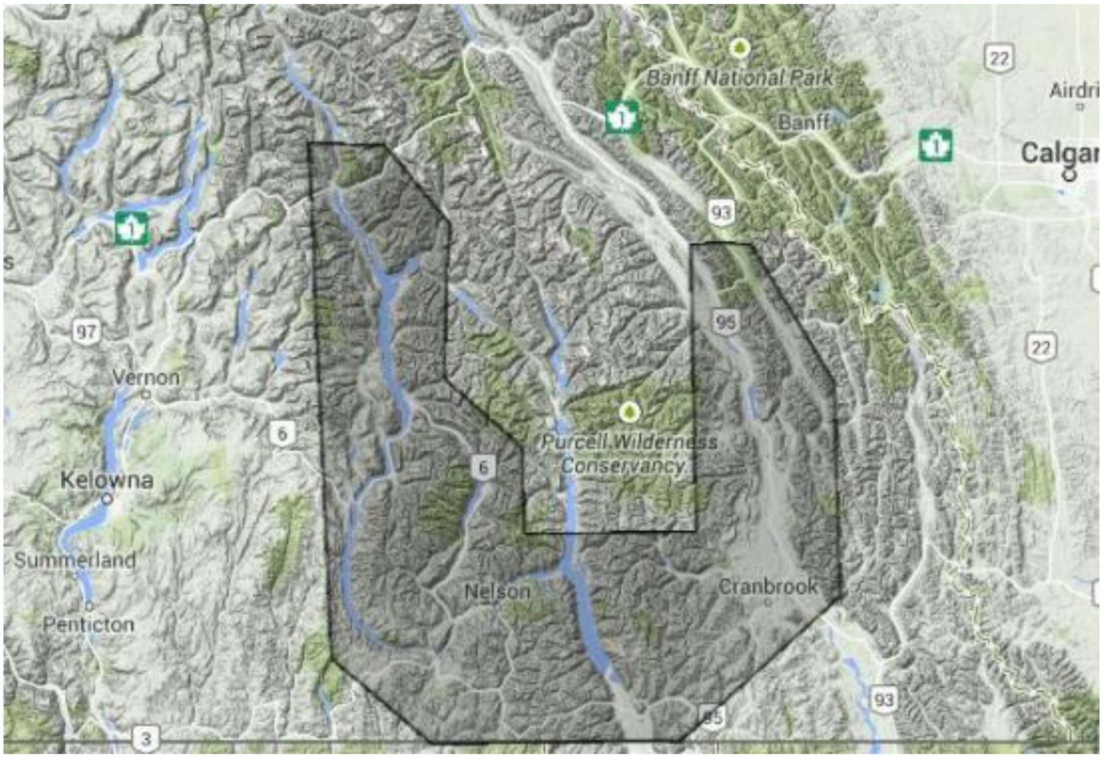

Figure 3-3: Overall study area in the Kootenay Region during the 2014/15 survey year. The study area essentially follows the Columbia River south from Revelstoke, including the Arrow Lakes Reservoir, as well as the headwaters at Columbia Lake. The Kootenay River is followed from south of Columbia Lake to Cranbrook, and again at Creston and near the confluence with the Columbia in Castlegar

To remain consistent with the first year of study, this regional area included all sites previously included during the first year of study. That local area remains the area of interest for some management questions related specifically to the Hugh Keenleyside Dam and the Waldie Island vicinity. That local area is roughly bounded by the Hugh Keenleyside Dam in the west, the Brilliant Dam in the east, and the Kinnaird Bridge (Hwy 3) to the south, and follows the Columbia and Kootenay Rivers between these locations (Figure 3-4). Within this local study area, the focus is on Waldie Island and immediately adjacent locations (e.g., Breakwater Island) (Figure 3-5).

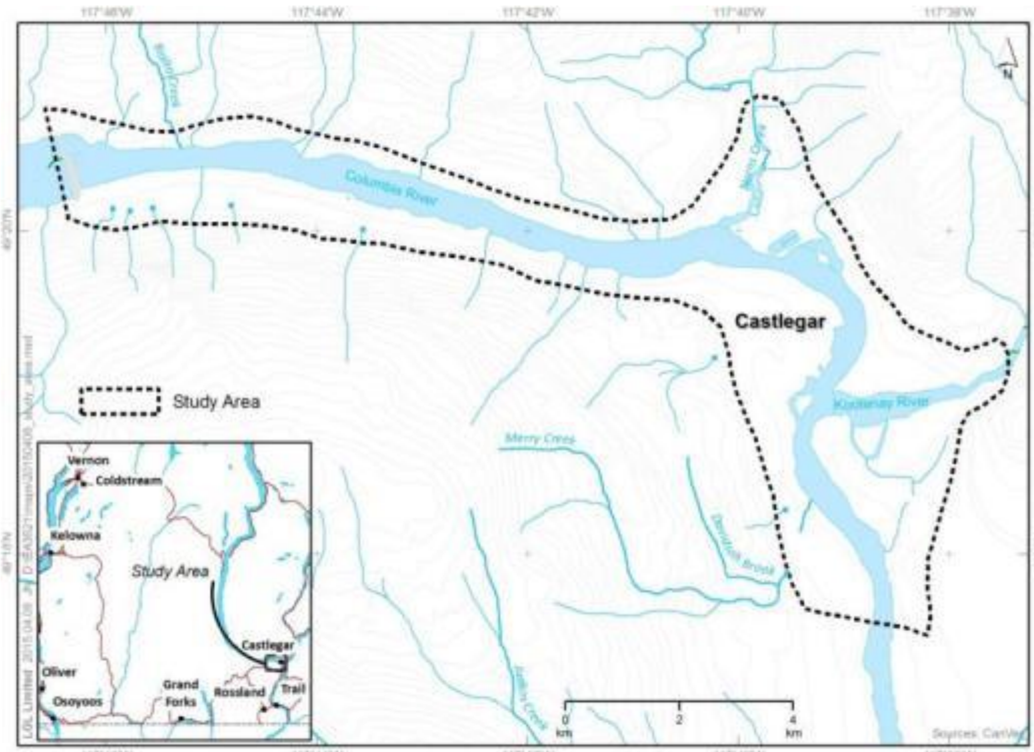

Figure 3-4: The CLBMON-49 study area is bounded by the Hugh Keenleyside Dam in the west, the Brilliant Dam in the east, and the Kinnaird Bridge to the south, and includes all shoreline locations within that area

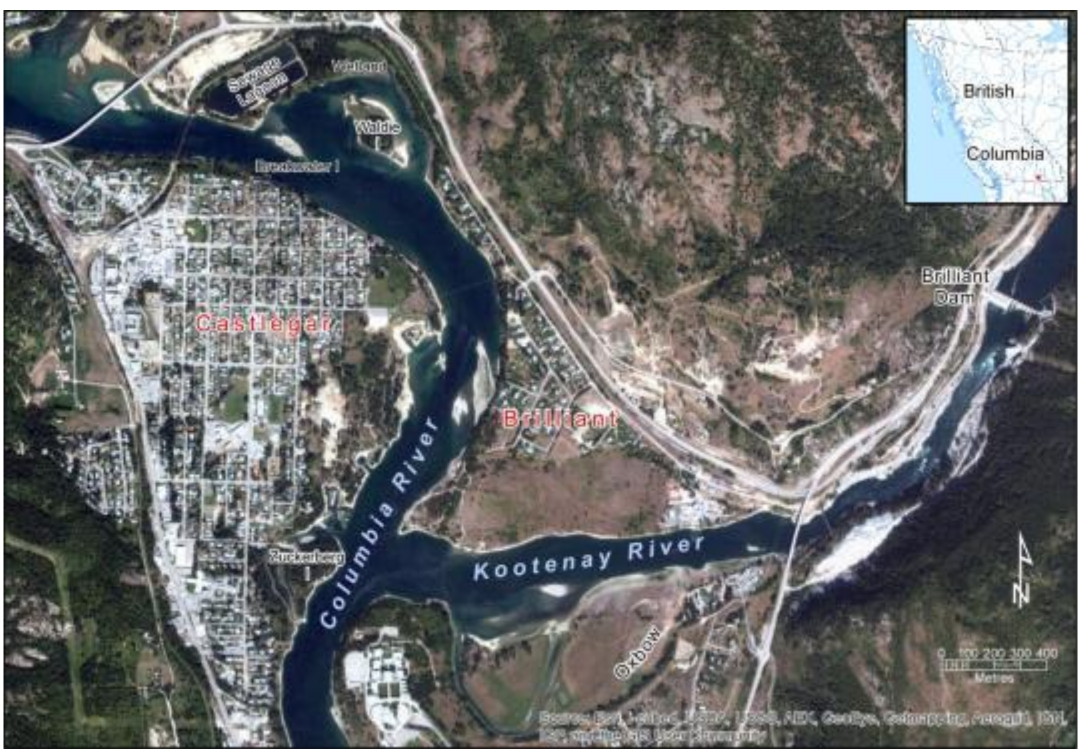

Figure 3-5: Satellite view of area of interest for CLBMON-49. Locations within the main area of interest (Waldie Island, Breakwater Island, etc.) are labelled

Water and shoreline sampling was conducted at 63 locations spanning the regional study area (Figure 4-2, Appendix A). In addition to these locations, scans for herons were completed at multiple locations where shoreline sampling was not possible due to access reasons. Including sites where shoreline sampling occurred, herons were searched for at approximately 121 unique locations. Sampling and observation sites in Castlegar were selected to include all areas visited during the 2013/14 field season. Most vantage points in the Castlegar area were at the same location as shoreline sampling sites. However, several key vantage sites were accessed solely to scan for herons including Nimby Point (north end of 2nd Ave.), the old log ramp just west of the Pass Creek delta, and the Waldie Island Trail running between the south end of Old Mill Rd. and the west end of Brilliant Rd. which provides visibility into the sewage lagoons (via an installed observation platform), Breakwater Island, Waldie Island, and the surrounding foreshore areas on both sides of the Columbia River.

Survey areas outside of the Castlegar area were chosen in part based on heron locations from existing data sources (i.e., Christmas Bird Count data and eBird). Christmas Bird Count and eBird data sources both have inherent limitations, but these were only used to identify sampling areas. Areas with varying levels of historic habitat suitability, from high (such as around Castlegar and Creston) to moderate (such as around Nakusp and Invermere) to low (such as Revelstoke and Cranbrook) were selected for sampling. Within each of these broad areas, precise locations for sampling were identified using locations of historic sightings and by using digital maps to determine additional sites that appeared to have (1) a waterbody (e.g., lake or river), and (2) public access. Additional serendipitous sampling was encouraged in the field at sites that looked appropriate and as time permitted.

4.0 STUDY DESIGN AND METHODS

4.1 Study Objectives and Scope

The Water Use Plan Consultative Committee outlined the general objectives to be addressed by CLBMON-49. The objectives of this study are:

1. Address whether there was an operational link between the mountain whitefish flows and impacts to herons on Waldie Island;
2. Assess the response of herons to flow and stage regime from the Hugh Keenleyside Dam during the winter period due to its potential effects on availability of shallow-water foraging and winter refuge habitats; and
3. Provide information on habitat use and feasible mitigative actions.

4.2 Study Approach

The general approach for this program is, by necessity, opportunistic in nature. Given BC Hydro’s operational constraints, an experimental approach cannot be taken. That is, BC Hydro cannot alter flow rates/water elevations at specific times specifically to provide a controlled, experimental basis for this study. Rather, heron counts and habitat surveys were completed throughout the period of interest (November 1 to February 28), encompassing varying water elevations and flow rates through predictable operationally-mediated changes. Survey sessions cannot be scheduled for a specific flow rate or water elevation, given the variability around those measures, but were planned to span the period prior to and after flows related to management of the Mountain Whitefish. Water flow/elevation data were then compiled based on data provided by BC Hydro following the sampling period. As a consequence of this opportunistic study design, regional data on heron numbers are used to better understand fine-scale changes in the Castlegar area. Together, these data are used to infer wintering heron habitat suitability in the Castlegar area, especially around Waldie Island.

4.3 Field Schedule

Field sampling incorporating heron counts and shoreline surveys was conducted between November and February to coincide with the heron over-wintering period prior to, during, and after flows related to Mountain Whitefish management, as documented by Machmer (2003). To survey the region as a whole, two sampling periods were established, each twelve days in duration. The first sampling period occurred from November 17 to 28, 2014 and the second occurred from February 10 to 21, 2015.

With two sessions completed, the total number of comprehensive survey days was 24, equivalent to the effort expended during 2013/2014 despite a broadening of the study area, and a reduction in the total number of survey sessions. The sampling effort is also consistent with Machmer (2003), despite the weekly sampling of that study.

In addition to the heron and shoreline sampling survey days, near-daily counts of herons were made on the Waldie Island area throughout the year with the cooperation of local citizens. These daily observations provide count data with higher resolution than any previous surveys, and span the entire pre-, during, and post-whitefish flow periods. Thus, during the November 1, 2014 to February 1, 2015 survey period, 24 days of heron counts plus shoreline sampling was conducted by LGL and ONA biologists, while heron counts of Waldie Island were completed on 120 days by local observers.

4.4 General Data Collection

The focus of this study is on the herons of Waldie Island and immediate surroundings. However, herons are capable of dispersing throughout the region (and beyond) for reasons that may not be related to flows from the Hugh Keenleyside Dam. For a better regional understanding of heron numbers and distribution to be obtained, broad surveys of the Kootenay region were completed twice during the survey period, once prior to whitefish flows, and once post-whitefish flows.

In addition to counting herons, shoreline sampling was conducted whenever possible during these two survey sessions. Shoreline sampling was conducted at all sites surveyed during the 2013/14 field season, in addition to novel locations throughout the Kootenays. Behavioural observations were done opportunistically wherever herons were encountered to determine the instantaneous behaviour of all observed herons.

For both behavioural and shoreline surveys environmental conditions were recorded. These conditions included the air temperature (°C), wind speed (km/h), and relative humidity (per cent) (all measured with a Kestrel® 4000 weather meter [Nielsen-Kellerman, http://www.nkhome.com]), and cloud cover, ceiling height and precipitation assessed visually. Other initial data common to all survey types were the start and end time, site name, date, GPS location and elevation, observer names, and the number and age(s) of any herons and eagles present.

Due to the limited field time each day (due to day length) and each sampling period, surveys were completed from dawn until dusk. Although some weather conditions (e.g., fog, heavy snow) could prevent surveys from being completed, these conditions were virtually absent during the sampling sessions.

Water elevation was based on measurements from the Norns Creek gauge (CNN). Water flow rate was the sum of Hugh L. Keenleyside Dam (HLK) and the adjacent Arrow Lakes Generating Station (ALH) discharges. Elevation and flow measurements were collated from data provided by BC Hydro and Poisson Consulting Ltd. after the field season ended.

4.5 Heron Surveys

Upon arriving at a site, all visible shoreline and surrounding trees were surveyed for heron presence and abundance (RIC 1998). Initial scans were conducted by naked eye, and with the aid of 8x or 10x binoculars. Herons are large and conspicuous birds when perched in the open; however, they can be considerably less visible when perched in trees or tucked into shoreline rocks or vegetation (Figure 4-1).

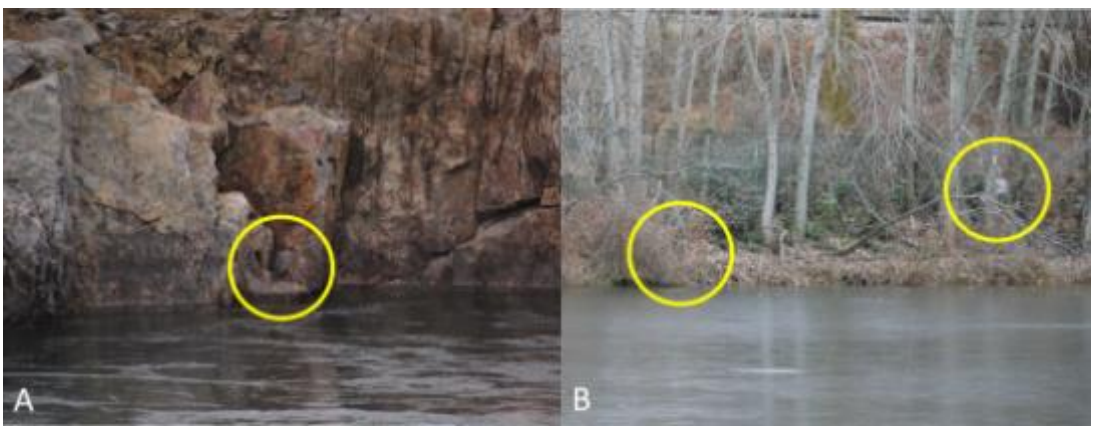

Figure 4-1: Herons are large, conspicuous birds when perched in the open, but can be considerably harder to detect against rocky (A: HLK Dam) or vegetated (B: Castlegar Sewage Lagoon) backgrounds

For this reason, a more detailed scan using a 20-60x spotting scope was also conducted (RIC 1998). The total number of herons present (if any) was recorded. Whenever possible, each individual was assigned to an age class of immature or adult based on plumage characteristics. Next, if more than one heron was present at a site, the distance between individuals was recorded. A range finder was used to accurately measure distance, and a compass bearing recorded, from the georeferenced observation location to the bird(s). The physical location of each bird (e.g., 4 m from shore in river, 10 m high on outer branch of tree, etc.) was also noted. While the observer conducted the initial scan, the recorder documented environmental and count data on standardized data sheets. Data sheets were also developed for recording start and end times, site, and weather details for sites where no herons were recorded, to document survey effort.

When herons were encountered, brief behavioural observations were recorded based on what the individual was doing at the time of observation. Multiple behaviours were recorded if observed, but no formal behavioural observation period was implemented. Nonetheless, the behavioural categories were defined as:

- Resting – either standing or perched in tree, with or without head tucked into back. Typically with neck retracted, and little to no movement.
- Preening – remaining in place, but actively grooming by rubbing feathers through bill, often with some flapping or stretching to re-arrange feathers.
- Foraging – wading slowly through water or sitting motionless but with neck extended. Obviously focused on ground, water or water's edge.
- Alert – remaining in place, but with neck extended and sometimes appearing somewhat agitated, such as in response to some disturbance. No obvious intent of foraging (i.e., not focused on substrate).
- Walking – moving purposefully along a substrate, but no obvious intent of foraging.
- Flying – flight along a path, for any distance. Often, but not always, preceded by other behaviours (e.g., preening or alert).
- Other – observer defined category for any behaviours not easily classifiable into one of the above (e.g., stretching [without preening], defecating).

Natural or anthropogenic factors influencing wildlife use, such as human or wildlife-induced disturbances, were noted. As Bald Eagles are known predators of Great Blue Herons (Vennesland and Butler 2011), and have the potential to affect heron density and distribution, all eagle observations were also recorded, regardless of their perceived activity.

4.6 Shoreline Surveys

4.6.1 Habitat Availability

Habitat availability was assessed digitally for the area downstream of Hugh Keenleyside Dam at different water elevations. Using a subset of a LiDAR point cloud comprised by ~47 million bathymetric and topographic 3D points, a digital elevation model (DEM) was created. The topographic and bathymetric datasets were collected on October 2012 and November 2011, respectively. Using aerial imagery from Fall 2012, the study area in the Columbia River was delineated. Based on available imagery and the DEM, the delineated area was selected as the upper shore line from west of Pass Creek to south of the Columbia/Kootenay confluence, and along the Kootenay River as far as Brilliant Dam. The Waldie Island and Breakwater Island areas were independently delineated. Once the DEM and the area of study were created, different water levels were used to simulate the potential change in habitat availability.

4.6.2 Habitat Suitability

Shoreline characteristics and water physicochemical parameters were recorded to aid in assessing the potential impacts of increasing flow and water elevations on wintering herons. Shoreline surveys were completed throughout the study region (Figure 4-2, Appendix A). Shoreline sampling procedures generally followed the Canadian Aquatic Biomonitoring Network (CABIN) field manual (2012). All data were recorded on standardized datasheets printed on waterproof paper. In addition to recording environmental conditions, surveyors took photographs of each site (upstream, downstream, cross-stream, substrate, and shoreward), as well as the general physical attributes of the shoreline areas including stream habitat type (riffle, rapids, straight run, or pool/back eddy), surrounding vegetation (presence and dominance of vegetation groups: shrubs, deciduous trees, coniferous trees), width of shoreline (from vegetation edge to water's edge), length of shoreline, periphyton and macrophyte coverage, and locations of sources of disturbance (e.g., roads, walking paths) (CABIN 2012).

Macrophyte coverage referred to the quantity of rooted aquatic vegetation that was present within the water or its reach, including submergent, emergent (e.g., bullrushes, reeds), and floating (e.g., duck weed, water lilies) vegetation. Periphyton is a mix of algae, detritus, cyanobacteria and microbes that are attached to submerged surfaces (e.g., rocks) (CABIN 2012). Together, macrophyte and periphyton coverage can characterize benthic macroinvertebrate microhabitat. Macrophyte and periphyton coverage are expected to influence fish presence and abundance by providing cover and macroinvertebrate forage. However, no direct estimates of fish presence or availability are made in this study. It is acknowledged that fish availability is an important component of habitat suitability. However, given current data limitations, this study has an inherent assumption that fish presence is possible at any shoreline site, and that fish abundance does not markedly change across time periods, or in other words, that prey availability is constant among sites.

