Fishery Data Series No. YY-XX

Alexander Creek Northern Pike Suppression

by

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Month year

Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

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**Weights and measures (metric)**

centimeter cm

deciliter dL

gram g

hectare ha

kilogram kg

kilometer km

liter L

meter m

milliliter mL

millimeter mm

**Weights and measures (English)**

cubic feet per second ft3/s

foot ft

gallon gal

inch in

mile mi

nautical mile nmi

ounce oz

pound lb

quart qt

yard yd

**Time and temperature**

day d

degrees Celsius °C

degrees Fahrenheit °F

degrees kelvin K

hour h

minute min

second s

**Physics and chemistry**

all atomic symbols

alternating current AC

ampere A

calorie cal

direct current DC

hertz Hz

horsepower hp

hydrogen ion activity pH

(negative log of)

parts per million ppm

parts per thousand ppt,

‰

volts V

watts W

**General**

Alaska Administrative

Code AAC

all commonly accepted

abbreviations e.g., Mr., Mrs., AM, PM, etc.

all commonly accepted

professional titles e.g., Dr., Ph.D.,

R.N., etc.

at @

compass directions:

east E

north N

south S

west W

copyright ©

corporate suffixes:

Company Co.

Corporation Corp.

Incorporated Inc.

Limited Ltd.

District of Columbia D.C.

et alii (and others) et al.

et cetera (and so forth) etc.

exempli gratia

(for example) e.g.

Federal Information

Code FIC

id est (that is) i.e.

latitude or longitude lat or long

monetary symbols

(U.S.) $, ¢

months (tables and

figures): first three

letters Jan,...,Dec

registered trademark ®

trademark ™

United States

(adjective) U.S.

United States of

America (noun) USA

U.S.C. United States Code

U.S. state use two-letter abbreviations (e.g., AK, WA)

**Mathematics, statistics**

*all standard mathematical*

*signs, symbols and*

*abbreviations*

alternate hypothesis HA

base of natural logarithm *e*

catch per unit effort CPUE

coefficient of variation CV

common test statistics (F, t, χ2, etc.)

confidence interval CI

correlation coefficient

(multiple) R

correlation coefficient

(simple) r

covariance cov

degree (angular ) °

degrees of freedom df

expected value *E*

greater than >

greater than or equal to ≥

harvest per unit effort HPUE

less than <

less than or equal to ≤

logarithm (natural) ln

logarithm (base 10) log

logarithm (specify base) log2, etc.

minute (angular) '

not significant NS

null hypothesis HO

percent %

probability P

probability of a type I error

(rejection of the null

hypothesis when true) α

probability of a type II error

(acceptance of the null

hypothesis when false) β

second (angular) "

standard deviation SD

standard error SE

variance

population Var

sample var

fishery Data Series report no. YY-XX

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Dave Rutz, Parker Bradley, and Cody Jacobson, Kristine Dunker

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Month Year

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# Abstract

In an effort to increase salmon production in the Alexander Creek drainage in Southcentral Alaska, invasive northern pike *Esox lucius* were annually suppressed in up to 69 side-sloughs of Alexander Creek from 2011 through 2018. During that time, 20,035 invasive northern pike were captured in gillnets and removed from Alexander Creek, ranging in length from 104 to 1,035 mm and with a higher ratio of males to females captured.

ADF&G has conducted aerial escapement surveys on the Alexander Creek drainage to index spawning adult Chinook salmon *Oncorhynchus* *tshawytscha* since 1979. ADF&G’s sustainable escapement goal (SEG) for this system of 2,100-6,000 has either not been met or has only minimally been achieved for the past 19 years. After 6 years of pike suppression efforts, escapements of adult Chinook salmon from 2014 through 2016 increased to their highest levels in nearly a decade. However, 2017 and 2018 saw extremely low returns, a pattern that other systems in the Susitna drainage without pike also experienced.

To investigate dietary preferences and prey distribution, we analyzed the stomach contents of pike captured during suppression efforts in the side sloughs of Alexander Creek. During these efforts 14,751 pike were dissected and examined for stomach contents. Of those, 17% of the pike stomachs were empty, and 83% contained at least one prey item. The most common prey items selected by northern pike in order of abundance included: slimy sculpins *Cottus cognatus*, juvenile salmon *Oncorhynchus spp.*, threespine sticklebacks *Gasterosteus aculeatus*, lamprey *Petromyzontidae spp.*, and leeches *Hirudo spp*.

In addition, minnow trapping events were conducted annually from 2011–2016 and coincided with spring suppression efforts to assess relative abundance and spatial and temporal distribution of juvenile salmon in the creek. For all six years of the study, only 319 juvenile salmon were captured in the minnow traps, of which 39% were Chinook salmon and 61% were coho salmon *Oncorhynchus kisutch*. Catch rates in the Deshka River, a system with pike but much less pike habitat, were much higher for both Chinook salmon and coho salmon compared with Alexander Creek. Suppression efforts will likely need to continue for several more years before juvenile salmon productivity, and adult salmon returns, shows strong signs of recovery.

Key words: Northern pike, Alexander Creek, suppression, invasive species, Chinook salmon, Susitna River, gillnets

# Introduction

## Synopsis

The northern pike *Esox lucius* is a predatory fish that is invasive to Southcentral Alaska and is responsible for the loss of several fisheries across the region. Alexander Creek in the Susitna River basin is one of the most heavily impacted systems. The primary goal of this project is to restore the quality of salmon rearing habitat in Alexander Creek by annually reducing the number of mature northern pike in the backwater sloughs of Alexander Creek.

## Background

Invasive northern pike pose a significant threat to salmon habitats in Southcentral Alaska ([ADF&G 2007](#_ENREF_1)). Northern pike are native throughout much of the state but do not naturally occur south and east of the Alaska Range (Figure 1). It is thought that northern pike were first introduced by an air charter operator to the Yentna River drainage (Bulchitna Lake, Lake Creek drainage) in the late 1950’s and, from there, subsequently spread throughout the Susitna River basin via natural migration and further illegal stockings**.** Based on reports from local residents, it is believed that northern pike were illegally introduced to Alexander Lake in the late 1960s, although there was no harvest record of them prior to 1985 ([Mills 1986](#_ENREF_9)).

Anecdotal accounts from Alexander Creek area residents suggest that dispersal of northern pike from the lake to the lower river occurred slowly over a 30-year period. The first documented catch of northern pike in the lower Alexander Creek was in the mid-1990s near river mile (RM) 0-1. Today, northern pike are widespread throughout the system. The majority of the drainage is shallow, low velocity, meandering, with numerous side-slough channels, interconnecting shallow lakes and ponds, tens of thousands of acres of adjacent wetland areas and dense aquatic instream vegetated areas, making it ideal northern pike habitat ([Morrow 1980](#_ENREF_10), [Inskip 1982](#_ENREF_5), [Mecklenburg et al. 2002](#_ENREF_8)).

Prior to 2000, Alexander Creek was one of the most productive Chinook salmon *Oncorhynchus tshawytscha* systems in the entire Northern Cook Inlet (NCI) area. During its productive years, this system experienced more than 26,000 angler days of sport fishing effort. Fisheries of Alexander Creek historically generated an average of 13,700 angler-days for the 20-year period from 1980–1999 (Oslund et al. 2013).

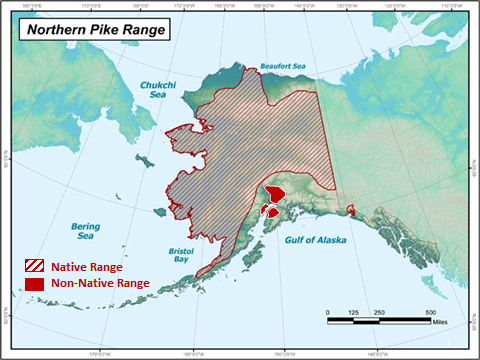


Figure 1. Distribution of native and non-native northern pike in Alaska.

