

Risk Assessment and Status of Invasive Northern Pike Suppression Efforts in the Columbia River Basin – 2019 Action Plan

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EXECUTIVE SUMMARY

Northern Pike (*Esox lucius*) are a highly successful aquatic invasive species known to have detrimental effects on native fish populations. They are ambush predators and are primarily piscivorous, however they have an opportunistic and diverse diet and are known to consume invertebrates, birds, amphibians and small mammals. Northern Pike are adaptable and prefer slow-moving, shallow, weedy habitats found within lakes, creeks, and large rivers. Northern Pike are native to many areas in North America including the northeastern United States, and in Canada they are found in northern British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec and Labrador. Northern Pike were first detected in the Canadian Columbia River in 2009 and were confirmed in 2010 during BC Hydro's Large River Indexing surveys. Thought to have entered this system from the Pend d'Oreille River, Northern Pike are now considered established in U.S. and Canadian portions of the Columbia River as spawning and recruitment has been successful at these locations.

The spread of Northern Pike to non-native regions of North America is concerning for resource managers, as Pike have the potential to cause significant impacts on native fish stocks. Management efforts in the Canadian Columbia River Basin have varied since implementation in 2011, and the most effective method of management identified to date is active suppression. Suppression efforts were initiated in 2014 and at that time the population of Northern Pike was estimated to be 725 (95% CI: 478-2759) individuals. Since 2014, 420 Northern Pike have been removed from the Columbia River system and the population is now estimated to be approximately 99 (95% CI 25-172) individuals. Thirty-three of those Pike were removed from the Columbia River in 2018, along with 15 removed from the Pend d'Oreille River. In the U.S., similar suppression efforts have been ongoing since 2011 and in 2018 3,110 Northern Pike were removed in the U.S. including 806 from the Kettle River, 1901 from the Columbia River, and 403 from the Pend d'Oreille River.

An assessment of the ecological and economic risks from the introduction of Northern Pike was conducted by the Okanagan Nation Alliance and is provided within this document. Ecological impacts have been evaluated by river section within the Columbia River Basin and include threats to habitat availability and food resources for native fish populations. The primary economic risks include threats to salmon stocks, salmon recovery, sport fishing and to First Nations cultural and economic values.

Data gaps identified for the Canadian populations of Northern Pike in the Columbia River Basin include: the population status of Northern Pike in the Canadian Kettle and Pend d'Oreille Rivers, identification of juvenile rearing habitats and winter behaviour of Northern Pike, and the threat of Northern Pike to Species at Risk in the Columbia River [White Sturgeon (*Acipenser transmontanus*), Columbia Sculpin (*Cottus hubbsi*), Umatilla Dace (*Rhinichthys umatilla*)].

Recommendations for management of Northern Pike in the Canadian Columbia River Basin include: continued active suppression, development of an Early Detection and Rapid Response Protocol for high-risk waterbodies, implementation of a formal Transboundary Northern Pike Suppression Committee, exploring additional opportunities to involve anglers in Northern Pike management, updating the Provincial Priority Invasive Species List, and conducting upstream fish migration barrier trials at high-risk locations.

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1.0 Introduction

The objective of this document is to provide an update to the information in the “Northern Pike Suppression in the Columbia River System” report developed by AMEC Foster Wheeler (2017) and to incorporate the long-term management objectives of the Okanagan Nation Alliance (ONA) and the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD) for Northern Pike. The original report was developed for the Columbia Basin Trust (CBT) and the MFLNRORD with the objective of summarizing Northern Pike Suppression efforts in the both the Canadian and U.S. Columbia River Systems, identifying information needs and data gaps and providing recommendations to strengthen suppression efforts.

Northern Pike have become established in several parts of the Columbia-Kootenay watershed and it is unlikely they will become completely eradicated (VanPoorten *et al.* 2018). Active suppression has been identified as a necessity in both the U.S. and Canadian Columbia River watersheds as Northern Pike are prolific in these systems and can show tremendous population growth in a short amount of time (i.e., one fallow season). Efforts in Canada to date suggest that annual suppression programs have significantly reduced the Pike population and continued efforts are required to keep the impacts of Pike negligible on native species. It is paramount that the suppression programs continue with at least the same amount of effort [summarized in Appendix C] in key, known areas in Canada. Preferably, annual efforts should increase as modelling efforts have shown duplicating suppression efforts has had increased positive effects (Van Poorten *et al.* 2018).

In 2017, the ONA prepared a 5-year suppression plan recommending long-term planning and secure funding to ensure suppression efforts remain in place and are well resourced for consecutive years. It is clear that the effort put into resourcing suppression programs on an annual basis leaves little time for planning, particularly when most organizations’ fiscal planning cycle (i.e. March-April) coincides with the optimal early spring suppression targets for pre-spawn Northern Pike. Numerous stakeholders and Columbia-based industries receive benefit from the aquatic and fisheries resources and are willing financial supporters. There is strength in numbers when numerous sources of financial support share the burden of backing a significant suppression program. Long-term financial support allows for leveraging from funders by merging collaborative support momentum and corporate responsibility. We suggest collaboration continue within and among all concerned parties interested in participating in and supporting long-term Northern Pike suppression in the Columbia Basin.

This updated report includes summaries of suppression efforts conducted in 2018 in both the Canadian and U.S. systems, identifies existing data gaps and provides recommended actions for future management based on the results of suppression efforts to date. It also considers ecological and economic risks posed by current Northern Pike populations in the Columbia River and the risks posed by further species expansion within the Columbia system.

1.1 Background

Northern Pike (*Esox lucius*) are a highly successful aquatic invasive species native to North America and Eurasia and are widespread throughout Canada (Harvey 2009). Northern Pike are biologically adaptable and can occupy differing habitats including lakes, creeks, and riverine environments, though they are often found in areas of slow-

moving, shallow waters. Pike have an opportunistic and diverse diet that can include fish, invertebrates, amphibians, birds and small mammals. Northern Pike can be a long-lived species and grow to over 1 m in length. With its large size, Northern Pike can consume large prey species, up to one-third to one-half of its body length (DFO 2011). Pike can tolerate a wide range of environmental conditions including low and high water temperatures (0.1-29.0°C), and oxygen levels as low as 0.3 mg/l (DFO 2011). It is a host to many parasites, and one in particular, *Triaenophorus crassus*, uses salmonids as an intermediate host. Cascading ecosystem trophic effects due to Northern Pike predation are a known impact, causing increases in zooplankton and invertebrate numbers following reductions in planktivorous fish populations (Bradford *et al.* 2008).

Although considered native in the northeastern section of British Columbia (B.C.), Northern Pike were first recorded as illegally introduced into areas of southern B.C. in 2005 at Haha Lake in the East Kootenays. In the Columbia River system, the introduction of Northern Pike likely originated from Flathead Lake in Montana where they were illegally introduced in the 1980's (AMEC 2017). Northern Pike were first reported in the Canadian Columbia River system in 2009, and confirmed in 2010 during BC Hydro's Large River Indexing Program CLBMON-45 (Ford and Thorley 2010). Having entered the system through illegal stocking of the U.S. portion of the Pend d'Oreille River, this invasive species is now established in the Columbia River system below Hugh Keenleyside Dam (HLK). Environmental DNA (eDNA) results have also identified Northern Pike presence in the Canadian Kettle River system (Carim *et al.* 2018); however, these results have not been corroborated by the physical capture of Northern Pike at this location.

Recognizing the risk of Northern Pike on native fish populations, B.C. fisheries managers initiated various suppression efforts from 2011 to 2017 including gillnetting, electrofishing, and angler incentive programs. This resulted in the removal of 372 Northern Pike from the Canadian portion of Columbia River, below Hugh Keenleyside Dam by 2017 (Baxter and Lawrence 2017). In 2018, overall Canadian Northern Pike suppression efforts resulted in the removal of 48 pike from the Lower Columbia and Pend d'Oreille Rivers using gillnetting and electrofishing methods (Wood 2019). As well, the Okanagan Nation Alliance initiated a Pike Angler Bounty Program resulting in the return of four heads (see poster in Appendix E) and two additional Northern Pike were captured during BC Hydro's Large River Indexing Program (CLBMON-45; Golder, ONA and Poisson 2019). Although there are additional components of Pike suppression that will likely improve efficiency in removals and reduce risk of future spread, these past netting suppression activities have clearly shown that targeted spring pike netting focused before and during pike spawning (typically early May in the Columbia River) has reduced pike abundance and net catch rate by almost 90% (Baxter and Lawrence 2017).

Suppression efforts in the U.S. portion of the study area began upstream of the Columbia River in 2011 in the Box Canyon Reservoir (Pend d'Oreille River) and downstream in 2015 on Lake Roosevelt (Columbia River). Using a variety of methods [gillnetting, beach seining, electrofishing, angler incentive programs] in an aggressive suppression program, U.S. fisheries managers removed a substantial number of Northern Pike from these two systems. In 2018, the Spokane Tribe of Indians, Colville Confederated Tribes and Washington Department of Fish and Wildlife removed 2,707 Northern Pike from the U.S. Columbia and Kettle Rivers (H. McLellan, pers. comm., Jan 9, 2018). In addition, the Kalispel Tribe removed 403 Northern Pike from the upper and lower reservoirs of the Pend d'Oreille River in Washington (N. Bean, pers. comm., Jan 14, 2019).

Through their efforts in 2018, the Spokane Tribe of Indians captured a Northern Pike only 10 miles upstream of Grand Coulee Dam (K. Thurman, pers. comm., Jan 2, 2019); indicating Northern Pike are now inhabiting the majority of the non-anadromous section of the Columbia River, between Grand Coulee Dam and Hugh Keenleyside Dam. Further migration downstream and below Grand Coulee Dam, and below Chief Joseph Dam into anadromous waters presents a high risk to salmon and other native fish species.

The current known extent of Northern Pike in the Columbia River basin is shown in Appendix A. Further details on Canadian and U.S. suppression efforts are provided in Section 3.0.