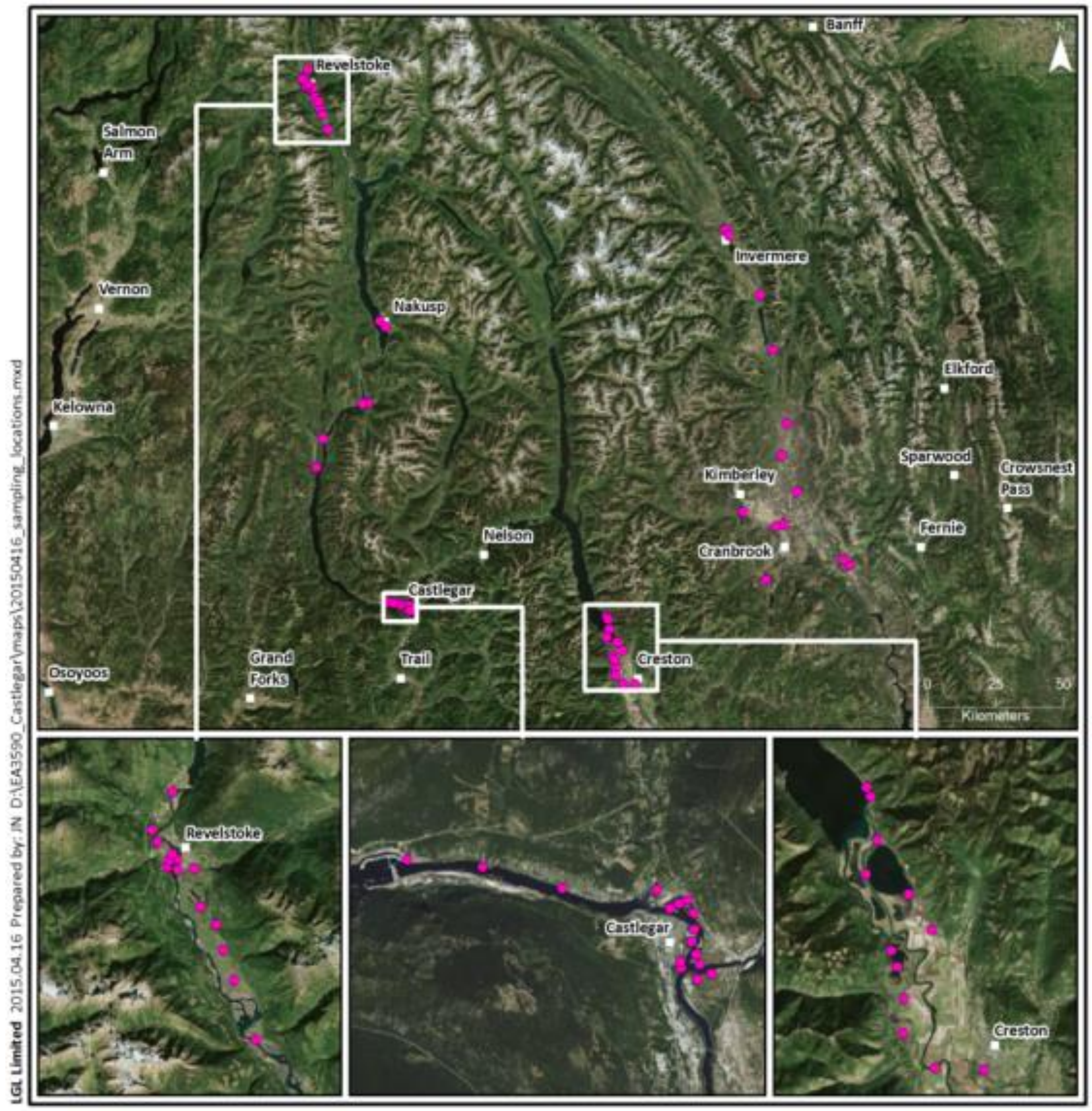

Figure 4-2: **Shoreline sampling locations (pink dots) were scattered throughout the study region to sample representative sites both with and without heron activity. Sampling locations around Castlegar (bottom middle) were the same as those surveyed in 2013/14**

Water chemistry data were measured at three locations (separated by approximately 5 to 10 m) at each site to create an average site value. In the water near shore (at a depth of roughly 30 cm), water chemistry data were measured using a YSI Pro2030 instrument, a YSI 6-Series Sonde (YSI Inc., <www.ysi.com>), a pHTestr 30 meter (Eutech Instruments PTE Ltd. <http://www.eutechinst.com/>), and a Triton Turbidity Wedge (Triton Environmental Consultants Ltd, Richmond, BC) . The recorded water chemistry variables and their definitions (based on RIC 1998b) are described in Table 4-1.

Table 4-1: Physicochemical and environmental variables collected during shoreline sampling at each survey site. These variables are the same as those measured during the 2013/14 field-season. Definitions and justifications for the measured parameters were compiled from the Canadian Aquatic Biomonitoring Network (CABIN 2012) and Guidelines for Interpreting Water Quality Data (RISC 1998b)

Parameter	Definition and Justification
Dissolved Oxygen (mg/L)	Dissolved oxygen (DO) is the amount of oxygen dissolved in water, and is essential for respiratory metabolism of most aquatic organisms. The concentration of DO is a function of daily and seasonal factors such as temperature, photosynthetic activity and river discharge. Higher concentrations of DO are generally considered better for supporting diverse animal communities.
Specific Conductance (µS/cm)	A measurement of the ability of water to conduct an electric current. Conductivity is affected by temperature, and specific conductance is temperature corrected conductivity. Specific conductance values increase with greater ion concentration in the water, and can be used as an alternative measure of dissolved solids. It can be used to indicate potential pollution.
pH	pH is a unit-less measurement of hydrogen-ion concentration in the water, ranging from acidic to basic. Lethal effects on aquatic life occur below pH 4.5 (too acidic) and above pH 9.5 (too basic), and young fish and aquatic insects are especially vulnerable to extreme pH values. Water within a pH range of 6.5 to 9 is optimal for the greatest diversity of aquatic organisms.
Temperature (˚C)	Temperature is the intensity of heat stored in a volume of water. Temperature affects the solubility of compounds which can exacerbate the effects of pollutants. In addition, cold water is more likely to support ice formation which can impact a heron’s ability to forage.
Turbidity (NTU)	Turbidity is a measure of the clarity of water due to suspended particulate matter. It is measured in Nephelometric Turbidity Units. More turbid water has greater particulate matter and appears murkier. Water with high turbidity is associated with decreased oxygen levels, decreased photosynthetic activity, disease-causing micro-organisms, reduced growth rates of fish or other aquatic organisms, and cessation of egg and larval development.
Macrophyte and Periphyton coverage	Macrophyte coverage refers to the quantity of rooted aquatic vegetation that was present within the water or its reach, including submergent, emergent, and floating vegetation. Periphyton is a mix of algae, detritus, cyanobacteria and microbes that are attached to submerged surfaces. Together these characterize benthic macroinvertebrate microhabitat.

Parameter	Definition and Justification
Substrate Class	Dominant substrate ranges from organic cover to bedrock. Macrophyte and periphyton coverage will be influenced by the substrate type. Herons are expected to be able to utilize most substrates, but certain preferences may exist.
Water Velocity (m/s)	Water velocity is the measure of the speed of water flowing past a specific point in a given period of time. Water velocity may influence a heron's ability to forage.

Finally, the dominant substrate class (Table 4-2) and local water velocity (m/s) were measured. Water velocity was measured using a head rod measurement technique (CABIN 2012). This consisted of placing a meter stick vertically in the stream with the narrow edge in line with the oncoming flow of water and measuring the water level (flowing water depth [D1]). Then, with the wide ruler surface perpendicular to the water flow, the water level was again measured at the upstream side of the ruler and recorded (depth of stagnation [D2]). Velocity was then calculated using the formula:

$$Velocity = \sqrt{\left(2\left((D2 - D1)/100\right)9.81\right)}$$

Table 4-2: Dominant substrate codes and definitions (from CABIN 2012)

Code	Definition	Code	Definition
0	Organic Cover	5	3.2-6.4 cm (large pebble)
1	<0.1 cm (fine sand, silt , clay)	6	6.4-12.8 cm (small cobble)
2	0.1-0.2 cm (coarse sand)	7	12.8-25.6 cm (large cobble)
3	0.2-1.6 cm (gravel)	8	>25.6 cm (boulder)
4	1.6-3.2 cm (small pebble)	9	bedrock

4.7 Climatic Conditions

Local environmental data were downloaded from Environment Canada for the Nov. 1, 2014 to Feb. 28, 2015 period. In total, data from 16 stations were accessed. These stations were selected as they represent locations throughout the entire study region. The stations, as named by Environment Canada, are: Golden A, Revelstoke A, Revelstoke Airport, Nakusp CS, New Denver, Kaslo, Kimberley PCC, Cranbrook Airport, Cranbrook A, Nelson NE, Nelson Rixen Creek, Nelson CS, Castlegar BCHPA Dam, Castlegar A, Warfield, and Creston Campbell.

Historical average temperatures for the entire region were compiled and downscaled by WorldClim using climatic time series data over a 50-year time period (1950-2000) (Hijmans et al. 2005) and the SRTM (USGS 2004) digital elevation model. This global dataset is composed of several layers of temperature and other bioclimatic variables in grid format with a spatial resolution of 30 arc-seconds, which is equivalent to one squared kilometre at the equator. These data were visualized in ArcGIS 10.3.

4.8 Data Analysis

As discussed, the formal testing of management hypotheses was abandoned owing to the inability to alter flow rates experimentally and the low sample size of wintering herons. In order to be valid and biologically meaningful, statistical testing should be based on studies that have a good study design (including controls and replication) and adequate sample sizes. The lack of experimental ability makes it challenging to link flow regime from the Hugh Keenleyside Dam to heron counts in the Castlegar area. Furthermore, the influence of covarying factors such as time or environmental conditions further confounds any observed trends. For this reason we have pursued a greater focus on habitat attributes and heron distribution and abundances in the greater region. However, to align with the study objectives, we maintain some analyses related to shoreline parameters measured among locations and time periods, and to daily heron counts and water elevation in the Castlegar area. It is important to consider that there were a limited number of sites with herons present, limiting the power of any tests analysing that response. Results of all statistical tests were considered significant at $\alpha = 0.10$. All statistical analyses were carried out using R (R Core Team 2014).

4.8.1 Habitat Parameters

We investigated differences in habitat parameters for surveys conducted in November 2014 (pre-whitefish flow) vs. February 2015 (post-whitefish flow). All parameters failed the Shapiro-Wilk test for normality ($p < 0.1$), thus non-parametric tests were employed for significance testing. To test for differences in habitat parameters between pre- and post- whitefish flow periods, we performed paired Wilcoxon Signed-Rank Tests ($n = 44$ sites visited in Nov and Feb) for the following variables: water temperature, dissolved oxygen, specific conductance, pH, turbidity (YSI), velocity, air temperature.

The Wilcoxon Signed Rank Test considers the magnitude of the difference for each before-and-after paired sample, and assigns mean ranks to this absolute difference. Additionally, the sign of the difference (+/-) is added, and the lesser of the sum of the positive ranks or negative ranks is compared to a critical value ($\alpha = 0.1$; d.f. = 43). If the calculated value is smaller than the critical value, then the values can be considered to differ statistically. Wilcoxon tests were performed using the 'stats' package in R (R Core team 2014). Because multiple tests were conducted, we corrected the p-values for the number of variables that were formally tested. A bonferroni correction was applied in which p-values are multiplied by the number of tests conducted. Thus the adjusted p-value equals the unadjusted p-value multiplied by the number of tests conducted.

To examine the variation in environmental parameters between sites at Castlegar and all other areas, we created boxplots of each parameter of interest by locality. There were 16 sites that fell within the Castlegar area (30 observations), and the remaining 47 sites were from other localities (77 observations). We plotted locality by air temperature, water temperature, turbidity, water velocity, dissolved oxygen, specific conductance, and pH.

4.8.2 Regional Heron Presence

A multiple logistic regression was conducted to determine if a suite of habitat variables could predict the probability of heron presence. Owing to a small sample size of sites with heron presence, only numerical factors were included (i.e., no categorical variables such as substrate type) to retain sufficient degrees of freedom for the analysis. The resulting variables included were: air temperature, water temperature, turbidity, water velocity, dissolved oxygen, specific conductance, and pH. A site was considered to have heron presence if a heron was detected within a 250 m buffer from the sampling location.

Only sites from which no herons were observed in any time period (either November or February) were selected for heron 'absence' data (November and February). Due to missing values for some parameters, 21 of the 95 records were excluded, leaving only 74 observations used to fit the Generalized Linear Model (GLM). Of the original 14 observations of heron presence, two were excluded in this process, due to missing values. All variables were tested for correlations using a Spearman Rank correlation test, performed with the 'Hmisc' package in R (Harrell et al. 2013). The Spearman Rank correlation was chosen (rather than Pearson) since these parameters were found to deviate significantly from normal. No variables were sufficiently correlated to justify their removal from the full GLM ($-0.7 < r < 0.7$).

The GLM was run with a binomial error structure. The residual deviances were small relative to the degrees of freedom, thus overdispersion was not suspected. However to test whether the quasibinomial error structure was a better fit, we re-ran the GLM using the 'quasibinomial' family (Crawley 2007). The binomial GLM was tested against the quasibinomial GLM using an ANOVA test (specifying 'test' = chi.test, for presence/absence data). The quasibinomial model did not improve fit, thus the binomial error structure was chosen in subsequent analyses.

For the GLM, a stepwise procedure was used to remove variables from the full model, one-at-a-time, until the best model was found (by means of Akaike Information Criterion). ANOVA test was subsequently used to compare the reduced model to the fuller version and to the initial (saturated) model, until any further removals produced a significantly poorer fit.

4.8.3 Castlegar Heron Counts

A multiple regression was conducted to determine whether the maximum daily count of herons on Waldie Island could be predicted by Keenleyside flow rate, tailrace elevation data, air temperature, precipitation, and/or snow height in two winter survey periods (2013/14 and 2014/15) and three levels of whitefish-flow period (pre-, during, and post-). Count data were selected from November 1, 2013 to February 28, 2014 (Winter 1) and November 1, 2014 to February 28, 2015 (Winter 2), totaling 240 observation days. During this time period at least one heron was detected on 123 days. Further, 18 rows of data were omitted from the final data table, due to missing data, leaving 222 observations and 8 variables for model building.

All variables were tested for correlations using a Spearman Rank correlation test, performed with the 'Hmisc' package in R (Harrell et al. 2013). The Spearman Rank correlation was chosen (rather than Pearson) since these parameters were found to deviate significantly from normal. Elevation and flow were significantly, positively correlated ($r = 0.74$, $n = 240$, $p < 0.0001$), thus, flow was excluded. The heron prediction model was therefore run with water elevation, air temperature, precipitation, snow depth, winter survey period, flow period, and the interaction of winter survey period by flow period as the initial predictive variables. The GLM was run with a quasi-poisson error structure, appropriate for overdispersed count data (residual deviance = 226.5; residual degrees of freedom= 212).

For the GLM, stepwise procedures by AIC were not possible due to the quasi-poisson error structure, therefore term deletions were performed manually, in a step-wise fashion. Variables were removed from the full model, one-at-a-time, until the best model was found. ANOVA tests were subsequently used to compare each reduced model to the fuller version and to the initial (saturated) model, until any further removals produced a significantly poorer fit.

We used the residual deviance of the final model to test for deviance goodness of fit. If the residual difference is small, the goodness of fit test will be insignificant ($p > 0.1$), indicating that the model fits the data to an acceptable level. The approximate R^2 for the model was calculated as the squared Pearson correlation coefficient of heron counts by the fitted final model.

5.0 RESULTS

5.1 Heron Abundance, Density and Distribution

During the 2014/15 field season herons were detected on 12 of 24 survey dates. Heron numbers ranged from 0 to ~24 individuals on any given day. In the broader region, herons were more widespread in November than in February (Figure 5-1). The November survey located at least 31 herons from five separate regions. These included three birds at the Burton Creek mouth (south of Nakusp), at least 12 birds in Castlegar, at least 14 birds in Creston, one bird near Revelstoke, and one near the former town of Lumberton, just north of Moyie Lake (Figure 5-1). The February survey found at least 25 birds from only two regions: at least 24 birds around Creston, and a single bird near Invermere (Figure 5-1). In addition, though outside of our target study area, a single heron was seen from the highway west of Revelstoke (the Three Valley Gap area) on February 10, 2015.

Contrary to the winter of 2013/14, the majority of heron detections in 2014/15 in Castlegar were from Waldie Island proper. In addition to Waldie Island, herons were detected from the sewage lagoons and Pass Creek, but these were likely all birds that were undertaking movements from Waldie Island. Up to two herons were observed on the rip-rap below the Hugh Keenleyside Dam, and one bird was found on the shores of the Kootenay River, close to the confluence of the Kootenay and Columbia rivers. These locations are consistent with observations from the previous year. Coordinates for all heron locations are provided in Appendix B.

Typically herons were seen roosting on foreshore areas, though individuals were found roosting in trees along the southern edge of Waldie Island. At Duck Lake near Creston, herons were concentrated on the frozen surface of the lake itself. Other herons were observed near water kept open by sluice gates.

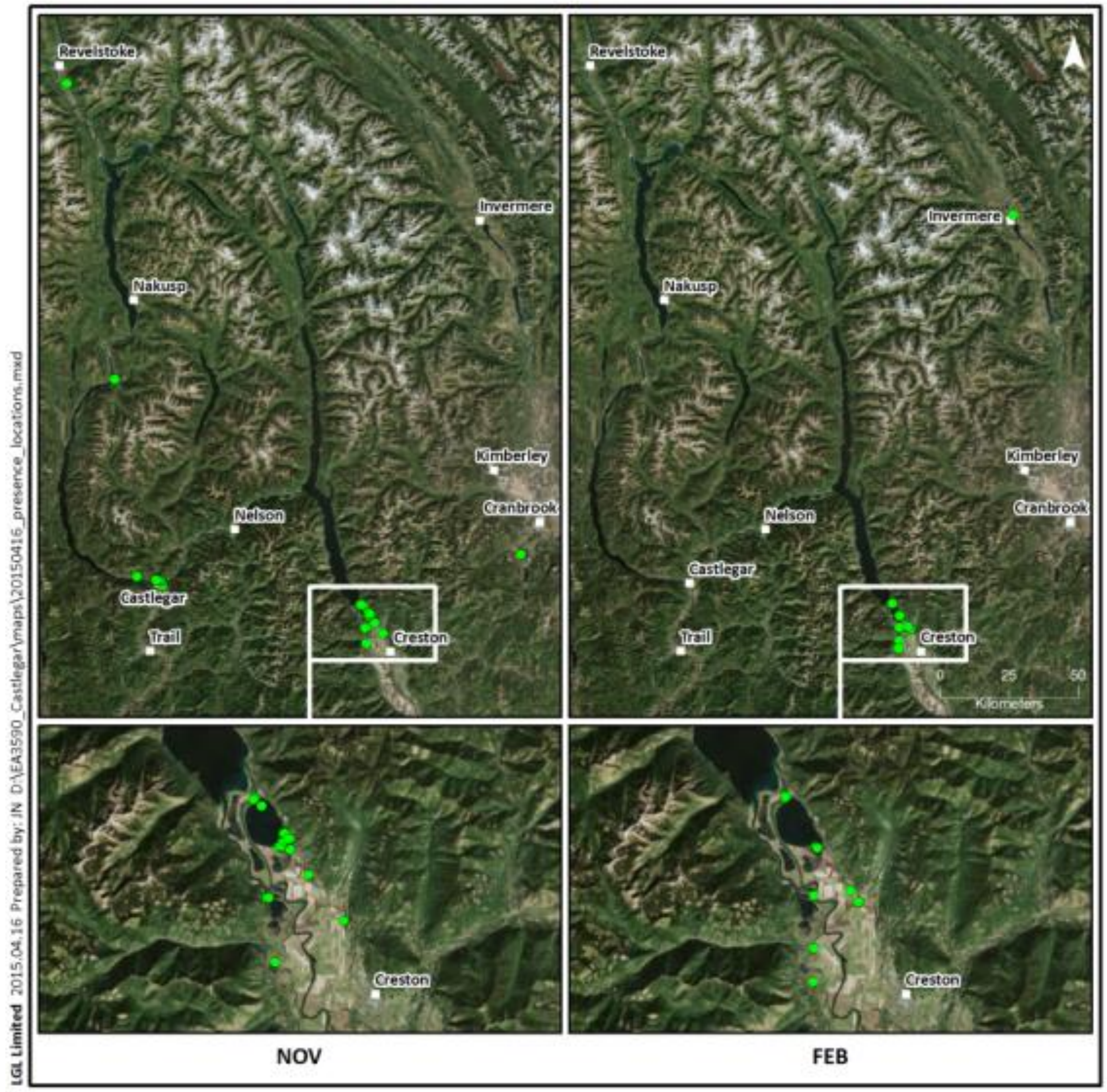

Figure 5-1: Locations (green dots) of Great Blue Herons observed during November 2014 (left panel) and February 2015 (right panel). Dots represent each location where a heron was seen, but do not refer to unique individuals. Bottom figures illustrate the distribution of heron sightings in the Creston area, where they typically were observed in the vicinity of Duck Lake. Herons were more widespread in November than in February

Around Waldie Island, and during our study period, daily counts show that heron numbers were highest in November (especially during the first quarter of the month), and declined gradually through the pre-whitefish flow period (Figure 5-2). Counts continued to decline during the whitefish flow period from mid to late December through mid-January, and herons were virtually absent from the Waldie Island area from mid-January onwards (Figure 5-2).