During that same period, the Chinook salmon fishery contributed greater than 90% of the sport fishing effort, and an average of 2,880 Chinook salmon were harvested annually ([Ivey et al. 2007](#_ENREF_6)). From 1977–2010, the peak of the sport fishery occurred in 1991 with a reported 26,235 days of effort and 6,548 Chinook salmon harvested ([Whitmore and Sweet 1998](#_ENREF_20)). A more recent average (2001–2010) for sport fishing effort on Alexander Creek was approximately 2,000 angler days. During the Chinook salmon fishery peak, ten full time lodges, seven guide operations, three boat rental services and numerous charter services (both float plane and boat) were in operation, primarily targeting Chinook salmon.

Since the late 1990s, northern pike have reduced the population size of multiple fish species in the Alexander Creek drainage. In recent years aerial indices of Chinook salmon escapements have shown a downward trend with a dramatic drop in the past fifteen years. The Sustainable Escapement Goal (SEG) established for Chinook salmon on Alexander Creek ranges between 2,100-6,000 fish. This goal has not been achieved since 2005. Prior to that, from 2000 through 2004, the goal was either only barely met or not achieved.

Figure 2. Adult Chinook salmon escapement into Alexander Creek, 1979, 1982–2018.

Escapement counts fell to record lows of 885, 440, 185, 275, 177, 343 and 181 respectively for the years between 2006 and 2012 (Oslund et al. 2013; Figure 2). Because of poor returns, the Chinook sport fishery has been severely restricted since 2001, closed to harvest since 2008, and designated as a Stock of Concern by the Alaska Board of Fisheries since 2011. Aerial surveys have been flown on Alexander Creek annually since 1979 and have also shown a distinct change in Chinook salmon spawner distribution patterns. Since 1992, Chinook salmon spawners disappeared from the tributaries upstream of Alexander Lake, and since about 1998, declined sharply in the mainstem of Alexander Creek both upstream and downstream of the Sucker Creek confluence. From 2007 through 2013, less than 10% of Alexander Creek drainage Chinook salmon were observed spawning in the mainstem of the creek. Harvest of coho salmon *Oncorhynchus kisutch* has been below the historical average of 1,683 since 2004, ranging from 757 fish in 2005 to only 10 fish reported in 2008 ([Ivey et al. 2007](#_ENREF_6)). The once popular and abundant rainbow trout *Oncorhynchus mykiss* and Arctic grayling *Thymallus arcticus* fisheries were also closed to harvest in 1996 ([Whitmore and Sweet 1998](#_ENREF_20)). Despite these fisheries becoming catch-and-release, catch rates have declined over the past 20 years for both species. ([Oslund et al. 2017](#_ENREF_13)).

## Need

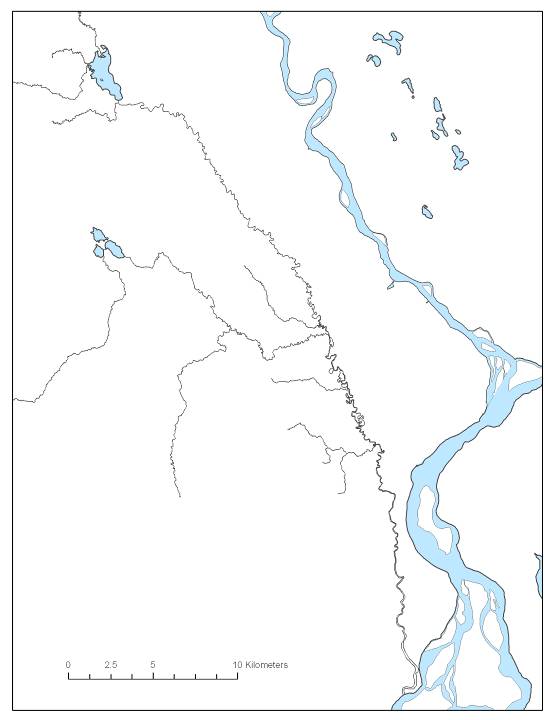
The mission of the Alaska Department of Fish and Game’s (ADF&G) Sport Fish Division is “to protect and improve the state’s recreational fisheries resources”, and a crucial objective of the Division’s strategic plan is to “minimize impacts of invasive species on fish stocks, recreational fisheries, and fish habitat.” Removing northern pike from vital salmon rearing habitat directly relates to this objective. ADF&G has had an aquatic nuisance species management plan since 2002 (ADF&G 2002) and an invasive northern pike management plan since 2007 ([ADF&G 2007](#_ENREF_1)). Goals and objectives in these plans address the need to remove invasive northern pike where possible and improve salmon populations that have been impacted by northern pike. Alexander Creek is recognized as the Sport Fish Division’s highest invasive northern pike control priority (ADF&G 2010). The activities conducted under this project align with several plans and initiatives, and ADF&G believes this project will result in the eventual natural re-establishment of Chinook and other salmon species as well as Arctic grayling, rainbow trout and other resident fishes in Alexander Creek.

To reduce northern pike abundance, restore impacted salmonid habitat, and increase salmonid productivity and sport fishing opportunities within the Alexander Creek drainage, a long-term northern pike suppression program was initiated in 2011. Since then, ADF&G has been intensively gill-netting side-channel sloughs of Alexander Creek on an annual basis. Feasibility projects preceded this work in 2009 and 2010. Suppression efforts are conducted during the pike spawning period (ice-out to early June) when pike are most mobile and concentrated in the side slough channels of Alexander Creek ([Rutz 1996](#_ENREF_17)).

# Methods

## study area

Alexander Creek is a remote river system that flows into the west side of the Susitna River approximately eight river miles upstream from where the Susitna River drains into Cook Inlet (Figure 3). Aside from Alexander Lake and adjacent wetlands, several clear water tributaries draining Mount Susitna and the Beluga Mountains contribute to the mainstem flow. Sucker Creek, the most prominent tributary, enters the mainstem at approximately river mile 20 and currently provides the majority of spawning and rearing habitat for Chinook and coho salmon. Alexander Creek’s mainstem can be characterized as a tannin-stained, low gradient, slow velocity, meandering channel with a large portion of the river comprising dense vegetative mats. The creek’s length is approximately 66 km (40 miles) from its headwaters at Alexander Lake to its confluence with the Susitna River. This drainage encompasses hundreds of square miles and is comprised of interconnecting shallow lakes and ponds, vast expanses of adjacent wetlands and marshes, and numerous backwater side-sloughs and oxbow-channels which are typically shallow stagnant waters with low flows containing dense aquatic vegetation, all of which provide optimum spawning and rearing habitat for pike. Northern pike are well suited to this type of system (Threinsen 1966, Eddy and Surber 1974, [Inskip 1982](#_ENREF_5), [Rutz 1996](#_ENREF_17)), and to date, they have expanded throughout its entirety.



Study Reach 3

Study Reach 2

Study Reach 1

Susitna River

Yetna River

Alexander Creek

Sucker Lake

Sucker Cr.

Alexander Lake

Figure 3. Map of the Alexander Creek drainage, tributaries, and study reaches.

