Columbia River Northern Pike Suppression - 2018

Submitted To:

Columbia Basin Trust
Castlegar, BC

B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development
Nelson, BC

Submitted by:

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Matt Neufeld, Fish Biologist, B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Nelson, BC

Guy Martel, B.C. Hydro, Burnaby, BC

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EXECUTIVE SUMMARY

Northern Pike (*Esox lucius*), a fish endemic to northern regions of Canada, are a recent non-native species invader of the Columbia River system in both Canada and the United States. Northern Pike are a piscivorous top predator that can significantly impact sportfish populations and the recovery of species of conservation concern. Northern Pike were first detected in the Canadian section of the Columbia River in 2009. Since the initial detection, strategies to inventory and suppress the non-native predator have included a gill-net suppression program, changes to daily angling quota (unlimited), an angler incentive/awareness program, acoustic telemetry, otolith geochemistry, environmental DNA detection (eDNA), habitat reduction, and juvenile detection programs. Northern Pike have primarily been observed in the Robson Reach near Castlegar, BC. Habitats in this section of the Lower Columbia River include slow-moving, shallow water with abundant instream cover that provides suitable habitat for Northern Pike spawning, rearing and feeding; this habitat type is limited elsewhere in the Lower Columbia River. The status of Northern Pike in the Canadian section of the Pend d'Oreille River, a tributary entering the Lower Columbia River near the international border believed to be the pathway of introduction of Northern Pike to the Columbia system, has been relatively unknown until the current study. In response to the conservation concerns that Northern Pike pose to the Lower Columbia River, the B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development initiated annual gill-net suppression programs between 2014 and 2017. Overall, this program successfully removed 323 Northern Pike and the population estimate dropped by approximately 86% between 2014 and 2017.

Due to continued concern about the proliferation of this species in the Columbia and Pend d'Oreille rivers in Canada, a Northern Pike suppression program was also conducted in 2018. The 2018 program included desktop reviews of potential Northern Pike habitat areas and Northern Pike control actions as well as a suppression program that built on the successful techniques used during the 2014-2017 programs. On the Columbia River, suppression efforts included a Spring Index Gill-Netting (SPIN) program in May, with additional gill-netting in summer/fall, boat electrofishing in late summer/fall and angling in spring. On the Pend d'Oreille River, suppression efforts included a SPIN program and angling in both Seven Mile and Waneta reservoirs during spring 2018.

In the Lower Columbia River study area, a total of 27 Northern Pike including 7 females and 20 males were removed in 2018. Twenty-two Northern Pike (NP) were removed during 525.3 hours of gill-netting resulting in an overall catch-per-unit-effort (CPUE) of 0.04 NP/net hour. Five Northern Pike were removed during 19,867 seconds of boat electrofishing resulting in an overall CPUE of 0.9 NP/electrofishing hour. No Northern Pike were captured by angling in 2018. Catch-rates during the annual May SPIN surveys are used to track the status of Northern Pike in the Lower Columbia River and in 2018 the CPUE during SPIN surveys was 0.05 NP/net hour, higher than the 2017 SPIN CPUE (0.04 NP/net hour) but substantially lower than during the initial SPIN program in 2014 (0.44 NP/net hour). In total, 510 fish were caught as bycatch in the Lower Columbia River study area in 2018 of which 243 fish were captured during gill-net surveys (79.4% were released alive) and 267 fish were captured during boat electrofishing surveys (97.8% were released alive). Two White Sturgeon (*Acipenser transmontanus*) were captured as bycatch in 2018 during fall gill-netting surveys and were released alive and unharmed.

In the Pend d'Oreille River study area, a total of 15 Northern Pike including 5 females and 10 males were removed in 2018. The 15 Northern Pike were removed during 308.4 hours of gill-netting resulting in an overall CPUE of 0.05 NP/net hour. No Northern Pike were captured by angling in 2018. In total, 163 fish were caught as bycatch in the Pend d'Oreille River study area in 2018 of which 123 were released alive (75.5%).

Ongoing, effective annual suppression is recommended to maintain the low catch rates observed in 2018. In the Columbia River study area, this includes SPIN surveys in May, gill-net surveys in potential Northern Pike habitat areas downstream of Trail, BC and surveys that target juvenile Northern Pike in the late summer/fall. In the Pend d'Oreille River study area, this includes SPIN surveys in April and surveys that target juvenile Northern Pike in the late summer/fall both in Seven Mile and Waneta reservoirs.

TABLE OF CONTENTS

PAGE

TABLE OF CONTENTS (cont'd)

PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Northern Pike (*Esox lucius*), a fish endemic to northern regions of Canada, are a recent non-native species invader of the Columbia River system in both Canada and the United States. Northern Pike (NP) are a slow-water, predatory species whose preferred habitat includes shallow lakes, marshes and backwater sloughs with extensive instream cover (McPhail 2007). NP have the potential to significantly impact sportfish populations and the recovery of species listed under the Species-at-Risk Act (SARA) in the Columbia River through competition, predation and the introduction of disease (Baxter and Neufeld 2014).

Northern Pike were first detected in the U.S. Columbia River in 2007 and in the Canadian Columbia River in 2009 (Lee et al. 2010; Baxter and Neufeld 2015). Anecdotal reports from anglers suggested the population of NP was increasing in the Lower Columbia River in Canada, whereas direct evidence of NP capture occurred near Castlegar, B.C. during subsequent river indexing surveys in 2010 (Golder and Poisson 2013). At the same time, NP were observed in the Columbia River downstream of the Canada-U.S. border in Lake Roosevelt near Colville and Kettle Falls, WA (Lee and King 2015). The source of the invasion was likely from the Flathead Lake system in Montana where fisheries managers believed NP were illegally introduced in the 1980s (McMahon and Bennett 1996). The species was thought to have then traveled via the Clark Fork River into Lake Pend d'Oreille, into the Pend d'Oreille River and downstream into the Columbia River (Bailey 2016). The Pend d'Oreille River enters the Columbia River near Trail, BC just upstream of the international border (Figure 1). However, a recent genetic evaluation suggests NP were likely introduced directly to the Pend d'Oreille River by illegal human transport (Carim et al. 2018). Carim et al. (2018) found that NP in the Pend d'Oreille River and Lake Roosevelt are most genetically similar to NP from two small lakes upstream of Lake Coeur d'Alene, Idaho, not those in the Clark Fork River, and because there is no direct water connection between the systems, NP are believed to have been moved between the systems illegally.

Following the discovery of NP in the Lower Columbia River (LCR), the river section between Hugh L. Keenlyside (HLK) Dam and the U.S. border, fisheries managers responded with removal and research programs aimed at suppressing and evaluating the population in Canada since 2014 (e.g., Baxter and Neufeld 2015). Recognizing the concerns and threats associated with the NP introductions in the LCR, the B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD) made changes to angling regulations (unlimited daily quota effective 2011), implemented an incentive/education program aimed at encouraging anglers to remove NP from the LCR (2013) and initiated the adult gill-netting program in 2014. Teck Metals Ltd. provided annual funding for the adult gill-netting suppression program (2014-2017), with additional grants provided by the Columbia Basin Trust (CBT). The 2014-2017 program resulted in the removal of 323 NP (Baxter and Lawrence 2018). Population estimates generated annually dropped by approximately 86% between 2014 and 2017 (Baxter and Lawrence 2018).

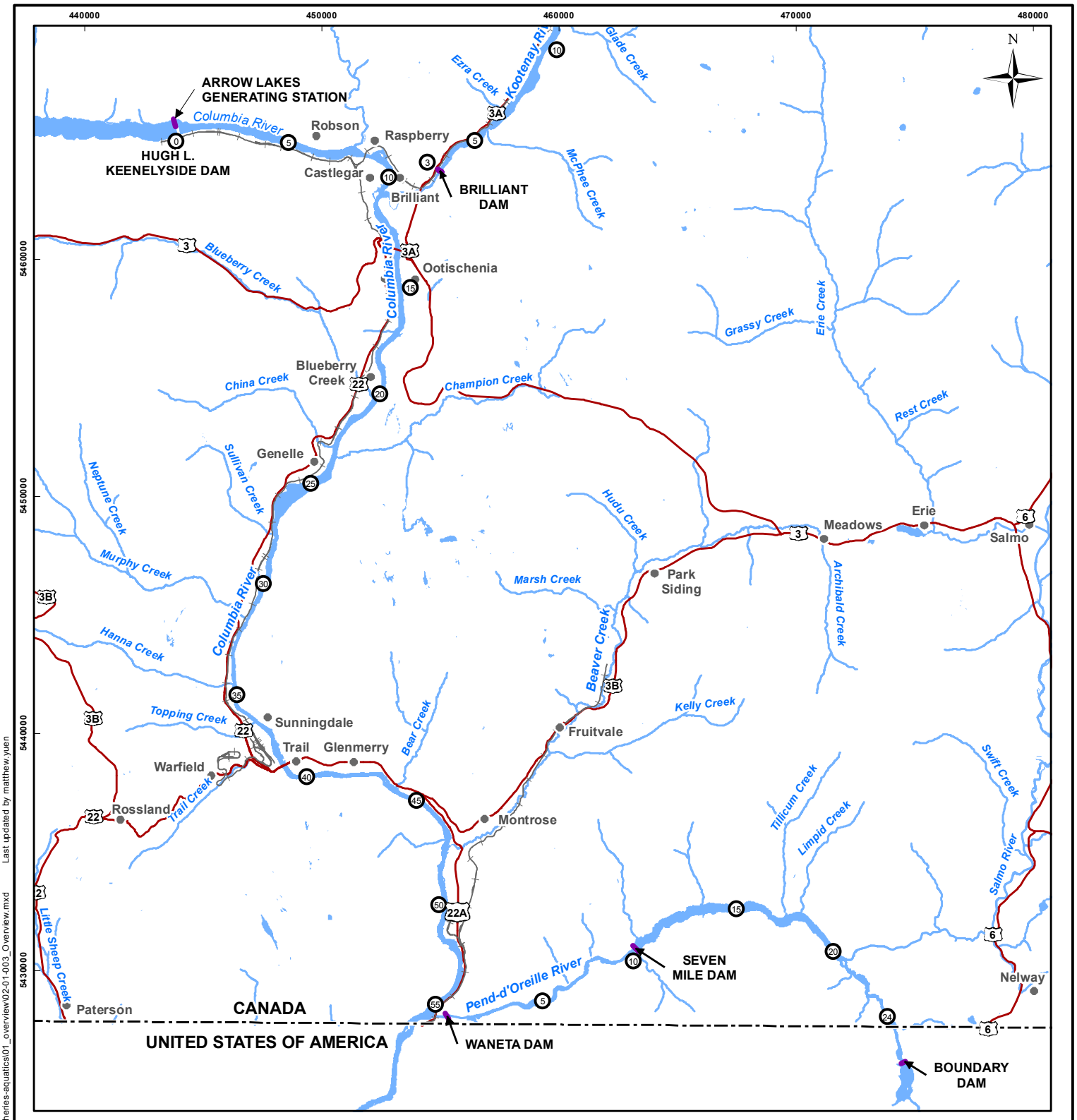
Recent evidence indicates that NP are successfully recruiting in the LCR. Microchemical analysis of otoliths conducted by Thompson Rivers University (TRU) demonstrated that most NP adults removed from the LCR were recruits from the Columbia River and only 1 of the 50 NP assessed was from the Pend d'Oreille River (Doutaz, in prep). Attempts to capture juveniles in the Robson Reach in 2015 were unsuccessful (Golder 2015) but juveniles have since been captured from the Robson Reach (n=1; ONA 2016) and from Kootenay Oxbow in the Lower Kootenay River near the

confluence of the LCR (n=14; Baxter and Lawrence 2018). Approximately 30 juvenile NP were observed during trial boat surveys conducted in shallow, slack water habitat in Kootenay Oxbow in September 2017; targeted suppression was then undertaken using juvenile specific gill-nets resulting in the removal of half of the NP observed (Baxter and Lawrence 2018).

Northern Pike suppression in Lake Roosevelt, the U.S. portion of the Columbia River downstream of the international boundary, began in 2016. Suppression efforts were focused in the Kettle Falls region of Lake Roosevelt and approximately 1,200 NP were removed during the initial year of the program (Elliott Kittel, Fisheries Biologist, Spokane Tribe of Indians, pers. comm. 2017). In 2017, nearly 5,000 NP were removed from Lake Roosevelt using various capture methods including an angler incentive program (Elliott Kittel, pers. comm. 2017). The fisheries co-managers of Lake Roosevelt (Colville Confederated Tribes, Spokane Tribe of Indians and the Washington Department of Fish and Wildlife) have proposed to expand and continue their suppression program between 2018 and 2022 (Holly McLellan, Fisheries Biologist, Colville Confederated Tribes, pers. comm., 2017).

Though the numbers of adult NP in the LCR have declined, an acoustic telemetry study observed that one of 15 NP tagged in the Robson Reach traveled downstream to the U.S. border in February 2017, likely remained in Lake Roosevelt for approximately 6 months, then returned to the Robson Reach in September (Doutaz, in prep). These findings highlight the necessity for an ongoing and effective NP suppression program in the LCR to limit recruitment from downstream inputs. In addition, ongoing suppression efforts that also target juvenile NP life stages and suppression in adjacent tributaries such as the Pend d'Oreille River are required to maintain low NP numbers in the LCR (Amec Foster Wheeler 2017). During the same telemetry study, NP use of habitat in the vicinity of HLK was very low and no tags migrated upstream through the HLK navigation lock into Arrow Lakes Reservoir (ALR; Doutaz, in prep). Based on these observations, lack of angler reports of NP captures and limited NP habitat availability in ALR, the likelihood of capturing NP in the ALR is low and suppression effort may not be required at this time.

The CBT, in partnership with MFLNRORD and BC Hydro, contracted Wood Environment and Infrastructure Solutions and Mountain Water Research to conduct a Northern Pike suppression program in the LCR, its tributaries and the Pend d'Oreille River in 2018. The following report outlines the objectives, methods and outcomes of the 2018 suppression program.



