Regional Operational Plan No. ROP.SF.2A.2022.33

# Operational Plan: Matanuska-Susitna Valley and Anchorage Area Invasive Northern Pike Surveying and Monitoring, 2022–2024

by

Parker Bradley

Cody Jacobson

and

Kristine Dunker

October 2022

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 | $ft^3/s$ |
| 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 (negative log of) | pH |
| 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 | $H_A$ |
| base of natural logarithm | *e* |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, 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) | $log_2$, etc. |
| minute (angular) | ′ |
| not significant | NS |
| null hypothesis | $H_O$ |
| 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 |

*REGIONAL OPERATIONAL PLAN NO. ROP.SF.2A.2022.33*

# OPERATIONAL PLAN: MATANUSKA-SUSITNA VALLEY AND ANCHORAGE AREA INVASIVE NORTHERN PIKE SURVEYING AND MONITORING, 2022–2024

by
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Division of Sport Fish
333 Raspberry Road, Anchorage, Alaska, 99518-1565

October 2022

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## SIGNATURE PAGE

| | |
|---|---|
| Project Title: | Matanuska-Susitna Valley and Anchorage Area Invasive Northern Pike Surveying and Monitoring |
| Project leader(s): | Parker Bradley, Cody Jacobson, and Kristine Dunker |
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| Period Covered | June 2022 through October 2024 |
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| Plan Type: | Category II |

**Approval**

| Title | Name | Signature | Date |
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| Research Coordinator | Tim McKinley | | 10/21/2022 |

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# ABSTRACT

This project will conduct surveys to detect invasive northern pike *Esox lucius* ("pike") and determine baseline catch per unit effort (CPUE) throughout the Matanuska–Susitna (Mat–Su) Valley and Anchorage area. Waterbodies in these areas will be prioritized for sampling based on whether they fall into 1 of 3 categories: 1) waters with known pike presence, 2) waters with unconfirmed, suspected, or reported pike populations, and 3) vulnerable waters with no known pike populations. For waters in the first category, northern pike will be captured by means of gillnet surveys using a standardized protocol that adjusts netting effort to lake littoral area. Waters in the second category will be probed by means of gillnet surveys and environmental DNA (eDNA). In vulnerable waters where no known pike population occurs, eDNA detection methods will be the primary monitoring method. Results from this survey and monitoring project will be used to refine the known distribution of pike in the Mat–Su Valley and Anchorage area, increase the likelihood of early detections of new populations, and help prioritize future pike suppression and eradication projects in the region.

Keywords: invasive species, northern pike, *Esox lucius*, Matanuska-Susitna Valley, Anchorage, eDNA

# INTRODUCTION

## PURPOSE

The mission of the Alaska Department of Fish and Game (ADF&G), Division of Sport Fish (SF) is "to protect and improve the state's recreational fisheries resources," and an objective of the SF strategic plan is to "minimize impacts of invasive species on fish stocks, recreational fisheries, and fish habitat." Removing northern pike (*Esox lucius*; also referred to here as "pike") from vital salmon rearing habitat directly addresses this objective. ADF&G has an aquatic nuisance species management plan (Fay 2002) and an invasive northern pike management plan (ADF&G 2007). A new interagency management plan for northern pike will be available in the spring of 2022. Goals and objectives in these plans address the need to remove invasive northern pike where possible and improve salmon populations impacted by northern pike. The activities proposed in this project are aligned with several plans and initiatives, and ADF&G believes this project will provide the first step in a long-term program to effectively survey, monitor, and prioritize pike suppression and eradication projects in the Matanuska–Susitna (Mat–Su) Valley and Anchorage area.

## BACKGROUND

Northern pike is an invasive species in Southcentral Alaska that negatively impacts salmonid (*Oncorhynchus* spp.) populations via predation of juvenile salmon in invaded waters (ADF&G 2007). The effects of this are most severe in shallow, slow moving, vegetated lakes and streams where northern pike and rearing salmonids share complete habitat overlap (Sepulveda et al. 2013; Sepulveda et al. 2015). Northern pike are native throughout much of Alaska but do not naturally occur south and east of the Alaska Range (Figure 1). It is thought that pike were first introduced by an air charter operator to the Yentna River drainage (Bulchitna Lake, Lake Creek drainage) in the late 1950s and subsequently spread throughout the Susitna River basin via natural migration and further illegal stockings. Currently, northern pike have been documented from over 150 lakes and rivers in Southcentral Alaska[1].

More recent, smaller-scale "secondary" pike infestations (i.e., originating from the Susitna River basin infestation) have been reported widely throughout the Mat–Su Valley. Some of these infestations are the result of illegal actions by people intentionally transporting pike. Over time,

[1] ADF&G "pike mapper" https://adfg.maps.arcgis.com/apps/webappviewer/index.html?id=ad27ebc052814b66a60d0e52701e64f7&_ga=2.30854847.1642248700.1601938699-959016251.1583185835

pike have continued to spread throughout the watershed. Many reports of pike in the Mat–Su Valley and Anchorage have come from sport anglers; however, most reports lack live or dead specimens, preventing conclusive identification and knowledge of the extent of infestation.

To effectively prioritize and design northern pike suppression and eradication projects, it is necessary to begin with baseline information about the pike population in a given area, and what other species may occur (e.g., Baxter and Neufeld 2015). This project will lay the foundation for a long-term northern pike surveying and monitoring program for the Mat–Su Valley and Anchorage area.