## Objectives

The ultimate goals of this project are twofold: first to restore productivity of anadromous and resident fish populations and, second, to restore sport fishing opportunities on a sustainable yield basis. To accomplish these goals, this project had three primary and three secondary objectives focused on reducing the number of northern pike and measuring successes by monitoring resident and anadromous fish populations: Specific objectives for this project are as follows:

### Primary Objectives

1. Reduce the number of northern pike in up to 69 side channel sloughs of Alexander Creek between May 7 and June 7 such that the final daily catch in each slough is equal to or less than 15% of the peak daily catch or such that the catch remains at less than two pike for three consecutive days.
2. Reduce the number of northern pike in 20 side channel sloughs of Alexander Creek between August and September for 3-5 days each until the final daily catch in each slough is equal to or less than 15% of the fall peak daily catch.
3. Calculate the mean CPUE of juvenile salmonids from minnow trap surveys in Alexander Creek in May and June to evaluate if a 60% increase in mean CPUE above the 2011 baseline of 0.06 has occurred and compare these with CPUEs of juvenile salmonids from minnow trap surveys in the Deshka River.

### Secondary Objectives

1. Calculate the mean length and length range, as well as sex and maturity ratios for northern pike in gillnet catches.
2. Dissect pike captured in gillnets for stomach content analysis to investigate dietary patterns.
3. Identify and enumerate all bycatch (non-target species) captured in gillnets during the pike suppression efforts.

## Study Design

### Overview

As stated, the primary goal of annual pike suppression in Alexander Creek is to increase salmonid productivity and restore fisheries in the drainage by suppressing the invasive northern pike population. Given the size and complexity of the Alexander system, complete eradication of northern pike would be extremely costly and logistically-prohibitive and, thus, not likely a feasible option. However, relieving some of the predation pressure on salmon fry, fingerling and smolt has potential to increase their abundance by contributing to greater survival ([Muhlfeld et al. 2008](#_ENREF_11), Sepulveda et al. 2013). Over time, it is expected that greater survival of juvenile salmon may result in larger annual returns of these species and other resident fish populations. Eventually, ADF&G hopes to restore salmon and resident fish production to levels observed during the mid to late 1990s when viable fisheries co-existed with a much smaller northern pike population ([Whitmore and Sweet 1998](#_ENREF_20)).

To accomplish this, a spring northern pike gillnetting program was initiated in Alexander Creek’s side-channel sloughs (Appendix 1) and has been conducted annually since 2011. Gillnetting occurs in up to 69 slough channels located adjacent to the mainstem of Alexander Creek. Operations commence in early to mid-May and continue through early June during the spring spawning period when northern pike are the most mobile and concentrated (Diana et al. 1977, [Rutz 1996](#_ENREF_17)). Suppression efforts strived to achieve an 85% reduction in pike catch in the targeted sloughs.

Data on the CPUE and relative abundance of juvenile salmonids in Alexander Creek were also collected via minnow trap surveys to establish a baseline dataset for eventual evaluation of the long-term success of the northern pike suppression efforts in increasing salmon productivity. These juvenile salmon assessment efforts will continue annually. Adult Chinook salmon returns to Alexander Creek have been indexed by ADF&G via aerial surveys since 1979 (Oslund et al. 2017). Based on the multigenerational life cycles of Chinook salmon and, to a lesser degree, coho salmon, it is not anticipated that any large-scale increases in salmon abundance will be observed until at least 2020. Progeny from a single year class may rear up to two years in freshwater and spend from one to five years in the ocean prior to returning to their natal streams. Given this and the fact that straying likely is accounting, at least initially, for recolonization of historic spawning areas, it is conceivable that the reestablishment of spawning areas will be a long-term process. This project has laid the foundation for long-term salmon restoration in the Alexander Creek drainage.

### Primary Objectives 1 and 2 - Northern pike suppression

In the spring of each of the study years (2011–2018), and in the summer and fall of 2014–2016, gillnetting was conducted in the side-sloughs of Alexander Creek. Northern pike were targeted in up to 69 side-sloughs with variable mesh gillnets while congregated for spawning from approximately early May to early June, and then once monthly in July, August and September from 2014–2016 (water level permitting). For the spring suppression efforts, two to three field camps were set up along the mainstem of Alexander Creek. For the summer and fall sampling efforts, a two-man roving crew was assigned. The first camp was located in the lower river near Trail Creek at RM 12 and sampled study reach #1, the second camp was upstream of the confluence with Sucker Creek (RM 23) and sampled study reach #2, and the third camp was at the outlet of Alexander Lake (RM 40) and sampled study reach #3 (Figure 3). Two technicians were assigned to each field camp and were responsible for gillnetting sloughs along their corresponding study reach of the creek. Each study reach had between 12 and 23 side-sloughs channels that were targeted. The numbers of sloughs sampled from year to year varied depending upon water levels as many of the sloughs dried out or became hydrologically disconnected from the mainstem of the creek at lower water levels. Despite these conditions, at least 51 sloughs were netted in total each year. Sloughs furthest downstream in each study reach were fished first. The number of gillnets fished per slough was dependent on the surface area and length of each slough (gillnet saturation varied between one and five gillnets per slough). Gillnet suppression efforts took place in an upstream progression throughout the field season until all sloughs were eventually fished. Each slough was given a unique number and GPS location, beginning with the slough furthest downstream.

Gillnet dimensions were 36 m in length by 2 m in depth and composed of four panels of differing mesh sizes. The four panels in increasing order of mesh size along the gillnet length were 3.1 cm (1.25”), 3.8 cm (1.5”), 4.4 cm (1.75”) and 5.1 cm (2”). All deployed nets were monofilament with a 9.5 mm (3/8”) foam top line and 20-lb lead line. All gillnets were fished overnight and checked once every 24 hours, with the first gillnet set being the first checked. Before a gillnet was checked, the crew was instructed to disturb the aquatic weed beds by either walking or driving boats through them to potentially herd more northern pike into the gillnets prior to sampling. Nets were moved periodically throughout the season to optimize catches. Netting ceased for most sloughs once a day’s catch was equal to or less than 15% of the previous peak catch, fewer than two pike were caught over a three-day period, or the slough became hydrologically disconnected from the main river.

### Primary Objective 3 - Assessment of juvenile salmon

To document relative abundance and the spatial and temporal distribution of juvenile salmon in Alexander Creek, 360 minnow traps were deployed annually by three field crews in early May and early June throughout a 30-mile stretch of Alexander Creek. In addition, between 2014 and 2016, minnow trapping was also conducted on Alexander Creek between June and August. Though increased minnow trapping efforts were scheduled on a bi-monthly basis, actual sampling was conducted more opportunistically based on water levels. Water levels on Alexander Creek for much of the summer and fall months are fairly low and boat access to a large portion of the creek is not possible. Rather than risk boat and motor problems, minnow trapping events were only undertaken when water conditions were conducive to river boat travel. In addition, the Deshka River was also minnow trapped (2014–2016) to compare how catch numbers vary between a productive salmon system (i.e. Deshka) that has only been slightly impacted by invasive pike predation to that of a system that has been highly impacted by pike invasion like Alexander Creek.

These data provide a rough estimate or benchmark for measuring future success of suppression efforts on Alexander Creek. All minnow traps were soaked for approximately 24 hours prior to checking (Swales 1987). All fish captured in the traps were identified to species and enumerated. A select number of juvenile salmon were measured to the nearest mm of fork length. Data were recorded in a field book and transferred to datasheets back at the field camps. Mean lengths were calculated for all juvenile salmon by species. The CPUE was calculated as the catch of juvenile salmon per trap set:



where:

 = the number or juvenile salmon captured

t = the total number of minnow traps deployed and

= the number of juvenile salmon captured per trap set

### Secondary Objective 1 - Mean length, sex, and maturity

For the eight study years, (2011–2018), the majority of northern pike captured during the suppression efforts were measured to the nearest mm of fork length and examined for sex determination and maturity.

*Mean Length*

Mean lengths and length ranges were calculated for all fish captured each year.

*Sex Composition*

Field crews were instructed to identify sex of northern pike captured during the suppression efforts. Sex was only documented for the portion of northern pike that were dissected for stomach contents and physically examined for presence of gonads or for those fish that that extruded reproductive products. The percent of northern pike identified to sex for all study years was calculated as the number of males or females identified divided by the total number of pike identified to sex. If crew members were not positive identifying a fish as male or female, they labeled it as unknown.