Legend

- Populated Place
- Kilometer Marker
- Dam
- Road
- Railway
- Watercourse
- Waterbody

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Kilometers
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References:
DataBC Data Distribution Service
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CLIENT: CBT and MFLNRORD

PROJECT: Northern Pike Suppression

TITLE: Overview map of the Lower Columbia and Pend d'Oreille rivers and major tributaries

DATE:	PERMIT No:	
December 13, 2018	N/A	**Figure 1**

GIS FILE: 02-01-003_Overview.mxd

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1.1 Key Deliverables

Key deliverables of the 2018 program were to:

a) Conduct an adult Northern Pike suppression project in the LCR and its tributaries, where Northern Pike are known to occur (all within Canada), that builds on past suppression activities.

b) Identify juvenile Northern Pike habitat and conduct effective suppression techniques that target this life stage (i.e., gill-netting, boat electrofishing etc.).

c) Identify and assess additional areas of Northern Pike habitat use in the LCR system in Canada.

d) Assess the Pend d'Oreille River Northern Pike population and conduct suppression activities as described in (a) and (b) above.

e) Employ measures to reduce bycatch mortality of native and SARA-listed species (e.g., no overnight sets, short set duration (~4 hours)).

f) Investigate potential Northern Pike control actions that could further support suppression outcomes.

g) Secure and manage any regulatory approvals and permits, including SARA permit, necessary to carry out the project.

h) Coordinate and work with applicable agencies, researchers, First Nation and stakeholders to ensure project success and reduce duplication of efforts.

i) Provide project status updates to CBT, MFLNRORD and BC Hydro via email at intervals mutually agreed upon between the CBT and the Successful Proponent.

j) Support CBT to carry out public communications about the project, should they be required. And,

k) Develop and implement a Safety and Emergency Response Plan for the project.

2.0 METHODS

The following methods were used to identify suitable habitat areas, capture and remove NP from the Lower Columbia and Pend d'Oreille rivers in 2018. A scientific fish collection permit was obtained from the MFLNRORD (CB18-305337) and a Species-at-Risk-Act permit for incidental capture of White Sturgeon (*Acipenser transmontanus*) was obtained from Fisheries and Oceans Canada (18-PPAC-00017) prior to the initiation of suppression activities. A safety and emergency response plan was developed and implemented prior to the initiation of the field program.

2.1 Study Areas

The Lower Columbia River study area includes the 58 km long section of the Columbia River between Hugh. L. Keenlyside (HLK) Dam and the U.S. border (Figure 1). It also includes the approximate 2.8 km section of the Lower Kootenay River between Brilliant Dam and the confluence with the LCR. The Lower Kootenay River is the only tributary to the Columbia River other than the Pend d'Oreille with suitable NP habitat and where NP have previously been captured (Section 2.2). Outside of the study area, Arrow Lakes Reservoir is located upstream of HLK Dam (Figure 1) and Lake Roosevelt is located downstream of the U.S./Canada border (not depicted).

The Canadian section of the Pend d'Oreille River extends into Canada from the U.S. for approximately 25 km before it reaches a confluence with the Columbia River downstream of Waneta Dam, just upstream of where the Lower Columbia River enters the U.S. (Figure 1). The Pend d'Oreille study area includes two separate reservoirs: Waneta Reservoir upstream of Waneta Dam to Seven Mile Dam (9 km long), and, Seven Mile Reservoir upstream of Seven Mile Dam to the U.S. border (15 km long, Figure 1). Seven Mile Reservoir continues for approximately 2 km upstream of the U.S./Canada border until it reaches Boundary Dam (Figure 1).

2.2 Background Information Review

Desktop reviews of pre-existing data for the LCR and its tributaries as well as for the Pend d'Oreille River were conducted prior to conducting suppression surveys.

For the LCR, a desktop review was conducted to determine whether there were any other areas outside the Robson Reach suppression area that could concentrate NP, since past efforts were minimal. Information on juvenile NP sampling techniques, timing and potential habitat areas were also reviewed. Sources of information for the LCR background information review included:

- Results of LCR suppression programs between 2014 and 2017 (Baxter and Neufeld 2015; Baxter 2016; Baxter and Doutaz 2017; Baxter and Lawrence 2018);
- Maps produced by AMEC (2015) that used background information collected for the LCR, known NP habitat preferences, and researcher's expertise to identify potential NP locations with similar habitat to the Robson Reach;
- Telemetry data collected by Dan Doutaz (Thompson Rivers University, Master's Candidate) between May 2016 and September 2017 describing the movements of acoustically tagged NP that migrated outside of the Robson Reach (Doutaz, in prep);

- Captures in the LCR downstream of the Kootenay River confluence during CLBMON-45 Lower Columbia River Fish Indexing Surveys that have been conducted consistently from 2009 to present (e.g. Golder and Poisson 2014); and,

- Knowledge and experience of study team members during various LCR fisheries programs.

For the Pend d'Oreille River, a desktop review was conducted to determine potential locations of suitable NP habitat in both Seven Mile and Waneta reservoirs to be targeting during suppression surveys. Sources of information for the Pend d'Oreille River background information review included:

- Maps produced by AMEC (2015) that used previous habitat assessments and NP habitat suitability indices to identify potential NP habitat areas in Seven Mile Reservoir. Locations of previous NP captures were also identified;

- Habitat evaluation, gill-netting and angling surveys conducted by Dan Doutaz (Thompson Rivers University, Master's Candidate) between May 2016 and August 2017 in Seven Mile and Waneta reservoirs (Doutaz, in prep);

- Information collected during ongoing NP suppression programs in Box Lake and Boundary reservoirs upstream in the U.S. portion of the Pend d'Oreille River including suppression timing, methodology, habitat preference observations and lessons learned (e.g. WDFW, 2018);

- Knowledge and experience of study team members during previous Seven Mile and Waneta reservoir fisheries programs.

2.2.1 Northern Pike Control Actions

A desktop review was conducted to investigate control actions that could further support suppression outcomes. A list of NP control actions was compiled from recent evaluations conducted by AMEC (2015), Amec Foster Wheeler (2017) and Dan Doutaz (Thompson Rivers University, Master's Candidate). Method, overall effectiveness and applicability to this project were summarized. Only NP control methods were included in this review; research methods (e.g. telemetry, eDNA, life history assessments, etc.) were not included.

2.2.2 Habitat Identification

Background information was compiled to develop a list of areas with potential NP habitat to target during additional adult NP suppression surveys (Section 2.4.2) and juvenile NP suppression surveys (Section 2.4.3).

2.2.3 Ground Truth

Shallow water boat surveys were used to ground truth potential NP habitat areas identified during the background information review (Section 2.1) as well as visually locate NP and identify hazards prior to conducting suppression activities. To complete shallow water boat surveys, the boat operator slowly maneuvered through shallow nearshore areas while field crew members made

observations and identified hazards. If suitable habitat conditions and/or NP were observed, suppression activities were immediately conducted. Shallow water boat surveys were conducted prior to all gill-netting and boat electrofishing activities.

2.3 Survey Timing

A summary of survey locations, dates and methods used during the 2018 suppression program is provided in Table 1.

Table 1: Timing and methods for Northern Pike suppression surveys conducted in the Lower Columbia and Pend d'Oreille river study areas, 2018.

Location		Dates	Survey Type	Methods
Pend d'Oreille River	Seven Mile Reservoir	April 30 - May 1	Spring Index Netting	Gill-netting; angling
	Waneta Reservoir	May 2 - 4		
Columbia River		May 9 – 12 May 14 - 17	Spring Index Netting	Gill-netting; angling
Columbia River		Aug 20 - 21	Adult Suppression in Additional Areas	Gill-netting
Columbia River		Sep 10 - 13	Juvenile Suppression	Boat electrofishing; Gill-netting
Columbia River		Oct 17 - 18	Juvenile Suppression	Boat electrofishing; Gill-netting

2.4 Gill-Net Suppression

Gill-nets were the primary technique used to remove NP during the 2018 program. Further details on the different gill-net surveys used are provided below.

2.4.1 Spring Index Gill-Netting (SPIN) Suppression

The goal of spring index gill-netting (SPIN) programs is to remove as many NP as possible prior to their spawning period using a consistent level of effort to allow comparison with previous and future SPIN assessments. SPIN catch rates are used to track the prevalence of NP in spawning habitats and provide an indication of NP abundance (Amec Foster Wheeler 2017). Previous assessments have found water temperature reaching 8°C to be the critical period when NP are staging in nearshore spawning habitat and catch-rates during this period have been higher compared to other seasons (Baxter and Neufeld 2015). SPIN surveys were conducted on both the LCR and Pend d'Oreille River in 2018.

Monofilament gill-nets with the same specifications as those that have been found to be the most effective for removal of various NP age cohorts during previous suppression efforts conducted in the LCR (Baxter and Neufeld 2015), Lake Roosevelt (Lee and King 2015), and Pend d'Oreille River (Nick Bean, Fisheries Biologist, Kalispel Tribe of Indians, pers. comm. 2017) were used (Table 1). Mountain Water Research's 18-foot aluminum jet boat was the primary vessel used to deploy and retrieve gill-nets during this project. SPIN NP suppression efforts were conducted by a crew of two that deployed 8 nets twice per day to remain consistent with previous LCR SPIN surveys. On the Pend d'Oreille, a crew of two deployed 6 or 8 nets twice per day; 9 gill-nets were also set overnight to increase sampling effort in suitable locations. Gill-nets were set in suitable NP spawning habitat in shallow bays with aquatic vegetation and woody debris. Gill-nets were also

set in areas within these areas known to limit bycatch of salmonids and White Sturgeon. Gill-nets were set for a maximum of 4 hours, or checked within a 4 hour period, to reduce bycatch mortality of native and SARA-listed species such as White Sturgeon.

Survey data recorded during all gill-net suppression surveys included location (site name and UTM), date, start and end time, water temperature (°C) and average sample depth (m).

Table 2: Dimensions of gill-nets used during Northern Pike Spring Index Netting Suppression, 2018.

Panel Number	Length (m)	Depth (m)	Mesh Size (cm)
1	9.1	1.8	2.5
2	9.1	1.8	3.2
3	9.1	1.8	3.8
4	9.1	1.8	4.5
5	9.1	1.8	5.0
Total Net Length	**46 m**	-	-

2.4.2 Additional Adult Gill-Netting Surveys

Additional adult gill-netting surveys occurred in the LCR outside of the SPIN assessment; only SPIN surveys were conducted in the Pend d'Oreille in 2018. A background information review was conducted to identify other potential NP habitat areas outside the Robson Reach (Section 2.1). During the summer period, 2 days were spent by a three-person crew to ground truth the potential adult NP habitat identified during the background information review. Methods employed included shallow water boat surveys to identify areas with suitable NP habitat (abundant aquatic vegetation and/or woody debris). When suitable habitat was identified, gill-nets were deployed and retrieved and data was recorded following the same methods used during SPIN surveys (Section 2.4.1).

2.4.3 Juvenile Gill-Netting Surveys

Gill-nets were also used to target juvenile NP in the late summer/fall in the LCR. Juvenile gill-nets were 46 m long and 1.5 m deep with all the panels containing 2.5 cm mesh. Juvenile gill-nets were deployed and retrieved and data was recorded following the same methods used during SPIN surveys (Section 2.4.1).

2.5 Boat Electrofishing

Boat electrofishing surveys were conducted in the LCR in the late summer/fall with an aluminum jet boat equipped with a Smith Root GPP 7.5 boat electrofishing unit. All surveys required three crew members; one boat operator and two crew members at the bow that were responsible for operating the boat electrofishing unit, netting and identifying potential hazards. Following a boat survey of potential habitat areas (Section 2.2), the boat electrofishing unit was powered-on and maneuvered slowly in an upstream direction through shallow, vegetated shoreline areas. All stunned fish were quickly netted out of the river and into a recovery tub on the boat deck that had been filled with fresh river water. At the end of a sampling section (typically a habitat type break

such as the end of a vegetated bay), the boat electrofishing unit was turned off and captured fish were processed.

Data recorded during boat electrofishing surveys included site location, date, start and end time, start and end UTMs, water temperature (°C), conductivity (µs), average sample depth (m), electrofisher voltage settings, electrofishing seconds, site length (m), average site width (m), water clarity, instream velocity, cloud cover along with a description of instream cover types and the proportion of the sample section occupied by each.

2.6 Angling

Angling was conducted opportunistically during SPIN surveys in the LCR and Pend d'Oreille River. Spin fishing rods with lures were used from a boat near suitable NP habitat areas while gill-nets were soaking. Number of anglers and hours per rod were recorded.

2.7 Fish Processing

All captured NP were euthanized and then measured for fork length (mm), weight (g), scanned for Floy and Passive Integrated Transponder (PIT) tags, and assessed for sex/maturity. Stomachs of all NP captured during the project were removed by dissection and recorded as being empty or full. When stomach contents were present, they were removed and prey items were identified to species, if possible. Fish observed within the stomachs of NP were identified to species, when possible, and fork length was recorded. NP carcasses were returned to the river.

Bycatch were kept in the water during gill-net sampling and released alive, if possible, with the exception of non-native species that were euthanized. A count of bycatch by species per net was recorded. Bycatch captured during boat electrofishing surveys were transferred into a fresh-water tub until fully recovered before being released, with the exception of non-native species that were euthanized. A count of bycatch species by electrofishing site was recorded. During all surveys, the fork length (mm) of bycatch was estimated to reduce handling time and the status (alive or dead) at time of release were recorded.

Otolith, cleithra and DNA samples were collected from eight adult NP captured during the late summer/fall suppression surveys. The samples were collected at the request of the Colville Confederated Tribes (CCT) (Washington, USA) to be used in their NP DNA study map for the Columbia River watershed. This request was made after the SPIN program was already completed. Otolith and cleithra samples were removed, cleaned of flesh and stored in sample envelopes. DNA samples were collected by removing a piece of either the pectoral or dorsal fin and preserving it in ethanol. All samples were labeled and transferred to the CCT for further analysis.

2.8 Data Analysis

Field datasheets were scanned at the end of every field day and saved to a secure network that is backed-up daily to an off-site storage location. Data was entered into Excel spreadsheets, reviewed for data entry errors and then QA/QC'ed by another technician. Catch-per-unit-effort (CPUE) was determined for gill-netting by calculating the number of NP captured per gill-netting hour of effort (NP/net hr). This calculation was then multiplied by 8 to achieve a CPUE per standard sampling effort day (NP/8hr net). CPUE was determined for boat electrofishing by calculating the

number of NP captured per electrofishing hour (NP/hr); electrofishing hours were calculated from the actual electrofishing seconds used.

