Columbia River Project Water Use Plan

KINBASKET AND ARROW LAKES RESERVOIRS

Reference: CLBMON 39

Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone

Study Period: 2017

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May 23, 2018

CLBMON 39: Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone

Year 10 (2017)

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Cover photo: Magnolia Warbler (*Setophaga magnolia*), Machete Island banding station, Revelstoke Reach, 2017. Photo: Michal Pavlik, CBA Ltd.

EXECUTIVE SUMMARY

In 2008, BC Hydro implemented CLBMON 39, a 10-year monitoring program designed to determine the effects of reservoir operations on neotropical migrant songbirds in Revelstoke Reach during fall migration. In the first three years of this study, research focused on the migration monitoring station at Machete Island. In 2011, monitoring in other habitats in Revelstoke Reach was implemented to assess the impacts of reservoir operations across the diversity of habitats throughout the Reach. This report summarizes the work that was conducted in Year 10 (2017).

In 2017, two sites in the drawdown zone (Airport Islands and Machete Island) and one site outside of the drawdown zone (Jordan River) were monitored by constant effort mist netting. The water levels of Arrow Lakes Reservoir at the beginning of the fall migration season (August 1) were higher than the long-term average for that time of year but water levels gradually dipped below the long-term average in September.

At Machete Island banding station, 35 surveys were conducted for a total of 2076 net-hours. The first survey was conducted on August 3, 2017 and the last one on September 22, 2017. The average number of open mist nets per day was 10.9 ± 0.47 (mean ± SE). A total of 5426 birds of 61 species were captured, with an overall capture rate of 2.6137 birds/net-hour. Yellow-rumped Warbler (*Setophaga coronata*) was the most frequently captured species (22.2% of all captured birds) with an overall capture rate of 0.5809 birds/net-hour. In total, 4468 individuals of 60 species were newly captured (new individuals for the season) and the capture rate for newly captured birds was 2.1522 birds/net-hour. Of the newly captured birds of known age (99.9% of all newly captured birds), 91.8% were HY (juvenile birds hatched in 2017), and 8.2% were AHY (adult birds more than one year old). 472 individuals of 29 species were recaptured at least once later in the season (874 recaptures total). The overall recapture rate was 13.1% and the overall same day recapture rate was 6.5%. In 2017, we captured one species at Machete Island that had not been previously captured under CLBMON 39 at any station: Virginia Rail (*Rallus limicola*). In addition, of the 61 species captured at Machete Island in 2017, 24 other species were captured only at Machete Island but not at Jordan River or Airport Islands. Compared to the previous years of monitoring at this site, the capture rate for newly captured birds and the overall capture rate in 2017 (2.1522 and 2.6137 birds/net-hour, respectively) were higher than in any of the previous years.

At Airport Islands banding station, 7 surveys were conducted for a total of 220.75 net-hours. The average number of open nets per day was 6.9 ± 0.94 (mean ± SE). The overall capture rate was 0.7022 birds/net-hour. In total, 155 birds from 17 species were captured, with Yellow-rumped Warbler being the most frequently captured species (0.2174 birds/net-hour). The capture rate for newly captured birds was 0.5798 birds/net-hour and the overall recapture rate was 4.7%. The recapture rate for same day recaptures was 15.6%. Rusty Blackbird (*Euphagus carolinus*), was captured at this site in 2017, this species has not been previously captured under CLBMON 39 at any station. In addition, we banded two species that have not been previously captured at this site: Black-capped Chickadee (*Poecile atricapillus*) and Swainson's Thrush (*Catharus ustulatus*). Compared to the previous years of monitoring at this site, the capture rate for newly captured birds and the overall capture rate were the second highest to date (in 2011 the capture rate for newly captured birds and the overall capture rate were 0.6785 and 0.8135 birds/net-hour, respectively).

At Jordan River banding station, 7 surveys were conducted for a total of 284.5 net-hours. The average number of open nets per day was 7.3 ± 0.18 (mean ± SE). In total,

400 birds of 33 species were captured, with an overall capture rate of 1.4060 birds/net-hour. The most frequently captured species was Yellow-rumped Warbler (0.5413 birds/net-hour). The capture rate for newly captured birds was 1.3076 birds/net-hour and the overall recapture rate was 2.4%. The recapture rate for same day recaptures was 3.8%. In 2017, no new species were captured at this site and only one species – Cassin's Vireo (*Vireo cassinii*) – was captured exclusively at this site. Compared to the previous years of monitoring at this site, the capture rate for newly captured birds and the overall capture rate in 2017 (1.3076 and 1.4060 birds/net-hour, respectively) were the highest recorded to date.

Key recommendations: (1) no field surveys are proposed, (2) analyze the data collected under the CLBMON 39 in years one to ten and provide a comprehensive final report.

KEYWORDS

reservoir operations, neotropical migrants, songbirds, fall migration, stopover habitat, Revelstoke Reach, Arrow Lakes Reservoir, British Columbia, BC Hydro

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CBA collaborates with the Okanagan Nation Alliance (ONA) for delivery of CLBMON 39, with ONA biologists and technicians providing field and technical support, and insight into the perspectives and protocols of the Syilx (Okanagan) people. Autumn Solomon and Mike Dunn of the ONA staff contributed to field studies. Dave DeRosa managed the ONA's involvement.

Field studies were completed by CBA staff (James Bradley, Catherine Craig, Michal Pavlik, Emily Williams and Emily Smith) and ONA staff (Autumn Solomon and Mike Dunn). Michal Pavlik planned the 2017 field study program and worked as bander-in-charge. John Cooper acted as Project Manager. Suzanne Beauchesne provided supervisory and technical assistance throughout the project.

Louise Laurin (Canadian Wildlife Service [CWS] Bird Banding Office) processed bird banding and capture permits. CBA would also like to thank the community of Revelstoke for providing a safe and enjoyable home base for the field crew during the field season.

Michal Pavlik and John Cooper prepared this report.

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1 INTRODUCTION

Since the late 1980s, neotropical migrant birds have become a focus of wildlife managers due to population declines and threats to habitats in their breeding and wintering ranges (Terborgh 1989, DeSante and George 1994, Sherry and Holmes 1996). In Canada, neotropical migrants, and in particular long distance migrants, are declining at a faster rate compared to short distance migrants and resident birds (NABCIC 2012). Nearctic-Neotropical migrant birds (neotropical migrants) include more than 200 species that generally breed north of the Tropic of Cancer, and at least 5% of the population winters south of that latitude (U.S. Fish & Wildlife Service 2011). This group of birds is comprised mainly of songbirds such as flycatchers, swallows, vireos, thrushes, warblers, sparrows and tanagers, but it also includes some species of waterfowl, raptors, gulls, terns, shorebirds, hummingbirds, swifts and others (DeGraaf and Rappole 1995). This report focuses on neotropical migrant songbirds.

Early research on the decline of neotropical migrant songbirds focused on the fragmentation of breeding habitat and destruction of tropical forests on wintering grounds (e.g., Robinson and Wilcove 1994). In the 1990s, however, attention turned to the importance of stopover habitat use during migration (e.g., Yong et al. 1998, Moore 2000). Neotropical migrant songbirds need to replenish energy reserves during migration and may stop at one or more sites during migration to refuel (e.g., Skagen et al. 2004). Research has demonstrated that mortality rates during migration can be up to 15 times higher than mortality rates on breeding or wintering grounds (Sillett and Holmes 2002). However, the extent to which mortality is affected by loss of suitable stopover habitat is less well known. Reductions in the availability of stopover habitat may lead to increased competition for limited food resources, thereby increasing stress levels or reducing the ability of migratory birds to gain the weight necessary to continue along their migration route. Both increased stress and reduced refuelling rates can lead to increased mortality during migration, thus resulting in a negative impact on migratory songbird populations (Alerstam and Hedenström 1998). To accommodate the needs of all migrant songbird species a wide variety of habitat types are needed (Suomala et al. 2010).

Revelstoke Reach is unique in the Columbia River reservoir network because it has a relatively flat, well vegetated floodplain that is usually inundated by water for only a few weeks each year. Vegetated areas include riparian cottonwood forest, willow scrublands, wetlands and grasslands, all of which provide habitat for neotropical migrant birds. Most of the rest of the Columbia River reservoir network has steep shorelines and long periods of high water levels, which precludes persistent vegetation (Bonar 1979) and provides little habitat for neotropical migrant birds. The wetlands, riparian forest and shrub-savannah areas of the upper portion of Revelstoke Reach provide high quality habitat for breeding and migratory birds (Tremblay 1993, AXYS 2002, Boulanger et al. 2002, Jarvis and Woods 2002, MCA 2003, Boulanger 2005, Green and Quinlan 2007, CBA 2013a, 2013c). In part, this habitat is the result of revegetation programs undertaken by BC Hydro to control dust in Revelstoke Reach (McPhee and Hill 2003).

CLBMON 39 Arrow Lakes Reservoir Neotropical Migrant Use of the Drawdown Zone Monitoring Program is one of several wildlife monitoring programs initiated by BC Hydro in 2008 as a result of the water use planning process. The Columbia River Water Use Planning Consultative Committee (BC Hydro 2005) recommended that monitoring be conducted to determine how variation in reservoir levels affects the abundance and habitat use of neotropical migrant songbirds in Revelstoke Reach during the fall migration by capitalizing on data gathered at the long-term migration monitoring station

on Machete Island (Jarvis and Woods 2002). More than 60 species of neotropical migrants have been recorded at the migration monitoring station during fall migration (Jarvis and Woods 2002, Easton 2007, MCA 2009).

CLBMON 39 is designed to provide information that will support future decisions about how to manage the operating regime of the Arrow Lakes Reservoir in order to protect neotropical migrant songbird populations during fall migration and balance ecological health with recreational opportunities, flood control, power generation and other water use plan requirements.

The CLBMON 39 program was initiated in 2008 with constant effort mist-netting surveys at Machete Island banding station. In 2011, fall monitoring of neotropical migrant songbirds in other habitats throughout Revelstoke Reach was implemented to assess the impacts of reservoir operation across the diversity of habitats. In 2008–2013, in addition to population monitoring, fattening rates of neotropical migrants were assessed through analyses of blood plasma metabolites assays. In 2015, the original CLBMON 39 Terms of Reference (ToR) were revised to improve the study's ability to address requirements defined by the Consultative Committee and to address shortcomings in framing of the initial management questions. This report reflects changes incorporated in the revised ToR.

This report provides results of Year 10 of the 10-year study.

1.1 Scope and Objectives

CLBMON 39 is a 10-year fall migration monitoring program specifically designed to:

1) Determine the migration patterns of neotropical migrants in Revelstoke Reach over time (within season, across seasons, and across years).
2) Assess whether reservoir operations affect populations of neotropical migrants that use the area as a stopover site.
    a) Examine the effects of reservoir operation on the abundance, diversity, habitat availability, and fattening rate of neotropical migrants in Revelstoke Reach.
    b) Identify species that have a higher likelihood of being affected by reservoir operations.
3) Determine whether there are specific times during the migratory season when minor adjustments to flow rates or water levels will enhance the ability of the drawdown area to support neotropical migrants.
4) Provide information with respect to how wildlife physical works or revegetation can increase utilization of treated riparian habitat by neotropical migrants.
5) Determine habitat use by neotropical migrants in the drawdown zone of Revelstoke Reach over time (within season, across seasons, and across years) and the impacts of reservoir operations on habitat availability and quality.

1.2 Management Questions

BC Hydro has provided nine specific management questions that are to be addressed at the completion of CLBMON 39. The management questions are as follows:

1) What is the seasonal and annual variation in the abundance and species richness of neotropical migrants in Revelstoke Reach during fall migration?

2) Which habitats within the drawdown zone in Revelstoke Reach are utilized by neotropical migrants and what are their characteristics?

3) Do reservoir operations influence the species richness or abundance of neotropical migrants using habitat in the drawdown zone during fall migration? If so, how do reservoir operations influence the species richness or abundance?

4) Which neotropical migrants are most affected by reservoir operations?

5) Do reservoir operations affect the fattening rates of neotropical migrants using the drawdown zone during fall migration?

6) Can operational adjustments be made to reduce impacts on neotropical migrants during fall migration or are mitigation measures required to minimize the loss of stopover habitat?

7) *Original question 7 deleted (as per updated ToR).*

8) Are the ongoing revegetation projects effective at improving utilization of the treated habitat in the drawdown zone by neotropical migrants?

9) Does the operation of Arrow Lakes Reservoir impact the availability or quality of stopover habitat in Revelstoke Reach for neotropical migrants?

1.3 Management Hypotheses

The primary hypotheses to be tested by this study are as follows:

H1: Annual and seasonal variation in reservoir levels do not influence neotropical migrant abundance or species richness in habitats in the drawdown zone of Revelstoke Reach during fall migration.

H_{1A}: Changes in the diversity (species richness) of neotropical migrants in Revelstoke Reach are not attributable to reservoir operations.

H_{1B}: Changes in the abundance of neotropical migrants in Revelstoke Reach are not attributable to reservoir operations.

H2: Annual and seasonal variation in reservoir levels do not influence fattening rates of neotropical migrants in Revelstoke Reach during fall migration.

H3: Annual and seasonal variation in reservoir levels do not influence the availability or quality of habitat for neotropical migrants

H4: Revegetation does not affect utilization of the area by neotropical migrants as measured by migrant species richness or abundance.

The manner in which the relevant management hypotheses are related to the management questions and objectives is outlined in Appendix 1.

1.4 Study Areas

The CLBMON 39 study area was defined as the drawdown zone of Revelstoke Reach. Revelstoke Reach is the northernmost arm of the Arrow Lakes Reservoir south of Revelstoke, BC, between the Monashee and Selkirk Mountains (Figure 1). This hydroelectric reservoir, regulated by the Hugh Keenleyside Dam near Castlegar, B.C., is licensed to operate between 420 m and 440.1 m elevation under constraints imposed by the Columbia River Treaty. The drawdown zone is the area between these reservoir elevation extremes. The reservoir is typically operated to store water in spring and summer, and occasionally into the fall, and to release water through Keenleyside Dam during the winter months, creating a cyclical annual pattern of reservoir elevations (Figure 2, Appendix 2).