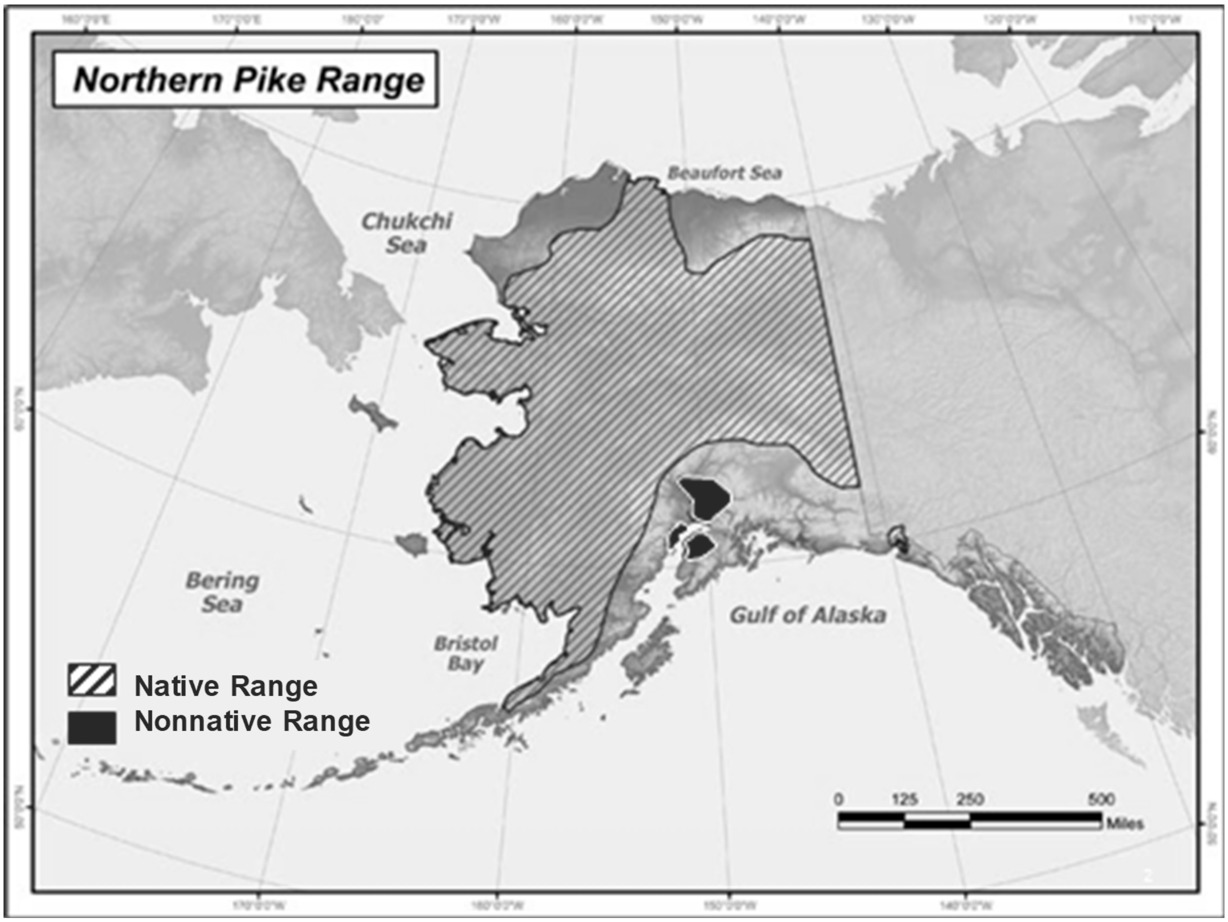


Figure 1.–Northern pike range in Alaska.

# OBJECTIVES

## PRIMARY OBJECTIVES

1) Document catch-per-unit-effort (CPUE) of northern pike in waters where they are confirmed to be present and document the presence of other fish species.
2) Document presence or probable absence of northern pike in unconfirmed, suspected, or reported waters.
3) Monitor highly vulnerable waterbodies for northern pike presence with annual eDNA surveys.

## SECONDARY OBJECTIVES

1) Document length, weight, stomach contents, and sex for all northern pike captured, and collect otoliths and cleithra from each.
2) Generate bathymetric maps of waterbodies containing northern pike populations.

# METHODS

## STUDY AREA

This project will take place in the Mat–Su Valley and Anchorage area. The Mat–Su Valley is made up of 2 watersheds totaling approximately 65,000 square kilometers and containing thousands of lakes and miles of river. The Mat–Su Valley also contains the fastest-growing human population in the state and is home to approximately 100,000 residents, and Anchorage is home to nearly 300,000 residents. There is a wide variety of aquatic habitats ranging from high gradient clear streams and large glacial rivers to low gradient swamp and marsh habitat. This low gradient habitat, which is optimal for northern pike, primarily occurs on the west side of the Parks Highway and supports many of the confirmed and suspected northern pike populations (Figure 2). The watershed also supports all 5 species of Pacific salmon in addition to many resident fish species such as rainbow trout (*Oncorhynchus mykiss*), burbot (*Lota lota*), Arctic grayling (*Thymallus arcticus*), and longnose suckers (*Catostomus catostomus*). Many of these waters are also stocked with rainbow trout and other hatchery fish to provide additional angler opportunity.

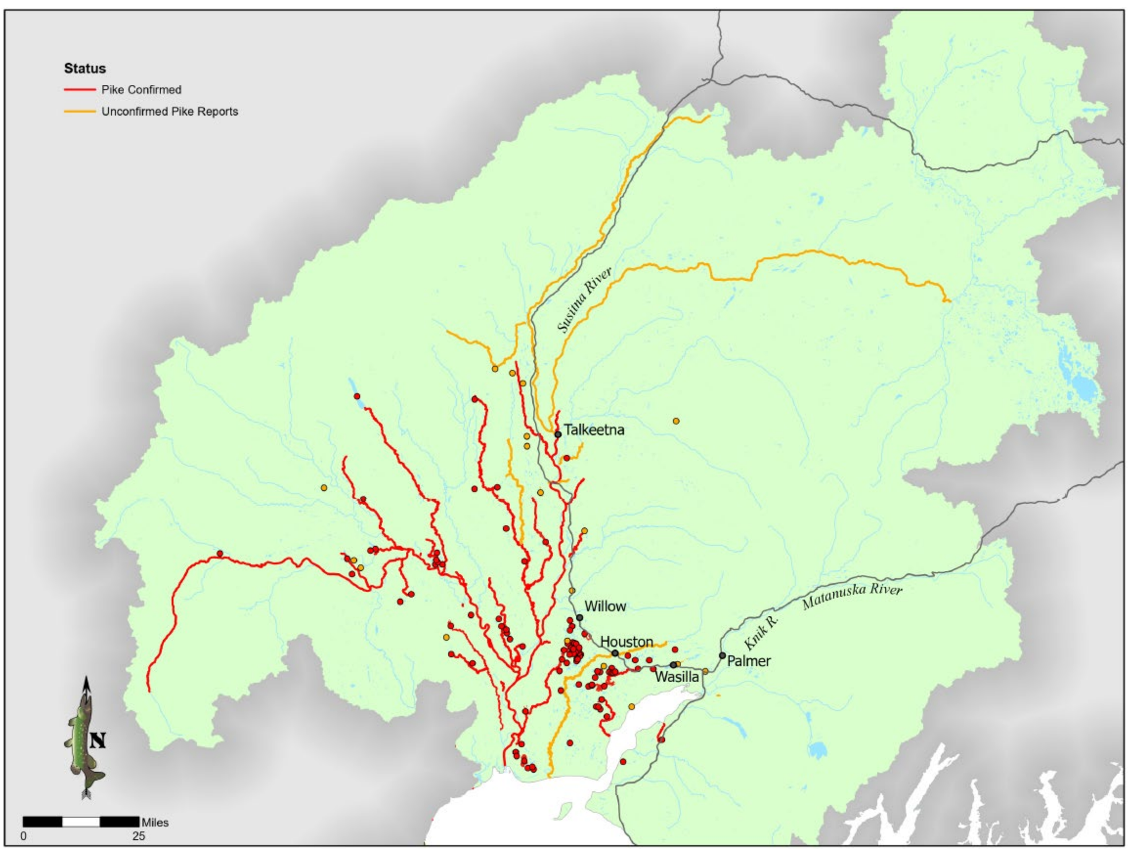


Figure 2.–Map of the Mat-Su drainage and Anchorage areas with confirmed and unconfirmed northern pike waters.

