# Columbia River Project Water Use Plan

## KINBASKET AND ARROW LAKES RESERVOIRS

## Arrow Lakes Reservoir: Neotropical Migrant Use of the Drawdown Zone

**Implementation Year 9**

**Reference: CLBMON 39**

**Study Period: 2016**

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

## *Year 9 (2016)*

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**Cover photo:** Yellow-breasted Chat (*Icteria virens*), Machete Island banding station, Revelstoke Reach, 2016. 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 songbird migration monitoring station at the north end of Revelstoke Reach, 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 9 (2016) and briefly reviews overall progress.

In 2016, 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.

At Machete Island banding station, mist net sampling was conducted on 44 days for a total of 2800 net-hours. The first survey was conducted on August 2, 2016 and the last one on September 25, 2016. The average number of mist nets set up per day was 11.7 ± 0.37 (mean ± SE). A total of 3038 birds of 61 species were captured, with an overall capture rate of 1.0850 birds/net-hour. Common Yellowthroat (*Geothlypis trichas*) was the most frequently captured species (20.3% of all captured birds) with an overall capture rate of 0.2200 birds/net-hour. At Machete Island, we captured three species that have not been previously captured under CLBMON 39 at any station: Yellow-breasted Chat (*Icteria virens*), Brewer's Sparrow (*Spizella breweri*) and Golden-crowned Sparrow (*Zonotrichia atricapilla*).

In total, 2307 individuals of 59 species were newly captured (new individuals for the season) and the capture rate for newly captured birds was 0.8239 birds/net-hour. Of the birds of known age (99.6% of all newly-captured birds), 83% were HY (juvenile or “hatch year” birds hatched in 2016), and 17% were AHY (adult birds, or “after hatch year”, more than one year old). 341 individuals of 30 species were recaptured at least once (460 recaptures total). The overall recapture rate was 20.2 % and the overall same day recapture rate was 9.6%.

At Airport Islands banding station, 7 surveys were conducted for a total of 352 net-hours. The average number of open nets per day was 8.6 ± 0.30 (mean ± SE). The overall capture rate was 0.3267 birds/net-hour. In total, 115 birds from 16 species were captured, with Common Yellowthroat being the most frequently captured species (0.1534 birds/net-hour). The capture rate for newly banded birds was 0.2159 birds/net-hour and the overall recapture rate was 18.5%. The recapture rate for same day recaptures was 30.3%. We captured and banded four species that have not been previously captured at this site: American Tree Sparrow (*Spizelloides arborea)*, Lazuli Bunting (*Passerina amoena*), Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) and Townsend's Warbler (*Setophaga townsendi*).

At Jordan River banding station, 8 surveys were conducted for a total of 290.25 net-hours. The average number of open nets per day was 6.8 ± 0.25 (mean ± SE). In total, 248 birds of 33 species were captured, with an overall capture rate of 0.8544 birds/net-hour. The most frequently captured species was American Redstart (*Setophaga ruticilla*; 0.1378 birds/net-hour). The capture rate for newly banded birds was 0.7373 birds/net-hour and the overall recapture rate was 6.1%. The recapture rate for same day recaptures was 3.7%.

To monitor the response of migrants to BC Hydro revegetation projects, surveys of 23 effectiveness monitoring plots were conducted - 14 treatment plots (planted with cottonwood stakes) and 9 control plots (untreated area located in similar habitat). In total, 161 effectiveness monitoring surveys were conducted and 135 migrants of 11 species were recorded on plot. Of these, 70% of migrants and 9 species were recorded on cottonwood treatment plots and 30% of migrants and 8 species were recorded on control plots. Common Yellowthroat was the most frequently recorded species.

Pooling effectiveness monitoring data from all years (2011-2014 and 2016, n = 919), the mean cumulative annual abundance of migrants, but not species richness, was significantly higher on treatment plots than control plots. However, there was no significant increase in abundance or species richness on treatment plots over time (since 2011). To date, the areas treated with cottonwood stakes have not provided a clear increase in neotropical migrant songbird utilization of these areas.

Four years of permanent habitat plot sampling (3183 surveys) documented bird occurrence on permanent plots under various flooding conditions. Pooling data from all years, water depth had a negative effect on the probability of the presence of a neotropical migrant on grassland and shrub plots but a positive effect on presence on forest plots. No neotropical migrants were recorded on unvegetated permanent plots. This confirms our results from previous years and highlights the effect that water depth has on neotropical migrant use of plots with different vegetation structures.

Pooling random habitat plot data from four years of surveys (2011-2014, n = 220), abundance and species richness of neotropical migrants varied among strata. Plots from forest and shrub habitats had significantly higher abundance and species richness of migrants than grassland or unvegetated plots. In addition, grassland plots had higher abundance and species richness than unvegetated plots. There was no significant difference in abundance or species richness between plots from forest and shrub habitats.

Key recommendations for Year 10 of CLBMON 39 are: (1) continue daily constant effort capture-banding surveys at Machete Island during the fall migration period, (2) continue once-weekly capture-banding surveys at the two satellite banding sites (Jordan River and Airport Islands).

## 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. Kayla Williams of the ONA contributed to field studies. Al Peatt managed the ONA's involvement.

Field studies were completed by CBA staff (Devon Anderson, Corey Bird, Catherine Craig, Ryan Gill, Michal Pavlik and Emily Williams) and ONA staff (Kayla Williams). Michal Pavlik planned the 2016 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.

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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). In the Americas, neotropical migrant birds include more than 200 species that generally breed north of the Tropic of Cancer, with at least 5% of the population wintering 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. While there has been slow and steady expansion of vegetation in some areas, 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, MCA 2009, CBA 2010a, 2011a, 2012, 2013a, 2013b, 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, MCA 2009, CBA 2010b, CBA 2011b). 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. Therefore, this project focuses on the effects of reservoir water levels on neotropical migrants during fall migration (monitoring of neotropical migrants during spring migration is conducted under CLBMON 11B-2). The CLBMON 39 program was initiated in 2008 with constant effort mist netting surveys at Machete Island banding station. In 2011, monitoring of neotropical migrant songbirds in other habitats in Revelstoke Reach was implemented to assess the impacts of reservoir operation across the diversity of habitats throughout the reach. The following surveys were initiated in 2011: (1) Constant effort mist netting surveys at the satellite banding sites to determine migrant songbird use of the drawdown zone, (2) permanent plot surveys to assess the effects of reservoir water levels, (3) random plot surveys to assess neotropical migrant habitat use and preferences, and (4) effectiveness monitoring surveys to assess effectiveness of revegetation (planted cottonwood stakes) in Revelstoke Reach. In addition, in 2008–2013 physiological health monitoring (fattening rates) of neotropical migrants was assessed through analyses of blood plasma metabolite assays.

The 2014 study recommended that permanent and random plots be discontinued, and that fall surveys of effectiveness monitoring be temporarily discontinued (CBA 2015). In 2015, the original CLBMON 39 Terms of Reference (ToR) were revised and this report reflects changes incorporated in the revised ToR (BC Hydro 2015). In 2016, effectiveness monitoring surveys as well as constant effort mist-netting surveys were conducted.

This report provides results of Year 9 (2016) of the 10-year study.

## 1.1 Scope and Objectives

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

1) Determine the fall 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 fall 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 fall 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 fall neotropical migrants.

5) Determine habitat use by fall 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 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, BC and under constraints from the Columbia River Treaty, is licensed to operate with water levels between 420 m and 440.1 m elevation. 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).

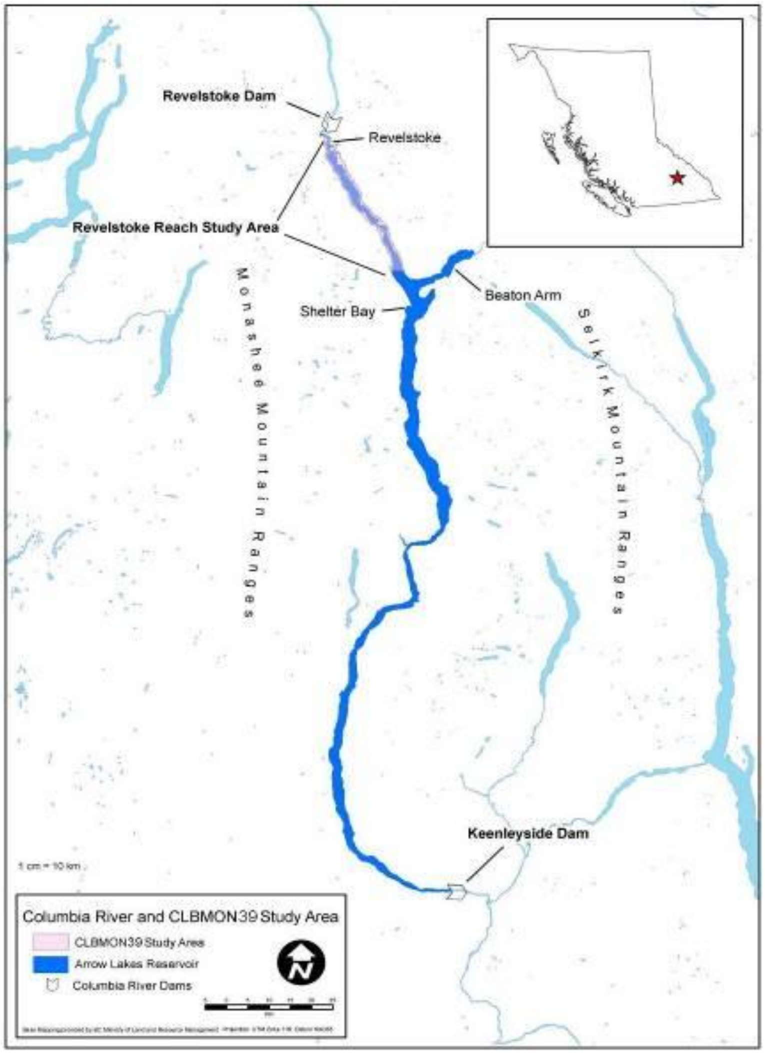


**Figure 1: CLBMON 39 study area in Revelstoke Reach, Arrow Lakes Reservoir**

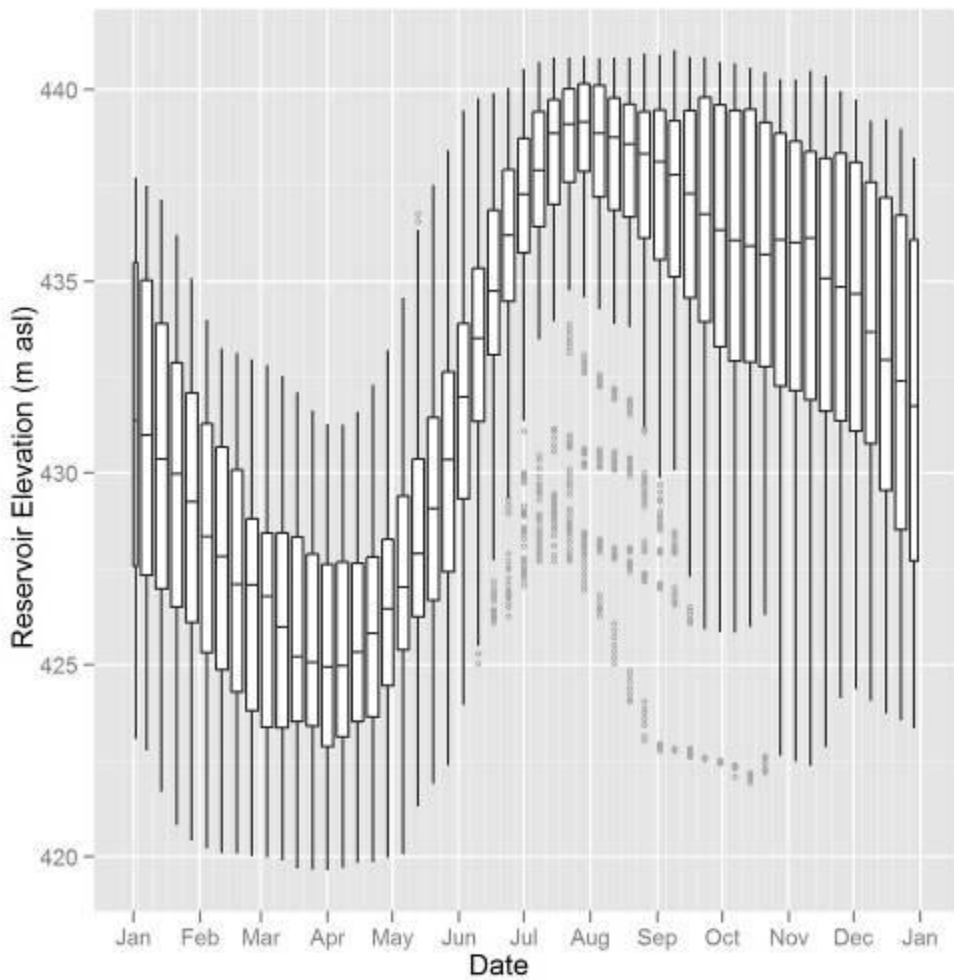


**Figure 2: Historical hydrological data from Arrow Lakes Reservoir (1968–2008) plotted in weekly intervals**

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*), Engelmann 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 to provide wildlife habitat 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 2016 is provided below. For a detailed account of these methods, refer to the CLBMON 39 protocol report (CBA 2016a).

## 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. Mist nets are fine-meshed nets strung in bird habitat for a set period of time/day. Birds are captured passively when they fly into the nets. To investigate reservoir level effects, banding stations were set up at different elevations both in and outside of the drawdown zone. Each captured bird is banded with a uniquely numbered metal leg band to allow individual identification. 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 stations will be used to:

- determine the occurrence patterns of migratory songbirds in Revelstoke Reach over time (MQ1);
- assess whether reservoir operations affect abundance and diversity 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 2016

In 2016, 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 2016 (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 because trees are felled for aircraft safety reasons as they become taller. The banding station area is dominated by black cottonwood, willow, alder, and red-osier dogwood. Snowberry, twinberry and reed canarygrass are abundant in the understory. In 2016, there were 13 nets installed at this site (Figure 8).

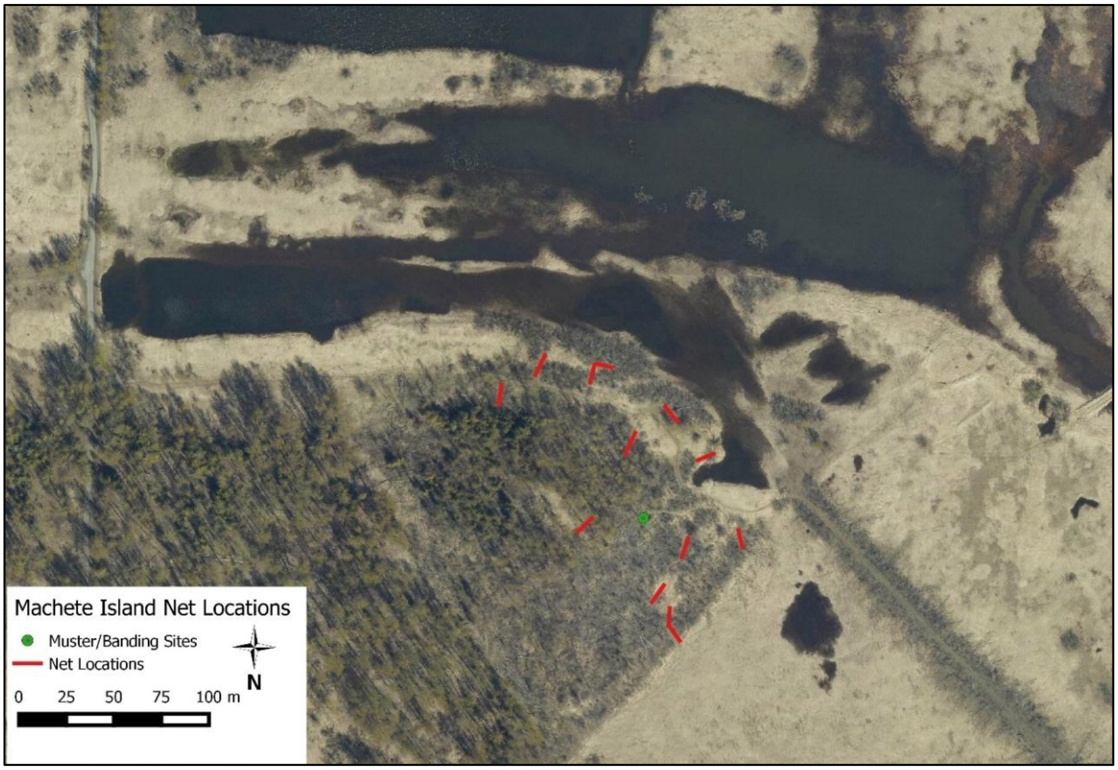


**Figure 8: Machete Island banding station layout in 2016**

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 its 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 2016 nine nets were installed at this site (Figure 10).

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 2016 seven nets were installed at this site (Figure 10).

