Lower Columbia River
Invasive Northern Pike Suppression – 2016 Update

Jeremy T.A. Baxter[1] and Dan J. Doutaz[2]

Prepared for:

Teck
Trail Operations

25 Aldridge Ave.
Trail, BC
Canada
V1R 4L8

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[1] Mountain Water Research, 107 Viola Crescent, Trail BC, V1R 1A1
e-mail: jbaxter@redmtn.ca

[2] Thompson Rivers University Research Center, 900 McGill Rd, Kamloops BC, V2C 0C8
e-mail: dan_doutaz@hotmail.com

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EXECUTIVE SUMMARY

Invasive Northern Pike (*Esox lucius*) recently colonized the Canadian portion of the Lower Columbia River (LCR) after illegal introductions to US tributaries of the Columbia drainage (Pend D'Oreille River) upstream of BC, and have now moved downstream into the Columbia River near Trail, and upstream to the Hugh Keenleyside Dam (HLK). First detected in the LCR in 2009, Northern Pike have the potential to significantly impact sport fish populations and the recovery of species listed under the Species-at-Risk Act (SARA)through competition, predation, and introduction of disease. To control the invasion of Northern Pike, the Province of British Columbia's Ministry of Forest Lands and Natural Resource Operations (MFLNRO) and Teck Metals Ltd. initiated a four year (2014 to 2017) Northern Pike gill-netting suppression program. This report summarizes the 2016 Northern Pike Gill-Net Suppression Program implemented by the MFLNRO and Teck Metals Ltd.

A total of 331 Northern Pike (NP) have been successfully removed during the gill-netting (n=288), large river indexing (n=16) and angler incentive programs (n=27) in the Lower Columbia River since 2014. Over 87% of the pike removed were during the gill netting efforts. The number of pike removed by gill-nets per year was significantly reduced in 2016 (n=39) when compared to 2014 (n=133), and 2015 (n=116). To provide an indication of abundance a simple Lincoln-Petersen mark and recapture estimate was conducted in 2016 using PIT tag recaptures and estimated the population of NP in the Robson Reach area to be 107 with a lower 95% confidence interval (CI) of 59 and an upper 95% CI of 155.

The gill netting effort occurred over 10 days with 407 net hours in 2016, 15 days with 659 net hours in 2015, and 15 days with 475 net hours in 2014. The reduction in pike captures in 2016 may be an indication of suppression success combined with the lack of suitable habitat in the study area, or may be a result of the reduction in total gill-netting effort in 2016 by five sampling days. The gill-netting average Catch Per Unit Effort (CPUE) in 2016 was 0.19 NP/hr per net or 1.55 NP/day (8 hr) per net. The CPUE for a single crew of two deploying eight nets a day for 8 hours in the study area in 2016 was 12.40 NP/day and the catch rates are very similar when compared to the 2014 (11.98 NP/day) and 2015 (12.93 NP/day) CPUE averages suggesting that the reduced number of sampling effort (5 days) in 2016 resulted in the lower total NP catch for the year.

For all study years (2014-2016) approximately 51% (n=147) of the NP stomachs examined (n=288) contained food and in most cases included whole fish. NP diet consisted primarily of native salmonids (Rainbow Trout, Kokanee and Mountain Whitefish) and other native fish species (Sucker, Sculpin, Pikeminnow, and Dace). Fish listed under SARA were not observed in the stomachs of the NP captured during this study. The average fork length of captured NP was 68 cm in 2014, 58 cm in 2015, and 62 cm in 2016. The average weight of captured NP was 3.15 kg in 2014, 2.04 kg in 2015, and 2.38 kg in 2016. The gender distribution, determined by dissection, of NP for all three years was 123 males (45%), 118 females (44%) and 30 of unknown sex (11%). A total of 1,030 fish were caught as bycatch in gill-nets in the three years of the suppression program, 820 of which were released alive (79.6%).

Invasive NP pose significant threats to the Columbia River ecosystem including predation of native species, introduction of a wide variety of parasites and diseases, and competition with other species for common food resources (Baxter and Neufeld, 2015). The current gill-netting suppression program has successfully eliminated approximately 40% to 50% of the estimated NP population and continues to be a viable option of control.

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&

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BACKGROUND & STUDY AREA

Recognizing the concerns and threats associated with the Northern Pike (*Esox Lucius*; NP) introductions in BC, the Ministry of Forest Lands and Natural Resource Operations (MFLNRO) initiated a recent gill netting program, a change to angling regulations (unlimited daily quota) and the implementation of an incentive/education and award program aimed at encouraging anglers to remove NP from the Lower Columbia River (LCR). In addition to MFLNRO mitigation strategies, Teck Metals Ltd implemented a four year (2014 to 2017) NP gill netting suppression program as part of the Upper Columbia River White Sturgeon Recovery Initiative and Waneta Dam Upgrade compensation commitments to complement the Ministry's efforts and assess the impacts to native fish species (in particular White Sturgeon) by investigating prey through stomach analysis.

The initial gill-netting suppression program in 2014 successfully removed a total of 133 NP, and when combined with the angling effort and Large River Indexing Program, the total known and recorded NP removed from the Lower Columbia River in 2014 was 163 or 20% of the estimated population (Baxter and Neufeld, 2015). In 2014, sampling occurred throughout the Columbia River from the HLK dam to the US border and all of the NP captured were from the Robson Reach area, directly upstream of Castlegar, BC (Figure 1), where NP spawning was confirmed (Baxter and Neufeld, 2015). Considering the success of the 2014 suppression results, commitments to continue removing invasive NP from the Columbia River in the Robson Reach area in 2015 were fulfilled and a total of 125 NP were removed for that year (Baxter, 2016). Capture efforts have been most successful in the spring when NP are in shallow water spawning. Controlling invasive NP in the LCR before they can spawn and establish themselves is now a priority for fisheries managers and a continuation of the gill-netting suppression program occurred in 2016 with all of the effort occurring during the spawning period.

This report summarizes the data collected during the 2016 NP gill netting suppression program conducted by the Mountain Water Research (MWR) for MFLNRO and Teck Metals Ltd. Additional funding for the 2016 project was also provided by Thompson Rivers University (TRU) to conduct research on NP life history in the LCR, locate spawning areas, and determine the risk of passage of NP into the Arrow Lakes Reservoir.