*Maturity*

As with sex composition, maturity of northern pike captured during suppression efforts was only verified for those pike that were either extruding reproductive products (eggs or milt) or through physical examination of gonads from those fish that were dissected for stomach analysis.

### Secondary Objective 2 - Stomach content analysis

To document spatial and temporal shifts of prey items in northern pike diets (particularly juvenile salmon), stomach contents of northern pike captured during suppression efforts were identified and enumerated. Approximately 50% of the pike captured were dissected by ADF&G during 2011 and 2012 and > 90% between 2013 and 2018.

Prey items in stomachs were identified to the lowest possible taxonomic level and enumerated. Stomach contents of captured pike were also documented by river section to investigate spatial and temporal availability of food items. Because several species of invertebrates and vertebrates were found within the same stomachs, proportions of stomachs with major food items (salmonids, resident fish, and other vertebrates) ingested were individually calculated as a proportion of the total number of non-empty stomachs. This method did not consider the amount or bulk of food items per stomach. However, it provides a general assessment of prey items ingested at the time of sampling (Hyslop 1980). Stomach contents were collected and analyzed using established methods (Diana 1979).

### Secondary Objective 3 - Assessment of bycatch

As with all major gillnet suppression projects, it was expected that a certain amount of bycatch (non-targeted species catch) would occur ([Rutz 1996](#_ENREF_17), [1999](#_ENREF_18), [Massengill 2010](#_ENREF_7)). All bycatch for each of the study years was enumerated and identified to species. Attempts were made to remove all live bycatch from gillnets as quickly and carefully as possible and release them away from gillnet locations to minimize their chance of being recaptured. Over the duration of the study, gillnets were deployed strategically (i.e. deploying further away from mainstem and adjacent to shoreline) to reduce bycatch numbers and still maximize northern pike catches.

# Results

## Primary Objectives

### Primary Objectives 1 and 2 – Northern pike suppression

During this study, sampling crews fished gillnets for a total of 197,505 gillnet hours to catch 20,035 northern pike from up to 69 side-slough channels in a 30 mile stretch of Alexander Creek (Table 1). Of the 20,035 northern pike caught during the study, 19,577 were caught in the spring. Timing of spring sampling was highly variable and depended largely on timing of spring break-up (Table 2). Netting effort and catches were highest in the initial years of the study. The average number of northern pike captured per slough showed a decreasing trend from a peak of 58 pike per slough in 2011 and 2013, to 20 pike per slough in 2017 and 2018. Catch-per-unit-effort showed no discernible trend throughout the project, except for a steady increase since 2015. The northern pike reduction quota (objectives 1 and 2) of obtaining an 85% reduction rate was met with varying success. Success rates for achieving reduction quota varied from only 63% of sloughs achieving this goal in 2018 to 98% in 2016. However, for the sloughs which were sampled until objective 1 was met, the average time it has taken to meet the objective has steadily decreased from an average of 6.4 days in 2011 to 3.3 days in 2018 (p = 0.03) (Figure 4).

Table 1. Spring northern pike gillnet catch and effort for Alexander Creek, 2011–2018.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Years** | | | | | | | |  |
|  | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **Total** |
| **Number of Pike Caught** | 3,987 | 2,988 | 3,626 | 2,814 | 1,926 | 2,108 | 997 | 1,131 | 19,577 |
| **Total Net Hours** | 38,383 | 39,659 | 23,976 | 23,520 | 25,248 | 24,096 | 11,064 | 9,111 | 195,057 |
| **Total Net Days** | 1,599 | 1,652 | 999 | 980 | 1,052 | 1,004 | 461 | 380 | 8,127 |
| **Average Catch/Slough** | 58 | 47 | 58 | 46 | 31 | 35 | 20 | 20 |  |
| **CPUE Pike/Net Hour Fished** | 0.104 | 0.075 | 0.151 | 0.120 | 0.076 | 0.087 | 0.090 | 0.124 |  |
| **Sloughs Fished** | 69 | 63 | 62 | 61 | 63 | 60 | 51 | 56 | 485 |
| **Sloughs Achieving 85% Quota** | 62 | 59 | 46 | 55 | 60 | 59 | 37 | 35 | 413 |
| **Sloughs Not Achieving 85% Quota** | 7 | 4 | 16 | 6 | 3 | 1 | 14 | 21 | 72 |
| **% of Sloughs Achieving Quota** | 90% | 94% | 74% | 90% | 95% | 98% | 73% | 63% | 85% |

Table 2. Timing of field sampling activities for the northern pike suppression project, spring 2011–2018.

|  |  |  |
| --- | --- | --- |
| **Year** | **Start Date** | **End Date** |
| **2011** | 12-May | 5-June |
| **2012** | 8-May | 31-May |
| **2013** | 25-May | 12-June |
| **2014** | 7-May | 29-May |
| **2015** | 5-May | 27-May |
| **2016** | 28-Apr | 22-May |
| **2017** | 13-May | 29-May |
| **2018** | 16-May | 27-May |

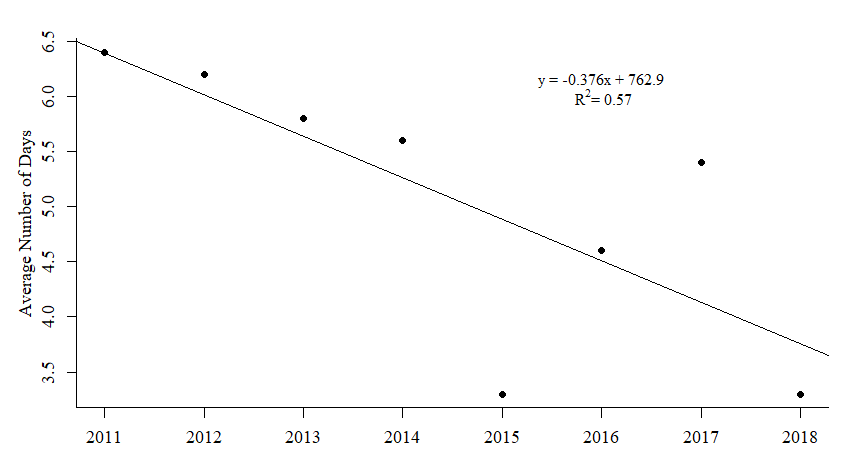


Figure 4. Average number of days it has taken to meet primary objective 1 in each slough, spring 2011–2018.

Fall gill netting turned out to be logistically prohibitive and not as productive, primarily due to low water. Many sloughs that had water in the spring were dry in the fall. Additionally, traveling the creek was difficult on boats and equipment, so fall netting was not continued after 2016. In total, 458 pike were captured during these efforts in 2014–2016 (Table 3). Unless stated otherwise, all results reflect only data from the spring suppression events.

Table 3. Fall northern pike gillnet catch and effort for Alexander Creek, 2014–2016.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Years** | | | |
|  | **2014** | **2015** | **2016** | **Total** |
| **Number of Pike Caught** | 256 | 64 | 138 | 458 |
| **Total Net Hours** | 1,800 | 336 | 312 | 2,448 |
| **Total Net Days** | 75 | 14 | 13 | 102 |
| **Average Catch/Slough** | 8 | 10 | 35 |  |
| **CPUE Pike/Net Hour Fished** | 0.142 | 0.190 | 0.442 |  |
| **Sloughs Fished** | 31 | 7 | 4 | 42 |
| **Sloughs Achieving 85% Quota** | 9 | 1 | 1 | 11 |
| **Sloughs Not Achieving 85% Quota** | 22 | 6 | 3 | 31 |
| **% of Sloughs Achieving Quota** | 29% | 14% | 25% | 26% |

### Primary Objective 3 - Assessment of juvenile salmon

For the spring sampling portion of the study, a total of 360 minnow traps were fished for a 24-hour period annually from 2011 through 2016. Only minimal minnow trapping occurred in 2017 and 2018. Timing of these trapping events coincided with spring gillnet suppression efforts. During the spring juvenile salmon assessments, success of capturing juvenile salmon was very low, with only 321 captured during the entire six years of the project. Catches included 123 Chinook salmon and 196 coho salmon (Table 4). Additional minnow trapping took place in June through August of 2014 through 2016, which resulted in capture of 325 juvenile salmon, of which 142 were Chinook salmon and 183 were coho salmon.