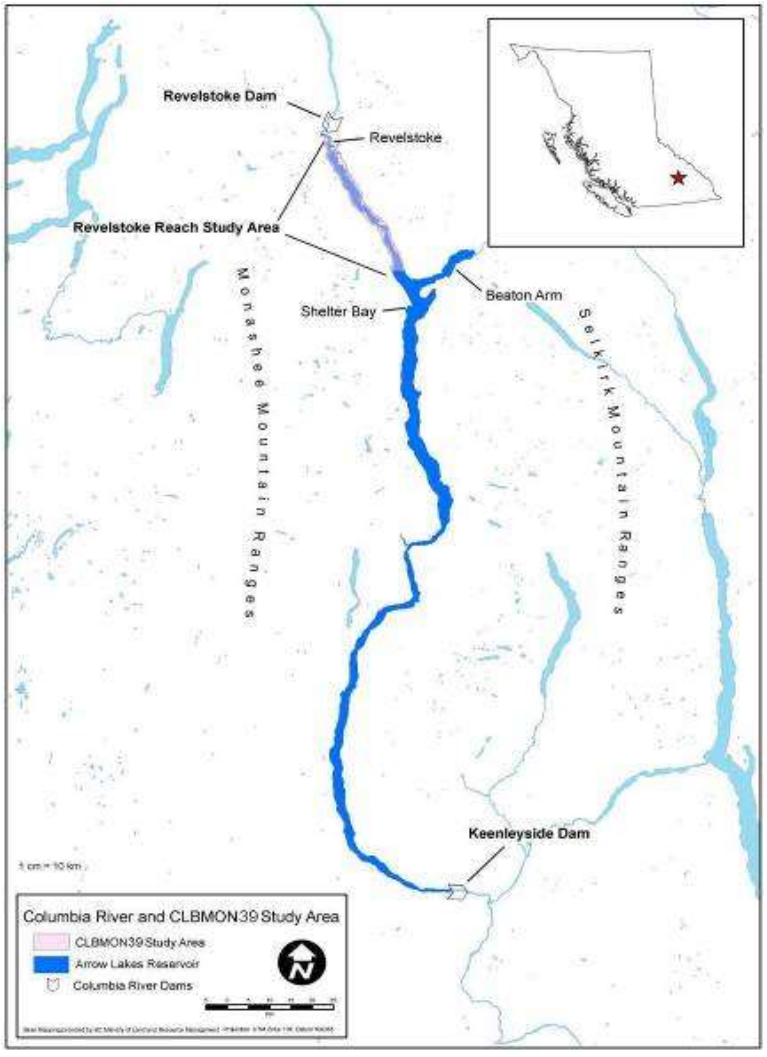

Figure 1: CLBMON 39 study area in Revelstoke Reach, Arrow Lakes Reservoir.

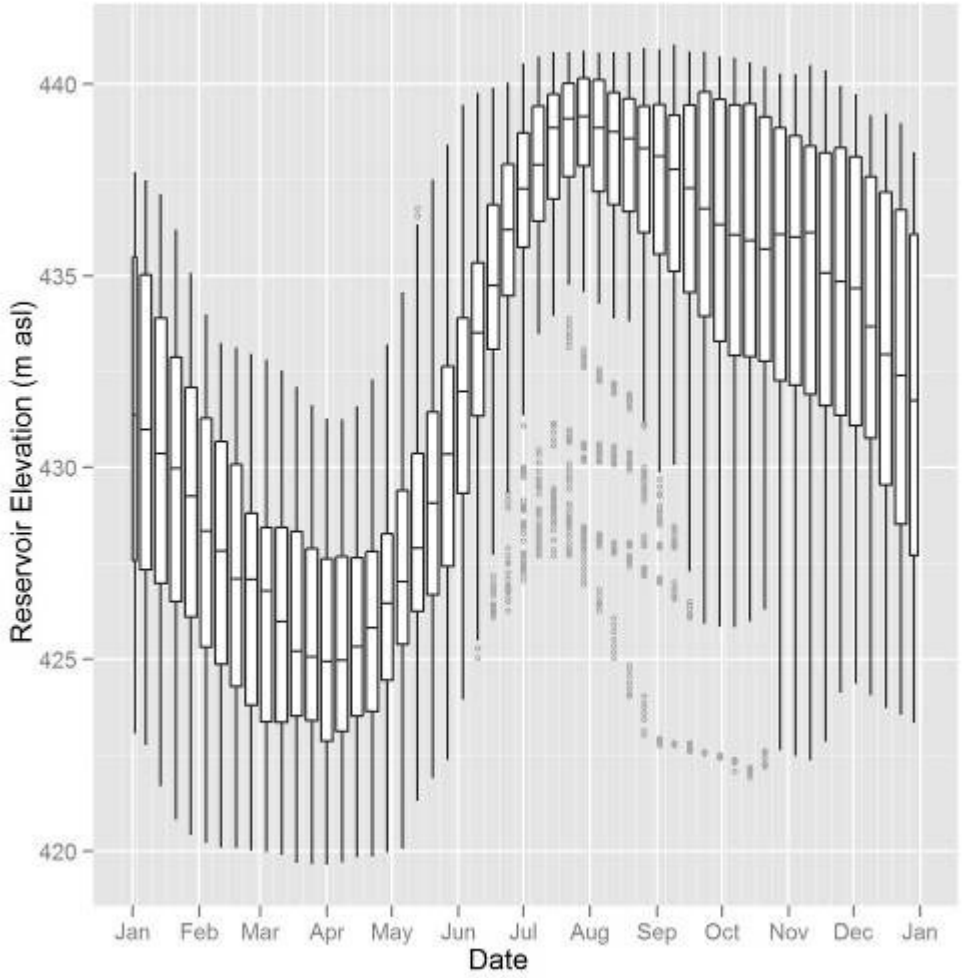

Figure 2: **Historical hydrological data from Arrow Lakes Reservoir (1968–2008) plotted in weekly intervals.**

Revelstoke Reach contains the Columbia River as it flows south from the Revelstoke Dam towards the Arrow Lakes Reservoir, and is comprised largely of drawdown zone habitats. The Revelstoke Reach drawdown zone includes most of the level valley bottom habitat in the area.

Revelstoke Reach lies within the Interior Cedar Hemlock (ICH) biogeoclimatic zone and consists of two subzones (ICHmw2 and ICHmw3) (Meidinger and Pojar 1991). The valley bottom habitats in the area were naturally vegetated with old-growth stands dominated by western redcedar (*Thuja plicata*), Englemann spruce (*Picea engelmannii*) and black cottonwood (*Populus balsamifera* ssp. *trichocarpa*). As the area was settled, much of the valley bottom area was cleared for farming and ranching. Prior to dam completion in 1968, Revelstoke Reach consisted of productive farm lands. The present day vegetation of the Revelstoke Reach drawdown zone is influenced mostly by elevation (Korman 2002), which is a reflection of the timing and extent of annual flooding. The lowest elevation drawdown habitats (below 433 m) are unvegetated. The substrate typically consists of sand, gravel, or silt, and sites become submerged early in the season and

usually remain flooded for most of the growing season (Figure 3). Tree stumps are a common feature in some of these habitats.

Figure 3: **Example of unvegetated habitat in Revelstoke Reach (elevation ~432 m), 12 Mile area.**

Above 433 m, the Revelstoke Reach drawdown zone is vegetated extensively by reed canarygrass (*Phalaris arundinacea*) and sedges (*Carex* spp.), particularly lenticular sedge (*C. lenticularis*) and Columbia sedge (*C. aperta*) (Figure 4). Although reed canarygrass and sedges dominate the drawdown zone grasslands, bluejoint grass (*Calamagrostis canadensis*), water horsetail (*Equisetum fluviatile*), scouring rush (*Equisetum hyemale*) and several species of forbs are locally dominant (Moody 2002). Above 436 m, willow shrubs (typically *Salix sitchensis*) have become established both naturally and as a result of planting efforts in the past (Figure 5). At the lower extent of their distribution in the drawdown zone (around 436 m), willows usually grow as sparsely distributed solitary shrubs, but above 437 m they commonly grow in dense clusters of varying sizes. Cottonwood saplings and other species of willow (e.g., *Salix scouleriana*) are abundant in many of these patches.

Figure 4: **Example of grassland habitat in Revelstoke Reach (elevation ~436 m), Airport West area.**

Figure 5: **Example of shrub habitat in Revelstoke Reach (elevation ~438 m), Rob's Willows area.**

Near the full pool elevation (439 m to 440 m), some patches of mature cottonwood riparian habitat occur, but this habitat type is uncommon throughout the Revelstoke Reach drawdown zone. The most extensive patches occur at Machete Island and on the banks of rivers entering the drawdown zone (e.g., the Illecillewaet and Columbia Rivers) (Figure 6).

Figure 6: Example of riparian forest habitat in Revelstoke Reach (elevation ~439 m), Machete Island.

In these patches, black cottonwood is usually a dominant canopy species, and there can be a diversity of other tree and shrub species, such as twinberry (*Lonicera involucrata*), hardhack (*Spiraea douglasii*), snowberry (*Caprifoliaceae* sp.), red-osier dogwood (*Cornus stolonifera*), willow (*Salix* spp.), alder (*Alnus* sp.), trembling aspen (*Populus tremuloides*), Engelmann spruce, western white pine (*Pinus monticola*), western redcedar, Sitka mountain-ash (*Sorbus sitchensis*) and paper birch (*Betula papyrifera*).

As part of the CLBWORKS-2 project, cottonwood stakes were planted extensively in Revelstoke Reach in spring 2010 and 2011 (Figure 7). Several areas at elevations above 438 m were planted with stakes approximately 1.5 m–2 m in length and 5 cm–15 cm in diameter. Larger stakes were planted with the aid of a small excavator; smaller stakes were hand planted. Treated sites typically contained no shrubs or trees, and reed canarygrass was the dominant ground cover (Keefer and Moody 2010). The treatment

protocol in 2010 was to plant the stakes at least 1.5 m apart; average spacing was 2 m (Keefer and Moody 2010).

Figure 7: Example of site planted with cottonwood stakes (Wildlife Physical Works project) in Revelstoke Reach (elevation ~438 m), 12 mile area, September 23, 2016.

2 METHODS

An overview of approaches used to answer CLBMON 39 management questions and hypotheses is provided in Appendix 1. A brief overview of methods used in 2017 is provided below. For a detailed account of these methods, refer to the CLBMON 39 protocol report (CBA 2017a).

2.1 Constant Effort Mist Netting

Constant effort mist netting, with its largely consistent capture effort each year, provides a standardized and comprehensive means of assessing seasonal and annual variation in the abundance, diversity, juvenile/adult ratio and stopover length of neotropical migrants. To investigate reservoir level effects, banding stations were set up at different elevations both in and outside of the drawdown zone. An advantage of the mark-recapture (banding) approach is that we can separate high detection rates caused by (small) populations that are using the site over an extended period of time (e.g., where

individuals could be counted repeatedly over time) from high detections caused by (large) populations that spend very little time at the site.

Data from the migration monitoring station(s) will be used to:

- determine the migration patterns of migratory songbirds in Revelstoke Reach over time (MQ1);
- assess whether reservoir operations affect populations of neotropical migrants that use this area as a stopover site (MQ3 and MQ4); and
- determine whether there are specific times during the migratory season when minor adjustments to flow rates or water levels will enhance the ability of the drawdown area to support birds (MQ6).

Data collected at the migration monitoring stations will also be used to interpret results from other aspects of the study.

2.1.1 Monitoring Sites in 2017

In 2017, we monitored three constant effort mist-netting sites: Machete Island banding station, Airport Islands banding station and Jordan River banding station (Table 1).

Table 1: CLBMON 39 constant effort mist netting sites in 2017 (DDZ = drawdown zone).

Banding Site	Within DDZ?	Mean Elevation (m ASL)	Survey Intensity	Description
Machete Island	Yes	439	Daily	Large riparian site positioned high in the drawdown zone
Airport Islands	Yes	437	Weekly	Smaller riparian site positioned low in the drawdown zone
Jordan River	No	475	Weekly	Control riparian site outside of the drawdown zone

Machete Island banding station is situated at the eastern end of Machete Island, a forested upland area of about 20 ha located between the north end of the Revelstoke Airport and the confluence of the Columbia and Illecillewaet Rivers (Appendix 3). Mist-netting surveys at this site were initiated in 2008. Machete Island lies within the drawdown zone of Arrow Lakes Reservoir, with small portions being slightly above water levels when the reservoir reaches full pool at 440.1m ASL. Machete Island is forested primarily with mature black cottonwood with smaller amounts of alder, willow, spruce and western redcedar. Common understorey shrubs are red-osier dogwood, willow, alder, beaked hazelnut (*Corylus cornuta*), snowberry, twinberry and rose (*Rosa* sp.). The edges of the cottonwood forest are covered mostly with willow shrubs surrounded by shrub savannah and grassland habitats. The area of Machete Island where the banding station is located is lacking the mature tree component and is dominated by black cottonwood, willow, alder, and red-osier dogwood. Snowberry, twinberry and reed canarygrass are abundant in the understory. In 2017, 13 nets were installed in the same net lines as previous years at this site (Figure 8).

Figure 8: Machete Island banding station layout in 2017.

Airport Islands banding station is situated in the drawdown zone of Arrow Lakes Reservoir, west of the Revelstoke Airport (Appendix 3). It is positioned approximately 2 meters lower in the drawdown zone compared to Machete Island. Due to lower relative position, this site has more variability in annual water level fluctuation (Figure 9), compared to Machete Island banding station.

Figure 9: Net line at Airport Island banding station in a year with high water levels (left, August 21, 2012) and the same net in a year with low water levels (right, August 25, 2014).

Airport Islands banding station is situated on slightly raised ground covered by patches of willow shrubs (with only a small amount of cottonwood) within grasslands, open shrub savannah and wetlands. Mist-netting surveys at this site were initiated in 2011, and in 2017 nine nets were installed in the same net lines as previous years at this site (Figure 10).

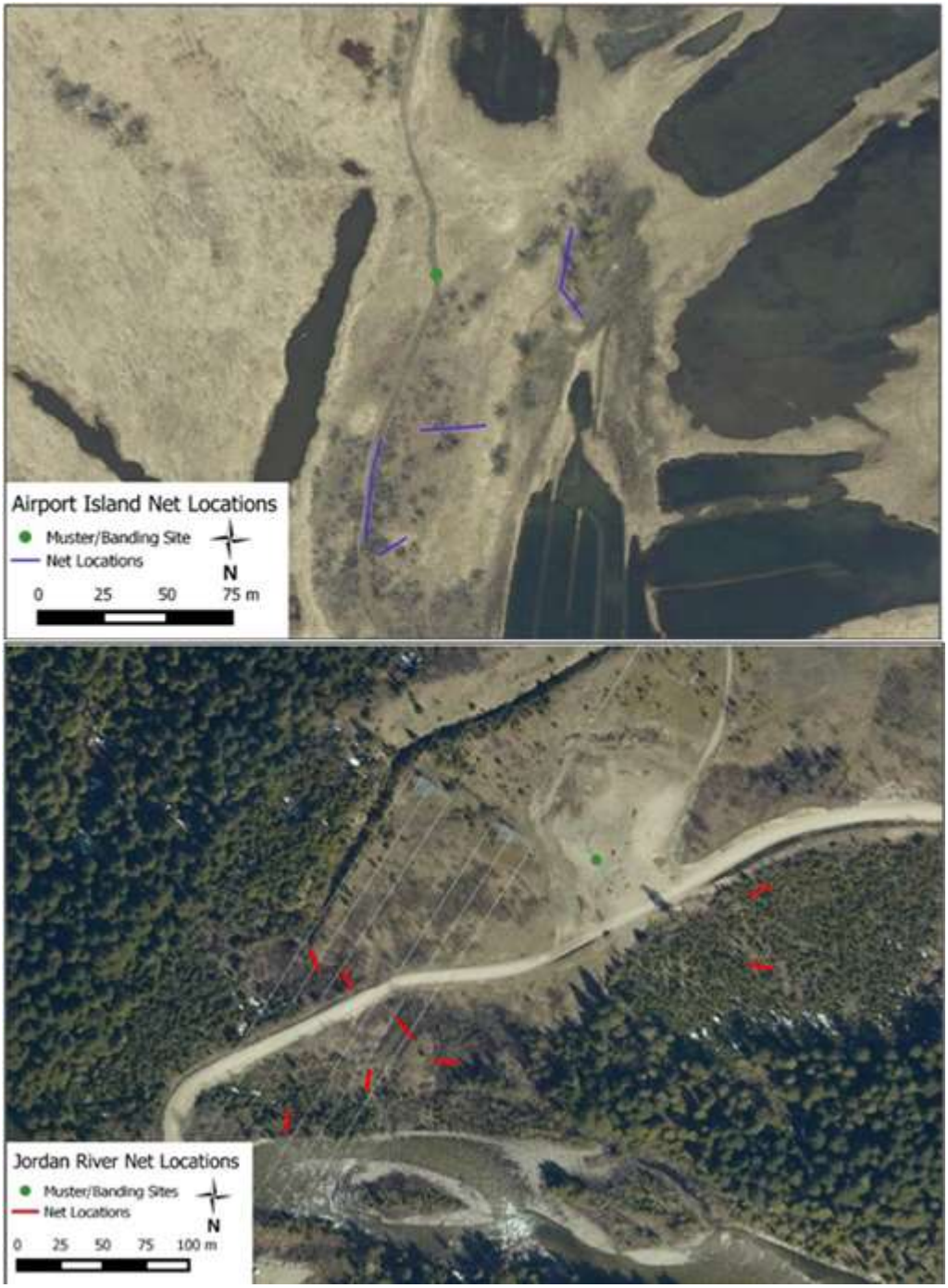

Figure 10: Airport Islands and Jordan River banding station layout in 2017.