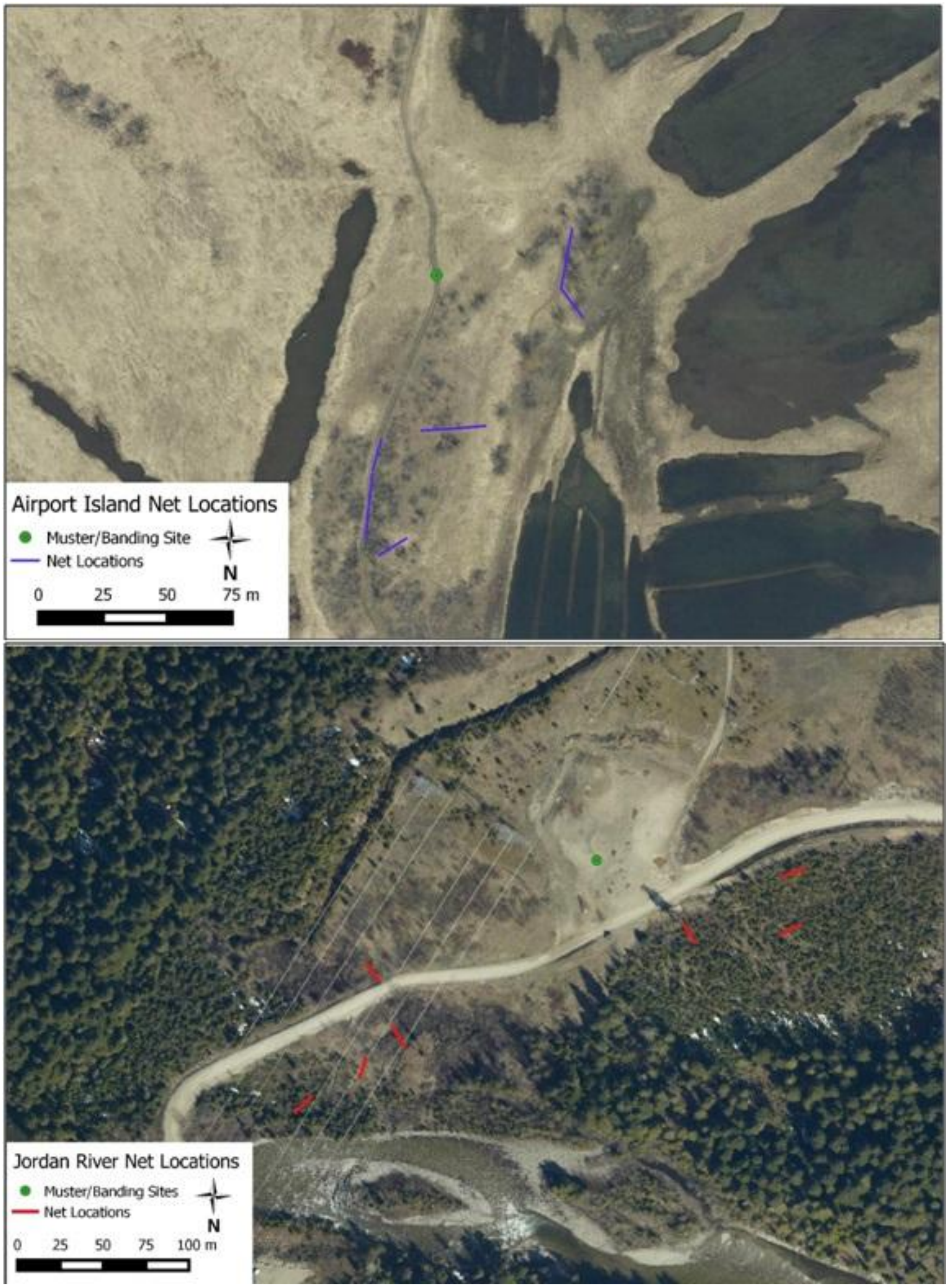


**Figure 10:** **Airport Islands and Jordan River banding station layout in 2016**

**Figure 11: Neotropical migrants captured in a 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 2016, 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.

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.

**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 2016a),which follows the North American Banding Council's mist netting and bird handling safety recommendations (Smith et al. 1999, NABC 2001).

## 2.2 Effectiveness Monitoring Plot Sampling

The permanent plot before and after control impact (BACI) survey approach was selected to determine if revegetation projects are effective at providing or enhancing stopover habitat for migratory neotropical songbirds. This approach is being used to address MQ 8.

To monitor the response of neotropical migrant songbirds to revegetation projects, effectiveness monitoring plots were established in 2011. In 2016, 14 treatment plots (planted with cottonwood stakes) and nine control plots (untreated area located in similar habitat) were monitored (Appendix 4). Both treatment and control plots were surveyed once per week. Typically, all effectiveness monitoring plots were surveyed on the same day. Surveys were conducted during the first six hours after sunrise, if possible. The order in which the plots were surveyed was changed every week to minimize bias related to the time of the day when surveys were conducted.

At the beginning of the survey, weather conditions were recorded. At each plot start time, the percent of the plot that was flooded, the average water depth and whether the plot was completely underwater (no vegetation available) were recorded. One observer then documented bird occurrence and behaviour within plot for at least 10 minutes or until census saturation time (CST—the shortest time interval in which the observer was able to count all birds on the plot) was reached. The observer then moved to the next plot. If the plot was completely underwater and no vegetation was visible, the observer recorded general plot survey data and surveyed the plot for at least 1 minute or until CST was reached, and then moved to the next plot. If the plot was completely flooded but some vegetation was visible (e.g., willow shrubs extending above the water surface), the observer conducted a regular 10-minute survey. Bird observations were recorded by minute (minutes from start). During the survey period, the observer moved slowly around the plot (on foot or in a kayak) to detect birds that may have been hidden within the plot. Data recorded included CST; bird detections before and after CST; bird species, number, sex, age, migratory status, behaviour and location (on plot, off plot, overhead); bird detections based on visual confirmation; bird detections based on flushing from the vegetation; substrate type being used; and height from the ground when the bird was first detected. For each bird observation, the distance from the observer was estimated.

## 2.3 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 2016 were submitted to the Migratory Bird Populations Division–Bird Banding Office in Ottawa.

## 2.4 Data Summary and Analysis

The purpose of this report is to review work conducted in Year 9 (2016). 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
- species and number of birds recorded during effectiveness monitoring surveys

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). Newly captured birds included both all newly captured and banded birds and all newly captured (for the year) recaptures from previous years. Recaptured birds were all previously captured and banded birds (within year), excluding same day recaptures. Capture rate (for newly captured birds) was calculated as the number of newly captured birds per net-hour. Same-day recapture rate was calculated as the number of same-day recaptures divided by the number of newly captured birds. 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. 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.

Because of the large number of unidentified “Traill's” Flycatchers (a species group with two virtually identical species (Willow Flycatcher (*Empidonax traillii*) and Alder Flycatcher (*Empidonax alnorum*)) records, for the purpose of this report we decided to pool those records into one taxon (Traill's Flycatcher was split into two species in 1973; AOU 1973).

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

For analysis of the effectiveness monitoring plots, data from 14 treatment plots (planted with cottonwood stakes) and nine control plots (untreated area located in similar habitat) were included (Appendix 4). We first used a GLM model to test the difference in mean annual bird abundance and species richness on plot (cumulative number of birds (species) on plot in a year) between treatment and control plots. In this model, the number of birds (species) on plot per year was the dependent variable, strata (treatment vs. control) was a main effect and year was a covariate. We started with a model with Poisson distribution, but due to over dispersion we used a quasipoisson GLM model instead. For both abundance and species richness, year was not a significant covariate and we removed it from the model. To test the response of migrants to the treatment over time, we used GLMM with a Poisson distribution (lmer function from LME4 package (Bates et al. 2011)) and modelled variation in migrant abundance and species richness among years. In both models, plot id was included as a random intercept.

For an updated permanent plot analysis, data collected on 98 permanent plots that were surveyed weekly in fall 2011-2014, were used. To model the effect of water depth on the probability of the presence of a neotropical migrant songbird on plot, we used GLMM with the random effect 'plot-week' (observations from the same plot in the same week). We used glmmPQL function from the MASS package (Venables and Ripley 2002). Controlling for the plot area, the probability of the presence of a songbird on plot was modelled as a function of water depth, with ‘plot-week’ as random effect. Because we expected a different relationship between water depth and presence of migrants on plot among strata (due to different vertical vegetation structure and different abundance of migrants; CBA 2013c), we analyzed plots from each stratum separately. The effect of flooding was expressed by the relative water depth on plot on the day of survey. Water depth was calculated by subtracting the elevation of a plot from the reservoir water level on the day of survey (positive value when plot was flooded and negative when it was dry). All calculated water depth values were cross-compared with water depth values recorded in the field. We set *a priori* maximum and minimum meaningful water depth for these analyses to be ± 4 meters and therefore surveys with calculated water depth greater than 4 m were given a water depth value of 4 m and surveys with water depth less than -4 m were given a water depth value of -4 m. Detailed permanent plot methodology is provided in CBA (2013c).

In four years of fall random plot surveys (2011 to 2014), 239 random plot surveys were conducted. We excluded any incomplete surveys and any surveys with missing data. In one case of a duplicate survey of the same plot, the second survey was excluded. In addition, 6 plots contained open water habitat at the time of survey and these surveys were excluded. For the updated random plot analysis, data from 220 plots were used. Although prior-survey habitat stratification was used to unsure that a representative number of plots from all habitats present within the drawdown zone were being surveyed (CBA 2015), plots were assigned to strata based on the vegetation collected after each survey. Vegetation data collected on each plot after the bird survey was used to assign random plots into one of the five broad habitat strata (unvegetated, grassland, shrub, forest or open water). Plots with ≥ 5% tree cover (> 5 m high) were assigned to forest strata, plots with ≥ 5% shrub cover and < 5% tree cover were assigned to shrub strata, plots with ≥ 10% grass/herbaceous cover and < 5% shrub cover were assigned to grassland strata and plots with < 10% grass/herbaceous cover were assigned to unvegetated strata. In addition, plots that were composed entirely of water with no vegetation available to migrants were classified as 'open water' strata. In total, 60 plots were assigned to forest strata, 63 to shrub strata, 73 to grassland strata and 24 to unvegetated strata. Due to non-normality of the data (both for abundance and species richness) we used Kruskal Wallis tests. To reveal any differences within groups, post-hoc Mann-Whitney tests with Bonferroni corrections were used. Random plot stratification, selection and survey methodology followed protocols described in CBA (2015).

# 3 RESULTS

## 3.1 Reservoir Operations of Arrow Lakes Reservoir in 2016

In 2016, the reservoir water level peaked on June 11 through 13, when the water reached its annual maximum of 437.2 m ASL. During the 2016 study period, water levels of the Arrow Lakes Reservoir were lower than the long-term average and the second lowest observed during the CLBMON 39 study period (CLBMON 39 started in 2008). At the beginning of the fall migration survey period, the reservoir levels were at 433.0 m ASL (on August 1, 2016), and gradually descended to 427.9 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 2 and the last one on September 25. During this period, 44 surveys were conducted for a total of 2800 net-hours. Relatively low water levels in Arrow Lake Reservoir in 2016 did not affect the access or operation of the banding station. Persistent rain prevented the operation of the banding station on 6 days. In addition, on 5 days, monitoring was not conducted at Machete Island due to effort at other stations (Jordan River and Airport Islands).

All staff were trained according to the banding station protocols, and care was taken that everyone was properly trained in safe extracting and bird handling techniques. From August 2 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 addition, on a few days some nets had to be temporary closed due to strong wind, heavy precipitation or the presence of a black bear (*Ursus americanus*) at the banding station. The number of open nets each day varied, with an average of 11.7 ± 0.37 (mean ± SE) nets. The total number of net-hours for the whole season was 2800 (Table 2).

**Table 2: Mist netting capture effort at Machete Island banding station in 2016**

| Month | No. days nets open | No. days all net closed | Mean No. open nets (SE) | No. net-hours |
|---|---|---|---|---|
| August | 25 | 5 | 10.8 (0.59) | 1492 |
| September | 19 | 6 | 12.9 (0.05) | 1308 |
| Total | 44 | 11 | 11.7 (0.37) | 2800 |

The survey effort was distributed relatively evenly throughout the fall migration period with the highest number of net-hours in week 4 and 6 (452.25 and 451.25 net-hours, respectively) and the lowest in week 0 (74.75 net-hours; Table 3). The total number of net-hours each net was open is provided in Appendix 5.

**Table 3: Weekly mist netting survey effort and number of net-hours at Machete Island banding station throughout the 2016 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 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| No. of surveys | 1 | 5 | 6 | 7 | 6 | 4 | 6 | 5 | 4 | 44 |
| Net-hours | 74.75 | 273.50 | 355.25 | 336.25 | 452.25 | 250.25 | 451.25 | 307.50 | 299.00 | 2800.00 |

### 3.2.2 Total Number of Captured Birds

A total of 3038 birds of 61 species were captured at Machete Island banding station in 2016 with an average capture rate of 1.0850 birds per net-hour (Appendix 6, Appendix 7). The most frequently captured species was Common Yellowthroat (*Geothlypis trichas*; 20.3% of all captured birds) with a capture rate of 0.2200 birds/net-hour. Another commonly captured species was Traill's Flycatcher (14.7% and 0.1593 birds/net-hour), followed by Yellow-rumped Warbler (*Setophaga coronata*; 8.0% and 0.0864 birds/net-hour), American Redstart (*Setophaga ruticilla*; 5.9% and 0.0636 birds/net-hour), Red-eyed Vireo (*Vireo olivaceus*; 5.2% and 0.0561 birds/net-hour), Song Sparrow (*Melospiza melodia*; 4.3% and 0.0464 birds/net-hour), Warbling Vireo (*Vireo gilvus*; 4.2% and 0.0457 birds/net-hour), Swainson's Thrush (*Catharus ustulatus*; 4.1% and 0.0450 birds/net-hour), Gray Catbird (*Dumetella carolinensis*; 3.8% and 0.0411 birds/net-hour), Yellow Warbler (*Setophaga petechia*; 2.6% and 0.0286 birds/net-hour) and Orange-crowned Warbler (*Oreothlypis celata*; 2.5% and 0.0275 birds/net-hour) (Appendix 7). The overall capture rate for each net is provided in Appendix 5.

Out of 61 species captured at Machete Island in 2016 (Appendix 7), three species have not been previously captured under CLBMON 39. These species were: Yellow-breasted Chat (*Icteria virens*), Brewer's Sparrow (*Spizella breweri*) and Golden-crowned Sparrow (*Zonotrichia atricapilla*). All three species are uncommon within Revelstoke Reach, and while they haven't been captured under CLBMON 39, they have been previously recorded in the Revelstoke Reach. In 2016, 27 species were captured at Machete Island but not at Jordan River or Airport Islands. These species were: Veery (*Catharus fuscescens*), Purple Finch (*Haemorhous purpureus*), Pine Siskin (*Spinus pinus*), Tennessee Warbler (*Oreothlypis peregrina*), Eastern Kingbird (*Tyrannus tyrannus*), Clay-colored Sparrow (*Spizella pallida*), White-crowned Sparrow (*Zonotrichia leucophrys*), Northern Waterthrush (*Parkesia noveboracensis*), Western Wood-Pewee (*Contopus sordidulus*), Red-naped Sapsucker (*Sphyrapicus nuchalis*), Downy Woodpecker (*Picoides pubescens*), Red-winged Blackbird (*Agelaius phoeniceus*), Dusky Flycatcher (*Empidonax oberholseri*), Magnolia Warbler (*Setophaga magnolia*), Yellow-breasted Chat, Black-headed Grosbeak (*Pheucticus melanocephalus*), Brewer's Sparrow, Fox

Sparrow (*Passerella iliaca*), Nashville Warbler (*Oreothlypis ruficapilla*), Brown-headed Cowbird (*Molothrus ater*), Chipping Sparrow (*Spizella passerina*), Chestnut-sided Warbler (*Setophaga pensylvanica*), Golden-crowned Sparrow, Olive-sided Flycatcher (*Contopus cooperi*), Pacific-slope Flycatcher (*Empidonax difficilis*), Sora (*Porzana carolina*) and Sharp-shinned Hawk (*Accipiter striatus*).

### 3.2.3 Number of Newly Banded Birds

In 2016, 2307 individual birds of 59 species were newly captured and banded (Appendix 7). The most numerous newly banded bird was Common Yellowthroat with 472 individuals (20.5% of all newly banded birds), followed by Traill's Flycatcher (Alder and Willow Flycatchers combined; 309 individuals and 13.4%), Yellow-rumped Warbler (234 individuals and 10.1%), American Redstart (144 individuals and 6.2%), Red-eyed Vireo (109 individuals and 4.7%), Swainson's Thrush (93 individuals and 4.0%), Warbling Vireo (89 individuals and 3.9%), Song Sparrow, Gray Catbird and Yellow Warbler (all three with 68 individuals and 2.9%) and Orange-crowned Warbler (59 individuals and 2.6%) (Appendix 7).

In addition to the 59 species banded, two species (Rufous Hummingbird and Sharp-shinned Hawk) were captured but released unbanded.

### 3.2.4 Migration Chronology

Migration, as measured by capture rate (number of birds captured per net-hour) varied throughout the monitoring period (Figure 13). The average daily capture rate of newly captured birds was 0.95 ± 0.118 (mean ± SE). Capture rate peaked around mid-August and slowed down by the end of August. In September, the capture rate was relatively low and constant throughout the month.