When maximum daily heron counts are considered for the entire year, a distinct annual pattern appears to be emerge. In general herons are absent or occur in very low numbers (1 or 2 individuals) from early January through to late July or August. Then in the late summer heron numbers increase quite rapidly and peak around mid-September. Heron numbers decline through late September and early October before again climbing in late October or early November, when they again gradually decline to early January. This pattern is similar across two full years of data, though the exact timing of heron peaks and the actual counts differ somewhat between years.

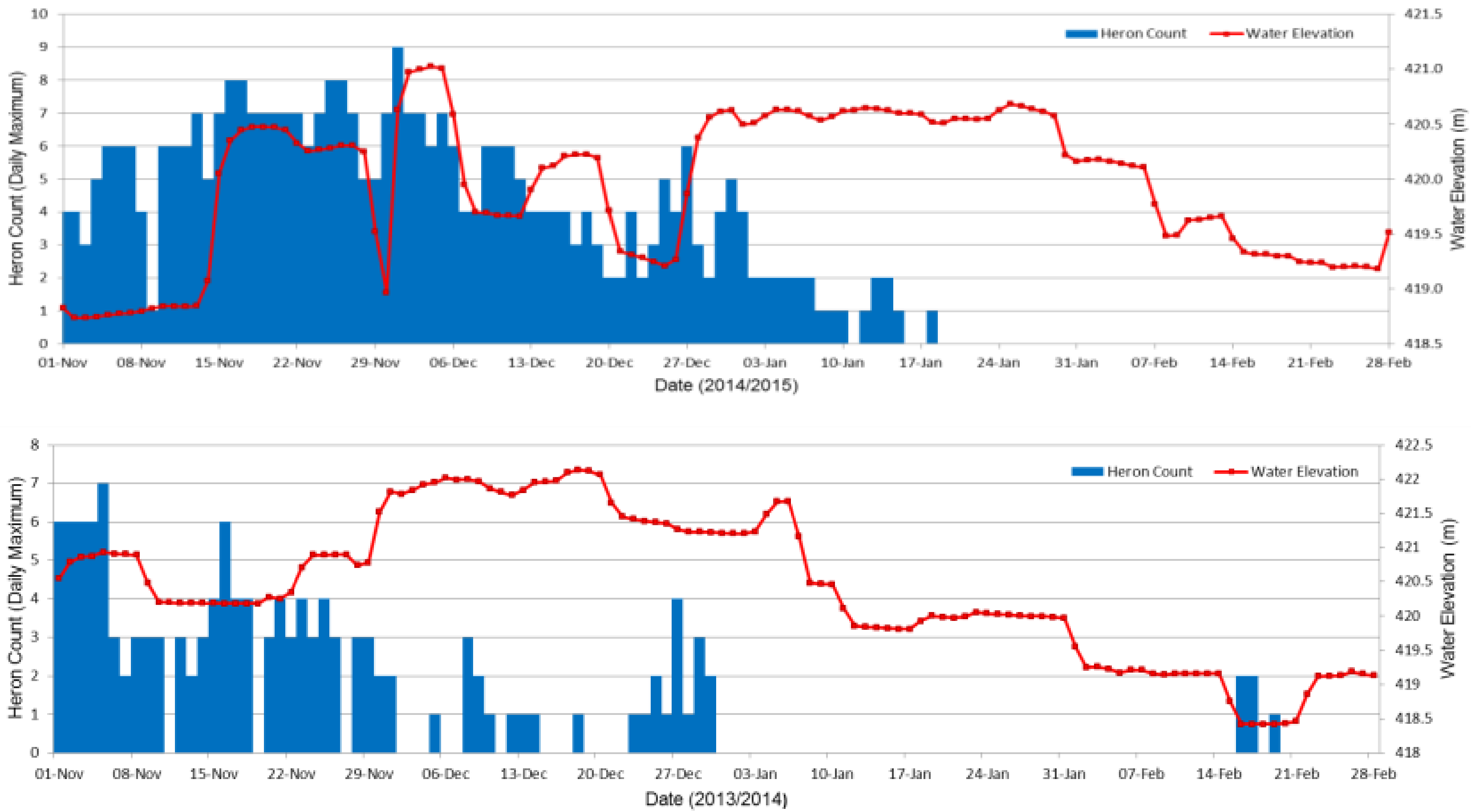

Figure 5-2: Maximum daily heron counts and daily average water elevations for the November 2014 to February 2015 survey period (top panel) and the November 2013 to February 2014 survey period (bottom panel). Note that the vertical axes values are slightly different between these two graphs. Daily count data provided by Caroline Halligan, and elevation data provided by BC Hydro and Poisson Consulting Ltd

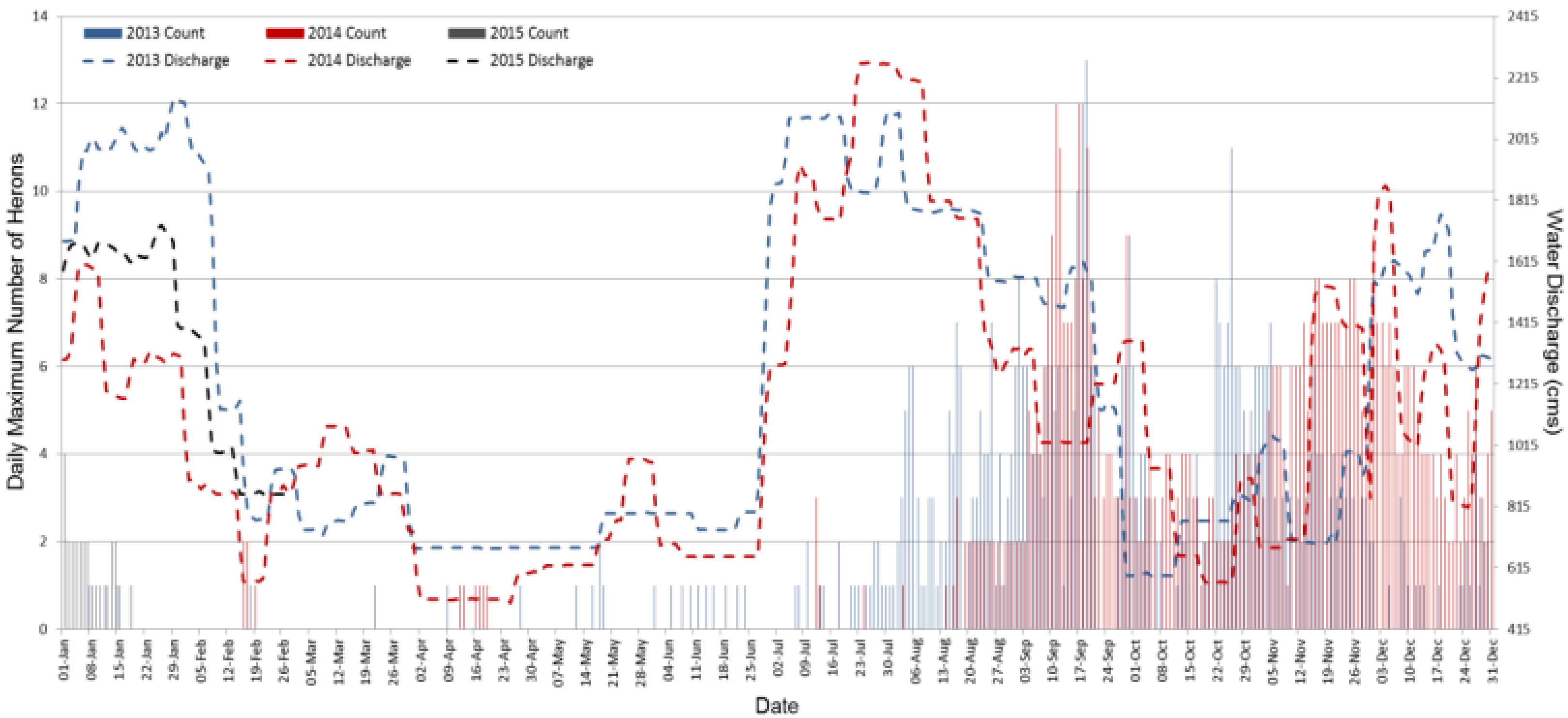

Figure 5-3: Daily maximum heron counts in the Waldie Island area during 2013 (blue bars), 2014 (red bars), and early 2015 (black bars), from a property overlooking the area. Seasonal fluctuations in numbers correspond to distinct periods of the annual cycle (e.g., breeding, dispersal). The water flow rate is overlaid for comparison. Data courtesy of Caroline Halligan

5.1.1 Christmas Bird Count Results

Previous surveys indicate a variable overwintering heron population around Castlegar, albeit one that is currently lower than in the early 2000s. Dedicated surveys following methods comparable to this study found up to 29, 26, and 21 individual herons in the winters of 2000/01, 2001/02 and 2002/03 respectively (Machmer 2003). Dedicated surveys for herons were not completed, to our knowledge, between 2003 and the commencement of this study. However, Christmas Bird Count data present a longer-term (though variable by count) dataset for a variety of areas throughout British Columbia and the northern United States, that can be used to help determine how, or if, heron numbers have changed over time at local levels.

The Christmas Bird Count is a long-term citizen science initiative administered in Canada through Bird Studies Canada with data housed by the National Audubon Society. These counts are carried out by individuals with varying levels of experience and training, are not heron-specific, and may not be properly corrected for effort or environmental conditions. While caveated, these data still provide supplementary information on heron abundance throughout the Kootenay region. In general, the Christmas Bird Count data for the Castlegar area over the past two years has aligned well with counts that we have completed in the area.

Historical Christmas Bird Count data were obtained for 25 counts within the Kootenay region of B.C. and related areas of the northern United States (http://birds.audubon.org/data-research). Bald Eagles are a known predator of Great Blue Herons, and while eagle impacts on wintering herons is not well documented, their count totals are also included here (see Appendices Appendix C-Appendix H).

Christmas Bird Count data from Castlegar and Creston indicate highly variable winter heron counts (Table 5-1). Heron numbers appear to be higher in Castlegar and Creston than any other Christmas Bird Count conducted in the region. Although data from Castlegar only go back to 2005, heron counts were higher than in Creston on six out of ten years, though the highest overall counts were observed in Creston. Based solely on these data, there is obvious inter-annual variation, though no strong case could be made for an overall decline in numbers across the entire period. Indeed, combining counts for these two locations shows a remarkably stable winter count over time, with the exception of a couple winters with low counts at both locations (Table 5-1). However, at this time there is no direct evidence to support or refute the idea that herons may travel between these two regions based on local conditions.

Heron numbers on Christmas Bird Counts in adjacent regions of the United States (Montana, Idaho, and Washington) show similar inter-annual variation with no clear long-term trends (AppendicesAppendix F-Appendix H). The count for Spokane goes back to 1940, and clearly shows strong inter-annual variation with no obvious long term trend (with the exception of a possible initial population increase during early decades of the count) (Appendix H). Heron numbers are also relatively low overall, although a couple counts typically record greater numbers of herons than counts in the Kootenays of B.C. These include Spokane (Washington), with counts typically exceeding 20 individuals, and notably Indian Mountain (Idaho) where counts have reached 100 individuals. Counts at Indian Mountain (at the south end of Lake Coeur d'Alene) appear to have maintained high numbers since the early 2000s. The north end of Lake Coeur d'Alene does not record particularly high numbers of herons (a maximum of 30, but typically single-digits). Interestingly, the habitat around the Indian Mountain count appears similar to the Creston area, with a mixture of water channels, marshy habitats, and agricultural fields, in addition to a large lake.

Table 5-1: Great Blue Heron and Bald Eagle count results from the Castlegar and Creston Christmas Bird Counts from the 2005 count year to present

	Heron Count			Eagle Count	
Count Year	**Castlegar**	**Creston**	**Combined**	**Castlegar**	**Creston**
2005	2	23	25	4	14
2006	16	11	27	10	9
2007	4	15	19	10	27
2008	19	4	23	11	21
2009	7	1	8	15	32
2010	17	3	20	14	15
2011	18	9	27	12	25
2012	10	15	25	12	20
2013	4	24	28	13	34
2014	5	3	8	14	21
Median Count	*9*	*10*	*24*	*12*	*21*

5.2 Heron Behaviour

In total, herons were found on 97 occasions. However, this total includes all observations of all herons, such that this number is higher than the total number of herons owing to multiple encounters of the same individuals on the same or subsequent days. When herons were located, their behaviour was noted. Behaviours were recorded 42 times for adult herons, 31 times for immature herons, and 24 times on herons of unknown age. The most frequently encountered behaviour was resting (n = 45), with the number higher for birds that included at least a resting phase in addition to some other behaviour during the observation (n = 51) (Table 5-2). Herons, when not resting, exhibited a variety of behaviours. Herons appeared alert on 14 occasions, although birds that were alert for at least part of the time totaled 28 observations. Birds were typically alert during some disturbance event (e.g., dog walkers, trains). Disturbances occasionally escalated to the point that the heron flushed. Herons were noted in flight for at least part of the observation in 25 instances, with many, though not all, appearing to be caused by specific disturbances. As with last year's results, foraging was only rarely observed (n = 6). Only adults were observed foraging, excepting one bird of undetermined age. Foraging herons were only noted from the Duck Lake area of Creston, and one bird potentially waiting to forage at Leach Lake near Creston.

Table 5-2: Behaviours of all Great Blue Herons observed during surveys in the Kootenay region during the winter of 2014/2015. Numbers refer to the number of observations in each age and behaviour category, but do not refer to unique number of individuals which is less owing to multiple sampling of individual herons. Behaviour codes are RE: resting, AL: alert, FO: foraging, PR: preening, and FL: flying. Categories listed with "other" indicate that multiple behaviours were shown by one individual during an observation, such as those listed above as well as "walking"

	Behaviour						
Age	**RE**	**RE + Other**	**AL**	**AL + Other**	**FO**	**PR**	**FL**
Adult	19	20	7	13	5	2	8
Immature	20	22	3	8	0	2	4
Unknown	6	9	4	7	1	0	13
Total	*45*	*51*	*14*	*28*	*6*	*4*	*25*

Related to foraging, it was clear from the first year's behaviour results that herons around Castlegar were predominantly foraging at night (Hentze et al. 2015). This was also true of observations made by Machmer (2003). Herons in the Creston area appeared to be using a different strategy, at least in November. There, herons were standing on the frozen surface of the south end of Duck Lake, often hundreds of metres from shore (Figure 5-4). Although the lake was mostly frozen across, holes in the ice provided foraging opportunity. Herons were observed fishing from these holes, occasionally shifting to alternative ice holes to resume foraging. On one occasion, a heron was observed catching a (unidentified) fish from an ice hole, and other capture attempts were documented that appeared unsuccessful. This ice fishing strategy is regularly observed during the winter from this locality (Marc-André Beaucher pers. comm.).

Figure 5-4: A Great Blue Heron forages above an ice hole on an otherwise frozen-looking Duck Lake near Creston. This behaviour was not observed anywhere else in the study area, and may be unique, but common, at this location

These ice holes may remain open in part due River Otter (*Lontra canadensis*) activity. On one occasion at Leach Lake in Creston, six River Otters were observed catching multiple fish (possibly sculpins) from ice holes in the lake. An adult heron flew in from the north and landed on the ice, and proceeded to walk around the otters (Figure 5-5). It is not known whether the heron was attracted to potential fish scraps left by the otters or to the presence of an obviously productive foraging location. Such observations were not documented from anywhere else in the region, and may be indicative of a foraging situation unique, albeit regular, to the Creston area.

Figure 5-5: A Great Blue Heron (rear centre) flew in and approached a group of six (four visible here in foreground) River Otters as they dived in and around holes in the ice during November 2014. The otters were actively and successfully catching fish (possibly sculpins). River Otter activity may aid in the maintenance of these ice holes which are then utilized by Great Blue Herons

In the Castlegar area the majority of herons were seen resting (n=27) or preening (n=4), with two observations of alert birds and two additional observations of alert birds that then flushed due to disturbances (once due to human activity, the other due to a passing train). This is consistent with 2013/14 results, but is in contrast to observations in the Creston area, where the full suite of recorded behaviours was observed.

5.3 Habitat Availability

As discharge rates from Hugh Keenleyside Dam increase, so does the downstream water elevation. Potentially available shoreline areas are any exposed, essentially non-vegetated areas below the maximum high-water mark. The elevation of shoreline areas is critically important in determining whether a given increase in water elevation will flood that habitat. In addition, the location of exposed land will have an effect on the extent and rapidity by which it floods as waters rise. For example, an increase in water levels could reduce the length of available shoreline, the width, or both concomitantly. For this reason, low-lying islands are particularly susceptible to changes in available habitat with changing water elevations.

Waldie Island and Breakwater Island are two locations that are reliably used by Great Blue Herons during the winter period in the Castlegar area. Herons were frequently encountered on Breakwater Island during the 2013/14 winter, only occasionally being seen on Waldie Island. In 2014/15 this pattern was reversed, with herons preferring the shores of Waldie Island. Both of these islands have a large decline in shoreline area as water elevations increase (Appendix I). The lowest water levels from November to February were recorded in November (418.12 m) while the maximum was recorded in December (421.08 m). The greatest change in shoreline area overall occurred in November, which experienced a 2.39 m change in water elevation during the pre-whitefish-flow period (Appendix I). The most stable month was January, which had relatively even water elevations during the whitefish spawning period, and a difference of only 0.82 m between the minimum and maximum water elevations. Despite these overall changes, different sites respond slightly differently owing to site-specific topography. For example, Waldie Island had a 73.4 per cent decrease in shoreline area in November between minimum and maximum water elevations that month. In December, Waldie Island experienced a 62.1 per cent decrease, for a total shoreline loss between November minimums and December maximums of 78.9 per cent (Figure 5-6). Breakwater Island, being shallower, had losses of 80.9 per cent in November, and 99.8 per cent in December, and a total shoreline loss between minimum and maximum water elevations of 99.9 per cent (Figure 5-6). Overall, water levels rising from 418.12 m to 421.08 m signify inundation of approximately 59.8 ha (66 per cent) of land.

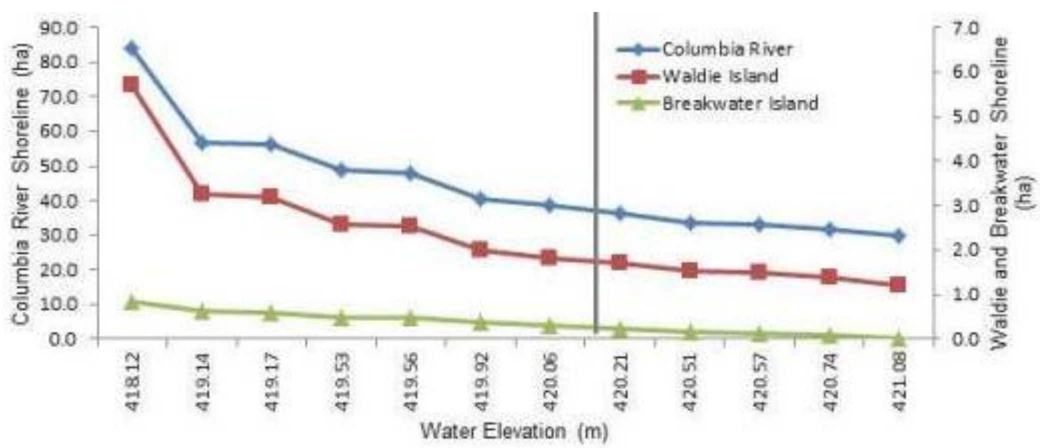

Figure 5-6: The amount of shoreline area (potential heron habitat) in hectares available at various water elevations from the minimum recorded during the November to February period in 2014/15 (418.12 m) to the maximum recording during this time interval (421.08 m). The Columbia River area is based on an area from just west of Pass Creek to just south of the Columbia/Kootenay River confluence, and includes the section of the Kootenay River downstream of the Brilliant Bridge. The vertical grey line in the graph represents the median water elevation for the study period. Note that Waldie Island and Breakwater Island are plotted based on a different axis (right axis) than Columbia River (left axis)

Despite December having the highest water elevations and therefore the lowest shoreline habitat available at that time, January had the highest average and highest minimum water elevations. Thus, available shoreline area is lowest overall in January, followed by December (Figure 5-7). The amount of shoreline habitat as measured by the monthly average for each month is roughly the same in November and February.