# STUDY DESIGN

## Primary Objective 1: Documenting CPUE of Northern Pike in Confirmed Waters

Waterbodies in the “confirmed pike waters” category are shown in red in Figure 2. Prioritized waterbodies in this category are listed in Appendix A1. The primary purpose of documenting CPUE is to establish a baseline for later comparison and to document the degree of infestation. By utilizing repeatable and consistent sampling techniques and effort, comparisons can be made between waterbodies, and future efforts can be prioritized. However, circumstances such as severe bycatch or high public use of lakes may prevent use of certain gear types and methods. In these cases, alternative gear or methods (see examples below) will be used to keep sampling effort in that given waterbody consistent between years.

### *Sampling*

For open water sampling, the waterbody will be divided into sections, with each section containing approximately 1.6 km of shoreline (Figure 3). One gillnet per each 0.16 km of shoreline will be fished in each section (10 gillnets per 1.6 km of shoreline). Gillnets will be set overnight along the littoral zone and checked the following day approximately 24 hours later. Nets will be distributed uniformly in the littoral zone of each section, and net locations will be recorded with GPS for repeatability, noting the start and stop times for each set. The nets will be pulled as they are checked and reset in the next section of the lake. This will repeat until all sections have been sampled.

Lakes with significant bycatch concern will have the same density of nets per section, but the nets will be set for a shorter duration (approximately 4–5 hours) and they will be closely monitored. Throughout the sampling period, the crew will continuously boat along the nets and remove any northern pike or bycatch that are captured. A new section will be sampled each day until all sections have been sampled.

Some lakes (e.g., Nancy Lake or Big Lake) will be too big to sample with this amount of effort. In these cases, netting effort may be limited to specific areas of the waterbody that provide good pike habitat. In addition, other gear types may be used depending on the circumstances such as fyke nets or hook-and-line. Use of these gear types will be specific to the waterbody, but effort will be made to remain consistent between sampling years at that given waterbody.

Sampling frequency for confirmed pike waterbodies will occur at least once every 5 years.

### *Lake Mapping*

Lake bathymetry data will also be collected to produce volume estimates and a bathymetric map useful for planning northern pike control and eradication efforts. To collect bathymetry data, we will use a boat-mounted Lowrance HDS chart plotter and transducer to record $x$, $y$, $z$ mapping data. Mapping will take place in roughly 40-hectare sections. For each section, the perimeter will be mapped as near shore as safely feasible, followed by a repeat of the perimeter circuit about 20 m farther offshore. After 2 complete section perimeter circuits, the rest of the lake section will be mapped by sequential line transects, typically orientated along the greatest length of each section. Typically, transects lines should be no greater than 40 m apart and all mapping will be done traveling at a slow speed (<5 mph); this can be gauged by watching the GPS track on the Lowrance unit’s monitor.

