Summary

In 2005, northern pike (*Esox lucius*) was confirmed to be present in Haha Lake through the captures of two adults. This was the first occurrence of pike outside of its native range in BC and immediate action was taken as northern pike pose many threats and are of management priority in BC. Intensive gillnetting, trapping and electroshocking (>5,500 hrs, >3000 hrs and >17,000 seconds) was conducted in 2005-2006 to determine the extent of pike in Haha Lake and the Haha Creek watershed and remove all captured individuals. This resulted in six additional adults being removed from the lake. Since the majority of the pike from previous sampling efforts were found to be mature individuals that were expected to spawn the spring of 2006, we conducted a follow up survey in 2011 to determine if the pike removed in 2005-6 was able to reproduce before removal or if any pike were missed in the removal effort. The time frame seemed appropriate, as any pike spawned in 2005-2006 would be near adult size in 2011. Therefore, the main objective of this study was to conduct a follow up survey in Haha Lake to determine if previous efforts to remove northern pike were successful. This was accomplished through one week of intensive gill net sampling conducted in each of July and September of 2011. A total of 1816 hours of gill net effort were expended over the entire study. No northern pike were encountered during the study. Only three fish species were captured and included Yellow perch, Northern pikeminnow and Largemouth bass, demonstrating the fish community in Haha Lake remains dominated by introduced species. It is unlikely that northern pike remain in any numbers within Haha Lake. This is encouraging as the program has only used conventional fisheries techniques to date, with gill netting the primary method. Results from this study will help inform management decisions for small systems where introduced species pose threats to aquatic diversity.
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Introduction

Haha Lake, a small lake in southeastern BC, has had problems with introduced species impacting the native fish community for several decades. Historically, native species recorded in the lake included; rainbow trout (*Oncorhynchus mykiss*), redside shiner (*Richardonius balteatus*) and northern pikeminnow (*Ptycheilus oregonensis*). The introduced yellow perch (*Perca flavescens*), Eastern brook trout (*Salvelinus fontinalis*), and largemouth bass (*Micropterus salmoides*) have also been documented, but their timing of introduction is unknown. In 2005, another introduced species, the northern pike (*Esox lucius*), was confirmed in Haha Lake by the Ministry of Environment (MoE) after anglers reported catching two adults (Seaton 2007). The most likely introduction pathway was intentional illegal introduction to establish a recreational fishery. This was the first occurrence of pike outside of its native range in BC, which is restricted to the extreme north and northeastern part of the province. Therefore immediate action was taken as northern pike pose many threats when introduced into new systems.

Northern pike pose a severe threat to aquatic ecosystems where they are not native. They have been responsible for the decline and eradication of native fish species through high predation rates (Bradford et al. 2008), resulting in changes to fish communities. Further, they are a very adaptable species, capable of surviving in a wide range of habitats. These characteristics, combined with their recreational desire, have resulted in their introduction into many systems around North America. Pike are common hosts to a number of parasites. Two tapeworms of concern, *Diphyllobothrium latum* and *Triaenophorus crassus; D. latum*, which can be transmitted to humans if inadequately cooked and *T. crassus*, which is transferable to salmonids. Shortly after anglers reported the first occurrence of northern pike, MoE sampling caught an additional six adult pike over the following year. Effort to catch these few fish was high, with more than 5,500 gillnetting hours conducted across all lakes within the watershed, the majority (73%) being on Haha. Additional sampling gear types were deployed throughout the watershed in the spring with over 3000 hours of trapping and more than 17,000 seconds of electrofishing resulting in no pike captures. Though northern pike were present only in small
numbers and that their distribution was limited to Haha Lake (Seaton 2007), they were of significant management concern and were considered a high priority both regionally and provincially.

Should Haha Lake support a reproductive viable population of northern pike, this could result in a source population for individuals looking to illegally introduce pike into other watersheds for recreational purposes. The potential impacts on native fish populations in the Kootenay Region would be devastating. In the East Kootenays near Haha Lake, biologically and recreationally important populations of westslope cutthroat trout (*Oncorhynchus clarkii lewisi*), bull trout (*Salvelinus confluentus*) and mountain whitefish (*Prosopium williamsoni*) would be at risk of increased mortality due to predation if pike were introduced into Lake Koocanusa. Other important aquatic ecosystems in the West Kootenays face a similar risk, with the lower Kootenay River and Kootenay Lake supporting a variety of native species including the endangered white sturgeon (*Acipenser transmontanus*) and the Gerrard rainbow trout (*Oncorhynchus mykiss*). Northern pike have already been confirmed in the lower Columbia River (Ford and Thorley 2011) near the outlet of the Kootenay River but remain closed to fishing. Northern pike poses a significant predatory risk to many systems and it is imperative to control or eradicate pike populations, especially while they remain at a manageable geographic scale like Haha Lake.