Table 4. Number of juvenile Chinook salmon (KS) and coho salmon (SS) captured in minnow traps by study reach and year on in Alexander Creek, 2011–2016.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Species** | |  |  |
|  | **Year** | **Study reach** | **KS** | **SS** | **Total** | **Percent** |
| **Spring** |  |  |  |  |  |  |
|  | **2011** | **1** | 17 | 3 | 20 | 100 |
|  |  | **2** | 0 | 0 | 0 | 0 |
|  |  | **3** | 0 | 0 | 0 | 0 |
|  |  | **Total** | **17** | **3** | **20** |  |
|  | **2012** | **1** | 9 | 11 | 20 | 51 |
|  |  | **2** | 7 | 12 | 19 | 49 |
|  |  | **3** | 0 | 0 | 0 | 0 |
|  |  | **Total** | **16** | **23** | **39** |  |
|  | **2013** | **1** | 15 | 11 | 26 | 42 |
|  |  | **2** | 15 | 21 | 36 | 58 |
|  |  | **3** | 0 | 0 | 0 | 0 |
|  |  | **Total** | **30** | **32** | **62** |  |
|  | **2014** | **1** | 7 | 23 | 30 | 54 |
|  |  | **2** | 4 | 10 | 14 | 25 |
|  |  | **3** | 3 | 9 | 12 | 21 |
|  |  | **Total** | **14** | **42** | **56** |  |
|  | **2015** | **1** | 10 | 22 | 32 | 48 |
|  |  | **2** | 6 | 13 | 19 | 28 |
|  |  | **3** | 6 | 10 | 16 | 24 |
|  |  | **Total** | **22** | **45** | **67** |  |
|  | **2016** | **1** | 12 | 25 | 37 | 49 |
|  |  | **2** | 7 | 15 | 22 | 29 |
|  |  | **3** | 5 | 11 | 16 | 21 |
|  |  | **Total** | **24** | **51** | **75** |  |
|  |  | **All Years** | **123** | **196** | **319** |  |
| **Summer/Fall** | **2014** | **1** | 21 | 19 | 40 | 57 |
|  |  | **2** | 3 | 12 | 15 | 21 |
|  |  | **3** | 3 | 12 | 15 | 21 |
|  |  | **Total** | **27** | **43** | **70** |  |
|  | **2015** | **1** | 9 | 53 | 62 | 47 |
|  |  | **2** | 17 | 30 | 47 | 35 |
|  |  | **3** | 5 | 19 | 24 | 18 |
|  |  | **Total** | **31** | **102** | **133** |  |
|  | **2016**a | **1** | 142 | 182 | 324 | 100 |
|  |  | **2** | 0 | 1 | 1 | 0 |
|  |  | **3** | - | - | - |  |
|  |  | **Total** | **142** | **183** | **325** |  |
|  |  | **All Years** | **200** | **328** | **528** |  |
|  |  | **Total** | **323** | **524** | **847** |  |

a Water was too low to access study reach 3 and most of study reach 2.

In 2011, 100% of the 20 juvenile salmon captured during the minnow trapping events occurred in study reach 1 (Table 4; Figure 5). In 2012, 49% of the salmon captured came from study reach 2, and by 2013, that had increased to 58%. In 2014, high water events thwarted sampling efforts throughout most of the spring, but 56 juvenile salmon were still captured in the minnow traps. This was the first year of the study in which juvenile salmon were captured in all three study reaches. Between 2014 and 2016, over 20% of the juvenile salmon captured in Alexander Creek came from study reach 3.

Figure 5. Proportion of the total Chinook and coho salmon minnow trap catches from each study reach, spring 2011–2016.

CPUE as measured by catch of juvenile salmon per trap was estimated for all minnow trapping events during the spring and summer on Alexander Creek and the Deshka River (Table 5). Catches for spring minnow trapping events on Alexander Creek were low for both juvenile Chinook and coho salmon. From 2011 to 2016, CPUE for Chinook salmon did not significantly increase. However, during that time, CPUE for coho salmon showed a steady increase from 0.01 fish/trap in 2011 to 0.14 fish/trap in 2016. The baseline CPUE for juvenile salmonids combined in 2011 was 0.06 fish/trap and by 2016, that had increased 246% to 0.208 fish/trap.

For the summer minnow trapping efforts on Alexander Creek (2014–2016), CPUE was variable for both Chinook and coho salmon, with highest catch rates occurring in 2016. This is likely a result of sampling primarily occurring in study reach 1 where catches are typically highest, hence skewing catch rates higher than other years where all study reaches were sampled. Field circumstances that year prevented sampling in study reaches 2 and 3. Minnow trapping events were also conducted on the Deshka River from 2014–2016 to compare a system that was only slightly impaired by invasive pike to Alexander Creek. As expected, catch rates for both Chinook and coho salmon averaged much higher on the Deshka River than Alexander Creek.

Table 5. Number of traps, total number captured, and CPUE (number of fish per minnow trap set) of juvenile Chinook and coho salmon in Alexander Creek 2011–2016 and the Deshka River 2014–2016.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Year** | **# Traps** | **Chinook** | **Coho** | **Chinook CPUE** | **Coho CPUE** |
| **Alexander Creek Spring** | **2011** | 360 | 17 | 3 | 0.05 | 0.01 |
|  | **2012** | 360 | 16 | 23 | 0.04 | 0.06 |
|  | **2013** | 360 | 30 | 32 | 0.08 | 0.09 |
|  | **2014** | 360 | 14 | 42 | 0.04 | 0.12 |
|  | **2015** | 360 | 22 | 45 | 0.06 | 0.13 |
|  | **2016** | 360 | 24 | 51 | 0.07 | 0.14 |
|  | **Total** | **2160** | **123** | **196** | **0.06** | **0.09** |
| **Alexander Creek Summer/Fall** | **2014** | 1080 | 27 | 43 | 0.03 | 0.04 |
|  | **2015** | 670 | 31 | 102 | 0.05 | 0.15 |
|  | **2016** | 150 | 142 | 183 | 0.95 | 1.22 |
|  | **Total** | **1900** | **200** | **328** | **0.11** | **0.17** |
| **Deshka River** | **2014** | 300 | 362 | 620 | 1.21 | 2.07 |
|  | **2015** | 300 | 132 | 1295 | 0.44 | 4.32 |
|  | **2016** | 125 | 151 | 521 | 1.21 | 4.17 |
|  | **Total** | **725** | **645** | **2436** | **0.89** | **3.36** |

## SECONDARY OBJECTIVES

### Secondary Objective 1 - Mean length, sex, and maturity

Northern pike sampled from all study years (2011–2018) ranged in length from 104 mm to 1,035 mm FL (Table 6). The fork length, means and ranges for each study year are shown in Table 6. As expected, female northern pike were larger (Casselman 1974) than males for each of the study years.