Abundance of different species peaked at different times. For the four most frequently captured species at Machete Island, American Redstart, Traill's Flycatcher and Yellow-rumped Warbler were the most abundant at the study site in the first half of the season, with the peak around mid-August (Figure 14). The abundance of Common Yellowthroat was relatively constant throughout the season without any marked peaks (Figure 14).

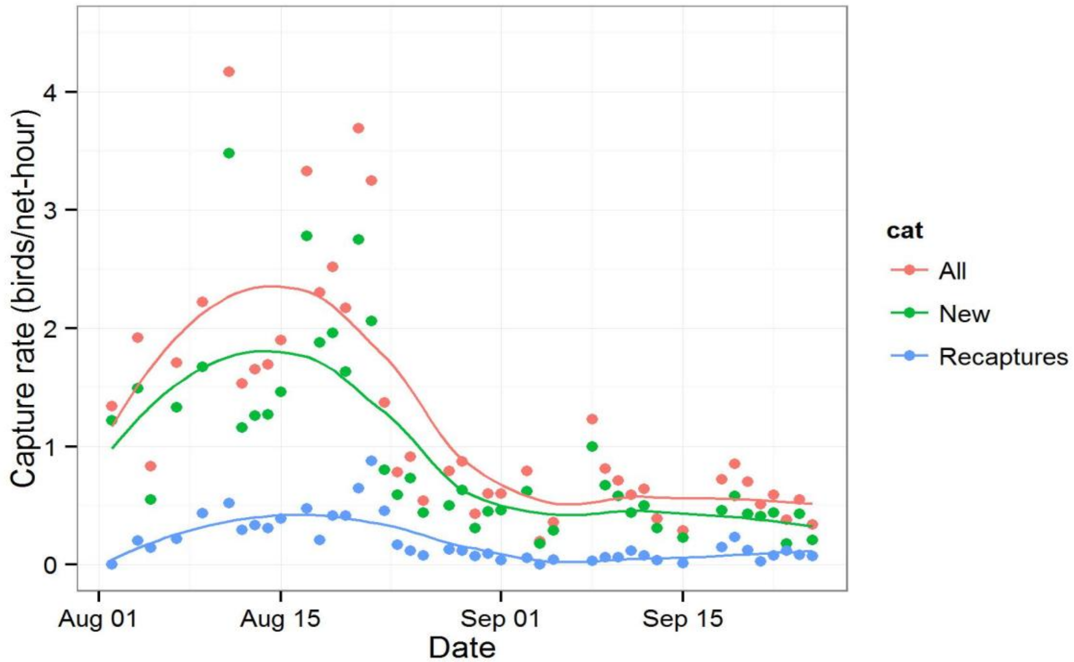


**Figure 13:** **Number of birds captured per net-hour at Machete Island banding station throughout the season in 2016. All = all birds captured, New = newly captured birds (including recaptures from previous years), and Recaps = Recaptures (excluding same day recaptures)**

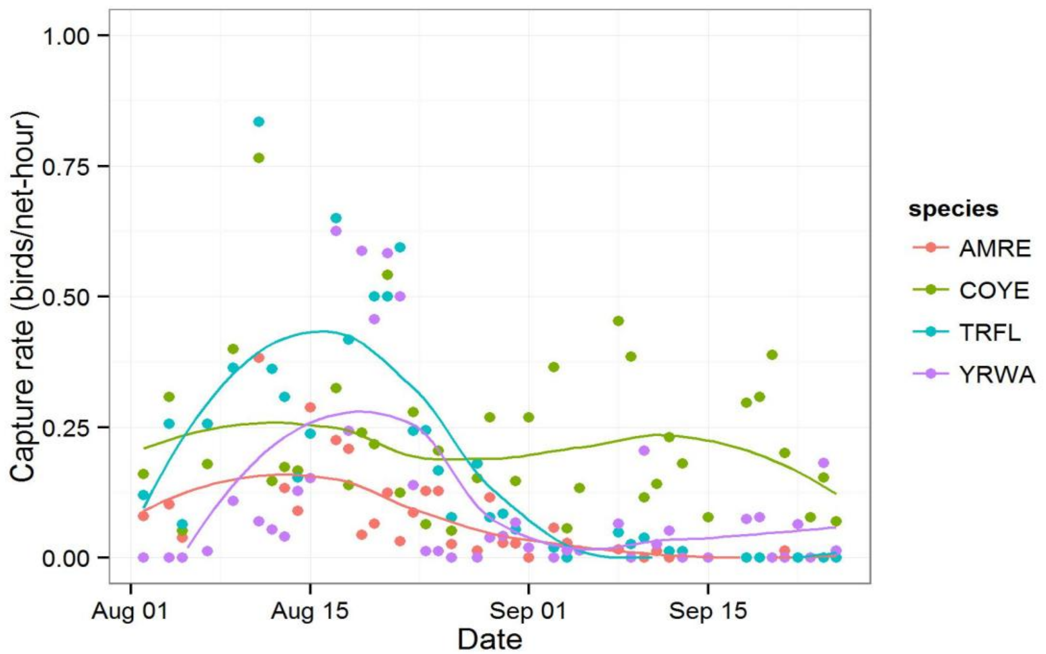


**Figure 14:** **Migration chronology of the four most frequently captured species at Machete Island banding station in 2016 (excluding same day recaptures). AMRE = American Redstart, COYE = Common Yellowthroat, TRFL = Traill's Flycatcher, YRWA = Yellow-rumped Warbler**

### 3.2.5 Age Ratio of Captured Birds

Of the 2298 newly-banded birds of known age (99.6% of all newly-captured birds), 1910 individuals (83.1%) were HY (juvenile birds hatched in 2016), and 388 individuals (16.9%) were AHY (adult birds more than one year old) (Appendix 8). HY birds outnumbered AHY birds throughout the season, with the difference being more prominent in the first half of the season (Figure 15).

Of the 909 birds that could be reliably sexed (39.4% of all newly-captured birds), 513 (56.4%) were males and 396 (43.6%) were females. Of the birds of known sex, 409 males (79.2%) and 276 females (69.7%) were HY; the remainder were AHY (Appendix 8).

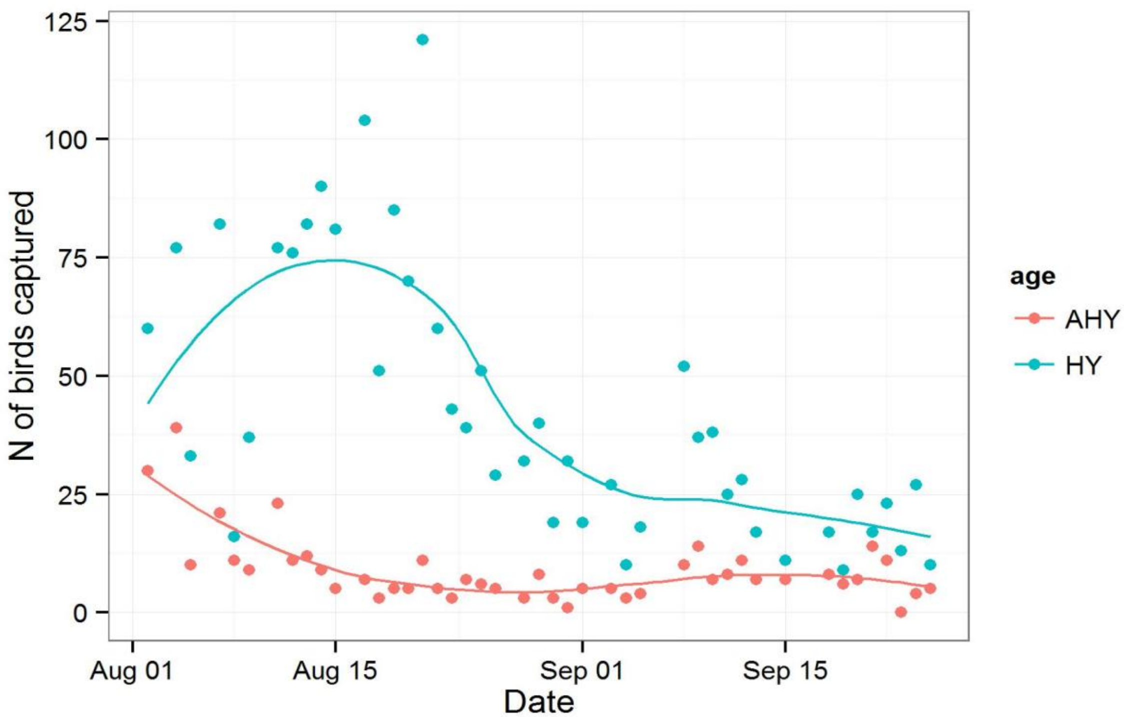


**Figure 15: Number of adult (AHY - after hatch year) and juvenile (HY - hatch year) newly captured birds at Machete Island banding station in 2016**

### 3.2.6 Recaptures of Banded Birds

In 2016, 341 individuals of 30 species were recaptured one or more days after their initial capture (460 recaptures total; Appendix 7).

Of these, one individual was recaptured seven times (seven different days), one bird five times, eight birds four times, 20 birds three times, 49 birds twice, and 258 birds only once. The overall recapture rate was 20.2%.

In addition, 203 individuals were recaptured at least once in the same day as they were banded (222 same day recaptures total; Appendix 7) and the overall same day recapture rate was 9.6%.

The average daily recapture rate for the whole season was 0.146 ± 0.0151 (mean + SE). Daily recapture rate varied throughout the season (Figure 16). For Common Yellowthroat, the most frequently captured species in 2016, 15.9% of newly captured individuals were recaptured at least once later in the season.

In 2016, 37 individuals banded in previous years were recaptured. All of them were previously banded at Machete Island.

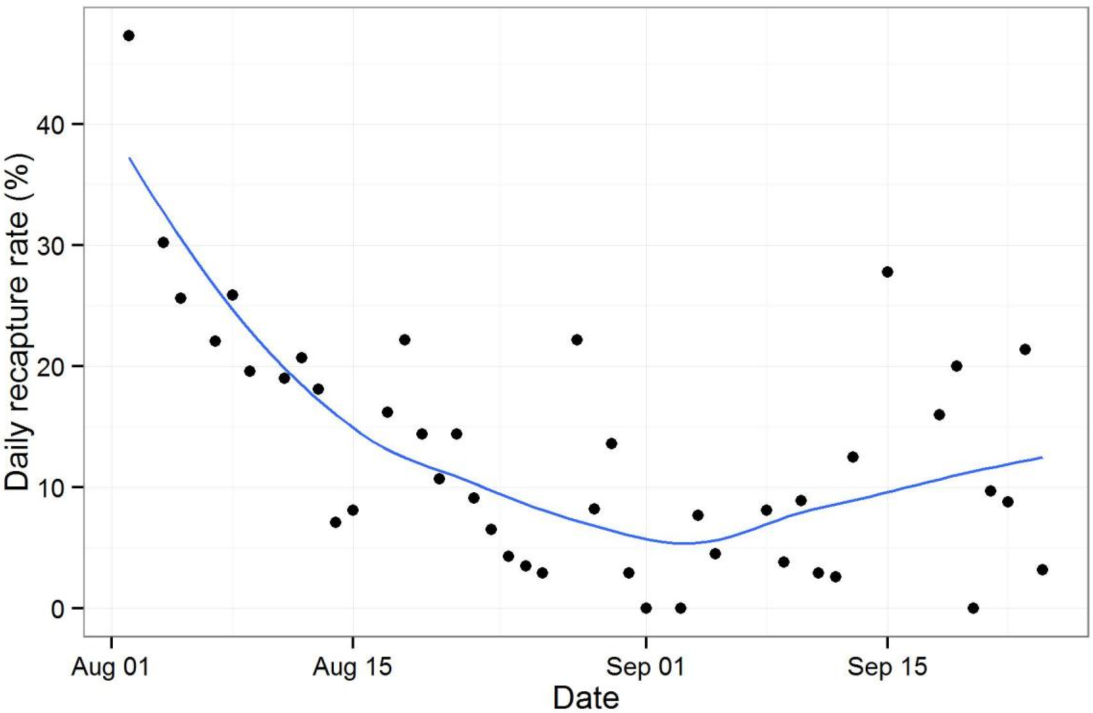


**Figure 16: Daily recapture rate at Machete Island banding station in 2016 (with Loess smoother)**

## 3.3 Satellite Banding Stations

### 3.3.1 Survey Effort

In 2016, in addition to daily surveys at Machete Island, two satellite sites were monitored for a total of 15 surveys and 642.25 net-hours (Table 4). At Airport Islands, the first survey was conducted on August 6, 2016; the last was conducted on September 25, 2016. The number of nets open varied from 7 to 9 with a mean of 8.6 ± 0.30 (mean ± SE).

At Jordan River, the first survey was conducted on August 4, 2016; the last one on September 24, 2016. The average number of open nets was 6.8 ± 0.25 (mean ± SE) and ranged from 5 to 7 nets.

The variation in the number of used nets and net-hours per week reflected the fact that the number of open nets varied from day to day depending on weather and capture rate– the number of nets was always adjusted to allow for the safe processing of captured birds. During week 5 (September 1 through 7) persistent rain (on days when surveys at these two stations were scheduled) prevented us from opening any nets. The total number of net-hours for the entire season and the overall capture rate for each net is provided in Appendix 5.

**Table 4: Mist netting survey effort (number of net-hours) at Airport Islands banding station and Jordan River banding station in 2016**

| Banding Site | N of surveys | Week 1<br>4–10 Aug | Week 2<br>11–17 Aug | Week 3<br>18–24 Aug | Week 4<br>25–31 Aug | Week 5<br>1–7 Sep | Week 6<br>8–14 Sep | Week 7<br>15–21 Sep | Week 8<br>22–28 Sep | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Airport Islands | 7 | 42.00 | 51.75 | 53.50 | 54.00 | . | . | 96.75* | 54.00 | 352.00 |
| Jordan River | 8 | 73.50* | 42.00 | 7.25 | 42.00 | . | 42.00 | 42.00 | 41.50 | 290.25 |
| Total | 15 | 115.50 | 93.75 | 60.75 | 96.00 | . | 42.00 | 138.75 | 95.50 | 642.25 |

* two surveys during the week

### 3.3.2 Bird Captures and Recaptures

At Airport Islands, the overall capture rate was 0.3267 birds/net-hour. In total, 115 birds from 16 species were captured (Appendix 9). Common Yellowthroat was the most frequently captured species (0.1534 birds/net-hour), followed by Yellow Warbler (0.0369 birds/net-hour), Traill's Flycatcher (0.0256 birds/net-hour), Yellow-rumped Warbler (0.0256 birds/net-hour), Savannah Sparrow (*Passerculus sandwichensis*; 0.0170 birds/net-hour), Dark-eyed Junco (*Junco hyemalis*; 0.0142 birds/net-hour), and American Tree Sparrow (*Spizelloides arborea*; 0.0114 birds/net-hour). The capture rate for newly captured birds was 0.2159 birds/net-hour, and the overall recapture rate was 18.4%. The recapture rate for the same-day recaptures was 30.3%.

In 2016, we captured four species that have not been previously captured at this site: American Tree Sparrow, Lazuli Bunting (*Passerina amoena*), Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) and Townsend's Warbler (*Setophaga townsendi*). American Tree Sparrow and Yellow-headed Blackbird were the only species captured exclusively at this site in 2016.

At Jordan River, 248 birds of 33 species were captured (Appendix 10). The overall capture rate was 0.8544 birds/net-hour, the capture rate for newly captured birds was 0.7373 birds/net-hour and the overall recapture rate was 6.1%. The most commonly captured species was American Redstart (0.1378 birds/net-hour), followed by Swainson’s Thrush (0.1309 birds/net-hour), Warbling Vireo (0.1137 birds/net-hour), Golden-crowned Kinglet (*Regulus satrapa*: 0.0896 birds/net-hour), Ruby-crowned Kinglet (*Regulus calendula*; 0.0413 birds/net-hour), Black-capped Chickadee (*Poecile atricapillus*) and MacGillivray’s Warbler (*Geothlypis tolmiei*: both 0.0379 birds/net-hour), Traill's Flycatcher (0.0345 birds/net-hours), and Dark-eyed Junco and Song Sparrow (both 0.0276 birds/net-hour). The recapture rate for same-day recaptures was 3.7%.

In 2016, no new species was captured at this site and two species were captured exclusively at this site: Varied Thrush (*Ixoreus naevius*) and Steller's Jay (*Cyanocitta stelleri*).

## 3.4 Injuries and Casualties

At Machete Island, one Common Yellowthroat showed signs of stress and later died at the banding station. One Lincoln's Sparrow (*Melospiza lincolnii*) was found in the net with a cut on the skin on the neck and was successfully released (unbanded). One Common Yellowthroat at Airport Islands and one American Redstart at Jordan River suffered a minor leg injury.