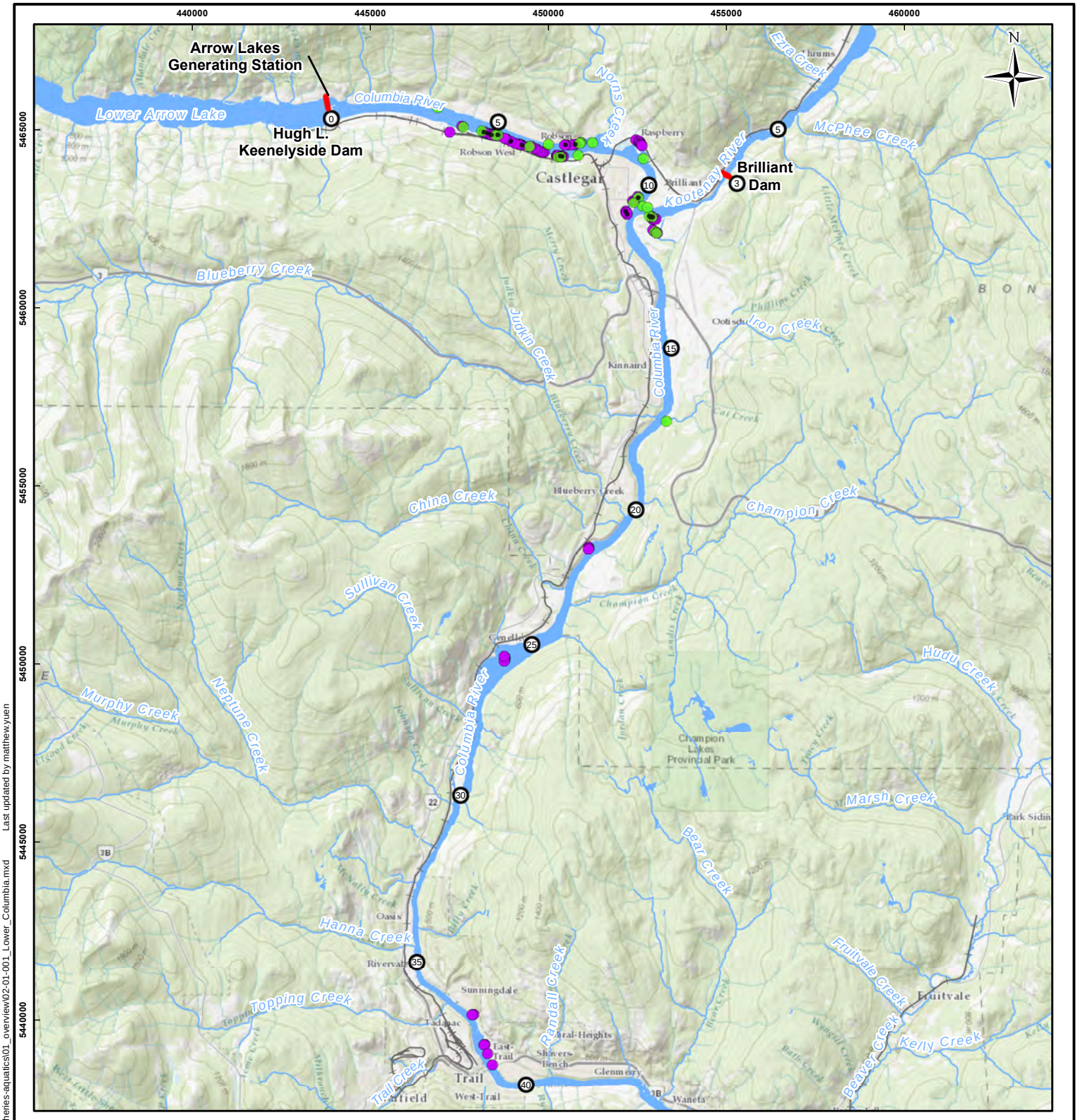
3.0 RESULTS

3.1 Lower Columbia River

3.1.1 Columbia River Habitat Identification

High-use NP habitat areas identified during suppression efforts between 2014 and 2017 included the Robson Reach (including the area between HLK Dam and Castlegar, B.C.), Kootenay River Oxbow, Waldies Island, and Zuckerberg Island (Baxter and Lawrence 2018; Figure 2). NP have primarily been captured in shallow, slackwater embayments with instream cover (i.e., aquatic vegetation, large woody debris, coarse woody debris and log booms). AMEC (2015) also compiled background information on potential NP habitats in the LCR during a desktop review.

Telemetry data was collected from 15 NP captured, tagged and released in the Robson Reach with acoustic and Floy tags in 2016 (Doutaz, in prep). Only one of the tagged NP traveled downstream of the Castlegar area (Figure 2). The NP began its downstream migration on February 2, 2017 and was last detected just upstream of the U.S. border on February 22, 2017 (20 day period). The tagged NP presumably spent the next 6 months in the U.S. before being detected again on August 1, 2017 when it was back at the U.S. border migrating upstream until its final detection at the Kootenay River confluence on September 6, 2017 at the conclusion of the study (35 day period). The highest residence times of the tagged NP during the migrations, approximately 10 days each, were observed near Genelle and Trail.



Legend

- 5 Kilometer Marker
- Northern Pike Captured
- Boat Electrofishing Sample Location
- Gill Net Sample Location
- Dam
- Road
- Railway
- Watercourse
- Waterbody

0 1 2 3 4 5
Kilometers
SCALE:1:150,000

References:
DataBC Data Distribution Service
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CLIENT: CBT and MFLNRORD

PROJECT: Northern Pike Suppression

TITLE: Lower Columbia River

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Additional adult NP or adult NP habitat areas identified include:

- Waterloo Eddy (RKm 17) – Potential NP habitat may be found in a bay adjacent to the boat launch on the left downstream bank. The bay can be disconnected from the mainstem during low flow periods. This location was identified during previous NP suppression activities but has never been sampled (J. Baxter, Mountain Water Research, pers. comm. 2018).

- Genelle (RKm 26) – During the upstream migration of the acoustically tagged NP described above, this fish remained near Genelle along the right downstream bank of the LCR from August 24 to September 2, 2017 before continuing its upstream migration (Doutaz, in prep).

- Sunningdale (Rkm 34.9) – One adult NP was captured north of Trail in 2013 during BC Hydro's Large River Indexing Program on the left downstream bank (Golder and Poisson 2014);

- South of Trail (RKm 43.5) – During the downstream migration of the acoustically tagged NP described above, this fish remained in an area south of Trail near the left downstream bank from February 8 to 18, 2017 before continuing its downstream migration into the U.S. (D. Doutaz, in prep);

- Small vegetated bays at the Beaver Creek confluence area (RKm 47.5) – Potential NP habitat was identified on both banks of the river (AMEC 2015); and,

- South of Beaver Creek (Rkm 49.8) – One adult NP was captured south of the Beaver Creek confluence in 2013 during BC Hydro's Large River Indexing Program on the right downstream bank (Golder and Poisson 2014).

Juvenile NP (young-of-the-year (YOY)) have been captured in the following locations in the LCR:

- Robson Reach (RKm 7) – One YOY (125 mm fork length, 11.8 g) was captured by fyke net on July 27, 2016 on the right downstream bank (ONA 2016). Habitat at the capture location consisted of low velocity (0.09 cm/s), shallow (0.2 – 1.2 m), well oxygenated (10.25 mg/L) water with primarily sand substrate and trace amounts of vegetation and pebbles (ONA 2016).

- Kootenay River Oxbow (Rkm 0.4) – 32 YOY were observed during a boat survey in shallow (<30 cm depth), low flow, vegetated areas of the Kootenay Oxbow in September 2017. Fourteen of the YOY (260 to 390 mm) were captured by gill-netting in the area they were observed (Baxter and Lawrence 2018).

The timing of juvenile suppression in the LCR is essential because YOY NP that were spawned in the spring need to be large enough to capture, aquatic vegetation needs to be abundant, and suitable habitat such as that observed in the Kootenay Oxbow in 2017 needs to be available (Jeremy Baxter, Mountain Water Research, pers. comm., 2018). A window of opportunity for successful juvenile NP capture was identified in late August to mid-September when the combined

discharge from HLK and BRD dams is above 65 kcfs (1,851 m^3/s) and before flow reductions begin in late September (Jeremy Baxter, pers. comm., 2018).

3.1.2 SPIN Adult NP Suppression

SPIN surveys on the LCR occurred in May over an 8-day period in the high-use NP areas identified during suppression efforts between 2014 and 2017: the Robson Reach (including the area between HLK Dam and Castlegar, B.C.); Kootenay River Oxbow; Waldies Island; and, Zuckerberg Island (Baxter and Lawrence 2018; Figure 2; Appendix A).

In total, 19 NP were removed during 367.4 gill-net hours of effort resulting in a catch-rate of 0.05 NP/hr during the 2018 LCR SPIN surveys (Table 3; Appendix B). Two of the three females captured were in spawning condition but had not yet spawned and one was immature. The majority of males were in spawning condition (n=12) and the remaining four were immature. The majority of NP captured had empty stomachs (n=13) and the contents of those that were full included Mountain Whitefish (*Prosopium williamsoni*), Redside Shiner (*Richardsonius balteatus*), dace (*Rhinichthys sp.*) and sculpin (*Cottus sp*.). Mountain Whitefish, ranging from 150-230 mm fork length, was the most common prey item and was observed in four of the full NP stomachs.

Table 3: Gill-net sampling effort and Northern Pike captured during Spring Index Netting (SPIN) surveys in the Lower Columbia and Kootenay rivers, 2018.

Dates (2018)	Hours of Net Effort	Northern Pike Captured			CPUE (NP/hr)	Length Range (mm)	Weight Range (g)
		Female	Male	Total			
May 9 - 12 and May 14 - 17	367.37	3	16	19	0.05	380-920	400-7700

*CPUE (catch-per-unit-effort) was calculated as the number of Northern Pike captured per hour of gill-net effort.

The majority of NP were removed from the Robson Reach (n=16) between RKm 4.6 and 7.3 (Figure 2). The remaining three were removed from the channel between Zuckerberg Island and the mainland at RKm 11.0. In general, one or two NP were captured per gill-net set. The exception was a gill-net set at RKm 4.6 on May 11, 2018 where five NP were captured on the same net. No NP were captured in the Kootenay Oxbow area (RKm 0.5-0.6) during SPIN surveys in 2018.

Included in the catch were four of the seven remaining NP that had been tagged with external Floy tags and internal Vemco Ltd. acoustic tags and released by Dan Doutaz (Thompson Rivers University, Master's Candidate) in 2016. Acoustic tags were recovered from two of the NP though their Floy tags had fallen out (Appendix B). Floy tags were recovered from the other two NP but acoustic tags were not retrieved from their body cavities (Appendix B). That means 11 of the 15 tagged and released NP have been recaptured and removed.

A total of 196 non-target fish were captured as bycatch during 2018 LCR SPIN surveys, with the majority (84%) being released alive (Table 4). No White Sturgeon were encountered.

Table 4: Bycatch captured during Northern Pike suppression surveys in the Lower Columbia and Kootenay rivers, 2018. Total capture numbers are provided with the number released alive in brackets.

Species	Latin Name	Gill-Net Sampling			Boat Electrofishing
		Spring	Summer	Fall	Fall
Bull Trout	*Salvelinus confluentus*	-	1 (0)	-	-
Eastern Brook Trout	*Salvelinus fontinalis*	1 (0)	-	-	-
Kokanee	*Oncorhynchus nerka*	-	-	-	3 (3)
Lake Whitefish	*Coregonus clupeaformis*	65 (57)	3 (3)	2 (2)	0 (0)
Longnose Dace	*Rhinichthys cataractae*	-	-	-	1 (1)
Mountain Whitefish	*Prosopium williamsoni*	38 (35)	3 (1)	21 (15)	11 (11)
Northern Pikeminnow	*Ptychocheilus oregonensis*	12 (11)	1 (1)	-	26 (26)
Peamouth Chub	*Mylocheilus caurinus*	10 (9)	-	-	-
Prickly Sculpin	*Cottus asper*	-	-	-	1 (1)
Rainbow Trout	*Onchorynchus mykiss*	34 (22)	5 (3)	5 (4)	10 (10)
Redside Shiner	*Richardsonius balteatus*	-	-	-	43 (43)
Smallmouth Bass	*Micropterus dolomieu*	-	-	1 (0)	-
Sucker sp.	*Catostomus sp.*	32 (30)	2 (1)	-	165 (165)
Walleye	*Sander vitreus*	4 (0)	1 (0)	-	5 (0)
White Sturgeon	*Acipenser transmontanus*	-	-	2 (2)	-
Yellow Perch	*Perca flavescens*	-	-	-	1 (0)

Notes: Spring = May 9-12 and 14-17 surveys; Summer = August 20-21 surveys; Fall = September 10-13 and October 17-18 surveys.

Each crew member spent approximately 1.5 hours per day angling during the SPIN surveys. Total angling effort was approximately 24 hours. No NP were captured by angling.

3.1.3 Adult NP Suppression in Other Areas of the LCR

Additional adult NP suppression activities were also conducted outside of the main suppression area (i.e., Robson Reach) as prioritized during the background information review (Section 3.1.1). Priority sites included areas at Genelle and near Trail (Section 3.1.1). Therefore, gill-net sampling was conducted near Genelle on August 20, 2018 and Trail on August 21, 2018 (Table 5, Figure 1, Appendix A). However, conditions downstream of Trail were not suitable to safely or effectively gill-net in this area, so an area upstream of Trail was sampled where one NP had been captured in 2013 and suitable habitat had been observed.

As outlined in Table 5, NP were not observed at the Genelle and Trail sampling locations within the 87.8 hours of total gill-net effort being expended.

A total of 16 non-target fish were captured as bycatch, 56% being released alive (Table 4). Waterfowl (n=2) were also captured and perished. No White Sturgeon were encountered.

Table 5: Gill-net sampling effort and Northern Pike captured in additional sites of the Lower Columbia River, 2018.

Location	Dates (2018)	Hours of Net Effort	Northern Pike Capture			CPUE (NP/hr)
			Female	Male	Total	
LCR - Genelle	20-Aug	54.72	0	0	0	0
LCR - Trail	21-Aug	33.31	0	0	0	0

*CPUE (catch-per-unit-effort) was calculated as the number of Northern Pike captured per hour of gill-net effort.