2.0 Risk Assessment

2.1 Ecological Risk

Aquatic invasive species are widely recognized as a major threat to global and local ecological diversity and ecosystem stability (CCFAM 2004). Aquatic invasive species such as zebra and quagga mussels (*Dreissenid spp.*) have permanently altered the aquatic ecosystem in the Great Lakes causing dramatic changes in the diatom and algae concentrations, which are the very the base of the food web (Evans *et al.* 2011). Canada has approximately 20 percent of the world's freshwater resources and therefore has one of the highest global risks to inland aquatic species introductions in the world (CCFAM 2004).

A number of aquatic invasive species are already present in the Columbia River system, these include aquatic macrophytes such as Eurasian Watermilfoil (*Myriophyllum spicatum*) and Curly-leaf Pondweed (*Potamogeton crispus*), and fish species such as Common Carp (*Cyprinus carpio*), Largemouth (*Micropterus salmoides*) and Smallmouth Bass (*M. dolomieu*), Yellow Perch (*Perca flavescens*), Tench (*Tinca tinca*) and Walleye (*Sander vitreus*). Each invasive species has had its own unique set of circumstances that led to its arrival, establishment, and ultimate spread through the system. In order to protect aquatic environments from invasive species, biological risk assessments are required so effective decisions regarding policies, regulations, legislation, and management plans can be developed (Mandrak *et al.* 2012).

An invasive species risk assessment for specific waterbodies and waterbody types was approved by the Canadian Council of Fisheries and Aquaculture Ministers in 2004 (CCFAM 2004). A Canadian national framework for conducting aquatic invasive species biological risk assessments was developed in 2011 by Mandrak *et al.* (2012). The ultimate goal of risk assessments is to provide the best information available so that sound and timely decisions can be made on how to control new introductions of non-native species. A summary of the key information components in Mandrak *et al.* (2012) required to conduct an invasive species biological risk assessment are provided below:

- Analysis of the pathways of transportation and movement availability throughout the system, and the risk of the invasive species using these transport vectors to spread into other areas of the system;
- Evaluation of all the life stages of the target aquatic invasive species, and analysis of the ability of each life stage to establish and survive in a specific system or area of that system;

- Estimation of the biological consequences of the introduction of a new species to other species and to the overall stability of the ecosystem;
- Provide recommendations and identify uncertainties of the assessment process;
- Provide opportunity to agencies and stakeholders for review and comments;
- Development both short and long-term management actions, and then implement actions as soon as possible.

For the Columbia River system, the risk of Northern Pike establishment to fish communities and to the overall ecological structure within large systems is still relatively unknown (DFO 2011). There are many instances where introduced Northern Pike have caused impacts to native populations through predation; the most severe impacts being in small lakes and areas with extensive littoral zones (Bradford *et al.* 2008). A DFO risk assessment for invasive Northern Pike introductions in B.C. found that the ecological consequences associated with their establishment in the Columbia River system (including the Okanagan River system) were the highest in the Province (DFO 2011). The risk of continued spread and establishment within the Columbia system was also ranked as high. From a cultural and socio-economic perspective, the risk of Northern Pike predating on the Columbia River's natural and supplemental populations of Pacific salmon (*Oncorhynchus spp.*) is one of the greatest risks it poses (Harvey 2009). Salmon are a key cultural species to the First Nations and Tribes of the Columbia River basin and are a keystone species that provide food and nutrients to support birds, animals, and oceanic aquatic mammals such as Killer whales and seals.

In this report, a modified version of the CCFAM 2004 invasive species ecological risk assessment was conducted for Northern Pike in the Columbia River system, with the results provided in Tables 1 and 2. Many of the components of the CCFAM 2004 and Mandrak *et al.* (2012) biological risk assessment processes were incorporated into this current Columbia River assessment. However, the information provided is still relatively broad and will have some large information data gaps associated with it.

The Canadian sections included in this modified ecological risk assessment include the following areas (Table 1):

- (a) Revelstoke Dam upstream to Columbia Lake;
- (b) Hugh Keenleyside Dam upstream to Revelstoke Dam;
- (c) Brilliant Dam upstream to the Kootenay River headwaters;
- (d) Mainstem of the Columbia River from the US border upstream to Brilliant and Hugh Keenleyside Dams;
- (e) Waneta Dam upstream to Boundary Dam on the US border;
- (f) Kettle River from the US border upstream to Christina Lake; and,
- (g) Okanagan River from the US border upstream to Okanagan Lake.

The American sections included in this modified ecological risk assessment include the following (Table 2):

- (a) Pend d'Oreille River from Flathead Lake to the Canadian border;
- (b) Lake Roosevelt from Grand Coulee dam upstream to the Canadian border;
- (c) Mainstem Columbia River from the mouth upstream to Grand Coulee dam;
- (d) Columbia River estuary.

Table 1: Canadian Columbia River Modified Ecological Risk Assessment by River Section

| Waterbody Area | Migration Barriers | | Habitat Availability | Food Resources | Other Risks |
|--|--|---|---|--|---|
| | Upstream | Downstream | | | |
| (a) Revelstoke Dam, upstream to the headwaters at Columbia Lake, inclusive of Mica Dam. | Revelstoke Dam is impassable by fish and poses a barrier to upstream migration. | Revelstoke Dam is 175 m high and can pose a barrier to downstream migration. However, there is still some potential risk of downstream movement. | Suitable slow-water shallow bays for spawning and rearing are available, especially in Kinbasket Reservoir and in the upper Columbia River closer to the headwaters. | Food resources are available for all pike life stages, although to varying degrees in the areas upstream of Revelstoke Dam. | The headwater areas around Columbia Lake and the Columbia Wetland Complexes provide ideal habitat for all life stages. The risk of introduction from pike from native populations in Alberta is high. |
| (b) Hugh Keenleyside Dam (HLK) upstream to Revelstoke Dam | HLK has a navigation lock that provides some passage between the river below the dam and the Arrow Lakes Reservoir upstream. | HLK has a navigation lock that provides some passage between the river below the dam and the Arrow Lakes Reservoir upstream. HLK is 52 m high and has spill gates that could also provide downstream passage. | There are some suitable Northern Pike habitats available in the Arrow Lakes reservoir, however, they are not ideal and experience up to 20 m in drawdowns each year. Wetland complexes near Revelstoke would provide more suitable habitat and are inhabited by invasive species such as Yellow Perch and Common Carp; temperature suitability for spawning in combination with terrestrial flooding may not often occur. | Cyprinid and salmonid populations exist throughout the reservoir and could provide adequate food resources for juvenile and adult pike. Annual reservoir fertilization increases the phytoplankton resources and would be beneficial to larval Pike. | The main risk for the Arrow Lakes reservoir would be the incidental passage of pike through the HLK navigation locks. HLK operational staff have observed fish species such as Kokanee, White Sturgeon, Mountain Whitefish, and sculpin within the lock. The lock is used for recreational passage occasionally and commercial log barges on a regular basis. |
| (c) Brilliant Dam upstream to the | Brilliant Dam poses a complete | Downstream barriers in the Kootenay River system include | Suitable slow-water shallow bays for spawning and rearing | Food resources are available for all pike life stages, although to | The area above Brilliant Dam extends for hundreds of kilometers, which includes a 190 |

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| <p>Kootenay River headwaters</p> | <p>physical barrier to upstream migration from the lower Columbia River into the Kootenay and Slocan River systems.</p> | <p>Libby Dam (129 m high), the Kootenay River dams between the Slocan River and Kootenay Lake, and the Brilliant Dam (43 m high). Due to the limited height of each dam and the spring freshet conditions that occur each spring, downstream migration is considered highly plausible.</p> | <p>are available, especially in Brilliant Reservoir, the North and South ends of Kootenay Lake, large sections of the Slocan River, the US portion of the Kootenay River, and areas within Kooconusa Reservoir (US). The upper headwaters of the river are faster flowing and experience cooler temperatures due to proximity to glacial runoff waters.</p> | <p>varying degrees in the areas upstream of Brilliant Dam. Brilliant Reservoir has abundant macrophyte beds and cyprinids.</p> <p>The cool and fast flowing waters of the Kootenay River upstream of Lake Kooconusa may provide some food resource limitations to pike.</p> | <p>km section that flows through Montana and Idaho, exposing the river to the risk of introduction from illegal stocking. There are many slow, warm-water areas within the Kootenay and Slocan River systems that could support all life stages of pike.</p> <p>Pike were found in Haha Lake in 2005. It is generally assumed that no escapes into the Kootenay River occurred because of a lack of strong connectivity. However, there are occasional pike captures in Kootenay River tributaries above Kooconusa Reservoir. This highlights the risk of upstream introductions making their way downstream through the Kootenay system.</p> |
| <p>(d) Mainstem of the Columbia River from the US border upstream to the Brilliant Dam (Kootenay River) and Hugh Keenleyside Dam.</p> | <p>There are no upstream migration barriers from Roosevelt Lake and the Pend Oreille River into this section of the river.</p> <p>Downstream movement of Pike from the Pend d'Oreille and upstream into this section has</p> | <p>There are no downstream migration barriers from this section of the river into Roosevelt Lake (US).</p> | <p>Suitable habitat for all life stages is available, especially in the areas such as Robson Reach, Zuckerberg Island, Kootenay River confluence/Selkirk College oxbow, Waterloo Eddy, and the mouth of Beaver Creek. The success of suppression gill net efforts suggests incubation and/or rearing habitat may be limited.</p> | <p>Cyprinid, catostomid and salmonid populations exist throughout the reservoir and could provide adequate food resources for juvenile and adult pike.</p> <p>Primary productivity below HLK is considered good and could support larval production.</p> | <p>Pike are already in this section of the river system.</p> <p>There are several risks that this section of the river poses for other areas: this could be a source of pike for illegally stocking into other waterbodies; Pike could migrate through the HLK navigation lock and become established in the Arrow Lakes reservoir.</p> |