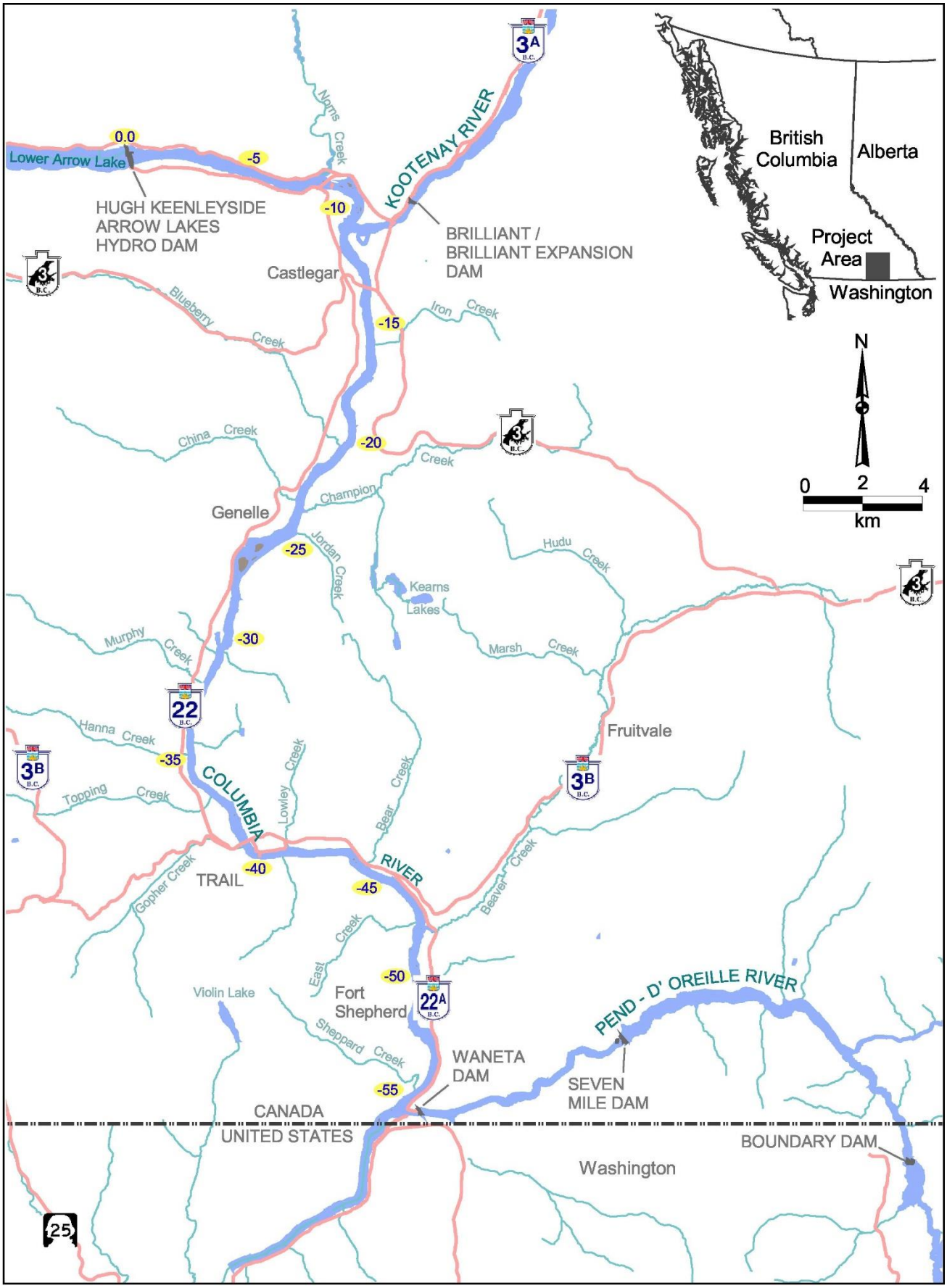

Figure 1. LCR Northern Pike Gill Net Suppression study area.

METHODS

Acoustic Tagging

To collect information on NP spawn timing and movement patterns, adult NP were tagged in the spring of 2016 by Thompson Rivers University masters student Dan Doutaz. The fifteen NP tagged were captured with gill nets, and to reduce capture stress the nets were set for very short periods of time and monitored continually. The captured adults had Vemco V13-1x-A69-1303 69 KHz tags inserted internally to make use of the existing array of 25 acoustic receivers maintained by BC Hydro in the mainstem of the LCR to detect acoustically tagged White Sturgeon (*Acipenser transmontanus*). All fish with an acoustic tag inserted in their body cavity also had a brightly coloured Floy tag inserted near the dorsal fin to provide permanent identification for anglers and the suppression team.

Gill Net Suppression

As a result of the 2014 sampling program (Baxter and Neufeld, 2015), all of the gill-netting in 2015 and 2016 was completed where the highest concentrations of pike are known to occur, which is in the Robson Reach area downstream of HLK dam and near the Kootenay River Oxbow and Zuckerberg Island area. Monofilament gill nets with the same specifications as 2014 and 2015 were used in 2016 and have also been identified in the US as being highly effective for NP removal (Table 1).

Table 1. Gill-net dimensions used for the LCR NP mechanical suppression in 2016.

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**	-	-

An 18-foot aluminum jetboat was used to access the river habitat which pike prefer. Sets were selected in shallow water bays known to have high NP abundance, and in locations that limited bycatch of salmonids and White Sturgeon. Gill nets were set for a maximum of 4 hrs to limit native bycatch and mortality. All bycatch was released alive if possible. All subsequent net-sets were completed during daylight hours and checked frequently. All captured NP were euthanized and then measured for weight and length, scanned for a PIT tag, and assessed for sex/maturity. The stomach contents of all captured NP were examined in the field at time of capture and recorded, with the exception of 43 stomachs from 2015 that were preserved and sent to the TRU lab for analysis. All of the heads from each NP in 2014 and 2015 were removed and kept frozen for age analysis of the cleithrum and otolith stream chemistry analysis by the TRU lab. Cleithra are paired, flat bones, and are components of the pectoral girdle. In NP the cleithrum is located below the skin of the posterior edge of the operculum opening and is used for aging individual fish (Euchner, 1988). The cleithrum and otolith sample analysis is ongoing at this time. Total gill-netting effort in 2016 was conducted in late May and June over two 5-day sessions (10 days total) during the projected spawning period with a crew of two deploying 8 nets twice a day if possible (Table 2).

Table 2. LCR NP gill-netting schedule and effort, 2016.

Date	Nets Deployed	Total Set Hours
16-May-2016	16	39.23
17-May-2016	14	50.10
18-May-2016	8	48.23
19-May-2016	15	40.27
20-May-2016	8	28.68
30-May-2016	8	37.77
31-May-2016	12	53.77
01-Jun-2016	12	50.83
02-Jun-2016	14	43.05
03-Jun-2016	6	15.02
Total	**113.00**	**406.95**

Table 3 describes the gill netting data collected for each net-set in 2016.

Table 3. LCR NP gill-netting data collection description, 2015.

• Date	• Set ID	• Location (UTM)
• Time in	• Time out	• Total Hours Deployed
• Float Number	• Area Description	• System and Water Temperature
• Species Captured	• Bycatch Count	• Bycatch Released Alive
• Fork Length of all NP	• Weight of all NP	• PIT Tag Number
• NP Gender	• NP Maturity	• NP Stomach Contents