## 3.5 Species at Risk

At Machete Island banding station, we captured one Olive-sided Flycatcher and one Yellow-breasted Chat. Olive-sided Flycatcher - a blue-listed species in BC (species of Special Concern in BC) - was captured into a mist net on August 22, 2016, banded and released. Yellow-breasted Chat - a red-listed species in BC (species endangered or threatened in BC) - was captured into mist net on August 21, 2016, banded and released. This individual was also later recaptured and released on August 22 and on August 29.

No other species at risk was captured in 2016.

## 3.6 Effectiveness Monitoring Plot Sampling

In 2016, 23 effectiveness monitoring plots (14 treatment and 9 control plots) were surveyed once per week and 161 surveys were conducted in total. The first survey was conducted on August 6, 2016; the last was conducted on September 23, 2016.In total, 412 individuals of 41 species were recorded (Appendix 11).

Overall, 140 birds (14 species) were recorded on plot, 162 birds (34 species) were recorded off plot and 110 birds (11 species) were recorded overhead (Appendix 11).

Of the 135 neotropical migrant songbirds (11 species identified) recorded on plot, 70% and 9 species were recorded on cottonwood treatment plots, and 30% and 8 species were recorded on control plots (Table 5).

Common Yellowthroat was the most frequently detected species, followed by Lincoln's Sparrow, Savannah Sparrow, Song Sparrow and Cedar Waxwing (*Bombycilla cedrorum*; Table 5). Three species were recorded on cottonwood treatment plots only, two species were recorded on control plots only, and the remaining six species were detected on both cottonwood treatment and control plots (Table 5).

**Table 5: Species and number of neotropical migrating songbirds detected on cottonwood treatment (CT) and control (CC) plots during effectiveness monitoring surveys in fall 2016**

| Common Name | CT | CC | Total |
|---|---|---|---|
| Common Yellowthroat | 36 | 23 | 59 |
| Lincoln's Sparrow | 18 | 8 | 26 |
| Savannah Sparrow | 15 | 4 | 19 |
| Song Sparrow | 14 | . | 14 |
| Cedar Waxwing | 4 | 1 | 5 |
| Ruby-crowned Kinglet | 2 | 1 | 3 |
| Orange-crowned Warbler | 1 | 1 | 2 |
| Traill's Flycatcher | 2 | . | 2 |
| Unidentified Sparrow | 1 | 1 | 2 |
| American Redstart | . | 1 | 1 |
| Warbling Vireo | . | 1 | 1 |
| Western Wood-pewee | 1 | . | 1 |
| Grand Total | 94 | 41 | 135 |

The differences in neotropical migrant abundance and species richness on plot among different planted areas in 2016 are presented in Figure 17.

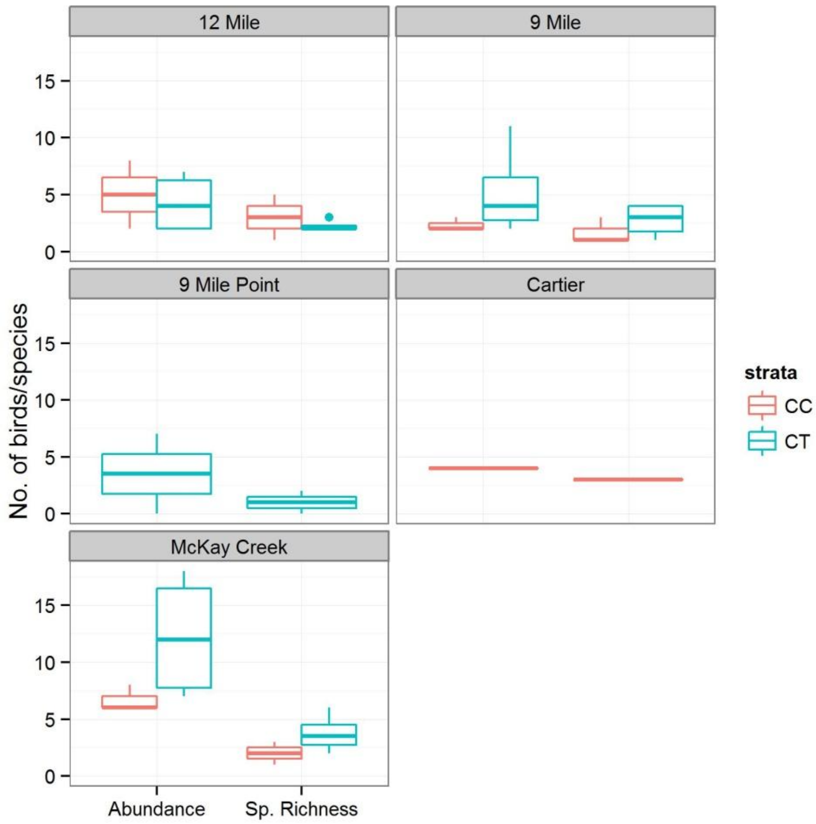


**Figure 17: Mean cumulative abundance and species richness of neotropical migrants on effectiveness monitoring plots in different planted areas in 2016 (CC = cottonwood control, CT = cottonwood treatment)**

## 3.7 Multi-year Datasets

Fall effectiveness monitoring surveys were conducted in years 2011-2014 and 2016 and during that time 919 surveys were conducted. In total, 663 neotropical migrants of 24 species were recorded on plot. Pooling data from all years, the mean cumulative annual abundance of migrants on treatment plots was significantly higher than on control plots (GLM (1,113): estimate = 0.607 ± 0.1935 (SE), $p < 0.01$). There was no significant difference in mean annual species richness between treatment and control plots (GLM (1,113): estimate = 0.229 ± 0.1307, $p < 0.05$).

To test for any changes in abundance and species richness of migrants on plots over time we included only surveys from a period when all plots were surveyed in all five years (n=689). On treatment plots, the mean cumulative annual abundance in 2012, 2013 and 2014 was lower than in 2011. In 2016, the mean abundance was slightly higher (than in 2011) but the difference was not significant (LMER(4,70), estimate = 0.061 ± 0.1569, $p = 0.70$). Similarly, only in 2016 the mean cumulative species richness was higher than in 2011 but it was not significant (LMER(4,70), estimate = 0.154 ± 0.2504, $p = 0.54$). The annual variation in fall cumulative abundance and species richness by planted area is plotted in Appendix 12 and Appendix 13, respectively.

During four years of permanent plot surveys (2011-2014), 3183 surveys were conducted and 4580 neotropical migrants of 54 species were recorded on plot. Pooling data from all years, water depth had a significant negative effect on the probability of the presence of a neotropical migrant on grassland plots (Appendix 14, GLMM: estimate = -0.394, SE = 0.0422, t = -9.34, $p < 0.001$) and shrub plots (Appendix 14, GLMM: estimate = -0.113, SE = 0.0305, t = -3.71, $p < 0.001$). Conversely, for forest plots, the water depth had a significantly positive effect on the presence of a migrant on plot (Appendix 14, GLMM: estimate = 0.252, SE = 0.0434, t = 5.82, $p < 0.001$). No bird was detected on unvegetated plots in any year.

To assess neotropical migrant habitat use and preferences in Revelstoke Reach, data from 220 random plots were analyzed. The abundance of migrants on plot was significantly different among strata (Table 6; Kruskal-Wallis: $\chi^2(3) = 30.2$, $p < 0.001$). Forest plots had significantly higher abundance than grassland plots ($p < 0.001$, r = 0.33) and unvegetated plots ($p < 0.001$, r = 0.46). Similarly, shrub plots had significantly higher abundance than grassland ($p < 0.01$, r = 0.24) and unvegetated plots.( $p < 0.001$, r = 0.43). In addition, grassland plots had higher abundance than unvegetated plots ($p < 0.05$, r = 0.26). Forest plots had higher abundance of migrants than shrub plots but the difference was not statistically significant (p = 0.14, r = 0.13).

**Table 6: Summary of abundance and diversity of neotropical migrant songbirds detected on plot by habitat strata**

| Strata | N | Abundance | | Species Richness | | Shannon's Entropy (H) | | Effective N of Species | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Forest | 60 | 3.60 | 5.403 | 1.42 | 1.565 | 0.37 | 0.490 | 1.23 | 1.352 |
| Grassland | 73 | 0.67 | 1.167 | 0.44 | 0.645 | 0.05 | 0.176 | 0.43 | 0.624 |
| Shrub | 63 | 1.86 | 3.277 | 1.06 | 1.401 | 0.23 | 0.455 | 1.01 | 1.268 |
| Unvegetated | 24 | 0.13 | 0.448 | 0.08 | 0.282 | 0.00 | 0.000 | 0.08 | 0.282 |

Similar to abundance, the species richness of migrants was also significantly different among strata (Table 6; Kruskal-Wallis: $\chi^2(3) = 30.3$, $p < 0.001$). Forest plots had significantly higher species richness than grassland plots ($p < 0.001$, r = 0.33) and unvegetated plots ($p < 0.001$, r = 0.46) and shrub plots had significantly higher species richness than grassland ($p < 0.01$, r = 0.25) and unvegetated plots ( $p < 0.001$, r = 0.44). Grassland plots had higher abundance than unvegetated plots ($p < 0.05$, r = 0.26). Forest plots had higher species richness of neotropical migrants than shrub plots but the difference was not significant (p = 0.13, r = 0.11).

# 4 DISCUSSION

This section summarizes field studies completed in 2016. An overview of the management questions, approaches and progress towards addressing these management questions is presented in Appendix 1.

## 4.1 Constant Effort Mist Netting

In 2016, three sites (Machete Island, Airport Islands and Jordan River) were surveyed by constant effort mist netting. For the Machete Island banding station, this was the fifth year of daily monitoring. During the 2011-2014 period, due to complexity of the scope 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 2016 (2800 net-hours) was similar to the previous years of daily monitoring (MCA 2008, CBA 2010b, 2011b, 2016b).

At Machete Island, the capture rate for newly captured birds and the overall total capture rate (0.8239 and 1.0850 birds/net-hour, respectively) were almost identical to those from 2014 and 2015 (CBA 2015 and CBA 2016b, respectively). These capture rates were lower than those from 2013 (CBA 2014) but higher than in any other year (MCA 2009, CBA 2010b, 2011b, 2012, 2013b). In 2016, as in all other previous years except for 2014, Common Yellowthroat was the most frequently captured bird at Machete Island (in 2014 Traill's Flycatcher was the most abundant species; CBA 2015). For Common Yellowthroat, the capture rate for newly captured birds in 2016 (0.1686 birds/net-hour) was similar to previously recorded values, with four years (2008, 2010, 2012 and 2014) having lower values and four years (2009, 2011, 2013 and 2016) having higher capture rates. To date, the lowest capture rate for newly-captured Common Yellowthroats was recorded in 2014 (0.1022 birds/net-hour; CBA 2015) and the highest in 2013 (0.3169 birds/net-hour; CBA 2014). In addition, the proportion of newly captured birds that were recaptured later in the 2016 season (20.2%) was one of the higher recorded to date. Only years 2009, 2012 and 2016 had higher recapture rates than 2016. In 2016, we added three new species (Yellow-breasted Chat, Brewer's Sparrow and Golden-crowned Sparrow) to the list of species captured at the Machete Island banding station under CLBMON 39. 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 influence the bird community much at the site.

In general, these results support our preliminary analyses which suggest a connection between the higher capture and recapture rates at Machete Island banding station and a lower water level (CBA 2013c). In years with high water level at the beginning of the survey period (beginning of August), capture rates were in general lower than in years with 'drier' conditions (Appendix 15). A full updated analysis of the constant effort mist netting dataset will be conducted for the Year 10 comprehensive final report.

At the Jordan River banding station, the capture rate for newly captured birds and the total capture rate recorded in 2016 (0.7373 and 0.8544 birds/net-hour, respectively) were the second highest to date (CBA 2012, 2013b, 2014, 2015, 2016b). American Redstart was the most frequently captured species, followed by Swainson's Thrush and Warbling Vireo which were the same three species as in 2014 (CBA 2015) and 2015 (CBA 2016b), albeit in different order. 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 six years (only in 2016 they ranked second and third). In 2016, we did not capture any new (previously un-captured) species at this site.

At Airport Islands banding station, the capture rate for newly captured birds (0.2159 birds/net-hour) and the overall capture rate (0.3267 birds/net-hour) were the lowest recorded since the beginning of monitoring in 2011. In 2016, Common Yellowthroat was the most frequently captured species at Airport Islands, similar to previous years (CBA 2012, 2013b, 2014, 2015, 2016b), though its capture rate for newly captured birds was the lowest recorded at this station. Four new species for this station were captured in 2016 (American Tree Sparrow, Lazuli Bunting, Yellow-headed Blackbird and Townsend's Warbler). Since the beginning of monitoring at this site in 2011, the Airport Islands banding station remains the site with the most dynamic changes in species composition and capture rates among years. However, the data from this station do not support a direct link between capture rate and the reservoir water level. A more in depth analysis will be conducted for Year 10 comprehensive final report to understand the relationship between bird utilization of this site and reservoir water conditions.

## 4.2 Effectiveness Monitoring Plot Surveys

Year 2016 was the fifth year of fall effectiveness monitoring surveys. These surveys are designed to assess the effectiveness of revegetation (with cottonwood stakes) in providing and/or enhancing habitat for neotropical migrants in Revelstoke Reach. Fall effectiveness monitoring surveys were initiated in 2011 and continued through 2014. In 2015, effectiveness monitoring surveys were temporarily discontinued for one year.

In 2016, we recorded 135 neotropical migrants of 11 species on plot and, of these, 70% were on treatment plots. This was very similar to the previous year (Year 2014; CBA 2015). To investigate whether the treatment with cottonwood stakes improved the utilization of these areas by neotropical migrants, we pooled data from all years together. We found that more neotropical migrants, but not higher cumulative species richness, were recorded on treatment plots compared to control plots. However, there was no significant increase in neotropical migrant abundance or species richness on treatment plots since they were planted. In fact, only in 2016 was the average cumulative annual abundance on a treatment plot was higher than that in the first year of monitoring (CBA 2012). As can be seen in Appendix 12 and Appendix 13, the variation in abundance and species richness at each site (Appendix 4) had a slightly different trend. While at the McKay Creek and 9 Mile sites the abundance and species richness had an increasing trend, these treatment areas had very low success rates and most of the cottonwood samplings at these sites died shortly after planting (especially at the McKay Creek site). At the McKay Creek site in particular, the relatively high migrant abundance appears to be driven primarily by species that forage in tall reed canarygrass that covers this site (Common Yellowthroat, Song Sparrow and Lincoln's Sparrow). Interestingly, at the site with arguably the best cottonwood sampling growth - at 12 Mile (Figure 18) - no clear increase in abundance or species richness was observed.

To date there has been no clear increase in utilization of areas treated with cottonwood samplings by neotropical migrants. Since within the 6 years after planting these treatments did not increase the utilization of these areas by migrants, with the current data MQ8 can be fully addressed. However, our data from other components of this program suggests that high quality shrub or forest habitat can have much higher bird density and diversity than grassland habitat. Therefore, it is likely that the sampling areas may need more time to mature in order to create a more valuable stopover habitat for migrants.

**Figure 18: Effectiveness monitoring plot at 12 Mile area with young cottonwood trees planted as part of the revegetation treatment with cottonwood stakes, September 23, 2016**

## 4.3 Permanent Plot Surveys

A permanent plot approach was selected to assess the effect of annual reservoir water level variation on neotropical migrant abundance and diversity within these plots. The data collected during the first two years of permanent plot monitoring (2011 and 2012) provided a very robust sample size (n = 1545) that allowed us to detect significant differences in migrant occurrence on plots from different strata based on flooding condition (water depth on plot; CBA 2013c). However, due to similarity in water regimes between 2011 and 2012, it was suggested to continue permanent plot sampling to obtain data from a year with different water conditions (low water). We therefore collected data from two additional years with different water regimes. While years 2011 and 2012 had relatively high water levels, the following two years (2013 and 2014) had relatively low water levels (Appendix 2). Due to the variation in reservoir levels among years and due to the habitat and elevational stratification of permanent plots, we have obtained a large dataset (n = 3183) of different plot flooding scenarios (Appendix 16).

In our preliminary analyses of the data collected on permanent plots in the first two years, we detected a significant effect of water depth on the presence of neotropical migrant songbirds on plot (CBA 2013c). Using the complete four year dataset, we re-ran these analyses and the results supported our original findings. Neotropical migrants were less likely to be present on grassland and shrub plots and more likely to be present on forest plots with increasing water depth on plot (Appendix 14). With this approach and using the robust dataset of permanent plot surveys, together with constant effort mist netting surveys, we are able to fully address all management questions related to the effect of reservoir water levels on neotropical migrants during fall migration, in particular MQ3 and MQ9.

## 4.4 Random Plot Surveys

MQ2 is being addressed primarily by random plot sampling. To date we have compiled four years (2011 to 2014) of fall random plot surveys (n = 239). As a first stage in answering this management question, Revelstoke Reach was divided into 50x50 m plots assigned to one of the *a priori* selected broad habitat strata (forest, shrub, grassland, wetland, unvegetated). As a second stage, Revelstoke Reach was divided into random plots based on the vegetation communities (CBA 2013c), and in 2014 all targeted vegetation communities have been sampled (CBA 2015). While the GIS-based stratification provided an important tool to ensure that all targeted habitats within the Revelstoke Reach are being sampled, it was less ideal for detailed habitat analysis. Therefore we classified all random plots into strata based on the detailed habitat/vegetation data collected on each random plot.