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| | already been confirmed. | | | | |
| (e) Pend d'Oreille dam upstream to the Boundary Dam on the US border, inclusive of Waneta Dam. | There are a number of dams that create upstream barriers to pike movement, including the Waneta Dam (76 m) and Seven Mile Dam (65 m). However, pike are already in each of the reservoirs upstream of the Canadian dams. | Several dams on the Pend d'Oreille River will impede downstream movement; however, downstream movement of pike has already been confirmed through this section, entrained most likely during spring freshets. | Suitable habitat for pike is lacking in the reservoirs, which are steep banked and experience daily elevation changes. However, some isolated areas of suitable bays with macrophytes have been identified (AMEC 2015). | Species such as Redside shiner, Peamouth chub, Yellow perch, Crappie, and juvenile Northern Pikeminnow and Sucker would provide adequate food resources for juvenile and adult pike. . | The Seven Mile and Waneta Dam reservoir could be utilized as long-term refuges for pike. Although the spawning and rearing habitat is not ideal, the food resources for juvenile and adult pike are extensive. A coarse fish barrier on the Salmo River, a tributary to the Pend d'Oreille entering Seven Mile Reservoir, has been assessed for passage and is considered passable under certain water conditions, allowing possible colonization of the Salmo Watershed. |
| (f) Kettle River from the US border upstream to Christina Creek and to Christina Lake. (Note: This assessment could also apply to the US portion of the Kettle River from Lake Roosevelt to the Canadian border) | There are no upstream barriers to pike migration from Roosevelt Lake, into the Kettle River, and into Christina Lake. Boundary Falls (12 m) is on the mainstem Kettle River, just west of Christina Lake and is a | There are no downstream migration barriers from Christina Lake, into the Kettle River, and into Roosevelt Lake (US). | This section of the Kettle River is shallow and warm in the summer and could support a limited population of pike. The north and south ends of Christina Lake, and the lake outlet, and parts of Christina Creek have ideal habitat for all life stages. The main lake itself could support a resident population of pike, but | The section of the Kettle River has the resources to support a limited population of pike. The north and south ends of Christina Lake, the lake outlet, and parts of Christina Creek have ideal food resources for all pike life stages. The main lake itself could support a resident population of pike, but to a lesser extent than | Christina Lake has the highest number of invasive fishes in the Kootenay-Boundary area, providing ideal feeding conditions for juvenile and adult Pike. A large resident population of pike has the potential to establish here. Although Boundary Falls is a physical barrier to upstream migration, the risk of illegal transport and introduction into the upper Kettle and Granby Rivers above the falls is high, as is seen with the establishment of smallmouth bass in upstream reaches. |

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| | physical barrier for pike migration to the Granby River and the Kettle River, past Grand Forks. | | to a lesser extent than the north and south ends. However, warm littoral zone and an abundance of recreational structures (i.e., rafts, docks) would provide ideal habitat. | the north and south ends. Production would still be high due to the abundance of fish such as Carp, Bass, shiners, and Pumpkinseeds. | |
| <p>(g) Okanagan River from the US border upstream to Okanagan Lake.</p> <p>(Note: this assessment could also apply to the US Okanagan River from the Columbia River to the Canadian border).</p> | <p>There are a series of small irrigation dams and vertical drop structures on the Okanagan River between the US border and Okanagan Lake. Zosel Dam is just across the border in Oroville, WA, and has fish passage structures. Similarly, McIntyre Dam (1.7 m high) just south of Vaseaux Lake and Skaha Lake outlet dam (6 m high) have been modified for Salmon and Steelhead passage.</p> | <p>There are no downstream migration barriers from Okanagan Lake, via the Okanagan River, and into the US Columbia River near Brewster, WA.</p> | <p>Suitable habitat exists for pike in much of the Okanagan River, as it is a warm, slow system. Habitat for all life stages would exist in all the lakes in the Okanagan system, especially those with warm, shallow bays commonly supporting macrophytes, such as Vaseaux Lake.</p> | <p>Extensive food resources for all life stages exist throughout the entire Okanagan system. The lakes would be more productive than the riverine sections.</p> | <p>Migration of pike from the US Columbia River into the Okanagan River may be an eventual reality due to lack of migration barriers.</p> <p>Illegal introduction into the Okanagan system would also be a risk.</p> <p>Upstream fish passage may occur through the Okanagan Lake outlet structure and could allow pike passage during high spring runoff events.</p> <p>Pike pose a significant predatory risk to the existing Salmon populations in the Okanagan River system.</p> |

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| | There is no upstream fish passage into Okanagan Lake because of a low outlet dam at Penticton. | | | | |
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Table 2: U.S. Columbia and Pend d'Oreille River Modified Ecological Risk Assessment by River Section.

| Waterbody Area | Migration Barriers | | Habitat Availability | Food Resources | Other Risks |
|---|--|--|--|--|---|
| | Upstream | Downstream | | | |
| (a) Pend d'Oreille River from Lake Pend d'Oreille to the Canadian border | Boundary Dam (100 m high), Box Canyon Dam (19 m high), and Albeni Falls Dam (27 m high) all pose upstream migration barriers for pike. However, plans are in place for all three dams for trap and truck passage structures for salmonids. | Several dams on the US Pend d'Oreille River will impede downstream movement. However, downstream movement of pike has already been confirmed through this section, most likely during spring freshets. | Habitat is available throughout the drainage with the Box Canyon reservoir being identified as having very good habitat for pike. Other reservoirs do not appear to be as productive due to lack of adequate habitat and reservoir water drawdown. | Baitfish and salmonid populations exist throughout the system and could provide adequate food resources for juvenile and adult pike. | The US Pend d'Oreille River already has pike throughout most of the system. Major risks include illegal introductions to other lakes and systems that may drain into the Kootenay River and loss of resources required to continue pike suppression efforts. |
| (b) Roosevelt Lake from the Grand Coulee dam upstream to the | There are no upstream barriers to pike migration from Grand Coulee dam to | There are no downstream barriers to pike migration from Lake Roosevelt to Grand Coulee Dam. | Habitat may be limited in Lake Roosevelt to non-productivity and hydroelectric drawdown. However, upstream habitat, | Food resources may be limited for larval pike. Juvenile and adult pike would have access to baitfish and salmonid food resources. | The size of the reservoir could limit the ability to adequately control the population. Therefore, a permanent resident source population of pike could reside in Lake Roosevelt. |

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| Canadian border. | the Canadian border. | | especially in Christina Lake and the Pend d'Oreille system may provide adequate habitat to keep a resident pike population in the reservoir. | In 2017, various age-class Pike were gillnetted less than 15 km upstream of Grand Coulee dam. This suggests that Roosevelt Lake can support a pike population. | <p>Angler lobby groups could limit the US Tribes and agencies' ability to reduce the population, especially of large pike due to their sportfish quality.</p> <p>Pike pose a significant risk to current native species populations, and to proposed anadromous Salmon reintroductions into the upper Columbia River system.</p> |
| (c) Mainstem Columbia River from the mouth upstream to the Grand Coulee dam. | There are numerous hydro facilities on the US Columbia River, many with upstream fish passage structures. However, Grand Coulee Dam (168 m high) is the largest dam and has no upstream fish passage. | Grand Coulee Dam may pose a partial barrier to downstream migration of pike from Lake Roosevelt. Over time, spring freshet may allow partial passage. | Although habitat is not ideal, and may not be found in many sections of the Columbia River below Grand Coulee, there are areas of ideal habitat (i.e. Lake Pateros), including several tributaries, where they could thrive and be a source location. | Pike are very adaptable and there are many sections of the US Columbia River that could sustain populations. | <p>Pike pose a serious risk to current Columbia River Salmon and other native species populations and to proposed Salmon reintroductions into the upper Columbia River system.</p> <p>Pike can establish populations quickly, the large area of river below Grand Coulee will present challenges in adequately controlling populations.</p> <p>The Columbia River below Grand Coulee to the estuary is over 700 km, posing many opportunities for illegal introductions.</p> |

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|--|---|---|--|--|---|
| <p>(d) Columbia River estuary near Astoria, OR.</p> | <p>There are no passage barriers in the Columbia River estuary.</p> | <p>There are no passage barriers in the Columbia River estuary.</p> | <p>It is unknown if habitat conditions would support egg and larval stages; however, juvenile and adult pike could potentially survive in the brackish estuary waters.</p> | <p>Estuaries are very productive and support life stages of many species of fish and birds. It is assumed that adequate food resources are available to support juvenile and adult pike.</p> | <p>Pike are able to withstand some extremes in water quality and have been documented to survive in estuarine environments. This would pose risks to juvenile salmonid populations, and ultimately, to the larger species mammal species, such as Killer Whales, that prey on the returning Salmon.</p> |
|--|---|---|--|--|---|

2.2 Economic Risk

In the U.S., the Northwest Power and Conservation Council (NPCC) is currently developing an economic review of the impact of Northern Pike in the Columbia River basin. The Washington Invasive Species Council has identified Northern Pike on the *Top 50 Priority Invasive Species for Action* list (Maroney 2019). The report will include a focus on suppression techniques and associated costs (Robinson 2019). An economic risk assessment for Northern Pike establishment in the Canadian portion of the Columbia Basin, including the Okanagan system, is required. Some approximate economic values from current salmon infrastructure and fisheries, as well as information on angler use in the basin are provided as context.

The priority economic sectors at risk from Northern Pike establishment in the Columbia River are to anadromous salmon and to the recreational sport fishery. In 2013, the Okanagan and Kootenay regions received 25% of the Province's total number of fishing days, or 899,405 days (FFSBC 2013). A 1981 creel survey (BC Fish and Wildlife 1981) on the Columbia River below HLK estimated that there were approximately 20,083 angler hours, or 837 days, expended fishing, primarily for Rainbow Trout. Using the 2015 Federal fishing survey data (FOC 2019), each freshwater angler spent approximately \$213 per day (in today's dollars) fishing, which equates to approximately \$170,000 spent per year by anglers. It is estimated that one billion dollars has been invested in salmon recovery over the past two decades in the U.S. Columbia River basin (Bush 2019). As an example of potential economic impacts, Northern Pike establishment resulted in the collapse of a multi-million-dollar Chinook sport fish industry in Alaska (Bradley 2019). Annual freshwater economic losses from Northern Pike in the Pactola Reservoir in South Dakota were estimated at \$15-24,000 per year due to predation on Rainbow Trout (Scheibel *et al.* 2016), posing an economic risk to future stocking of the reservoir.