Jordan River banding station is positioned above the drawdown zone and located along Jordan river, upstream from its confluence with the Columbia river (Appendix 3) and consists of a mix of riparian habitat (similar to habitat found at Machete Island; Figure 11) and upland habitat. Surveys at Jordan River banding station were initiated in 2011 and in 2017 eight nets were installed at this site (Figure 10). Of the seven net lines used in 2016, six were used again in 2017. One net line from 2016 could not be used in 2017 because it was destroyed and the area was filled with material due to parking lot expansion before the season. Two new net lines were created instead and used throughout the 2017 season.

Figure 11: **Neotropical migrants captured in net line in riparian habitat dominated by black cottonwood, willow, alder, red-osier dogwood and black twinberry at Jordan River banding station.**

2.1.2 Field Survey Procedures

In 2017, surveys at Machete Island were conducted daily (if possible) and surveys at the Jordan River and Airport Islands once per week. At Machete Island, net lines were prepared and nets were permanently installed on net poles. At Jordan River and Airport Islands only net poles were permanently installed, but nets were taken down after each survey. Usually all nets were opened at a site, but the number of nets used varied depending on the number of birds being captured so that the crew could safely handle and band all birds captured. When it was necessary to close some nets to ensure the safe handling of birds, we prioritized the closing of nets further from the banding station and those with fewer captures (on average) in order to save time on checking nets (consistent throughout the entire CLBMON 39 period).

Nets were opened 30 minutes before sunrise by unrolling them (Machete Island) or by putting them on the pre-installed poles (Jordan River and Airport Islands). Special care was taken to keep the bottom trammels of the nets about 30 cm off the ground to prevent large birds caught in the bottom shelf from sagging into wet grass or touching the ground. If the net lane was partly flooded or there was standing water below the net, the bottom trammel of the net was kept about 60 cm off the water surface to ensure that no birds sagged into the water. The opening time was recorded as the time when the first net was opened, and nets remained open for 6 hours, unless it was necessary to close the nets due to rain, high winds, presence of a predator (e.g., weasel) or too many birds being captured to process in a suitable time frame. Any net closures and reopening times were recorded so that an accurate count of “net-hours” could be made. Net-hours are the number of hours one 12-m mist net is open (one 12-m long mist net in operation for one hour = one net-hour).

To prevent data bias, no “pishing”, artificial lures, feeders, brush crashing or vegetation clearing was permitted closer than 10 m to open nets during migration monitoring periods.

Every 30 minutes after nets were opened, banding station staff visited each net and extracted all birds (Figure 12). To carry the birds, staff used holding bags with uniquely coloured and numbered clothes pegs that identified which net the bird was captured in. After all nets were checked and all birds were removed from the net, staff returned directly to the banding location to band and process the birds (Figure 12). The bander-in-charge then removed each bird from its holding bag and began the banding process. The bird was examined and the species was determined. Birds were then banded, aged and sexed, and wing chord, tail length, degree of skull ossification, moult, fat score and weight were noted on the datasheet. After collecting all required data, birds were released at the banding station.

Figure 12: CBA technician extracting birds from a mist net at Machete Island banding station (left). Banding tent at Machete Island banding station (right).

In order to ensure that each net was open for a similar length of time in each sampling session, nets were closed in the same order as they were opened. During the survey period mist netting poles were left installed at the sites but nets were taken down after each survey (Jordan River and Airport Islands) or nets were tightly rolled, tied closed with multiple ribbons and left on the poles until the next morning (Machete Island).

2.1.3 Permitting and Safety of Captured Birds

All banding activities were conducted under a Federal Scientific Permit to Capture and Band Migratory Birds. During the entire operation, the safety of captured birds was the second highest priority (right after personal safety). Our goal was to have zero capture casualties. All Banders-in-charge monitored the operation at all times and instructed the crew members on appropriate measures to prevent or minimize any potential casualty. Prior to commencing work, all crew members were familiar with the CBA banding station protocols (CBA 2017a),which follows the North American Banding Council's mist netting and bird handling safety recommendations (Smith et al. 1999, NABC 2001).

2.2 Data Collection and Management

All field data recorded on datasheets and in field notebooks were entered into digital databases (MS Excel format) on a regular basis and were backed up weekly onto an external hard drive that was stored off site. Newly entered data were reviewed for inconsistencies, and at the end of the field season, all digital data were thoroughly proofed for errors or inconsistencies relative to the original datasheets and field notebooks.

Banding data were entered into Bandit 4.0 software, which the Environment Canada Bird Banding Office uses for the submission of banding data. All banding data collected by CBA in 2017 were submitted to the Migratory Bird Populations Division–Bird Banding Office in Ottawa.

2.3 Data Summary and Analysis

The purpose of this report is to review work conducted in Year 10 (2017). The following summaries are provided:

- methods employed
- survey effort
- species and number of birds captured by constant effort mist netting at Machete Island banding station
- species and number of birds captured by constant effort mist netting at Airport Islands banding station
- species and number of birds captured by constant effort mist netting at Jordan River banding station

Net-hour is a survey effort unit defined as one 12-m mist net in use for 1 hour (one 12-m long mist net in operation for one hour = one net-hour). Total (overall) capture rate was calculated as the total number of captured birds (new, recaptures and unbanded birds) divided by the number of net-hours.

Newly captured birds included both all newly captured and banded birds and all newly captured (for the year) recaptures from previous years. Capture rate (for newly captured birds) was calculated as the number of newly captured birds per net-hour.

Recaptured birds were all previously captured and banded birds (within year), excluding same day recaptures. Recapture rate was calculated as the number of recaptures (excluding same-day recaptures) divided by the number of newly captured birds. Daily recapture rate - for each day, was the proportion of all newly captured birds that day that were recaptured later in the season (excluding same day recaptures). The daily recapture rate was not calculated for the last day of each season since no recapture was possible. Same-day recapture rate was calculated as the number of same-day recaptures divided by the number of newly captured birds.

Because of the large number of unidentified Traill's Flycatchers (*Empidonax alnorum/traillii*) records, for the purpose of this report we decided to pool records of Willow Flycatcher (*Empidonax traillii*), Alder Flycatcher (*Empidonax alnorum*) and Traill's Flycatcher into one taxon - Traill's Flycatcher.

Unless otherwise stated, all other data summaries were produced using MS Excel and the program R (R Development Core Team 2006).

3 RESULTS

3.1 Reservoir Operations of Arrow Lakes Reservoir in 2017

In 2017, the reservoir water level peaked on July 27, when the water reached its annual maximum of 439.6 m ASL. The water levels of Arrow Lakes Reservoir at the beginning of the fall migration season (August 1) were higher than the long-term average and gradually approached and dipped below the long-term average in the second half of the season (September). At the beginning of the fall migration survey period, the reservoir levels were at 439.5 m ASL (on August 1, 2017), and gradually descended to 434.6 m ASL by the end of the fall season (September 30; Appendix 2).

3.2 Machete Island Banding Station

3.2.1 Monitoring Effort

At Machete Island banding station, constant effort mist netting monitoring was conducted during fall migration in August and September. The first survey was conducted on August 3 and the last one on September 22. During this period, 35 surveys were conducted for a total of 2076 net-hours.

During the study period, Machete Island banding station was surveyed daily. Because of the unprecedented volume of birds banded, the survey experienced a band shortage that resulted in only 5 surveys being conducted in the first two weeks of September. As soon as the additional bands were received, daily banding operation resumed. In addition, persistent rain prevented the operation of the banding station on 2 days, and on 6 days, monitoring was not conducted at Machete Island due to effort at other stations (Jordan River and Airport Islands).

All staff were trained in the banding station protocols, and care was taken that everyone was properly trained in safe extracting and bird handling techniques. From August 3 onward, the number of nets opened daily varied from 5 to 13 (Table 2) to ensure safe and prompt processing of all captured birds. In 2017, two main factors influenced the number of nets opened in any given day. First, high water levels at the banding station in August did not initially allow us to operate all nets, due to some net lines being flooded. Water depth in the net lines was assessed daily, and nets were opened as soon as safe capture and mist-net operation could be assured. Second, the high volume of birds captured during the peak of migration allowed us to open only a limited number of nets during that time. Therefore, some nets had to stay closed to ensure safe handling and processing of all captured birds. In addition, on a few days some nets had to be temporary closed due to strong wind and/or precipitation. The average number of open nets each day was 10.9 ± 0.47 (mean ± SE; Table 2).

Table 2: Mist netting capture effort at Machete Island banding station in 2017.

Month	No. Days Nets Open	Mean No. Open Nets (SE)	No. Net-hours
August	24	10.9 (0.60)	1458.75
September	11	11.1 (0.74)	617.25
Total	35	10.9 (0.47)	2076

The total number of net-hours for the whole season was 2076. The survey effort varied throughout the fall migration period with the highest number of net-hours in weeks 1 and 2 (493.25 and 429.75 net-hours, respectively) and the lowest in week 8 (42 net-hours; Table 3). The total number of net-hours each net was open is provided in Appendix 4.

Table 3: Weekly mist netting survey effort (number of net-hours) at Machete Island banding station throughout the 2017 fall migration period.

Machete Island	Week 0 28 Jul – 3 Aug	Week 1 4–10 Aug	Week 2 11–17 Aug	Week 3 18–24 Aug	Week 4 25–31 Aug	Week 5 1–7 Sep	Week 6 8–14 Sep	Week 7 15–21 Sep	Week 8 22–28 Sep	Grand Total
No. of Surveys	1	7	6	5	5	3	2	5	1	35
No. of Net-hours	72	493.25	429.75	306.75	157.00	100.50	138.00	336.75	42.00	2076.00

3.2.2 Total Number of Captured Birds

A total of 5426 birds of 61 species were captured at Machete Island banding station in 2017 with an average capture rate of 2.6137 birds per net-hour (Appendix 5, Appendix 6). The most frequently captured species was Yellow-rumped Warbler (*Setophaga coronata*; 22.2% of all captured birds) with a capture rate of 0.5809 birds/net-hour. Another commonly captured species was Common Yellowthroat (*Geothlypis trichas*; 19.6% and 0.5125 birds/net-hour), followed by Orange-crowned Warbler (*Oreothlypis celata*; 8.9% and 0.2317 birds/net-hour), Yellow Warbler (*Setophaga petechia*; 8.8% and 0.2303 birds/net-hour), American Redstart (*Setophaga ruticilla*; 6.2% and 0.1623 birds/net-hour), Traill's Flycatcher (both Alder and Willow Flycatchers combined; 5.3% and 0.1382 birds/net-hour), Wilson's Warbler (*Cardellina pusilla*; 3.7% and 0.0968 birds/net-hour), MacGillivray's Warbler (*Geothlypis tolmiei*; 3.4% and 0.0896 birds/net-hour), and Red-eyed Vireo (*Vireo olivaceus*; 3.1% and 0.0800 birds/net-hour) (Appendix 6). The overall capture rate for each net is provided in Appendix 4.

Out of 61 species captured at Machete Island in 2017 (Appendix 6), only one species had not been previously captured under CLBMON 39 – Virginia Rail (*Rallus limicola*). In addition, 24 species were captured at Machete Island but not at Jordan River or Airport Islands. These species were:

- Gray Catbird (*Dumetella carolinensis*)
- Least Flycatcher (*Empidonax minimus*)
- Yellow-breasted Chat (*Icteria virens*)
- American Robin (*Turdus migratorius*)
- American Goldfinch (*Spinus tristis*)
- Clay-colored Sparrow (*Spizella pallida*)
- Western Wood-Pewee (*Contopus sordidulus*)
- Chipping Sparrow (*Spizella passerine*)
- White-crowned Sparrow (*Zonotrichia leucophrys*)
- Brown-headed Cowbird (*Molothrus ater*)
- Black-headed Grosbeak (*Pheucticus melanocephalus*)
- Downy Woodpecker (*Picoides pubescens*)
- Eastern Kingbird (*Tyrannus tyrannus*)
- European Starling (*Sturnus vulgaris*)
- Pacific Wren (*Troglodytes pacificus*)
- Blackpoll Warbler (*Setophaga striata*)
- Northern Flicker (*Colaptes auratus*)
- Purple Finch (*Haemorhous purpureus*)
- Red-naped Sapsucker (*Sphyrapicus nuchalis*)

- Sharp-shinned Hawk (*Accipiter striatus*)
- Dusky Flycatcher (*Empidonax oberholseri*)
- Red-breasted Nuthatch (*Sitta canadensis*)
- Sora (*Porzana carolina*)
- Steller's Jay (*Cyanocitta stelleri*)

3.2.3 Number of Newly Banded Birds

In 2017, 4468 individual birds of 60 species were newly captured and banded (Appendix 6). The average capture rate for newly captured individuals was 2.1522 birds/net-hour. The most numerous newly banded bird was Yellow-rumped Warbler with 1159 individuals (25.9% of all newly banded birds), followed by Common Yellowthroat (805 individuals and 18.0%), Orange-crowned Warbler (423 individuals and 9.5%), Yellow Warbler (395 individuals and 8.8%), American Redstart (260 individuals and 5.8%), Traill's Flycatcher (Alder and Willow Flycatchers combined; 214 individuals and 4.8%), Wilson's Warbler (175 individuals and 3.9%), and MacGillivray's Warbler (150 individuals and 3.4%) (Appendix 6).

In addition to the 60 species banded, nine Rufous Hummingbirds were captured but released unbanded.

3.2.4 Migration Chronology

The average daily capture rate of newly captured birds was 2.66 ± 0.362 birds/net-hour (mean ± SE). Migration, as measured by capture rate (number of birds captured per net-hour) varied throughout the monitoring period (Figure 13). Capture rate was relatively constant in the first three weeks of August but migration picked up rapidly in the fourth week of August and peaked in late August and early September. Past the first week of September migration slowed down significantly but capture rate remained relatively high until the end of the season. However, due to less intensive sampling during the first two weeks of September, the end of the peak migration is not documented as thoroughly as it's beginning.

The abundance of different species peaked at different times. Of the five most frequently captured species at Machete Island, American Redstart and Yellow Warbler were the most abundant at the study site in the first half of the season (Figure 14). The abundance of Yellow-rumped Warbler and Orange-crowned Warbler peaked in early September and the abundance of Common Yellowthroat peaked in late August (Figure 14).