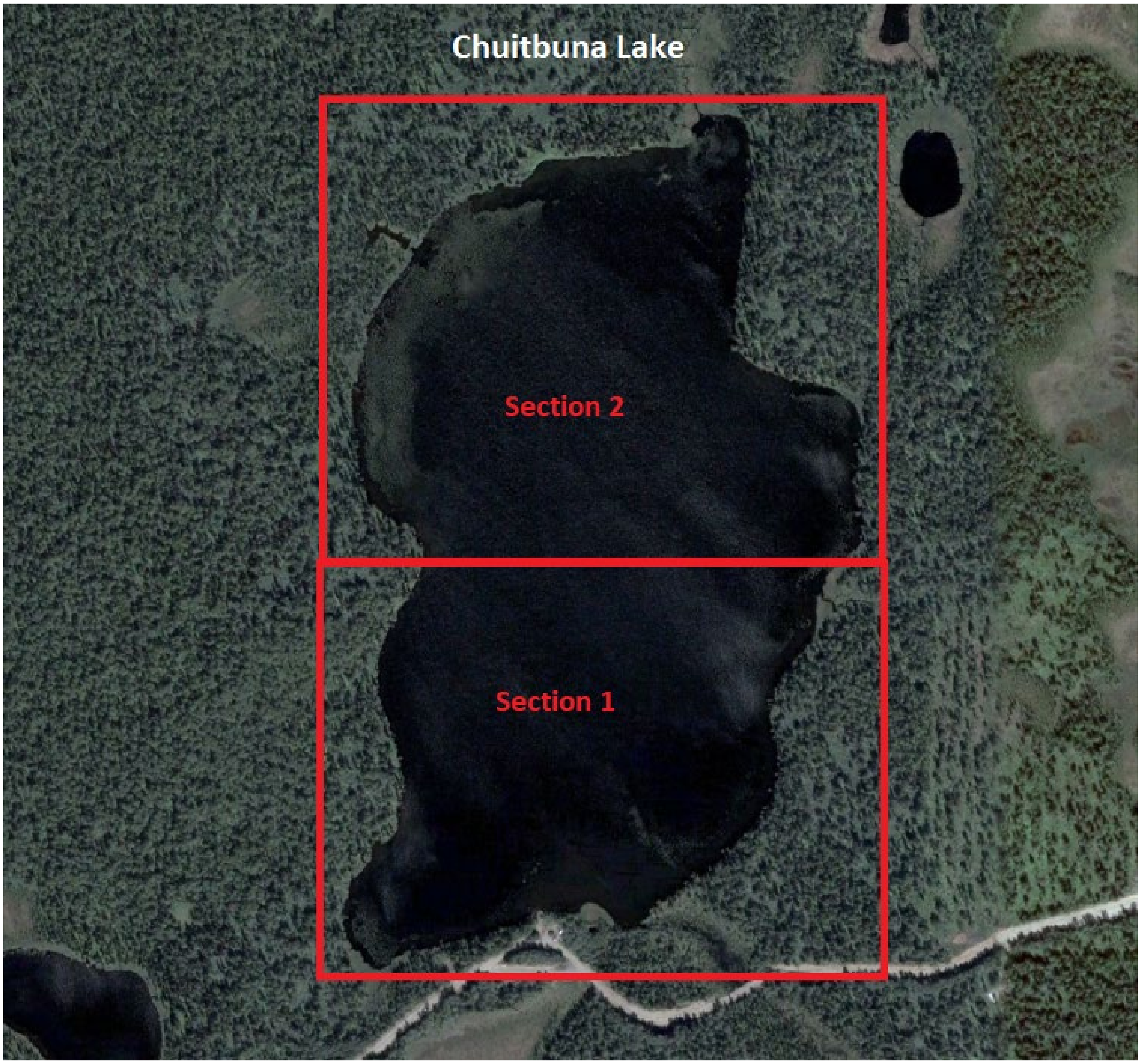


Figure 3.–Example of a lake broken into sections, each with approximately 1.6 km of shoreline.

## Primary Objective 2: Documenting Presence or Probable Absence in Suspected Pike Waters

Waterbodies with unconfirmed pike reports (orange in Figure 2), waterbodies with a surface connection to confirmed pike waters, or places with creditable reports, will be sampled according to Primary Objective 2. Prioritized waterbodies in this category are listed in Appendix A2. The primary purpose of Objective 2 is to confirm pike presence or probable absence in suspected pike waters and to further refine the known distribution of northern pike in southcentral Alaska. Methods will be geared toward determining, with confidence, whether pike are present or not. However, circumstances such as severe bycatch concern or lakes highly used by the public may prevent use of certain gear types and methods.

### *Sampling*

For open water sampling, the waterbody will be divided into sections, with each section containing approximately 1.6 km of shoreline (Figure 3). Like Objective 1, gillnetting effort for each section will be 1 gillnet per 0.16 km of shoreline. Gillnets will be set overnight along the littoral zone and checked the following day approximately 24 hours later. Nets will be distributed relatively uniformly, with high effort placed in ideal pike habitat. Locations will be recorded with GPS for repeatability, noting the start and stop times. The nets will be pulled as they are checked and reset in the next section of the lake. This will repeat until all sections have been sampled.

Lakes with significant bycatch concern will have a similar netting scheme, except the nets will be set for a shorter duration (approximately 4–5 hours) and they will be closely monitored. Throughout the sampling period, the crew will continuously boat along the nets and remove any northern pike or bycatch that are captured. A new section will be sampled each day until all sections have been sampled.

If netting takes place and no northern pike are captured, eDNA samples may be taken to confirm their absence. The number of eDNA samples will be based on the eDNA detection probabilities calculated in Appendix B1.

Some waterbodies are more easily accessed in the winter. Additionally, some waterbodies may have high waterfowl bycatch concerns and are best sampled in the winter. For winter sampling, under-ice gillnets and (or) tip-ups will be used. Tip-ups are devices used to suspend a piece of bait in the water column through a hole drilled in the ice. A flag attached to the spool springs up when a fish takes the bait, giving indication of a fish strike to the angler. Up to 20 tip-ups baited with herring, eulachon, or hotdogs will be used at a time. If under-ice gillnets are used, nets will either be set individually, or 2 may be tied together as a pair so that there is 61 m of gillnet per set. Under-ice gillnets will be 30.5 m long, 1.2 m deep, and composed of 32 mm monofilament mesh. Different numbers of nets and types of configurations will be set depending on the lake bathymetry (e.g., Figures 4 and 5). Depending on ambient temperatures, nets will be checked every 24 to 48 hours to avoid nets freezing in and becoming unrecoverable. In the spring with warmer temperatures, net sets can be checked once per week.

Once pike are confirmed, the waterbody will be added to the list for lake mapping, following methods outlined under the previous objective.

## Primary Objective 3: Monitoring Highly Vulnerable Waters

Waterbodies that fall into this category typically had prior pike populations that have been eradicated or are waterbodies with a fishery resource that would be extremely vulnerable if pike became established and where pike would be difficult and (or) expensive to eradicate. Prioritized waterbodies in this category are listed in Appendix A3. Early detection of pike in these waterbodies could result in successful eradication with gillnets if the response is quick and sufficient. In small, closed lakes (<16 ha), intensive under-ice gillnetting has proven to be an effective eradication alternative (R. Massengill, Fishery Biologist, ADF&G, Soldotna, personal communication) but only when the northern pike population is small (<30 individuals) and reproduction success is low as noted by the lack of multiple age classes or juvenile northern pike during sampling efforts. Successful eradication using gillnets alone has involved fishing gillnets continuously from fall ice-up until spring ice-out with gillnet densities of 1.25–5.0 nets/ha (R. Massengill, Fishery Biologist, ADF&G, Soldotna, personal communication). Because these systems often have a severe bycatch potential with gillnets, monitoring of these systems will utilize eDNA, which has zero potential for any impacts on native species.

### ***Sampling***

Primary sampling will be collection of eDNA samples annually in the fall. The number and location of samples will be based on the eDNA detection probabilities outlined in Appendix B1.