The Okanagan system has runs of Sockeye and Chinook which are supplemented with hatchery Sockeye releases from the ONA's new facility, the *kt cpi'əlki' stiml'* Hatchery (\$12 million invested), on Penticton Indian Band land. Since 2004, the investment in Sockeye recovery in the Okanagan Basin is valued at \$46 million (R. Bussanich, pers. comm., Jan 17, 2019). The Okanagan Sockeye fishery supports a traditional food fishery, a commercial fishery, direct retail sales and a sport fishery. Approximate sales per year are \$30-90,000 for commercial, \$3.5-\$35,000 for retail sales and \$500,000 for First Nation and sport fishery consumption (R. Bussanich, pers. com., January 30, 2019). In 2005, the estimated annual number of freshwater anglers in the Okanagan and Kootenay regions was 83,000, contributing \$103 million to the B.C. economy, or approximately 25% of the provincial freshwater fishery expenditure total (GSGislason 2009).

The re-establishment of historical salmon runs that were lost due to the construction of Grand Coulee Dam are a priority for the Nations and Tribes in the Columbia Basin. Northern Pike introductions pose a risk to the re-establishment of those runs in the Columbia, Pend d'Oreille, Salmo, Slocan and other large river systems. The cost of a salmon reintroduction program will require provisions to provide funding for invasive species management to ensure salmon survival.

An economic assessment of the cost of invasive species in Ontario noted that the majority (84.2%) of expenditures in 2018 were on control and management of invasive

species, while only 6.7% and 9.1% was expended on prevention and detection activities, respectively (Vyn 2018). Prevention has been identified as the policy with the greatest long-term net benefit in combating invasive species (Lodge *et al.* 2016). It was also identified in Vyn's (2018) assessment that funding was not sufficient in Ontario to combat invasive species. In Canada, economic loss and costs associated with invasive species are estimated at \$5.5 billion (CCFAM 2004).

Table 3: Economic risks of Northern Pike in the Columbia River Basin.

| Sector | Risk Level | Considerations | Uncertainty |
|---|--------------------------------|--|--|
| Salmon | Very High | <p>Pike are known to prefer soft-bodied species such as salmonids to other species. Pike may inhabit the same shallow, vegetated habitats that rearing salmon prefer.</p> <p>The mainstem of the Columbia River supports current Salmon populations with the potential of reintroduction of the species into historical upper Columbia River drainage locations.</p> | It is unknown if smolt outmigration rates due to impoundment, will make them more susceptible to predation. |
| Salmon aquaculture | Very High | <p>Other predatory species (i.e. Northern Pikeminnow) have been known to target salmon hatchery release locations. Pike may adapt the same behaviour, leading to reduced hatchery stock reaching the ocean.</p> <p>Pike may inhabit the same shallow, vegetated habitats that rearing salmon prefer. Alaska Fish and Game found that the threat of Northern Pike is greatest for juvenile Chinook and Coho due to similar habitat preferences (NFHP 2018).</p> | It is unknown if deterrence methods will limit the amount of pike staging at key smolt release locations. |
| Recreational sport fishery Tourism | Very High for salmonid species | Pike are known to prefer soft-bodied species such as salmonids to other species. Anglers targeting salmon, trout and other sportfish may see populations drastically reduced. | It is unknown if trout stocking can be justified in waters inhabited by viable populations of pike. Also the impact of pike on native trout and other sportfish populations is not well understood on the Columbia |
| First Nation or Tribe food fishery | Very high | Pike are known to prefer soft-bodied species such as salmonids over other species. Food fishers targeting salmon and trout may see populations drastically reduced. | Unknown loss of cultural and economic livelihood. |

One method of conducting an assessment of economic risk can include surveys to government, municipalities, regional districts, and non-government organizations. Considerations for an economic risk analysis survey should include the following (adapted from Vyn 2018):

- Type of expense (i.e., wages, equipment, education and outreach materials, travel, harvest);
- Type of activity (i.e., prevention, detection, collaboration, control, management).

Consideration of values, both financial and non-financial, must also be included when conducting an economic assessment. Non-financial (or non-user) value can include existence values (knowledge of continual existence), bequest values (preserving the resource for the future) and option values (having the option to use the resource). As an example in terms of recreational fishing, user value can be estimated using willingness to pay (Radtke *et al.* 2004).

3.0 Suppression Efforts

A thorough summary of suppression efforts conducted in both the Canadian and U.S. sections of the Columbia River from 2013-2017 was provided in AMEC (2017). The following section provides an update of known Northern Pike suppression efforts conducted in 2018 in both the Canadian and U.S. sections of the Columbia River.

3.1 Canada

Suppression efforts have been underway since 2013 and have included gillnetting, electrofishing and angler incentive programs. By 2017, a total of 372 Northern Pike were removed from the Columbia River below HLK, reducing the population size by ~86% to less than 100 individuals (Baxter and Lawrence 2018). These past netting suppression activities have clearly shown that targeted spring Pike netting focused before and during spawning (typically late April and May) has been able to significantly reduce adult Pike abundance and keep them suppressed (Baxter and Lawrence 2018). Although there are additional components of Pike suppression that will improve efficiency in removals, help target Young-Of-Year Pike and reduce risk of future spread, active suppression during spawning has been the most effective method of removal identified to date.

In 2018, the overall objective of efforts expended in the Canadian Columbia River was to continue to remove as many Northern Pike individuals (juvenile and adult) from the Columbia River system (inclusive of the Pend d'Oreille River) as possible, given a fixed funding source (i.e., CBT and MFLNRORD request for proposal [Wood 2018; Okanagan Nation Alliance 2018]) to continue to protect native fish populations. This was done using several different removal programs that included active suppression utilizing gillnets and electrofishing, an angler bounty program, a targeted sport fishing challenge and annual large river fish indexing.

3.1.1 Active Suppression

In 2018, Wood (formerly AMEC) conducted gillnet and electrofishing efforts in the Pend d'Oreille River of both the Waneta and Seven Mile Reservoirs. A total of 15 Northern Pike were captured, seven in the Seven Mile Reservoir and eight in the Waneta Reservoir through five days of Spring suppression efforts (Wood 2019). Efforts were also expended in the Lower Columbia River, resulting in the removal of 27 Northern Pike using gillnetting and electrofishing methods; these efforts resulted in 42 Northern Pike removed under Wood's suppression program. Under this program, sixteen days of effort were expended in the Columbia River between May, August, September and October.

In 2018, ONA conducted five days of suppression efforts through funding provided by Teck Metals, Zellstoff Celgar, and FortisBC. Efforts included three days of gillnetting in the Pend d'Oreille River in August, one day of gillnetting in the Lower Columbia River in September and one day of boat electrofishing in the Lower Columbia River in November. No Northern Pike were captured in either the Pend d'Oreille or Lower Columbia Rivers during these efforts.

3.1.2 Fishing Regulations, Angler Incentive Programs, Education & Outreach

The 2017-2019 Freshwater Fisheries Regulations for Region 4 (Kootenays) list unlimited daily quotas for Northern Pike from Hugh Keenleyside Dam to the Washington State border, inclusive of the Kootenay River (Brilliant Dam to the confluence) and Pend d'Oreille River (Waneta Dam to the confluence). Similarly, Northern Pike daily quotas are unlimited in the Pend d'Oreille River, which includes the Waneta and Seven Mile reservoirs.

The MFLRNORD initiated angler incentive programs in 2013-14 and 2015-16 in an attempt to increase public awareness and reduce Pike numbers in the Columbia River. In 2013-14, a \$500 reward was offered for Pike heads containing PIT tags (Baxter and Neufeld 2015), and in 2015-16, heads were submitted in exchange for a lottery entry toward prizes valued at \$2000 (M. Neufeld, pers. comm., Feb 26 2019). A total of 12 heads were returned in 2013-14 and 22 in 2015-16; it was concluded that the program was effective in increasing public awareness but limited in suppressing the population.

In 2018, the Okanagan Nation Alliance organized a Northern Pike Bounty Program with the financial support from the Regional District of the Kootenay Boundary, Regional District of Central Kootenay and Interfor. Anglers were offered a \$10 cash reward upon receipt of a Northern Pike head (Appendix E). Four local organizations volunteered to act as drop off locations for the Pike heads and various community organizations including the Christina Lake Stewardship Society (CLSS) and the Central Kootenay Invasive Species Society (CKISS) assisted public outreach through print, radio, and online advertisement. Four Northern Pike heads were submitted; three from the Columbia River and one from the Pend d'Oreille River. Otolith samples from the heads are now being used by the Colville Confederated Tribes to determine the waterbody origin using microchemistry analyses. Tissues samples were also retained from the heads to develop an environmental DNA (eDNA) primer which will aid in further research and monitoring within the Basin (C. Fuller. ONA, per comm. 2019).

The CLSS organized a Northern Pike fishing challenge on Christina Lake on June 23-24, 2018. No pike were caught during the challenge; however, participating anglers did verbally report that they had caught two small Northern Pike in the southern end of Christina Lake earlier in the year (A. Solomon, pers. comm.).

Education and outreach are critical components of the work conducted by CKISS, and preventing the introduction of invasive species is one of their primary goals. Education programs such as *Clean, Drain, Dry* and *Don't Let It Loose* provide information on all aspects of aquatic invasive species, and Northern Pike information is disseminated through these programs when applicable. In addition to raising awareness about invasive species at public outreach events, CKISS utilizes various mass and social media platforms; in 2018 they highlighted the ONA's Eurasian Watermilfoil and Northern Pike suppression project, and the Northern Pike Bounty program (K. Fraser, pers. comm., Jan 21, 2019). In their 2017 Columbia Basin Aquatic Invasive Species Priority List, CKISS lists Northern Pike as a high-risk species for establishment in the Columbia Region.

The Invasive Species Council of B.C. (ISCBC) website provides background biological information on Pike and has links to several articles on Northern Pike suppression efforts

in the Canadian Columbia River area. The ISCBC website also highlights some of the provincial regulations relevant to invasive species in B.C.