Boat electrofishing was also used on September 13, 2018 at Waterloo Eddy to investigate this additional area identified during the background information review (Section 3.1.1). However, NP were not observed during 586 electrofishing seconds expended, although suitable habitat was observed.

3.1.4 Juvenile NP Suppression

Juvenile suppression surveys focused on suspected spawning areas within the Robson Reach and locations where juveniles had previously been observed near the Kootenay River Oxbow (Appendix C, Photos 1 and 2) and Zuckerberg Island (Appendix A, Figure 2). LCR discharge conditions measured at Birchbank (Station Number 08NE049) ranged between 1,730 and 1,815 m^3/s (ECCC 2018) during these juvenile surveys (Section 3.1.1).

One juvenile was observed near the Kootenay River Oxbow outlet (RKm 0.5) on September 11, 2018 but it was not captured (Appendix C, Photo 2). No other juveniles were observed or captured during the targeted juvenile suppression sampling period.

However, eight NP adults, one of which was smaller and possibly spawned in 2017, were captured during these fall surveys (Table 6 and Table 7; Appendix B; Appendix C, Photo 3). Five adult NP were captured by boat electrofishing whereas three NP were captured during gill-netting (Table 6 and Table 7). Boat electrofishing resulted in an overall CPUE of 0.9 NP/electrofishing hour and the CPUE was higher in September than October (Table 7). Overall, gill-netting CPUE for both fall sessions was 0.04 NP/hr, similar to that during the 2018 SPIN surveys, and the CPUE was higher in September than October (Table 6). The majority of adult NP were captured in the Lower Kootenay River near the Kootenay River Oxbow outlet (RKm 0.3 to 0.6; n=5) during these fall sessions (Appendix B; Figure 2). Those captured in the LCR were from sites near the Millennium Park pedestrian bridge (RKm 10.4; n=2) and Pike Bay (RKm 5.0; n=1).

Table 6: Gill-net sampling effort and Northern Pike captured during juvenile suppression surveys in the Lower Columbia and Kootenay rivers, 2018.

Dates (2018)	Hours of Net Effort	Northern Pike Capture			CPUE (NP/ hr)	Length range (mm)	Weight range (g)
		Female	Male	Total			
Sep 12 - 13	55.02	1	2	3	0.05	460-985	800-7900
Oct 17 -18	14.87	0	0	0	0	-	-

*CPUE (catch-per-unit-effort) was calculated as the number of Northern Pike captured per hour of gill-net effort.

Table 7: Boat electofishing sampling effort and Northern Pike captured during juvenile suppression surveys in the Lower Columbia and Kootenay rivers, 2018.

Dates (2018)	Electrofishing Seconds	Northern Pike Capture			CPUE (NP/EF hr)	Length range (mm)	Weight range (g)
		Female	Male	Total			
Sep 10 - 13	10,035	2	2	4	1.43	565-775	1700-4200
Oct 17 -18	9,832	1	0	1	0.37	560	800

*CPUE (catch-per-unit-effort) was calculated as the number of Northern Pike captured per hour of boat electrofishing effort by converting effort from seconds to hours.

In total, 31 non-target fish were captured in gill nets and 299 were captured by boat electrofishing with live release rates of 74% and 95%, respectively (Table 4). White Sturgeon (n=2) were caught

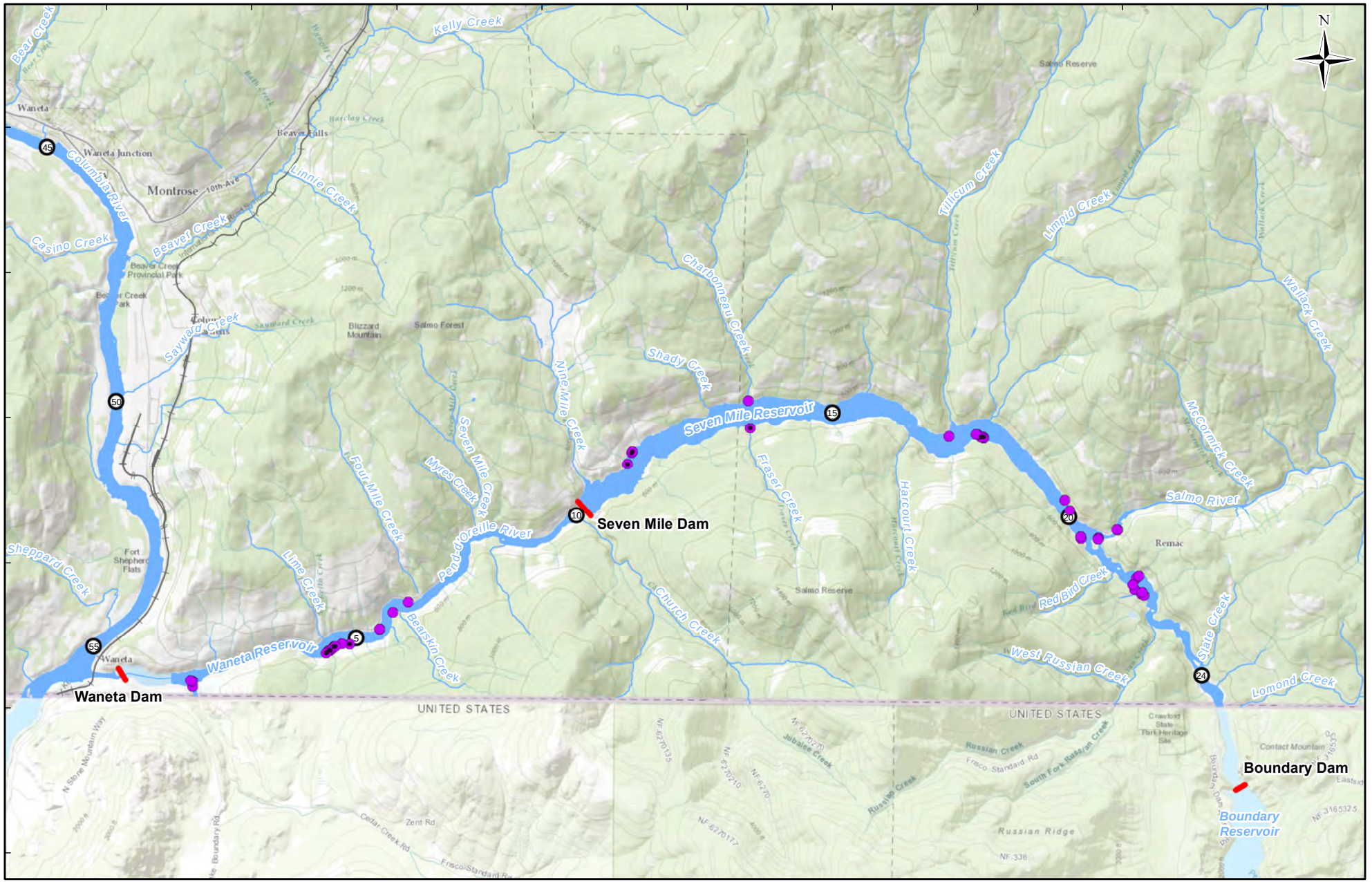
in gill nets on October 17 and 18, 2018. Both White Sturgeon were loosely caught in the gill-nets, easily released without being removed from the water, and they swam away immediately.

3.2 Pend d'Oreille River

3.2.1 Pend d'Oreille River Habitat Identification

A review of background information indicated that NP were initially captured in the Boundary Reservoir (WA, USA), the section of the Pend d'Oreille River immediately upstream of the Canadian portion, in 2007 and 2008 despite extensive sampling that occurred in 1999 (SCL 2010 as cited in AMEC 2015; Figure 3). Based on the various age classes captured, including YOY, the NP population may have been successfully reproducing by this time. Captures of NP in the Canadian portion of the Pend d'Oreille River were not documented until November 2012 when 3 NP were captured in Seven Mile Reservoir during boat electrofishing surveys (Westslope unpublished data 2012 as cited in AMEC 2015). Extensive sampling had also occurred in both Seven Mile and Waneta reservoirs from 1994-1995, but NP were not observed (R.L.&L. 1995 as cited in AMEC 2015).

More recently, AMEC (2015) compiled background information on NP observations and potential NP habitats for Seven Mile Reservoir during a desktop review. Sampling specifically targeting NP was conducted in Seven Mile and Waneta reservoirs by Dan Doutaz (Thompson Rivers University, Master's Candidate) between May 2016 and August 2017. It was noted that habitat availability and sampling success in both reservoirs was highly dependent on reservoir elevation that changed unpredictably and the numerous submerged snags created difficult gill-net sampling conditions in some areas (D. Doutaz, pers. comm., 2018).



Legend

- 5 Kilometer Marker
- Northern Pike Captured
- Gill Net Sample Location
- Dam
- Road
- Railway
- Watercourse
- Waterbody

0 1 2
Kilometers
Scale 1:90,000

References:
DataBC Data Distribution Service
Open Government License
(http://www.data.gov.bc.ca/)
Geogratis/Geobase
Open Government License - Canada
(http://data.gc.ca/eng/about-datagcca)

CLIENT: CBT and MFLNRORD

PROJECT: Northern Pike Suppression

TITLE: Pend d'Oreille River

DATE: February 14, 2019 | ANALYST: MY | QA/QC: CL

Figure 3

GIS FILE: 02-01-002_Pend_d_Oreille_River_landscape.mxd

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COORDINATE SYSTEM: NAD 1983 UTM Zone 11N

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Locations where adult NP or NP habitat have been identified in Seven Mile Reservoir include:

- Buckley's Campground (RKm 11.5) – Anglers have reported capturing NP at this location (AMEC 2015). One NP was captured on the left downstream bank at approximately 4 m depth in July 2016. However it was difficult to set gill-nets in suitable habitat on the left downstream bank due to public recreation (D. Doutaz, pers. comm., 2018).

- Fraser and Charbonneau creek outlet areas (RKm 13.5) – Four NP were captured in the area between June 2016 and August 2017 (D. Doutaz, pers. comm., 2018).

- Tillicum Creek confluence area (RKm 17.2 – 17.8) – Suitable NP habitat is present on both banks including the bay near the creek outlet on the right downstream bank and a shallow littoral area upstream of the creek outlet on the left downstream bank (AMEC 2015). This area had the highest capture rates during 2016 and 2017 gill-net surveys with 16 NP captured, mostly on the right downstream bank (D. Doutaz, pers. comm., 2018).

- Salmo River mouth (RKm 20.7) – Suitable NP habitat is present at the Salmo River confluence on the right downstream bank (AMEC 2015). One NP was captured in August 2017 and numerous large NP (>65 cm) were observed here in May 2017 (D. Doutaz, pers. comm., 2018).

- Shallow, littoral area (RKm 22) – Three NP were captured at this location in November 2012 during boat electrofishing surveys (Westslope unpublished data 2012 as cited in AMEC 2015) and three were captured by gill-nets in summer of 2016 and 2017 (D. Doutaz, pers. comm., 2018). Suitable NP habitat is present on the left downstream bank (AMEC 2015).

Locations where adult NP or NP habitat have been identified in Waneta Reservoir include:

- Bay 1 km upstream of Waneta Dam (RKm 2.0) – Three male NP were captured in a protected bay on the left downstream bank in May 2017 (D. Doutaz, pers. comm., 2018).

- Left downstream bank (RKm 4.0) – One NP was captured in June 2016 in a deep (> 4 m) area with submerged macrophytes. This area was noted to be a poor sampling location though a high prevalence of prey species were present (D. Doutaz, pers. comm., 2018).

- Right downstream bank near road (RKm 4.5) – Three NP were captured in late summer when aquatic vegetation was prevalent although habitat was not optimal during other seasons and a rapid shoreline drop-off was noted (D. Doutaz, pers. comm., 2018).

- Littoral area across from Waneta boat launch on left downstream bank (RKm 4.5 – 5) – This had the highest capture rates in Waneta Reservoir during June 2016 and May 2017 gill-net surveys with 32 NP captured. The presence of macrophyte beds and submerged woody debris was noted to provide suitable spawning habitat (D. Doutaz, pers. comm., 2018).

- Upstream of boat launch (RKm 5.5) – Three NP were captured between June 2016 and August 2017 on the right downstream bank (D. Doutaz, pers. comm., 2018).

3.2.2 SPIN Adult NP Suppression

SPIN suppression was conducted in the Pend d'Oreille River over a 5-day period between April 30 and May 4, 2018 (Table 8). Nets were set in potential NP habitat areas identified during the background information review or by the crew while in the field (Appendix A). In total, 308.4 gill-net hours were expended in the Pend d'Oreille River, 129.7 hours of which were spent in Seven Mile Reservoir and 178.7 in Waneta Reservoir, resulting in similar catch-rates between both reservoirs (Table 8; Appendix C, Photos 4 and 5). Water levels were high and turbid in both reservoirs and water level fluctuations observed in Waneta created challenging sampling conditions (Appendix C, Photo 6).

In total, 15 NP were removed from the Pend d'Oreille River, all of which were in spawning condition and captured females had not yet spawned (Appendix B). Seven NP were removed from Seven Mile Reservoir and 8 NP were removed from Waneta Reservoir (Table 8). NP, believed to be actively spawning, were removed at Buckley's Campground (Rkm 11.5) in Seven Mile Reservoir and across from the boat launch in Waneta Reservoir (Rkm 4.5). The majority of NP had empty stomachs (n=11) and the contents of those that were full included Yellow Perch (*Perca flavescens*), Northern Pikeminnow (*Ptychocheilus oregonensis*), suckers (*Catostomus sp*.), parasites and tapeworms. Yellow Perch were observed in two stomachs (130-180 mm fork length) while Northern Pikeminnow (365 mm fork length) and sucker species (200 mm) were each observed in one. Parasites were observed in stomachs of 11 NP; tapeworms were observed in one and the remaining 3 did not have either.

Table 8: Gill-net sampling effort and Northern Pike captured during Spring Index Netting (SPIN) surveys in the Pend d'Oreille River, 2018.