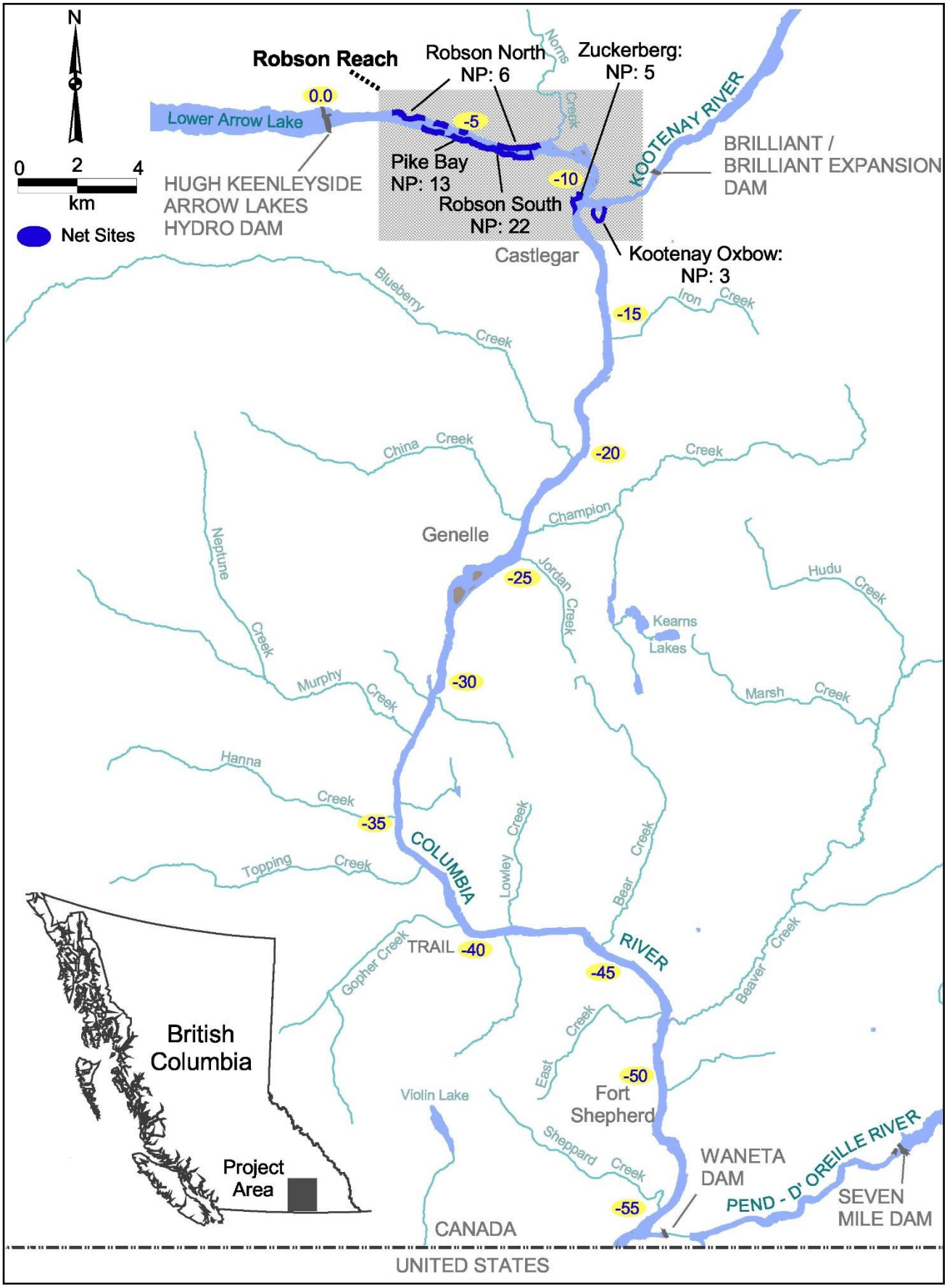

Figure 2. LCR NP Gill Netting Set Sites, 2016.

Data Analysis

The data were entered into a custom designed Access database and were screened for typographical errors through plotting and data summaries prior to plotting and analysis.

Two primary pieces of information collected during the gill netting were analyzed: the total amount of effort (net hours) and the average catch rate which is referred to as Catch Per Unit Effort (CPUE) in this report. A parallel calculation was done for each net set to expand the CPUE/hr by an 8 hour day to achieve a CPUE/8 hr day for each net-set.

In addition to the catch rates, analysis of other data included: A Lincoln-Petersen mark and recapture NP population estimate based on the number of PIT tags recaptured, length and weight frequencies of captured NP, NP gender distribution, NP stomach analysis by prey species, and bycatch rates.

Pathology Sampling

In 2015 and 2016, the NP were not screened for parasites. However, a total of nine pike samples collected during the 2014 gill-net surveys were submitted to the Provincial Freshwater Fisheries Society of BC (FFSBC) Fish Health Lab for standard disease screening (Baxter and Neufeld, 2015). Screening included viral tests (IHNv, IPNv and VHSv), bacterial tests (various pathogenic bacteria) and parasites (*Triaenophorus crassus* and others of interest) following standard Canadian Fish Health Protection Regulation (CFHPR) methods. The results of the 2014 disease screening can be found in the 2014 report (Baxter and Neufeld, 2015). Field observations estimate approximately 10% of NP sampled contained parasitic worms.

RESULTS

Gill Netting and Analysis

In 2016, a total of 49 NP were captured during the gill-netting program in the study area, of which 12 were TRU's tagged study fish. Ten of the tagged NP captured were released alive and healthy and two perished. The total gill net NP removal in 2016 was 39. An additional three NP were confirmed to be removed from the LCR in 2016 by Golder and Associates during the BC Hydro Large River Indexing Program, in addition to one of TRU's study fish which was captured and released. The NP gill-netting suppression program in 2016 focused on the Robson Reach Area and Kootenay River Oxbow area only based on capture rates established in 2014 (Baxter and Neufeld, 2015). The total number of NP caught by gill-netting each year can be found in Table 4 below. The average CPUE in 2016 was 0.19 NP/hr per net or 1.55 NP/day (8 hr) per net. The CPUE for a single crew of two deploying eight nets a day for 8 hours in the Robson Reach area in 2016 was 12.40 NP/day and the catch rates are very similar when compared to the 2014 and 2015 CPUE averages (Table 4). The initial suppression CPUE results in May of 2014 were much higher (0.44 NP/hr per net or 3.44 NP/day (8hr) per net) than subsequent sampling, which has since stabilized and is now consistently around 0.20 NP/hr per net.

Table 4. Northern Pike (NP) gill-netting Catch Per Unit Effort (CPUE) and totals for 2014 to 2016 in the study area of the Lower Columbia River.

Year	NP CPUE/hr per net	NP CPUE/8hr net	NP Total	NP Per day (8 nets)
2014	0.19	1.50	133	11.98
2015	0.20	1.62	129*	12.93
2016	0.19	1.55	49*	12.40

*total includes NP released for research (13 in 2015 and 10 in 2016).

A total of 1,030 fish were caught as bycatch in gill-nets in the three years of the suppression program, 820 of which were live releases (79.6%). Bycatch species caught in gill-nets included Rainbow Trout (*Oncorhynchus mykiss*), Kokanee (*Oncorhynchus nerka*), Bull Trout (*Salvelinus confluentus*), Brook Trout (*Salvelinus fontinalis*), Mountain Whitefish (*Prosopium williamsoni*), Lake Whitefish (*Coregonus clupeaformis*), Northern Pikeminnow (*Ptycheilus oregonensis*), Sculpin spp. (*Cottidae spp.*), Sucker spp. (*Catostomidae* spp.), Tench (*Tinca tinca*), Smallmouth Bass (*Micropterus dolomieu*), Yellow Perch (*Perca flavescens*), Walleye (*Sander vitreus*) and White Sturgeon (*Acipenser transmontanus*). Our analysis focuses on the NP since these fish were the primary target species and the ones for which biometric data were collected. In 2016, gill nets captured 178 non-target individuals and 80% were released alive. Bycatch mortalities in 2016 included Mountain Whitefish (n=10), Rainbow Trout (n=6), Sucker sp. (n=5), Tench (n=2), Yellow Perch (n=1), Eastern Brook Trout (n=1), Walleye (n=1), Smallmouth Bass (n=3) and Lake Whitefish (n=5). All other bycatch was released alive. The total bycatch caught in gill-nets for 2014 to 2016 can be found in Figure 3 below.

