Winter 2017

Environmental impact assessment: proposed eastern brook trout removal from Hozomeen Lake

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Environmental Impact Assessment:

Proposed Eastern Brook Trout Removal from Hozomeen Lake

Environmental Impact Assessment

Winter 2017

Huxley College of the Environment

Western Washington University

Dear Concerned Citizen**,**

The purpose of this Environmental Impact Assessment (EIA) is to explore the possible environmental impacts of eliminating invasive eastern brook trout (eastern brook trout) to promote the recovery of bull trout and native amphibians in the Upper Skagit Core Area. Eastern brook trout removal in Hozomeen Lake is the primary focus of this EIA. In addition to the proposed action, viable alternatives and a no action alternative are presented, and subsequent environmental impacts evaluated. The Washington State Environmental Policy Act (SEPA), and Washington Administrative Code (WAC) 197-11-430 requirements and specifications are the basis on which this information was compiled. The following EIA is strictly an academic exercise, and is in no way intended to serve as an official document.

As a key area for bull trout recovery, the Upper Skagit watershed has been the focus of nonnative species eradication. Eastern brook trout are considered the primary threat for recovery in this core area, and Hozomeen Lake serves as a source of reproducing eastern brook trout for the entire Upper Skagit watershed. The current management plan relies on the use of CFT Legumine™ (rotenone) to eradicate the reproducing population of eastern brook trout in these waters following protocols developed by the U.S. Fish and Wildlife Service and American Fisheries Society. A two-year period of monitoring and data acquisition will be followed by two years of treatment, and subsequent monitoring and appropriate data analysis. The length of the project is estimated at six years. In addition to the proposed course of action, this EIA explored a no action alternative and an alternative action using tiger muskellunge as a biological control for the eastern brook trout population.

Using information gathered from similar fish removal projects, research on the effects of rotenone, contacts from U.S. Fish and Wildlife, and other sources we have compiled a document that explains the potential and probable environmental impacts and options for mitigating possible impacts. We would like to thank you, the concerned citizen, for your time and attention in this matter. Your input is a valuable resource to the public agencies that determine the fate of these projects, and to the future of our natural resources.

Sincerely,

Bennet Murch

Troy Riling-Anderson

Logan Bates-Mundell

Aaron Burkhart

Jennifer MacDonald

Proposed Eastern Brook Trout Removal from Hozomeen Lake

Western Washington University

Environmental Impact Assessment

Environmental Science 493

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Date 3-6-17

Fact Sheet

Title

Eastern Brook Trout Removal from Hozomeen Lake

Description of project

The North Cascades National Park has proposed the removal of eastern brook trout (*Salvelinus fontinalis*) from Hozomeen Lake and Hozomeen Creek through the use of the piscicide rotenone to prevent the spread of eastern brook trout into the habitat of the ESA listed bull trout (*Salvelinus confluentus*). Two treatments of rotenone will be applied over two successive years, followed by monitoring through 2024.

Legal Description of Location

Hozomeen Lake is located in the northern portion of Ross Lake National Recreation Area. The coordinates for the lake are 48.9592° N, 121.0376° W.

Proposer

North Cascades National Park
810 State Route 20
Sedro Woolley, WA 98284

Lead Agency

North Cascades National Park

Related Permits and Laws

The Organic Act of 1916
Migratory Bird Treaty Act
National Historic Preservation Act
Wilderness Act of 1964
Enabling Legislation of North Cascades National Park
National Environmental Policy Act
Washington Park Wilderness Act of 1988
North Cascades National Park Service Complex Fish Stocking Act
State Environmental Policy Act
Endangered Species Act
Clean Air Act
Priority Habitat Species List (WDFW)
Washington State Surface Water Quality Criteria (WAC 172-201A-200)
Federal Insecticide, Fungicide, and Rodenticide Act
North Cascades National Park Complex Fish Stocking Act