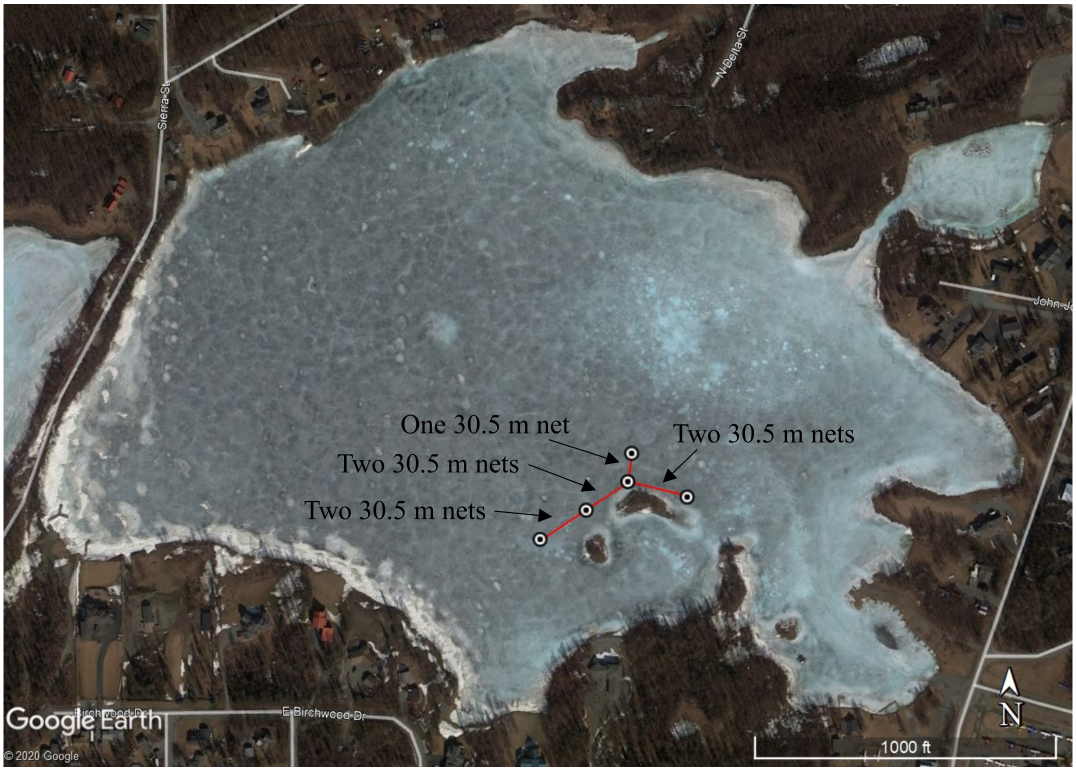


Figure 4.–Anderson Lake showing location of under-ice netting (total of 213.5 m of gillnets), with gillnets indicated by red lines and holes drilled in the ice indicated by dots.


Figure 5.–Sand Lake in Anchorage showing location of under-ice gillnet sets (total of 152.5 m linear nets), with gillnets indicated by red lines and holes drilled in the ice indicated by dots.

## DATA COLLECTION AND REDUCTION

### Fish Sampling

Gillnet GPS locations and set and check times will be recorded for each gillnet set. Start and stop times will also be recorded for other gear types used. All capture data will be recorded on water-resistant paper following the format in Appendix C1.

All northern pike will be dispatched and processed for fork length (nearest millimeter), sex, weight (nearest gram), and stomach contents. Cleithra bones will be removed and archived for age determination at a later date. Otoliths may be removed and archived. Each pike will be numbered in chronological order ("Fish #" column; Appendix C2) so archived otoliths and cleithras can be associated with the proper fish. All field data will be recorded on the northern pike sampling forms (Appendix C2). Data will be transferred from the data sheets to Microsoft Excel worksheets for analysis.

### eDNA Sampling

The eDNA sampling will follow protocols outlined in Abbott et al. (2021). Each eDNA sampling location will be recorded with a handheld GPS and given a unique identifying name. Control blank samples will be similarly labeled. Each duplicate water sample will be given a unique identifying name and labeled with the waterbody name and collection date. If funding allows, enough samples will be taken to have a 95% detection probability (Appendix B1). During sample filtration, an array of sample data will be recorded in an Excel file on a laptop computer. These data will include the sample collection and filtering dates, filtering time, number of filters used, waterbody name, unique sample identifier, initials of the collector and the person doing the filtering, collection site location (lat and long) and any comments. Original GPS location data will be downloaded to Garmin Basecamp software on a PC. Sample site location data will be converted in Basecamp to Excel format and copied into the same Excel file holding the sample collection and filtering data. The eDNA samples will be sent to an appropriate lab for analysis.

### Lake Mapping

After concluding the mapping survey, the mapping data, stored by the Lowrance chart plotter as an .sl2 file on an external memory SD card, will be downloaded to a computer and uploaded to a cloud-based subscription service (BioBase). BioBase will run algorithms on the data and generate a report that includes the lake volume, surface area estimates, and a printable bathymetric map.

## DATA ANALYSIS

### Northern Pike Surveys

#### *Gillnet Sampling*

The capture of a northern pike during a gillnet survey will confirm the presence of northern pike. If no northern pike are caught, we will conclude either no northern pike are present or that the population is very small, requiring follow up removal attempts.

#### *eDNA Sampling*

Analyzing eDNA detection results requires an understanding that nonliving sources of DNA and sample contamination can occasionally confound results. Local experience with eDNA sampling has indicated that positive eDNA detections are not always associated with the presence of a live northern pike population. On the Kenai Peninsula, northern pike eDNA surveys where only a single sample tested positive ($N$ = 7) have never been associated with a live northern pike population following subsequent gillnet surveys (R. Massengill, Fishery Biologist, ADF&G, Soldotna, personal communication). Therefore, when enough sampling occurs to obtain an 80% or greater detection probability, only eDNA surveys yielding greater than 1 positive eDNA detection will trigger the need for a follow-up gillnet survey. When there is a complete lack of positive eDNA detections in a survey, we will conclude the probability of failing to detect a northern pike population of 20 individuals is less than 0.20.

## Catch-Per-Unit-Effort Comparison

Northern pike CPUE can be calculated for each net set $k$, and location $l$ using Equation 1:

$$CPUE_{kl} = \frac{c_{kl}}{e_{kl}} \tag{1}$$

where

$c_{kl}$ = catch of northern pike in net set $k$ at location $l$, and

$e_{kl}$ = the fishing duration of net set $k$ (in hours) at location $l$ (total net hours).

The pooled CPUE at location $l$ is calculated by Equation 2:

$$CPUE_l = \frac{\sum_{k=1}^{m_l} c_{kl}}{\sum_{k=1}^{m_l} e_{kl}} \tag{2}$$

where

$m_l$ = total number of net sets at location $l$

Simple linear regression analysis (or an appropriate time series analysis) will be used to evaluate if CPUE of northern pike changes for a given waterbody between years. In addition, maps will be generated showing relative CPUE of netting efforts for each waterbody (e.g., Figure 6).