Table 6. Mean, minimum, and maximum fork lengths (mm) for male, female, and all northern pike combined captured in Alexander Creek during spring suppression efforts 2011–2018.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** |
| **Males** |  |  |  |  |  |  |  |  |
| Mean | 450 | 406 | 406 | 424 | 419 | 424 | 436 | 437 |
| Min | 189 | 188 | 187 | 188 | 171 | 200 | 197 | 235 |
| Max | 806 | 690 | 748 | 750 | 690 | 632 | 698 | 743 |
| **Females** |  |  |  |  |  |  |  |  |
| Mean | 493 | 477 | 432 | 445 | 451 | 438 | 468 | 489 |
| Min | 218 | 202 | 189 | 192 | 168 | 197 | 232 | 360 |
| Max | 775 | 1035 | 967 | 832 | 740 | 800 | 765 | 702 |
| **All** |  |  |  |  |  |  |  |  |
| Mean | 430 | 402 | 416 | 428 | 422 | 423 | 438 | 443 |
| Min | 110 | 174 | 187 | 170 | 104 | 152 | 185 | 184 |
| Max | 834 | 1035 | 967 | 832 | 740 | 800 | 765 | 743 |

For all study years, 19,710 northern pike were examined for sex determination, of which 15,094 (77%) were identified to sex, while 4,616 (23%) were documented as unknown sex (Table 7). Of the pike identified to sex, 9,312 (62%) were males and 5,782 (38%) were females. The male to female ratio was initially very high in 2011 and 2012; however, the number of unknown sex fish was also high in those years.

Table 7. Sex composition and ratios for spring Alexander Creek northern pike caught during the pike suppression efforts, 2011–2018.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sex** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **All Years** |
| **Male** | 1,774 | 1,321 | 1,986 | 1,337 | 968 | 902 | 504 | 520 | 9,312 |
| **Female** | 507 | 511 | 1,427 | 1,089 | 788 | 792 | 336 | 332 | 5,782 |
| **Unknown** | 1,935 | 1,115 | 129 | 392 | 204 | 410 | 152 | 279 | 4,616 |
| **Total** | 4,216 | 2,947 | 3,542 | 2,818 | 1,960 | 2,104 | 992 | 1,131 | 19,710 |
| **# ID to Sex** | 2,281 | 1,832 | 3,413 | 2,426 | 1,756 | 1,694 | 840 | 852 | 15,094 |
| **% Male** | 78% | 72% | 58% | 55% | 55% | 53% | 60% | 61% | 62% |
| **% Female** | 22% | 28% | 42% | 45% | 45% | 47% | 40% | 39% | 38% |
| **M/F Ratio** | 3.5:1 | 2.6:1 | 1.4:1 | 1.2:1 | 1.2:1 | 1.1:1 | 1.5:1 | 1.6:1 | 1.6:1 |

From 2011–2018, 19,216 northern pike were examined for maturity. Of those examined, 12,179 (63%) were identified as mature, 1,245 (7%) were determined to be immature, and 5,792 (30%) were documented as unknown.

### Secondary Objective 2. Stomach content analysis

The primary purpose for conducting stomach content investigations was to document the presence and spatial and temporal distributions of juvenile salmon selected as prey items and, to a lesser extent, identify and document other prey items selected by northern pike.

During the eight study years, 14,751 northern pike stomachs were analyzed, of which 12,188 (83%) contained at least one food item (Table 8). Percent of northern pike stomachs containing prey items varied from 81% in 2015 and 2016 to 85% in 2017.

Table 8. Spring Alexander Creek northern pike stomachs examined for content, 2011–2018.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Years** | | | | | | | |  |
| **Stomach** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **All Years** |
| **Empty** | 274 | 249 | 563 | 445 | 352 | 361 | 144 | 173 | 2,563 |
| **Non-empty** | 1,218 | 1,109 | 2,853 | 2,242 | 1,511 | 1,579 | 793 | 883 | 12,188 |
| **Total** | 1,492 | 1,358 | 3,416 | 2,687 | 1,863 | 1,940 | 937 | 1056 | 14,751 |
| **% Empty** | 18% | 18% | 17% | 17% | 19% | 19% | 15% | 16% | 17% |
| **% Non- empty** | 82% | 82% | 83% | 83% | 81% | 81% | 85% | 84% | 83% |

Of the 12,188 northern pike stomachs that were non-empty and examined for content, top prey items identified in order of magnitude (number of items found in all stomachs) included; 14,157 slimy sculpin *Cottus cognatus*, 11,318 juvenile salmon *Oncorhynchus* sp. (including those identified to species and, because of their state of degeneration, only identified to genus) 6,808 threespine sticklebacks *Gasterosteus aculeatus*, 6,334 lamprey *Petromyzontidae spp.*, and 4,194 leeches *Hirudo spp*. Other items included are listed in Appendices 2 and 3.

During the study, we were able to identify three of the five species of Alaskan pacific salmon in the stomachs of pike: Chinook salmon, coho salmon, and chum salmon *Oncorhynchus keta.* However, due to the degenerative state of most of the juvenile salmon identified in the stomach contents, we were only able to key a small portion to specific species. For the purpose of this report, all Pacific salmon species identified in stomach contents were referred to as juvenile salmon.

Of the 14,751 northern pike stomachs examined for content, 2,704 contained a total of 11,318 juvenile salmon. The percent of stomachs containing juvenile salmon has fluctuated annually and by study reach (Figure 6). Study reach 1 consistently had the highest percentage of stomachs containing at least one juvenile salmon, followed by study reach 2, then study reach 3.

Figure 6. Percent of northern pike stomachs containing at least one juvenile salmon by study reach 2011–2018.

Consumption of juvenile salmon depended highly on the size of northern pike, with the smaller pike having a higher consumption rate. Nearly 25% of stomachs from pike 100–200 mm contained at least one juvenile salmon. In contrast, only 11% of stomachs from pike 601–700 mm contained juvenile salmon. The percentage of stomachs containing at least one juvenile salmon steadily decreased with each increase in size class. Additionally, the smaller size classes had a higher average number of juvenile salmon per stomach, with pike 201–300 mm having the highest average (Figure 7). For example, on average, for almost every stomach examined from pike 201–300 mm, one juvenile salmon was recovered.

Figure 7. Length frequency distribution of northern pike captured in Alexander Creek 2011–2018 with stomachs assessed for content, and average number of salmon (±2 SE) per pike stomach by size class.

### Secondary Objective 3. Assessment of bycatch

Northern pike gillnet suppression efforts for the six study years yielded a total of 4,645 non-target animals (bycatch). The predominate non-targeted species captured was Arctic grayling, longnose suckers *Catostomus catostomus*, and whitefish (which include humpback whitefish *Coregonoeus pidschian* and round whitefish *Prosopium cylindraceum*) (Table 9). Bycatch varied from year to year from a low of 205 animals in 2016 to a high of 1,182 in 2013. After accounting for netting effort, there were no obvious trends or patterns of bycatch over time.