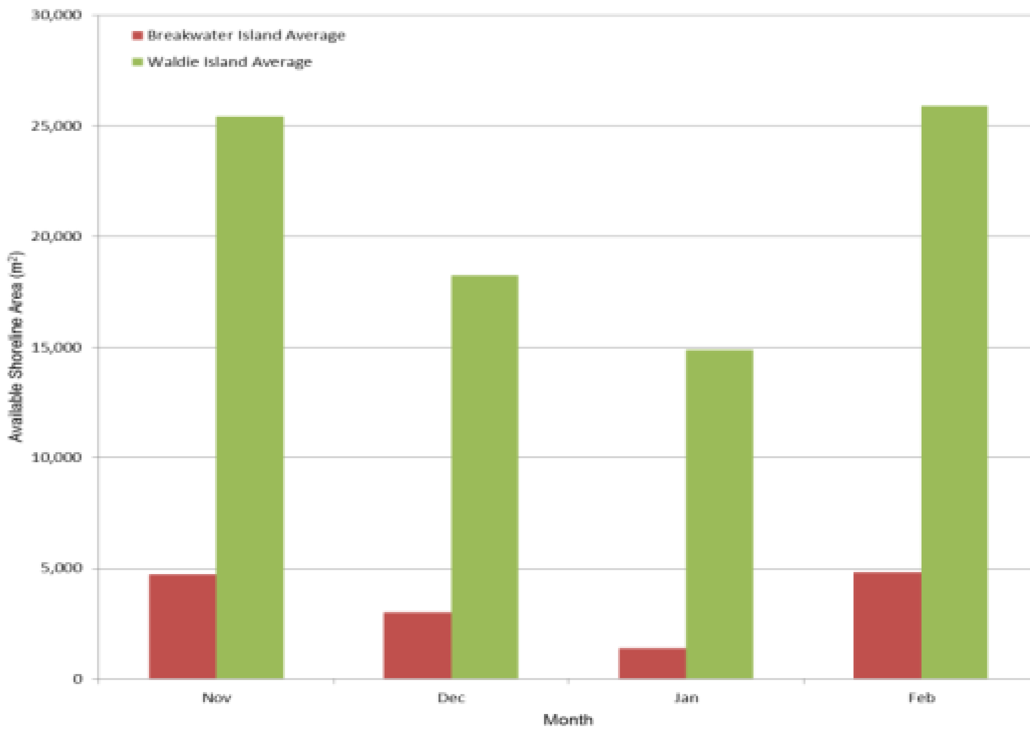

Figure 5-7: Amount of available potential shoreline habitat by month based on average water elevations for each month. Data are shown for Waldie Island (green bars) and Breakwater Island (red bars)

The main areas that are exposed during low water periods that become mostly or wholly submerged at high water elevations include the Pass Creek Delta, Breakwater Island and the extent of land between the island and the foreshore, Waldie Island and the mudflats separating it from the mainland shore, Tin Cup Rapids, the channels and flats north and west of Zuckerberg Island, and the shoreline along the eastern side of the Columbia River downstream of the confluence (Figure 5-8). With the exception of the east side of the Columbia and Tin Cup Rapids, herons have been observed at all these locations during the past two winters of surveys. Other than the forested portion and extreme upper reaches of Waldie Island, the area that retains the most shoreline habitat is the area just east of the Kootenay River oxbow (Figure 5-8). This habitat is mostly grassy, and may not be utilized by herons the same way that alternative shoreline areas would be.

Figure 5-8: **The available shoreline areas between the river and the high-water mark (orange areas) at the minimum (418.12 m, top panel) and maximum (421.08 m, bottom panel) water elevations present in the study area between November 1, 2014 and February 28, 2015. Water elevation was measured from the CNN gauge at Norns Creek (source BC Hydro). The bounds of the area for this analysis are outlined in blue**

5.4 Habitat Suitability

A total of 107 shoreline samples were conducted at 63 locations (Figure 4-2). Whenever possible, the same location was surveyed in both November and February sampling sessions. Due to access restrictions (e.g., ice cover, construction) during one of the sampling periods, only 44 locations were sampled in both November and February. The remaining 19 sites were surveyed once (ten in November, nine in February). The locations were distributed throughout the study region. In the Castlegar area, sampling sites were the same as during the winter of 2013/14, and were focused on areas around Waldie Island and the Columbia/Kootenay confluence. Elsewhere in the region, sampling sites were novel this year.

Sites were adjacent to a variety of land types and uses including city parks, greenspaces, fields, forests and commercial/industrial. Included in the shoreline surveys were assessments of macrophyte and periphyton coverage as they both contribute to habitat and food sources for invertebrates and fish, which in turn could benefit herons. Almost no macrophyte coverage was detected at any site. Similarly, very low periphyton coverage was detected, with most sites having no or extremely limited periphyton coverage. Only 13 samples had periphyton with >1 mm coverage.

Water physicochemistry data were recorded from each site. Three samples at each site were averaged for each site visit, and the mean and standard deviation of these averages, as well as a discussion, are presented in Table 5-3. In general, values for most parameters are similar among sites.

Table 5-3: Physicochemical and environmental variables collected during shoreline sampling at each survey site. These variables are the same as those measured during the 2013/14 field-season. Definitions and justifications for the measured parameters were compiled from the Canadian Aquatic Biomonitoring Network (CABIN 2012) and Guidelines for Interpreting Water Quality Data (RISC 1998b)

Parameter	Mean ± SD	Typical Limits and Discussion
Dissolved Oxygen (mg/L)	11.79 ± 2.32	Maximum solubility of oxygen is ~15 mg/L at 0˚C. Invertebrates require DO of higher than 4 mg/L, the point at which acute mortality occurs. Only three sites had DO approaching these levels, all were in Creston. Two sites had DO values of between 4.6 and 4.8 mg/L (measured only in February after being frozen over most of the winter). The third site in the channel south of Duck Lake had a very low DO concentration of 0.7 mg/L. All three of these sites had herons within their vicinity.
Specific Conductance (µS/cm)	181.47 ± 108.66	Natural waters vary from 50 to 1500 µS/cm with interior streams ranging up to 500 µS/cm. Only one sampling location had a measured specific conductivity less than 50 µS/cm (39.37

Parameter	Mean ± SD	Typical Limits and Discussion
		µS/cm at Pass Creek), with four other sites measuring approximately 50 µS/cm. These were often in streams or side channels. Two sites had values greater than 500 µS/cm, but still measured less than 560 µS/cm.
pH	7.51 ± 0.50	Natural fresh waters have a pH ranging from 4.0 to 10.0. Most lakes in BC have pH of 7.0 or greater. Lethal effects of aquatic life occur below pH 4.5 and above pH 9.5, with optimal levels being between pH 6.5 and 9.0. All of our recorded values fall within the range that aquatic life can tolerate, with our measurements ranging from pH 5.3 to 8.7. All of our measurements except for the one 5.3 value in Creston are also within the optimal pH level for aquatic organisms.
Temperature (˚C)	4.33 ± 2.38	Temperature naturally varies in a waterbody from 0˚ to 40˚ (hot springs). All of our temperature measurements fall between 0.0 and 8.8˚C. While the temperatures are all ok for supporting aquatic organisms, colder waters may be more prone to freezing, and therefore limit heron foraging potential. Of the ten average water temperatures <1˚C, eight were recorded in November.
Turbidity (NTU)	13.66 ± 42.54	Pure distilled water has a turbidity of 0 NTU. High levels of turbidity reduce light penetration and therefore plant growth and can thereby suppress fish productivity. Drinking water has a turbidity limit of 1 NTU for health, and 5 NTU for aesthetics. The majority of samples (67%) had very clear water, and turbidity levels that were <5 NTU. Five samples had turbidity values >50 NTU, with the most extreme being 346 NTU at the south-east end of Kootenay Lake. Higher levels were also recorded from Leach Lake in Creston and near Burton Ck. south of Nakusp. Two of the sites with highest recorded NTU values (both recorded in November) had low turbidity readings in February, indicating that the high turbidity level was temporary. Two sites in the top five of highest turbidity readings had herons present.
Macrophyte and Periphyton coverage	Macrophyte: typically 0-25% coverage	Higher macrophyte and periphyton coverage may increase invertebrate habitat which may influence fish presence. Macrophyte coverage varied from

Parameter	Mean ± SD	Typical Limits and Discussion
	Periphyton: typically 0-0.5 mm thick.	0% to 76-100%, but 94.2% of all sites had macrophyte coverage of either 0% or 1-25%. Periphyton coverage varied from none to lots (5-20 mm thick), but most (81.9%) had no or minimal (<0.5 mm thick) coverage.
Substrate Class	Organic cover to boulders (>25.6 cm)	The substrate may be related to stream flow, but prey may be more abundant in certain substrate types. Most of the samples were in either organic or fine sand/silt/clay substrates or else in cobble (6.4-25.6 cm) substrate.
Water Velocity (m/s)	0.26 ± 0.21	Water velocity varies as a function of stream size and the amount of water moving past. Water velocities were relatively slow in most locations, varying from 0 to 1.1 m/s. Only one site (Edgewood) had a velocity greater than 0.7 m/s. Twenty-one sites measured zero m/s. Five of the 14 sites with heron presence had zero velocity.

For the sites in which samples were taken in both November and February, the physicochemical parameters were compared between the time periods to see if any changes occurred. After correcting for multiple comparisons, pH and dissolved oxygen had significant differences between the time periods ($p<0.001$ for both) (Table 5-4, Figure 5-9). While significant, the difference in these variables between the time periods are relatively small, and additional sampling is needed to confirm these results. In general, all of the measured values are within ranges that should be tolerable to aquatic organisms in both time periods (Figure 5-9).

Table 5-4. Results of Wilcoxon Signed-Rank Tests for paired differences in physicochemical parameters between the months of November and February. Adjusted p-values are calculated for each test using the Bonferroni-correction method; *= significant at α = 0.1, 'n.s.' = non-significant

Parameter	Mean Difference (Nov-Feb)	Wilcoxon statistic (V)	P-value	P-adjusted	
pH	0.3689	844.5	9.16E-07	6.41E-06	*
DO	-1.0494	162	0.0001	0.0007	*
Air Temperature	-1.3159	292	0.03	0.21	n.s.
Water Temperature	0.7924	671	0.04	0.28	n.s.
Specific Conductance	5.7600	449	0.60	4.19	n.s.
Turbidity (YSI)	14.5951	366	0.83	5.84	n.s.
Water Velocity	-0.0087	457	0.95	6.65	n.s.

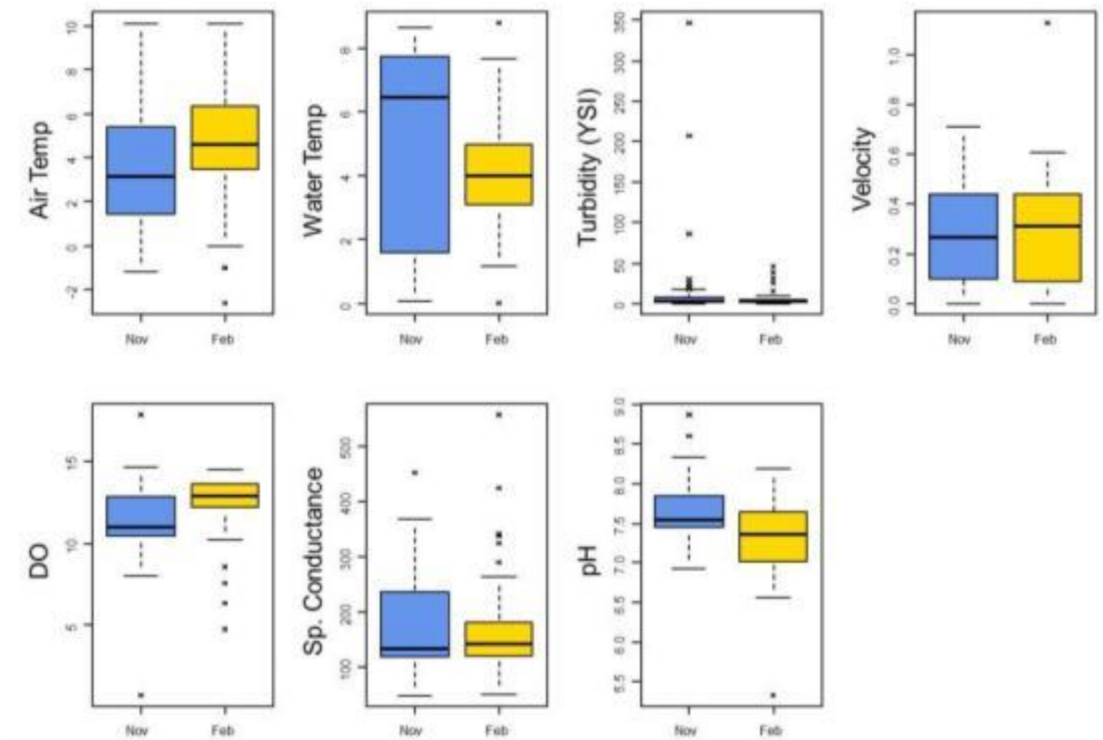

Figure 5-9. **Boxplots of the variation of average values of each habitat parameter measured at 44 paired sites in November and February from throughout the study region**

Shoreline parameters were also compared between sites in Castlegar and sites in all other localities surveyed (Figure 5-10). The temperature of air and water was slightly greater for Castlegar sites than for other sites. Additionally, water physicochemical parameters appeared more variable in other sites than Castlegar, perhaps owing to the greater number of data points, or the greater geographic extent of sampling. For example, turbidity and specific conductance boxplots show a wider spread in data points across all others sites than they do for sites in Castlegar (Figure 5-10). In general though, no major differences stand out that would indicate that habitat around Castlegar is more suitable based on these measured parameters than at other locations in the region.

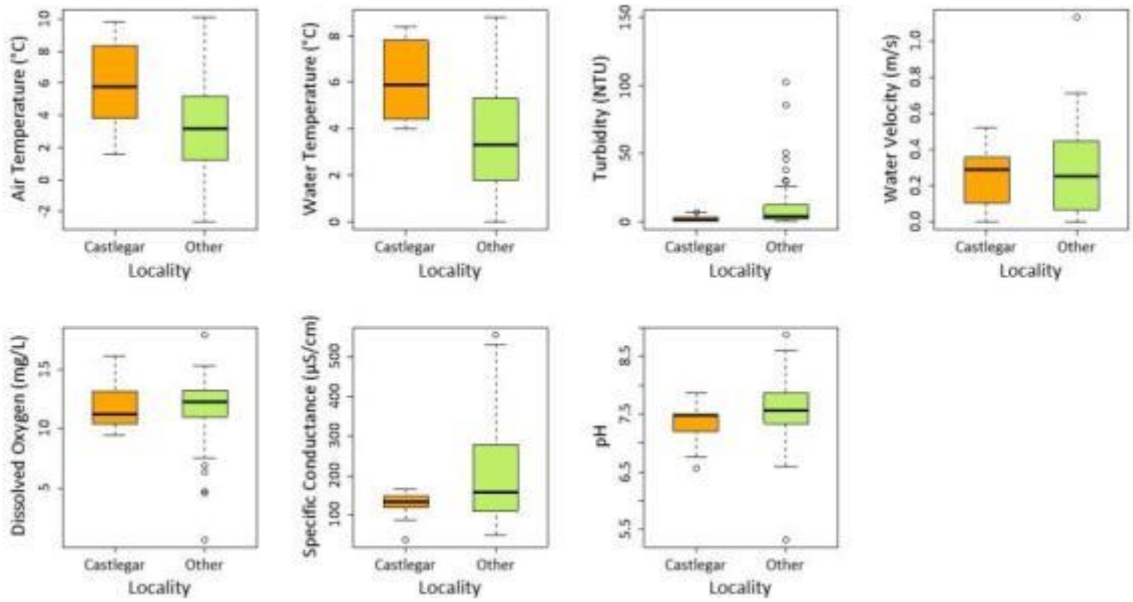

Figure 5-10: Boxplots of variation in environmental parameters by locality (Castlegar, n= 16 sites; Other, n= 47 sites)

5.5 Water Flow and Elevation

Flow rates out of Hugh Keenleyside Dam vary depending on inflows, storage, power generation, and Columbia River Treaty requirements. In the period between November 1, 2014 and February 28, 2015 flow rates varied from 682.1 cms to 1,862.9 cms. Flow rates were highly variable until early January, and peaked in early December. From about 02-29 January, flows remained relatively stable between 1600 and 1700 cms, and decreased throughout the month of February. This stable period corresponds to the peak whitefish spawning period.

Water elevation ranged from 418.12 m to 421.08 m as measured at the Norns Creek gauge (CNN). Machmer (2003) recommended winter water elevations be kept below 421.0 m to ensure suitable shoreline area remains around Breakwater Island (which becomes submerged at around 422 m). Based on the Norns Creek discharge rating curve this recommendation was amended to 420.7 m (BC Hydro 2012). During the winter of 2001/02 the recommended elevation was not exceeded, but it was exceeded on 16 days during the same time period in 2002/03 (Machmer 2003). In the period of November 1 to February 28 from the winters of 2004/05 to 2013/2014 (n = 1190 days) water elevations exceeded 420.7 m for at least a portion of the day on 131 days (11 per cent) (Figure 5-11). Daily average water elevation exceeded that level on 94 days (7.9 per cent). All but three of those dates have occurred since January 2012. This water elevation recommendation was exceeded on 15 dates during the 2014/15 winter period, with daily average water elevation only exceeding that limit on four dates (all in early December).

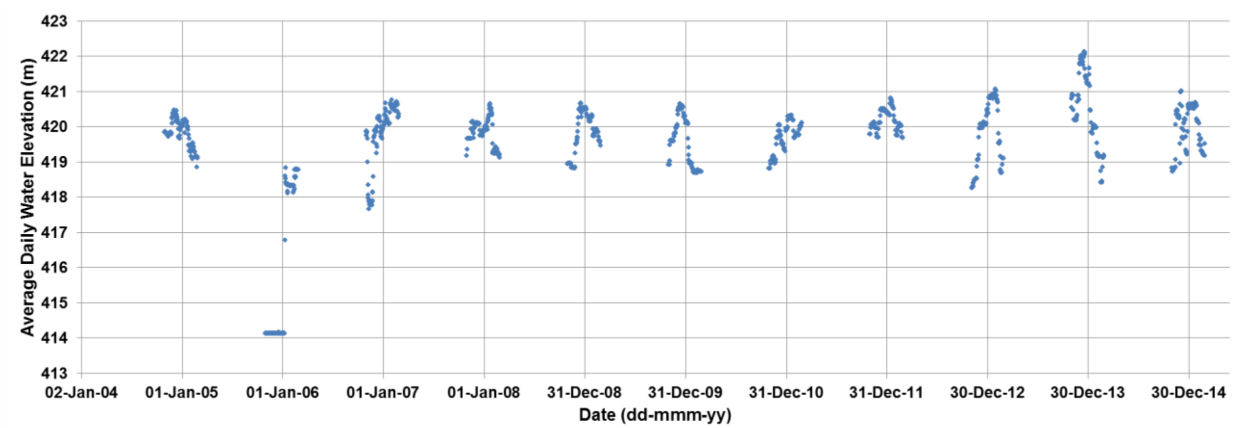

Figure 5-11: Average daily water elevations during the winter heron period (November through February) from 2004/05 to 2014/15. Water elevations were higher during the winter of 2013/14 than in any other winter over the past decade

The recommended water elevation was exceeded for 46 consecutive days between November 23, 2013 and January 7, 2014, peaking in mid-December. In addition, water elevation exceeded 422 m on five dates in December 2013. The recommended water elevation was only exceeded for six consecutive days during the winter of 2014/15, with no dates exceeding 422 m. There is a positive relationship between flow rates and water elevation with temporal changes in discharge being closely mirrored by elevation (Figure 5-12).

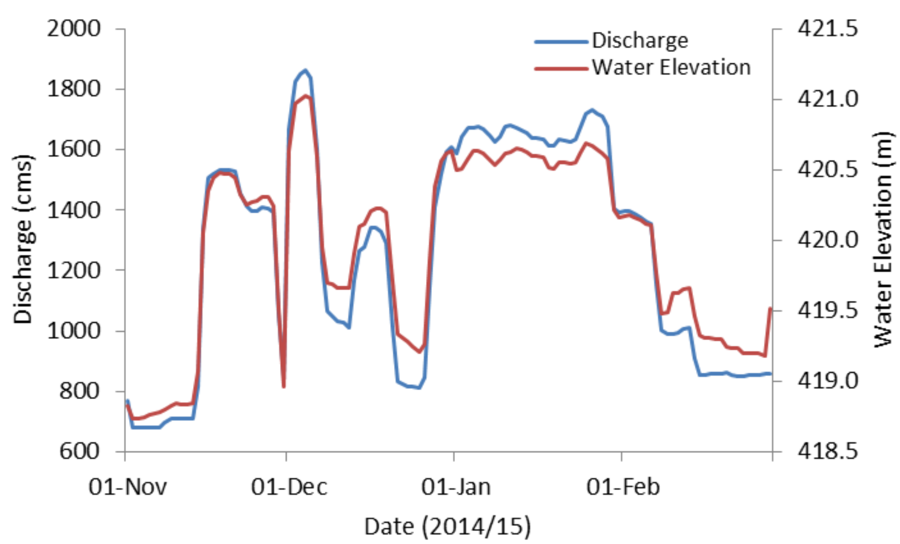

Figure 5-12: Flow rates out of Hugh Keenleyside Dam (HLK + ALH discharge) and water elevations as measured at the Norns Creek gauge. The two measurements are highly correlated, with changes in flow dictating water elevations

5.6 Climatic Conditions

Herons were present throughout the Kootenay region, though the distribution of birds differed between November and February survey periods. Absent effects of dam and reservoir operations, environmental conditions may, in part, explain some of these movements. We compared data from 16 Environment Canada weather stations throughout the Kootenays. There were clear temperature differences among months and locations, with the Rocky Mountain Trench (Golden, Kimberley, and Cranbrook stations) in particular being colder in all months between November 2014 and February 2015 than other stations (Figure 5-13). The warmest stations overall were Castlegar and Nelson, though most stations in the lower Columbia and Creston/Kootenay Lake regions were similar. Environmental conditions are more similar within a drainage basin than from north to south, although the most northerly sites within each basin (e.g., Golden, Revelstoke) tend to be colder overall. Average monthly temperature was highest in February, followed by November, for all weather stations.