3.1.3 Lower Columbia River Fish Indexing Program (CLBMON-45)

BC Hydro's Lower Columbia River Fish Indexing Program has been ongoing since 2001 and was the first program to document Northern Pike presence in the Canadian Columbia River. Since their first detection in 2009, 80 Northern Pike have been removed through this program by boat electrofishing, including two removed in 2018 (Golder, ONA and Poisson 2019). A summary of removals during CLBMON-45 by year can be found in Appendix B.

3.2 United States

3.2.1 Active Suppression

In 2018, a total of 806 Northern Pike were captured by the Spokane Tribe of Indians in the Kettle River, Kettle River Campground, Marcus, Singer Bay, and Colville River areas using gillnetting and electrofishing (K. Thurman, pers. comm., Jan 2, 2019). In addition, the Colville Confederated Tribes and Washington Department of Fish and Wildlife captured an additional 1,888 Northern Pike in the Columbia system throughout the year (H. McLellan, pers. comm., Jan 9, 2019). Another 13 Northern Pike were removed during Sturgeon monitoring.

In the Pend d'Oreille River system, the Kalispel Tribe of Indians began Northern Pike suppression efforts in the Box Canyon Reservoir in 2012 and in the Boundary Reservoir in 2016. Suppression efforts in 2018 included spring gillnetting in both reservoirs, resulting in the removal of 271 Northern Pike in the Box Canyon Reservoir and 132 in the Boundary Reservoir (N. Bean, pers. comm., Jan 14, 2019). In total, 17,464 Northern Pike have been removed from the Box Canyon Reservoir from 2012 to 2018, and 389 from the Boundary Reservoir from 2016 to 2018. These aggressive suppression efforts have reduced the relative abundance of Northern Pike in the Box Canyon Reservoir by more than 98% and in the Boundary Reservoir by more than 80%.

Lake Coeur d'Alene, which drains into the Spokane River, a tributary to Lake Roosevelt, has also had issues with Northern Pike introductions. The Coeur d'Alene Tribe has been conducting suppression efforts in the Windy Bay section of Lake Coeur d'Alene since 2015. John Firehammer, a Biologist with the Coeur D'Alene Tribe, estimated the population to have been around 300-400 fish when they started suppression in 2015. To date, Firehammer estimates the population has been reduced by 80%. Only 50 fish were captured in Windy Bay in 2018, which is a strong indication that the population is on the decline. Suppression efforts by the Coeur d'Alene Tribe will be extended in 2019 and will include the southern section of Lake Coeur d'Alene (Firehammer, pers. comm., Jan 14, 2019).

3.2.2 Gear Recommendations

The Colville Confederated Tribes and Spokane Tribe of Indians have both reported 2" (5 cm) stretch multifilament nylon gillnets to be the most effective at capturing Northern Pike; these nets reportedly captured more Pike per net with less bycatch due to the softer material and panel size of the net (Thurman and McLellan, pers. comm.). The Colville Tribe of Indians plans to also continue use monofilament multi-size panel mesh gillnets in 2019 as a comparison for effectiveness (McLellan, pers. comm., March 2019).

Electrofishing was also successful for the Spokane Tribe of Indians, removing 264 Northern Pike from shallow areas of the Columbia system in 2018. The Kalispel Tribe also reported success using boat electrofishing in previous years in the Box Canyon Reservoir (Pend d'Oreille River; AMEC 2017).

3.2.3 Angler Incentive Programs, Creel Surveys, Education & Outreach

The Spokane Tribe of Indians and the Washington Department of Fish and Wildlife recorded 61 Northern Pike captured by anglers during creel surveys in 2018. The Colville Confederated Tribes ran an Angler Incentive Program and had 603 Northern Pike heads returned for reward (see poster in Appendix E). The Coeur d'Alene Tribe of Indians also offered an angler reward program, however, the objective of their program was to gather data and not act as a suppression program, the program was discontinued in 2018 (Firehammer, pers. comm., Jan 14, 2019).

4.0 Data Gaps

Limited research has been conducted on the biology and population dynamics of Northern Pike in the Canadian Columbia River system, as the primary objective to date has been removal of Northern Pike from the system. However, in 2015, Dan Doutaz, an MSc Candidate at Thompson Rivers University, initiated research on spawning locations, movements and natal origins of Northern Pike in the Columbia River. A component of this work was to assess the applicability of utilizing eDNA as a method of early Northern Pike detection (Doutaz, *in prep.*). Baxter and Lawrence (2018) conducted Northern Pike population size estimates based on annual capture rates in the Lower Columbia River. In most suppression programs to date, the feeding behaviour of Northern Pike has been documented through dissection and analysis of stomach contents (Baxter and Neufeld 2015, Baxter 2016, Baxter and Lawrence 2018). Stomach content analysis is an important analysis to continue as changes in Pike diet can reflect resource availability; for instance, a diet of salmonids indicates food resources are ample within the system, however, stomach contents consisting primarily of invertebrates may indicate preferred food sources have been decimated (Bradley 2019).

Ongoing and future suppression and management efforts in the Canadian Columbia River system should be directed at answering these unknowns:

- **The population status, dynamics, life history and habitat use in the Canadian Kettle River.** eDNA results from a study conducted in the US detected Northern Pike DNA in the Canadian Kettle River (Carim *et al.* 2018). Northern Pike are present downstream in the U.S. Kettle River system and there are no barriers to fish passage along the Kettle River as far as the Christina Creek tributary of Christina Lake; Pike presence in the Canadian Kettle River below Cascade Falls and in Christina Lake is likely.
- **The population status of Northern Pike in the Canadian Pend d'Oreille.** As identified in AMEC (2017), little is known about this population. We recommend a more thorough evaluation of the life history of Northern Pike in the Pend d'Oreille River by:
 - Estimating population size and structure;

- Determining distribution and movements of Northern Pike to quantify habitat use and retention times within the two reservoirs;
 - Conducting a habitat suitability analysis for all Northern Pike life stages in Seven Mile and Waneta Reservoirs to identify potential spawning and rearing areas. AMEC (2015) conducted a spawning habitat suitability analysis for non-native species and identified ample Northern Pike spawning habitat in the mid-section of Seven Mile reservoir. Wood PLC captured eight Northern Pike in the Waneta reservoir between Waneta and Seven Mile Dams in early May in 2018 (Wood 2019), therefore an assessment of habitat availability and use in the Waneta reservoir and juvenile habitat availability in the Seven Mile reservoir would be beneficial.
 - Assessing the risk to the Salmo River from Pike introduction and the risk to native species, especially Bull Trout, if an existing, intermittently passable fish barrier is re-structured to prevent upstream pike migration. Studies assessing the efficacy of the Salmo River fish barrier have suggested it is ineffective at preventing migration of non-sportfish during high water levels (Baxter 2001, Doutaz and Heise 2016).
- **Evaluate the threat of Northern Pike to Species at Risk in the Columbia River.** To date, no Species at Risk have been identified within the stomach contents of Northern Pike captured within the Columbia River. White Sturgeon (*Acipenser transmontanus*), Umatilla Dace (*Rhinichthys umatilla*) and Columbia Sculpin (*Cottus hubbsi*) are all found within the Columbia River, and both sculpin and dace species have been identified in stomach contents (Baxter 2016). A 1999 Alaska Fish and Game study (Rutz 1999) did find sculpin in the stomach contents of Pike, as well as all five species of pacific salmon. Stomach analysis should continue as part of annual netting suppression to add the previous data sets. It is not yet known what other threats Northern Pike may pose on the recovery of these federally listed species (i.e., competition for habitat / food resources). A spatial model could be developed to quantify overlapping habitat use for listed species and Northern Pike in the Robson Reach to estimate the potential threat of displacement.
 - **Identify juvenile rearing locations in the Columbia River and Pend d'Oreille River to better target juvenile suppression efforts.**
 - Summer sampling efforts should be targeted in areas with submerged vegetation, where juvenile catch and growth rates have shown to be greatest (Holland and Huston 1984). Surveys should be conducted in late summer / early fall when Pike are large enough to be captured and sufficient aquatic vegetation is present (Wood 2019).
 - Pilot electrofishing techniques to identify and capture juvenile Northern Pike in shallow, vegetated locations (Thurman and McLellan, pers. comm). Utilize boat electrofishing in potential habitat areas (shallow, vegetated shorelines) in an upstream direction with the power on; 32 Young of the Year Northern Pike were observed in the Kootenay Oxbow using this method in September 2017 (Baxter and Lawrence 2018).

- Target optimal discharge rates – Baxter suggested targeting juveniles when discharge levels from Brilliant Dam (BRD) and Hugh L. Keenleyside Dam (HLK) combined were near 1851 m³/s and prior to the fall reduction period. In 2017, this discharge level was observed in September when a large number of Young of the Year Northern Pike were observed in Kootenay Oxbow (Baxter and Lawrence 2018).
- **Investigate winter behaviours of Northern Pike in the Columbia River.** All of the suppression and research on the Canadian population of Northern Pike has been conducted from April - November; consider conducting suppression efforts in the winter to determine habitat use. There is evidence that Northern Pike may be more active during the daytime during the winter months (DFO 2011).

5.0 Recommendations for Northern Pike Management

There are six primary recommendations for long-term management of Northern Pike in the Canadian Columbia River basin:

5.1 Continued Active Suppression and Monitoring

Past suppression efforts in Canada have included short-term, seasonally targeted gill netting in the Robson Reach (below HLK), downstream to the Trail/Waneta area (Baxter 2015, Baxter and Doutaz 2016, Baxter and Lawrence 2017) and in the Pend d'Oreille (Wood 2019). The results of these efforts suggest that targeted netting has the ability to reduce and control pike populations. Annual population estimates should be included in these estimates as a method of evaluating the efficacy of different methods and assessing the overall efficacy of the suppression program. Based on this information we recommend:

1. Commencing spring index netting (SPIN) prior to and during Northern Pike spawning to target congregations of adult spawners with the majority of effort focused in late April and early May targeting temperatures ~8C. Previous assessments have found water temperature reaching 8°C to be the critical period when Northern Pike are staging in nearshore spawning habitat and catch-rates during this period have been higher compared to other seasons (Baxter and Neufeld 2015). Known spawning habitats as well as shallow (<3 m) habitats with aquatic plants or other noticeable cover (logs, overhanging vegetation) should be targeted, both through gillnetting as well as boat electrofishing.
 - a. Two gillnet configurations should be fished daily to test capture efficiency and bycatch rates similar to the US approach. This includes both multifilament 5 cm stretch measure nets as well as monofilament varied mesh size panel nets (called SPIN or Spring Pike Index Nets; dimensions detailed in WOOD 2019) based on previous successes in the Columbia and Box Canyon reaches. In the Lower Columbia River, gillnet fishing times are limited due to the risk of capturing Species at Risk (primarily White Sturgeon) as bycatch; therefore, we recommend continuing short (~4 hour) daytime gillnet sets in the Columbia River. In the Pend d'Oreille River, however, this limitation does not exist, and we recommend trailing overnight gillnet sets to maximize catch rates of Northern Pike and determine risk related to bycatch rates of other species (Salmo River bull trout are the key species of concern).