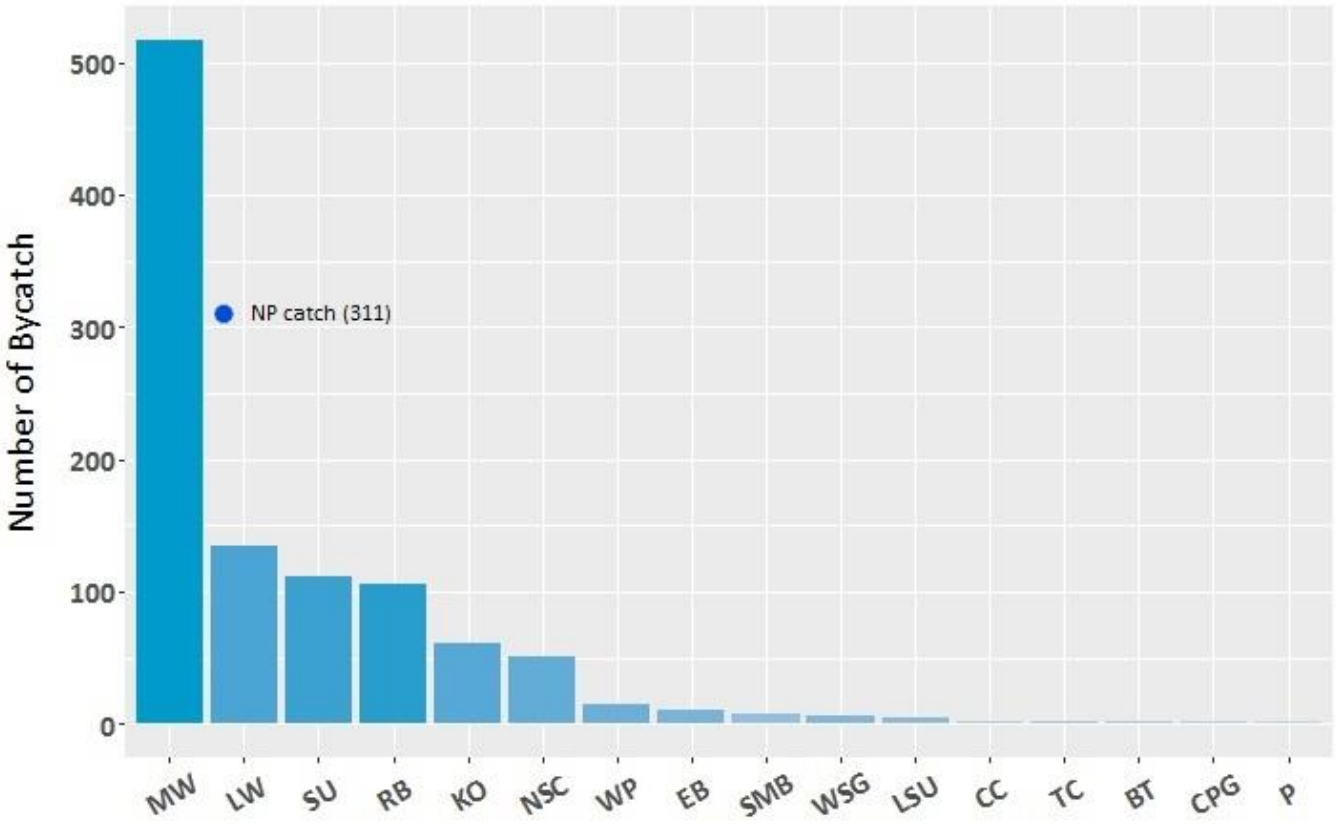

Figure 3. Total gill-net bycatch in 2014 to 2016. MW = Mountain Whitefish, LW = Lake Whitefish, SU = Sucker sp., RB = Rainbow Trout, KO = Kokanee, NSC = Northern Pike Minnow, WP = Walleye, EB = Eastern Brook Trout, SMB = Smallmouth Bass, WSG = White Sturgeon, LSU = Longnose Sucker, CC = Sculpin sp., TC = Tench, BT = Bull Trout, CPG = Carp sp., and P = Yellow Perch.

NP length and weight boxplots for all three years are presented in Figure 4. The average fork length of captured NP was 68 cm in 2014, 58 cm in 2015, and 62 cm in 2016. The average weight of captured NP was 3.15 kg in 2014, 2.04 kg in 2015, and 2.38 kg in 2016. The NP fork length range for all years was 29.5 cm to 105 cm and the NP weight range was 0.25 kg to 9.85 kg (Figure 10). A total of 271 NP were dissected from 2014-2016, and the gender distribution for all three years was 123 males (45%), 118 females (44%) and 30 of unknown sex (11%).

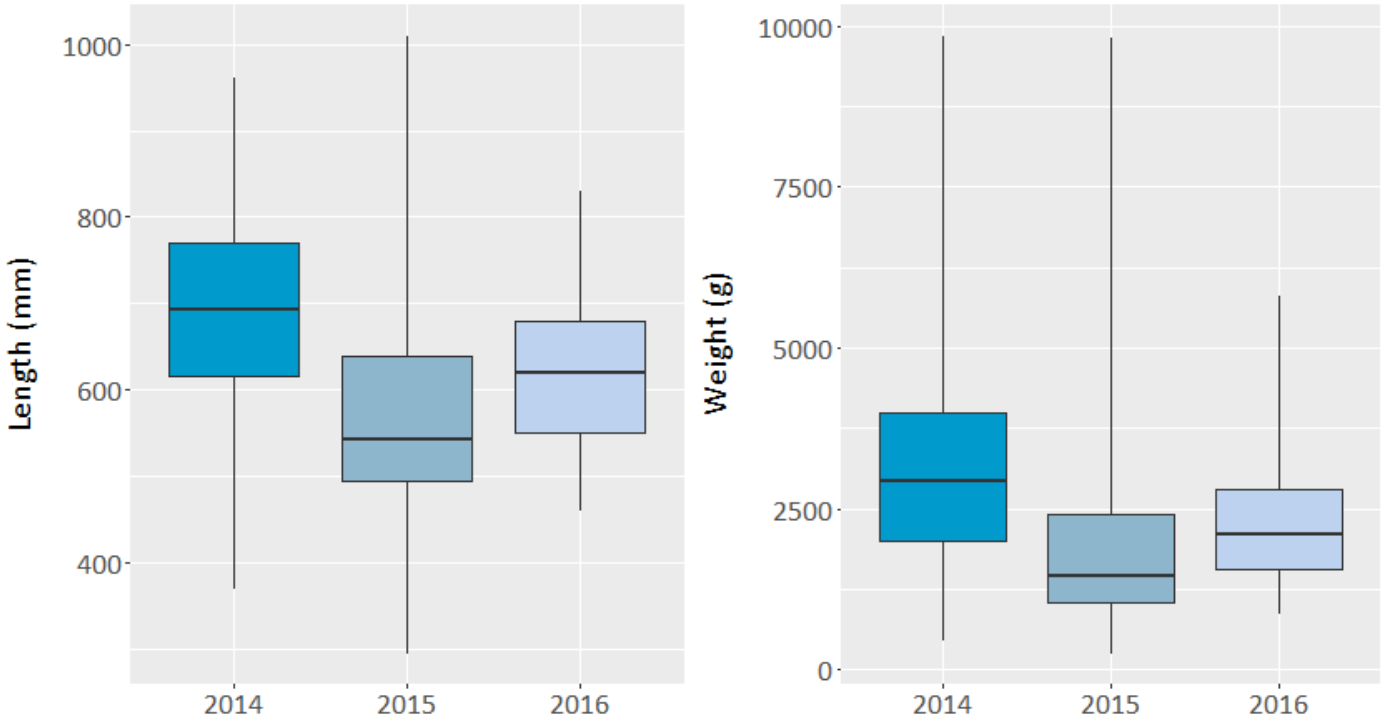

Figure 4. Length and weight boxplots of Northern Pike captured by gill-nets in the LCR in 2014 to 2016. The median value for lengths and weights by year is the line in the centre of the box, the upper hinge of the box is the third quartile value of the data and the lower hinge is the first quartile of the data, and the whiskers are the total range of length and weight.

NP were caught primarily in shallow water habitat less than 4 m deep and abundant in aquatic vegetation. The 2016 gill net set locations and total catch per location are presented in the aerial photo maps in Figures 5 through 11.