Since the majority of the pike from previous sampling efforts were found to be mature individuals that were expected to spawn the spring of 2006, a follow up survey was required to determine if pike were still present in Haha Lake and if any other age classes had become established. Therefore, the main objective of this study was to conduct a follow up survey in Haha Lake to determine if previous efforts to remove northern pike were successful. This was accomplished through two weeks of intensive gill net sampling conducted in July and September of 2011. Results from this study will help inform management decisions for small systems where introduced species pose threats to aquatic diversity.
Study Area

Haha Lake is located within the Haha Creek watershed, which is approximately 21.8 km southeast of Cranbrook, BC (Figure 1, Westover 2006) and flows in a southeasterly direction towards Lake Koocanusa. Haha Lake is the largest of four named lakes within the watershed connected through at least 30 km of stream. The Lake is shallow (8m deep), covers a total of 13.8 ha, and is generally muddy with vegetated shorelines. The lack of surface stream to channel connection to adjacent watersheds restricts fish movement out of the watershed (Seaton 2007).

Methods

Two week long sampling sessions were conducted in Haha Lake in 2011, the first occurring in mid-summer (July 26th-Aug 2nd) and the second in the late summer (Sept 12th-Sept 19th). Four to six gill nets were set daily and arranged throughout Haha Lake, ensuring the entire spatial extent of the lake was adequately sampled within each session. Gill nets measured 300 ft in length and were 8 ft deep. Each net had six panels (50 ft) with mesh sizes ranging from 1” to 3.5”. Gill nets had a lead bottom line and a floating top line to ensure separation of the mesh in the water column. Nets were anchored to the bottom at each end with lead weights (~3 kgs) and marked at the surface with buoys. Nets were left overnight and retrieved the following morning. During net retrieval, each captured fish was identified to species and measured for fork length (FL). All data were collected separately by net and 100% of captured fish were removed from the lake. A subsample of yellow perch and smallmouth bass were measured for fork length, weighed (g) and had their stomachs removed and preserved for another study.

The total catch per unit (one hour) of effort (CPUE) was calculated by species within each net set. CPUE was then expressed by session and by species captured within each session. We compared the size distributions of all captured species qualitatively by determining the percent of samples collected for increasing size classes (20 mm intervals, 80-320 mm). Gill nets are known to be highly selective with respect to fish size (Ricker 1975). We were interested if larger fish were more
vulnerable to capture in our gill netting and given that we were removing all
captures from the lake we tested if there were differences in the distributions of
total lengths between the two sampling sessions. This was conducted for each
species captured. To determine if the gill net sampling was size selective we tested
the distributions of total length for each species between the two sampling sessions
using a Kolmogorov Smirnov test.

Results

A total of 851 and 965 hours of gill net effort were expended during the first and
second sampling sessions, respectively. Mean sampling time per gill net was 23
hours across both sampling sessions. No northern pike were encountered during the
study. Only three fish species were captured during both sampling sessions and
included Yellow perch, Northern pikeminnow and Largemouth bass.

Yellow perch represented the largest percent of the total catch (Table 1) with a total
of 3399 individuals captured over both sampling sessions. Total catch over the
entire study was much smaller for northern pikeminnow (269) and smallmouth
bass (143) compared to the perch (Table 1).

Table 1. Total catch (N) and mean length (± SE) for three fish species collected in
each of two sampling sessions in Haha Lake in 2011.

<table>
<thead>
<tr>
<th>Species</th>
<th>Session 1</th>
<th>Session 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean Length</td>
</tr>
<tr>
<td>Largemouth bass</td>
<td>111</td>
<td>219.8 ± 4.4</td>
</tr>
<tr>
<td>Northern pikeminnow</td>
<td>188</td>
<td>257.6 ± 2.14</td>
</tr>
<tr>
<td>Yellow perch</td>
<td>1964</td>
<td>148.0 ± 0.72</td>
</tr>
</tbody>
</table>

CPUE was higher for the first sampling session compared to the second for all
species, with yellow perch having the highest CPUE’s across both sampling sessions
(Table 2). All species were captured proportionally less in the second session.
Table 2. Catch per unit effort for three fish species collected in each of two sampling sessions in Haha Lake in 2011.