In the Year 5 Interim report, we documented clear differences in species abundance and diversity among broad (a priori assigned) habitat strata (CBA 2013c). We re-ran this analysis with the complete dataset of fall random plots and enhanced strata designation (based on collected vegetation data). The results of this analysis support our previous findings, and suggest differences in neotropical migrant abundance and species richness among habitat strata. Moreover, the detailed vegetation data collected at all random plots can be used to reveal differences in stopover habitat selection and the distribution of certain species or groups of neotropical migrant in Revelstoke Reach during fall migration. By analyzing some groups of neotropical migrants with similar foraging and/or habitat preferences separately, we are able to compliment the constant effort mist netting approach in answering the MQ4.

## 4.5 Recommendations

For the 2017 season, we recommend continuing the mist netting surveys with the same effort as in 2016. During the fall migration period, Machete Island banding station should be surveyed daily while two satellite stations (Airport Islands and Jordan River) should be surveyed once per week.

We also recommend discontinuing the effectiveness monitoring plot surveys, because to date no clear increase in utilization of treated areas by migrants was documented and the relevant management question (MQ8) can be addressed.

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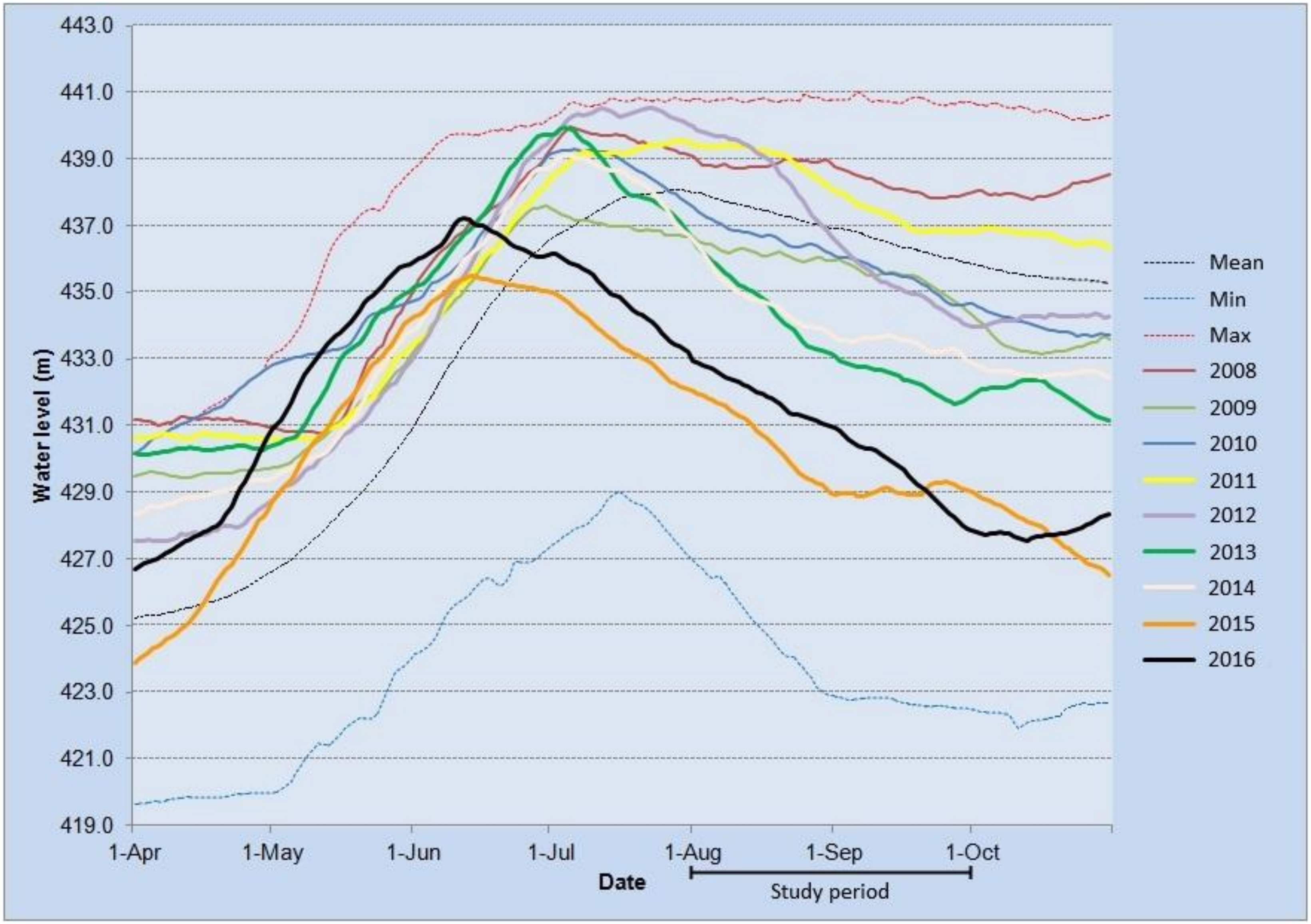
# 6 APPENDICES

## Appendix 1: Management objectives, questions, hypotheses and approaches and status of CLBMON 39 after Year 9 (2016)

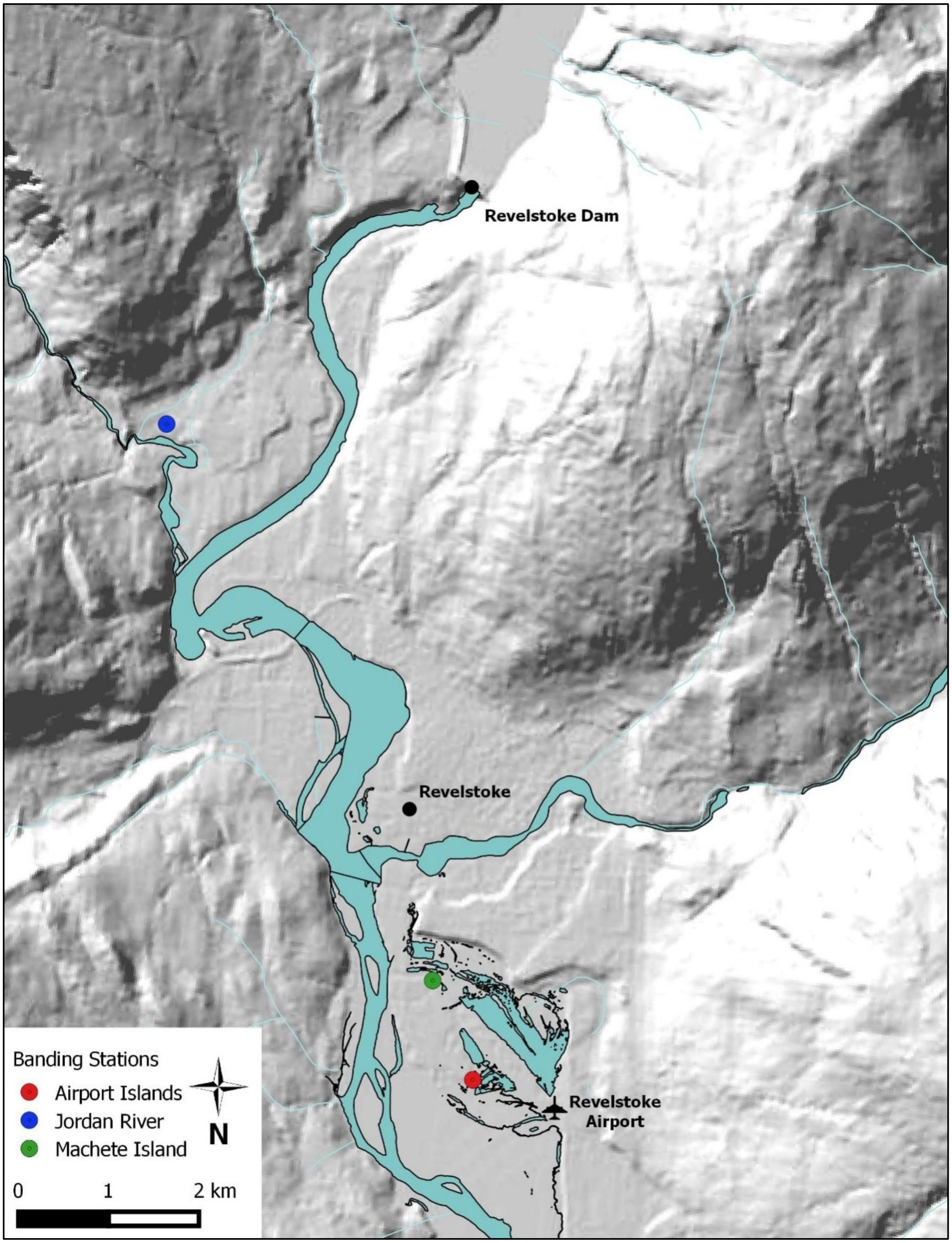
| Study Objective | Management Question | Management Hypothesis | Approach | Year 9 (2016) Status |
|---|---|---|---|---|
| **Objective 1:** Determine the migration patterns of neotropical migrants in Revelstoke Reach over time (within season, across seasons, and across years). | **MQ1:** What is the seasonal and annual variation in the abundance and species richness of neotropical migrants in Revelstoke Reach during fall migration? | | Constant effort mist netting<br>Random plot surveys<br>Permanent plot surveys | *- Preliminary multi-year analysis was conducted for the Year 5 interim review report.*<br>*- Summary of intra-annual and inter-annual variation in abundance and diversity of migrants documented through analyses of banding data collected.*<br>*- Data collected to date allow us to adequately address this management question.*<br>*- This analysis will be updated for the Year 10 comprehensive final report and combining datasets from multiple components of this study will further improve the description.* |
| **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<br>Permanent plot surveys | *- Preliminary analysis of the constant effort mist netting and permanent plot data was conducted for the Year 5 interim review report.*<br>*- Inter-annual changes in abundance and diversity of neotropical migrants were detected by analyzing migration monitoring banding data.*<br>*- 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, and increase use of forest habitats as water depths increase in those habitats.*<br>*- Data for the constant effort mist netting component are still being collected, and the final analysis of the constant effort mist netting dataset will be conducted in the Year 10 comprehensive final report.* |
| | **MQ4:** Which neotropical migrants are most affected by reservoir operations? | | Constant effort mist netting<br>Permanent plot surveys<br>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.*<br>*- Data for the constant effort mist netting component are still being collected. Data from the multiple components will be used to address this question and by comparing the results with the life histories of neotropical migrant species detected in Revelstoke Reach we will be able to adequately address this management question in the Year 10 comprehensive final report.* |
| | **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.*<br>*- All our data suggests that reservoir water levels do not significantly impact estimated fattening rates of neotropical migrants in Revelstoke Reach.* |

| Study Objective | Management Question | Management Hypothesis | Approach | Year 9 (2016) Status |
|---|---|---|---|---|
| **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<br>Permanent plot surveys<br>Random plot surveys | *- This MQ will be fully addressed for the Year 10 comprehensive final report after answers to the other questions are finalized.* |
| **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.*<br>*- An updated analysis of the complete dataset was conducted and it was shown that the revegetation projects (cottonwood treatment) have had little impact to utilization of these areas by migrants (as measured by 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.*<br>*- Comparison of abundance and diversity of migrants among habitat strata was provided and has been updated with the most recent data.*<br>*- On all random plots, detailed vegetation/habitat data were collected along with bird observation data which allows us to identify vegetation preferences and habitat utilization in the drawdown zone by neotropical migrants.* |
| | **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.*<br>*- It was demonstrated that the availability of stopover habitat depends on reservoir water levels.*<br>*- Two additional years of data with a good range of reservoir levels were collected and an updated analysis of the complete dataset of permanent plot data was run.*<br>*- Results confirmed our previous finding that the probability of the presence of a migrant on plot in different habitat types varied based on the water depth on plot and suggested that the reservoir levels influence stopover habitat quality.* |

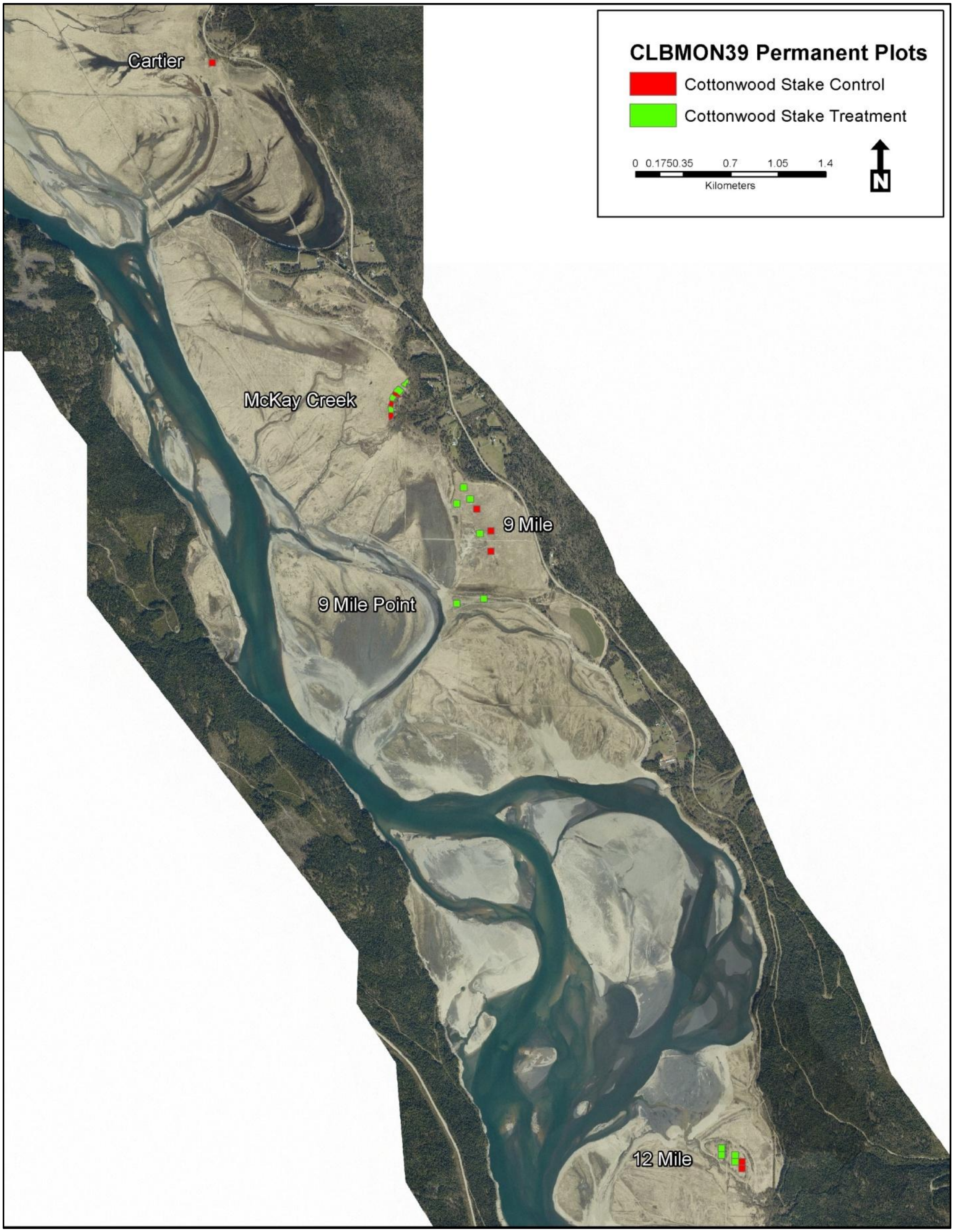
**Appendix 2: Water levels (m) in Arrow Lakes Reservoir in 2016 compared with data from 2008 to 2015 and mean, minimum and maximum elevation (1968–2008)**



**Appendix 3: CLBMON 39 constant effort mist-netting sites in Revelstoke Reach in 2016**



**Appendix 4: Layout of the effectiveness monitoring plots in Revelstoke Reach in 2016**



**Appendix 5: Survey effort and overall capture rate for each net during CLBMON 39 in 2016**

| Site | Net | Capture effort (in net/hours) | Capture rate (birds/net-hour) |
|---|---|---|---|
| Machete Island | M1 | 174.0 | 0.270 |
| | M2 | 240.5 | 1.297 |
| | M3 | 238.5 | 1.266 |
| | M4 | 240.5 | 1.368 |
| | M5 | 223.5 | 1.025 |
| | M6 | 223.5 | 0.604 |
| | M7 | 217.5 | 0.915 |
| | M8 | 194.8 | 0.668 |
| | M9 | 194.8 | 0.806 |
| | M10 | 187.8 | 0.522 |
| | M12 | 187.3 | 0.358 |
| | M14 | 239.0 | 2.866 |
| | M3A | 238.5 | 1.451 |
| Airport Islands | A1 | 41.5 | 0.386 |
| | A2 | 41.5 | 0.169 |
| | A3 | 41.5 | 0.120 |
| | A4 | 41.5 | 0.241 |
| | A5 | 41.5 | 0.120 |
| | A6 | 41.5 | 0.482 |
| | A7 | 35.5 | 0.479 |
| | A8 | 32.5 | 0.492 |
| | A9 | 35.0 | 0.286 |
| Jordan River | J3 | 42.5 | 1.388 |
| | J4 | 42.5 | 0.165 |
| | J5 | 42.3 | 0.308 |
| | J7 | 41.0 | 0.829 |
| | J9 | 41.5 | 1.349 |
| | J10 | 40.0 | 0.450 |
| | J11 | 40.5 | 1.457 |