Location	Dates (2018)	Hours of Net Effort	Northern Pike Capture			CPUE (NP/hr)	Length Range (mm)	Weight Range (g)
			Female	Male	Total			
Seven Mile Reservoir	April 30 - May 1	129.72	1	6	7	0.05	600 - 860	1700 - 5600
Waneta Reservoir	May 2 - May 4	178.67	4	4	8	0.04	575 - 800	1600 - 5200

In general, one or two NP were captured at most gill-net set locations. The exception was a gill-net set at RKm 4.5 in Waneta Reservoir on May 2, 2018 where three NP were captured on the same net and another one NP was also captured on a net set 100 m upstream on the same day (Figure 3).

A total of 163 non-target fish were captured as bycatch, the majority (75%) of which were released alive (Table 9).

Table 9: Bycatch captured during Northern Pike suppression surveys in the Pend d'Oreille River, 2018. Total capture numbers are provided with the number released alive in brackets.

Species	Latin Name	Spring Gill-Net Sampling
Brown Trout	*Salmo trutta*	1 (0)
Bull Trout	*Salvelinus confluentus*	1 (1)
Mountain Whitefish	*Prosopium williamsoni*	2 (2)
Northern Pikeminnow	*Ptychocheilus oregonensis*	21 (17)
Peamouth Chub	*Mylocheilus caurinus*	2 (2)
Rainbow Trout	*Onchorynchus mykiss*	6 (3)
Sucker sp.	*Catostomus sp.*	117 (98)
Walleye	*Sander vitreus*	10 (0)
Yellow Perch	*Perca flavescens*	3 (0)

Each crew member spent approximately 1.5 hours per day angling during the SPIN surveys. Total angling effort was approximately 7.5 hours. No Northern Pike were captured by angling.

4.0 DISCUSSION

4.1 Columbia River

In total, 27 NP were removed from the LCR in 2018. Gill-nets were used to remove 22 NP while boat electrofishing was used to remove 5 NP. All NP were removed between RKm 4.4 and 11.0 in the LCR which includes the Robson Reach, Waldie's Island, Millenium Park and Zuckerberg Island areas and RKm 0.3 and 0.6 in the Lower Kootenay River which includes the Kootenay River Oxbow outlet area. Similar to previous years, the majority of NP were removed from the Robson Reach during SPIN surveys (Baxter and Neufeld 2015; Baxter 2016; Baxter and Doutaz 2017; Baxter and Lawrence 2018). CPUE during 2018 SPIN surveys increased slightly from 2017 SPIN surveys but remained lower than during 2014-2016 SPIN suppression efforts and 88% lower than when suppression began in 2014 (Table 10). Similarities in the catch-rate between 2017 and 2018 suggest the level of effort expended during consistent mechanical suppression is maintaining lower numbers of NP compared to initial years of NP removal. SPIN CPUE is used to track the persistence of NP populations during suppression programs in adjacent watersheds including Lake Roosevelt and Box Canyon Reservoir in the Pend d'Oreille River (Amec Foster Wheeler 2017).

Table 10: Number of Northern Pike (NP) removed and catch-per-unit-effort (CPUE) during Spring Index Gill-Net (SPIN) suppression in the Lower Columbia River, 2014-2018. Results from 2014 to 2017 were compiled from data reported by Baxter and Lawrence (2018).

Year	NP Total	CPUE (NP/hr)	CPUE (NP/8hr net)
2014	92	0.44	3.48
2015	85	0.19	1.52
2016	49	0.13	1.02
2017	18	0.04	0.33
2018	19	0.05	0.41

Adult NP were also caught during fall gill-netting (n=3) and boat electrofishing surveys (n=5) targeting potential locations of juvenile NP habitat. The CPUE for both methods was higher in September than in October and the gill-netting CPUE in September was the same as that observed during 2018 SPIN surveys (0.05 NP/hr). Baxter and Neufeld (2015) found CPUE in spring 2014 was double and quadruple what it was in summer and fall, respectively, which differs from the 2018 observation. The majority of adults removed in the fall were located near the Kootenay River mouth (n=7 of 8) while in the spring the majority were in the Robson Reach (n=16 of 19). Telemetry studies conducted by Thompson Rivers University found NP that left the Robson Reach and migrated to the Kootenay River mouth, likely to feed on pre-spawning Mountain Whitefish, would return to the Robson Reach during the spring spawning period (Doutaz, in prep). Future suppression efforts could continue to exploit these observations and focus seasonal suppression where the highest number of NP removals have occurred during previous sampling.

Northern Pike were not captured in previously un-surveyed areas of the LCR downstream of Castlegar as well as near Genelle and Trail in 2018 though areas of suitable habitat were

observed. In 2014, gill-net sampling was also conducted between Beaver Creek and the Pend d'Oreille River outlet and no NP were captured (Baxter and Neufeld 2015). These results coupled with those of previous suppression and research programs support the suggestion that the Robson Reach to Kootenay River confluence area is the primary location exploited by non-native NP in the LCR study area (Amec Foster Wheeler 2017). However, un-surveyed areas remain downstream of Trail and additional assessment targeting these locations could further support these findings.

Recapture of four tagged NP released in 2016 provides an idea of the growth-rates of the NP in the LCR. At recapture two years after tagging, fork length had increased by an average of 191 mm (135 – 240 mm) and weight increased by 3,385 g (1,580 – 5,080) (unpublished data provided by D. Doutaz). Length-at-age data collected from the Columbia River study area suggests growth rates are similar in both U.S. and Canadian sections of the Columbia River (Doutaz, in prep; Lee and King 2015). Growth-rates are high compared with other regional populations and researchers have suggested this may be the result of the availability of abundant high-quality prey, the exploitation of the prey base by a new apex predator and relatively low densities of NP as they become established in new areas (Lee and King 2015 and references cited therein).

An annual population estimate was generated during the initial four years of this study based initially on 30 NP captured and released with Passive Integrated Transponder (PIT) tags by MFLNRORD and Golder Associates in 2013 and then incorporating 15 NP that were affixed with internal acoustic tags and external Floy tags in early 2016. The annual population estimate generated declined from a high of 725 (95%CI 478-2,759) in 2014 to 99 (95%CI 25-172) in 2017 (Baxter and Lawrence 2018). The authors acknowledged this was not a precise evaluation because a main assumption of the Lincoln-Peterson method, that the study area is a closed system, was violated. The migration of one NP out of the study area during a concurrent telemetry study in 2017 (Section 3.1.1) suggests tagged fish may have left the study area. A second assumption of the Lincoln-Peterson method, that individuals do not lose marks between the two sampling periods, was also violated because Floy tag loss was observed from two sonic tagged NP recaptured in 2018. Therefore, a mark-recapture population estimate could not be completed presently and comparisons to monitor the status of the NP population in the LCR is based on SPIN CPUE. As mentioned above, SPIN CPUE is used to track the persistence of NP populations during suppression programs in recently invaded areas (Amec Foster Wheeler 2017).

One juvenile NP was observed near the Kootenay River Oxbow outlet in early fall 2018 but juveniles were not directly captured via boat electrofishing or gill-netting during the present study even though specific habitats and previous capture locations were targeted. In addition, it was observed that discharge above 1,851 m^3/s (as measured at Birchbank) may provide more opportunities to capture juvenile NP (Section 3.1.1) and when surveys commenced on September 10, 2018, LCR discharge was 1,740 m^3/s, having been unexpectedly decreased from approximately 2,000 m^3/s two days prior (ECCC 2018). At this discharge, the Kootenay River Oxbow inlet was disconnected from mainstem flow and areas where juvenile NP were captured on September 13, 2017 when discharge was approximately 2,190 m^3/s were not wetted during the 2018 surveys. Similarly, the inlet and outlet to the backwater channel beside Zuckerberg Island, which has similar habitat to the Kootenay River Oxbow, were also disconnected during 2018 juvenile surveys. Future juvenile surveys may be more successful when discharge as measured at Birchbank is closer to 2,200 m^3/s and wetted areas are similar to what was observed in 2017 (ECCC 2018).

Previous attempts to capture juvenile NP in the LCR study area have included the use of various techniques with limited results. The Castlegar and District Wildlife Association in collaboration with Golder Associates Ltd., the West Kootenay Fly Fishing Association and the 10th Avenue Volunteers attempted to collect larval NP in June and July 2015. Backpack electrofishing, dip netting, beach seining, plankton towing, minnow trapping and light trapping were used day and night within the Robson Reach and no NP were captured (Golder 2015). The Okanagan Nation Alliance (ONA) used fyke and seine nets during spring and summer 2016 resulting in the capture of one YOY NP (12.5 cm fork length, 11.8 g) by fyke net on July 27 (ONA 2016). To date, the most successful removal of juvenile NP occurred in September 2017 following the observation of YOY NP (n=32) in the Kootenay River Oxbow. Two days of gill-netting using 2.5 cm mesh captured 14 of the observed juveniles (Baxter and Lawrence 2018). Overall, juvenile NP capture has been less successful in the Canadian section of the Columbia River compared with the U.S. though similar methods have been employed. While juveniles have been captured confirming that spawning in the LCR is successful, juvenile capture is rare, and the limited suitable habitat available may not support the abundance of rearing juveniles observed downstream.

Concurrent suppression programs in the LCR study area were undertaken by the ONA in 2018. No NP were captured during one day of gill-netting and one day of electrofishing in the LCR study area (Amy Duncan, Biologist, ONA, pers. comm., 2018). The Northern Pike Bounty Program that awarded anglers with $10 per NP head had a return of four NP heads (A. Duncan, pers. comm., 2019). Finally, two NP were captured during BC Hydro's LCR Fish Population Indexing Surveys (CLBMON-45) and euthanized (A. Duncan, pers. comm., 2019).

In total, LCR Northern Pike suppression programs have removed 405 NP from the LCR study area since 2014. Downstream in Lake Roosevelt, approximately 8,051 NP have been removed since suppression began in 2015. As of October, 2,021 NP had been removed during 2018 suppression efforts and 509 had been removed by the Colville Tribes' angler reward program (Brent Nichols, Spokane Tribe of Indians, Fisheries Manager, pers. comm. 2018). Spawning areas have been identified in the Kettle and Colville rivers and in Lake Roosevelt near the community of Evans north of Kettle Falls, Washington (Harrison 2018). The fisheries co-managers of Lake Roosevelt are concerned about downstream migration of NP below Grand Coulee Dam and into habitat areas that overlap with anadromous pacific salmon.

4.2 Pend d'Oreille River

In total, 15 NP (5 females and 10 males) were removed from the Pend d'Oreille River during spring 2018. The 15 NP were captured during 308.4 hours of gill-netting, resulting in an overall CPUE of 0.05 NP/net hour. In total, 163 fish were caught as bycatch in 2018 of which 123 were released alive (75.5%).

In Seven Mile Reservoir, NP (n=7) were captured at three separate areas located at RKm 11.3 to 11.5 on the north bank, Rkm 13.5 on the south bank and Rkm 17.8 on the south bank. Although gill-net sampling was conducted upstream of Rkm 17.8 to 22.0 including areas in and around the Salmo River mouth, no NP were captured in 2018. In the Waneta Reservoir, all NP (n=8) were captured in an approximately 500 m section of the reservoir (RKm 4.4 to 4.9) on the south bank. Catch-rates were similar between Seven Mile and Waneta reservoirs (0.5 NP/hr and 0.4 NP/hr, respectively) and were also similar to SPIN catch-rates in the LCR study area (0.5 NP/hr). Suitable spawning habitat areas were targeted during the 2018 gill-net suppression surveys, but these areas were limited in both reservoirs. Unpredictable water level fluctuations created difficult

sampling conditions and poor water clarity hid submerged snags from vision but these conditions were expected based on previous sampling (D. Doutaz, pers. comm., 2017). Despite the difficult sampling conditions, NP were captured and removed primarily at locations identified during the background information review (Section 3.2.1).

A concurrent suppression program in the Pend d'Oreille River was undertaken by the ONA in 2018 and no NP were captured during three days of gill-netting (Amy Duncan, Biologist, Okanagan Nation Alliance, pers. comm., 2018).

In Boundary Reservoir and Box Canyon Reservoir, upstream of the Canadian section of the Pend d'Oreille River, NP suppression occurs annually throughout March and April (e.g. WDFW 2018). Although the current program was conducted during the first week of May, the timing was suitable because female NP captured had not yet spawned. In the future, suppression surveys could be conducted earlier to be consistent with upstream suppression programs and to avoid the onset of freshet and associated difficulties including poor water clarity and runoff debris.

4.3 Summary of Northern Pike Control Actions

A summary of NP control actions is provided in Table 11. Control actions used in the Columbia River study area have included changes to angling regulations, angler incentive programs, education programs, gill-netting surveys, angling, boat electrofishing surveys, quatrefoil light trapping and habitat reduction programs. Similar strategies have been used in the U.S. section of the Columbia River (Amec Foster Wheeler 2017). In the Pend d'Oreille study area, gill-netting surveys and angling are the only control actions that have been used.

Table 11: Summary of Northern Pike control actions that may support suppression outcomes in the Lower Columbia River (LCR) and Pend d'Oreille River (PDO) study areas.