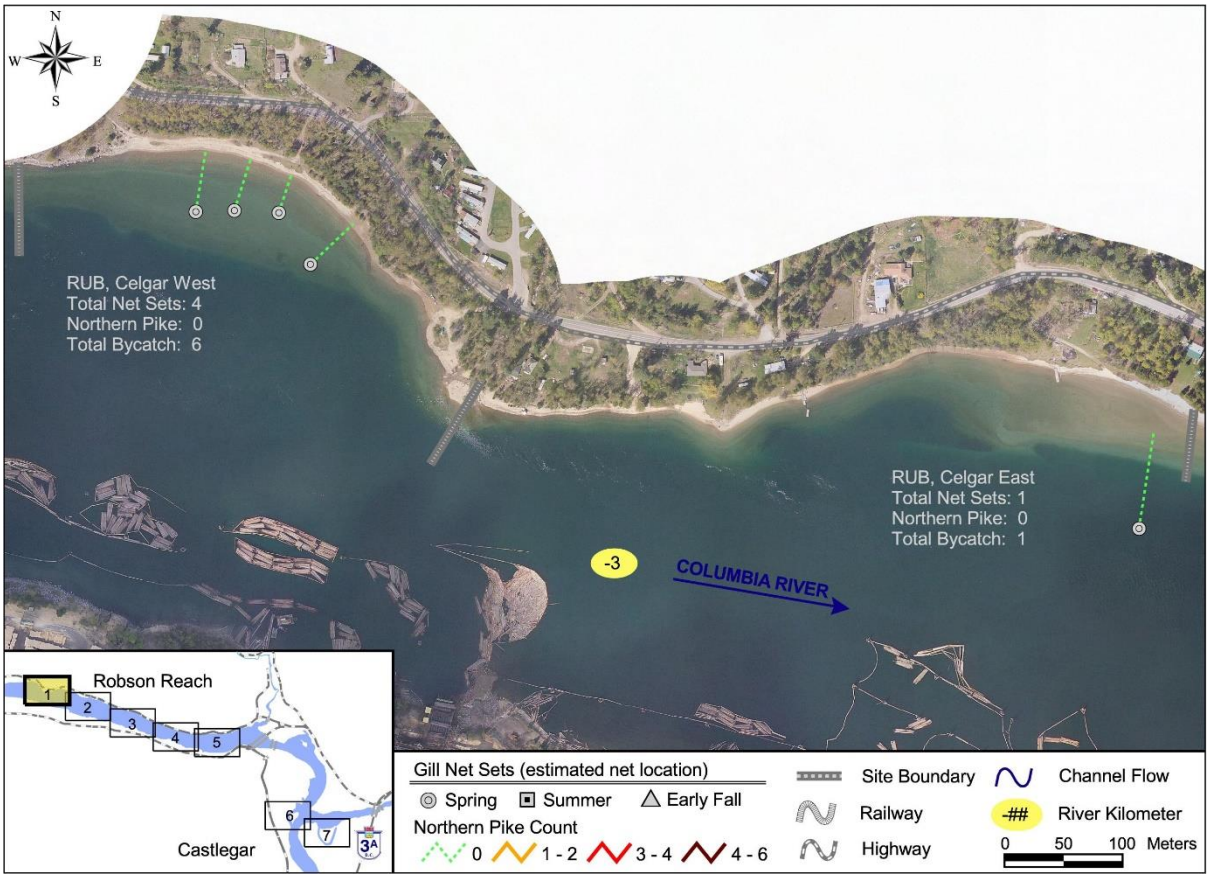

Figure 5. LCR NP gill netting set sites and catch per site in the Celgar Area of Robson Reach, 2016.

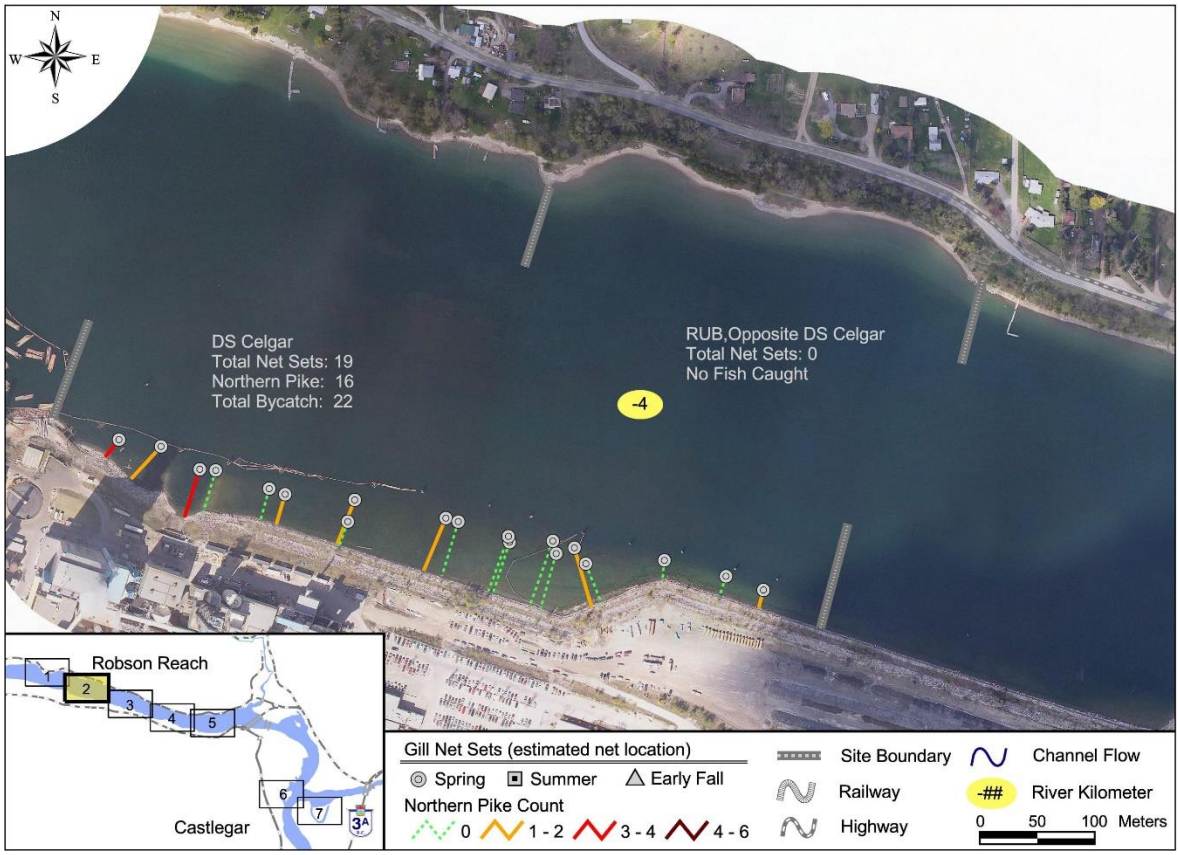

Figure 6. LCR NP gill netting set sites and catch per site in the Celgar DS Area of Robson Reach, 2016.