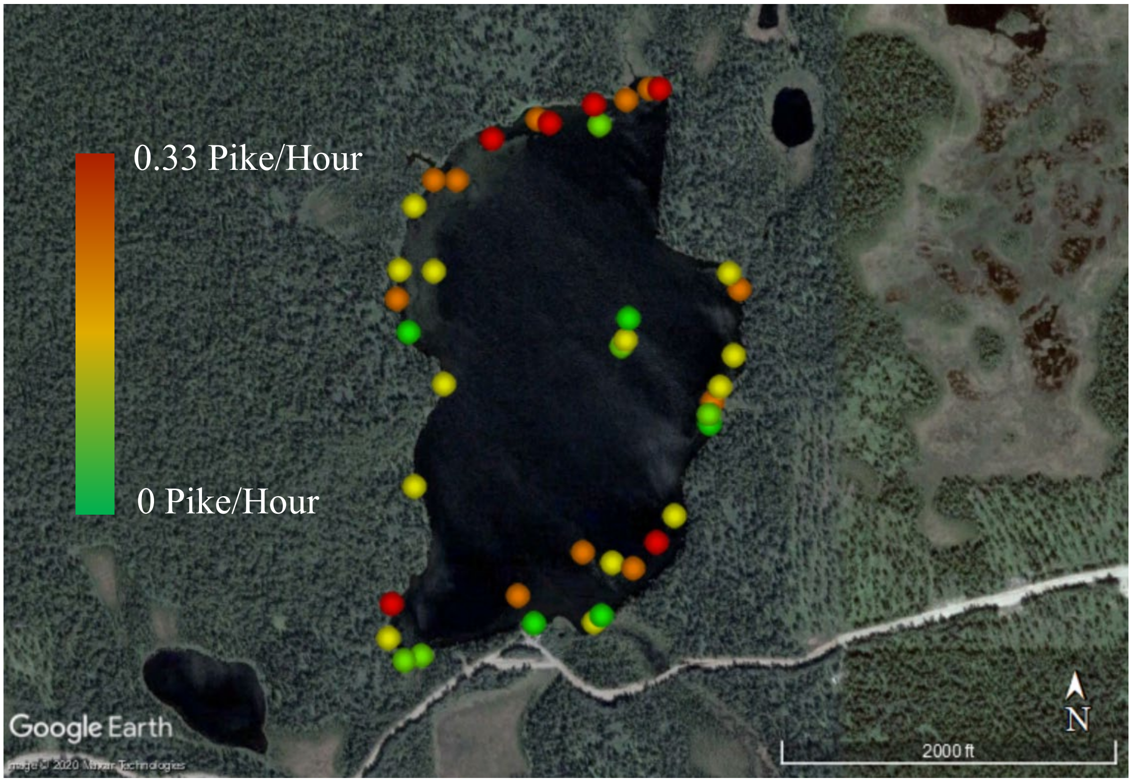


Figure 6.–Netting locations on Chuitbuna Lake in 2019 showing relative CPUE for each net.

# SCHEDULE AND DELIVERABLES

| Dates | Activity |
|---|---|
| June 2022–Oct 2024 | Perform open water netting and sampling |
| October 2022, 2023, 2024 | Collect eDNA samples |
| Winter 2022, 2023 | Data Entry<br>Otolith/cleithra prep/aging<br>Perform under-ice netting |
| Winter 2024 | Analyze data and write performance report for our State Wildlife Grant |

# RESPONSIBILITIES

*Kristine Dunker, Fishery Biologist III, ADF&G*
Duties: Provide oversight and make recommendations on study designs and project plans; assist with data analysis and project reporting; coordinate and assist with the completion of project deliverables.

*Parker Bradley, Fishery Biologist II, ADF&G*
Duties: Serve as the primary project biologist; assist with planning and coordinating field logistics; author State Wildlife Grant project report and presentations to the public.

*Cody Jacobson, Fishery Biologist I, ADF&G*
Duties: Assist with planning and coordinating field logistics and equipment procurement; supervise field activities and technicians.

*Mike Martz, Biometrician I, ADF&G*
Duties: Provide guidance on study design; assist with postseason data analysis; review project operational plans and reports.

*Fish and Wildlife Technicians, ADF&G*
Duties: Assist with field activities.

# REFERENCES CITED


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# APPENDIX A: LISTS OF PRIORITIZED WATERBODIES

Appendix A1.–List of prioritized waterbodies for Objective 1.

| Drainage | Waterbody name | Latitude, longitude | Stocked? | Anadromous? | Latest survey year | Mapped? | Surface area (acre) | Volume (acre/ft) | Max depth (ft) |
|---|---|---|---|---|---|---|---|---|---|
| Campbell Creek | Campbell Lake | 61.132746 -149.939426 | No | Yes | 2022 | No | NA | NA | NA |
| Chester Creek | West Chester Lagoon | 61.207348 -149.919044 | Yes | Yes | NA | No | NA | NA | NA |
| Fish Creek | South Rolly Lake | 61.666412 -150.133924 | Yes | Yes | 2022 | Yes | 108 | 2,842 | 63 |
| | Tanaina Lake | 61.674522 -150.093203 | Yes | Yes | 2022 | Yes | 110 | 3,175 | 110 |
| | Milo Lake | 61.670833 -150.080556 | No | Yes | 2020 | Yes | 60 | 778 | 40 |
| Goose Creek | Anna Lake | 61.466688 -149.963856 | No | No | 2021 | Yes | 113 | 1,630 | 29 |
| | Stephan Lake | 61.487713 -149.926555 | No | Yes | 2021 | Yes | 329 | 2,063 | 15 |
| | Loonsong Lake | 61.466667 -149.948611 | No | No | 2021 | Yes | 80 | 578 | 15 |
| Deshka River | Amber Lake | 62.165885 -150.542079 | No | Yes | 1980s | No | 180 | NA | NA |
| Little Meadow Creek | Blodgett Lake | 61.576944 -149.666667 | No | Yes | 2022 | Yes | 72 | 715 | 31 |
| Little Susitna River | Nancy Lake | 61.689391 -150.012691 | No | Yes | 2022 | Yes | 761 | NA | 65 |
| | East Papoose Lake | 61.540931 -150.069664 | No | Yes | 2021 | Yes | 166 | 1,956 | 40 |
| | Horseshoe Lake (Big Lake area) | 61.573386 -149.924215 | No | Yes | 2021 | Yes | 426 | 4,025 | 23 |
| | Hourglass Lake | 61.559762 -149.955898 | No | Yes | 2022 | Yes | 109 | 1,165 | 22 |
| | West Horseshoe Lake | 61.575875 -149.942795 | No | Yes | 2020 | Yes | 137 | 1,290 | 16 |
| Meadow Creek | Gerry Lake (Audra Lake) | 61.569685 -149.848360 | No | Yes | 2022 | Yes | 18 | 136 | 8 |
| | Beaverhouse Lake | 61.57297 -149.863652 | No | Yes | 2022 | No | 33 | NA | NA |
| | West Beaver Lake | 61.581403 -149.855246 | Yes | No | 2020 | Yes | 110 | 1,235 | 24 |
| | Stepan Lake | 61.572222 -149.816667 | No | Yes | 2020 | Yes | 62 | 587 | 17 |
| | Lynda Lake | 61.570833 -149.833333 | No | Yes | 2020 | Yes | 15 | 182 | 22 |
| | Big Lake | 61.578348 -149.841354 | No | Yes | 2021 | Yes | 3,085 | 87,546 | 82 |
| NA-Landlocked | Crystal Lake | 61.711812 -150.116258 | Yes | No | 2020 | No | 132 | 1,548 | 24 |
| | Lalen Lake | 61.600317 -149.691805 | Yes | No | 2022 | Yes | 112 | 700 | 13 |
| | Leo Lake | 61.435780 -149.899945 | No | No | 2021 | Yes | 30 | 96 | 6 |
| | Memory Lake | 61.625593 -149.419047 | Yes | No | NA | Yes | 90 | 734 | 20 |
| | Prator Lake | 61.616686 -149.733509 | Yes | No | 2022 | Yes | 92 | 1,116 | 24 |
| | Baptist Pond | 61.574189 -149.725109 | No | No | 2021 | Yes | 9 | 41 | 10 |