Table 9. Bycatch (nontarget species) of animals captured in gillnets during the northern pike spring suppression efforts on Alexander Creek, 2011–2018.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Years | | | | | | | | |  |
| Species | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total | |
| Arctic grayling | 175 | 593 | 387 | 356 | 542 | 92 | 95 | 146 | 2,386 | |
| Whitefish | 175 | 113 | 211 | 257 | 121 | 11 | 46 | 13 | 947 | |
| Longnose sucker | 139 | 220 | 456 | 101 | 108 | 50 | 80 | 75 | 1,229 | |
| Rainbow Trout | 18 | 52 | 93 | 37 | 43 | 19 | 36 | 18 | 316 | |
| Burbot | 12 | 37 | 7 | 2 | 6 | 4 | 0 | 4 | 72 | |
| Chinook salmon | 2 | 8 | 12 | 3 | 8 | 6 | 0 | 0 | 39 | |
| Coho salmon | 1 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 5 | |
| Dolly Varden | 0 | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 6 | |
| Muskrat | 32 | 21 | 16 | 10 | 7 | 7 | 4 | 8 | 105 | |
| Beaver | 1 | 2 | 0 | 1 | 0 | 0 | 2 | 1 | 7 | |
| Vole | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | |
| Bird | 15 | 37 | 10 | 17 | 27 | 13 | 14 | 7 | 140 | |
| Total | 571 | 1084 | 1195 | 786 | 864 | 205 | 277 | 272 | 4,645 | |

# DISCUSSION and RECOMMENDATIONS

## Discussion

The impacts of northern pike in Alexander Creek started becoming obvious in the early 2000’s. This is evident when comparing the escapement counts between Alexander Creek and the Talachulitna River, which have very similar escapement goals (2,100-6,000 for Alexander Creek and 2,200-5,000 for the Talachulitna River). Index counts between the two systems were very similar during the 1980’s and 1990’s (Figure 8). However, by the early 2000’s, counts began to deviate substantially between the two systems. The impacts northern pike were having on Alexander Creek Chinook salmon were especially obvious by 2003 when every west side Cook Inlet stream with an escapement goal exceeded the upper end of their goals by 15% to 91%. In the same year, Alexander Creek fell just under the lower end of the escapement goal. Index counts in Alexander Creek have continued to follow a similar pattern to that of the Talachulitna River, however, at a much-reduced number.

Figure 8. Adult Chinook salmon escapement into Alexander Creek and the Talachulitina River, 1979–2018.

A study on the effectiveness of gillnetting to remove invasive northern pike from lakes on the Kenai Peninsula demonstrated that catch rates of northern pike could be substantially reduced within two years of continuous northern pike suppression(Massengill 2010), though this may just be the case for small lakes with limited northern pike habitat. Northern pike populations in larger systems with more pike habitat are more difficult to suppress. For example, in the Yampa River, Colorado, suppression efforts initially reduced the population of northern pike, but eventually the population stopped decreasing (Zelasko et al. 2016). However, northern pike suppression efforts in Box Canyon Reservoir in Washington has resulted in a 98% decrease in relative abundance from 2012 to 2017 (Joe Maroney, personal communication). Some of that success may be attributed to the fact suppression efforts begin in March, potentially before a majority of the pike spawn. Bioenergetics modeling of other large-scale invasive fish control programs, such as the systematic removal of lake trout *Salvelinus namaycush* to conserve cutthroat trout *O. clarki* stocks in Yellowstone Lake, demonstrates that suppression projects in large systems can dramatically reduce predation pressure on native fishes and bolster their recovery over time (Ruzycki et al. 2003). One challenge with the Alexander pike suppression project is that a baseline population estimate for northern pike in Alexander Creek does not exist because it was logistically and financially prohibitive to develop one at the onset of this project. However, without baseline population estimates for pike in Alexander Creek, it is now difficult to speculate the specific impact our suppression efforts are having on the overall population. Our catches have shown our efforts are very successful in reducing the number of pike in specific sloughs within a given year. However, with extensive pike spawning and rearing habitat in Alexander Creek, it is possible the recruitment rate is near the mortality rate, resulting in no changes in overall pike population numbers between years. However, many factors can affect population trends and stability, and it has been shown animal populations can have varying responses to additional mortality as a result of suppression efforts (Abrams and Quince 2005, Zipkin et al. 2009, Zelasko et al. 2016).

While the CPUE of northern pike between years has been variable, there has been a steady increase in catch rates since 2015. While the reason for this increase is unknown, it is very possible this results from the establishment of another invasive species. In 2014, a small patch of the common waterweed *Elodea canadensis* was discovered in Alexander Lake. By 2016, about 70% of the lake was infested with dense matts of this aquatic vegetation. Chemical treatments attempting to eradicate the elodea in 2016 were unsuccessful and, to date, both Alexander and Sucker Lakes are completely infested. Prior studies of pike movement in the Alexander System had previously shown little movement of pike between Alexander Lake and the Creek (Rutz et al. 2019). However, though speculative, it is very possible the dense mats of elodea now have displaced pike from the lake into the creek, which could explain the increase in catch rates.

While we do not have pike population values, we do have other ways of measuring success of the Alexander Creek pike suppression. While numbers of juvenile salmon captured in minnow traps during the study were far below our original expectations, we did observe some positive trends. The consistent increase in juvenile salmon distribution up the drainage suggests their production and survival rates may be improving, potentially as a result of pike suppression efforts. Additionally, overall CPUE rates in the minnow traps, while very low, did increase each year. It will be important for minnow trapping events to resume and be conducted in a consistent manner to further evaluate response of salmonid populations.

Another positive sign of salmon recovery from observations during aerial surveys is that recolonization of historical spawning areas on Alexander Creek’s mainstem, both upstream and downstream of the confluence with Sucker Creek, was observed 2014–2016 as well as increases in abundance of other salmon species (chum, coho and pink salmon).

In analyzing northern pike stomach contents, we found that pike prey items, both in number of prey enumerated and numbers of pike stomachs containing a particular prey item, varied from year to year. However, no significant trends were observed. It is likely that the variability observed may be related to the timing opportunity of available prey rather than selectivity (Rutz 1996, 1999, Sepulveda et al. 2013, 2015). Northern pike are opportunistic feeders and seasonal change in the diet of pike appear to be related to the availability of prey items (Frost 1954, Lawler 1965, Chapman 1989).

However, one consistent observation each year was the high relative consumption of juvenile salmonids, particularly by the smaller pike. Pervozvanskiy et al. (1988) showed that northern pike account for up to 35% of the stocked Atlantic salmon *Onychoryncs salar* smolt mortality in the Keret River in Russia. Larsson (1985) found that at least 50% of migrating Baltic salmon are lost to predation from northern pike during downstream migration. Information obtained from the Por’ya River (Karelian Autonomous Republic, Old Russia) showed that in some years, northern pike consume 30-33% of migrating wild juvenile salmon (Smirnov et al. 1977). According to Movchan and Checkenkov (1979) more than 70% of juvenile hatchery salmon released in the Shuya River (White Sea Basin) from the Kem Hatchery are eaten by northern pike. Because stomach content analysis of Alexander Creek northern pike was only conducted for less than one month of the year and all pike stomachs were not sampled, it is likely that the number of juvenile salmon that were enumerated in pike stomachs over the course of the study was only a small fraction of those ingested by pike throughout the year. Sepulveda et al. 2015, showed pike ages 2 to 4 had the highest overall consumption of juvenile salmonid biomass. Within one summer, it was estimated that northern pike in Alexander Creek could consume 1.1 metric (realized consumption) and 1.66 metric tons (potential consumption) of juvenile salmonids (Sepulveda et al. 2015).

Given that restoration efforts have only been going on for a short duration (since 2011), and the fact that Chinook salmon are a multi-generational species, it will likely take another two or three years before we can demonstrate, with confidence, that our efforts are achieving success. Though it is not expected that Chinook salmon abundance on Alexander Creek will ever rebound fully to the pre-pike era, a more reasonable expectation of success would likely be between 40 and 60% of historical averages. Given the positive signs observed during this project, it appears the suppression efforts on Alexander Creek are benefiting salmonid production on this system and moving closer toward that goal.