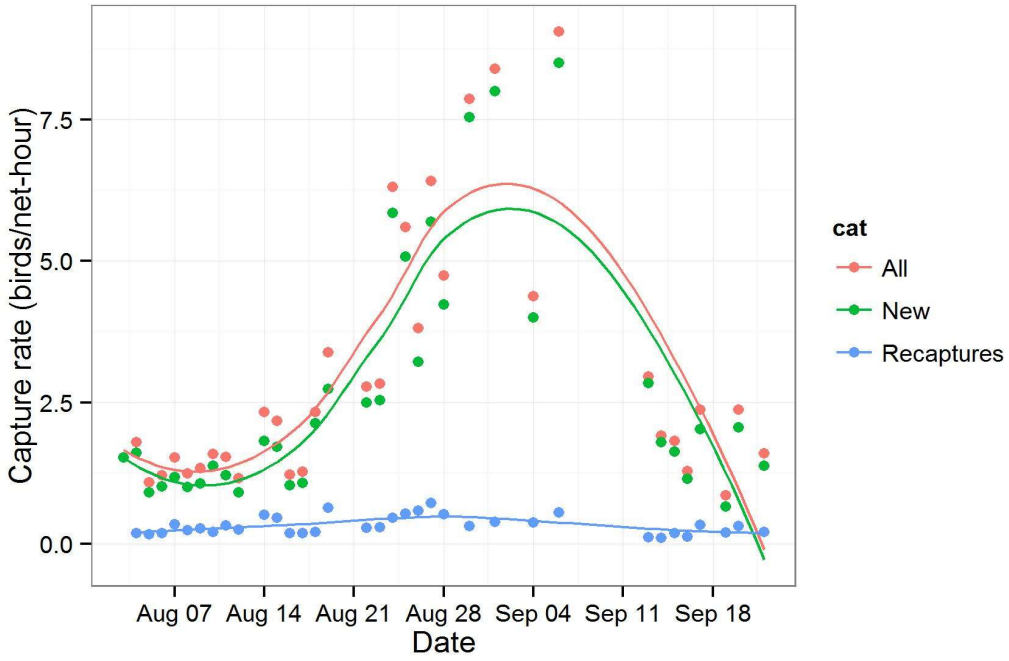

Figure 13: **Number of birds captured per net-hour at Machete Island banding station throughout the season in 2017. All = all birds captured (excluding unbanded birds and same day recaptures), New = newly captured birds (including recaptures from previous years), and Recaps = Recaptures (excluding same day recaptures).**

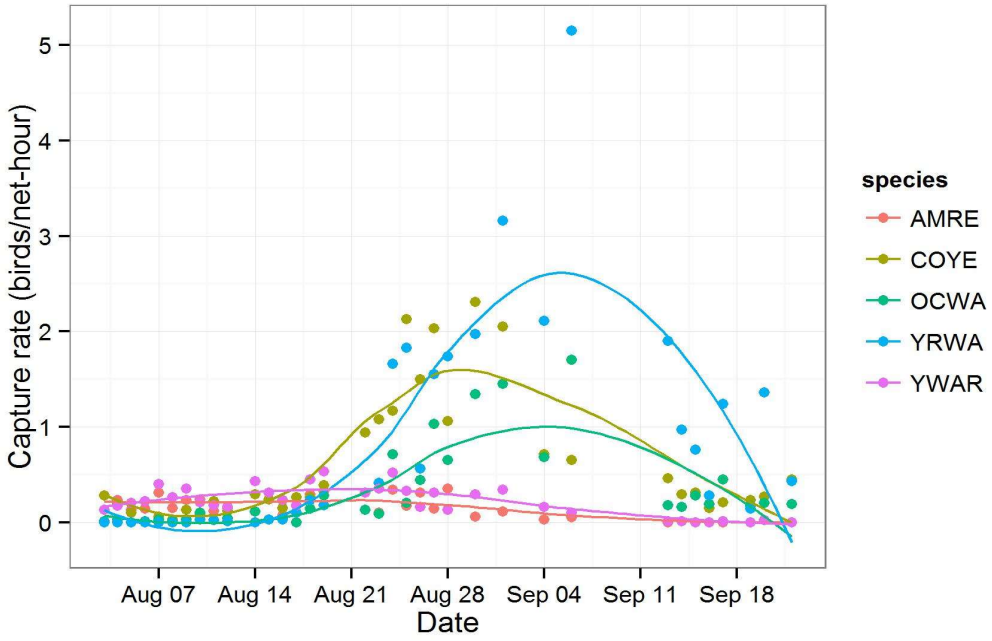

Figure 14: **Migration chronology of the five most frequently captured species at Machete Island banding station in 2017 (excluding same day recaptures). AMRE = American Redstart, COYE = Common Yellowthroat, OCWA = Orange-crowned Warbler, YRWA = Yellow-rumped Warbler, and YWAR = Yellow Warbler.**

3.2.5 Age Ratio of Captured Birds

Of the 4463 newly captured birds of known age (99.9% of all newly captured birds), 4099 individuals (91.8%) were HY (juvenile birds hatched in 2017), and 364 individuals (8.2%) were AHY (adult birds more than one year old; Appendix 7). HY birds outnumbered AHY birds throughout the season, with the difference being more prominent in the middle of the season (Figure 15).

Of the 2721 birds that could be reliably sexed (60.9% of all newly captured birds), 1448 (53.2%) were males and 1273 (46.8%) were females. Of the birds of known sex, 1344 males (92.8%) and 1129 females (88.7%) were HY; the remainder were AHY (Appendix 7).

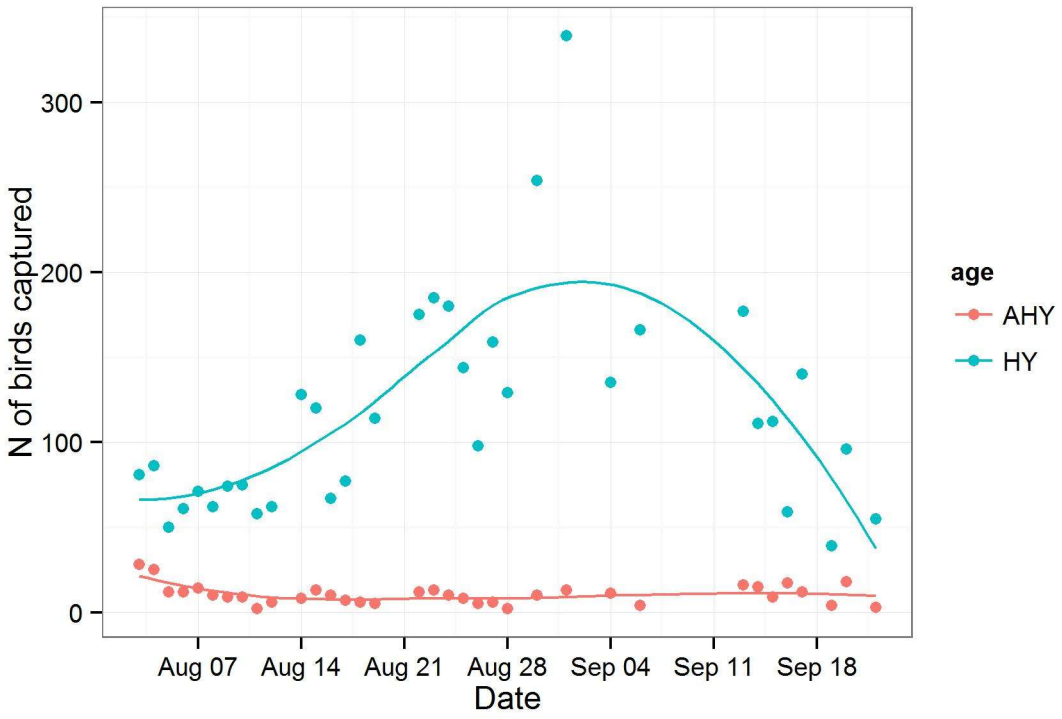

Figure 15: **Number of after hatch year (AHY) and hatch year (HY) newly captured birds at Machete Island banding station in 2017.**

3.2.6 Recaptures of Banded Birds

In 2017, 472 individuals of 29 species were recaptured on at least one additional banding survey within the same season (874 recaptures total; Appendix 6).

Of these, one individual was recaptured on ten additional survey days, one bird nine days, one eight days, one seven days, one six days, one five days, four birds were recaptured four more days, 17 birds three days, 84 birds twice, and 361 birds only once more. The overall recapture rate was 13.1%.

In addition, 274 individuals were recaptured at least once in the same day as they were banded (290 same day recaptures total; Appendix 6) and the overall same day recapture rate was 6.5%.

The average daily recapture rate for the whole season was 0.12 ± 0.018 (mean + SE). Daily recapture rate varied throughout the season (Figure 16). For Yellow-rumped Warbler, the most frequently captured species in 2017, only 1.7% of newly captured individuals were recaptured at least once later in the season.

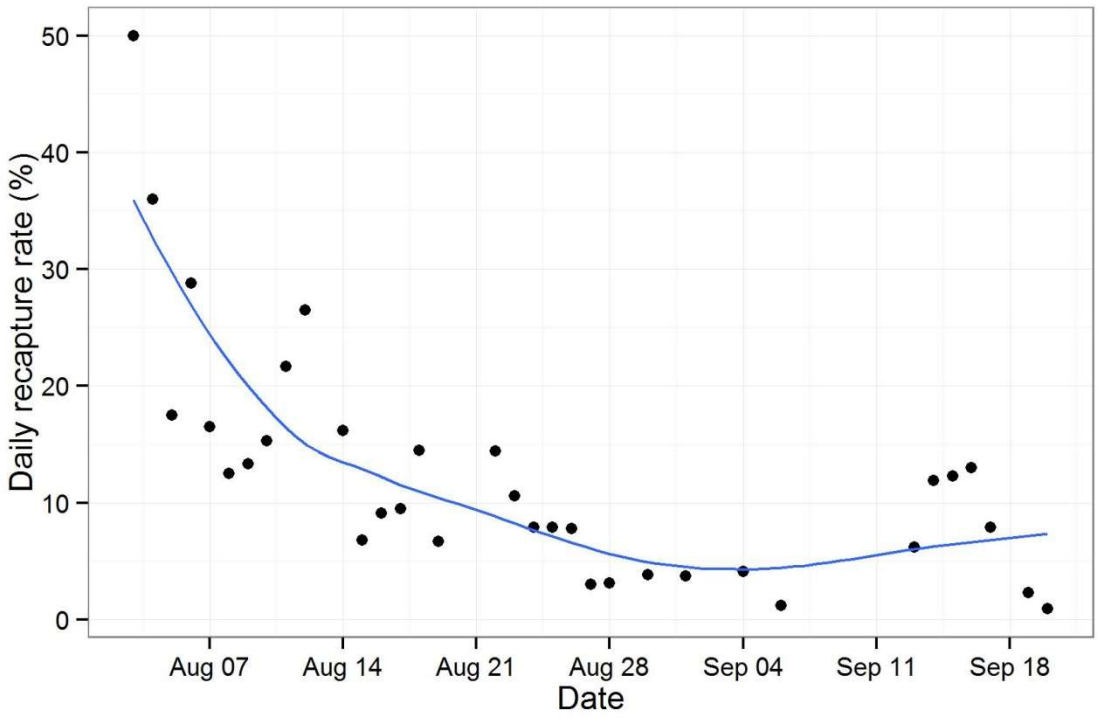

Figure 16: Daily recapture rate at Machete Island banding station in 2017 (with Loess smoother).

In 2017, 44 individuals banded in previous years were recaptured (Table 4). All of them were previously banded at Machete Island.

Table 4: List of birds banded in previous years that were recaptured at Machete Island in 2017 (AHY = after hatch year, M = male, F = female, U = unknown).

Recapture date	Species	Age when recaptured	Sex	Banding date	Time since banded
2017-08-03	Red-eyed Vireo	AHY	U	2010-08-11	6 years, 11 months and 23 days
2017-09-17	Audubon's Warbler	AHY	F	2011-09-03	6 years, 0 months and 14 days
2017-08-17	American Redstart	AHY	F	2011-09-05	5 years, 11 months and 12 days
2017-08-23	Veery	AHY	U	2013-07-31	4 years, 0 months and 23 days
2017-08-15	American Redstart	AHY	F	2014-08-23	2 years, 11 months and 23 days
2017-08-05	Red-eyed Vireo	AHY	U	2015-06-10	2 years, 1 month and 26 days
2017-08-10	Willow Flycatcher	AHY	F	2015-06-16	2 years, 1 month and 25 days
2017-09-01	American Redstart	AHY	M	2015-08-07	2 years, 0 months and 25 days
2017-08-30	Veery	AHY	U	2015-08-17	2 years, 0 months and 13 days
2017-08-14	American Redstart	AHY	F	2015-08-10	2 years, 0 months and 4 days
2017-09-22	Black-capped Chickadee	AHY	U	2015-09-19	2 years, 0 months and 3 days
2017-08-09	American Redstart	AHY	F	2015-08-08	2 years, 0 months and 1 day
2017-08-03	Traill's Flycatcher	AHY	U	2015-08-07	1 year, 11 months and 27 days
2017-08-25	Yellow Warbler	AHY	F	2016-05-27	1 year, 2 months and 29 days
2017-08-16	Yellow Warbler	AHY	M	2016-05-31	1 year, 2 months and 16 days
2017-08-08	Yellow Warbler	AHY	F	2016-06-03	1 year, 2 months and 5 days
2017-08-06	Yellow Warbler	AHY	F	2016-07-03	1 year, 1 month and 3 days
2017-08-27	Yellow Warbler	AHY	M	2016-08-04	1 year, 0 months and 23 days
2017-08-27	Gray Catbird	AHY	U	2016-08-07	1 year, 0 months and 20 days
2017-08-17	American Redstart	AHY	M	2016-08-02	1 year, 0 months and 15 days
2017-08-22	American Redstart	AHY	M	2016-08-07	1 year, 0 months and 15 days
2017-08-22	Yellow-rumped Warbler	AHY	F	2016-08-08	1 year, 0 months and 14 days
2017-09-14	Common Yellowthroat	AHY	F	2016-08-31	1 year, 0 months and 14 days
2017-08-15	Black-capped Chickadee	AHY	U	2016-08-02	1 year, 0 months and 13 days
2017-08-23	Red-eyed Vireo	AHY	U	2016-08-11	1 year, 0 months and 12 days
2017-08-25	Common Yellowthroat	AHY	F	2016-08-14	1 year, 0 months and 11 days
2017-08-18	Swainson's Thrush	AHY	U	2016-08-07	1 year, 0 months and 11 days
2017-08-15	Red-eyed Vireo	AHY	U	2016-08-07	1 year, 0 months and 8 days
2017-08-10	Red-eyed Vireo	AHY	U	2016-08-04	1 year, 0 months and 6 days
2017-08-06	American Redstart	AHY	F	2016-08-02	1 year, 0 months and 4 days
2017-08-05	Red-eyed Vireo	AHY	U	2016-08-02	1 year, 0 months and 3 days
2017-08-16	Swainson's Thrush	AHY	U	2016-08-14	1 year, 0 months and 2 days
2017-08-14	American Redstart	AHY	M	2016-08-12	1 year, 0 months and 2 days
2017-09-13	Common Yellowthroat	AHY	M	2016-09-12	1 year, 0 months and 1 day
2017-08-12	American Redstart	AHY	F	2016-08-12	1 year, 0 months and 0 days
2017-08-05	American Redstart	AHY	F	2016-08-29	0 years, 11 months and 7 days
2017-08-03	Red-eyed Vireo	AHY	U	2016-08-04	0 years, 11 months and 30 days
2017-08-09	Yellow Warbler	AHY	M	2016-08-11	0 years, 11 months and 29 days
2017-08-14	Red-eyed Vireo	AHY	U	2016-08-17	0 years, 11 months and 28 days
2017-08-04	Common Yellowthroat	AHY	F	2016-08-11	0 years, 11 months and 24 days
2017-09-01	Common Yellowthroat	AHY	F	2016-09-09	0 years, 11 months and 23 days
2017-08-07	Red-eyed Vireo	AHY	U	2016-08-19	0 years, 11 months and 19 days
2017-08-05	American Redstart	AHY	M	2016-08-17	0 years, 11 months and 19 days
2017-08-03	Tennessee Warbler	AHY	F	2016-08-19	0 years, 11 months and 15 days

3.2.7 Injuries and Casualties

In 2017, two incidents involving long-tailed weasel (*Mustela frenata*) occurred. On August 7, a weasel killed a Virginia Rail in the net. The weasel was captured promptly in a trap and relocated away from the station. On August 16, a different long-tailed weasel killed 3 birds at the station (two Yellow Warblers and one Savannah Sparrow - *Passerculus sandwichensis*). The weasel was captured immediately and relocated.