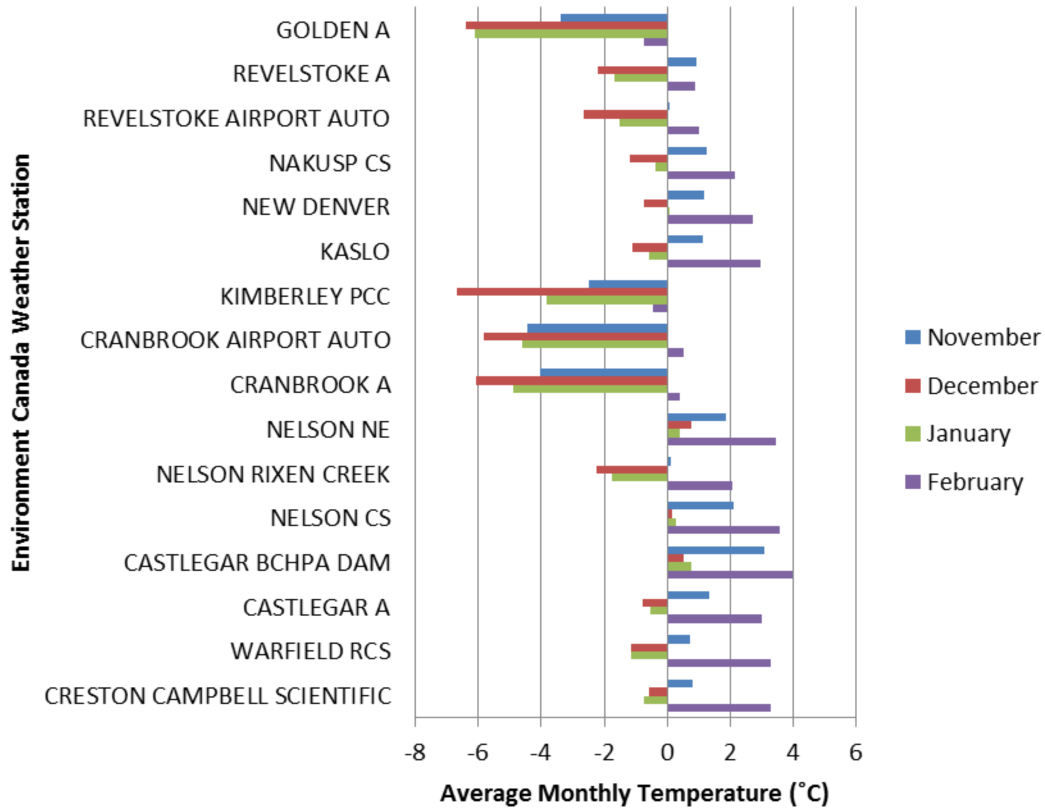

Figure 5-13: Average monthly temperatues in the November through February period (2014/2015) at various Environment Canada weather stations throughout the Kootenay region. Stations in the Rocky Mountain Trench are noticeably colder than other stations

Herons are likely excluded from areas with frozen waterbodies and high snow depth that prevent or limit foraging opportunities. The proportion of days within the study period (n=120 days) that have average temperatures below freezing and snow depth >10 cm varies by location (Figure 5-14). The locations with the highest proportion of cold days and high snow depth are those within the Rocky Mountain Trench between Golden and Cranbrook. During the winter of 2014/2015, the Castlegar area had the lowest proportions of days with temperatures lower than 0˚ C and snow depths greater than 10 cm. Note that Creston had a moderately high number of days with freezing temperatures, despite a relatively low proportion of days with less than 10 cm of snow.

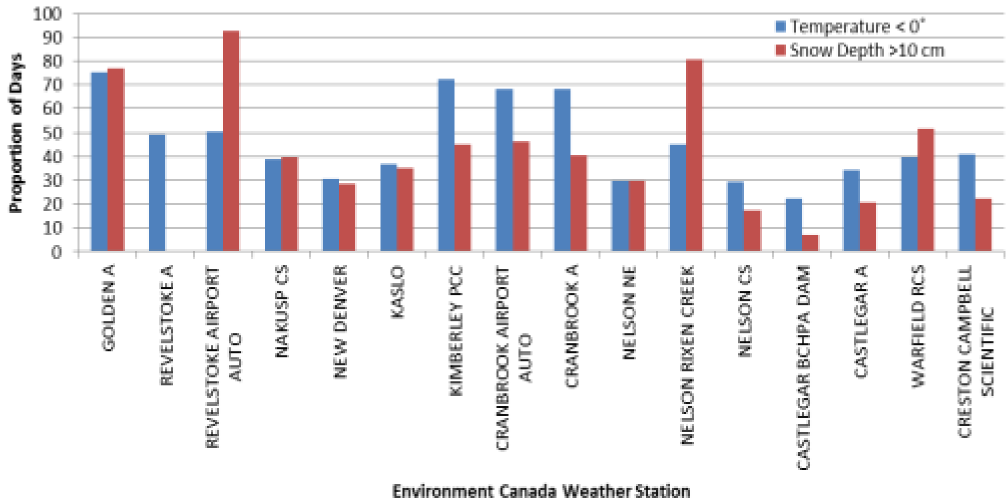

Figure 5-14: The proportion of days with below freezing temperatures (blue bars) and snow depths greater than 10 cm (red bars) at Environment Canada weather stations throughout the Kootenay region

These results from 2014/15 align nicely with the 50-year average (1950-2000) climate normals for the region (Figure 5-15). Differences are apparent among months and regionally across the study area. January stands out as being historically the coldest month for the region, but more notable are the temperature differences between the various rivers and lakes. For example, the temperature difference between the Rocky Mountain Trench and the remainder of the Kootenay and Columbia systems are striking (Figure 5-15). The Rocky Mountain Trench appears colder in all months, with average temperatures below freezing across the entire valley. The Columbia system and the lower Kootenay including Kootenay Lake, are similar in temperature within each month. In both of these areas, November is the warmest month, with February showing an increased temperature from December and January.

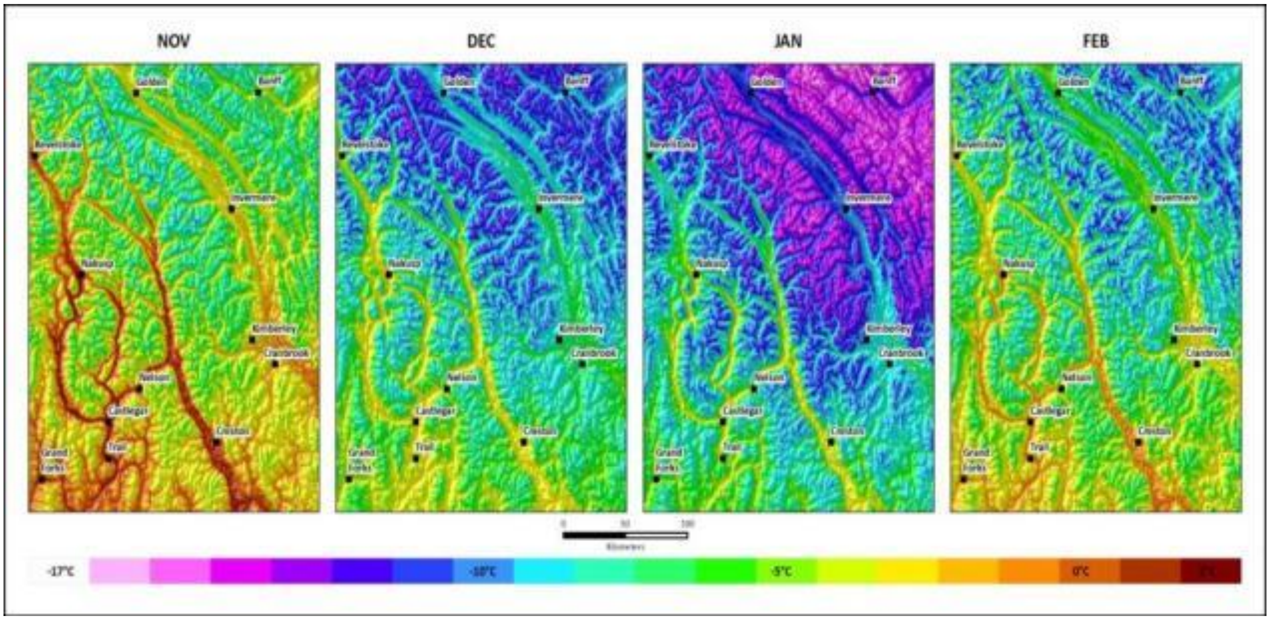

Figure 5-15: Temperature scaling based on the 50-year climate normals (1950-2000) for the Kootenay region. Orange and red colouration indicates temperatures ≥0˚ C. January and December are the coldest months in the heron winter period, but note that the Rocky Mountain Trench (Golden to Cranbrook) remains cooler than adjacent areas of the Kootenay and Columbia systems on any given month

5.7 Regional Heron Presence

A multiple logistic regression was conducted to determine if a suite of habitat variables could predict the probability of heron presence. The best model of habitat variables that explained heron presence included only dissolved oxygen, which had a negative relationship with heron presence (DO: Estimate= -0.37, SE= 0.18, z-value= -2.018, p-value= 0.04). All other parameters resulted in an increase in AIC score and lack of improvement in model fit. Our final model passed the deviance goodness of fit test (Res.Dev.= 63.65, df= 84, p = 0.95) because we found no significant difference between the model and the observed data (i.e. the p-value of the chi-square test is above 0.05). The approximate R^2 for the model was 0.13, which indicates a weak effect of dissolved oxygen on heron presence. The mean value for dissolved oxygen in sites where herons were observed was 9.9 mg/L (± 1.08 =1 s.e.), whereas, the mean for sites where herons were not detected was 12.1 mg/L (± 0.17 = 1s.e.). The explanatory ability of dissolved oxygen to predict heron presence is weak, and sample sizes for sites with herons are few, so additional data collection is necessary to determine if this trend holds true. Dissolved oxygen is typically higher in faster moving streams, and there was weak evidence that herons selected sites with lower local water velocities (Hentze et al. 2015). More data are needed to help determine what, if any, variables best explain heron presence.

Parameters that could not be tested statistically (the categorical values) can be compared descriptively. Comparing average values only, a couple factors are notable. The first is that while variable, the average macrophyte coverage class is higher (in the 1-25% category) for sites with herons, than sites without (Table 5-5). In addition, the substrate of sites with herons tends to be finer (averaging gravel or fine sand, silt, and clay) than sites without herons (small to large pebbles) (Table 5-5). Finally, in November sites with herons tended to have pools and back eddies as the dominant stream types. All of these factors are consistent with lower stream velocities.

Table 5-5: Average/dominant values for categorical parameters for sites with and without heron presence between November and February sampling periods

Month	Heron Presence	n	Macrophyte Coverage Class	Periphyton Coverage Class	Substrate Class	Dominant Stream Habitat
November	Y	11	1-25%	none	gravel	Pool/Back Eddy
November	N	43	0%	Thin layer < 0.5 mm	small pebbles	Straight Run
February	Y	3	1-25%	none	fine sand, silt, clay	Straight Run
February	N	38	0%	none	large pebbles	Straight Run

There is much overlap in most of the measurements for numeric parameters (Table 5-6). While average differences exist (e.g., stream velocity) between sites with and without herons in each sampling period, additional sampling is needed. For example, in February only three sites with shoreline sampling had herons present, limiting any comparisons in that time period (Table 5-6). Sites with herons had on average lower stream velocities and dissolved oxygen levels, perhaps related to the finer average substrate and increased macrophyte coverage detected at those sites.

Table 5-6: Average values for physicochemical parameters ± 1 standard error

Month	Heron Presence	n	Water Temperature	Air Temperature	Dissolved Oxygen	Specific Conductance	pH	Turbidity	Velocity
November	Y	11	5.78 ± 0.82	4.61 ± 1.02	10.66 ± 1.25	207.63 ± 36.80	7.68 ± 0.16	29.81 ± 19.29	0.19 ± 0.06
November	N	43	4.57 ± 0.44	2.90 ± 0.44	11.48 ± 0.19	177.22 ± 15.30	7.70 ± 0.06	16.51 ± 8.31	0.27 ± 0.03
February	Y	3	3.31 ± 0.53	2.13 ± 1.82	7.10 ± 1.48	164.78 ± 56.67	6.85 ± 0.12	2.49	0.13 ± 0.07
February	N	38	3.53 ± 0.26	4.13 ± 0.41	12.86 ± 0.25	182.92 ± 18.32	7.42 ± 0.09	7.84 ± 1.85	0.27 ± 0.04

5.8 Castlegar Heron Counts

Variables were removed one at a time from the predictive heron GLM until further removals produced a model with significantly poorer fit than the previous. In the end, heron counts were most strongly explained by snow depth (cm), period (pre, during, and post-whitefish flows), winter survey year (year1: 2013-2014, year2: 2014-2015), and the interaction between winter survey year and period. The final model explained approximately 69% of the variation in heron counts (R^2= 0.694). The model fit reasonably well based on the goodness-of-fit test of residual deviance being not statistically significant (R.Dev= 228.6, df= 215, p= 0.25). However, the relationship between flow and heron count is quite weak (rspearman= -0.25, p<0.001, n= 230), thus heron counts are mainly explained by the time period of the observations, with more herons observed in early winter and more in the recent study season (winter 2014-2015; Figure 5-16). There was no evidence for a relationship between observed heron counts and water elevation (rspearman= 0.08, p= .22, n=240), nor heron counts and flow rates (rspearman = -0.07, p= .26, n=240) (Figure 5-17).

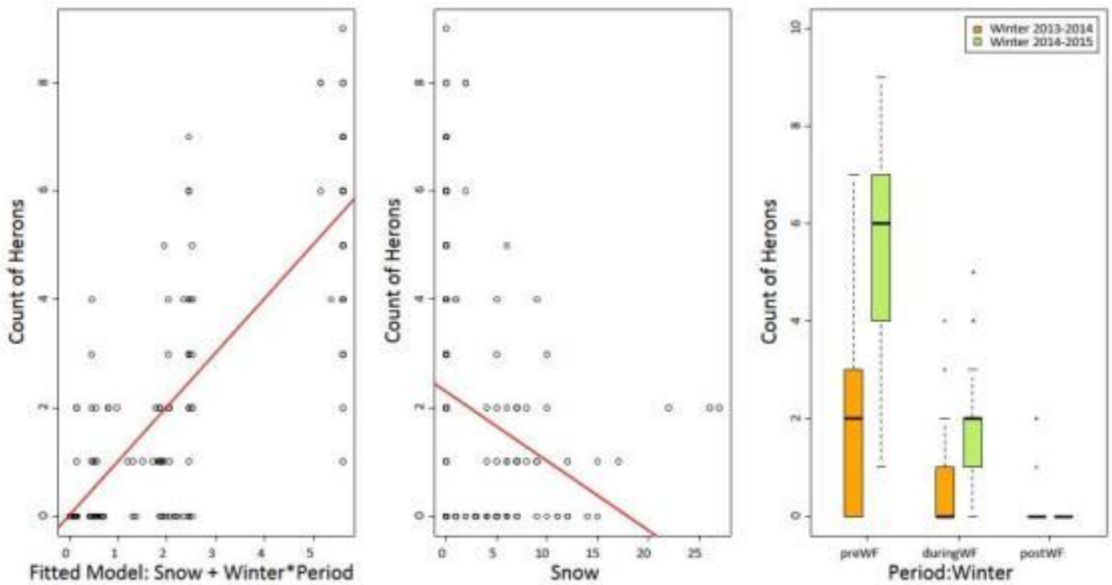

Figure 5-16: **Relationship between Waldie Island heron counts and the final quasi-poisson model fit (left panel), snow depth (middle panel), and the survey time period (Flow: before, during, after whitefish flows; and winter survey period: November 1, 2013 to February 28, 2014 and November 1, 2014 to February 28, 2015; right panel)**

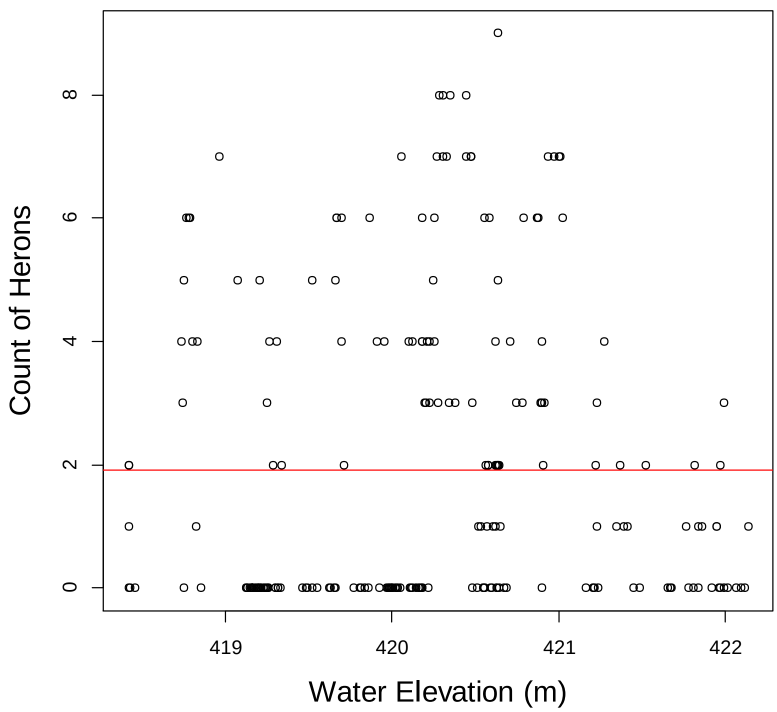

Figure 5-17: **Relationship between Waldie Island heron counts and water elevation. The red line illustrates the lack of a detectable trend between heron counts and water elevation. Heron counts are daily maximums from November 1, 2013 to February 28, 2014 and November 1, 2014 to February 28, 2015**

6.0 DISCUSSION AND MANAGEMENT QUESTIONS

This study, while building upon the framework developed during the previous study year, presents a regional view of Great Blue Heron abundance and site use. By understanding the locations that herons are using in the broader region, we are better able to understand the habitat choices, behaviours, and potentially the abundance of birds that utilize the Waldie Island and Castlegar areas. Surveys in the Castlegar area during November and February, as well as daily observations, confirm that numbers remained lower in the 2014/15 winter than those presented by Machmer (2003) in the early 2000s. However, numbers were slightly higher than during the winter of 2013/14, indicating that there is inter-annual variation. Christmas Bird Count data, while not as rigorous, also suggest strong inter-annual variation in heron counts at any given location throughout the region. However, cumulative totals of herons in the Castlegar and Creston counts (the two areas with highest Great Blue Heron counts overall) show a fairly consistent number of herons among years. The extent to which fluctuations in heron counts in the Castlegar area, are related to local conditions or BC Hydro flows from the Hugh Keenleyside Dam remain unknown.

Regarding the objectives of this study, there is little evidence that variation in heron numbers are related to flows through the Hugh Keenleyside Dam and related water elevations. There is a strong temporal trend for heron counts to be highest prior to mountain whitefish flows in November, and declining throughout December and into the peak whitefish flow period. In both years of study, herons were essentially absent post-whitefish flows. However, caution is warranted when considering only water flows related to mountain whitefish management. Although heron counts differ among the whitefish flow periods (prior to, during, and post), the time-scale over which these periods correspond may coincide with specific aspects related to Great Blue Heron life history (e.g., post-breeding dispersal, courtship, etc.). Indeed, our regression comparing maximum daily heron counts to water elevation, select environmental conditions, and temporal attributes found essentially no support for the role of water elevation on heron counts overall. While statistically it is difficult to assess the effect of flow rates on heron counts near Waldie Island, water elevations do have a notable effect on the amount of potential shoreline habitat available to herons. At the upper limits of water elevation during the winter period, the majority of potential shoreline habitat is lost, with features such as Breakwater Island (a regularly used feature, although not in 2014/15) becoming mostly or entirely submerged. While unproven, high water elevations may limit the number of herons that can successfully overwinter (by limiting the amount of potential habitat). Once habitat becomes inundated in the winter, herons may depart the region altogether, no longer responding to local changes in such variables as water elevation. In addition, herons are relatively long-lived (Vennesland and Butler 2011), and if herons use past experience to inform winter site selection, they may chose more stable locations, so long as foraging opportunity and safety occur at alternate sites. Although water elevations were highest during December for a brief period, they were highest overall during the month of January, with high elevations being sustained over a relatively long period of time as flows stabilised during the peak whitefish spawning period (Figure 5-2). The duration of an inundation event, rather than the elevation per se, could potentially affect the distribution or abundance of herons in the region, even though a direct link between water flows (or elevation) and heron counts is lacking.