## Appendix 6: Bird species detected during CLBMON 39 in 2016

| Common Name | Scientific Name | Code | Machete Island banding station | | Jordan River banding station | | Airport Islands banding station | |
|---|---|---|---|---|---|---|---|---|
| | | | Observed | Captured | Observed | Captured | Observed | Captured |
| Alder Flycatcher | *Empidonax alnorum* | ALFL | x | | | | | |
| American Crow | *Corvus brachyrhynchos* | AMCR | x | | | | x | |
| American Dipper | *Cinclus mexicanus* | AMDI | | | x | | | |
| American Goldfinch | *Spinus tristis* | AMGO | x | x | x | | x | |
| American Pipit | *Anthus rubescens* | AMPI | x | | | | x | |
| American Redstart | *Setophaga ruticilla* | AMRE | x | x | x | x | | x |
| American Robin | *Turdus migratorius* | AMRO | x | 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 | | | | | |
| Black-capped Chickadee | *Poecile atricapillus* | BCCH | x | x | x | x | | |
| Belted Kingfisher | *Megaceryle alcyon* | BEKI | x | | x | | x | |
| Brown-headed Cowbird | *Molothrus ater* | BHCO | | x | | | | |
| Black-headed Grosbeak | *Pheucticus melanocephalus* | BHGR | x | x | | | | |
| Brown Creeper | *Certhia americana* | BRCR | | | | x | | |
| Canada Goose | *Branta canadensis* | CANG | x | | x | | x | |
| Cassin's Vireo | *Vireo cassinii* | CAVI | x | x | | x | | |
| Clay-colored Sparrow | *Spizella pallida* | CCSP | | x | | | x | x |
| Cedar Waxwing | *Bombycilla cedrorum* | CEDW | x | x | x | x | | x |
| Chipping Sparrow | *Spizella passerina* | CHSP | x | x | | | | |
| Cooper's Hawk | *Accipiter cooperii* | COHA | | | x | | | |
| Common Raven | *Corvus corax* | CORA | x | | x | | x | |
| Common Yellowthroat | *Geothlypis trichas* | COYE | x | x | x | | x | x |
| Chestnut-sided warbler | *Setophaga pensylvanica* | CSWA | | | | 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 | | | | |
| Eurasian Collared-Dove | *Streptopelia decaocto* | EUCD | x | | | | | |
| European Starling | *Sturnus vulgaris* | EUST | | x | | | | |
| Fox Sparrow | *Passerella iliaca* | FOSP | | x | | | | |
| Great Blue Heron | *Ardea herodias* | GBHE | x | | | | x | |
| Golden-crowned Kinglet | *Regulus satrapa* | GCKI | | x | x | x | | |
| Gray Catbird | *Dumetella carolinensis* | GRCA | x | x | x | x | | |
| Greater Yellowlegs | *Tringa melanoleuca* | GRYE | x | | | | x | |
| Green-winged Teal | *Anas crecca* | GWTE | x | | | | | |
| Hammond's Flycatcher | *Empidonax hammondii* | HAFL | | x | | x | | |
| Hermit Thrush | *Catharus guttatus* | HETH | x | x | | x | | |
| Indigo Bunting | *Passerina cyanea* | INBU | | x | | | | |
| Killdeer | *Charadrius vociferus* | KILL | x | | | | | |
| Lapland Longspur | *Calcarius lapponicus* | LALO | x | | | | | |
| Lazuli Bunting | *Passerina amoena* | LAZB | | x | | x | | |
| Least Flycatcher | *Empidonax minimus* | LEFL | x | x | | x | | x |
| Long-eared Owl | *Asio otus* | LEOW | x | x | | | | |
| Lincoln's Sparrow | *Melospiza lincolnii* | LISP | x | x | x | x | | x |

| Common Name | Scientific Name | Code | Machete Island banding station | | Jordan River banding station | | Airport Islands banding station | |
|---|---|---|---|---|---|---|---|---|
| | | | Observed | Captured | Observed | Captured | Observed | Captured |
| Mallard | *Anas platyrhynchos* | MALL | x | | x | | x | |
| Magnolia Warbler | *Setophaga magnolia* | MAWA | | x | | x | | |
| Merlin | *Falco columbarius* | MERL | x | | | | x | |
| MacGillivray's Warbler | *Geothlypis tolmiei* | MGWA | x | x | x | x | | |
| Mourning Warbler | *Geothlypis philadelphia* | MOWA | | x | | | | |
| Nashville Warbler | *Oreothlypis ruficapilla* | NAWA | | x | | x | | |
| Northern Flicker | *Colaptes auratus* | NOFL | x | | x | x | | |
| Northern Harrier | *Circus cyaneus* | NOHA | x | | | | x | |
| Northern Waterthrush | *Parkesia noveboracensis* | NOWA | x | x | | | | |
| Northern Rough-winged Swallow | *Stelgidopteryx serripennis* | NRWS | x | | | | | |
| Orange-crowned Warbler | *Oreothlypis celata* | OCWA | x | x | x | x | | x |
| Olive-sided Flycatcher | *Contopus cooperi* | OSFL | | x | | | | |
| Osprey | *Pandion haliaetus* | OSPR | x | | x | | x | |
| Pacific Wren | *Troglodytes pacificus* | PAWR | | x | | x | | |
| Pectoral Sandpiper | *Calidris melanotos* | PESA | x | | | | | |
| Pine Siskin | *Spinus pinus* | PISI | x | x | x | | | |
| Pileated Woodpecker | *Dryocopus pileatus* | PIWO | | | x | | | |
| Prairie Falcon | *Falco mexicanus* | PRFA | x | | | | | |
| Purple Finch | *Haemorhous purpureus* | PUFI | | x | | | | |
| Red-breasted Nuthatch | *Sitta canadensis* | RBNU | x | x | x | | | |
| Ruby-crowned Kinglet | *Regulus calendula* | RCKI | x | x | x | x | x | x |
| Red Crossbill | *Loxia curvirostra* | RECR | x | | x | | | |
| Red-eyed Vireo | *Vireo olivaceus* | REVI | x | x | x | x | | |
| Red-tailed Hawk | *Buteo jamaicensis* | RTHA | x | | x | | | |
| Rufous Hummingbird | *Selasphorus rufus* | RUHU | x | x | | | | |
| Red-winged Blackbird | *Agelaius phoeniceus* | RWBL | x | x | | | x | |
| Savannah Sparrow | *Passerculus sandwichensis* | SAVS | x | x | x | | x | x |
| Semipalmated Sandpiper | *Calidris pusilla* | SESA | x | | | | | |
| Sora | *Porzana carolina* | SORA | | | | | | x |
| Song Sparrow | *Melospiza melodia* | SOSP | x | x | x | x | | |
| Spotted Sandpiper | *Actitis macularius* | SPSA | x | | | | | |
| Sharp-shinned Hawk | *Accipiter striatus* | SSHA | x | x | x | x | | |
| Steller's Jay | *Cyanocitta stelleri* | STJA | x | | x | | | |
| Swainson's Thrush | *Catharus ustulatus* | SWTH | x | x | x | x | | |
| Tennessee Warbler | *Oreothlypis peregrina* | TEWA | | x | | | | |
| Townsend's Warbler | *Setophaga townsendi* | TOWA | | x | | | | |
| Traill's Flycatcher | *Empidonax alnorum/traillii* | TRFL | x | x | x | x | x | x |
| Turkey Vulture | *Cathartes aura* | TUVU | x | | x | | | |
| Unidentified *Accipiter* Hawk | *Accipiter* (sp) | UAHA | | | x | | | |
| Unidentified *Calidris* sandpiper | *Calidris*(sp) | UCSA | x | | | | x | |
| Unidentified *Empidonax* Flycatcher | *Empidonax*(sp) | UEFL | x | | | | | |
| Unidentified Blackbird | | UNBL | x | | | | x | |
| Unidentified Duck | | UNDU | x | | x | | x | |
| Unidentified Hawk | | UNHA | x | | | | | |
| Unidentified *Larus* Gull | *Larus*(sp) | UNLG | x | | x | | | |
| Unidentified Owl | | UNOW | x | | | | | |

| Common Name | Scientific Name | Code | Machete Island banding station | | Jordan River banding station | | Airport Islands banding station | |
|---|---|---|---|---|---|---|---|---|
| | | | Observed | Captured | Observed | Captured | Observed | Captured |
| Unidentified Sapsucker | | UNSA | x | | | | | |
| Unidentified Shorebird | | UNSH | x | | x | | x | |
| Unidentified Sparrow | | UNSP | x | | x | | | |
| Unidentified Swallow | | UNSW | x | | | | x | |
| Unidentified Teal | | UNTE | | | | | x | |
| Unidentified Warbler | | UNWA | x | | | | | |
| Unidentified Woodpecker | | UNWO | x | | | | | |
| Vaux's Swift | *Chaetura vauxi* | VASW | x | | x | | x | |
| Varied Thrush | *Ixoreus naevius* | VATH | x | x | x | | | |
| Veery | *Catharus fuscescens* | VEER | x | x | | x | | |
| Virginia Rail | *Rallus limicola* | VIRA | | | | | x | |
| Warbling Vireo | *Vireo gilvus* | WAVI | x | x | x | x | | |
| White-crowned Sparrow | *Zonotrichia leucophrys* | WCSP | x | x | x | x | | |
| Western Meadowlark | *Sturnella neglecta* | WEME | | | | | x | x |
| Western Tanager | *Piranga ludoviciana* | WETA | x | x | | x | | |
| Western Wood-Pewee | *Contopus sordidulus* | WEWP | x | x | | | | |
| Willow Flycatcher | *Empidonax traillii* | WIFL | | x | | | | |
| Wilson's Snipe | *Gallinago delicata* | WISN | x | | | | x | x |
| Wilson's Warbler | *Cardellina pusilla* | WIWA | x | x | x | x | | x |
| White-throated Sparrow | *Zonotrichia albicollis* | WTSP | | x | | x | | |
| Yellow-headed Blackbird | *Xanthocephalus xanthocephalus* | YHBL | x | x | | | x | |
| Yellow-rumped Warbler | *Setophaga coronata* | YRWA | x | x | x | x | x | x |
| Yellow Warbler | *Setophaga petechia* | YWAR | x | x | x | x | x | x |

**Appendix 7: Banding data summary from Machete Island banding station, Revelstoke Reach, 2016**

| 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*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COYE | 472 | 20.5 | 0.1686 | 64 | 13.6 | 75 | 15.9 | 139 | 5 | 616 | 0.2200 |
| TRFL | 309 | 13.4 | 0.1104 | 45 | 14.6 | 87 | 28.2 | 132 | 5 | 446 | 0.1593 |
| YRWA | 234 | 10.1 | 0.0836 | 6 | 2.6 | 2 | 0.9 | 8 | . | 242 | 0.0864 |
| AMRE | 144 | 6.2 | 0.0514 | 8 | 5.6 | 26 | 18.1 | 34 | . | 178 | 0.0636 |
| REVI | 109 | 4.7 | 0.0389 | 7 | 6.4 | 40 | 36.7 | 47 | 1 | 157 | 0.0561 |
| SOSP | 68 | 2.9 | 0.0243 | 13 | 19.1 | 46 | 67.6 | 59 | 3 | 130 | 0.0464 |
| WAVI | 89 | 3.9 | 0.0318 | 4 | 4.5 | 35 | 39.3 | 39 | . | 128 | 0.0457 |
| SWTH | 93 | 4.0 | 0.0332 | 15 | 16.1 | 17 | 18.3 | 32 | 1 | 126 | 0.0450 |
| GRCA | 68 | 2.9 | 0.0243 | 11 | 16.2 | 34 | 50.0 | 45 | 2 | 115 | 0.0411 |
| YWAR | 68 | 2.9 | 0.0243 | 4 | 5.9 | 4 | 5.9 | 8 | 4 | 80 | 0.0286 |
| OCWA | 59 | 2.6 | 0.0211 | 7 | 11.9 | 7 | 11.9 | 14 | 4 | 77 | 0.0275 |
| WIWA | 54 | 2.3 | 0.0193 | 6 | 11.1 | 6 | 11.1 | 12 | . | 66 | 0.0236 |
| CEDW | 53 | 2.3 | 0.0189 | 1 | 1.9 | 7 | 13.2 | 8 | . | 61 | 0.0218 |
| VEER | 38 | 1.6 | 0.0136 | 8 | 21.1 | 15 | 39.5 | 23 | . | 61 | 0.0218 |
| LISP | 49 | 2.1 | 0.0175 | 3 | 6.1 | 5 | 10.2 | 8 | 2 | 59 | 0.0211 |
| MGWA | 49 | 2.1 | 0.0175 | 3 | 6.1 | 2 | 4.1 | 5 | . | 54 | 0.0193 |
| LEFL | 44 | 1.9 | 0.0157 | 1 | 2.3 | 8 | 18.2 | 9 | . | 53 | 0.0189 |
| RCKI | 30 | 1.3 | 0.0107 | 4 | 13.3 | 8 | 26.7 | 12 | 1 | 43 | 0.0154 |
| PUFI | 27 | 1.2 | 0.0096 | 1 | 3.7 | 7 | 25.9 | 8 | 1 | 36 | 0.0129 |
| BCCH | 16 | 0.7 | 0.0057 | 3 | 18.8 | 16 | 100.0 | 19 | . | 35 | 0.0125 |
| PISI | 29 | 1.3 | 0.0104 | . | . | . | . | . | . | 29 | 0.0104 |
| TEWA | 23 | 1.0 | 0.0082 | . | . | 3 | 13.0 | 3 | . | 26 | 0.0093 |
| EAKI | 23 | 1.0 | 0.0082 | 1 | 4.3 | . | . | 1 | . | 24 | 0.0086 |
| WTSP | 13 | 0.6 | 0.0046 | 1 | 7.7 | 6 | 46.2 | 7 | . | 20 | 0.0071 |
| AMRO | 17 | 0.7 | 0.0061 | . | . | . | . | . | 2 | 19 | 0.0068 |
| CCSP | 12 | 0.5 | 0.0043 | . | . | 3 | 25.0 | 3 | 1 | 16 | 0.0057 |
| WCSP | 9 | 0.4 | 0.0032 | 2 | 22.2 | 2 | 22.2 | 4 | 1 | 14 | 0.0050 |
| SAVS | 13 | 0.6 | 0.0046 | . | . | . | . | . | . | 13 | 0.0046 |
| NOWA | 11 | 0.5 | 0.0039 | 1 | 9.1 | . | . | 1 | . | 12 | 0.0043 |
| DEJU | 9 | 0.4 | 0.0032 | 1 | 11.1 | . | . | 1 | . | 10 | 0.0036 |
| LAZB | 10 | 0.4 | 0.0036 | . | . | . | . | . | . | 10 | 0.0036 |
| GCKI | 5 | 0.2 | 0.0018 | 1 | 20.0 | . | . | 1 | 1 | 7 | 0.0025 |
| RUHU | . | . | . | . | . | . | . | . | 7 | 7 | 0.0025 |
| WEWP | 7 | 0.3 | 0.0025 | . | . | . | . | . | . | 7 | 0.0025 |
| RNSA | 6 | 0.3 | 0.0021 | . | . | . | . | . | . | 6 | 0.0021 |
| DOWO | 3 | 0.1 | 0.0011 | . | . | 2 | 66.7 | 2 | . | 5 | 0.0018 |
| RWBL | 5 | 0.2 | 0.0018 | . | . | . | . | . | . | 5 | 0.0018 |
| WETA | 5 | 0.2 | 0.0018 | . | . | . | . | . | . | 5 | 0.0018 |
| DUFL | 4 | 0.2 | 0.0014 | . | . | . | . | . | . | 4 | 0.0014 |
| CBCH | 3 | 0.1 | 0.0011 | . | . | . | . | . | . | 3 | 0.0011 |
| MAWA | 3 | 0.1 | 0.0011 | . | . | . | . | . | . | 3 | 0.0011 |
| YBCH | 1 | 0.0 | 0.0004 | . | . | 2 | 200.0 | 2 | . | 3 | 0.0011 |
| BHGR | 1 | 0.0 | 0.0004 | . | . | . | . | . | 1 | 2 | 0.0007 |
| BRSP | 1 | 0.0 | 0.0004 | . | . | 1 | 100.0 | 1 | . | 2 | 0.0007 |
| CAVI | 2 | 0.1 | 0.0007 | . | . | . | . | . | . | 2 | 0.0007 |
| FOSP | 1 | 0.0 | 0.0004 | 1 | 100.0 | . | . | 1 | . | 2 | 0.0007 |
| HAFL | 2 | 0.1 | 0.0007 | . | . | . | . | . | . | 2 | 0.0007 |
| HETH | 2 | 0.1 | 0.0007 | . | . | . | . | . | . | 2 | 0.0007 |
| NAWA | 2 | 0.1 | 0.0007 | . | . | . | . | . | . | 2 | 0.0007 |
| NOFL | 2 | 0.1 | 0.0007 | . | . | . | . | . | . | 2 | 0.0007 |
| TOWA | 2 | 0.1 | 0.0007 | . | . | . | . | . | . | 2 | 0.0007 |
| BHCO | 1 | <0.1 | 0.0004 | . | . | . | . | . | . | 1 | 0.0004 |
| CHSP | 1 | <0.1 | 0.0004 | . | . | . | . | . | . | 1 | 0.0004 |
| CSWA | 1 | <0.1 | 0.0004 | . | . | . | . | . | . | 1 | 0.0004 |
| GCSP | 1 | <0.1 | 0.0004 | . | . | . | . | . | . | 1 | 0.0004 |
| OSFL | 1 | <0.1 | 0.0004 | . | . | . | . | . | . | 1 | 0.0004 |
| PSFL | 1 | <0.1 | 0.0004 | . | . | . | . | . | . | 1 | 0.0004 |
| RBNU | 1 | <0.1 | 0.0004 | . | . | . | . | . | . | 1 | 0.0004 |
| SORA | 1 | <0.1 | 0.0004 | . | . | . | . | . | . | 1 | 0.0004 |
| SSHA | . | . | . | . | . | . | . | . | 1 | 1 | 0.0004 |
| **Total** | **2307** | **100.0** | **0.8239** | **222** | **9.6** | **466** | **20.2** | **688** | **43** | **3038** | **1.0850** |