On August 15 one Warbling Vireo (*Vireo gilvus*) was killed in the net by a Sharp-shinned Hawk.

During net opening on September 4, one of the mist nets was found disturbed with ribbons on one side of the net untied, netting unrolled and two pockets partially open. Unfortunately, 17 birds were found dead in the netting: four Yellow-rumped Warblers, 2 Black-capped Chickadees (*Poecile atricapillus*), three Common Yellowthroats, one Gray Catbird, four Orange-crowned Warblers, one Red-eyed Vireo, one Tennessee Warbler (*Oreothlypis peregrina*) and one Wilson's Warbler. It is not known what caused this situation, however we suspect that an animal (most likely a deer) got tangled in the net and while trying to free itself ripped the ribbons and partially open two net pockets. However, the situation was promptly analyzed, and preventative measures were adopted. These included tying rolled nets in such a way that accidental opening by animal (or a child) was not possible. The changes were incorporated into the banding station protocol. All banding staff were informed of the incident and the new procedures to avoid any similar incident occurring in the future.

Four captured birds had an unspecified growth on their right leg, three (Common Yellowthroat, Yellow Warbler and Yellow-rumped Warbler) were banded on the left leg, one (Common Yellowthroat) with multiple areas of growth was released unbanded. Two birds (White-throated Sparrow and Common Yellowthoat) had a leg injury and were released unbanded. Two Yellow-rumped Warblers had a deformed bill, both were banded and released.

3.2.8 Species at Risk Captured

In 2017, we captured three Yellow-breasted Chats. Yellow-breasted Chat is a red-listed species in BC (species endangered or threatened in BC). All three individuals (male, female and juvenile) were captured and banded on August 3, 2017. All three were recaptured later in the season, with the last recapture on August 25, 2017. When first captured on Aug 3, the female still had an extensive brood patch and the juvenile was relatively recently fledged and not able to sustain longer distance flight. This led us to suspect that the Yellow-breasted Chat nested at Machete Island in 2017.

3.3 Airport Islands Banding Station

3.3.1 Survey Effort

At Airport Islands, seven surveys were conducted for a total of 220.75 net-hours (Table 5). The first survey was conducted on August 11, 2017; the last was conducted on September 19, 2017. The number of nets open varied from 3 to 9 with a mean of 6.9 ± 0.94 (mean ± SE).

At the beginning of the season, Airport Islands banding station was completely flooded by the reservoir. We were able to set up this station in the second week of August but at

that time only 3 net lines could be used. It wasn't until the end of August when all the net lines were operational. In addition to flooding, the number of open nets at Airport Islands during each survey varied depending on weather; on some days a few to all nets had to be closed due to strong wind. The total number of net-hours in each week of the season is provided in Table 4 and the overall capture rate for each net is provided in Appendix 4.

Table 5: Mist netting survey effort (number of net-hours) at Airport Islands banding station in 2017.

Airport Islands	Week 1 4–10 Aug	Week 2 11–17 Aug	Week 3 18–24 Aug	Week 4 25–31 Aug	Week 5 1–7 Sep	Week 6 8–14 Sep	Week 7 15–21 Sep	Grand Total
No. of Surveys	0	1	1	2	1	1	1	7
No. of Net-hours	.	18.00	30.75	51.00	29.00	42.50	49.50	220.75

3.3.2 Bird Captures and Recaptures

At Airport Islands, the overall capture rate was 0.7022 birds/net-hour. In total, 155 birds from 17 species were captured (Appendix 8). Yellow-rumped Warbler was the most frequently captured species (0.2174 birds/net-hour), followed by Common Yellowthroat (0.1948 birds/net-hour), Traill's Flycatcher (0.0680 birds/net-hour), Lincoln's Sparrow (*Melospiza lincolnii*, 0.0544 birds/net-hour), Savannah Sparrow (0.0408 birds/net-hour), Orange-crowned Warbler (0.0317 birds/net-hour), Black-capped Chickadee (0.0227 birds/net-hour), and Northern Waterthrush (*Parkesia noveboracensis*, 0.0181 birds/net-hour). Migration chronology of the five most abundant species is provided in Figure 17. The capture rate for newly captured birds was 0.5798 birds/net-hour, and the overall recapture rate was 4.7%. The recapture rate for the same day recaptures was 15.6%.

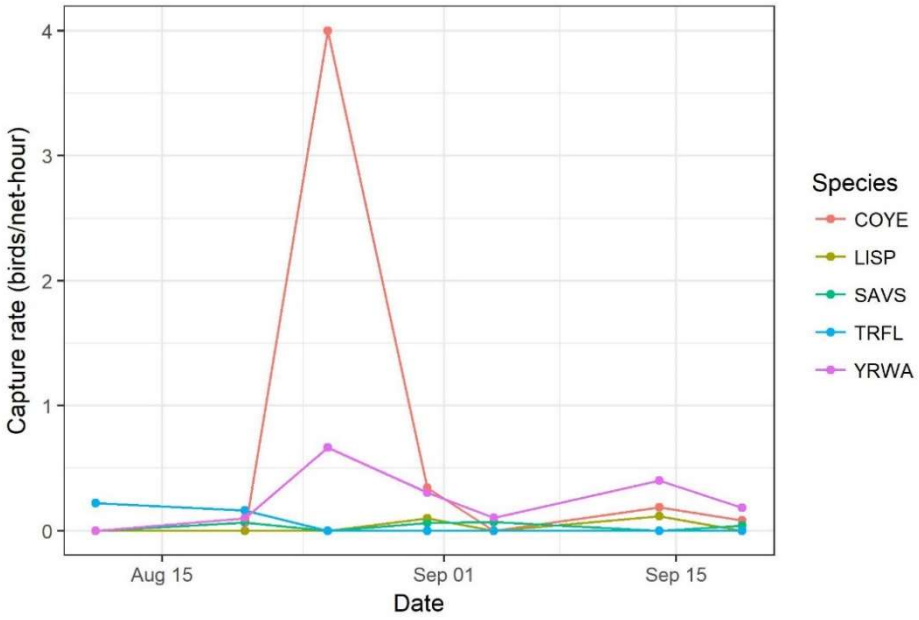

Figure 17: **Migration chronology of the five most abundant species (COYE = Common Yellowthroat, LISP = Lincoln's Sparrow, SAVS = Savannah Sparrow, TRFL = Traill's Flycatcher and YRWA = Yellow-rumped Warbler) at Airport Islands banding station in 2017.**

In 2017, Rusty Blackbird (*Euphagus carolinus*) was the only species captured exclusively at this site. Rusty Blackbird was also a new species for the project – this species has not been captured at any station as part of the CLBMON 39 study.

In addition, in 2017 we captured two species that have not been previously captured at this site: Black-capped Chickadee and Swainson's Thrush (*Catharus ustulatus*).

3.3.3 Injuries and Casualties

At Airport Islands, two Common Yellowthroats were killed in the net by a long-tailed weasel. We tried to trap the weasel right away but with no luck. We did not see any weasel for the rest of the season.

3.3.4 Species at Risk Captured

At Airport Islands banding station, we captured one Rusty Blackbird - a blue-listed species in BC (species of Special Concern in BC). This bird was captured in a mist net on August 31, 2017, banded and released.

3.4 Jordan River Banding Station

3.4.1 Survey Effort

At Jordan River, seven surveys were conducted for a total of 284.5 net-hours (Table 6). The first survey was conducted on August 8, 2017; the last one on September 21, 2017. The average number of open nets was 7.3 ± 0.18 (mean ± SE) and ranged from 7 to 8 nets.

Table 6: Mist netting survey effort (number of net-hours) at Jordan River banding station in 2017

Jordan River	Week 1 4–10 Aug	Week 2 11–17 Aug	Week 3 18–24 Aug	Week 4 25–31 Aug	Week 5 1–7 Sep	Week 6* 8–14 Sep	Week 7* 15–21 Sep	Grand Total
No. of Surveys	1	1	1	1	1	0	2	7
No. of Net-hours	38.50	42.00	42.00	42.00	42.00	.	78.00	284.50

* No mist netting was conducted in week 6 due to persistent rain on the survey day. The survey was conducted on the next available date, which was at the beginning of week 7 (hence 0 survey in week 6 and two surveys in week 7).

3.4.2 Bird Captures and Recaptures

At Jordan River, 400 birds of 33 species were captured (Appendix 9). The overall capture rate was 1.4060 birds/net-hour, the capture rate for newly captured birds was 1.3076 birds/net-hour and the overall recapture rate was 2.4%. The most commonly captured species was Yellow-rumped Warbler (0.5413 birds/net-hour), followed by American Redstart (0.1617 birds/net-hour), Swainson's Thrush (0.1406 birds/net-hour), Warbling Vireo (0.1371 birds/net-hour), and Chestnut-backed Chickadee (*Poecile rufescens;* 0.0457 birds/net-hour), Golden-crowned Kinglet (*Regulus satrapa;* 0.0457 birds/net-hour), and MacGillivray's Warbler (0.0457 birds/net-hour). The migration chronology of the five most frequently captured species is provided in Figure 18. The recapture rate for same-day recaptures was 3.8%.

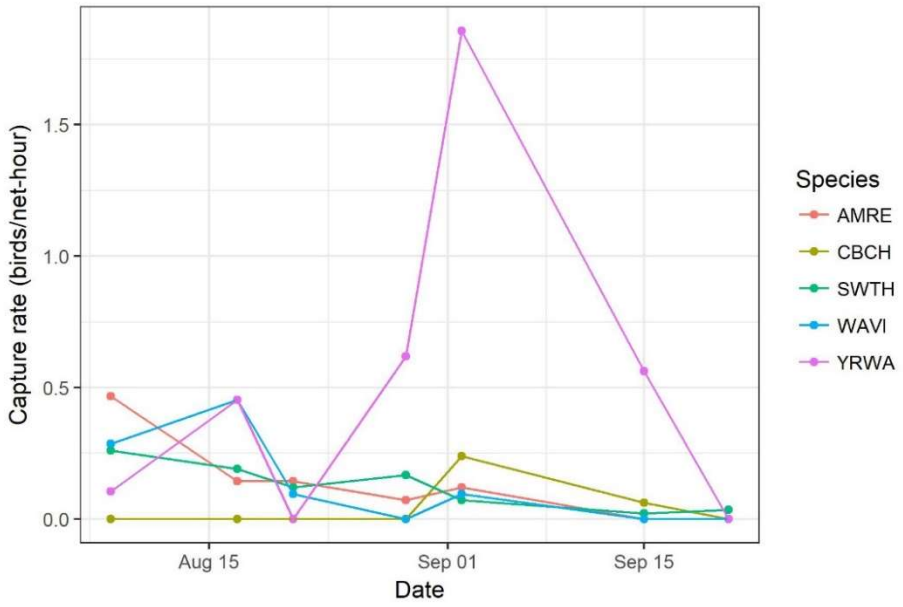

Figure 18: Migration chronology of the five most abundant species (AMRE = American Redstart, CBCH = Chestnut-backed Chickadee, SWTH = Swainson's Thrush, WAVI = Warbling Vireo and YRWA = Yellow-rumped Warbler) at Jordan River banding station in 2017.

In 2017, no new species were captured at this site and one species – Cassin's Vireo (*Vireo cassinii*) – was captured exclusively at this site.

3.4.3 Injuries and Casualties

One Swainson's Thrush had a bill deformity, was banded and released. One Varied Thrush (*Ixoreus naevius*) had two tumor-like growths on its head and was banded and released. One Golden-crowned Kinglet died at the station, presumably due to stress. One Yellow-rumped Warbler had a minor wing strain, was put into a recovery box for 30 minutes and then successfully released.

3.4.4 Species at Risk Captured

No species at risk was captured in 2017 at Jordan River banding station.

4 DISCUSSION

This section summarizes field studies completed in 2017. An overview of the management questions, approaches and progress towards addressing these management questions is presented in Appendix 1.

4.1 Machete Island banding station

Within the 10-year frame of the CLBMON 39 project, year 2017 was the sixth year of daily mist netting monitoring at Machete Island banding station. During the remaining four years (2011-2014 period), due to the complexity of the CLBMON 39 project, this site was monitored with lower intensity, usually once per week (CBA 2012, 2013b, 2014, 2015).

The survey effort in 2017 (2076 net-hours) was the lowest of all the previous years of daily monitoring (MCA 2008, CBA 2010, 2011, 2016, 2017b). Similarly, the average number of nets per survey in 2017 (10.9) was one of the lowest to date; only 2008 had a lower average number of open nets per survey (10.8; MCA 2008). One reason for the decreased sampling effort in 2017 was that high water levels in the first weeks of the survey period prevented safe mist net surveys in some of the net lines. Another reason for decreased sampling effort was that the high volume of birds being captured during peak migration prevented the safe operation of all the nets simultaneously.

However, despite the low survey effort in 2017, the capture rate for newly captured birds and the overall capture rate in 2017 (2.1522 and 2.6137 birds/net-hour, respectively) were much higher than in any previous year. The closest capture rates to 2017 were recorded in 2013, when the capture rate for newly captured birds was 1.2229 birds/net-hour and overall capture rate was 1.6015 bird/net-hour (CBA 2014). In all other years, the capture rates were less than half of those seen in 2017 ((MCA 2008, CBA 2010, 2011, 2012, 2013b, 2015, 2016, 2017b).

Year 2017 was the first year during CLBMON 39 monitoring when Yellow-rumped Warbler was the most frequently newly captured species at Machete Island banding station. It's capture rate for newly captured birds (0.5583 birds/net-hour) was also much higher than in any other year, with 2009 having the second highest capture rate (0.1260 birds/net-hour; CBA 2010).