- b. Boat electrofishing is also recommended to target Northern Pike, especially in shallow weedy locations, following the recommendations in Wood (2019). Boat electrofishing has proven effective in identifying young of the year Northern Pike in fall (Baxter and Lawrence 2018), as well as for capturing adults in the Robson Reach (Wood 2019). Pulse frequency and current output (amperes) should be closely monitored as to balance between capture of target species and minimizing harm to non-target species, which may include the SARA-listed White Sturgeon; this method has been used successfully during BC Hydro's Lower Columbia River Adult Fish Indexing Program (CLBMON 45) and Mid-Columbia River Adult Fish Indexing (CLBMON 16).
2. Targeting juvenile Pike in the summer (July-September) using gillnets and boat electrofishing. Gillnets should be 2.5 cm stretch measure monofilament mesh or smaller based on capture results from Baxter and Lawrence (2018) and Wood (2019). Overnight fyke nets sets could also be used as a passive sampling method to be checked concurrent to gillnet sampling. Efforts should coincide with dam operations when combined discharge from HLK and BRD dams is above 65 kcfs (1,851 m³/s) and before flow reductions begin in late September (Jeremy Baxter, pers. comm., 2018).

Captured Pike will be euthanized, measured and weighed, with gonads and stomachs inspected for sexing and diet. Euthanized pike will then be disposed of at the point of capture/assessment. Cleithrum (cheekbone) and otoliths will be retained from each pike as these may be used for ageing and to provide raw data for future size-at-age (growth) analyses. Similarly, tissue samples from organs and muscle can be retained and frozen for pathogen analyses.

An example suppression plan can be found in Appendix C summarizing the above recommendations for efforts in the Canadian Columbia River Basin.

5.2 Develop Early Detection and Rapid Response Protocol

Early detection of aquatic invasive species is critical to implementing effective suppression and management programs. Management protocols can include prevention efforts, monitoring programs and a rapid response plan, and would make a response more effective when Northern Pike are identified in new waterbodies. Examples of possible early detection and rapid response management protocols for pike are included below, and the recommendation is to resource building on these through development of more detailed Rapid Response Plan. Possible protocols included:

1. Implement Preventative Measures

- Education and outreach - educating the public about invasive species and what to do in the event you intercept an invasive species.
 - Invasive Species Reporting through the BC Inter-Ministry Invasive Species Working Group (<https://www.for.gov.bc.ca/hra/invasive-species/report.htm>).
 - Increasing public awareness of ecological and economic dangers associated with Northern Pike.

2. Regular Monitoring

- Regular Environmental DNA (eDNA) samples should be collected at locations where Pike presence is suspected or has not yet been confirmed. eDNA has also been

effective in detecting Northern Pike following eradication efforts and can be used post-treatment to monitor presence/absence (Dunker et al. 2016)

- Active fish inventory sampling programs, such as snorkel surveys, electrofishing and gillnetting, especially in high risk areas (i.e. Christina Creek).
- Creel surveys to collect angler information and observations.
- Angler incentive programs, including lotteries or challenges.

3. Development of a Rapid Response Plan

- Ensure a clear suppression plan has been developed and staff and resources are available to implement, people know their roles, and all permits are in place.
- Determine a preferred suppression method. A number of methods have been trialed for Northern Pike Suppression and their effectiveness can vary depending on the habitat and resident native species. For example, multifilament gillnets with varying panel sizes have been effective for targeting Northern Pike in riverine and reservoir environments, whereas chemical treatments have been used successfully in some lakes in Alaska. Other methods can include lake barriers, passage restrictions (e.g., weirs), prey manipulation, or habitat manipulation (Southern Alaska Northern Pike Control Committee, 2019).
- Ensure suppression efforts can be funded. Establishment of an “emergency fund” will enable rapid response plans to be implemented effectively.
- Identify data gaps in newly-populated waterways and implement research to increase effectiveness of suppression programs.
 - For example, determine spawning and juvenile rearing locations to target suppression activities.
 - Conduct microchemistry analysis to determine natal origin of Pike.
- Include a list of contacts (see Appendix C) who are knowledgeable and experienced in Northern Pike suppression that can provide guidance on the program.

4. Annual Evaluation and Updating of Program

- Review objectives of the plan annually to assist with priorities, targets, and budgeting.
- Conduct review of information from other jurisdictions to see if new methods or ideas have been developed for Northern Pike management

5.3 Collaborative Transboundary Management

The first recommendation in AMEC’s Northern Pike Suppression Efforts in the Columbia Basin (2017) report was to establish a Northern Pike Suppression Committee. Over the past several years, stakeholder meetings have been held on both sides of the border to share updates, work plans and successes and failures of suppression programs. To date, a formal transboundary Northern Pike Suppression Committee has not been established. The following objectives were outlined in AMEC (2017):

- Share information and identify data needs.
- Identify long-term funding sources.
- Provide input on proposals for priority activities,
- Provide advice on immediate responses to Northern Pike invasions of new waterways,
- Maintain connection with US Columbia River Northern Pike Fisheries Managers.

In addition to these objectives, we recommend the Committee conduct the following tasks:

- Develop terms of reference.

- Establish an annual meeting commitment with funding to support group.
- Delegate a chair from each of the U.S. and Canada to organize meetings and facilitate the group.

5.4 Explore Opportunities for Angler Involvement

Angler incentive programs have been trialed in the Columbia Region previously by the Ministry of Forests, Lands and Natural Resource Operations and the Okanagan Nation Alliance with limited return success compared to targeted removal efforts. However, in addition to removal, the other objectives of these programs were to increase angler awareness and public information of Northern Pike, which was considered effective. The objective of increasing angler awareness and encouraging anglers to harvest pike are important to continue to support. Recommendations to increase angler involvement are to:

- Increase public awareness of Northern Pike by offering talks within the community and to local fish and wildlife groups;
- Invest in public awareness by erecting information kiosks at the primary boat launches within the Northern Pike infestation areas (i.e., Robson Reach boat launch, Gyro Park boat launch, Beaver Creek boat launch, Buckley Campground boat launch). There is interest from the Trail Wildlife Association to contribute funding and monitoring time to this effort (Malette, pers. comm., Jan 17, 2019);
- Develop a *Northern Pike in the Columbia River* social media page where anglers can post photos and share information on captures, capture locations, fish sizes, etc. (Malette, pers. comm., Jan 17, 2019) and,
- Continue to investigate other opportunities to encourage angler participation that are consistent with both Indigenous Objectives and Provincial Policy/Legislation.

5.5 Update the Invasive Species Regulations in B.C.

Identify Northern Pike as an aquatic invasive species on the Provincial Inter-Ministry Invasive Species Working Group list of Priority Invasive species to provide an accurate resource for the public and for resource managers. As well, the Wildlife Act-Controlled Alien Species Regulations should identify Northern Pike as a restricted fish species under Schedule 3 of the Controlled Alien Species regulations (BC Regulations 2009). Doing so will ensure effective environmental, trade and transport policies are in place to prevent the further spread of Northern Pike.

5.6 Evaluate use of fish barriers to prevent upstream migration

In North America, various types of fish barriers have been either trialed or proposed for prevention of invasive fish migration for species such as Asian Carp. Some examples of potential fish barriers include the use of underwater strobe lights, water cannons, depleted oxygen levels, increased CO₂ levels, chemical deterrents, net barriers, bubble barriers, acoustic curtains, pheromones as attractants or repellants and various combinations of several of these at one location.

Wittmann *et al.* (2014) used a risk assessment process called Structured Expert Judgement and concluded that for invasive Carp full hydraulic separation could prevent 99% of access to the Great Lakes, physical barriers could prevent 95-100%, and electric barriers could prevent 85-95%. Events such as catastrophic flooding and angler movement of Carp were acknowledged as known possible introduction paths that would allow for any type of barrier to be breached.

Recommended locations to further evaluate fish barriers in the Canada Columbia River system include the following:

- Christina Lake outlet or further downstream in Christina Creek--physical barrier.
- Salmo River mouth, at Seven Mile reservoir--physical barrier enhancement with provisions for Bull Trout passage. If barrier options that limit pike also limit bull trout passage, an assessment of the risks to both scenarios should be conducted (ie allowing or not allowing passage).
- Hugh Keenleyside Dam lock--electric barrier coupled with another method such as a bubble curtain. Electric barriers could have issues maintaining their deterrence when waves from large boats are created (Wittmann et al. 2014).
- Okanagan River--physical barrier with some alternative method for upstream salmon passage, i.e. trap and truck.
- Brilliant Dam—if future fish passage is considered methods should not allow upstream pike access.