<table>
<thead>
<tr>
<th>Species</th>
<th>Session 1</th>
<th>Session 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Largemouth bass</td>
<td>0.13</td>
<td>0.04</td>
</tr>
<tr>
<td>Northern pikeminnow</td>
<td>0.23</td>
<td>0.09</td>
</tr>
<tr>
<td>Yellow perch</td>
<td>2.31</td>
<td>1.49</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2.67</strong></td>
<td><strong>1.61</strong></td>
</tr>
</tbody>
</table>

All species were captured over a range of sizes indicating established age classes within the lake, with yellow perch having the most dominant size class (Figure 1). Northern pikeminnow represented the largest fish collected followed by largemouth bass and yellow perch (Figure 3). We tested the distribution of lengths between fish captured in the first and second sessions. Smallmouth bass were significantly larger (D = 0.29, P = 0.02) during the first sampling session compared to the second (Table 1). The opposite result was found for the other fish species, with both northern pikeminnow (D = 0.22, P = 0.01) and yellow perch (D = 0.11, P < 0.01) being captured at significantly larger total lengths during the second sampling session (Table 1).
Figure 1. Overview of the Haha Creek watershed.

Figure 2. Percent of the total catch by length for three species collected in Haha Lake in 2011.
Figure 3. Number of fish caught by total length classes for three species of fish collected over both sampling periods in Haha Lake, 2011
Discussion

The objective of this study was to conduct a follow up survey in Haha Lake to determine if previous efforts to remove northern pike were successful. No northern pike were collected in our sampling, despite over 1,800 hours of gill net effort. This indicates that the eradication in 2005-2006 was successful in removing all pike from Haha Lake (Seaton 2007). During the eradication in 2005-2006 pike were only present in limited numbers and that their distribution within the Haha Creek watershed was restricted to Haha Lake Sampling (electrofishing, angling, trapping and gill nets) conducted from September 2005 to the fall of 2006 removed several northern pike. All of these fish were assumed to be large enough to be mature. If any remaining pike reproduced successfully in the time that elapsed until this sampling occurred, we assume they would have been present in our catch as they had several years to grow through the juvenile to adult stages (McPhail 2007). However, limited habitat availability combined with intense removal sampling in previous years has likely eradicated northern pike from Haha Lake.

The fish community in Haha Lake is dominated by introduced species, namely yellow perch and largemouth bass. Conditions in Haha Lake appear very suitable for yellow perch as previous sampling (2005-2006) had a CPUE of 0.92 for yellow perch, catching 3700 individuals and removing them all (Seaton 2007). The yellow perch population appeared to recover from the impacts of this removal as we collected more yellow perch in this study with less effort resulting in a CPUE as high as 2.31 during the first sampling session. Efforts to remove yellow perch from this watershed would likely need to be more extensive compared to efforts to eradicate pike. Both largemouth bass and northern pikeminnow were collected in significantly smaller numbers in the second session compared to the first, suggesting that the sampling had an impact on population abundance. The only differences between the two sessions was that water levels were higher in the first session and water temperature was likely higher in the second session, though neither were measured. However, given the small size of Haha Lake we assume that all fish had equal probability of capture in both sessions as sampling occurred throughout the lake.
Gill net sampling selected for larger individuals for both yellow perch and northern pikeminnow with the mean length of fish being smaller in the second sampling session. Largemouth bass captured in the second session were larger compared to the first. This is likely a result of bass being in much smaller numbers in the lake compared to the other two species.

The only listed species in the Lake, the western painted turtle (*Chrysemys picta*), was not impacted by our sampling. The painted turtles were responsible for consuming fish from the gill nets and were routinely observed around the nets during retrieval. Any partially eaten samples in the nets were noted, but not counted in the totals, as lengths could not be attained. However, given that the fish caught in the nets served as an attractant for the turtle’s future studies should acknowledge this risk and mitigate against it.

It is unlikely that northern pike remain in any numbers within Haha Lake. This is encouraging as the program has only used conventional fisheries techniques to date, with gill netting the primary method. Though gill netting appeared to be effective in removing the small numbers of individuals in Haha Lake, the extension of this technique is likely limited to small systems where little to no connectivity to other watersheds exists. Further, systems where multiple age classes are established may prove more challenging and labor intensive if complete removal of the species is the main objective.
References