Control Method	Overall Effectiveness	Potential Towards Supporting Suppression Outcomes	Additional Information
Angler education/awareness programs	Difficult to measure effectiveness. Researchers have identified that the prevention of illegal human transport and education is key. Ongoing programs including Clean, Drain, Dry and Don't Let it Loose.	LCR – High. PDO – High.	Amec Foster Wheeler 2017; Carim et al. 2018
Angler incentive/reward programs	Limited effectiveness in LCR. Low angler returns during two reward programs in LCR. Has been more effective in Lake Roosevelt. Potential benefit with respect to angler education. Increased risk of illegal human transport.	LCR – Low. PDO – Low.	Amec Foster Wheeler 2017; Harrison 2018
Boat electrofishing – juveniles/adults	Effective for capture of juveniles in shallow, nearshore areas during the day. Effectiveness dependent on habitat and water conditions (e.g., reservoir elevation). For example, in Lake Roosevelt method effectiveness was moderate to high, whereas in Box Canyon (PDO) effectiveness was low. May also be effective for adults based on 2018 capture results.	LCR – High. Trialed in 2018 and successfully captured adults; no juveniles were captures. PDO – Moderate. Suitable habitat areas are limited and can be targeted.	Amec Foster Wheeler 2017
Full or partial barrier net - forebay of Waneta, Seven Mile or Boundary dams	Effective for prevention of downstream migration, assuming upstream populations are self-sustaining. Nets at Boundary Dam may reduce immigration to Seven Mile Reservoir. However, does not control existing populations within Seven Mile Reservoir. Mesh size, net construction, and local environmental conditions will influence effectiveness. Costs may be prohibitive.	LCR – Not applicable. PDO - Low. Emigration rates from Boundary Reservoir are unknown and 2018 catch-rates in PDO were low. Significant effort and cost.	AMEC 2015
Gill-net suppression	Highly effective. Direct examples of gill-net suppression reducing the prevalence of NP in Columbia and PDO watersheds. Can target seasonal high-use habitats to maximize catch and limit impacts to non-target species.	LCR – High. Successfully used to reduce prevalence of NP in LCR. PDO – High. Initial use in 2018 was successful. Suitable habitat is limited and can be targeted.	Amec Foster Wheeler 2017

Control Method	Overall Effectiveness	Potential Towards Supporting Suppression Outcomes	Additional Information
Guidance or collection nets - forebay of Waneta, Seven Mile or Boundary dams	Effective for prevention of downstream migration, assuming upstream populations are self-sustaining. Moderate effectiveness for controlling populations within Seven Mile Reservoir. Costs may be prohibitive.	LCR – Not applicable. PDO – Low. Emigration rates from Boundary Reservoir are unknown and 2018 catch-rates in PDO were low. Significant effort and cost.	AMEC 2015
Habitat reduction – aquatic vegetation control	Variable effectiveness. Removing vegetative cover has resulted in lower NP survival and production in some systems. High costs include multiple treatments of physical removal or use of an herbicide to kill vegetation. Detailed vegetation mapping required prior to implementation. Benthic barriers and scuba diver hand-removal was trialed in LCR in 2017 (Golder and ONA 2019). Immediate benefits of both methods recorded and benthic barriers were more cost effective; long-term success not evaluated.	LCR – Low to Moderate. Results of 2017 trial were “promising” (CKISS 2018). Significant effort and cost. PDO – Low. Significant effort and cost.	Golder and ONA 2019; CKISS 2018; Franklin and Smith 1963
Habitat reduction – modification of reservoir operations to reduce critical habitat areas (e.g., spawning habitat)	Moderate to high effectiveness, depending on frequency and coverage. Detailed assessment to determine drawdown zone requirements. May require salvage of native fish species. Extensive regulatory and operation approvals may be required. Operational costs may be prohibitive.	LCR – Low. PDO – Moderate. Evaluation suggests spawning habitat is limited and could be targeted.	AMEC 2015
Non-physical barriers – low voltage fish guidance systems, acoustic fish deterrents, strobe light deterrents and bubble curtains	Variable effectiveness. Studies specifically targeting NP are limited. Multiple technologies often used together for increased effectiveness. Potential to prevent movement of NP through HLK navigation lock and colonization of Arrow Lakes. High cost for implementation and there are significant considerations for deployment in public access waterways.	LCR – Moderate. Significant effort and cost. PDO – Low. Significant effort and cost. Generally not effective for controlling downstream movement.	Parasiewicz *et al.* 2016; Weber *et al.* 2016; Gross *et al.* 2013; U.S. Army Corps of Engineers 2013; Noatch & Suski 2012
Quatrefoil light trapping - juveniles	Effective for capture of juvenile NP in nursery habitat. Identification of nursey habitat required to be effective. Survey timing is important as method targets small (<100 mm) larval life stages. Trialed unsuccessfully in LCR in 2015.	LCR – Moderate. Could be used near spawning habitats in the Robson Reach over a longer time period than 2015 trials. PDO – Moderate. Suitable habitat areas are limited and can be targeted.	Golder 2015; Pierce *et al.* 2006

At this time, annual gill-net suppression surveys targeting NP habitat appear to be an effective means of maintaining low catch-rates in the Columbia River watershed and future suppression programs should prioritize the use of this method. Boat electrofishing has also proven to be a successful means of removing NP and is a suitable supplemental technique to use during future suppression programs. If catch-rates increase, other methods such as quatrefoil light trapping, non-physical barriers, aquatic vegetation removal and modification of reservoir operation to reduce suitable habitat (Table 11) could be considered.

5.0 RECOMMENDATIONS

1. Conduct annual Northern Pike SPIN suppression in the Columbia River study area over a 10-day period in May in areas with suitable habitat between the Robson Reach and the Kootenay River confluence.
2. Conduct late-summer Northern Pike suppression in the Columbia River study area targeting juvenile habitat using methods including boat electrofishing and/or gill netting. Targeting surveys when LCR discharge is near 2,200 m^3/s could provide access to habitats where juveniles have previously been observed.
3. Investigate suitable habitat areas near Trail (Rkm 44) and Beaver Creek (Rkm 48) that have not previously been targeted for NP removal.
4. Conduct annual Northern Pike SPIN suppression in the Pend d'Oreille River study area in April. Future suppression efforts should target suitable habitat areas identified in 2018.
5. Trial late-summer Northern Pike suppression in the Pend d'Oreille study area targeting juvenile habitat using methods including boat electrofishing and/or gill netting.

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Appendix A

Survey Data

Table A1. Northern Pike suppression gill-net survey data for Pend d'Oreille and Columbia river study areas, 2018.

Sample ID	Location[1]	River Km	Set Date	Set Time	Pull Date	Pull Time	Total Time[2]	Hours of Effort	Water Temp (°C)	Depth (m)		UTM		Comments
										Min	Max	Easting	Northing	
GN1	SEV	20.63	30-Apr-18	9:38	30-Apr-18	12:03	2:25	2.42	9.5	1.00	6.00	472071	5430426	
GN2	SEV	20.65	30-Apr-18	9:43	30-Apr-18	12:14	2:31	2.52	9.5	1.20	6.25	472065	5430404	
GN3	SEV	20.71	30-Apr-18	9:46	30-Apr-18	12:24	2:38	2.63	9.5	0.25	5.50	472402	5430559	Salmo River mouth
GN4	SEV	20.70	30-Apr-18	9:50	30-Apr-18	12:30	2:40	2.67	9.5	0.30	6.00	472392	5430565	Salmo River mouth
GN5	SEV	20.38	30-Apr-18	9:57	30-Apr-18	12:37	2:40	2.67	9.5	1.10	4.00	471778	5430412	
GN6	SEV	20.36	30-Apr-18	10:01	30-Apr-18	12:46	2:45	2.75	9.5	5.00	10.00	471770	5430447	Deep set
GN7	SEV	19.91	30-Apr-18	10:04	30-Apr-18	12:55	2:51	2.85	9.5	1.00	3.00	471580	5430899	
GN8	SEV	19.72	30-Apr-18	10:11	30-Apr-18	13:05	2:54	2.9	9.5	0.90	5.00	471496	5431079	
GN9	SEV	21.80	30-Apr-18	13:15	30-Apr-18	15:25	2:10	2.17	9.5	0.80	3.00	472699	5429528	
GN10	SEV	21.69	30-Apr-18	13:20	30-Apr-18	15:35	2:15	2.25	9.5	0.50	1.80	472729	5429735	
GN11	SEV	21.71	30-Apr-18	13:23	30-Apr-18	15:39	2:16	2.27	9.5	0.25	1.75	472769	5429769	
GN12	SEV	21.95	30-Apr-18	13:26	30-Apr-18	15:43	2:17	2.28	9.5	0.25	1.50	472817	5429450	
GN13	SEV	21.99	30-Apr-18	13:34	30-Apr-18	15:44	2:10	2.17	9.5	0.50	1.65	472859	5429430	
GN14	SEV	21.93	30-Apr-18	13:39	30-Apr-18	15:46	2:07	2.12	9.5	0.90	2.00	472825	5429485	
GN15	SEV	21.68	30-Apr-18	13:48	30-Apr-18	15:53	2:05	2.08	9.5	0.25	7.50	472666	5429621	
GN16	SEV	21.68	30-Apr-18	13:51	30-Apr-18	15:55	2:04	2.07	9.5	0.50	2.00	472666	5429621	
GN17	SEV	17.87	30-Apr-18	16:09	01-May-18	9:32	17:23	17.38	9.5	0.60	1.25	470103	5432143	Overnight set
GN18	SEV	17.86	30-Apr-18	16:14	01-May-18	9:18	17:04	17.07	9.5	0.50	1.50	470088	5432160	Overnight set
GN19	SEV	17.83	30-Apr-18	16:16	01-May-18	9:02	16:46	16.77	9.5	0.50	1.70	470057	5432163	Overnight set
GN20	SEV	11.30	01-May-18	8:33	01-May-18	14:20	5:47	5.78	10	0.25	6.00	463968	5431701	
GN21	SEV	11.50	01-May-18	8:37	01-May-18	14:55	6:18	6.3	10	0.25	4.50	464044	5431891	
GN22	SEV	11.52	01-May-18	8:39	01-May-18	14:36	5:57	5.95	10	0.25	4.60	464055	5431918	
GN23	SEV	13.57	01-May-18	8:47	01-May-18	13:49	5:02	5.03	10	0.50	5.00	466048	5432784	
GN24	SEV	13.52	01-May-18	8:51	01-May-18	14:04	5:13	5.22	10	0.25	5.50	466082	5432315	
GN25	SEV	17.72	01-May-18	9:40	01-May-18	13:25	3:45	3.75	10	0.50	2.50	469997	5432199	
GN26	SEV	17.70	01-May-18	9:42	01-May-18	13:29	3:47	3.78	10	0.30	5.00	469969	5432205	
GN27	SEV	17.22	01-May-18	9:45	01-May-18	13:37	3:52	3.87	10	0.25	5.00	469503	5432174	
GN28	WAN	6.23	02-May-18	8:43	02-May-18	13:17	4:34	4.57	10.5	0.25	6.00	460192	5429313	Parallel to bank - snagged
GN29	WAN	5.90	02-May-18	8:49	02-May-18	13:42	4:53	4.88	10.5	0.90	2.10	459930	5429138	Parallel to bank
GN30	WAN	5.48	02-May-18	8:52	02-May-18	Lost	-	-	10.5	0.60	1.80	459704	5428844	Perpendicular to bank - drifted into current with increase of water levels and was unretrievable
GN31	WAN	5.49	02-May-18	8:56	02-May-18	13:58	5:02	5.03	10.5	0.50	1.95	459703	5428854	Parallel to bank
GN32	WAN	4.87	02-May-18	9:00	02-May-18	14:08	5:08	5.13	10.5	0.45	5.10	459191	5428593	Perpendicular to bank
GN33	WAN	4.73	02-May-18	9:03	02-May-18	14:17	5:14	5.23	10.5	0.25	1.40	459054	5428598	Parallel to bank
GN34	WAN	4.58	02-May-18	9:06	02-May-18	14:25	5:19	5.32	10.5	0.25	7.50	458913	5428547	Perpendicular to bank
GN35	WAN	4.48	02-May-18	9:09	02-May-18	14:49	5:40	5.67	10.5	0.25	2.50	458854	5428484	Parallel to bank
GN36	WAN	1.99	03-May-18	9:00	03-May-18	13:42	4:42	4.7	9.5	0.50	15.00	456485	5427862	
GN37	WAN	2.00	03-May-18	9:03	03-May-18	13:48	4:45	4.75	9.5	0.50	7.50	456486	5427957	

Sample ID	Location[1]	River Km	Set Date	Set Time	Pull Date	Pull Time	Total Time[2]	Hours of Effort	Water Temp (°C)	Depth (m)		UTM		Comments
										Min	Max	Easting	Northing	
GN38	WAN	1.97	03-May-18	9:05	03-May-18	13:55	4:50	4.83	9.5	0.25	13.00	456451	5427967	
GN39	WAN	4.46	03-May-18	9:12	03-May-18	14:08	4:56	4.93	9.5	0.15	3.50	458824	5428482	
GN40	WAN	4.44	03-May-18	9:15	03-May-18	14:01	4:46	4.77	9.5	0.15	2.90	458806	5428463	
GN41	WAN	4.52	03-May-18	9:18	03-May-18	14:14	4:56	4.93	9.5	0.80	5.00	458882	5428508	
GN42	WAN	4.44	03-May-18	14:05	04-May-18	9:05	19:00	19	9.5	0.15	2.90	458806	5428463	Overnight set
GN43	WAN	4.46	03-May-18	14:10	04-May-18	9:15	19:05	19.08	9.5	0.15	3.50	458824	5428482	Overnight set
GN44	WAN	4.52	03-May-18	14:20	04-May-18	9:22	19:02	19.03	9.5	0.80	5.00	458882	5428508	Overnight set
GN45	WAN	4.42	03-May-18	14:22	04-May-18	8:50	18:28	18.47	9.5	0.90	2.10	458785	5428443	Overnight set
GN46	WAN	4.57	03-May-18	14:25	04-May-18	9:30	19:05	19.08	9.5	0.75	5.60	458900	5428532	Overnight set
GN47	WAN	4.61	03-May-18	14:29	04-May-18	9:45	19:16	19.27	9.5	0.50	6.00	458935	5428556	Overnight set
GN48	LCR	7.26	09-May-18	9:55	09-May-18	14:37	4:42	4.7	8.8	0.75	5.00	450745	5464594	
GN49	LCR	7.21	09-May-18	10:01	09-May-18	14:49	4:48	4.8	8.8	0.55	6.10	450695	5464581	
GN50	LCR	7.11	09-May-18	10:03	09-May-18	14:52	4:49	4.82	8.8	0.45	5.80	450608	5464572	
GN51	LCR	7.05	09-May-18	10:10	09-May-18	14:05	3:55	3.92	8.8	0.55	3.80	450550	5464574	
GN52	LCR	6.73	09-May-18	10:13	09-May-18	15:04	4:51	4.85	8.8	0.25	3.45	450219	5464278	
GN53	LCR		09-May-18	10:17	09-May-18	15:10	4:53	4.88	8.8	0.25	6.95	450330	5464265	
GN54	LCR	6.85	09-May-18	10:19	09-May-18	15:16	4:57	4.95	8.8	0.35	8.10	450364	5464263	
GN55	LCR	6.90	09-May-18	10:21	09-May-18	15:33	5:12	5.2	8.8	0.40	7.00	450416	5464249	
GN56	LCR	6.39	10-May-18	8:41	10-May-18	15:07	6:26	6.43	8.8	0.50	7.00	449883	5464371	
GN57	LCR	6.35	10-May-18	8:45	10-May-18	15:11	6:26	6.43	8.8	0.40	4.10	449840	5464384	
GN58	LCR	6.32	10-May-18	8:49	10-May-18	15:15	6:26	6.43	8.8	0.35	2.20	449806	5464376	
GN59	LCR	6.27	10-May-18	8:53	10-May-18	15:23	6:30	6.5	8.8	0.40	2.30	449759	5464397	
GN60	LCR	6.17	10-May-18	8:57	10-May-18	15:33	6:36	6.6	8.8	0.50	2.85	449666	5464450	
GN61	LCR	6.11	10-May-18	9:00	10-May-18	15:41	6:41	6.68	8.8	0.40	3.30	449611	5464473	
GN62	LCR	5.97	10-May-18	9:02	10-May-18	15:49	6:47	6.78	8.8	0.30	2.10	449479	5464529	
GN63	LCR	5.99	10-May-18	9:05	10-May-18	15:59	6:54	6.9	8.8	0.20	2.80	449503	5464536	
GN64	LCR	4.83	11-May-18	8:43	11-May-18	15:36	6:53	6.88	9	0.50	7.00	448394	5464859	
GN65	LCR	4.79	11-May-18	8:47	11-May-18	15:41	6:54	6.9	9	0.40	5.10	448361	5464882	
GN66	LCR	4.78	11-May-18	8:49	11-May-18	15:51	7:02	7.03	9	0.20	5.90	448342	5464880	
GN67	LCR	4.77	11-May-18	8:52	11-May-18	16:01	7:09	7.15	9	0.40	4.70	448327	5464873	
GN68	LCR	4.72	11-May-18	8:54	11-May-18	16:09	7:15	7.25	9	0.25	5.10	448290	5464899	
GN69	LCR	4.68	11-May-18	8:57	11-May-18	16:13	7:16	7.27	9	0.60	3.20	448247	5464909	
GN70	LCR	4.63	11-May-18	8:59	11-May-18	16:17	7:18	7.3	9	0.60	4.40	448198	5464929	
GN71	LCR	3.96	11-May-18	9:04	11-May-18	16:20	7:16	7.27	9	1.00	2.60	447566	5465095	
GN72	LCR	5.74	12-May-18	8:29	12-May-18	13:01	4:32	4.53	8.8	0.25	4.50	449250	5464572	
GN73	LCR	5.69	12-May-18	8:33	12-May-18	13:06	4:33	4.55	8.8	0.40	7.00	449208	5464585	
GN74	LCR	5.65	12-May-18	8:37	12-May-18	13:09	4:32	4.53	8.8	0.50	7.90	449171	5464598	
GN75	LCR	5.64	12-May-18	8:39	12-May-18	13:16	4:37	4.62	8.8	0.45	6.10	449154	5464591	
GN76	LCR	5.55	12-May-18	8:43	12-May-18	13:22	4:39	4.65	8.8	0.35	5.10	449062	5464616	
GN77	LCR	5.41	12-May-18	8:50	12-May-18	13:29	4:39	4.65	8.8	0.50	7.10	448935	5464675	