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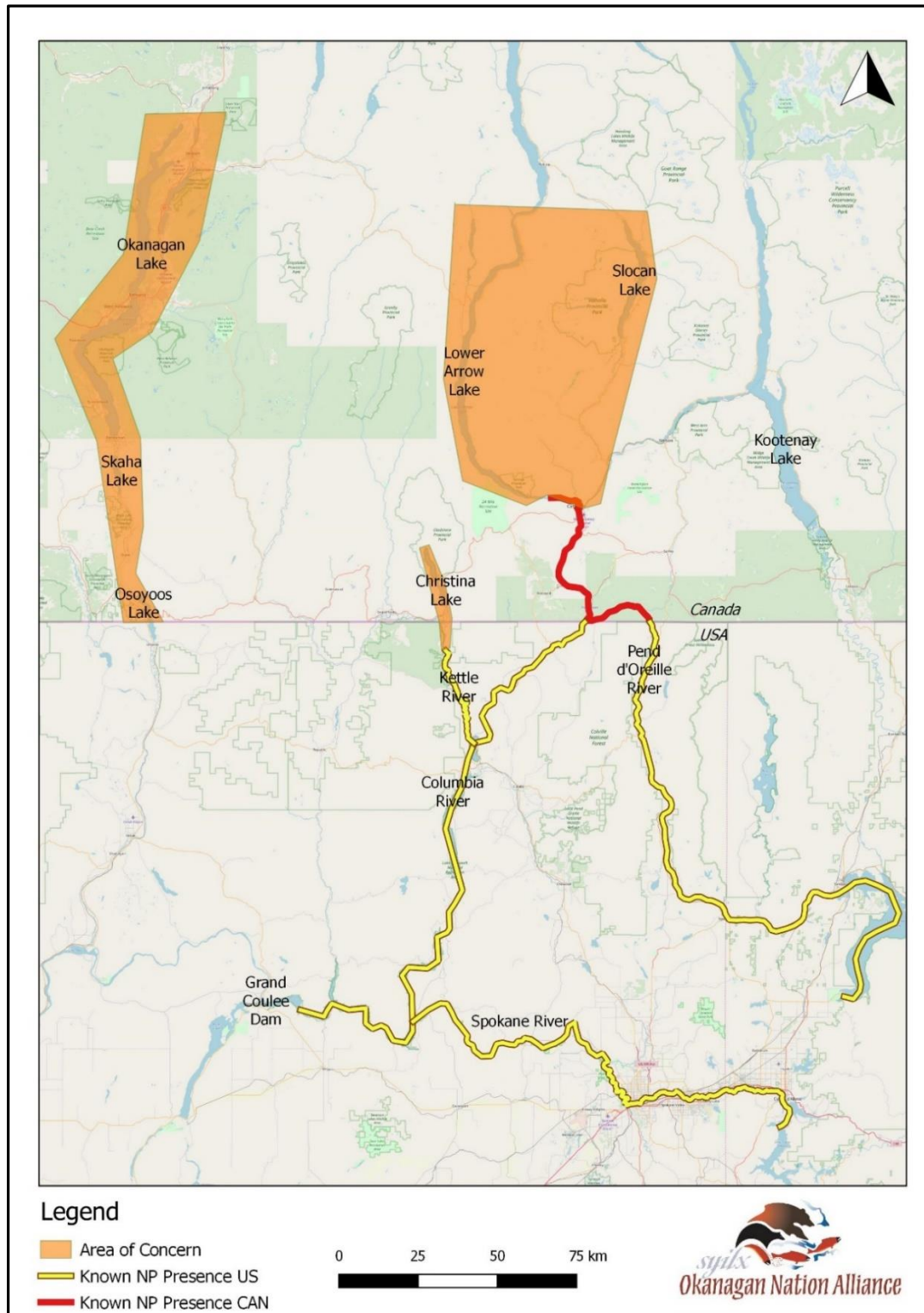
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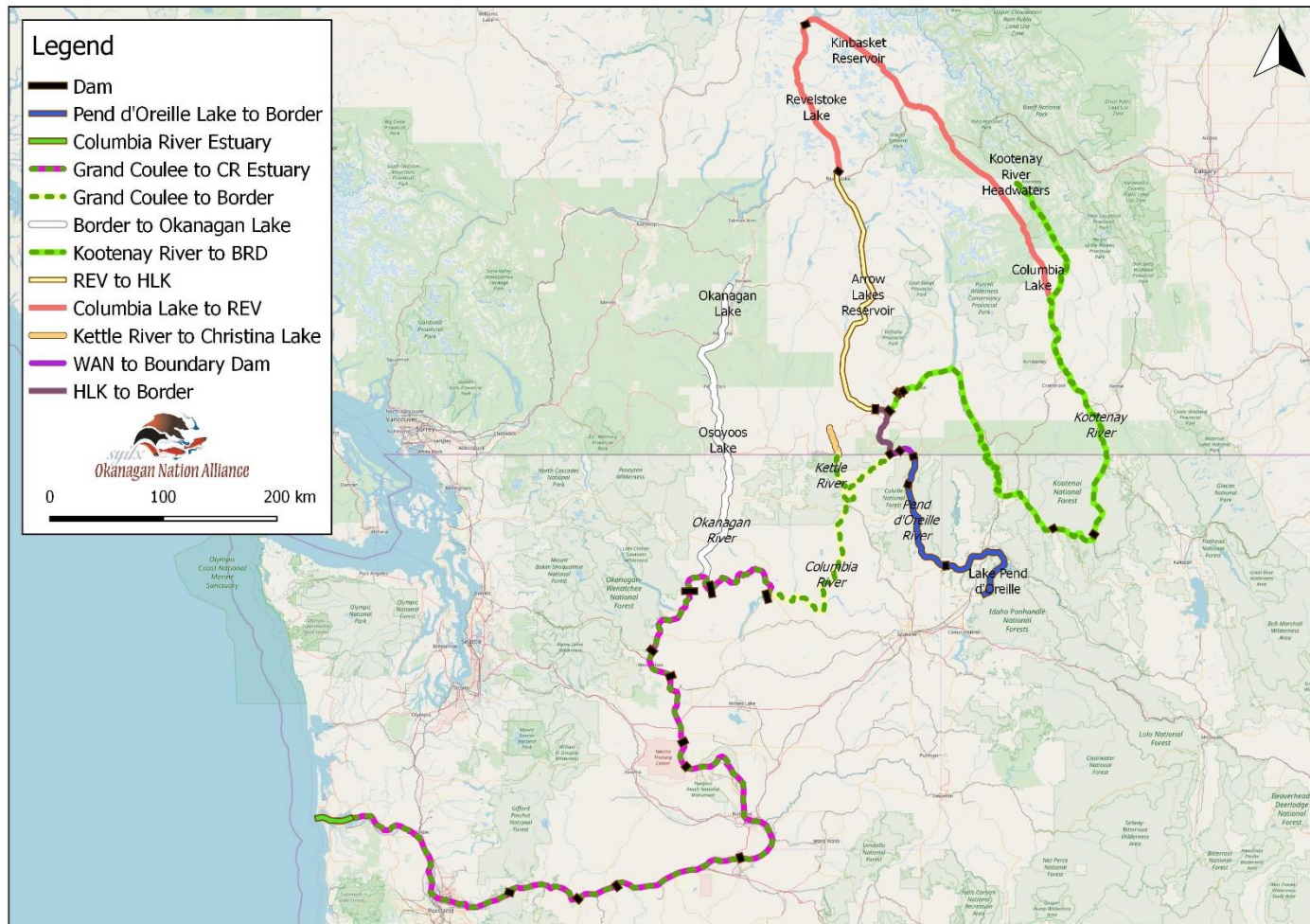
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APPENDICES

Appendix A –Northern Pike presence and at-risk waterbodies in the Columbia River Watershed



Appendix B – Canadian and U.S. River Sections used for the Northern Pike Modified Ecological Risk Assessment.



Appendix C – Canadian Columbia River Northern Pike Suppression Effort Summary and Recommendations for Future Effort

Canadian Active Suppression (2010 to 2018)

| Year | Managing Authority | Number of Pike Captured | Sampling Seasons | # Days Sampled | Methods Used | CPUE | Location | Population Estimate |
|-----------|--|-------------------------|--------------------------|----------------|---|--------------------|---------------------------------------|---------------------|
| 2014 | Mountain Water Research (funded by Teck) | 133 | Apr, May, Aug, Nov | 16 | gillnetting | 0.19 NP/hr per net | Lower Columbia River | 725 (478-2759) |
| 2015 | Mountain Water Research (funded by Teck) | 116 | May, Aug, Sept | 17 | gillnetting | 0.20 NP/hr per net | Lower Columbia River | 410 (151-670) |
| 2015 | Golder Associates | 0 | June, July | 4 | light traps, minnow traps, backpack electrofishing, dip netting, plankton tow | 0 | Robson Reach (larval sampling) | - |
| 2016 | Mountain Water Research (funded by Teck) | 39 | | | gillnetting | 0.13 NP/hr per net | Lower Columbia River | |
| 2016 | Okanagan Nation Alliance | 1 | Apr, July, Aug, Sept | 22 | fyke netting, beach seine | - | Robson Reach (juvenile sampling) | n/a |
| 2017 | Mountain Water Research (funded by Teck) | 35 | May, Sept | 15 | gillnetting | 0.05 NP/hr per net | Lower Columbia River | 99 (25-172) |
| 2018 | Wood PLC (formerly AMEC) | 42 | Apr, May, Aug, Sept, Oct | 21 | gillnetting, boat electrofishing | - | Lower Columbia River & Pend d'Oreille | |
| 2018 | Okanagan Nation Alliance | 0 | August, Sept, Nov | 5 | gillnetting, boat electrofishing | 0 | Lower Columbia River & Pend d'Oreille | - |
| 2010-2018 | Large River Indexing | 80 | Sept, Oct, Nov | N/A | boat electrofishing | - | Lower Columbia River | - |

Angler Incentive Program Results (2013 to 2018)

| Year | Country | Managing Authority | Number of Angler Returns | Incentive |
|---------|---------|--------------------|--------------------------|--|
| 2013-14 | Canada | MFLNRO | 12 | \$500 reward for PIT tagged Pike |
| 2015-16 | Canada | MFLNRO | 22 | Lottery entry to draw for \$2000 in prizes |
| 2017-18 | Canada | ONA | 4 | \$10/head |