When heron presence was tested using the water physicochemical data collected at each site, none of the measured parameters appears to have a strong influence on determining site presence. The best model included solely dissolved oxygen, though the effect of this parameter was weak. The low number of sites with herons present limits statistical inference. However, virtually all the parameters were within tolerable levels for supporting aquatic organisms (Table 5-3). In theory, this should allow for heron foraging opportunities, and indicates that potential foraging habitat is not limited in the region, at least where sites remain ice free. Alternatively, it is possible that herons are keying in on specific, but as yet unknown or unmeasured, variables (e.g., fish density, see below). Regarding site presence, it is also possible that herons are utilizing a greater range of sites than we have detected, but are doing so outside our limited observation periods (e.g., at night). For example, some sites during the winter of 2013/14 were known to be used by herons owing solely to tracks visible in the soft, muddy substrate, but no evidence remains of heron presence at sites with rocky substrates

The presence and distribution of target prey may also influence the presence and distribution of herons. We do not have fish data concurrent with heron surveys, and the presence and accessibility of fish to herons remains an underlying assumption in this study. Machmer (2003) reported that fish densities of all fish species were higher during the night than the day in Castlegar. Such a pattern is consistent with our findings of heron behaviour. That herons appear to be foraging nocturnally in Castlegar would support that fish densities are highest during the night; though alternatively, it may indicate that the rate of prey capture is highest at night regardless of density (for example, if fish are less likely to detect a predator at night). Machmer (2003) also indicated that fish densities had inconsistent responses to flow period over the two study seasons. During the 2001/02 surveys, fish densities were lower during whitefish flows, relative to pre- or post-flows, while no significant differences were found with flow period in 2002/03. Fish densities and heron numbers were both lower in 2002/03 than in 2001/02, while flow rates and water elevations were higher (Machmer 2003). In addition, fish populations appear to be dynamic, including species composition. For example, the density of both subadult and adult Mountain Whitefish appears to have declined between the 1990s and 2012; adult density was lower in 2010 to 2012 than all other study years (Ford et al. 2013). In contrast, Northern Pike went undetected in fish surveys near Castlegar prior to 2010, but appear to be increasing and have been consistently found since that time (Ford et al. 2013). It is not known if herons have a preference for fish species in the area. Shifting fish densities and species composition may influence heron use of a site, but the situation is dynamic and the role of fish on heron abundance and distribution is not understood. While we cannot address fish specifically for our year of study, it is important to note that they are another component of the system that may be influenced by flows as well as being influential to herons.

Herons are plastic in their foraging ability, and they may prey upon a variety of organisms including fish, rodents, reptiles and amphibians, and occasionally even birds (Vennesland and Butler 2011). In Creston, herons behaved differently than in Castlegar, exhibiting a greater amount of active behaviour (e.g., foraging, alert, flying). Birds were witnessed foraging from ice holes on Duck Lake, an apparently common behaviour for wintering birds at this location. This strategy is one that is not available to herons in most other areas in the Kootenays, either because lakes are not available, or because those that are freeze over in entirety.

While it is convenient in speech and writing to describe the over-wintering heron "population", the population dynamics of this group of herons are also unknown. Wintering herons may be from one or many breeding colonies, each with its own specific set of conditions and potentially limiting factors. Breeding heron inventories were initiated in 2002, with Bald Eagle nest inventories added beginning in 2006 (Machmer 2009). Those inventories found high rates of heron nest failure, rising steadily from 20 per cent in 2002 to ~44 per cent in 2005 and 2006 (Machmer and Steeger 2003; 2004; Machmer 2005; 2006; 2007). Eagle harassment and predation was implicated as a leading factor in nest failures in most cases, and colony abandonment was documented as a result. In contrast, eagle populations appeared to increase through the period. Bald Eagles are one of the main predators of Great Blue Herons (Gebauer and Moul 2001, Vennesland and Butler 2011). Increased rates of nest failure and colony abandonment have been directly linked to eagle predation and disturbance (Buter et al. 1995, Vennesland and Butler 2004, Machmer 2009). Despite the presence of herons through the summer months in Castlegar, no nesting currently is known from the area. Herons nested unsuccessfully at Waldie Island in the past, though the last known active nest was in 2001. As no known nesting occurs in the vicinity of Waldie Island, overwintering herons must be from one or more other breeding locations. Changing configurations of these heron colonies and lower success rates could have implications on the number of herons overwintering on the Columbia and elsewhere in the Kootenays, especially if high nesting failure rates persist. In other words, the over-wintering heron population cannot be considered separate from the breeding population(s), and apparent declines could be attributable to conditions on the wintering grounds, breeding grounds, migration stopovers, or any combinations thereof.

In addition, it may be incorrect to refer to "overwintering" populations when referring to any specific location. The pattern in occurrence that has revealed itself over the past two winters in Castlegar suggests that herons are largely absent from early to mid-January and remain so for the remainder of the winter and spring. This trend is similar to that found by Machmer (2003) in the early 2000s when more herons were present; in that study, heron numbers declined through January and February, after which time they were largely absent from the study area. It is not known to where the herons that were present in November and December dispersed. Furthermore, even if herons were present in all months, without individual-specific tags (e.g., colour bands, wing tags, telemetry) we cannot be certain that it is the same individuals present all winter. Elsewhere in the region herons appeared to withdraw from many areas, especially northern ones, being more widely distributed in November than in February. Such temporal changes in heron distribution are important to consider when identifying the impacts of variables, such as water elevation, which also vary temporally.

Herons have been shown to be very susceptible to both eagle and human disturbance at their breeding colonies (summarized in Gebauer and Moul 2001; Vennesland and Butler 2011). While considerably less research appears to have been undertaken on disturbance effects on the wintering grounds, wintering herons in the Kootenay region have few areas where they are not exposed to disturbances. Eagles are one such source of disturbance. While no eagle attacks of Great Blue Herons were noted in 2013/14 or 2014/15, Machmer (2003) reported such events on four occasions in 2002/03. Furthermore, she noted disturbance by eagles on 45.8 per cent of all observation dates. Herons were observed to be disturbed by humans, dogs, vehicles and trains during the 2013/14 and 2014/15 seasons. On several occasions birds were flushed from shorelines and/or trees by people and dogs walking close by. Humans and dogs (both leashed and unleashed) were encountered at many sampling locations, even when sampling locations were away from paths. For example, in February near the Columbia-Kootenay confluence, eight people were fishing, four trucks were present (some of which were running), and one dune buggy was operating. During the past two winters, humans and dogs appeared to be the greatest source of disturbance to herons. In contrast, no eagle activity was conclusively attributed to heron disturbance. Some areas, such as sewage lagoons (only the Castlegar sewage lagoon had heron presence) and islands, may offer refuge to herons by limiting direct access by humans, though these areas are not completely isolating to human activities (e.g., herons in the Castlegar sewage lagoons were flushed by approaching trains in both years of study).

While human disturbances may not directly lead to a population decline, repeated disturbances could affect their utilization of specific sites. Contrary to the winter of 2013/14, no herons were observed by us on Breakwater Island in 2014/15. Rather, herons were present on Waldie Island, from which they were largely absent the previous year. While speculative, this may have been due to extensive construction activity around the sewage lagoons. A slump and leakage at the south-east corner of the sewage lagoon berm triggered extensive work in the area commencing around September 22, 2014 (W. Volovsek pers. comm.). This work activity was ongoing during the November sampling period. This construction could have affected the number of herons that chose to winter in the area, or it may have precluded herons from Breakwater Island (though the construction was not on Breakwater Island itself). Heron numbers declined around the time that construction activities commenced, but a mid-September decline was also apparent in 2013 when no construction occurred, so any link is tenuous.

Figure 6-1: The view looking from the south bank of the Columbia River towards the Castlegar waste water treatment plant prior to (left panel) and during (right panel) construction. Construction activity in the fall of 2014 removed extensive vegetation along the sewage lagoon berm as well as reinforcing the berm with rip-rap (visible in right panel). Note the proximity of Breakwater Island in the foreground to the construction area behind. Such activity may have affected the distribution of herons in the Waldie Island area during the winter of 2014/15. Photos © Walter Volovsek

As disturbances may influence site utilization, so too may climate. In the interior in general, frozen wetlands and waterways limit heron foraging habitat, and therefore their range (Gebauer and Moul 2001). Comparison of historical climate averages as well as climate data from the past winter (November through February) shows that there are subregional differences in factors such as temperature and snow cover (Figures Figure 5-13 to Figure 5-15). In particular, the Rocky Mountain Trench is colder and snowier than other areas in the Kootenays. Northern sites, such as Revelstoke, are also colder and snowier than most sites further south. The climate data indicate that February was warmer than both December and January (Figure 5-13). Climate across this time period may interact with life history stages of herons in ways that might help explain temporal changes in heron counts, or may mask effects of water flow rates or elevation.

As sites in the north and in the Rocky Mountain Trench become unhospitable to birds by eliminating foraging opportunities, birds likely disperse to other areas. This is exemplified by anecdotal observations, such as in the slough north of Columbia Lake in the Athalmer area, where on November 27 water was almost entirely frozen over and no herons were observed, but where, according to a local naturalist, only two weeks prior five herons were present when there was significantly more open water. Looking at the annual count data for the past two years in the vicinity of Waldie Island, there appears to be a spike in heron numbers twice: once in early to mid-September, and again in October or November. Additional years of data collection will be needed to determine whether this two-peak pattern is true or spurious, but if true, it could represent two arrival periods for birds in the Castlegar area. The first a result of post-breeding dispersal and fall migration, and the second a result of deteriorating conditions in other regions forcing birds into remaining suitable habitat. The initial increase in heron numbers in late July and August aligns with the reported dispersal of herons (mostly young) away from breeding colonies (including birds dispersing from colonies in the United States) (Campbell et al. 1990). Counts are likely then augmented by the southward migration of herons in September and October (Campbell et al. 1990). In the interior, the largest numbers of herons are typically found in March, during spring migration (Campbell et al. 1990). That numbers do not increase in Castlegar is likely attributable to the fact that no known heronries are present. Courtship activities begin in February (Vennesland and Butler 2011), with birds arriving at breeding colonies beginning in March in the interior, though in January on the coast (Campbell et al. 1990, Vennesland and Butler 2011). It is possible that a reduction in heron numbers from January onwards in the Castlegar area represents birds that are departing to return to areas closer to breeding colonies in preparation for pair formation and courtship. That numbers decline earlier than expected for birds to be departing towards breeding colonies may in fact be some evidence for a water flow effect, especially when high water elevations are maintained for longer periods, such as during the whitefish flow period. That herons do not appear to return following that decline in December and January may then best be explained by migration back towards breeding colonies. The complex interaction of life history, climate, and water flow management in the lower Columbia River and elsewhere in the region hampers our ability to detect effects, but continued monitoring in Castlegar and elsewhere will help elucidate the winter distribution and abundance of herons.

In summary, the dynamics influencing overwintering herons along the Lower Columbia River are complex and likely interconnected. Flow regime may certainly impact shoreline utilization or heron abundance, most likely via maintaining low shoreline availability during whitefish flow periods, but additional data are required before any linkages can be made. It is clear that increasing elevation restricts the amount of potential shoreline habitat, with effects greatest on small islands such as Breakwater Island. Confounding our ability to detect such a trend are changes in breeding success and colony structure, lack of flow manipulation ability, and other impacts such as human-caused disturbances. These other factors must be considered, and additional years of data collection necessary, before any conclusions can be made.

6.1 Management Questions

6.1.1 MQ1: Where are the shoreline areas that are used by Great Blue Herons?

Herons were located at roughly twenty locations throughout the region (Figure 5-1). The majority were detected around Castlegar (Waldie Island area) and north of Creston (Duck Lake). Around Castlegar the most frequently used location was Waldie Island, specifically the southern and western sides. Herons were also seen in the Castelgar sewage lagoons, near Pass Creek and the opposite shoreline, at the Hugh Keenleyside Dam, and along the Kootenay River upstream of the confluence. These foreshore locations align with where herons were seen in 2013/14. However, in 2013/14, herons were only rarely witnessed on Waldie Island, instead frequenting Breakwater Island during the day. No herons were observed on Breakwater Island in 2014/15, possibly due to ongoing construction along the Waldie Island Trail and sewage lagoons adjacent to the island. Consistent with the previous year, no herons were observed on any shoreline between the Hugh Keenleyside Dam and the Pass Creek area, or along the Columbia River downstream of Waldie Island.

In Creston, herons were present both at the northern and southern ends of Duck Lake, along the channel to the southeast of the lake, and in the wetland complexes around Leach Lake and Corn Creek.

Elsewhere in the region, herons were observed south of Revelstoke at Montana Slough (n=1), at Burton Creek south of Nakusp (n=3), near Lumberton (n=1) and in Invermere (n=1). With the exception of the Invermere heron, during the February sampling period birds were only found in Creston. Birds appeared to withdraw from all other locations, including Castlegar.

Herons were found in a variety of habitats (e.g., flowing river, frozen lake, agricultural field) and there does not appear to be anything particularly unique about sites that were chosen. On average though, herons may be choosing sites with finer substrates and lower dissolved oxygen content, reflecting the lower water velocities at those locations. However, there is much overlap between sites where herons were present compared to where they were absent. In general, herons were only found where open water remained, with the exception of Duck Lake where herons congregated and foraged from holes in the ice. Our observations are limited to dusk, dawn, and daylight periods, and it is possible that distributions are different at night.

6.1.2 MQ2: How does the flow regime affect the area, distribution, and attributes of shoreline areas?

High flow rates out of Hugh Keenleyside Dam are related to higher water elevations as measured at the CNN (Columbia below Norns Creek) gauge. As water elevations increase, the amount of available shoreline decreases (Figure 5-6).

During the 2014/15 winter, the water elevation rose from 418.12 m to 421.08 m. The minimum water elevation occurred in November while the maximum occurred in December. Between these time periods, 66.0 per cent of potential shoreline habitat was lost due to inundation. At Waldie Island and Breakwater Island, the amount of potential shoreline habitat flooded was 78.9 per cent and 99.9 per cent respectively. Monthly average and minimum water elevations were highest in January, making that the month in which shoreline habitat was most limited for the longest period of time. The lowest ultimate amount of potential shoreline habitat occurred in December, for a short period of time, corresponding to the maximum winter water elevation. At sites with long shorelines paralleling the river, changes in water elevation may not affect foraging opportunities greatly, so long as some shoreline habitat remains. Thus, changes were most pronounced at islands, especially small, low elevation ones like Breakwater Island, which experienced concomitant decreases in shoreline area and length as water elevations increased.

At high water elevations, shoreline habitat is limited to a small upstream area in the Pass Creek delta, higher areas of Waldie Island mainly composed of the forested interior of that island, and the large grassy field habitat near the Kootenay River oxbow (Figure 5-8). In comparison, much habitat is available throughout the area during lower water events including channels and backwater areas around Zuckerberg Island and Waldie and Breakwater Islands, as well as sandbars near Pass Creek, and exposed gravel bars near the Tin Cup Rapids (Figure 5-8). The above areas represent approximately 59.8 ha of potential heron foraging and/or roosting habitat that is temporarily lost when water elevations peak.

There does not appear to be much difference in physicochemical parameters of water samples taken in the different time periods, or between sites with and without herons. This indicates that most of the habitat present could be utilized by herons, so long as security and foraging requirements are met. Sites may be underutilized owing to low numbers of wintering herons. At present it does not appear that flow regime impacts the attributes of shoreline sites in ways that influence heron use, though more study is needed on this point.

6.1.3 MQ3: Are there physical works that could improve the availability of shoreline areas for Great Blue Herons on Waldie Island and in the Castlegar area?

Additional years of data collection are required to answer this question, and no physical works should be conducted until all project years are completed and the whole dataset analysed. Up to this point in time, no physical works are proposed.

One issue, if Breakwater Island proves to be an important local shoreline roosting location, is the lack of shoreline availability at this location as water levels rise. The rate of habitat loss is greatest when water elevations increase from about 418 to 419 m, and the majority of shoreline area on this island is lost above about 421 m. One possibility to mitigate this would be to increase the size of Breakwater Island, particularly along the streamside and downstream sides. Such an increase would benefit most from building the island up to ensure that it does not become inundated during flooding periods. The island should not be extended along any direction that would increase its accessibility from the mainland shoreline.

Before any physical works should be implemented, additional data are needed on the influence of water elevation on wintering herons, particularly pertaining to important wintering locations.

6.1.4 MQ4: How does the suitability of winter habitat on Waldie Island and in the Castlegar area compare to habitat used by wintering Great Blue Herons elsewhere in the surrounding region?

The only two locations where herons appeared to congregate in any numbers during the November to February period were around Waldie Island in Castlegar and around Duck Lake in Creston. Sightings elsewhere included a bird in Revelstoke along a small stream entering Montana Slough from the highway, three birds at the mouth of Burton Creek south of Nakusp, a bird along a shallow, slow moving stream near Lumberton, and a bird in a slough just north of Columbia Lake. These birds were in a range of habitats and adjacent land uses, but were all present in open water with the exception of the Duck Lake birds. The Duck Lake birds, while on ice, were congregated around open ice holes from which they were able to hunt, and thus open water, while a very small amount, was still present.

In addition to having permanently open water, the Castlegar area and Waldie Island experience great changes in the amount of available shoreline habitat as water elevations fluctuate. While habitat might remain available, foraging habitat may be unsuitable if fish do not quickly move into areas recently flooded, as some evidence suggests (Machmer 2003). Thus, stable habitats may actually be more suitable, even if the area of those habitats is more restricted.

There does not appear to be much difference in physicochemical parameters of water samples taken in the Castlegar area versus the broader Kootenay region. Both air and water temperatures were higher on average in Castlegar than other locations. That air and water temperatures are higher and open water habitat is available may be one reason why herons are typically more numerous in Castlegar than other locations in the region (excepting Creston). In general, there is a lower range in values from Castlegar samples than all other locations, but this is expected given that all sites in Castlegar are connected in the same Columbia River system and geographic location, given the wide geographic spread and site types otherwise sampled. That physicochemical parameters do not appear to differ indicates that habitat is likely suitable throughout the region, and is unoccupied due to lack of availability (e.g., ice cover), an unmeasured variable (e.g., fish density), or simply because the region, which is along the northern extent of the interior wintering Great Blue Heron range, does not support a large enough winter population to occupy the remaining sites.

Security and foraging opportunity must be considered under habitat suitability. Foraging opportunity is assumed, but the nocturnal and crepuscular only foraging around Castlegar may limit habitat suitability compared to Creston where herons forage diurnally (and where nocturnal foraging is also assumed). Security does seem to be granted around Waldie Island owing to sites with limited human or dog access and good vantages or elevated perching sites (e.g., Waldie Island, Breakwater Island, Castlegar sewage lagoons). Both these considerations may be reflected in the selection of Duck Lake as a wintering site, where foraging is apparently successful through ice holes, and the frozen lake provides a buffer around potential disturbances as well as a good vantage over any potential threats.

Currently, habitat parameters indicate that sites around Waldie Island are not more, or less, suitable than elsewhere in the region. Instead, suitability is likely reflective of other considerations such as security and foraging opportunity. There is a potential that the duration of inundation events, especially related to its effects on fish occupancy, may reduce habitat suitability near Waldie Island over the course of the winter period, but more study is required.

6.1.5 MQ5: Are there operational changes that could improve habitat availability and suitability for Great Blue Herons on Waldie Island and in the Castlegar area?

In the early 2000s a higher number of herons were observed in the winter period than have been observed the past two winters. A study during the early 2000s (Machmer 2003) failed to definitively link flow regime to heron counts in this period. While counts are lower now, there is still weak to no evidence for an effect of water elevation on counts. However, there is a clear relationship between the water elevation and the amount of available potential habitat. Previously a maximum water elevation of 420.7 m has been recommended to ensure that enough shoreline remains, particularly around Breakwater Island which becomes submerged at elevations around 422 m (Machmer 2003, revised by BC Hydro 2012).

A water elevation of 420.7 translates to a loss of approximately 63 per cent of shoreline habitat overall in the Castlegar study area. The losses to Waldie Island and Breakwater Island are approximately 75.5 per cent and 90.7 per cent respectively. Above that elevation, the extent to which increases affect shoreline habitat relates to the topography of the shoreline feature. For example, increasing water elevations by 0.4 m above the recommended maximum reduces Waldie Island shoreline area by an additional ~3 per cent, but ~9 per cent to Breakwater Island. The rate of shoreline loss decreases as water elevation increases. We thus continue recommending that 420.7 m be kept as an operational maximum whenever possible, but acknowledge that temporary habitat loss occurs even at lower elevation levels. Maximizing shoreline availability requires keeping elevations as low as possible during the winter period. However, given the lack of explanatory power of water elevation on heron counts, there does not appear to be strong justification for maximizing habitat, so long as frequently used sites such as Waldie and Breakwater Islands remain available.

In particular, lowering the water elevations in January, when average water elevations in 2014/15 were 1 m higher than in November, would provide a useful contrast to better determine if water elevations are limiting the number of herons at that time period, or if herons depart regardless for unrelated reasons.

There does not appear to be any difference in habitat suitability with water elevation on variables that we measured. As herons are not relying on shoreline vegetation for any aspect of daily activity, and as shoreline vegetation may actually hinder a heron’s ability to detect a predator, the regular cycle of inundation and exposition of shoreline areas would not appear to negatively affect the suitability of that habitat for herons, and may actually benefit them in some situations. However, the flooding process may impact heron prey. It has been reported that recently inundated areas have low fish use (Machmer 2003). Machmer (2003) also comments that during the winter period, the rate of recolonization by fish to recently inundated areas may be slow. As a result, nearshore habitat where herons hunt following inundation events may not be productive foraging grounds. This would suggest that the lower water elevations could be the most suitable for wintering herons, and that higher nearshore habitats, even if available, may not be as suitable. If this is the case, the recommendation would remain to keep water elevations as low as possible given other operational constraints.