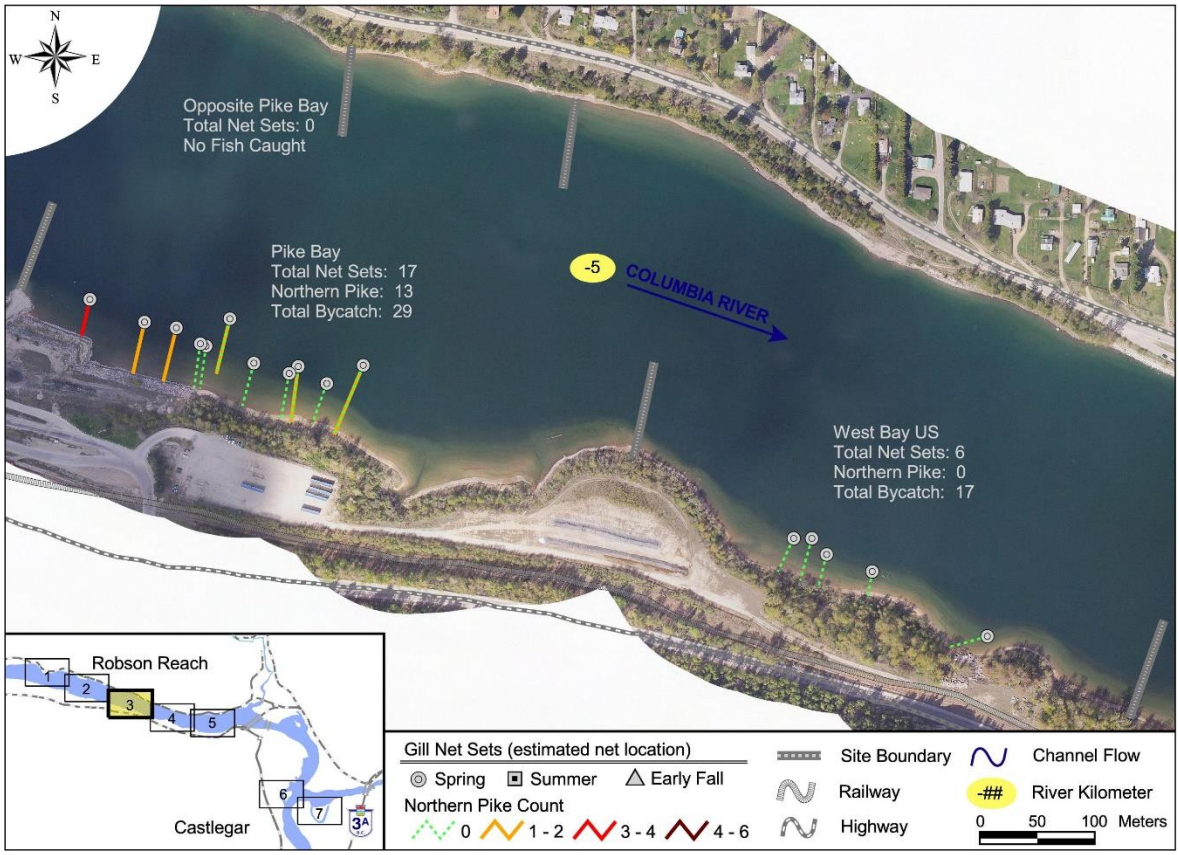

Figure 7. LCR NP gill netting set sites and catch per site in the Pike Bay Area of Robson Reach, 2016.

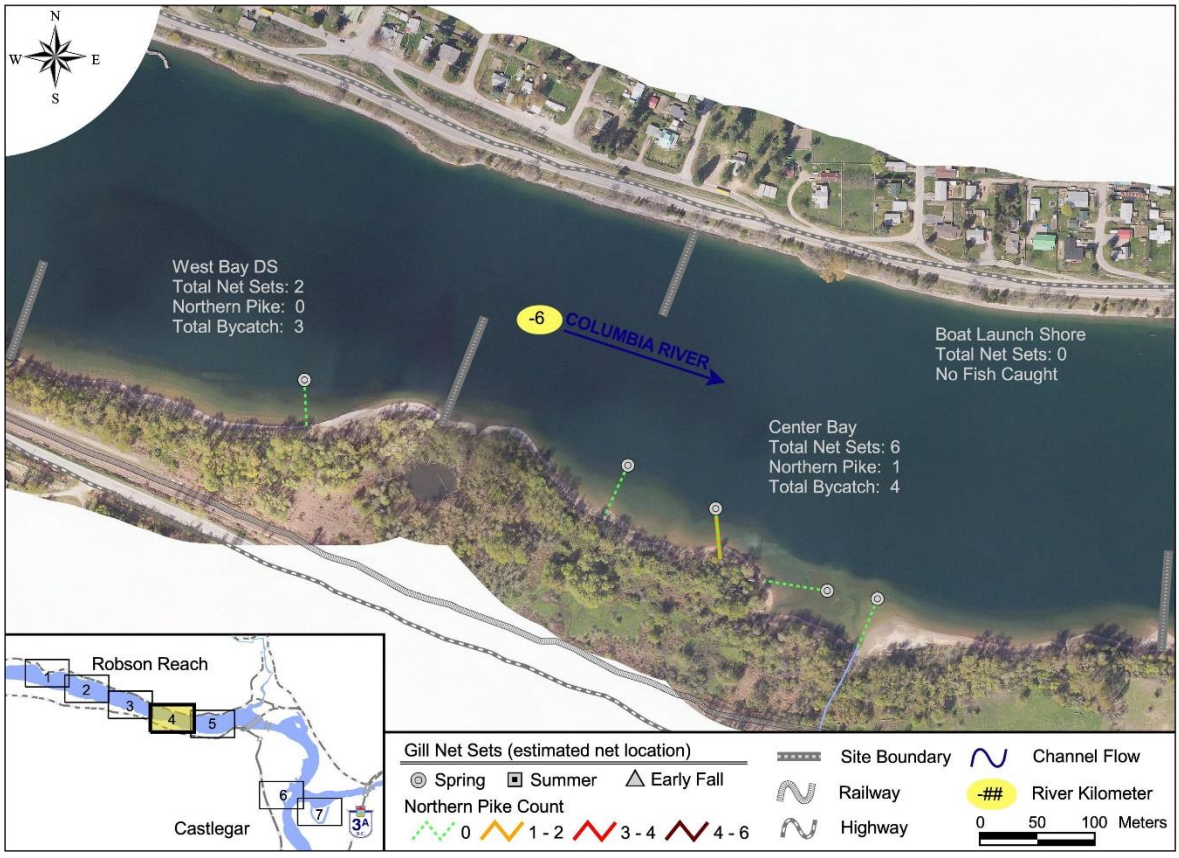

Figure 8. LCR NP gill netting set sites and catch per site in the Center Bay Area of Robson Reach, 2016.