Sample ID	Location[1]	River Km	Set Date	Set Time	Pull Date	Pull Time	Total Time[2]	Hours of Effort	Water Temp (°C)	Depth (m)		UTM		Comments
										Min	Max	Easting	Northing	
GN78	LCR	5.28	12-May-18	8:55	12-May-18	13:39	4:44	4.73	8.8	0.35	5.90	448823	5464729	
GN79	LCR	5.21	12-May-18	8:59	12-May-18	13:45	4:46	4.77	8.8	0.40	7.90	448761	5464766	
GN80	LCR	7.21	14-May-18	9:36	14-May-18	15:11	5:35	5.58	11	0.50	4.00	450695	5464590	
GN81	LCR	7.12	14-May-18	9:38	14-May-18	15:18	5:40	5.67	11	0.40	4.90	450617	5464576	
GN82	LCR	6.97	14-May-18	9:40	14-May-18	15:23	5:43	5.72	11	0.50	3.60	450467	5464578	
GN83	LCR	6.95	14-May-18	9:42	14-May-18	15:30	5:48	5.8	11	0.40	3.00	450448	5464573	
GN84	LCR	6.73	14-May-18	9:56	14-May-18	15:56	6:00	6	11	0.20	6.10	450236	5464282	
GN85	LCR	6.73	14-May-18	9:58	14-May-18	15:51	5:53	5.88	11	0.35	2.90	450245	5464262	
GN86	LCR	6.79	14-May-18	10:01	14-May-18	15:45	5:44	5.73	11	0.35	6.00	450304	5464265	
GN87	LCR	6.86	14-May-18	10:05	14-May-18	15:36	5:31	5.52	11	0.50	7.10	450372	5464253	
GN88	LCR	8.83	15-May-18	8:45	15-May-18	15:45	7:00	7	9.5	0.50	1.10	452475	5464698	
GN89	LCR	8.82	15-May-18	8:49	15-May-18	15:35	6:46	6.77	9.5	0.50	1.10	452455	5464718	
GN90	LCR	8.89	15-May-18	8:51	15-May-18	15:29	6:38	6.63	9.5	0.50	1.30	452532	5464675	
GN91	LCR	8.91	15-May-18	8:55	15-May-18	15:27	6:32	6.53	9.5	0.50	1.50	452545	5464678	
GN92	LCR	8.95	15-May-18	8:59	15-May-18	15:22	6:23	6.38	9.5	0.50	1.90	452570	5464633	
GN93	LCR	8.97	15-May-18	9:02	15-May-18	15:17	6:15	6.25	9.5	0.80	2.10	452583	5464593	
GN94	LCR	8.99	15-May-18	9:07	15-May-18	15:12	6:05	6.08	9.5	1.00	2.20	452600	5464581	
GN95	LCR	9.02	15-May-18	9:10	15-May-18	15:09	5:59	5.98	9.5	1.00	2.70	452618	5464556	
GN96	LCR	4.61	16-May-18	8:40	16-May-18	15:43	7:03	7.05	10	0.50	4.50	448180	5464936	
GN97	LCR	4.62	16-May-18	8:43	16-May-18	15:38	6:55	6.92	10	0.50	5.50	448194	5464930	
GN98	LCR	4.63	16-May-18	8:47	16-May-18	15:33	6:46	6.77	10	0.60	3.60	448199	5464919	
GN99	LCR	4.64	16-May-18	8:51	16-May-18	15:25	6:34	6.57	10	0.60	4.20	448213	5464912	
GN100	LCR	4.69	16-May-18	8:54	16-May-18	15:21	6:27	6.45	10	0.50	3.60	448255	5464905	
GN101	LCR	4.74	16-May-18	8:59	16-May-18	15:15	6:16	6.27	10	0.40	5.00	448304	5464893	
GN102	LCR	4.78	16-May-18	9:02	16-May-18	15:09	6:07	6.12	10	0.40	5.25	448344	5464878	
GN103	LCR	4.82	16-May-18	9:05	16-May-18	15:04	5:59	5.98	10	0.30	6.10	448379	5464866	
GN104	LCR	10.58	17-May-18	8:31	17-May-18	13:15	4:44	4.73	10.8	1.00	4.20	452357	5463007	
GN105	LCR	10.58	17-May-18	8:33	17-May-18	13:09	4:36	4.6	10.8	1.00	4.10	452406	5462993	
GN106	LCR	10.97	17-May-18	8:38	17-May-18	13:04	4:26	4.43	10.8	1.00	2.70	452163	5462704	
GN107	LCR	11.01	17-May-18	8:41	17-May-18	12:58	4:17	4.28	10.8	0.50	3.90	452176	5462652	
GN108	LCR	11.03	17-May-18	8:43	17-May-18	12:43	4:00	4	10.8	1.00	3.80	452207	5462619	
GN109	LKR	0.57	17-May-18	8:49	17-May-18	12:33	3:44	3.73	10.8	0.70	2.80	453005	5462127	
GN110	LKR	0.53	17-May-18	8:52	17-May-18	12:27	3:35	3.58	10.8	0.50	3.80	452962	5462141	
GN111	LKR	0.49	17-May-18	8:56	17-May-18	12:21	3:25	3.42	10.8	0.40	3.90	452925	5462184	
GN112	LCR	25.89	20-Aug-18	8:31	20-Aug-18	15:35	7:04	7.07	17	0.20	2.00	448764	5450112	
GN113	LCR	25.86	20-Aug-18	8:33	20-Aug-18	15:25	6:52	6.87	17	0.20	1.80	448767	5450144	
GN114	LCR	25.84	20-Aug-18	8:35	20-Aug-18	15:22	6:47	6.78	17	0.20	2.10	448771	5450173	
GN115	LCR	25.83	20-Aug-18	8:38	20-Aug-18	11:54	3:16	3.27	17	0.50	2.90	448753	5450216	
GN116	LCR	25.91	20-Aug-18	8:42	20-Aug-18	15:30	6:48	6.8	17	0.20	1.80	448754	5450086	
GN117	LCR	21.73	20-Aug-18	8:55	20-Aug-18	16:01	7:06	7.1	17	0.10	1.90	451127	5453285	

Sample ID	Location[1]	River Km	Set Date	Set Time	Pull Date	Pull Time	Total Time[2]	Hours of Effort	Water Temp (°C)	Depth (m)		UTM		Comments
										Min	Max	Easting	Northing	
GN118	LCR	21.76	20-Aug-18	8:57	20-Aug-18	15:53	6:56	6.93	17	1.00	1.90	451122	5453242	
GN119	LCR	21.77	20-Aug-18	8:58	20-Aug-18	15:39	6:41	6.68	17	0.60	1.20	451119	5453225	
GN120	LCR	25.83	20-Aug-18	11:57	20-Aug-18	15:10	3:13	3.22	17	0.20	3.20	448753	5450216	
GN121	LCR	38.72	21-Aug-18	8:28	21-Aug-18	9:27	0:59	0.98	16.8	0.20	1.20	448424	5438748	Pulled early due to water fowl in area and limited pike habitat
GN122	LCR	38.08	21-Aug-18	8:35	21-Aug-18	15:07	6:32	6.53	16.8	0.10	3.40	448210	5439319	Limited pike habitat
GN123	LCR	38.09	21-Aug-18	8:38	21-Aug-18	15:01	6:23	6.38	16.8	0.20	2.60	448184	5439304	
GN124	LCR	37.23	21-Aug-18	8:49	21-Aug-18	14:50	6:01	6.02	16.8	0.10	3.50	447875	5440159	Surveyed ~5km of river upstream and downstream of Trail and picked best sites
GN125	LCR	37.23	21-Aug-18	9:09	21-Aug-18	14:56	5:47	5.78	16.8	0.10	1.50	447893	5440159	Continously monitored nets to keep water fowl away
GN126	LCR	38.39	21-Aug-18	9:20	21-Aug-18	15:15	5:55	5.92	16.8	0.10	1.40	448291	5439056	
GN127	LCR	37.23	21-Aug-18	9:38	21-Aug-18	11:20	1:42	1.7	16.8	0.10	4.50	447851	5440147	
GN128	LKR	0.54	12-Sep-18	9:25	12-Sep-18	15:35	6:10	6.17	17	0.20	0.50	453017	5462487	Juvenile net - Kootenay Oxbow Mouth
GN129	LKR	0.48	12-Sep-18	9:32	12-Sep-18	15:30	5:58	5.97	17	0.20	0.60	452957	5462475	Juvenile net - Kootenay Oxbow Mouth
GN130	LKR	0.43	12-Sep-18	9:38	12-Sep-18	15:28	5:50	5.83	17	0.20	0.60	452906	5462493	Juvenile net - Kootenay Oxbow Mouth
GN131	LKR	0.40	12-Sep-18	9:40	12-Sep-18	13:40	4:00	4	17	0.20	2.50	452886	5462544	
GN132	LKR	0.40	12-Sep-18	9:45	12-Sep-18	13:30	3:45	3.75	17	0.50	2.50	452887	5462558	
GN133	LKR	0.60	12-Sep-18	10:20	12-Sep-18	15:15	4:55	4.92	17	0.20	1.00	453029	5462098	Juvenile net - Kootenay Oxbow
GN134	LKR	0.63	12-Sep-18	10:25	12-Sep-18	15:15	4:50	4.83	17	0.20	1.00	453053	5462097	Juvenile net - Kootenay Oxbow
GN135	LKR	0.40	12-Sep-18	13:32	12-Sep-18	15:45	2:13	2.22	17	0.50	2.50	452887	5462558	
GN136	LCR	10.99	12-Sep-18	13:53	12-Sep-18	16:11	2:18	2.3	17	0.20	2.50	452189	5462668	
GN137	LCR	10.43	13-Sep-18	9:02	13-Sep-18	13:52	4:50	4.83	14.7	0.20	1.50	452494	5463130	
GN138	LKR	0.42	13-Sep-18	9:07	13-Sep-18	13:58	4:51	4.85	14.7	0.50	2.50	452906	5462547	
GN139	LCR	6.74	13-Sep-18	11:35	13-Sep-18	14:23	2:48	2.8	14.9	0.50	8.80	450247	5464283	
GN140	LCR	6.82	13-Sep-18	11:42	13-Sep-18	14:15	2:33	2.55	14.9	0.50	7.20	450332	5464249	
GN141	LCR	4.84	17-Oct-18	11:25	17-Oct-18	14:57	3:32	3.53	12.2	0.50	3.50	448400	5464855	
GN142	LCR	4.92	17-Oct-18	11:28	17-Oct-18	15:05	3:37	3.62	12.2	0.50	8.90	448480	5464839	
GN143	LCR	4.62	18-Oct-18	10:38	18-Oct-18	14:35	3:57	3.95	11.8	0.45	7.00	448198	5464930	
GN144	LCR	3.67	18-Oct-18	10:42	18-Oct-18	14:28	3:46	3.77	11.8	0.10	9.70	447225	5464935	

Notes:

[1] SEV = Seven Mile Reservoir; WAN = Waneta Reservoir; LCR = Lower Columbia River; LKR = Lower Kootenay River

[2] In the Columbia River study area, gill-nets set >4 hours were inspected mid-set and redeployed.

Table A2. Northern Pike suppression boat electrofishing (EF) survey data for the Columbia River study area, 2018.