* Species Code: see definition in Appendix 5; ** No. of Newly Captured: for CLBMON 39 in 2016 (included first recaptures of birds banded in previous year); *** Capture Rate/Total Capture Rate: in birds/net-hour

**Appendix 8: Age and sex of newly banded birds captured at Machete Island banding station in 2016 (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 | | |
| COYE | 87 | 384 | 1 | 33 | 72 | 105 | 54 | 183 | 237 | 130 | 472 |
| TRFL | 33 | 275 | 1 | 8 | 1 | 9 | . | . | . | 300 | 309 |
| YRWA | 7 | 227 | . | 4 | 81 | 85 | 3 | 93 | 96 | 53 | 234 |
| AMRE | 34 | 109 | 1 | 17 | 24 | 41 | 17 | 45 | 62 | 41 | 144 |
| REVI | 41 | 67 | 1 | 2 | . | 2 | . | . | . | 107 | 109 |
| SWTH | 21 | 71 | 1 | . | . | . | . | . | . | 93 | 93 |
| WAVI | 8 | 81 | . | 2 | . | 2 | . | . | . | 87 | 89 |
| GRCA | 21 | 47 | . | 3 | . | 3 | . | . | . | 65 | 68 |
| SOSP | 9 | 58 | 1 | 3 | . | 3 | . | . | . | 65 | 68 |
| YWAR | 17 | 51 | . | 5 | 26 | 31 | 12 | 9 | 21 | 16 | 68 |
| OCWA | 11 | 48 | . | 3 | 29 | 32 | 5 | 14 | 19 | 8 | 59 |
| WIWA | 16 | 38 | . | 11 | 18 | 29 | 5 | 19 | 24 | 1 | 54 |
| CEDW | 16 | 37 | . | 8 | . | 8 | 1 | . | 1 | 44 | 53 |
| LISP | 8 | 41 | . | . | . | . | . | . | . | 49 | 49 |
| MGWA | 1 | 48 | . | 1 | 4 | 5 | . | 8 | 8 | 36 | 49 |
| LEFL | 2 | 42 | . | . | . | . | . | . | . | 44 | 44 |
| VEER | 6 | 32 | . | . | . | . | . | . | . | 38 | 38 |
| RCKI | 8 | 21 | 1 | 5 | 9 | 14 | 3 | 12 | 15 | 1 | 30 |
| PISI | 11 | 18 | . | 7 | . | 7 | . | . | . | 22 | 29 |
| PUFI | 1 | 26 | . | 1 | . | 1 | . | . | . | 26 | 27 |
| EAKI | 8 | 15 | . | 2 | . | 2 | 3 | . | 3 | 18 | 23 |
| TEWA | 3 | 20 | . | 1 | . | 1 | 1 | . | 1 | 21 | 23 |
| AMRO | . | 17 | . | . | . | . | . | . | . | 17 | 17 |
| BCCH | 3 | 13 | . | . | . | . | . | . | . | 16 | 16 |
| SAVS | 3 | 10 | . | . | . | . | . | . | . | 13 | 13 |
| WTSP | . | 13 | . | . | . | . | . | 2 | 2 | 11 | 13 |
| CCSP | 4 | 8 | . | 1 | . | 1 | . | . | . | 11 | 12 |
| NOWA | 2 | 9 | . | . | . | . | . | . | . | 11 | 11 |
| LAZB | 1 | 9 | . | 1 | . | 1 | . | . | . | 9 | 10 |
| DEJU | . | 9 | . | . | 1 | 1 | . | 4 | 4 | 4 | 9 |
| WCSP | 1 | 8 | . | . | . | . | . | . | . | 9 | 9 |
| WEWP | . | 7 | . | . | . | . | . | . | . | 7 | 7 |
| RNSA | . | 6 | . | . | . | . | . | 4 | 4 | 2 | 6 |
| GCKI | . | 5 | . | . | 2 | 2 | . | 3 | 3 | . | 5 |
| RWBL | 1 | 3 | 1 | 1 | 1 | 2 | . | 2 | 2 | 1 | 5 |
| WETA | . | 5 | . | . | 3 | 3 | . | 2 | 2 | . | 5 |
| DUFL | 1 | 3 | . | . | . | . | . | . | . | 4 | 4 |
| CBCH | . | 3 | . | . | . | . | . | . | . | 3 | 3 |
| DOWO | . | 3 | . | . | 2 | 2 | . | 1 | 1 | . | 3 |
| MAWA | 1 | 2 | . | . | . | . | . | 1 | 1 | 2 | 3 |
| CAVI | . | 2 | . | . | . | . | . | . | . | 2 | 2 |
| HAFL | . | 2 | . | . | . | . | . | . | . | 2 | 2 |
| HETH | . | 2 | . | . | . | . | . | . | . | 2 | 2 |
| NAWA | . | 2 | . | . | 1 | 1 | . | 1 | 1 | . | 2 |
| NOFL | . | 2 | . | . | . | . | . | 2 | 2 | . | 2 |
| TOWA | . | 2 | . | . | . | . | . | 2 | 2 | . | 2 |
| BHCO | . | 1 | . | . | 1 | 1 | . | . | . | . | 1 |
| BHGR | . | 1 | . | . | . | . | . | 1 | 1 | . | 1 |
| BRSP | 1 | . | . | . | . | . | . | . | . | 1 | 1 |
| CHSP | . | 1 | . | . | . | . | . | . | . | 1 | 1 |
| CSWA | . | 1 | . | . | . | . | . | . | . | 1 | 1 |
| FOSP | . | 1 | . | . | . | . | . | 1 | 1 | . | 1 |
| GCSP | . | 1 | . | . | 1 | 1 | . | . | . | . | 1 |
| OSFL | . | . | 1 | . | . | . | . | . | . | 1 | 1 |
| PSFL | . | 1 | . | . | . | . | . | . | . | 1 | 1 |
| RBNU | . | 1 | . | . | . | . | . | . | . | 1 | 1 |
| SORA | . | 1 | . | . | . | . | . | . | . | 1 | 1 |
| YBCH | 1 | . | . | 1 | . | 1 | . | . | . | . | 1 |
| **Total** | **388** | **1910** | **9** | **120** | **276** | **396** | **104** | **409** | **513** | **1398** | **2307** |

* Species Code: see definition in Appendix 5

**Appendix 9: Banding data summary from Airport Islands banding station, Revelstoke Reach, 2016**

| 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*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COYE | 33 | 43.4 | 0.0938 | 10 | 30.3 | 11 | 33.3 | 21 | . | 54 | 0.1534 |
| YWAR | 6 | 7.9 | 0.0170 | 5 | 83.3 | 2 | 33.3 | 7 | . | 13 | 0.0369 |
| TRFL | 6 | 7.9 | 0.0170 | 3 | 50.0 | . | . | 3 | . | 9 | 0.0256 |
| YRWA | 9 | 11.8 | 0.0256 | . | . | . | . | . | . | 9 | 0.0256 |
| SAVS | 5 | 6.6 | 0.0142 | . | . | . | . | . | 1 | 6 | 0.0170 |
| DEJU | 2 | 2.6 | 0.0057 | 3 | 150.0 | . | . | 3 | . | 5 | 0.0142 |
| ATSP | 2 | 2.6 | 0.0057 | 1 | 50.0 | 1 | 50.0 | 2 | . | 4 | 0.0114 |
| AMRE | 2 | 2.6 | 0.0057 | 1 | 50.0 | . | . | 1 | . | 3 | 0.0085 |
| LAZB | 3 | 3.9 | 0.0085 | . | . | . | . | . | . | 3 | 0.0085 |
| LISP | 3 | 3.9 | 0.0085 | . | . | . | . | . | . | 3 | 0.0085 |
| YHBL | 2 | 2.6 | 0.0057 | . | . | . | . | . | . | 2 | 0.0057 |
| OCWA | 1 | 1.3 | 0.0028 | . | . | . | . | . | . | 1 | 0.0028 |
| RUHU | . | . | . | . | . | . | . | . | 1 | 1 | 0.0028 |
| SOSP | 1 | 1.3 | 0.0028 | . | . | . | . | . | . | 1 | 0.0028 |
| TOWA | 1 | 1.3 | 0.0028 | . | . | . | . | . | . | 1 | 0.0028 |
| **Total** | **76** | **100.0** | **0.2159** | **23** | **30.3** | **14** | **18.4** | **37** | **2** | **115** | **0.3267** |

* Species Code: see definition in Appendix 5
** No. of Newly Captured: for CLBMON 39 in 2016 (included first recaptures of birds banded in previous year)
*** Capture Rate/Total Capture Rate: in birds/net-hour

**Appendix 10: Banding data summary from Jordan River banding station, Revelstoke Reach, 2016**

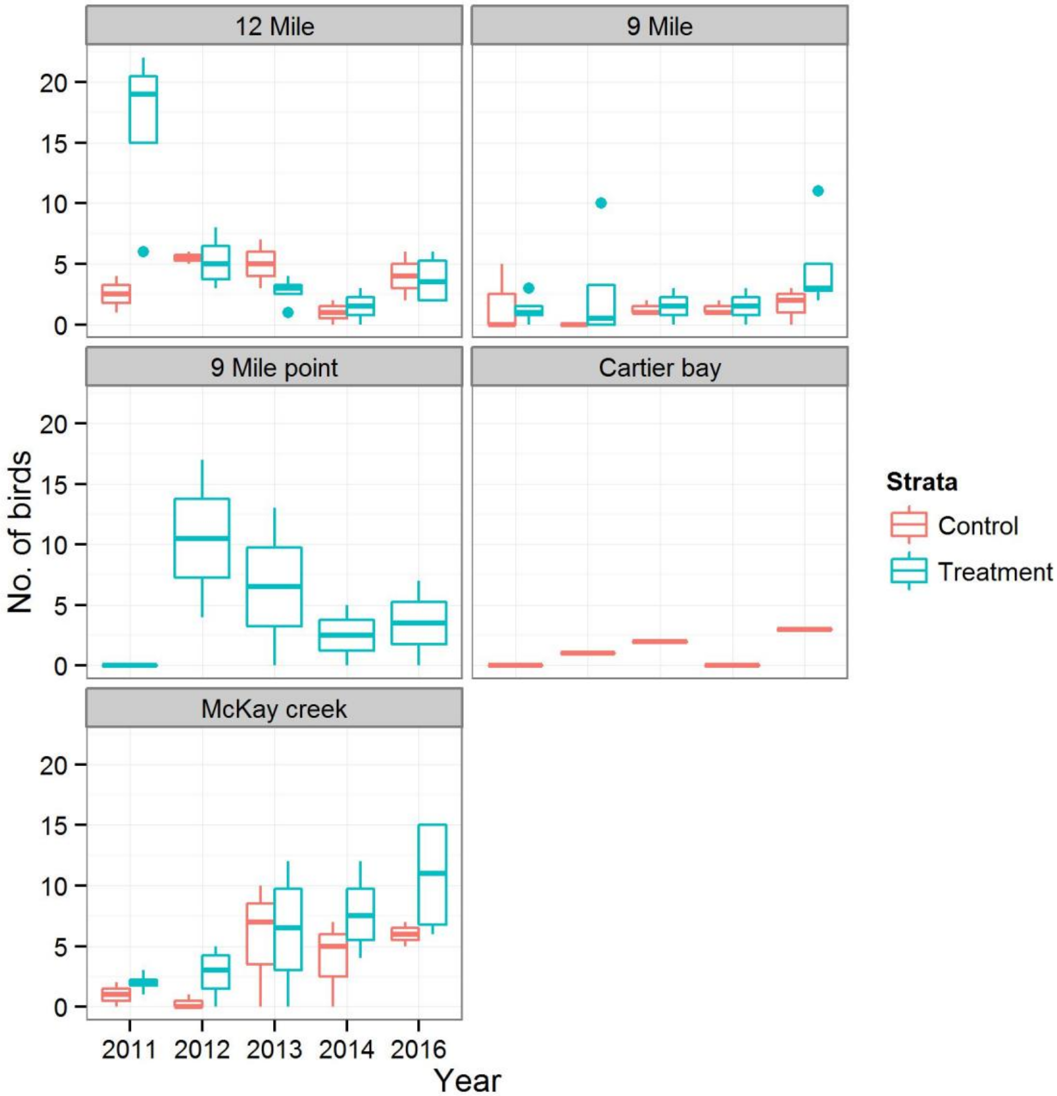
| Species Code* | No. of Newly Captured** | % | Capture Rate*** | No. of Same-Day Recap | % | No. of Recap | Recap Rate (%) | Total No. Recaptures | No. of Unbanded | Total No. | Total Capture Rate*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AMRE | 31 | 14.5 | 0.1068 | 4 | 12.9 | 4 | 12.9 | 8 | 1 | 40 | 0.1378 |
| SWTH | 34 | 15.9 | 0.1171 | . | . | 3 | 8.8 | 3 | 1 | 38 | 0.1309 |
| WAVI | 27 | 12.6 | 0.0930 | 1 | 3.7 | . | . | 1 | 5 | 33 | 0.1137 |
| GCKI | 24 | 11.2 | 0.0827 | . | . | 2 | 8.3 | 2 | . | 26 | 0.0896 |
| RCKI | 12 | 5.6 | 0.0413 | . | . | . | . | . | . | 12 | 0.0413 |
| BCCH | 7 | 3.3 | 0.0241 | 2 | 28.6 | 2 | 28.6 | 4 | . | 11 | 0.0379 |
| MGWA | 8 | 3.7 | 0.0276 | . | . | . | . | . | 3 | 11 | 0.0379 |
| TRFL | 7 | 3.3 | 0.0241 | 1 | 14.3 | 1 | 14.3 | 2 | 1 | 10 | 0.0345 |
| DEJU | 8 | 3.7 | 0.0276 | . | . | . | . | . | . | 8 | 0.0276 |
| SOSP | 6 | 2.8 | 0.0207 | . | . | 1 | 16.7 | 1 | 1 | 8 | 0.0276 |
| CEDW | 4 | 1.9 | 0.0138 | . | . | . | . | . | . | 4 | 0.0138 |
| COYE | 3 | 1.4 | 0.0103 | . | . | . | . | . | 1 | 4 | 0.0138 |
| LISP | 4 | 1.9 | 0.0138 | . | . | . | . | . | . | 4 | 0.0138 |
| VATH | 4 | 1.9 | 0.0138 | . | . | . | . | . | . | 4 | 0.0138 |
| WIWA | 4 | 1.9 | 0.0138 | . | . | . | . | . | . | 4 | 0.0138 |
| GRCA | 3 | 1.4 | 0.0103 | . | . | . | . | . | . | 3 | 0.0103 |
| HETH | 3 | 1.4 | 0.0103 | . | . | . | . | . | . | 3 | 0.0103 |
| LEFL | 3 | 1.4 | 0.0103 | . | . | . | . | . | . | 3 | 0.0103 |
| REVI | 3 | 1.4 | 0.0103 | . | . | . | . | . | . | 3 | 0.0103 |
| YWAR | 3 | 1.4 | 0.0103 | . | . | . | . | . | . | 3 | 0.0103 |
| LAZB | 2 | 0.9 | 0.0069 | . | . | . | . | . | . | 2 | 0.0069 |
| OCWA | 2 | 0.9 | 0.0069 | . | . | . | . | . | . | 2 | 0.0069 |
| RBNU | 2 | 0.9 | 0.0069 | . | . | . | . | . | . | 2 | 0.0069 |
| WTSP | 2 | 0.9 | 0.0069 | . | . | . | . | . | . | 2 | 0.0069 |
| AMRO | 1 | 0.5 | 0.0034 | . | . | . | . | . | . | 1 | 0.0034 |
| CAVI | 1 | 0.5 | 0.0034 | . | . | . | . | . | . | 1 | 0.0034 |
| CBCH | 1 | 0.5 | 0.0034 | . | . | . | . | . | . | 1 | 0.0034 |
| HAFL | 1 | 0.5 | 0.0034 | . | . | . | . | . | . | 1 | 0.0034 |
| NOFL | 1 | 0.5 | 0.0034 | . | . | . | . | . | . | 1 | 0.0034 |
| STJA | 1 | 0.5 | 0.0034 | . | . | . | . | . | . | 1 | 0.0034 |
| WETA | 1 | 0.5 | 0.0034 | . | . | . | . | . | . | 1 | 0.0034 |
| YRWA | 1 | 0.5 | 0.0034 | . | . | . | . | . | . | 1 | 0.0034 |
| **Total** | **214** | **100.0** | **0.7373** | **8** | **3.7** | **13** | **6.1** | **21** | **13** | **248** | **0.8544** |