## Recommendations

Although results are not conclusive yet, they appear to be very promising. We recommend continuing the pike suppression efforts on Alexander Creek for at least another few years at a reduced and consistent level. This would involve four ADF&G technicians operating out of two field camps and gill netting side-sloughs for a fixed unit of time before moving nets. Additional effort may be put into beginning sampling as early as possible to potentially capture female pike before they spawn, which would hopefully increase the impact on the overall population as has been documented in Box Canyon Reservoir. If suppression efforts continue to show promise and, knowing that pike numbers would rebound if suppression efforts were discontinued, we also recommend that a much smaller scaled-down, cost-effective version of pike suppression be continued in perpetuity. This reduced effort would consist of two fish and game technicians gillnetting up to 60 or more side sloughs adjacent or attached to Alexander Creek’s mainstem for a one-month period commencing in early May. Additionally, a dedicated minnow trapping event should take place in June so that crews in May can focus on capturing pike. Future pike suppression efforts on Alexander Creek will be essential for restoration of both anadromous and resident fish populations as well as reestablishing sport fisheries. The expense of instituting a scaled-down cost-effective pike suppression project is a small price to pay for the restoration of what was once a multimillion-dollar sport fishery.

It is additionally recommended that Alexander Creek remain a high priority system for Chinook salmon aerial surveys as this continues to be a quick and cost-effective means of monitoring the strength of the adult Chinook salmon run returning to Alexander Creek.

Historical information from aerial surveys show that prior to northern pike encroachment, up to 10% of the Chinook and a significant portion of the coho salmon escapement from the Alexander Creek drainage could be attributed to tributaries located upstream of Alexander Lake (Bear, Toms, Deep and No-name creeks). These tributaries have been devoid of spawning salmon for the past two decades. If it is decided that salmon production be re-established upstream of the outlet of Alexander Lake, then it will become necessary to expand northern pike suppression efforts to include Alexander Lake and portions of those previously mentioned tributaries.

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# Appendix 1. Side channels and sloughs along Alexander Creek.



# Appendix 2. Number of individual food items found in non-empty stomachs, 2011–2018 Alexander Creek.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **All Years** |
|  | **1,123 Non-empty Stomachs** | **1,109 Non-empty Stomachs** | **3,172 Non-Empty Stomachs** | **2,244 Non-empty Stomachs** | **1,505 Non-empty Stomachs** | **1,619 Non-empty Stomachs** | **793 Non-empty Stomachs** | **883 Non-empty Stomachs** | **Total 10,772 Non-empty Stomachs** |
| ***Juvenile Salmon*** | 1,576 | 1,594 | 1,298 | 742 | 2021 | 3,493 | 297 | 297 | 11,318 |
| ***Rainbow Trout*** | 30 | 13 | 28 | 17 | 51 | 52 | 34 | 31 | 256 |
| ***Whitefish*** | 40 | 25 | 31 | 108 | 32 | 26 | 31 | 6 | 299 |
| ***Arctic Grayling*** | 51 | 112 | 241 | 398 | 198 | 95 | 25 | 19 | 1,139 |
| ***Pike*** | 39 | 6 | 17 | 24 | 5 | 7 | 8 | 7 | 113 |
| ***Sculpin*** | 1,266 | 2,153 | 5,296 | 2,351 | 1,178 | 1154 | 306 | 453 | 14,157 |
| ***Burbot*** | 76 | 115 | 105 | 751 | 250 | 152 | 91 | 126 | 1,666 |
| ***Unknown Fish*** | 207 | 141 | 416 | 332 | 338 | 219 | 172 | 207 | 2,032 |
| ***Stickleback*** | 511 | 242 | 1,737 | 999 | 857 | 619 | 800 | 1043 | 6,808 |
| ***Other Fisha*** | 0 | 0 | 27 | 30 | 53 | 49 | 45 | 48 | 252 |
| ***Lamprey*** | 675 | 281 | 1,620 | 1,319 | 570 | 785 | 770 | 314 | 6,334 |
| ***Leech*** | 540 | 455 | 698 | 758 | 489 | 628 | 199 | 427 | 4,194 |
| ***Snail*** | 16 | 2 | 14 | 7 | 2 | 5 | 2 | 0 | 48 |
| ***Scud*** | 115 | 243 | 115 | 2,060 | 85 | 92 | 34 | 8 | 2,752 |
| ***Dragon Fly*** | 205 | 97 | 496 | 471 | 162 | 294 | 131 | 91 | 1,947 |
| ***Damsel Fly*** | 1 | 0 | 21 | 0 | 1 | 0 | 0 | 1 | 24 |
| ***Caddis Fly*** | 12 | 0 | 7 | 17 | 5 | 13 | 49 | 1 | 104 |
| ***Beetle*** | 41 | 9 | 29 | 49 | 18 | 10 | 1 | 42 | 199 |
| ***Macro Invert.*** | 98 | 279 | 249 | 74 | 105 | 68 | 48 | 595 | 1,516 |
| ***Wood Frog*** | 108 | 30 | 39 | 183 | 56 | 50 | 9 | 152 | 627 |
| ***Rodent*** | 23 | 1 | 0 | 2 | 10 | 0 | 8 | 2 | 46 |

a Other fish include Dolly Varden and longnose suckers

# Appendix 3. Number of stomachs individual food items were found in, 2011–2018 Alexander Creek.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **All Years** |
|  | **1,123 Non-empty Stomachs** | **1,109 Non-empty Stomachs** | **3,172 Non-Empty Stomachs** | **2,244 Non-empty Stomachs** | **1,505 Non-empty Stomachs** | **1,619 Non-empty Stomachs** | **793 Non-empty Stomachs** | **883 Non-empty Stomachs** | **Total 10,772 Non-empty Stomachs** |
| ***Juvenile Salmon*** | 281 | 273 | 751 | 292 | 366 | 508 | 111 | 124 | 2,706 |
| ***Rainbow Trout*** | 29 | 12 | 28 | 17 | 51 | 48 | 30 | 29 | 244 |
| ***Whitefish*** | 33 | 23 | 30 | 100 | 31 | 26 | 28 | 6 | 277 |
| ***Arctic Grayling*** | 47 | 104 | 212 | 372 | 180 | 93 | 24 | 19 | 1,051 |
| ***Pike*** | 29 | 6 | 17 | 23 | 5 | 7 | 8 | 7 | 102 |
| ***Sculpin*** | 391 | 458 | 1,289 | 685 | 440 | 473 | 167 | 175 | 4,078 |
| ***Burbot*** | 51 | 99 | 97 | 442 | 211 | 140 | 77 | 107 | 1,224 |
| ***Unknown Fish*** | 136 | 111 | 314 | 267 | 269 | 176 | 131 | 152 | 1,556 |
| ***Stickleback*** | 156 | 95 | 676 | 456 | 319 | 281 | 270 | 300 | 2,553 |
| ***Other Fisha*** | 0 | 0 | 14 | 21 | 31 | 43 | 38 | 43 | 190 |
| ***Lamprey*** | 301 | 168 | 917 | 686 | 349 | 455 | 392 | 197 | 3,465 |
| ***Leech*** | 166 | 136 | 286 | 261 | 225 | 272 | 123 | 153 | 1,622 |
| ***Snail*** | 4 | 1 | 8 | 3 | 2 | 5 | 2 | 0 | 25 |
| ***Scud*** | 27 | 18 | 52 | 59 | 35 | 13 | 4 | 7 | 215 |
| ***Dragon Fly*** | 51 | 41 | 231 | 181 | 79 | 112 | 82 | 26 | 803 |
| ***Damsel Fly*** | 1 | 0 | 17 | 0 | 1 | 0 | 0 | 1 | 20 |
| ***Caddis Fly*** | 6 | 0 | 4 | 9 | 1 | 5 | 16 | 1 | 42 |
| ***Beetle*** | 30 | 3 | 23 | 26 | 9 | 9 | 1 | 9 | 110 |
| ***Macro Invert.*** | 37 | 77 | 210 | 56 | 41 | 17 | 28 | 121 | 587 |
| ***Wood Frog*** | 59 | 24 | 31 | 101 | 45 | 47 | 7 | 83 | 397 |
| ***Rodent*** | 20 | 1 | 0 | 2 | 8 | 0 | 8 | 2 | 41 |

a Other fish include Dolly Varden and longnose suckers