6.1.6 Management Questions Summary

Several management questions are addressed by this study (Table 6-1). As always, additional data and a complete analysis of the entire dataset are necessary to confidently answer them, but we are at least partially able to answer all management questions. This study has benefited from a broadening of the study area and investigations of herons elsewhere in the Kootenay region, as the Castlegar area is not a microcosm. Rather, a complex of variables related to climatic conditions and heron breeding success will impact how many herons are present in the Castlegar area during the winter months.

Table 6-1: Relationships between management questions (MQs), methods and results, Sources of Uncertainty, and the future of project CLBMON-49

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
1 – Where are the shoreline areas that are used by Great Blue Herons?	Yes	• Mapped heron locations showing all shoreline areas where herons detected. • Distribution of herons aligns with historical Christmas Bird Count data. • Occupied sites in Castlegar similar to those used in 2013/14.	• Broaden scope of area for desktop data collection (e.g., Christmas Bird Count data) to determine trends in heron numbers in adjacent regions (i.e., Okanagan Valley)	• Natural annual population variation • Variable dam flows among years and throughout the day • Human and other disturbances potentially limiting site utilization • Difficult to observe at night • Lack of experimentation to assess how varying the flows affects herons at different times through the winter period
2 – How does the flow regime affect the area, distribution, and attributes of shoreline areas?	Partially	• Shoreline areas increase with decreasing water elevation and vice versa. • Physicochemical parameters do not seem to be affected.	• Surveys should aim to capture the periods of highest and lowest water elevations taking duration of inundation into account	• Variable dam operations and inter-annual variation. • Uneven site response
3 – Are there physical works that could improve the availability of shoreline areas for Great Blue Herons on Waldie Island and in the Castlegar area?	Not at this time	• Locations where herons occur and knowledge of how water elevations affects the most commonly utilized roosting areas	• Surveys should aim to capture the periods of highest and lowest water elevations taking duration of inundation into account	• Variable dam operations • Natural annual population variation in numbers and site utilization • Lack of physical works to benefit herons already undertaken from which to inform recommendations
4 – How does the suitability of winter habitat on Waldie Island and in the Castlegar area compare to habitat used by wintering Great Blue Herons elsewhere in the surrounding region?	Partially	• Physicochemical parameters do not appear to differ • Water remains ice-free through entire winter period in Castlegar • Security and foraging opportunities present	• Include areas not surveyed previously such as near Nelson • Investigate heron use of habitats in adjacent regions, such as the United States, specifically habitats where high heron numbers are present.	• Only one year of data for areas outside of Castlegar • Unknown distribution, abundance, or site selection attributes of herons from areas with high winter abundances. • Unknown foraging opportunity or how fish presence/density varies among sites • Natural annual population variation
5 – Are there operational changes that could improve habitat availability and suitability for Great Blue Herons on Waldie Island and in the Castlegar area?	Partially	• Available potential shoreline habitat mapped out at different water elevations	• Surveys should aim to capture the periods of highest and lowest water elevations	• Unknown how fish or other aquatic organisms utilize recently inundated areas

7.0 RECOMMENDATIONS

The objectives of CLBMON-49 are to assess the response of herons to flow and stage regime from the Hugh Keenleyside Dam during the winter period due to its potential effects on availability of shallow-water foraging and winter refuge habitats, and to provide information on habitat use and feasible mitigative actions. The second year of study has provided a much more comprehensive picture of heron abundance, distribution, behaviour, and selection of sites through the Kootenay region. As with the 2013/14 year of study, heron numbers remained relatively low throughout the survey period, but especially during January and February. No big changes to the study program are recommended for year 3, but a few slight revisions are proposed.

7.1 Sampling Protocol

1. A broad cross-section of the Kootenays was surveyed in 2014/15, but areas around Kootenay Lake, such as near Nelson, were not surveyed due to time and budgetary constraints. Sampling that area should be considered, but may come at the expense of a site with low heron use, or where re-sampling sites was difficult due to increased snow and ice presence, such as Revelstoke.
2. The duration of the inundation during January was evident in this year's data. In addition, January had the highest average and highest minimum water elevations out of the four month period. Climate data indicate that January is colder than February. To ensure that conditions when sites may be most limited are measured, sampling should occur in November and January in the third year of study. Daily counts from the Waldie Island area should be continued with the cooperation of resident observers.

7.2 Hugh L. Keenleyside Dam Operations

The previous recommendation (Machmer 2003) of limiting water elevations at or below 420.7 m (based on the Norns Creek ratings curve) was largely met between 2005 and 2012. Water elevations exceeded that recommended limit for an extended period during the winter of 2013/14, and to a slightly lesser extent in 2012/13. While no definitive link has yet been made between water elevations and heron utilization of the Waldie Island area, given the apparent importance of Breakwater and Waldie islands as roosting locations, and their susceptibility to inundation at elevations above 422 m, operations should continue to attempt to limit the elevation to the previously recommended level. Elevations should be kept as low as possible during the stable whitefish flow period.

7.3 Additional Recommendations

The following recommendations address issues that might influence heron abundance and utilization of sites around Waldie Island, though they are not under BC Hydro's management authority. They are offered here for completeness and to highlight additional actions that appropriate decision-makers might take to benefit herons irrespective of hydro operations.

Breeding herons are extremely susceptible to disturbances during the breeding season. While disturbance impacts on non-breeding herons are less clear, they are unlikely to be beneficial. Human and dog (both leashed and unleashed) activity was noted near-daily during the past two winters of surveys at almost all shoreline locations, and their presence may limit heron utilization of otherwise suitable sites. Additionally, human-caused disturbances were noted multiple times. As the Waldie Island area appears to be the most significant wintering site for herons in the Castlegar area, consideration should be made to reduce potential disturbances in that area. These include:

1. Implementing and enforcing regulations requiring all dogs to be on leash on the Waldie Island Trail. As even the sound of dogs barking was noted to disturb herons, a complete dog ban would be ideal.
2. The current ban on human and dog activity on Waldie Island needs enforcement. Various users throughout the year (e.g., fishermen accessing via boat, and humans and on-leash and off-leash dogs during low water levels) have been noted on the island, depleting its utility as a wildlife reserve.
3. All human and dog activity (including watercraft) in the area between Breakwater Island, Waldie Island, and the mainland shore (the area referred to as Mill Pond), and along the backwater channel, including shorelines, between Waldie Island and the mainland should be banned and enforced. An enforced ban in this area would also benefit other wildlife that utilize this zone.
4. The boardwalk that previously was built along the Waldie Island Trail was destroyed during a high-water event in 2012. The boardwalk should be re-built to discourage trail users from walking on the beach and other shoreline areas, and to prevent further degradation of habitat.

8.0 ADDITIONAL REPORTING REQUIREMENTS

8.1 Data Deliverables

The following data deliverables have been or will be provided to BC Hydro to fulfill the Terms or Reference associated with CLBMON-49:

1.	Draft technical report	Submitted April 30, 2015
2.	Copies of notes, maps, photos	TBD
3.	Digital appendix (data)	TBD

8.1.1 Data Provided to BC Hydro

An MS Access or MS Excel database containing all 2013 through 2016 data will be provided to BC Hydro with the submission of the final report. This database conforms to the standards established by the B.C. Ministry of Environment for wildlife species inventories.

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APPENDICES

Appendix A: Shoreline sampling location coordinates for all sample sites in the Kootenay region during 2014/15 surveys

Region	Name	Zone	Easting	Northing
Burton	Burton Ck Mouth	11 U	436231	5536947
Burton	Burton Creek	11 U	437061	5536803
Burton	Burton South	11 U	435080	5536590
Castlegar	Breakwater Island North	11 U	452040	5464395
Castlegar	Bridgeview	11 U	452806	5463089
Castlegar	Grassland	11 U	453264	5462533
Castlegar	HLK Dam	11 U	444298	5465767
Castlegar	Kootenay Pt	11 U	452908	5462808
Castlegar	Midway	11 U	448876	5464976
Castlegar	Mill Site	11 U	446540	5465589
Castlegar	Oxbow	11 U	452829	5462386
Castlegar	Pass Creek	11 U	451646	5464924
Castlegar	PipelineX	11 U	452756	5463803
Castlegar	Twin Rivers Park	11 U	452664	5463453
Castlegar	Waldie East	11 U	452738	5464269
Castlegar	Waldie North	11 U	452540	5464629
Castlegar	Waldie West	11 U	452285	5464542
Castlegar	Zuckerberg Central	11 U	452365	5462703
Castlegar	Zuckerberg North	11 U	452345	5462925
Columbia Lake	Canal Flats	11 U	585607	5555724
Columbia Lake	Fairmont	11 U	580910	5575192
Cranbrook	Kootenay River South of Bull River	11 U	613740	5478898
Cranbrook	Norbury Creek	11 U	611379	5481057
Cranbrook	St. Eugene's Mission	11 U	589651	5493545
Cranbrook	St. Mary's - Wycliffe South	11 U	586616	5492837
Creston	Bridge Channel	11 U	525610	5456263
Creston	Corn Creek Pond	11 U	528011	5442731
Creston	Duck Lake South	11 U	528377	5451636
Creston	Dyke rd ditches	11 U	527906	5439735
Creston	Goat River	11 U	535012	5436626
Creston	Kootenay River South	11 U	530704	5436798
Creston	Kuskanook 87	11 U	524642	5460758
Creston	Kuskanook South	11 U	525044	5459990
Creston	Leach Lake North	11 U	526846	5446801
Creston	Leach Lake South	11 U	527354	5445432
Creston	Mid Channel	11 U	524607	5453367
Creston	South Duck Lake Channel	11 U	530396	5448588
Edgewood	Edgewood South	11 U	418032	5513983
Edgewood	Lower Inonoaklin	11 U	420433	5524119
Invermere	Columbia - North of Invermere	11 U	568179	5598651
Invermere	Windermere Lake North	11 U	569471	5596499
Kimberley	Marysville - St. Mary's River	11 U	574207	5498100
Kimberley	St. Mary's - Below treatment plant	11 U	574645	5497946
Lumberton	Lumberton	11 U	583036	5473938
Naksup	Nakusp Creek Mouth	11 U	441436	5565932
Naksup	South Nakusp Creek Mouth	11 U	443509	5563896
Revelstoke	Across from Log Dump	11 U	414430	5648994
Revelstoke	Airport South	11 U	417362	5645560
Revelstoke	Ball Park - West	11 U	415294	5649650

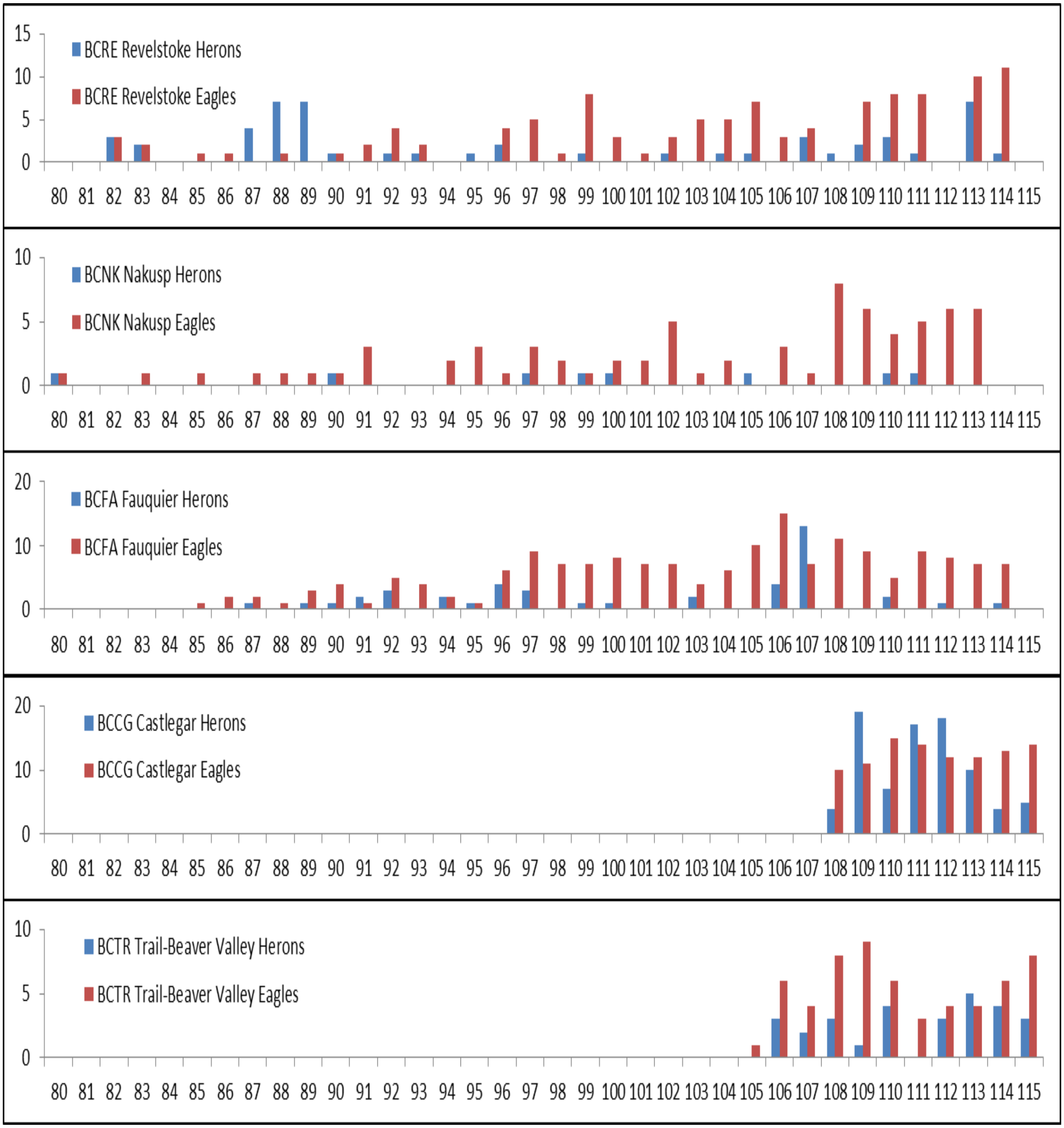
Region	Name	Zone	Easting	Northing
Revelstoke	Big Eddy	11 U	413611	5651114
Revelstoke	Cartier Bay	11 U	419325	5641859
Revelstoke	Illecillewaet Confluence	11 U	415393	5648722
Revelstoke	Illecillewaet River Bridge	11 U	416805	5648823
Revelstoke	Montana Slough	11 U	418774	5644080
Revelstoke	Moose Creek	11 U	414848	5655401
Revelstoke	Revelstoke-9 mile spit	11 U	420328	5639352
Revelstoke	Revi Reach South	11 U	422240	5634194
Revelstoke	Side Channel Across from Town	11 U	414603	5649523
Revelstoke	Side Channel S. of Bridge	11 U	414868	5650105
Revelstoke	Westside Channel	11 U	413095	5652126
Rocky Mountain Trench	H115 Kootenay	11 U	594166	5505248
Rocky Mountain Trench	Skookumchcuk	11 U	590698	5529448
Rocky Mountain Trench	Wasa Bridge	11 U	588724	5518182

Appendix B: UTM coordinates for all heron observations during 2014/15 surveys. Locations refer to the actual heron location (not the observer location). Locations are based on observations, and multiple points may pertain to a single individual (i.e., there are more observations than individual herons)

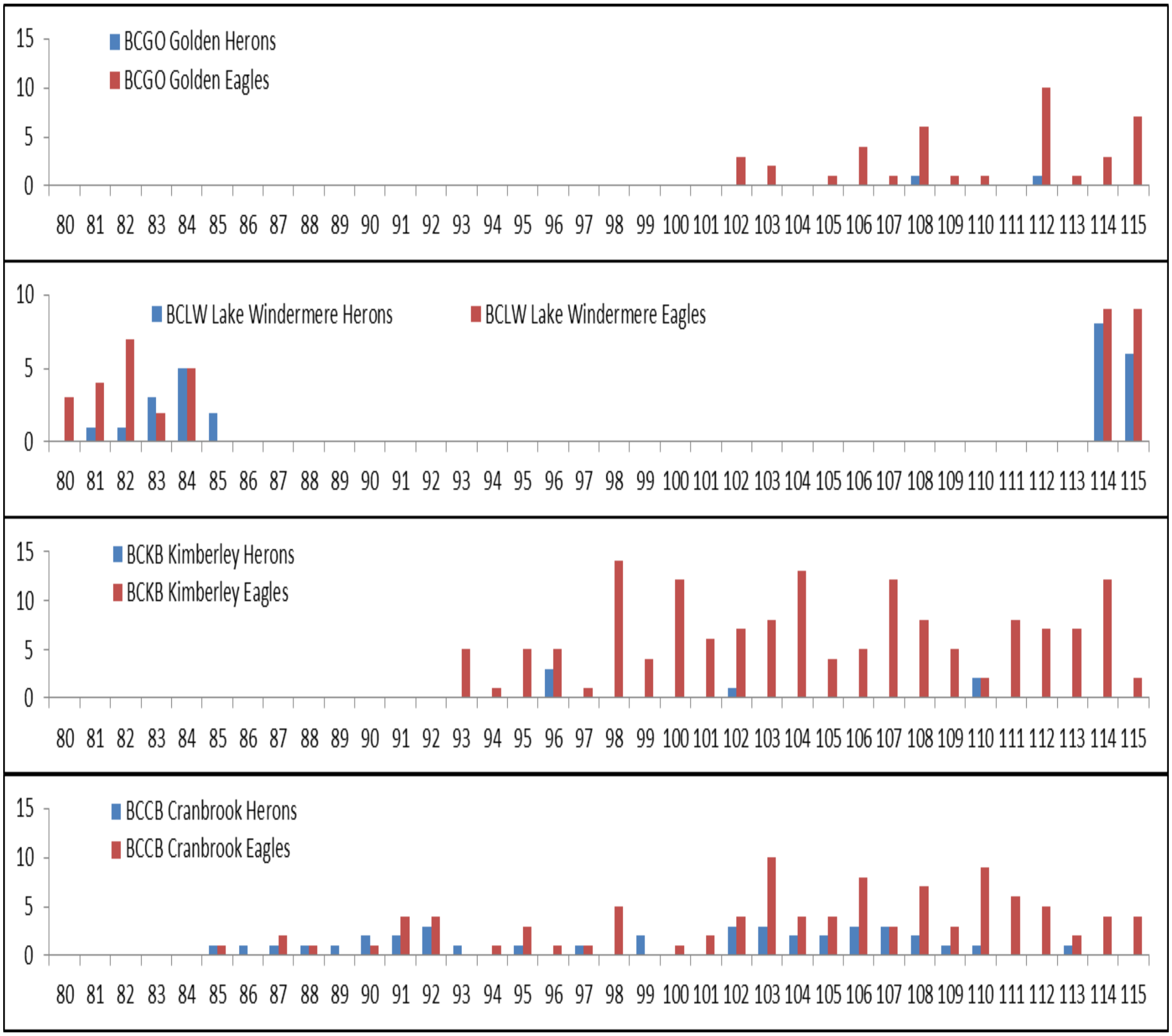
Region	Zone	Easting	Northing	Date
Burton	11 U	436243	5537120	20-Nov-14
Burton	11 U	436160	5536954	20-Nov-14
Burton	11 U	436233	5537014	20-Nov-14
Castlegar	11 U	452611	5464315	21-Nov-14
Castlegar	11 U	452613	5464320	21-Nov-14
Castlegar	11 U	452617	5464313	21-Nov-14
Castlegar	11 U	452639	5464304	21-Nov-14
Castlegar	11 U	452588	5464317	21-Nov-14
Castlegar	11 U	452520	5464337	21-Nov-14
Castlegar	11 U	451140	5464395	21-Nov-14
Castlegar	11 U	444160	5465802	21-Nov-14
Castlegar	11 U	452517	5464307	21-Nov-14
Castlegar	11 U	452519	5464322	21-Nov-14
Castlegar	11 U	452519	5464322	21-Nov-14
Castlegar	11 U	452527	5464336	21-Nov-14
Castlegar	11 U	452503	5464360	21-Nov-14
Castlegar	11 U	452505	5464359	21-Nov-14
Castlegar	11 U	452487	5464293	21-Nov-14
Castlegar	11 U	451448	5464825	21-Nov-14
Castlegar	11 U	451270	5464679	21-Nov-14
Castlegar	11 U	452519	5464307	22-Nov-14
Castlegar	11 U	452535	5464306	22-Nov-14
Castlegar	11 U	453347	5462643	22-Nov-14
Castlegar	11 U	452605	5464307	22-Nov-14
Castlegar	11 U	452617	5464313	22-Nov-14
Castlegar	11 U	451949	5464568	22-Nov-14
Castlegar	11 U	452518	5464332	22-Nov-14
Castlegar	11 U	452518	5464332	22-Nov-14
Castlegar	11 U	452518	5464332	22-Nov-14
Castlegar	11 U	452518	5464332	22-Nov-14
Castlegar	11 U	451136	5464395	22-Nov-14
Castlegar	11 U	451136	5464395	22-Nov-14
Castlegar	11 U	451136	5464395	22-Nov-14
Castlegar	11 U	451136	5464395	22-Nov-14
Castlegar	11 U	444015	5465678	22-Nov-14
Castlegar	11 U	444159	5465762	22-Nov-14
Creston	11 U	528171	5452813	23-Nov-14
Creston	11 U	527591	5451492	23-Nov-14
Creston	11 U	528584	5452300	23-Nov-14
Creston	11 U	528410	5452530	23-Nov-14
Creston	11 U	528264	5452725	23-Nov-14
Creston	11 U	527999	5451507	23-Nov-14
Creston	11 U	528403	5451980	23-Nov-14
Creston	11 U	525516	5455853	23-Nov-14
Creston	11 U	526132	5455143	23-Nov-14
Creston	11 U	527961	5452002	23-Nov-14
Creston	11 U	528595	5451296	23-Nov-14