Sample ID	Location[1]	River Km	Location Description[2]	Date	UTM Downstream		Start Time	End Time	Water Temp (°C)	Conduct-ivity	Mean Depth (m)	EF Seconds	EF Volts	Site Length (m)	Site Width (m)	Cloud Cover[3]	Instream Velocity[4]	Water Clarity[5]	Instream Cover (%)				Comments
					Easting	Northing													Aquatic Vegetation	Substrate	LWD	No Cover	
EF1	LKR	0.55	Kootenay Oxbow	10-Sep-18	452980	5462128	11:30	11:55	18.5	145	0.6	571	700	300	5	Partly Cloudy	Low	High	20	10		70	Very shallow; top end inaccessible with boat
EF2	LCR	10.62	Upstream of Zuckerberg	10-Sep-18	452387	5462956	12:15	12:23	15.3	115	1.2	286	700	200	5	Partly Cloudy	Low	High	50	50			
EF3	LCR	7.43	Downstream of Robson boat launch	10-Sep-18	450908	5464649	13:50	14:15	2:24	115	2	837	700	500	5	Clear	Low	High	50	45	5		Wind limited surface visibility
EF4	LCR	5.96	Upstream of LUB across from Robson	10-Sep-18	449470	5464537	14:40	15:20	15.3	115	2	1010	700	800	5	Clear	Low	High	100				Wind limited surface visibility
EF5	LCR	4.34	Celgar Booms	11-Sep-18	447599	5465073	9:13	9:37	15	115	1.5	1298	800	500	5	Clear	Low	Medium	70	10	20		
EF6	LCR	3.17	Across from Celgar Booms to Sawmill (LDB)	11-Sep-18	446884	5465621	10:02	10:20	15.1	112	1.5	609	800	400	5	Clear	Low	Medium	50	50			
EF7	LCR	10.44	Millenium Bridge	11-Sep-18	452522	5463103	10:41	11:14	15.3	115	1.5	620	800	50	10	Clear	Low/No	Medium	90			10	
EF8	LKR	0.35	Kootenay Oxbow Mouth	11-Sep-18	452832	5462571	11:30	11:59	18.7	145	0.5	708	700	200	5	Clear	Low/No	Clear	80	20			
EF9	LCR	9.19	Waldie's Island	11-Sep-18	452661	5464193	14:00	14:20	16	115	1.0	833	800	350	5	Partly Cloudy	Low	Medium	70	25	5		
EF10	LCR	6.76	LUB across from Robson	11-Sep-18	450271	5464234	14:20	14:28	15.4	115	2.0	220	800	30	5	Clear	Low	High	80			20	
EF11	LKR	0.39	Kootenay Oxbow Mouth	11-Sep-18	452869	5462533	14:38	14:52	18.3	143	0.5	647	800	200	5	Mostly Cloudy	Low	Medium	50	50			
EF12	LKR	0.13	Kootenay Eddy	11-Sep-18	452640	5462843	15:05	15:15	17.9	143	2.0	247	800	150	5	Overcast	Low	Medium	80	10		10	Wind limited surface visibility
EF13	LKR	0.60	Kootenay Oxbow Upper	12-Sep-18	453029	5462098	10:30	10:45	16.8	143	1.0	236	600	200	3	Overcast	Low	Medium	80			20	Backpack electrofisher in shallow water; shocked between and upstream of gill nets
EF14	LKR	0.42	Kootenay Oxbow Mouth	13-Sep-18	452906	5462547	9:13	9:26	17	143	0.2	455	800	817	5	Overcast	Low	Medium	80	20			
EF15	LCR	7.30	Across from Robson Boat Launch	13-Sep-18	450831	5464285	11:50	12:00	14.8	115	1.0	458	800	250	5	Overcast	Low	Medium	80	20			
EF16	LCR	17.00	Waterloo Eddy	13-Sep-18	453313	5456818	9:38	9:56	15.5	115	1.0-6.0	586	800	150	50	Overcast	Low/No	Medium	100				Good location for gill-nets in the future, bit too deep for boat electrofishing
EF17	LCR	10.62	Upstream of Zuckerberg	13-Sep-18	452387	5462956	10:30	10:48	14.8	115	1.0	414	800	150	5	Overcast	Low/No	High	80			20	
EF18	LKR	0.35	Kootenay Oxbow Mouth	17-Oct-18	452832	5462571	9:41	9:57	11.2	153	2.0	573	800	300	2	Clear	Low	High	50	50			Less aquatic vegetation than during September sampling
EF19	LKR	0.26	Kootenay Eddy	17-Oct-18	452776.96	5462811.4	10:02	10:10	11.4	153	2.0	236	800	100	2	Clear	Low	High	50	50			
EF20	LCR	5.01	Pike Bay	17-Oct-18	448577	5464859	10:25	11:04	13	126	1.5	1621	800	900	3	Clear	Low	Clear	100				Three passes of the the same area; abundant aquatic vegetation
EF21	LCR	7.42	Downstream of Robson boat launch	17-Oct-18	450894	5464629	13:02	13:10	12.6	135	1.5	420	800	100	3	Clear	Low	High	75	25			
EF22	LCR	7.75	Norns Creek Mouth	17-Oct-18	451228	5464641	13:14	13:20	12.6	135	1.0	242	800	50	3	Clear	Low	High	50	25	25		
EF23	LCR	9.19	Waldie's Island	17-Oct-18	452661	5464193	13:24	13:49	12.2	135	2.0	961	800	250	3	Clear	Low	High	5	70	25		
EF24	LCR	6.84	Across from Robson Boat Launch	17-Oct-18	450350	5464242	14:04	14:24	12.1	135	1.5	922	800	700	3	Clear	Low	High	60	35	5		
EF25	LCR	5.01	Pike Bay	17-Oct-18	448577	5464859	14:30	14:45	12.2	135	1.5	609	800	400	5	Clear	Low	High	100				
EF26	LCR	4.55	Pike Bay	18-Oct-18	448130	5464964	9:31	10:00	12.3	128	2.0	1434	800	500	30	Overcast	Low	High	70	30			
EF27	LCR	4.95	Pike Bay	18-Oct-18	448515	5464849	10:00	10:29	11.9	128	3.0	1093	800	400	50	Overcast	Low	High	80	20			
EF28	LCR	6.46	Robson dock ramp to Sturgeon Island	18-Oct-18	449989	5464591	10:51	11:10	11.9	128	4.0	986	800	1000	25	Overcast	Low	High	40	60			
EF29	LCR	7.39	Sturgeon Island to Robson Ferry Landing	18-Oct-18	450869	5464615	11:16	11:29	11.9	128	4.0	735	800	650	60	Overcast	Low	High	90	10			

Notes:

[1] LCR = Lower Columbia River; LKR = Lower Kootenay River

[2] LUB = left upstream bank; RUB = right upstream bank

[3] Clear = <10%; Partly Cloudy = 10-50%; Mostly Cloudy = 50-60%; Overcast = >90%

[4] High = >1.0 m/s; Medium = 0.5-1.0 m/s; Low = <0.5 m/s

[5] High = >3.0 m; Medium = 1.0-3.0 m; Low = <1.0 m

Appendix B

Northern Pike Capture Data

Table B1. Northern Pike captures during Pend d'Oreille and Columbia river study area suppression, 2018.

Sample ID[1]	RKm	Location[2]	Set/Start Date	Set/Start Time	Pull/End Date	Pull/End Time	Length (mm)	Weight (g)	Stomach	Comments[3]
GN18	17.9	SEV	30-Apr-18	16:14	01-May-18	9:18	670	2,500	Empty	Ripe male, parasites in stomach
GN19	17.8	SEV	30-Apr-18	16:16	01-May-18	9:02	600	1,700	Full	Ripe male; YP (130mm) and parasites in stomach
GN24	13.5	SEV	01-May-18	8:51	01-May-18	14:04	610	1,900	Empty	Ripe female; full of tapeworms
GN20	11.3	SEV	01-May-18	8:33	01-May-18	14:20	855	5,500	Empty	Ripe male; parasites in stomach
GN22	11.5	SEV	01-May-18	8:39	01-May-18	14:36	640	2,100	Empty	Ripe male; parasites in stomach
GN22	11.5	SEV	01-May-18	8:39	01-May-18	14:36	860	5,600	Empty	Ripe male; parasites in stomach
GN21	11.5	SEV	01-May-18	8:37	01-May-18	14:55	675	2,900	Empty	Ripe male; parasites in stomach
GN32	4.9	WAN	02-May-18	9:00	02-May-18	14:08	575	1,600	Full	Ripe female; YP (180mm) and parasites in stomach
GN34	4.6	WAN	02-May-18	9:06	02-May-18	14:25	715	3,600	Full	Ripe female; SU (200mm) and parasites in stomach
GN35	4.5	WAN	02-May-18	9:09	02-May-18	14:49	630	2,400	Full	Ripe male; NSC (365mm) and parasites in stomach
GN35	4.5	WAN	02-May-18	9:09	02-May-18	14:49	650	2,550	Empty	Ripe male; parasites in stomach
GN35	4.5	WAN	02-May-18	9:09	02-May-18	14:49	635	1,900	Empty	Ripe male; no parasites
GN40	4.4	WAN	03-May-18	9:15	03-May-18	14:01	800	5,200	Empty	Ripe female; parasites in stomach
GN45	4.4	WAN	03-May-18	14:22	04-May-18	8:50	645	2,400	Empty	Ripe male
GN47	4.6	WAN	03-May-18	14:29	04-May-18	9:45	800	4,900	Empty	Ripe female
GN48	7.3	LCR	09-May-18	9:55	09-May-18	14:37	920	7,700	Empty	Ripe female; floy tag (353)
GN53	6.8	LCR	09-May-18	10:17	09-May-18	15:10	920	7,500	Empty	Ripe male; sonic tag (54270), no floy
GN64	4.8	LCR	11-May-18	8:43	11-May-18	15:36	715	3,650	Empty	Ripe male
GN70	4.6	LCR	11-May-18	8:59	11-May-18	16:17	400	550	Full	Immature male; MW (180mm) in stomach
GN70	4.6	LCR	11-May-18	8:59	11-May-18	16:17	440	700	Full	Ripe male; MW (150mm) and two RSC (80mm) in stomach
GN70	4.6	LCR	11-May-18	8:59	11-May-18	16:17	750	3,900	Empty	Ripe male; sonic tagged (54274), no floy
GN70	4.6	LCR	11-May-18	8:59	11-May-18	16:17	765	3,650	Empty	Ripe male; floy tagged (358)
GN70	4.6	LCR	11-May-18	8:59	11-May-18	16:17	790	5,300	Empty	Ripe male
GN72	5.7	LCR	12-May-18	8:29	12-May-18	13:01	560	1,700	Full	Ripe male; MW (200mm) in stomach
GN77	5.4	LCR	12-May-18	8:50	12-May-18	13:29	520	1,200	Empty	Ripe male
GN77	5.4	LCR	12-May-18	8:50	12-May-18	13:29	530	1,400	Empty	Immature female
GN82	7.0	LCR	14-May-18	9:40	14-May-18	15:23	530	1,200	Full	Ripe male; MW (230mm) in stomach
GN87	6.9	LCR	14-May-18	10:05	14-May-18	15:36	430	650	Empty	Ripe male; bones in stomach
GN96	4.6	LCR	16-May-18	8:40	16-May-18	15:43	740	3,450	Empty	Ripe male
GN101	4.7	LCR	16-May-18	8:59	16-May-18	15:15	525	1,150	Empty	Ripe male
GN101	4.7	LCR	16-May-18	8:59	16-May-18	15:15	515	1,200	Full	Ripe female; sculpin (95mm) in stomach
GN106	11.0	LCR	17-May-18	8:38	17-May-18	13:04	410	600	Empty	Immature male
GN106	11.0	LCR	17-May-18	8:38	17-May-18	13:04	385	450	Empty	Immature male
GN108	11.0	LCR	17-May-18	8:43	17-May-18	12:43	380	400	Full	Immature male; 2 dace (40-70mm) in stomach

Sample ID[1]	RKm	Location[2]	Set/Start Date	Set/Start Time	Pull/End Date	Pull/End Time	Length (mm)	Weight (g)	Stomach	Comments[3]
GN132	0.6	LKR	12-Sep-18	9:45	12-Sep-18	13:30	760	4,300	Full	Male; MW (220 mm)
GN135	0.4	LKR	12-Sep-18	13:32	12-Sep-18	15:45	985	7,900	Empty	Female
GN138	0.4	LKR	13-Sep-18	9:07	13-Sep-18	13:58	460	800	Empty	Male
EF7	10.4	LCR	11-Sep-18	10:41	11-Sep-18	11:14	610	2,000	Full	Female; MW (120mm) in stomach;
EF7	10.4	LCR	11-Sep-18	10:41	11-Sep-18	11:14	565	1,700	Empty	Female
EF8	0.3	LKR	11-Sep-18	11:30	11-Sep-18	11:59	590	1,800	Empty	Male
EF11	0.4	LKR	11-Sep-18	14:38	11-Sep-18	14:52	775	4,200	Empty	Male
EF20	5.0	LCR	17-Oct-18	10:25	17-Oct-18	11:04	560	800	Empty	Female

Notes:

[1] GN = gill-net survey; EF = boat electrofishing survey

[2] SEV = Seven Mile Reservoir; WAN = Waneta Reservoir; LCR = Lower Columbia River; LKR = Lower Kootenay River

[3] YP = Yellow Perch; SU = unidentified sucker species; NSC = Northern Pikeminnow; MW = Mountain Whitefish; RSC = Redside Shiner

Appendix C

Photos

Photo 1. Surveying for juvenile Northern Pike during a boat electrofishing survey in the Kootenay River Oxbow (Rkm 0.4), 10 Sep 2018.

Photo 2. Gill-nets set to target juvenile Northern Pike in shallow, vegetated habitat at the Kootenay River Oxbow outlet (Rkm 0.4), 11 September 2018.

Photo 3. Northern Pike captured under the Millennium Park pedestrian bridge (Rkm 10.4) in the lower Columbia River on 11 September 2018 (left) and near the Kootenay River Oxbow outlet (Rkm 0.4) in the lower Kootenay River on 12 September 2018 (right).

Photo 4. Seven Mile Reservoir gill-net sampling habitat at RKm 17.9, 30 April 2018.

Photo 5. Waneta Reservoir gill-net sampling habitat at Rkm 4.5, 2 May 2018.

Photo 6. Turbidity observed in the Waneta Reservoir during gill-net sampling, 2 May 2018.