During the previous nine years of CLBMON 39 monitoring, Common Yellowthroat was the most frequently captured species at Machete Island in all years but 2014, when Traill's Flycatcher was the most abundant species (CBA 2015). In 2017, Common Yellowthroat was the second most abundant species after Yellow-rumped Warbler. However, its capture rate for newly captured birds in 2017 (0.3878 birds/net-hour) was also the highest recorded during CLBMON 39 monitoring. To date, the second highest capture rate for newly-captured Common Yellowthroats was recorded in 2013 (0.3169 birds/net-hour; CBA 2014) and the lowest in 2014 (0.1022 birds/net-hour; CBA 2015).

In 2017, we added one new species (Virginia Rail) to the list of species captured at the Machete Island banding station under CLBMON 39. However, Virginia Rail is not a neotropical migrant songbird and therefore this species falls outside of the scope of this project.

After ten years of monitoring under the CLBMON 39 project, we have obtained sufficient information to adequately describe the community of neotropical migrants that utilize Machete Island as a stopover site during fall migration and are able to address all relevant management questions. Although at Machete Island, we do add new, previously un-captured species to this list (almost) every year, these are usually rare or very uncommon species (for this area) that do not utilize this area on a regular basis and do not significantly influence the bird community at the site.

It appears that the results from 2017 do not support our preliminary analyses which suggested a connection between the utilization of the Machete Island banding station area (as measured by capture and recapture rates) and water level. In this preliminary analysis of three years of capture-recapture data from Machete Island it was suggested that there may by a negative relationship between high water level at the beginning of the survey period (beginning of August) and capture rates (CBA 2013c). However, the additional data collected since 2012 suggests that the relationship between utilization of the area by migrants and water levels may be more complex and highlights the importance of long term monitoring for addressing annual effects such as reservoir operations. A full updated analysis of the constant effort mist netting dataset will be conducted for the Year 10 final report.

4.2 Airport Islands banding station

While the number of surveys (n=7) at Airport Islands banding station in 2017 was similar to the previous six years, the overall capture effort (220.75 net-hours) was lower than in previous years (CBA 2012, 2013b, 2014, 2015, 2016, 2017b). This was primarily due to high water levels at this site in 2017, with net lines underwater at the beginning of the monitoring period and some not available until the end of August.

The capture rate for newly captured birds at Airport Islands banding station in 2017 (0.5798 birds/net-hour) and the overall capture rate (0.7022 birds/net-hour) were the second highest recorded to date (in 2011 the capture rate for newly captured birds was 0.6785 birds/net-hour and the overall capture rate was 0.8135 birds/net-hour; CBA 2012). In 2017, Yellow-rumped Warbler was the most frequently captured species (similar to 2012; CBA 2013b). It’s capture rate for newly-captured birds in 2017 (0.2174 birds/net-hour) was higher than in any previous year, with 2011 (0.1537 birds/net-hour) and 2012 (0.1156 birds/net-hour) being closest to 2017. For Common Yellowthroat, the capture rate for newly captured birds in 2017 (0.1586 birds/net-hour) was second highest after 2011 (0.3074 birds/net-hour; CBA 2012). Three new species for this station were captured in 2017 (Rusty Blackbird, Black-capped Chickadee and Swainson’s Thrush).

In general, the data from this station do not support a direct link between capture rate and the reservoir water levels. However, this site has exhibited dynamic changes in species composition and capture rates among years. A more in-depth analysis will be conducted for the Year 10 final report to understand the relationship between bird utilization of this site and reservoir water conditions.

4.3 Jordan River banding station

In 2017, the number of surveys at the Jordan River banding station (n=7) and the overall survey effort (284.5 net-hours) was similar to the previous two years (CBA 2016 and 2017b). In the first four years of monitoring (2011 to 2014), this site was monitored more intensively (9-15 surveys; CBA 2012, 2013b, 2014, 2015).

The capture rate for newly captured birds and the total capture rate in 2017 (1.3076 and 1.4060 birds/net-hour, respectively) were the highest recorded to date (CBA 2012, 2013b, 2014, 2015, 2016, 2017b). Unlike previous years, Yellow-rumped Warbler was the most frequently newly captured species (0.5413 birds/net-hour). Interestingly, this species is usually relatively uncommon at this site, with capture rates for newly captured birds ranging from 0.0408 birds/net-hour in 2012 (CBA 2013b) to as low as 0.0021 birds/net-hour in 2013 (CBA 2014). However, the next three most frequently captured species in 2017 (American Redstart, Swainson’s Thrush and Warbling Vireo) were the three most common species in 2014 (CBA 2015), in 2015 (CBA 2016) and in 2016 (CBA 2017b), albeit in 2014 and 2015 in different order. In 2017, we did not capture any new, previously un-captured species at this site.

Since the beginning of surveys at this site in 2011, the Jordan River banding station has had a fairly consistent composition of the most abundant species and their capture rates among years. Warbling Vireo and Swainson's Thrush were the two most abundant species at this site in five out of seven years (only in 2016 they ranked second and third and in 2017 third and fourth). A more in-depth analysis will be conducted for the Year 10 final report to understand the relationship between bird utilization of this site (outside of the drawdown zone) and the sites in the drawdown zone of Arrow Lake Reservoir.

5 RECOMENDATIONS

The following are the key recommendations:

(1) Since 2017 was the last year of the CLBMON 39 project, no more field surveys are being proposed.
(2) The data collected under the CLBMON 39 project in years one to ten need to be thoroughly analyzed and findings provided in a comprehensive final report.

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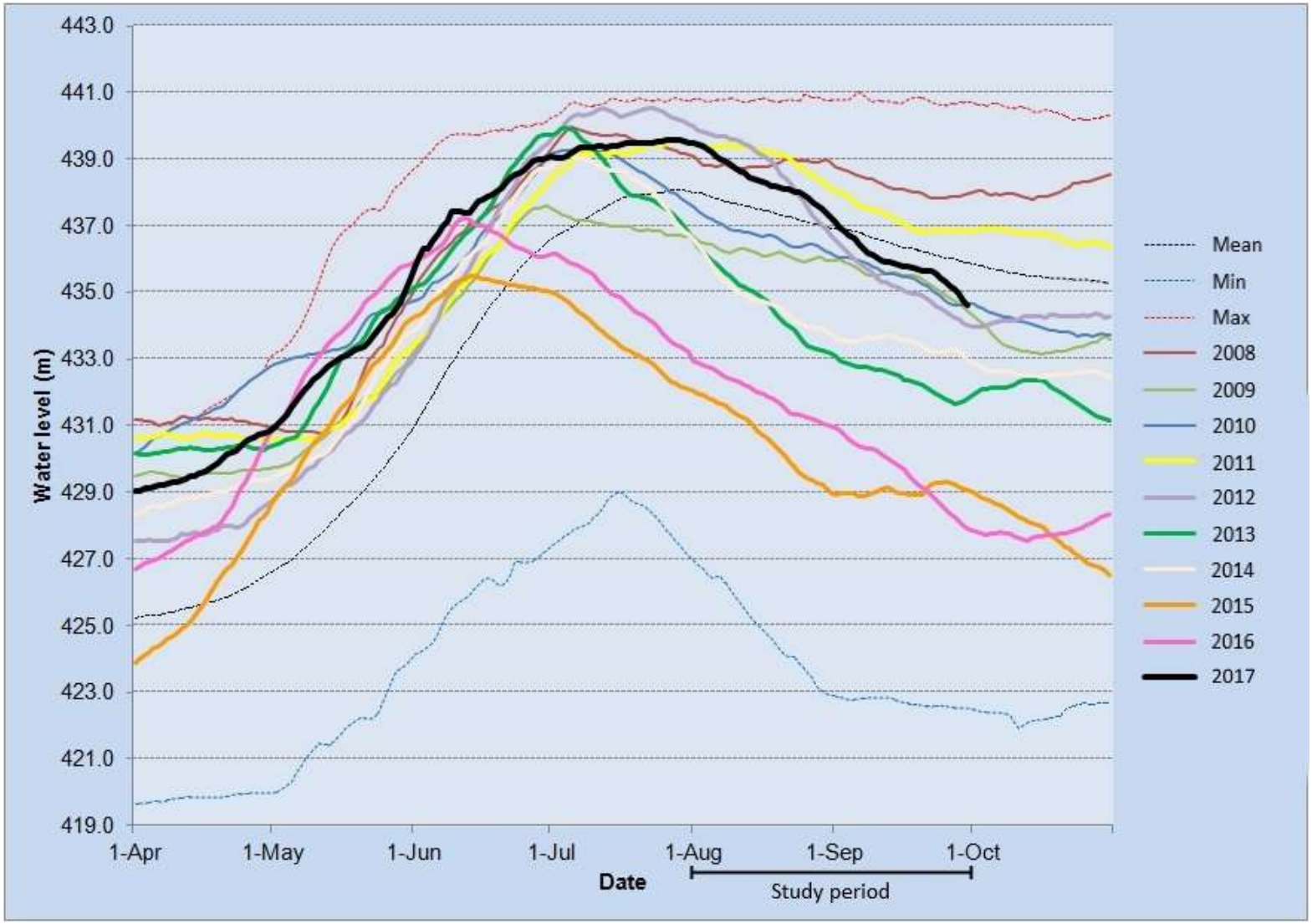
7 APPENDICES

Appendix 1: Management objectives, questions, hypotheses and approaches and status of CLBMON 39 after Year 10 (2017)

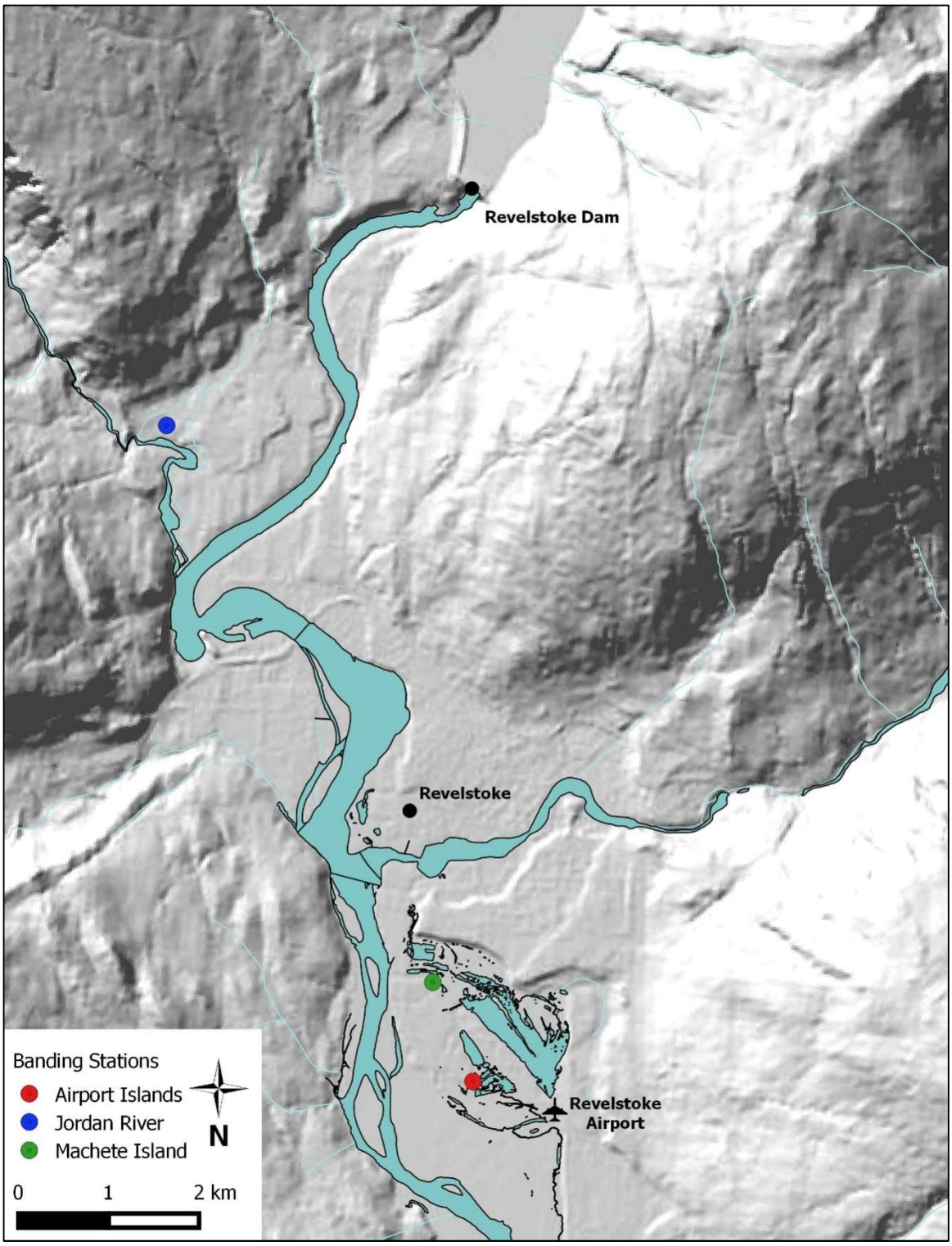
Study Objective	Management Question	Management Hypothesis	Approach	Year 10 (2017) Status
Objective 1: Determine the migration patterns of neotropical migrants in Revelstoke Reach over time (within season, across seasons, and across years).	**MQ1:**What is the seasonal and annual variation in the abundance and species richness of neotropical migrants in Revelstoke Reach during fall migration?		Constant effort mist netting Random plot surveys Permanent plot surveys	*- Preliminary multi-year analysis was conducted as part of the Year 5 interim review report.* *- Data collected to date allow us to adequately address this management question through updated analysis included in the Year 10 final report.*
Objective 2: Assess whether reservoir operations affect populations of neotropical migrants that use the area as a stopover site.	**MQ3:**Do reservoir operations influence the species richness or abundance of neotropical migrants using habitat in the drawdown zone during fall migration? If so, how do reservoir operations influence the species richness or abundance?	H1: Annual and seasonal variation in reservoir levels do not influence neotropical migrant abundance or species richness in habitats in the drawdown zone of Revelstoke Reach during fall migration.	Constant effort mist netting Permanent plot surveys	*- Preliminary analysis of the constant effort mist netting and permanent plot data was conducted as part of the Year 5 interim review report.* *- In Year 9, the updated analysis of permanent plot data confirmed a significant effect of water depth on the presence of migrants on plot. Reservoir operations seem to have no effect on use of unvegetated habitats, reduce use of shrub and grassland habitats as water depths increase in those habitats, and increase use of forest habitats as water levels rise.* *- For the Year 10 final report the analysis of permanent plot data will be further improved, and a complete analysis of the constant effort mist netting dataset will be conducted.*
	MQ4: Which neotropical migrants are most affected by reservoir operations?		Constant effort mist netting Permanent plot surveys Random plot surveys	*- Preliminary analysis was conducted for the Year 5 interim review report where significant annual changes in capture and recapture rate and stopover length of certain neotropical migrants were detected by analysing banding data. However, data collected in Years 6-10 suggest that the relationship may be more complex than originally suspected.* *- For the Year 10 final report, data from multiple components of this study will be used to address this question by comparing the results with the life histories of neotropical migrant species detected in Revelstoke Reach.*
	MQ5: Do reservoir operations affect the fattening rates of neotropical migrants using the drawdown zone during fall migration?	H2: Annual and seasonal variation in reservoir levels do not influence fattening rates of neotropical migrants in Revelstoke Reach during fall migration.	Physiology health monitoring	*- No significant inter-annual effect on estimated fattening rates was detected during three years (2008-2010) at Machete Island and there was no effect of year or site on variation in estimated fattening rate among sites with different flooding conditions.* *- All our data suggest that reservoir water levels do not significantly impact estimated fattening rates of neotropical migrants in Revelstoke Reach.*
Objective 3: Determine whether there are specific times during the migratory season when minor adjustments to flow rates or water levels will enhance the ability of the drawdown area to support neotropical migrants.	**MQ6:** Can operational adjustments be made to reduce impacts on neotropical migrants during fall migration or are mitigation measures required to minimize the loss of stopover habitat?		Constant effort mist netting Permanent plot surveys Random plot	*- This MQ will be fully addressed for the Year 10 final report after answers to the other questions are finalized.*