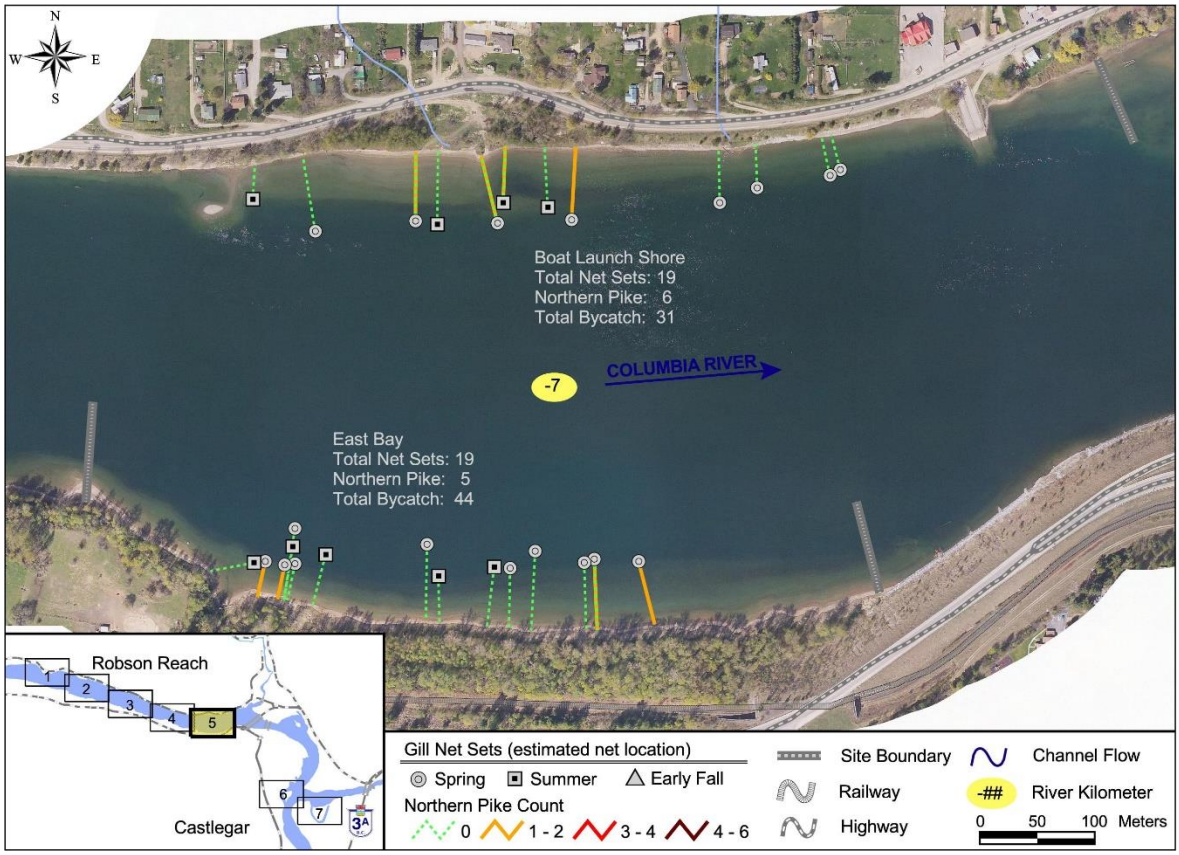

Figure 9. LCR NP gill netting set sites and catch per site in the Robson Boat Launch Area, 2016.

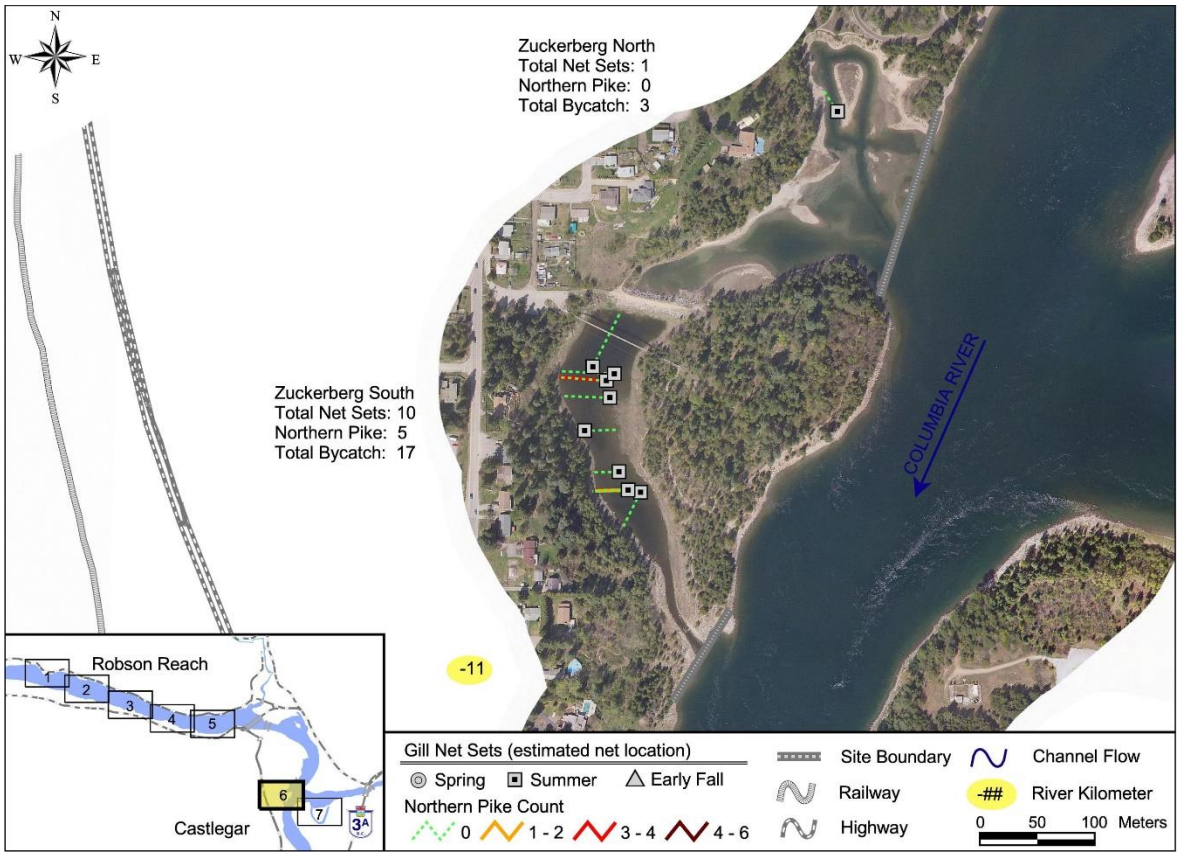

Figure 10. LCR NP gill netting set sites and catch per site in the Zuckerberg Island Area, 2016.

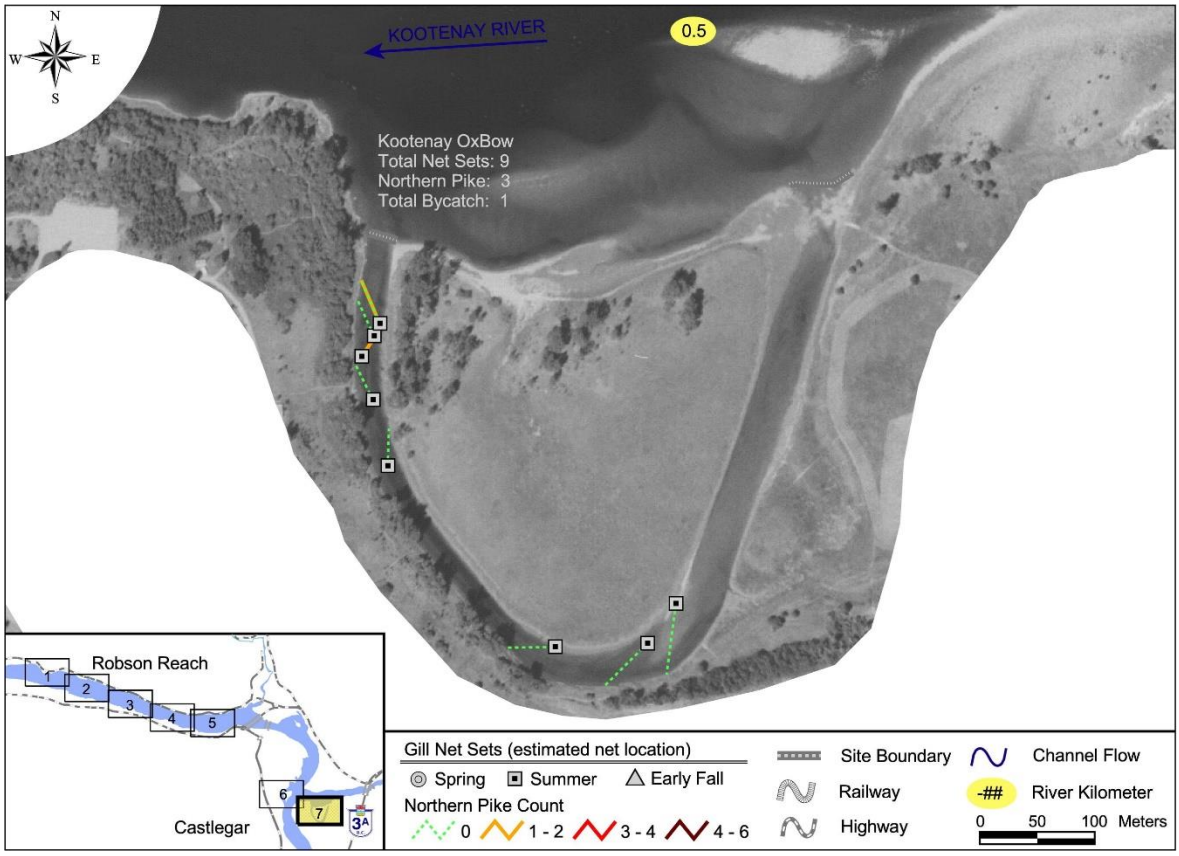

Figure 11. LCR NP gill netting set sites and catch per site in the Kootenay River Oxbow Area, 2016.