* Species Code: see definition in Appendix 5
** No. of Newly Captured: for CLBMON 39 in 2016 (included first recaptures of birds banded in previous year)
*** Capture Rate/Total Capture Rate: in birds/net-hour

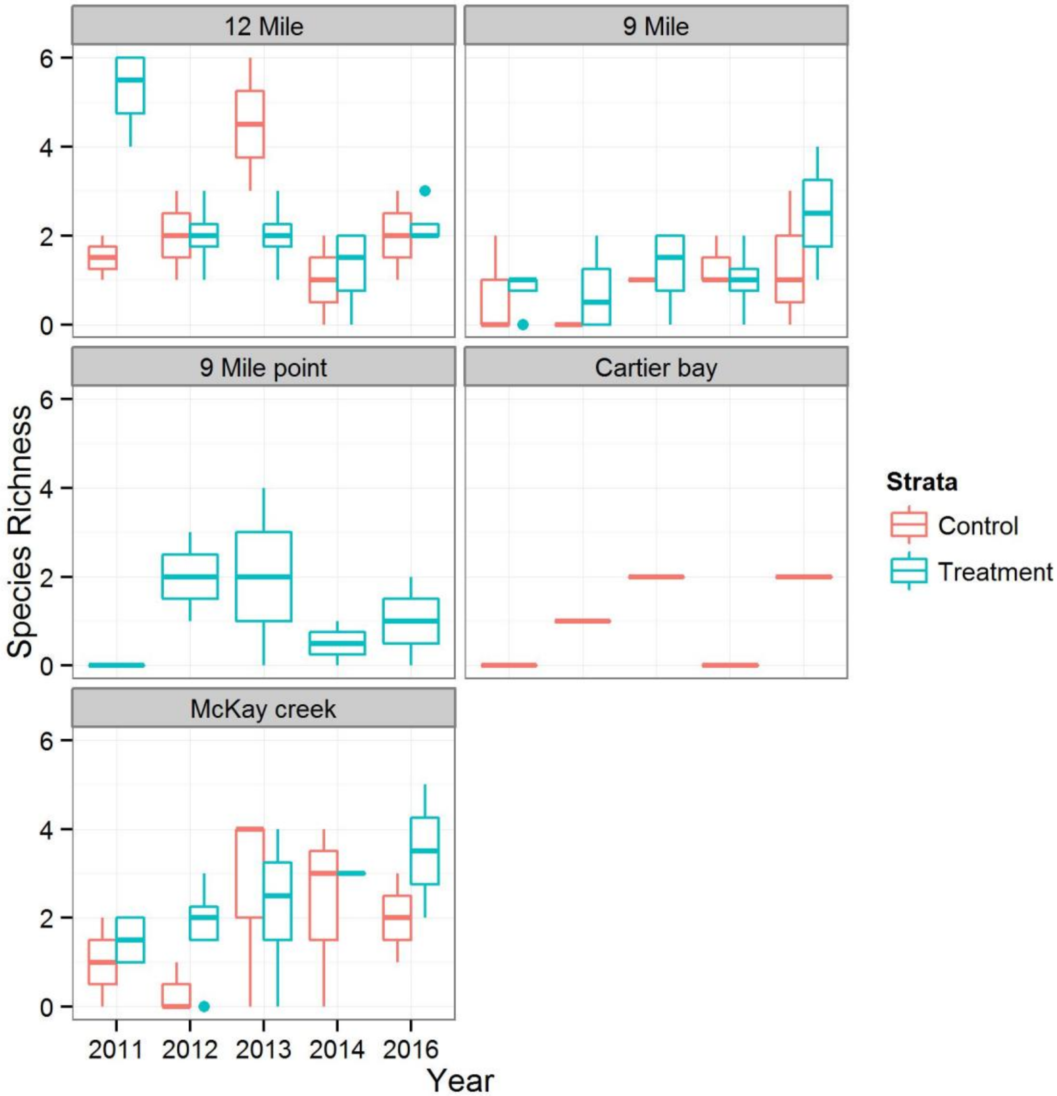
**Appendix 11: Species and number of birds detected on effectiveness monitoring plots during surveys in fall 2016**

| Common Name | On plot | Off plot | Overhead | Total |
|---|---|---|---|---|
| Common Yellowthroat | 59 | 23 | . | 82 |
| Savannah Sparrow | 19 | 21 | 2 | 42 |
| Yellow-rumped Warbler | . | 15 | 23 | 38 |
| Lincoln's Sparrow | 26 | 8 | . | 34 |
| Cedar Waxwing | 5 | 4 | 18 | 27 |
| Unidentified Sparrow | 2 | 2 | 13 | 17 |
| Mallard | . | 4 | 10 | 14 |
| Pine Siskin | . | 1 | 13 | 14 |
| Ruby-crowned Kinglet | 3 | 11 | . | 14 |
| Song Sparrow | 14 | . | . | 14 |
| American Pipit | . | . | 12 | 12 |
| Common Raven | . | 7 | 3 | 10 |
| Northern Rough-winged Swallow | . | 2 | 7 | 9 |
| Canada Goose | . | 8 | . | 8 |
| Warbling Vireo | 1 | 5 | . | 6 |
| American Crow | . | 5 | . | 5 |
| Black-capped Chickadee | 2 | 3 | . | 5 |
| Traill's Flycatcher | 2 | 3 | . | 5 |
| Bald Eagle | . | 4 | . | 4 |
| Vaux's Swift | . | . | 4 | 4 |
| Yellow Warbler | . | 4 | . | 4 |
| Great Blue Heron | 1 | 2 | . | 3 |
| Northern Flicker | . | 3 | . | 3 |
| Orange-crowned Warbler | 2 | 1 | . | 3 |
| Ring-billed Gull | . | 3 | . | 3 |
| Steller's Jay | . | 3 | . | 3 |
| Eastern Kingbird | . | 2 | . | 2 |
| Least Flycatcher | . | 2 | . | 2 |
| Pectoral Sandpiper | . | 2 | . | 2 |
| Red-eyed Vireo | . | 2 | . | 2 |
| Turkey Vulture | . | 2 | . | 2 |
| Unidentified Swallow | . | . | 2 | 2 |
| Unidentified Warbler | . | 1 | 1 | 2 |
| Western Wood-pewee | 1 | 1 | . | 2 |
| Wilson's Snipe | 2 | . | . | 2 |
| American Redstart | 1 | . | . | 1 |
| American Robin | . | 1 | . | 1 |
| Dusky Flycatcher | . | 1 | . | 1 |
| Gray Catbird | . | 1 | . | 1 |
| MacGillivray's Warbler | . | 1 | . | 1 |
| Northern Goshawk | . | . | 1 | 1 |
| Northern Harrier | . | 1 | . | 1 |
| Unidentified *Empidonax* Flycatcher | . | 1 | . | 1 |
| Unidentified Blackbird | . | . | 1 | 1 |
| Unidentified *Larus* Gull | . | 1 | . | 1 |
| Wilson's Warbler | . | 1 | . | 1 |
| Grand Total | 140 | 162 | 110 | 412 |

**Appendix 12: Mean cumulative annual abundance of neotropical migrants on effectiveness monitoring plots in different planted areas**

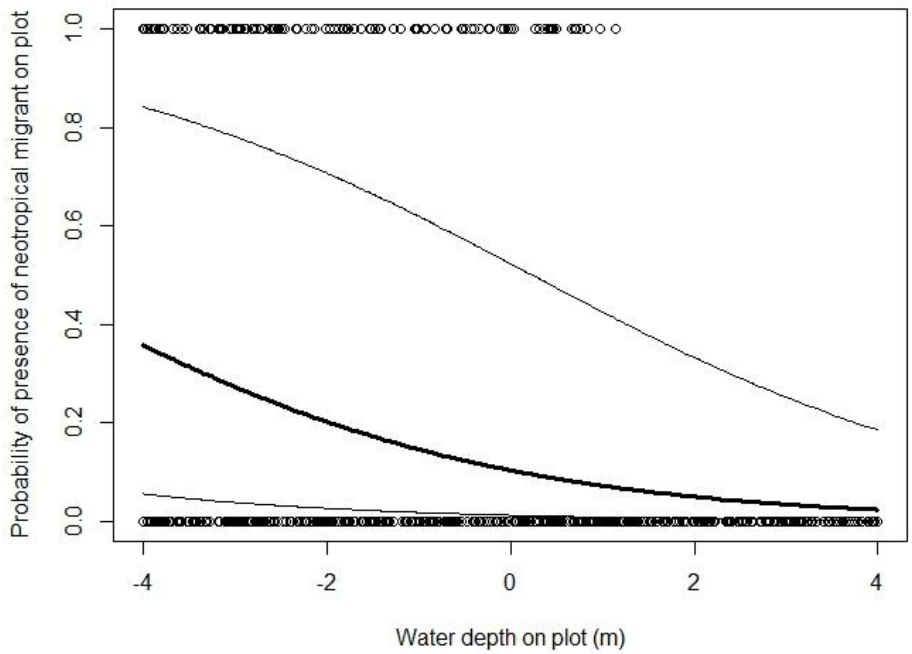


**Appendix 13: Mean fall annual species richness of neotropical migrants on effectiveness monitoring plots in different planted areas**

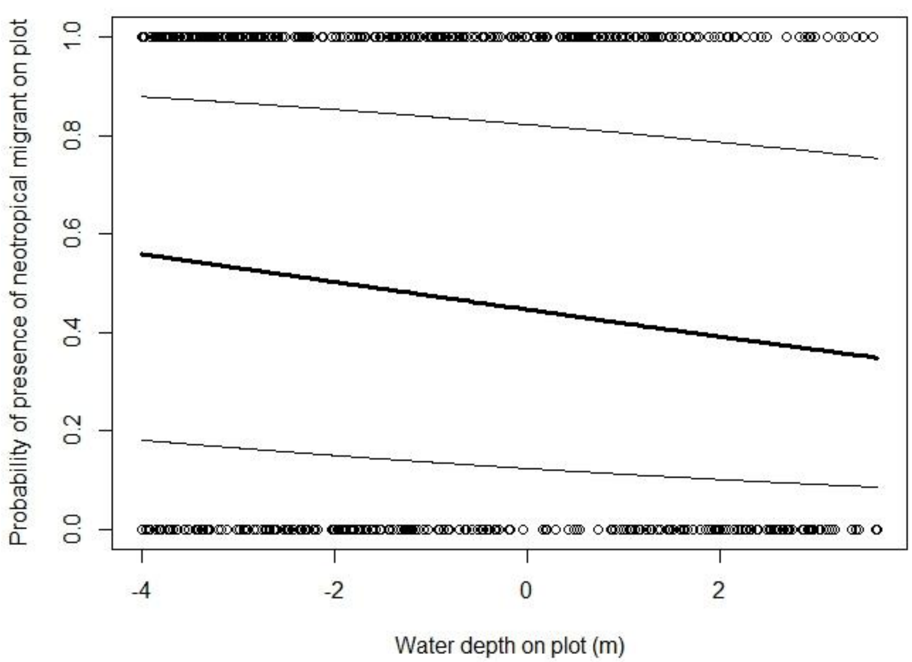


**Appendix 14: Probability of detecting a neotropical migrant songbird on plot from different strata in Revelstoke Reach based on water depth on plot**

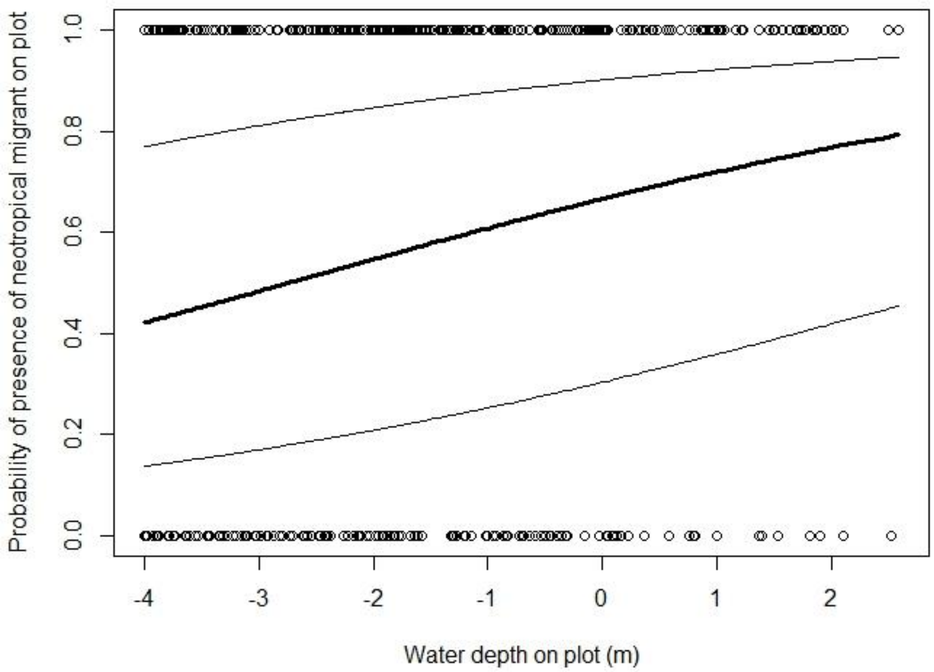
**a) Grassland**



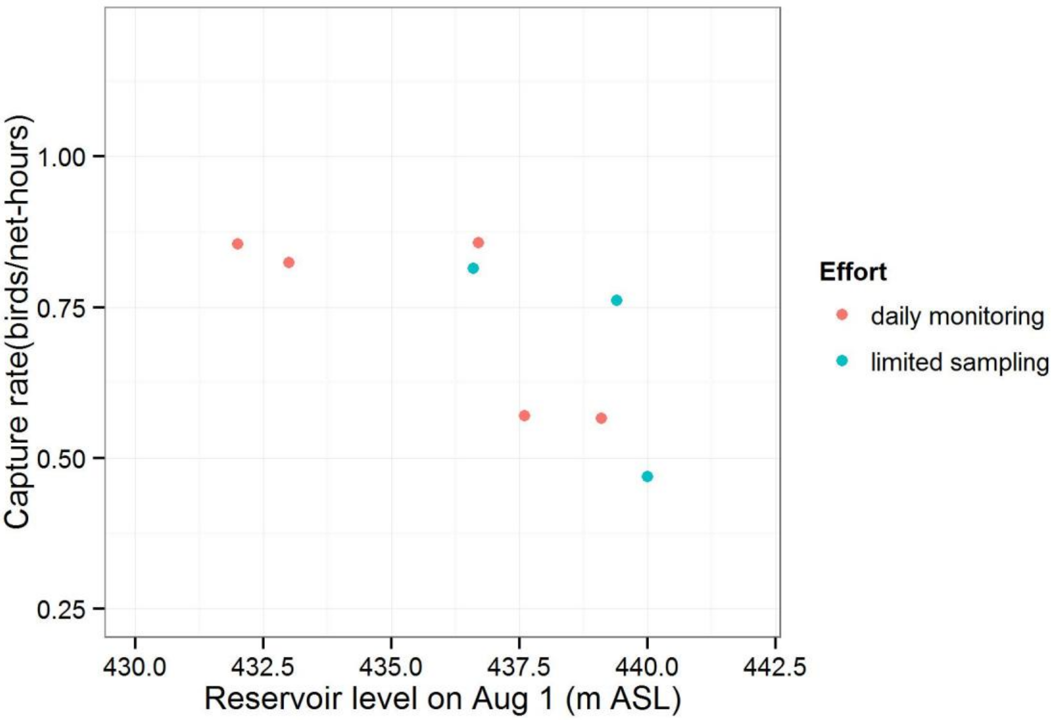

**b) Shrub**



**b) Forest**


Probability of presence of neotropical migrant on plot
0.0
0.2
0.4
0.6
0.8
1.0
-4
-3
-2
-1
0
1
2
Water depth on plot (m)

**Appendix 15: Capture rate at Machete Island banding station in relation to the reservoir water level at the beginning of the survey period (August 1). Years with daily monitoring (2008, 2009, 2010, 2015 ad 2016) and years with limited monitoring (weekly sampling) and shown. Average capture rate of newly banded birds is calculated for Aug-Sep migration period.**



**Appendix 16: Stratification of permanent plot surveys in fall 2011-2014 based on flooding conditions - calculated water depth on plot (Positive values indicating that the plot was flooded)**