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Appendix A1.–Page 2 of 2.

| Drainage | Waterbody name | Latitude, longitude | Stocked ? | Anadromous ? | Latest survey year | Mapped ? | Surface area (acre) | Volume (acre/ft) | Max depth (ft) |
|---|---|---|---|---|---|---|---|---|---|
| Sixmile Creek | Sixmile (Lower) Lake | 61.289710 -149.800865 | No | Yes | 2022 | Yes | 130 | 814 | 9 |
| Willow Creek | Long Lake | 61.716667 -150.083333 | No | Yes | 2020 | Yes | 241 | 2,541 | 23 |
| | Shirley Lake | 61.747170 -150.103700 | No | Yes | 2019 | No | 121 | NA | 20 |

*Note*: NA means not available or not applicable.

Appendix A2.–List of prioritized waterbodies for Objective 2.

| Drainage | Waterbody name | Latitude, longitude | Stocked? | Anadromous? | Latest survey year | Mapped? | Surface area (acre) | Volume (acre/ft) | Max depth (ft) |
|---|---|---|---|---|---|---|---|---|---|
| Birch Creek | Fish Lake | 62.250000 - 150.066667 | No | Yes | 1980s | No | 154 | NA | NA |
| Caswell Creek | Caswell Lake | 62.013452 -149.968042 | No | Yes | NA | No | NA | NA | NA |
| Little Susitna River | Horseshoe Lake (Pt. Mac) | 61.362500 -150.147222 | No | Yes | 2006 | No | 160 | NA | 23 |
| | West Papoose Lake | 61.535982 -150.094578 | No | Yes | NA | No | 192 | NA | 24 |
| | Yohn Lake | 61.469424 -150.174021 | No | Yes | NA | No | NA | NA | NA |
| Little Willow Creek | Kashwitna Lake | 61.829982 -150.073508 | Yes | Yes | 2020 | Yes | 156 | 1,080 | 13 |
| Meadow Creek | Lazy Lake | 61.572222 -149.805556 | No | No | NA | No | NA | NA | NA |
| | Twin Lake | 61.572055 -149.781711 | No | Yes | NA | No | NA | NA | NA |
| | Long Lake (Meadow Creek) | 61.577778 -149.766667 | No | Yes | NA | No | NA | NA | NA |
| NA-Landlocked | Island Lake | 61.627708 -149.617547 | No | No | 2021 | No | NA | NA | NA |
| | Knik Lake | 61.458249 -149.729576 | Yes | No | NA | Yes | 53 | 872 | 38 |
| | Matanuska Lake | 61.553995 -149.228059 | Yes | No | 2020 | Yes | 64 | 2,108 | 80 |
| | Pear Lake | 61.591782 -149.897018 | No | No | NA | No | 61 | NA | 12 |
| | Visnaw Lake | 61.618985 -149.675161 | Yes | No | 2022 | No | 131 | NA | 17 |
| | Loberg Lake | 61.559125 -149.257256 | Yes | No | NA | No | 11 | NA | 48 |
| Ninemile Creek | Scotty Lake | 62.318599 -150.322296 | No | No | NA | No | 220 | NA | 6 |
| | Aurora Lake | 62.274320 -150.355450 | No | No | NA | No | NA | NA | NA |
| Rolly Creek | North Rolly Lake | 61.674525 -150.129003 | Yes | No | NA | No | 122 | NA | 65 |
| Susitna River | Caswell Creek | 61.942572 -150.078495 | No | Yes | NA | No | NA | NA | NA |
| | Rabideaux Creek | 62.177134 -150.193550 | No | Yes | NA | No | NA | NA | NA |
| | Sunshine Creek | 62.175889 -150.115069 | No | Yes | NA | No | NA | NA | NA |
| Willow Creek | Rainbow Lake | 61.695881 -150.096068 | No | No | NA | No | 150 | NA | 45 |

*Note*: NA means not available or not applicable.

Appendix A3.–List of prioritized waterbodies for Objective 3.

| Drainage | Waterbody name | Latitude, longitude | Stocked? | Previously eradicated pike population?, year | Anadromous? | Latest survey year | Mapped? | Surface area (acre) | Volume (acre/ft) | Max depth (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| Cottonwood Creek | Wasilla Lake | 61.583333 -149.410150 | No | No | Yes | 2017 | No | 374 | NA | 48 |
| | Anderson Lake | 61.620686 -149.336494 | Yes | Yes, 2020 | Yes | NA | Yes | 105 | 808 | 28 |
| | Kings Lake | 61.617164 -149.359731 | Yes | Yes, 2020 | Yes | NA | Yes | 112 | 793 | 24 |
| | Cottonwood Lake | 61.596428 -149.333020 | No | No | Yes | 2017 | Yes | 254 | 2,977 | 43 |
| | Mud Lake | 61.596803 -149.345600 | No | No | Yes | 2017 | No | 55 | NA | 17 |
| Jim Creek | Jim Lake | 61.554167 -148.925000 | No | No | Yes | NA | No | 170 | NA | 5 |
| | Leaf Lake | 61.653521 -148.887568 | No | No | Yes | NA | No | NA | NA | NA |
| | Mud Lake | 61.561785 -149.949728 | No | No | Yes | NA | No | 50 | NA | 3 |
| | Swan Lake | 61.5269570 -148.90089 | No | No | Yes | NA | No | NA | NA | NA |
| Meadow Creek | Big Beaver Lake | 61.578348 -149.841354 | Yes | No | Yes | NA | No | 161 | NA | NA |
| NA-Landlocked | Finger Lake | 61.608704 -149.263784 | Yes | No | No | NA | Yes | 372 | 6,047 | 42 |
| | Sand Lake | 61.152480 -149.957299 | Yes | Yes, 2009 | No | 2021 | Yes | 78 | 1,188 | 37 |
| | Cheney Lake | 61.200313 -149.761945 | Yes | Yes, 2008 | No | 2021 | Yes | 27 | 161 | 16 |

*Note*: NA means not available or not applicable.