Population Estimate

A simple Lincoln-Petersen mark and recapture estimate was conducted using the PIT tag recaptures and all of the caught NP in 2016. The following formula was used:

$$N = \left[\frac{(n_1+1)(n_2+1)}{m_2+1}\right] - 1$$

n_1 = number of marked and released individuals: 27 (assumes 50% mortality of tags remaining from previous years).
n_2 = total number of individuals captured in 2016: 49 (only includes suppression program).
m_2 = number of marked re-captured individuals during the 2016 sampling: 12 (10 released alive for research).

The population of NP in the Robson Reach Area is estimated to be 107 with a lower 95% CI of 59 and an upper 95% CI of 155 (Figure 12). The population estimates for all three years and the total NP removed by year can be found in Table 5 below.

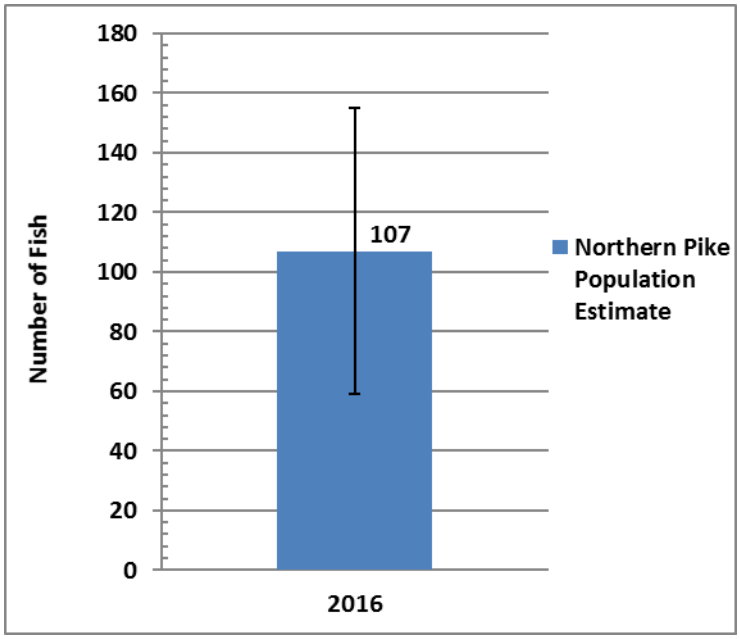

Figure 12. 2016 LCR NP population estimate in the study area, based on a Lincoln-Petersen mark and recapture. The error bars represent the upper and lower 95% CI.

Table 5. Northern Pike population estimates based on the mark and recapture results and the total NP removed by year.

Year	Population Estimate	NP Removed
2014	725	163
2015	410	125
2016	107	43

Northern Pike Stomach Analysis

The stomach contents of all NP captured by gill-nets in 2014 to 2016 were examined either in the field (n=245) or in the TRU lab (n=43) . Prey was identified to species when possible. For all study years (2014-2016) approximately 51% (n=147) of all the NP examined (n=288) contained food in their stomachs and in most cases included whole fish. Fish listed under SARA were not observed in the stomachs of any of the NP captured during this study. Some stomachs contained residual bones (vertebrae and operculum) of what was believed to be salmonid species, but almost half (49%) of stomachs sampled were completely empty. Leech species were found in two of the NP sampled, and 60% of NP diet consisted of native salmonids (Rainbow Trout, Kokanee and Mountain Whitefish). The size range (length) of NP prey fish species was 5 cm to 38 cm and included Dace spp., Sculpin spp., Redside Shiner, Longnose Sucker, Rainbow Trout, Mountain Whitefish, Kokanee, Northern Pike Minnow, Northern Pike and unidentified species.

DISCUSSION

In three years, the Invasive Northern Pike Suppression Program has successfully removed 331 NP from the study area, with over 87% of the total capture coming from the gill-nets. The number of NP removed by gill-nets per year was significantly reduced in 2016 (n=39) when compared to 2014 (n=133), and 2015 (n=116). The 2016 mark and recapture data estimate the current NP population in the Robson Reach area to be 107 with 39 of those being removed during the 2016 sampling. The suppression program continues to successfully remove approximately 30-40% of the estimated population in the study area annually, however more invasive NP can continue to move into the LCR from the Pend D'Oreille River at currently unknown rates.

The reduction in NP captures in 2016 may be an indication of suppression success combined with the lack of suitable habitat in the study area, or may be a result of the reduction in total gill-netting effort in 2016 by five sampling days. The CPUE for a single crew of two deploying eight nets a day for 8 hours in the study area in 2016 was 12.40 NP/day and the catch rates are very similar when compared to the 2014 (11.98 NP/day) and 2015 (12.93 NP/day) CPUE averages suggesting that the reduced number of sampling effort (5 days) in 2016 resulted in the lower total NP catch for the year.

A total of 1,625 hours of fyke net NP larval sampling was conducted by Okanagan Nation Alliance (ONA) in the Robson Reach area in 2016 and confirmed age 0+ NP (1 NP < 130 mm fork length) presence (A. Duncan, Pers.Comm). Spawning behaviour of large adult NP have been observed in shallow water habitat in the Robson Reach area near the Celgar pulp mill and have been dissected to reveal thousands of developed ripe eggs and milt. Subsequent sampling post-spawning also revealed spent NP suggesting that spawning was successful in the Robson Reach area. Based on the larval sampling conducted by ONA in 2016 and Golder and Associates (2015) the spawning success in the LCR Robson Reach area is very low. In the US, the Colville Confederated Tribes Fish and Wildlife Department electrofished the lower Kettle River (US Columbia River tributary) and successfully removed more than 1,000 NP young of the year (C. Lee, Pers. Comm.) suggesting spawning recruitment is much more successful in the Columbia River south of BC (Figure 13).

Figure 13. Young of the year NP removed by the Colville Confederated Tribes Fish and Wildlife Department from the lower Kettle River in the US in 2016. Photo credit: Shay Wolvert, Colville Tribes.

Invasive NP continue to have the potential to significantly impact native salmonids, dace and sculpin species in the Lower Columbia. Approximately 60% of the prey is made up of salmonids (42% MW, 10% RB, and 7% KO) and 20% of the prey were sculpin and dace species. SARA listed species have not been confirmed as prey. TRU sampling in the Canadian portion of the Pend D'Oreille has confirmed that NP are quite abundant, but it is currently unknow to what extent and how frequently NP may invade the LCR from this source. Four tagged NP have been released in the Waneta Reservoir on the Pend D'Oreille as part of the TRU research, and the program will continue to investigate the source of the invasive NP in the Lower Columbia River in 2017. TRU's continued research will also investigate if NP are currently moving through the HLK dam lock and entering the Arrow Lakes Reservoir. The Washington Department of Fish and Wildlife, the Spokane Tribe of Indians and the Colville Confederated Tribes have implemented a similar collaborative NP gill-netting suppression program on Upper Lake Roosevelt and the lower Kettle River and successfully removed 85 NP in 2016 (C. Lee, Pers. Comm.). The current suppression program in the LCR downstream of the HLK dam in the Robson Reach area has been a collaborative effort at successfully controlling the invasive NP population and gill-netting efforts should continue annually.

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