Study Objective	Management Question	Management Hypothesis	Approach	Year 10 (2017) Status
			surveys	
Objective 4: Provide information with respect to how wildlife physical works or revegetation can increase utilization of treated riparian habitat by neotropical migrants.	**MQ8:** Are the ongoing revegetation projects effective at improving utilization of the treated habitat in the drawdown zone by neotropical migrants?	H4: Revegetation does not affect utilization of the area by neotropical migrants as measured by migrant species richness or abundance.		*- Preliminary analysis was conducted for the Year 5 interim review report and additional data were collected in 2013, 2014 and 2016.* *- In Year 9, an updated analysis of the complete dataset was conducted, and it was shown that the revegetation projects (cottonwood treatment) have so far made negligible impact to utilization of these areas by migrants (as measured by the changes in abundance and diversity over time).*
Objective 5: Determine habitat use by neotropical migrants in the drawdown zone of Revelstoke Reach over time (within season, across seasons, and across years) and the impacts of reservoir operations on habitat availability and quality.	**MQ2:** Which habitats within the drawdown zone in Revelstoke Reach are utilized by neotropical migrants and what are their characteristics?		Random plot surveys	*- Preliminary analysis of random plot data was conducted for the Year 5 interim review report.* *- In Year 9, a comparison of abundance and diversity of migrants among habitat strata was updated.* *- For the Year 10 final report, the detailed vegetation/habitat data that were collected on all random plots along with bird observation data will be used to identify vegetation preferences and habitat utilization by neotropical migrants within the drawdown zone.*
	MQ9: Does the operation of Arrow Lakes Reservoir impact the availability or quality of stopover habitat in Revelstoke Reach for neotropical migrants?	H3: Annual and seasonal variation in reservoir levels do not influence the availability or quality of habitat for neotropical migrants.	Permanent plot surveys	*- Preliminary analysis of the permanent plot data was conducted for the Year 5 interim review report.* *- It was demonstrated that the availability of stopover habitat is dependant on reservoir water levels.* *- In Year 9, an updated analysis of permanent plot data was run and confirmed our previous finding, which suggested that reservoir levels influence stopover habitat quality (as expressed by the probability of the presence of a migrant on plot).* *- For the Year 10 final report, this analysis will be further improved.*

Appendix 2: Water levels (m) in Arrow Lakes Reservoir in 2017 compared with data from 2008 to 2016 and mean, minimum and maximum elevation (1968–2008)



Appendix 3: CLBMON 39 constant effort mist-netting sites in Revelstoke Reach in 2017



Appendix 4: Survey effort and overall capture rate for each net during CLBMON 39 in 2017

Site	Net	Capture Effort (in Net/hours)	Overall Capture Rate (Birds/net-hour)
Machete Island	M1	131.75	0.562
	M2	195.75	3.367
	M3	193.00	3.181
	M4	192.75	3.196
	M5	167.75	3.833
	M6	158.00	1.203
	M7	160.50	1.520
	M8	131.25	1.539
	M9	131.25	1.836
	M10	131.75	1.905
	M12	131.75	0.630
	M14	157.50	4.952
	M3A	193.00	4.238
Airport Islands	A1	28.25	0.708
	A2	25.25	0.158
	A3	25.25	0.238
	A4	29.25	0.923
	A5	20.00	0.800
	A6	25.25	1.624
	A7	20.00	0.500
	A8	23.75	0.589
	A9	23.75	0.674
Jordan River	J3	39.25	3.873
	J4	39.25	1.350
	J5	39.25	0.739
	J7	39.25	1.503
	J10	39.25	0.943
	J11	39.25	0.229
	J12	39.25	1.146
	J13	9.75	1.538

Appendix 5: Bird species detected during CLBMON 39 in 2017

Common Name	Scientific Name	Code	Machete Island		Airport Islands		Jordan River	
			Observed	Captured	Observed	Captured	Observed	Captured
Alder Flycatcher	*Empidonax alnorum*	ALFL	x	x				
American Crow	*Corvus brachyrhynchos*	AMCR	x		x		x	
American Goldfinch	*Spinus tristis*	AMGO	x	x	x		x	
American Kestrel	*Falco sparverius*	AMKE	x					
American Pipit	*Anthus rubescens*	AMPI	x		x		x	
American Redstart	*Setophaga ruticilla*	AMRE	x	x			x	x
American Robin	*Turdus migratorius*	AMRO	x	x			x	x
American Wigeon	*Anas americana*	AMWI	x		x			
Bald Eagle	*Haliaeetus leucocephalus*	BAEA	x		x		x	
Barn Swallow	*Hirundo rustica*	BARS	x				x	
Barrow's Goldeneye	*Bucephala islandica*	BAGO			x			
Belted Kingfisher	*Megaceryle alcyon*	BEKI	x		x		x	
Black Swift	*Cypseloides niger*	BLSW	x				x	
Black-capped Chickadee	*Poecile atricapillus*	BCCH	x	x	x	x	x	x
Black-headed Grosbeak	*Pheucticus melanocephalus*	BHGR	x	x				
Blackpoll Warbler	*Setophaga striata*	BLPW		x				
Brewer's Blackbird	*Euphagus cyanocephalus*	BRBL	x					
Broad-winged Hawk	*Buteo platypterus*	BWHA	x				x	
Brown-headed Cowbird	*Molothrus ater*	BHCO		x				
Bullock's Oriole	*Icterus bullockii*	BUOR	x					
California Gull	*Larus californicus*	CAGU			x			
Canada Goose	*Branta canadensis*	CANG	x		x			
Cassin's Vireo	*Vireo cassinii*	CAVI	x				x	x
Cedar Waxwing	*Bombycilla cedrorum*	CEDW	x	x			x	x
Chestnut-backed Chickadee	*Poecile rufescens*	CBCH	x	x			x	x
Chipping Sparrow	*Spizella passerina*	CHSP	x	x				
Clay-colored Sparrow	*Spizella pallida*	CCSP	x	x				
Common Loon	*Gavia immer*	COLO	x		x			
Common Nighthawk	*Chordeiles minor*	CONI	x					
Common Raven	*Corvus corax*	CORA	x		x		x	
Common Yellowthroat	*Geothlypis trichas*	COYE	x	x	x	x	x	x
Cooper's Hawk	*Accipiter cooperii*	COHA	x					
Dark-eyed Junco	*Junco hyemalis*	DEJU	x	x		x	x	
Downy Woodpecker	*Picoides pubescens*	DOWO	x	x			x	
Dusky Flycatcher	*Empidonax oberholseri*	DUFL		x				
Eastern Kingbird	*Tyrannus tyrannus*	EAKI	x	x				
European Starling	*Sturnus vulgaris*	EUST	x	x	x			
Evening Grosbeak	*Coccothraustes vespertinus*	EVGR	x				x	
Fox Sparrow	*Passerella iliaca*	FOSP		x				x
Gadwall	*Anas strepera*	GADW			x			
Golden-crowned Kinglet	*Regulus satrapa*	GCKI	x	x			x	x
Gray Catbird	*Dumetella carolinensis*	GRCA	x	x				
Great Blue Heron	*Ardea herodias*	GBHE	x		x			
Great Horned Owl	*Bubo virginianus*	GHOW	x					
Greater Yellowlegs	*Tringa melanoleuca*	GRYE			x			
Green-winged Teal	*Anas crecca*	GWTE	x		x		x	
Hairy Woodpecker	*Picoides villosus*	HAWO	x				x	
Hammond's Flycatcher	*Empidonax hammondii*	HAFL		x				x
Hermit Thrush	*Catharus guttatus*	HETH		x				x
Hooded Merganser	*Lophodytes cucullatus*	HOME	x					
Horned Lark	*Eremophila alpestris*	HOLA	x					
Killdeer	*Charadrius vociferus*	KILL	x		x			
Lapland Longspur	*Calcarius lapponicus*	LALO	x		x			

Common Name	Scientific Name	Code	Machete Island		Airport Islands		Jordan River	
			Observed	Captured	Observed	Captured	Observed	Captured
Lazuli Bunting	*Passerina amoena*	LAZB	x	x			x	x
Least Flycatcher	*Empidonax minimus*	LEFL	x	x				
Least Sandpiper	*Calidris minutilla*	LESA	x		x			
Lesser Yellowlegs	*Tringa flavipes*	LEYE	x					
Lincoln's Sparrow	*Melospiza lincolnii*	LISP	x	x	x	x		x
Long-billed Dowitcher	*Limnodromus scolopaceus*	LBDO			x			
Long-eared Owl	*Asio otus*	LEOW						
MacGillivray's Warbler	*Geothlypis tolmiei*	MGWA	x	x		x	x	x
Magnolia Warbler	*Setophaga magnolia*	MAWA		x				x
Mallard	*Anas platyrhynchos*	MALL	x		x		x	
Marsh Wren	*Cistothorus palustris*	MAWR	x	x		x		
Merlin	*Falco columbarius*	MERL	x		x			
Nashville Warbler	*Oreothlypis ruficapilla*	NAWA		x				x
Northern Flicker	*Colaptes auratus*	NOFL	x	x	x		x	
Northern Goshawk	*Accipiter gentilis*	NOGO	x					
Northern Harrier	*Circus cyaneus*	NOHA	x		x		x	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	NRWS	x		x			
Northern Shoveler	*Anas clypeata*	NSHO	x		x			
Northern Waterthrush	*Parkesia noveboracensis*	NOWA	x	x		x		
Olive-sided Flycatcher	*Contopus cooperi*	OSFL						
Orange-crowned Warbler	*Oreothlypis celata*	OCWA	x	x		x		x
Osprey	*Pandion haliaetus*	OSPR	x		x			
Pacific Wren	*Troglodytes pacificus*	PAWR		x				
Pied-billed Grebe	*Podilymbus podiceps*	PBGR	x		x			
Pileated Woodpecker	*Dryocopus pileatus*	PIWO	x				x	
Pine Siskin	*Spinus pinus*	PISI	x				x	
Prairie Falcon	*Falco mexicanus*	PRFA			x			
Purple Finch	*Haemorhous purpureus*	PUFI	x	x				
Red Crossbill	*Loxia curvirostra*	RECR	x				x	
Red-breasted Nuthatch	*Sitta canadensis*	RBNU	x	x			x	
Red-eyed Vireo	*Vireo olivaceus*	REVI	x	x			x	x
Red-naped Sapsucker	*Sphyrapicus nuchalis*	RNSA	x	x			x	
Red-tailed Hawk	*Buteo jamaicensis*	RTHA	x				x	
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL	x		x			
Ring-billed Gull	*Larus delawarensis*	RBGU			x			
Ruby-crowned Kinglet	*Regulus calendula*	RCKI	x	x		x		x
Rufous Hummingbird	*Selasphorus rufus*	RUHU	x	x	x	x	x	
Rusty Blackbird	*Euphagus carolinus*	RUBL			x	x		
Savannah Sparrow	*Passerculus sandwichensis*	SAVS	x	x	x	x	x	
Semipalmated Plover	*Charadrius semipalmatus*	SEPL	x					
Sharp-shinned Hawk	*Accipiter striatus*	SSHA	x	x	x		x	
Snow Goose	*Chen caerulescens*	SNGO			x			
Song Sparrow	*Melospiza melodia*	SOSP	x	x			x	x
Sora	*Porzana carolina*	SORA	x	x	x			
Steller's Jay	*Cyanocitta stelleri*	STJA	x	x			x	
Swainson's Thrush	*Catharus ustulatus*	SWTH	x	x	x	x	x	x
Tennessee Warbler	*Oreothlypis peregrina*	TEWA		x				x
Townsend's Warbler	*Setophaga townsendi*	TOWA		x				x
Traill's Flycatcher	*Empidonax alnorum/traillii*	TRFL	x	x		x		x
Turkey Vulture	*Cathartes aura*	TUVU	x				x	
Unidentified *Accipiter* Hawk	*Accipiter (sp)*	UAHA	x		x			
Unidentified Blackbird	*Icteridae (gen, sp)*	UNBL	x		x			
Unidentified *Buteo* Hawk	*Buteo (sp)*	UBHA	x					
Unidentified Dowitcher	*Limnodromus (sp)*	UNDO	x					

Common Name	Scientific Name	Code	Machete Island		Airport Islands		Jordan River	
			Observed	Captured	Observed	Captured	Observed	Captured
Unidentified Duck	*Anatinae (gen, sp)*	UNDU	x		x			
Unidentified *Empidonax* Flycatcher	*Empidonax (sp)*	UEFL	x					x
Unidentified Hawk	*Accipitridae (gen, sp)*	UNHA	x					
Unidentified Hummingbird	*Trochilidae (gen, sp)*	UNHU	x				x	
Unidentified *Larus* Gull	*Larus (sp)*	UNLG	x		x		x	
Unidentified Shorebird		UNSH	x					
Unidentified Sparrow	*Emberizidae (gen, sp)*	UNSP	x					
Unidentified Swallow	*Hirundidae (gen, sp)*	UNSW	x		x			
Unidentified Teal		UNTE	x		x			
Unidentified Thrush	*Turdidae (gen, sp)*	UNTH	x					
Unidentified Woodpecker	*Picadae (gen, sp)*	UNWO	x					
Unidentified Yellowlegs	*Tringa melanoleuca/flavipes*	UNYE			x			
Varied Thrush	*Ixoreus naevius*	VATH	x	x				x
Vaux's Swift	*Chaetura vauxi*	VASW	x				x	
Veery	*Catharus fuscescens*	VEER	x	x				x
Virginia Rail	*Rallus limicola*	VIRA		x				
Warbling Vireo	*Vireo gilvus*	WAVI	x	x			x	x
Western Sandpiper	*Calidris mauri*	WESA			x			
Western Tanager	*Piranga ludoviciana*	WETA	x	x				x
Western Wood-Pewee	*Contopus sordidulus*	WEWP	x	x				
White-crowned Sparrow	*Zonotrichia leucophrys*	WCSP	x	x				
White-throated Sparrow	*Zonotrichia albicollis*	WTSP	x	x				x
Willow Flycatcher	*Empidonax traillii*	WIFL	x	x	x	x		
Wilson's Snipe	*Gallinago delicata*	WISN	x		x			
Wilson's Warbler	*Cardellina pusilla*	WIWA	x	x		x	x	x
Yellow Warbler	*Setophaga petechia*	YWAR	x	x		x	x	x
Yellow-breasted Chat	*Icteria virens*	YBCH	x	x				
Yellow-rumped Warbler	*Setophaga coronata*	YRWA	x	x	x	x	x	x

Appendix 6: Banding data summary from Machete Island banding station, Revelstoke Reach, 2017