# APPENDIX B: ENVIRONMENTAL DNA SAMPLING

To develop an eDNA sampling effort sufficiently robust to detect northern pike populations with low abundance, the estimated mean detection probabilities of northern pike eDNA were used. The detection probabilities were estimated from the results of replicate 1-liter water samples collected at 1, 10, and 40 meters from a single, caged, live northern pike and were estimated to have a 0.89, 0.57, and 0.27 probability of detection, respectively. For this project, 1-liter samples will be collected in duplicate to account for the lower detection probabilities using the Biomeme Two3 device.

The following calculations will be used to estimate how many eDNA samples are needed to detect a small northern pike population ($N$ = 20) with a desired probability of detection provided lake acreage is known and no gillnet sampling occurs. Calculations will be based on 3 assumptions: 1) fish are randomly distributed throughout the littoral area, 2) there are no false detections, 3) the probability of detection beyond 40 meters is zero because no estimates are available for this region, and 4) all samples are taken at least 40 meters away from each other.

To account for differences in the probability of detection due to the distance between a northern pike and the sample site, we will divide the 40-meter radius circle around each sample site into 3 distinct subregions. These subregions will be the circular area less than 1 meter from the sample site and the donut-shaped areas between 1 and 10 meters and between 10 and 40 meters from the sample site, which we will label subregions 1, 2, and 3, respectively. Because previous work (Dunker et al. 2016) estimated the probability of detection at 1, 10, and 40 meters, we will use their estimates as conservative proxies for the probability of detection within the respective subregions.

If $P$ represents the probability of detecting a northern pike, $D$ is the event a northern pike is detected, and $R_i$ is the event that a single northern pike is present in a sampling subregion $i$ for $i$ = (1, 2 ,3), we note by the law of total probability and the definition of conditional probabilities, the following relationship can be used to calculate the probability of detection:

$$P(D) = P(D \mid R_1) \times P(R_1) + P(D \mid R_2) \times P(R_2) + P(D \mid R_3) \times P(R_3) \quad \text{(B1)}$$

Thus, the probability a northern pike is detected is equivalent to the probability a northern pike can be detected, given it is within a subregion, times the probability it is in the subregion summed over all subregions. The probability a northern pike can be detected in subregion $i$, given it is present in the subregion, $P(D \mid R_i)$, is 0.89, 0.57, or 0.27 for sampling subregions 1–3, respectively. Under the assumption that northern pike are randomly distributed throughout the littoral area, the probability a northern pike is present in subregion $i$ is the proportion of total area represented by that region:

$$P(R_i) = \frac{\textit{area of region } i}{\textit{total littoral area of lake}} \quad \text{(B2)}$$

where the fixed areas of the subregions are divided by the known total surface area, and the total littoral area of the lake is taken from Biobase results overlaid on Google Earth, and then using the area calculator tool.

-continued-

Finally, assuming northern pike are randomly distributed throughout the littoral area, sample sites are identical and at least 40 meters apart, and there are no false positives, it can be shown that the probability of detection given the northern pike is within detection range of a sample site is equal to the probability of detection given the northern pike is near 1 of $S$ sample sites for $S = 1, 2, \ldots, n$. Thus, the only change in our probability calculation for $S$ sites is that the proportion of area represented by each subregion is now $S \times \mathrm{P}(R_i)$. By another application of the law of total probability and definition of conditional probabilities, the probability of detection at $S$ sites is as follows:

$$P(\text{detection at } S \text{ sites}) = P(D \mid R_1) \times S \times P(R_1) + P(D \mid R_2) \times S \times P(R_2) + P(D \mid R_3) \times \mathrm{S} \times P(R_3) = S \times P(D) \quad \text{(B3)}$$

Because the $N$ pike are assumed to be randomly distributed throughout the littoral area, the number of northern pike that are successfully detected follows a Binomial[N, S × P(D)] distribution. Samples may be taken randomly or systematically throughout the littoral area as long as they are >40 m apart. The probability of at least 1 detection at $S$ sites is $1 - \left[1 - \mathrm{S} * \mathrm{P(D)}\right)]^N$. This expression is then set to the desired probability of detection and solved for $S$. Table B1 displays calculated eDNA sampling requirements for a variety of desired probabilities of detection and acreages assuming a population of $N = 20$ northern pike.

Table B1.–Number of samples required to achieve the desired probability of detection.

| | Littoral acres | | | | | |
|---|---|---|---|---|---|---|
| Probability of detection | 10 | 25 | 50 | 75 | 100 | 200 |
| 0.50 | 1 | 3 | 5 | 8 | 10 | 19 |
| 0.75 | 2 | 5 | 10 | 14 | 19 | 38 |
| 0.90 | 4 | 8 | 16 | 23 | 31 | 61 |
| 0.95 | 4 | 10 | 20 | 30 | 39 | 78 |

# APPENDIX C: SAMPLING FORMS

Appendix C1.–Northern pike capture form.

| NORTHERN PIKE SURVEY AND MONITOR NET FORM | | | | | | | | | Page _____ of _____ |
|---|---|---|---|---|---|---|---|---|---|
| | **WATERBODY:**<br>**SAMPLERS:** | | **SECTION # :** | | | **CAPTURE**<br>**DEVICE:** | | | **START DATE:**<br>**STOP DATE:** |
| **NET #** | **GPS LOCATION LAT./LONG.** | **START TIME:** | **STOP TIME:** | **# Northern Pike** | | | | | |
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Appendix C2.–Northern pike stomach sampling form.

**NORTHERN PIKE DISSECTION FORM** Page _____ of _____

**WATERBODY:**
**SAMPLERS:**

**SECTION # :**

**START DATE:** ______________________________
**STOP DATE:** ______________________________

| Fish # (NP Only) | NET # | FISH SPECIES | FORK LENGTH (mm) | WEIGHT (g) | SEX (M, F, U) | Stomach contents ( Yes/No ) | STOMACH CONTENT | DNA Card # | Fish # (1-10) |
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