Region	Zone	Easting	Northing	Date
Creston	11 U	533217	5445157	23-Nov-14
Creston	11 U	530168	5449105	23-Nov-14
Creston	11 U	526590	5447120	24-Nov-14
Creston	11 U	527278	5441555	24-Nov-14
Creston	11 U	526734	5447145	24-Nov-14
Creston	11 U	525429	5455666	25-Nov-14
Creston	11 U	527799	5451648	25-Nov-14
Creston	11 U	527773	5451658	25-Nov-14
Creston	11 U	528376	5452233	25-Nov-14
Creston	11 U	528617	5452288	25-Nov-14
Creston	11 U	528053	5452141	25-Nov-14
Creston	11 U	527997	5452741	25-Nov-14
Creston	11 U	528049	5452742	25-Nov-14
Creston	11 U	528084	5452741	25-Nov-14
Creston	11 U	528482	5452278	25-Nov-14
Creston	11 U	525573	5455891	16-Feb-15
Creston	11 U	525499	5455789	16-Feb-15
Creston	11 U	528318	5451386	17-Feb-15
Creston	11 U	528233	5451429	17-Feb-15
Creston	11 U	528233	5451429	17-Feb-15
Creston	11 U	528233	5451429	17-Feb-15
Creston	11 U	528195	5451465	17-Feb-15
Creston	11 U	528195	5451465	17-Feb-15
Creston	11 U	528195	5451465	17-Feb-15
Creston	11 U	528162	5451516	17-Feb-15
Creston	11 U	528162	5451516	17-Feb-15
Creston	11 U	528162	5451516	17-Feb-15
Creston	11 U	528141	5451583	17-Feb-15
Creston	11 U	528281	5451428	17-Feb-15
Creston	11 U	528279	5451438	17-Feb-15
Creston	11 U	528279	5451438	17-Feb-15
Creston	11 U	528279	5451445	17-Feb-15
Creston	11 U	528279	5451449	17-Feb-15
Creston	11 U	528280	5451466	17-Feb-15
Creston	11 U	528281	5451470	17-Feb-15
Creston	11 U	531881	5446789	17-Feb-15
Creston	11 U	531881	5446789	17-Feb-15
Creston	11 U	531881	5446789	17-Feb-15
Creston	11 U	531142	5447745	17-Feb-15
Creston	11 U	525558	5455928	17-Feb-15
Creston	11 U	528010	5447348	17-Feb-15
Creston	11 U	527994	5442761	18-Feb-15
Creston	11 U	527963	5439818	18-Feb-15
Invermere	11 U	569342	5596681	20-Feb-15
Lumberton	11 U	583094	5473876	27-Nov-14
Revelstoke	11 U	418753	5644080	18-Nov-14

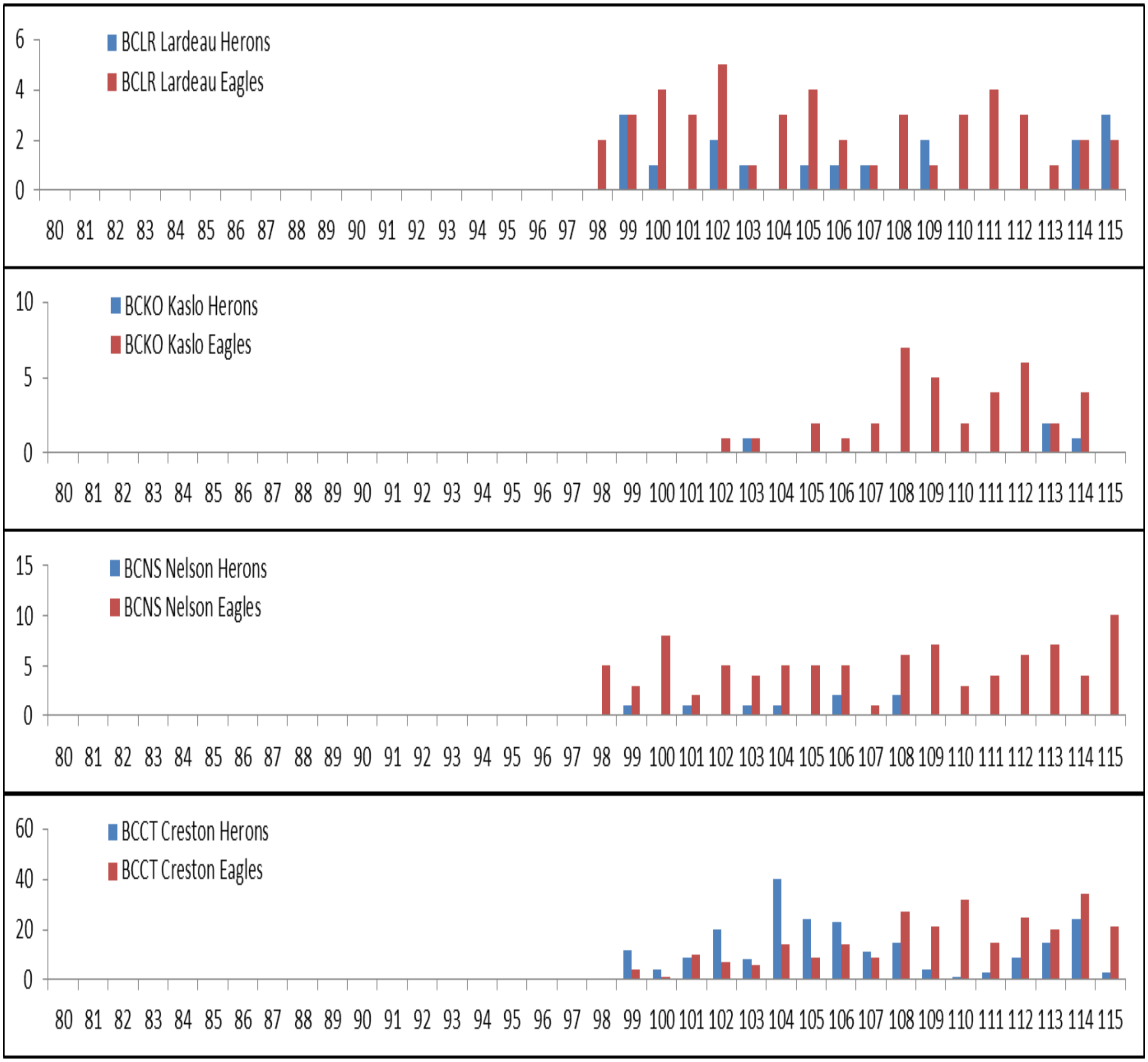
Appendix C: Christmas Bird Count results for counts along the Columbia River between Revelstoke and Trail. Note that the vertical axis values differ between graphs. The vertical axis refers to the number of herons (blue bars) and Bald Eagles (red bars). The horizontal axis gives the count year as indicated by the National Audubon Society. Count year "80" refers to the 1979-1980 count, while count year "115" refers to the 2014-2015 count



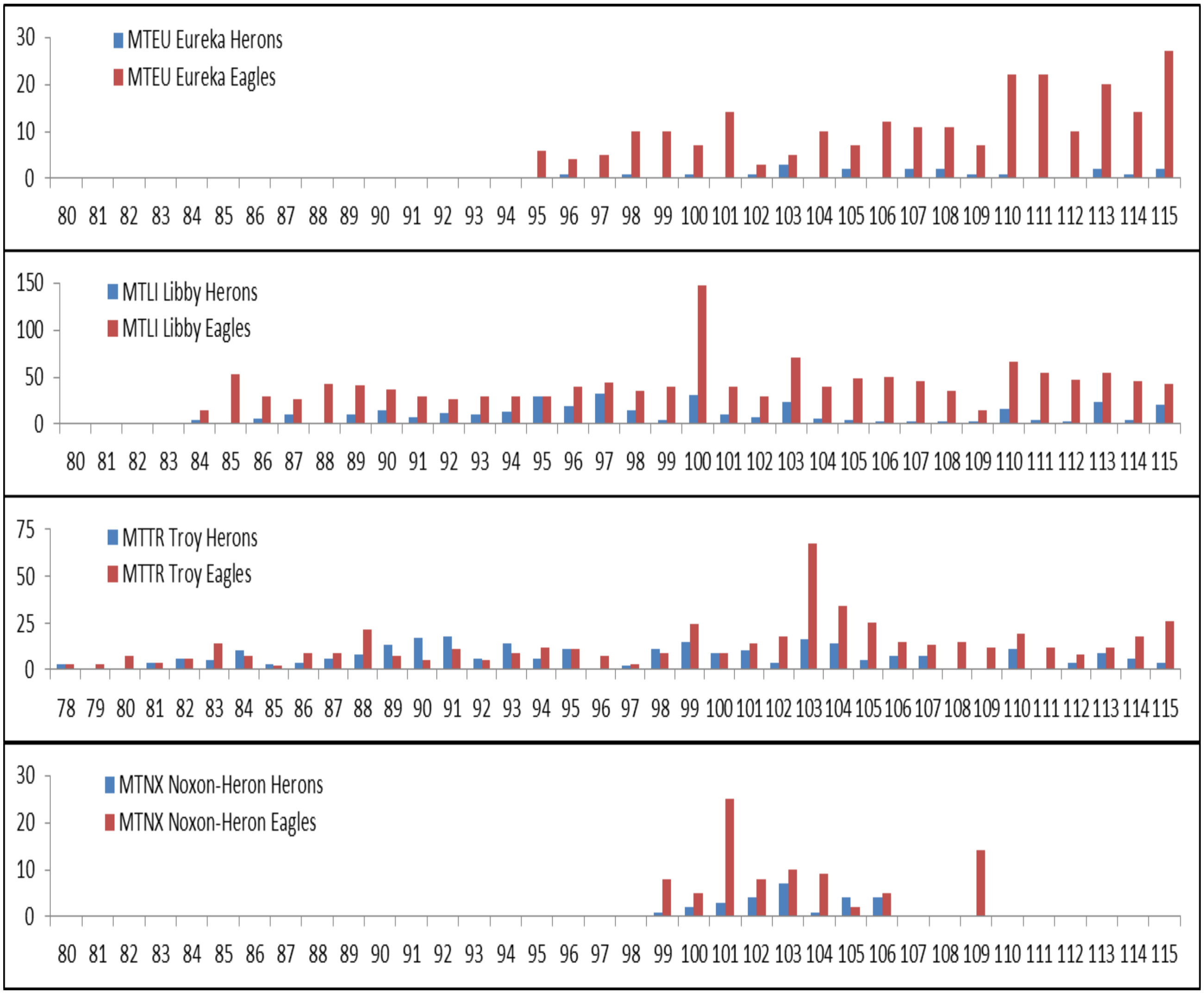
Appendix D: Christmas Bird Count results for counts along the Rocky Mountain Trench from Golden to Cranbrook. Note that the vertical axis values differ between graphs. The vertical axis refers to the number of herons (blue bars) and Bald Eagles (red bars). The horizontal axis gives the count year as indicated by the National Audubon Society. Count year "80" refers to the 1979-1980 count, while count year "115" refers to the 2014-2015 count



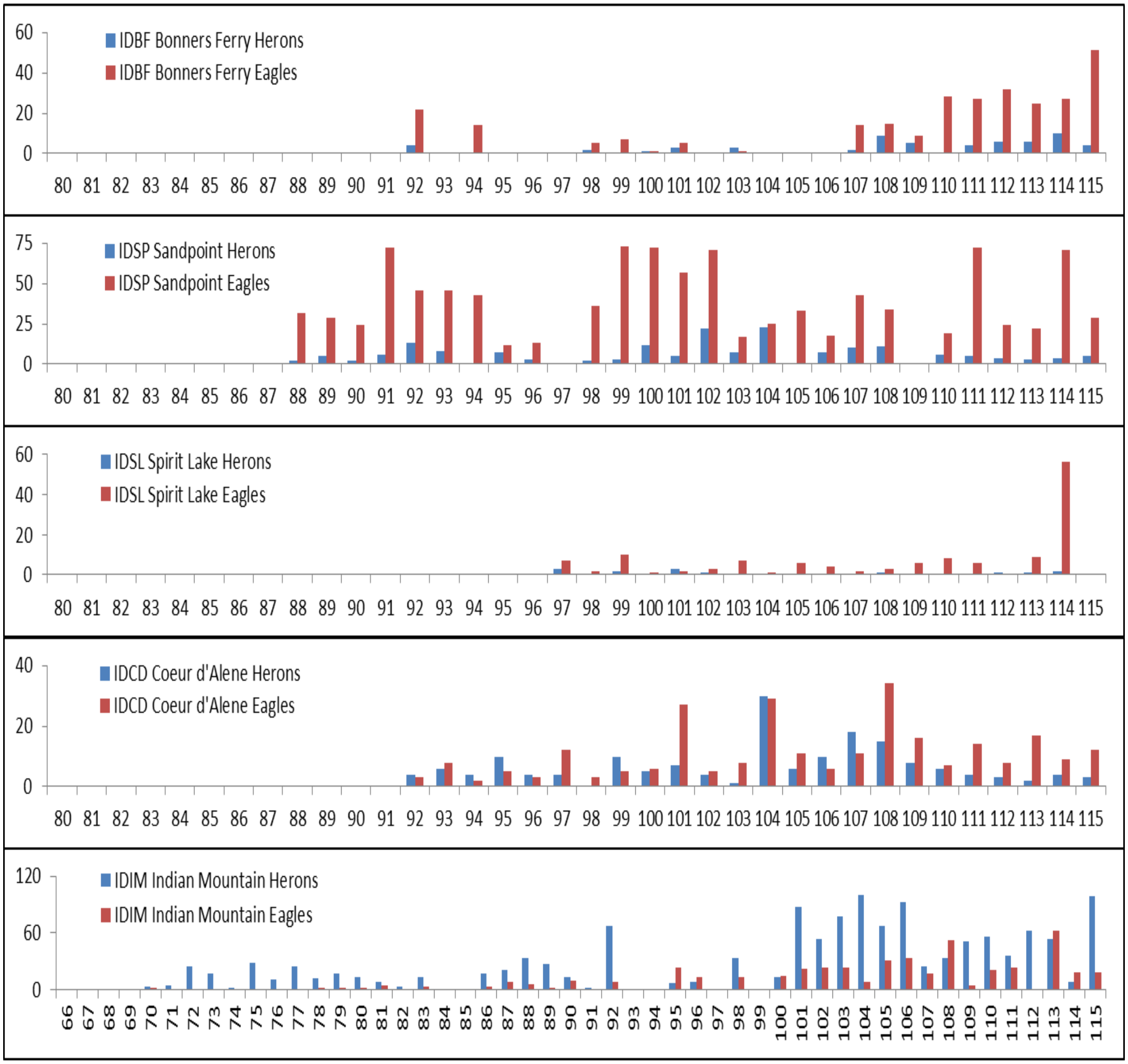
Appendix E: Christmas Bird Count results for the Kootenay Lake and Creston region. Note that the vertical axis values differ between graphs. The vertical axis refers to the number of herons (blue bars) and Bald Eagles (red bars). The horizontal axis gives the count year as indicated by the National Audubon Society. Count year "80" refers to the 1979-1980 count, while count year "115" refers to the 2014-2015 count



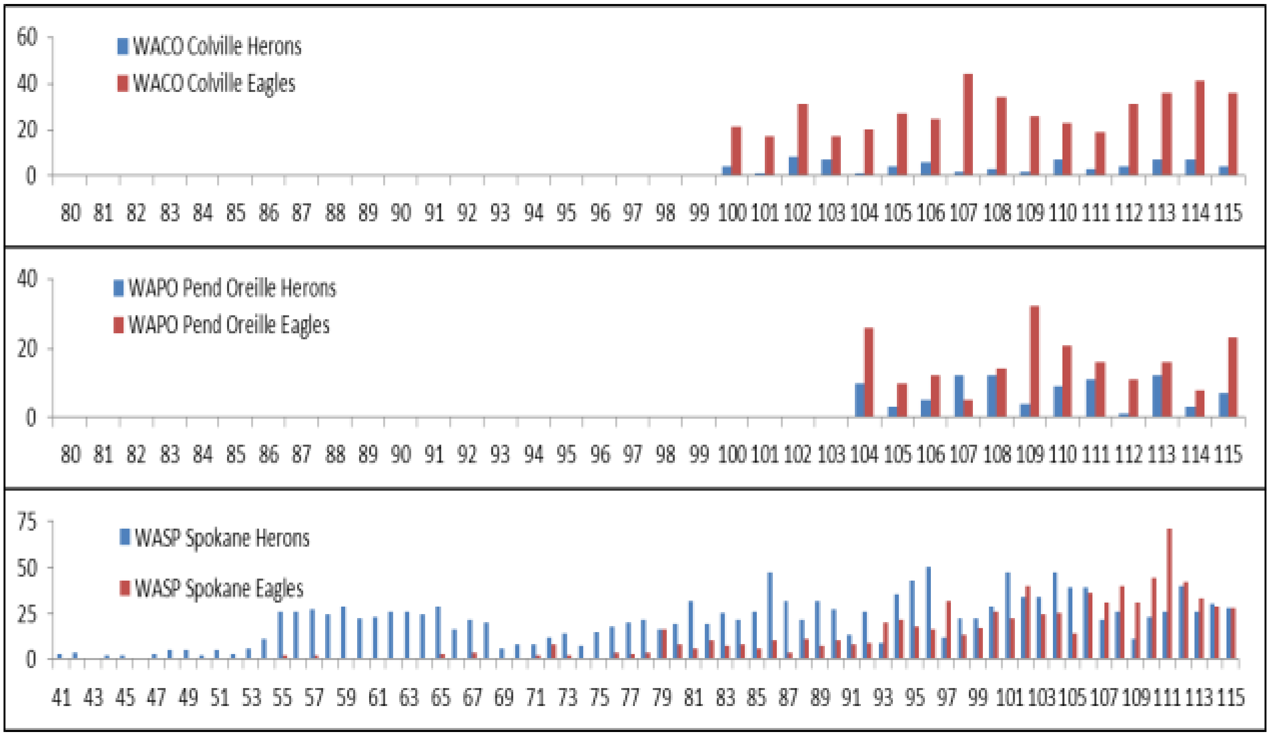
Appendix F: Christmas Bird Count results for northwest Montana. The Eureka, Libby, and Troy count circles all include portions of the Kootenay River. Note that the vertical axis values differ between graphs. The vertical axis refers to the number of herons (blue bars) and Bald Eagles (red bars). The horizontal axis gives the count year as indicated by the National Audubon Society. Count year "80" refers to the 1979-1980 count, while count year "115" refers to the 2014-2015 count



Appendix G: Christmas Bird Count results for northern Idaho. Most of these count circles are near large lakes. The Sandspit and Spirit Lake counts are near Lake Pend Oreille, and the Coeur d'Alene and Indian Mountain counts are near Lake Coeur d'Alene. Heron counts are higher at Indian Mountain than any other count circle considered, but have been especially high since approximately 2000 (count 101). Note that the vertical axis values differ between graphs. The vertical axis refers to the number of herons (blue bars) and Bald Eagles (red bars). The horizontal axis gives the count year as indicated by the National Audubon Society. Count year "80" refers to the 1979-1980 count, while count year "115" refers to the 2014-2015 count



Appendix H: Christmas Bird Count results for north-eastern Washington. The Spokane count has an extended dataset going back to 1940. Heron numbers are relatively high here, show interannual variation, but no overall population trend is obvious. Note that the vertical axis values differ between graphs. The vertical axis refers to the number of herons (blue bars) and Bald Eagles (red bars). The horizontal axis gives the count year as indicated by the National Audubon Society. Count year "80" refers to the 1979-1980 count, while count year "115" refers to the 2014-2015 count



Appendix I: Amount of available shoreline area for the Castlegar region in general, Breakwater Island, Waldie Island, and grand total. Values are presented for the monthly minimum, maximum, and average water elevations for the November to February survey period. Values underneath the month category indicate the water elevations that correspond to the resulting calculated areas

	Available Shoreline (m^2)												
SITE	**TOTAL AREA**	**NOV AVG**	**NOV MAX**	**NOV MIN**	**DEC AVG**	**DEC MAX**	**DEC MIN**	**JAN AVG**	**JAN MAX**	**JAN MIN**	**FEB AVG**	**FEB MAX**	**FEB MIN**
		419.56	420.51	418.12	420.06	421.08	419.17	420.57	420.74	419.92	419.53	420.21	419.14
Castlegar	2,266,967	481,129	334,284	840,930	384,390	296,554	563,144	329,502	317,221	405,977	487,171	365,153	569,601
Breakwater Island	8,541	4,720	1,593	8,343	3,015	10	6,035	1,393	773	3,593	4,803	2,418	6,156
Waldie Island	59,472	25,419	15,226	57,166	18,249	12,070	31,884	14,890	13,997	20,032	25,891	17,122	32,500
Total	2,334,980	511,268	351,102	906,439	405,655	308,634	601,063	345,785	331,990	429,601	517,865	384,693	608,257