Species Code*	No. of Newly Captured**	%	Capture Rate***	No. of Same-Day Recap	Same Day Recapture Rate (% new)	No. of Recaptures	Recapture Rate (% new)	Total No. Recaptures	No. of Unbanded	Total No.	Total Capture Rate***
YRWA	1159	25.9	0.5583	15	1.3	20	1.7	35	12	1206	0.5809
COYE	805	18.0	0.3878	80	9.9	156	19.4	236	23	1064	0.5125
OCWA	423	9.5	0.2038	21	5.0	33	7.8	54	4	481	0.2317
YWAR	395	8.8	0.1903	36	9.1	41	10.4	77	6	478	0.2303
AMRE	260	5.8	0.1252	21	8.1	50	19.2	71	6	337	0.1623
TRFL	214	4.8	0.1031	24	11.2	49	22.9	73		287	0.1382
WIWA	175	3.9	0.0843	11	6.3	14	8.0	25	1	201	0.0968
MGWA	150	3.4	0.0723	14	9.3	20	13.3	34	2	186	0.0896
REVI	100	2.2	0.0482	11	11.0	53	53.0	64	2	166	0.0800
GRCA	76	1.7	0.0366	9	11.8	23	30.3	32	2	110	0.0530
WAVI	90	2.0	0.0434	3	3.3	9	10.0	12	1	103	0.0496
SWTH	79	1.8	0.0381	5	6.3	14	17.7	19	1	99	0.0477
SOSP	58	1.3	0.0279	4	6.9	17	29.3	21	1	80	0.0385
LEFL	50	1.1	0.0241	12	24.0	17	34.0	29		79	0.0381
LISP	60	1.3	0.0289	6	10.0	4	6.7	10	2	72	0.0347
TEWA	43	1.0	0.0207	5	11.6	9	20.9	14	1	58	0.0279
CEDW	32	0.7	0.0154	2	6.3	17	53.1	19	2	53	0.0255
BCCH	25	0.6	0.0120	2	8.0	19	76.0	21		46	0.0222
VEER	38	0.9	0.0183	3	7.9	4	10.5	7		45	0.0217
NOWA	24	0.5	0.0116	1	4.2	2	8.3	3	2	29	0.0140
NAWA	20	0.4	0.0096	2	10.0	2	10.0	4	1	25	0.0120
SAVS	21	0.5	0.0101	.	.	.	.		2	23	0.0111
TOWA	16	0.4	0.0077	.	.	.	.			16	0.0077
RCKI	13	0.3	0.0063	.	.	1	7.7	1		14	0.0067
LAZB	13	0.3	0.0063	.	.	.	.			13	0.0063
MAWA	8	0.2	0.0039	1	12.5	.	.	1		9	0.0043
RUHU	.	.	.	.	.	.	.	.	9	9	0.0043
WETA	9	0.2	0.0043	.	.	.	.			9	0.0043
WTSP	6	0.1	0.0029	.	.	1	16.7	1	1	8	0.0039
YBCH	3	0.1	0.0014	.	.	5	166.7	5		8	0.0039
AMRO	6	0.1	0.0029	.	.	.	.		1	7	0.0034
AMGO	6	0.1	0.0029	.	.	.	.			6	0.0029
CCSP	6	0.1	0.0029	.	.	.	.			6	0.0029
DEJU	5	0.1	0.0024	.	.	.	.		1	6	0.0029
WEWP	6	0.1	0.0029	.	.	.	.			6	0.0029
CBCH	4	0.1	0.0019	1	25.0	.	.	1		5	0.0024
CHSP	5	0.1	0.0024	.	.	.	.			5	0.0024
GCKI	5	0.1	0.0024	.	.	.	.			5	0.0024
MAWR	5	0.1	0.0024	.	.	.	.			5	0.0024
WCSP	4	0.1	0.0019	1	25.0	.	.	1		5	0.0024
BHCO	4	0.1	0.0019	.	.	.	.			4	0.0019
BHGR	4	0.1	0.0019	.	.	.	.			4	0.0019
DOWO	4	0.1	0.0019	.	.	.	.			4	0.0019
EAKI	4	0.1	0.0019	.	.	.	.			4	0.0019
EUST	2	0.0	0.0010	.	.	2	100.0	2		4	0.0019
HAFL	4	0.1	0.0019	.	.	.	.			4	0.0019
PAWR	2	0.0	0.0010	.	.	2	100.0	2		4	0.0019
BLPW	3	0.1	0.0014	.	.	.	.			3	0.0014
FOSP	3	0.1	0.0014	.	.	.	.			3	0.0014
HETH	3	0.1	0.0014	.	.	.	.			3	0.0014
NOFL	3	0.1	0.0014	.	.	.	.			3	0.0014
PUFI	3	0.1	0.0014	.	.	.	.			3	0.0014
RNSA	3	0.1	0.0014	.	.	.	.			3	0.0014
SSHA	2	<0.1	0.0010	.	.	.	.			2	0.0010
VATH	2	<0.1	0.0010	.	.	.	.			2	0.0010
VIRA	1	<0.1	0.0005	.	.	.	.		1	2	0.0010
DUFL	1	<0.1	0.0005	.	.	.	.			1	0.0005
RBNU	1	<0.1	0.0005	.	.	.	.			1	0.0005
SORA	1	<0.1	0.0005	.	.	.	.			1	0.0005
STJA	1	<0.1	0.0005	.	.	.	.			1	0.0005
Total	**4468**	**100.0**	**2.1522**	**290**	**6.5**	**584**	**13.1**	**874**	**84**	**5426**	**2.6137**

* Species Code: see definition in Appendix 5; ** No. of Newly Captured: for CLBMON 39 in 2017 (included first recaptures of birds banded in previous year); *** Capture Rate/Total Capture Rate: in birds/net-hour

Appendix 7: Age and sex of newly banded birds captured at Machete Island banding station in 2017 (AHY = after hatch year, HY = hatch year, U = unknown)

Species Code*	Age			Sex							Grand Total
				Female			Male			U	
	AHY	HY	U	AHY	HY	Total	AHY	HY	Total		
YRWA	27	1132	.	13	446	459	13	413	426	274	1159
COYE	66	739	.	36	182	218	30	370	400	187	805
OCWA	16	407	.	7	186	193	7	171	178	52	423
YWAR	39	355	1	24	147	171	14	151	165	59	395
AMRE	38	222	.	22	46	68	16	105	121	71	260
TRFL	21	193	.	3	.	3	.	.	.	211	214
WIWA	19	155	1	13	71	84	5	82	88*	3	175
MGWA	2	148	.	1	21	22	1	10	11	117	150
REVI	25	75	.	.	.	.	.	.	.	100	100
WAVI	1	89	.	.	.	.	.	.	.	90	90
SWTH	8	71	.	1	.	1	.	.	.	78	79
GRCA	17	59	.	1	.	1	.	.	.	75	76
LISP	3	57	.	.	.	.	.	.	.	60	60
SOSP	6	51	1	.	.	.	.	.	.	58	58
LEFL	2	48	.	2	.	2	.	.	.	48	50
TEWA	7	36	.	2	.	2	.	3	3	38	43
VEER	5	33	.	.	.	.	.	.	.	38	38
CEDW	23	9	.	13	.	13	3	.	3	16	32
BCCH	3	22	.	.	.	.	.	.	.	25	25
NOWA	3	21	.	.	.	.	.	.	.	24	24
SAVS	5	16	.	.	.	.	.	.	.	21	21
NAWA	.	20	.	.	2	2	.	10	10	8	20
TOWA	.	16	.	.	7	7	.	4	4	5	16
LAZB	4	9	.	1	.	1	3	.	3	9	13
RCKI	1	12	.	.	6	6	1	6	7	.	13
WETA	.	9	.	.	2	2	.	4	4	3	9
MAWA	.	8	.	.	3	3	.	3	3	2	8
AMGO	3	3	.	.	.	.	3	1	4	2	6
AMRO	4	2	.	2	.	2	2	.	2	2	6
CCSP	3	3	.	.	.	.	.	.	.	6	6
WEWP	1	5	.	.	.	.	.	.	.	6	6
WTSP	.	6	.	.	.	.	.	.	.	6	6
CHSP	.	5	.	.	.	.	.	.	.	5	5
DEJU	.	5	.	.	1	1	.	2	2	2	5
GCKI	.	5	.	.	3	3	.	1	1	1	5
MAWR	.	5	.	.	.	.	.	.	.	5	5
BHCO	.	4	.	.	.	.	.	.	.	4	4
BHGR	.	4	.	.	2	2	.	2	2	.	4
CBCH	.	4	.	.	.	.	.	.	.	4	4
DOWO	1	3	.	1	1	2	.	1	1	1	4
EAKI	3	1	.	.	.	.	2	.	2	2	4
HAFL	.	4	.	.	.	.	.	.	.	4	4
WCSP	.	4	.	.	.	.	.	.	.	4	4
BLPW	.	3	.	.	.	.	.	.	.	3	3
FOSP	2	1	.	.	.	.	.	.	.	3	3
HETH	1	2	.	.	.	.	.	.	.	3	3
NOFL	1	2	.	.	1	1	1	1	2	.	3
PUFI	.	2	1	.	.	.	.	.	.	3	3
RNSA	1	2	.	.	.	.	1	1	2	1	3
YBCH	2	1	.	1	.	1	1	.	1	1	3
EUST	1	1	.	1	.	1	.	.	.	1	2
PAWR	.	2	.	.	.	.	.	.	.	2	2
SSHA	.	2	.	.	1	1	.	1	1	.	2
VATH	.	2	.	.	1	1	.	1	1	.	2
DUFL	.	1	.	.	.	.	.	.	.	1	1
RBNU	.	1	.	.	.	.	.	1	1	.	1
SORA	.	1	.	.	.	.	.	.	.	1	1
STJA	.	1	.	.	.	.	.	.	.	1	1
VIRA	.	.	1	.	.	.	.	.	.	1	1
Total	**364**	**4099**	**5**	**144**	**1129**	**1273**	**103**	**1344**	**1448**	**1747**	**4468**

Appendix 8: Banding data summary from Airport Islands banding station, Revelstoke Reach, 2017

Species Code*	No. of Newly Captured**	%	Capture Rate***	No. of Same-Day Recap	%	No. of Recap	Recap Rate (%)	Total No. Recaptures	No. of Unbanded	Total No.	Total Capture Rate***
YRWA	48	37.5	0.2174	.	.	.	.	.	.	48	0.2174
COYE	35	27.3	0.1586	4	11.4	4	11.4	8	.	43	0.1948
TRFL	9	7.0	0.0408	5	55.6	1	11.1	6	.	15	0.0680
LISP	10	7.8	0.0453	2	20.0	.	.	2	.	12	0.0544
SAVS	9	7.0	0.0408	.	.	.	.	.	.	9	0.0408
OCWA	4	3.1	0.0181	2	50.0	1	25.0	3	.	7	0.0317
BCCH	3	2.3	0.0136	2	66.7	.	.	2	.	5	0.0227
NOWA	2	1.6	0.0091	2	100.0	.	.	2	.	4	0.0181
SWTH	1	0.8	0.0045	2	200.0	.	.	2	.	3	0.0136
RCKI	1	0.8	0.0045	1	100.0	.	.	1	.	2	0.0091
DEJU	1	0.8	0.0045	.	.	.	.	.	.	1	0.0045
MAWR	1	0.8	0.0045	.	.	.	.	.	.	1	0.0045
MGWA	1	0.8	0.0045	.	.	.	.	.	.	1	0.0045
RUBL	1	0.8	0.0045	.	.	.	.	.	.	1	0.0045
RUHU	.	.	.	.	.	.	.	.	1	1	0.0045
WIWA	1	0.8	0.0045	.	.	.	.	.	.	1	0.0045
YWAR	1	0.8	0.0045	.	.	.	.	.	.	1	0.0045
Total	**128**	**100.0**	**0.5798**	**20**	**15.6**	**6**	**4.7**	**26**	**1**	**155**	**0.7022**

* Species Code: see definition in Appendix 5
** No. of Newly Captured: for CLBMON 39 in 2017 (included first recaptures of birds banded in previous year)
*** Capture Rate/Total Capture Rate: in birds/net-hour

Appendix 9: Banding data summary from Jordan River banding station, Revelstoke Reach, 2017

Species Code*	No. of Newly Captured**	%	Capture Rate***	No. of Same-Day Recap	%	No. of Recap	Recap Rate (%)	Total No. Recaptures	No. of Unbanded	Total No.	Total Capture Rate***
YRWA	154	41.4	0.5413	.	.	.	.	.	.	154	0.5413
AMRE	38	10.2	0.1336	6	15.8	1	2.6	7	1	46	0.1617
SWTH	35	9.4	0.1230	4	11.4	1	2.9	5	.	40	0.1406
WAVI	38	10.2	0.1336	.	.	1	2.6	1	.	39	0.1371
CBCH	13	3.5	0.0457	.	.	.	.	.	.	13	0.0457
GCKI	11	3.0	0.0387	.	.	1	9.1	1	1	13	0.0457
MGWA	13	3.5	0.0457	.	.	.	.	.	.	13	0.0457
OCWA	7	1.9	0.0246	1	14.3	1	14.3	2	.	9	0.0316
YWAR	9	2.4	0.0316	.	.	.	.	.	.	9	0.0316
SOSP	6	1.6	0.0211	.	.	2	33.3	2	.	8	0.0281
BCCH	6	1.6	0.0211	.	.	1	16.7	1	.	7	0.0246
REVI	5	1.3	0.0176	1	20.0	1	20.0	2	.	7	0.0246
WIWA	6	1.6	0.0211	1	16.7	.	.	1	.	7	0.0246
HAFL	5	1.3	0.0176	.	.	.	.	.	.	5	0.0176
RCKI	5	1.3	0.0176	.	.	.	.	.	.	5	0.0176
COYE	3	0.8	0.0105	.	.	.	.	.	.	3	0.0105
TEWA	2	0.5	0.0070	1	50.0	.	.	1	.	3	0.0105
CEDW	2	0.5	0.0070	.	.	.	.	.	.	2	0.0070
VEER	2	0.5	0.0070	.	.	.	.	.	.	2	0.0070
WTSP	2	0.5	0.0070	.	.	.	.	.	.	2	0.0070
AMRO	1	0.3	0.0035	.	.	.	.	.	.	1	0.0035
CAVI	1	0.3	0.0035	.	.	.	.	.	.	1	0.0035
FOSP	1	0.3	0.0035	.	.	.	.	.	.	1	0.0035
HETH	1	0.3	0.0035	.	.	.	.	.	.	1	0.0035
LAZB	1	0.3	0.0035	.	.	.	.	.	.	1	0.0035
LISP	1	0.3	0.0035	.	.	.	.	.	.	1	0.0035
MAWA	1	0.3	0.0035	.	.	.	.	.	.	1	0.0035
NAWA	.	.	.	.	.	.	.	.	1	1	0.0035
TOWA	1	0.3	0.0035	.	.	.	.	.	.	1	0.0035
TRFL	.	.	.	.	.	.	.	.	1	1	0.0035
UEFL	.	.	.	.	.	.	.	.	1	1	0.0035
VATH	1	0.3	0.0035	.	.	.	.	.	.	1	0.0035
WETA	1	0.3	0.0035	.	.	.	.	.	.	1	0.0035
Total	**372**	**100.0**	**1.3076**	**14**	**3.8**	**9**	**2.4**	**23**	**5**	**400**	**1.4060**

* Species Code: see definition in Appendix 5
** No. of Newly Captured: for CLBMON 39 in 2017 (included first recaptures of birds banded in previous year)
*** Capture Rate/Total Capture Rate: in birds/net-hour