Large River Indexing (CLBMON-45) Northern Pike Catch Summary, 2010 – 2018 (Golder, ONA and Poisson 2018)

https://www.bchydro.com/toolbar/about/sustainability/conservation/water_use_planning/southern_interior/columbia_river/lower-columbia-fish.html

| Year | Number Observed | Number Captured | Total |
|--------------|-----------------|-----------------|------------|
| 2010 | 3 | 4 | 7 |
| 2011 | 1 | 8 | 9 |
| 2012 | 10 | 1 | 11 |
| 2013 | 90 | 45 | 135 |
| 2014 | 16 | 9 | 25 |
| 2015 | 6 | 3 | 9 |
| 2016 | 0 | 4 | 4 |
| 2017 | 7 | 4 | 11 |
| 2018 | 0 | 2 | 2 |
| Total | 133 | 80 | 213 |

Example Suppression Plan for Canadian Columbia River Basin Efforts

| Priority | Month | Life Stage | Columbia River | Pend d'Oreille River | Gear Type |
|----------|---|------------|--|--|---|
| High | April - when water temperatures reach 8°C | Adult | | Seven Mile & Waneta reservoirs, target locations identified in Wood (2019) | SPIN gillnetting (see section 5.1 1a for gillnet specs) and trial electrofishing |
| High | May/June – when water temperatures reach 8°C | Adult | At previously identified spawning locations from Baxter and Lawrence 2018 including: Robson Reach, Kootenay Oxbow, Waldie Island, Zuckerburg Island and locations near Genelle / south of Trail as identified in Wood (2019) | Seven Mile & Waneta reservoirs, target locations identified in Wood (2019) | SPIN gillnetting (see section 5.1 1a for gillnet specs) should be the primary method; opportunistic electrofishing |
| High | Mid-August – September targeting 1851 m ³ /s discharge combined from BRD and HLK | Juvenile | Robson Reach and Kootenay Oxbow as identified in ONA (2016) and Baxter and Lawrence (2018). Opportunistic sampling in habitats with similar characteristics | Seven Mile & Waneta reservoirs, target locations identified in Wood (2019) | 2.5 cm stretch monofilament gillnets with opportunistic boat electrofishing as per Baxter and Lawrence (2018) or fyke netting as per ONA (2016) |
| Medium | October – November | Adult | Robson Reach | Seven Mile & Waneta Reservoirs | Boat electrofishing at night in the LCR as per Golder, ONA and Poisson (2019) and in the Pend d'Oreille as per AMEC (2015) |

Appendix D – List of Canadian and U.S. Columbia River Northern Pike Stakeholders, and Working Groups/Webinars/Meetings.

Canadian Stakeholders

- Columbia Basin Trust (Tim Hicks, Krista Watts, Michael Hounjet)
- Ministry of Forests, Lands and Natural Resource Operations and Rural Development (Holger Bohm, Matt Neufeld)
- Ministry of Environment (Martina Beck)
- Thompson Rivers University (Brian Heise, Dan Doutaz)
- Central Kootenay Invasive Species Society (Erin Bates, Khaylish Fraser)
- Okanagan Nation Alliance
- BC Hydro (Guy Martel)
- Teck Metals (Adam Brooks)
- Zellstoff Celgar (Sandy Hinton)
- FortisBC (Maureen Grainger and Blair Weston)
- Regional District of Central Kootenay
- Regional District of Kootenay Boundary
- Christina Lake Stewardship Society
- Salmo River Streamkeepers (Gerry Nellestijn)
- Mountain Water Research (Jeremy Baxter)
- Wood PLC (Louise Porto and Crystal Lawrence)
- Golder Associates
- Castlegar and District Wildlife Association (Luis Cancela)
- West Kootenay Fly Fishing Club (Rod Zavaduk)
- Trail Wildlife Association (Al Mallette)

U.S. Stakeholders

- Spokane Tribe of Indians (Kaitlin Thurman, Brent Nichols)
- Colville Confederated Tribes (Holly McLellan, Bret Nine)
- Kalispel Tribe of Indians (Joe Maroney, Nick Bean, Jason Olsen)
- Washington State Department of Fish and Wildlife (Charles Lee)
- Couer d'Alene Tribe (Jon Firehammer)
- Washington Invasive Species Council (Justin Bush)


Northern Pike Working Groups/Webinars / Meetings

- 2019 January 16, Webinar. Biosecurity and Invasive Species Initiative Webinar Series #1: Invasive Species Impacts on Fisheries. Hosted by the Western Governors Association.
- 2018 July 18-19, Airway Heights, WA. Mid and Upper Columbia Interagency Northern Pike Forum.
- 2018 July 24, Spokane, WA. Pacific Northwest Northern Pike Forum and Coordination Meeting
- 2016 July, Castlegar, B.C. Northern Pike Meeting Summary, hosted by the Columbia Basin Trust.
- 2016 June, Castlegar, B.C. (Northern Pike Stakeholder Meeting hosted by the Columbia Basin Trust (Transboundary).

Appendix E – Canadian and U.S. Posters for Northern Pike Angler Bounty Programs.

CAUGHT PIKE ?

NORTHERN PIKE
POSE SIGNIFICANT THREATS
TO THE COLUMBIA RIVER FISHERIES



Cash Reward of \$10 per Pike Caught

DROP OFF LOCATIONS

CASTLEGAR

Johnny's Grocery & Gas (Tempo)
Open: 7am-9pm daily
Address: 2593 Broadwater Road, Robson, BC
Phone: 250 365-7941

Golder Associates Ltd.
Open: 9am-5pm Mon-Fri
Address: 201 Columbia Ave, Castlegar, BC
Phone: 250 365-0344

TRAIL

Regional District Kootenay Boundary Office
Open: 8:00am-4:30pm Mon-Fri
Address: 202-843 Rossland Ave, Trail, BC
Phone: 250 368-3990

CHRISTINA LAKE

Living Arts Centre
Open: 10am-4pm daily
Address: Hwy 3-1675 Kimura Rd, Christina Lake, BC
Phone: 250 447-6161

WHY ARE THEY A THREAT?









They prey on native and important game species, introduce parasites and disease, and compete with other species for food resources.


HOW TO HELP?

Help keep their numbers low by participating in the Northern Pike Bounty Program. Receive a \$10 cash reward for every Northern Pike **HEADS ONLY** dropped off at our participating locations.

Visit one of our Drop off locations for complete rules and regulations

Thank you to our sponsors



FOR MORE INFORMATION

Autumn Solomon, Northern Pike Bounty Program Coordinator
Okanagan Nation Alliance, Castlegar Office Phone: 250 488-2541 Email: Columbia-tech2@sylix.org
www.okanagannation.com

WANTED

Northern Pike Heads- \$10 Reward



Attention Anglers:

Help protect Lake Roosevelt from Invasive Northern Pike!

Northern Pike pose significant threats to the Columbia River fisheries including predation on native and important game fish species, introductions of parasites and disease, and competition with other species for food resources.

Drop off locations located at the Noisy Water Gas Station and near the Park Service Kettle Falls fish cleaning station

Fill out the label with: Name, address, phone number, email, date of capture, and general location of capture
(Pike from Lake Roosevelt and the Kettle River only)

Place the head and the label in the bag and deposit into the freezer
¹A \$10 Reward will be mailed to you



**Questions:
Holly McLellan
Colville Confederated Tribes
(509) 209-2415**

¹Allow 2-3 weeks for processing
\$10,000 to be awarded, \$590 limit per person
Funding provided by the Colville Confederated Tribes

Available: https://media.spokesman.com/photos/2017/04/13/pike_reward_poster.jpg

NOTICE TO ANGLERS

\$500 REWARD

Offered for the Return of Northern Pike Heads

The Ministry of Forests, Lands and Natural Resource Operations is offering a chance for anglers to win one of four prizes valued at \$500 in retail credit from local participating sporting good suppliers.

To enter the draw pike heads should be presented at the **FrontCounter BC in Castlegar** at 845 Columbia Avenue (Mon-Friday, 8:30 am – noon, 1:00 pm – 4:30pm) to register applicants for the reward draw. Every head returned is a ticket in the draw and a total of four prizes will be drawn in March, 2016.

This reward program will be in effect until March 25, 2016 (depending on results may be extended).

Anglers will also be asked to provide some basic information such as where the pike was caught.

This program is part of an effort to reduce pike numbers, gain information on the distribution and abundance of this non-native invasive predator, and assess the impact on native fish populations.

Northern Pike
Daily Quota:
UNLIMITED

**Anglers are
encouraged to
kill all
captured pike.**



For further information contact the
Ministry of Forests, Lands and
Natural Resource Operations:
Phone: (250) 354-6333

What are invasive species?

Invasive species are animals or plants that are not native to the province, or are outside of their natural distribution, and can negatively impact B.C.'s environment, people or economy. They pose a significant threat to aquatic ecosystems.

Invasive predatory fish like northern pike prey on our native fish that support sport, commercial and First Nation fisheries.

Report Sightings

Help stop the spread of northern pike.

- ▶ It is **ILLEGAL** to possess live fish or release live fish into B.C.'s lakes or streams.
- ▶ If you see an aquatic invasive species, or someone moving live fish, report this activity to the Conservation Officer 24 Hour Hotline **1-877-952-RAPP (7277)**.
- ▶ The offence holds a **penalty of up to \$100,000** for first time offenders, and/or a prison term of up to 12 months for a second offence.
- ▶ **A REWARD of up to \$20,000** is available to anyone providing information leading to the successful prosecution of individuals responsible for the illegal transfer of fish species in B.C. waters.

\$500 REWARD

Offered for the return of northern pike heads

Tags have been placed in the head of a number of pike throughout the Columbia River and each pike head returned with a tag will be worth \$500. These tags will not be visible to anglers, so anglers are encouraged to return the heads of all captured pike.

Pike heads should be presented at the FrontCounter BC office in Castlegar at 845 Columbia Avenue (Mon. to Fri. 8:30 a.m. – 12:00 p.m. and 1:00 p.m. to 4:30 p.m.) to determine if they are eligible for the reward.

Anglers will also be asked to provide some basic information such as where the pike was caught.

This reward program will be in effect from August 21, 2013 until March 15, 2014 (depending on results it may be extended).

For more information, contact the Fish, Wildlife and Habitat Management Branch at 250 354-6333



Ministry of
Forests, Lands and
Natural Resource Operations

Northern Pike
in the Columbia
River Drainage

Non-native Predators



Ministry of
Forests, Lands and
Natural Resource Operations