Contributors:
Bennet Murch: Built Environment Elements, Table of Contents
Troy Riling-Anderson: Summary of Proposed action, Alternative Actions, Birds & Mammals, Fish, Geology, Topography, Climate, Summary of Findings
Logan Bates-Mundell: Vegetation, ½ of Macroinvertebrates, Mammals, Table of Contents
Aaron Burkhart: Air Quality, Odor, Floods, Runoff/Absorption, Fact Sheet, Concerned Citizen letter.
Jennifer MacDonald: Soils, Surface water, Groundwater, Public Water Supplies, Zooplankton, ½ of Macroinvertebrates,

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Table of Contents

SECTION ONE: AN OVERVIEW

Executive Summary

Objective of Proposal

The main objective of eastern brook trout removal from Hozomeen Lake and Creek is the elimination of the primary threat to bull trout in the Upper Skagit Core Area, and promoting a viable population of bull trout that will be more resilient to future ecosystem changes caused by climate change. Removal of eastern brook trout will also serve to complete an additional objective, the depredation of a number of amphibian species listed as threatened or concerned. Amphibian populations are expected to rebound with the removal of eastern brook trout. Amphibian populations supressed from eastern brook trout predation include western toad, tailed frog, Cascades frog, Columbia spotted frog, Oregon spotted frog, long-toed salamander,and western red legged frog. Complete eradication of eastern brook trout will restore the natural ecosystem function and food web dynamic within the Hozomeen Lake and Creek area.

Summary of Proposal

The preferred action for the elimination of invasive eastern brook trout from the Upper Skagit Core Area is treatment of Hozomeen Lake with piscicide, rotenone (CFT Legumine™ and Prentox™). Eradication of eastern brook trout populations will serve to eliminate the primary threat to bull trout, reduce predation on multiple amphibian species, prevent rainbow trout predation in the Upper Skagit and Fraser River systems, and restore food web dynamics in Hozomeen Lake and Creek. Hozomeen Lake will be treated twice over a two-year period. *The North Cascades National Park Service complex: Mountain Lakes Fishery Management Plan,* outlines basic biotic and abiotic features of Hozomeen Lake, but additional baseline data on chemical, physical, and biological features will be collected for two years prior to treatment. Baseline data will insure that a detailed treatment plan, adhering to specific physical, chemical, and biological features of Hozomeen Lake is implemented. After baseline data collection, rotenone treatment will occur during baseflow in late September or October. Rotenone does not kill developing embryos, and to ensure complete eradication of eastern brook trout, Hozomeen Lake will have to be treated over two successive years. Rotenone treatment methods, rates, concentration, and deactivation will follow procedures outlined in the rotenone standard operating procedure manual (Finlayson et al. 2010). After rotenone application, seven years of ecosystem response monitoring will detail the rebound of macroinvertebrates, plankton, amphibians and other biotic. A final effectiveness report in 2024 will determine if project goals were meet.

Application

Rotenone will be applied in liquid form via peristaltic pumps in floating crafts with electric trolling motors. Rotenone will be applied at surface, and at depth to insure the thermocline does not prevent the vertical distribution of the chemical. Littoral areas around the lake that are difficult to treat from floating craft will be treated on foot with hand applicators. Complete rotenone application will occur in the treatment area in a forty-eight hour period to insure that potential rapid rotenone degradation does not lower the effectiveness of the treatment. Early stages of the application will focus on pumping rotenone into the hypolimnion. Eastern brook trout will be able to sense the rotenone in the water, and begin to move towards the surface of the lake. After significant upwards fish migration has been confirmed, rotenone application will then be focused on the surface of the lake. As the surface rotenone begins to sink the eastern brook trout will be trapped between two layers or rotenone. If applied at the correct rate and concentration, and barring any major setbacks, rotenone should naturally degrade via hydrolysis and photolysis within a week (Rawhouser pers comm 2017). Treated fish will have their air bladder punctured and sunk to the bottom of the lake. Hozomeen Lake has a single outlet, Hozomeen Creek. Efforts will be made to prevent rotenone from entering Hozomeen Creek and flowing into Ross Lake. Sentential fish will be placed in cages at the outlet of Hozomeen Lake, and at various locations and depths in Hozomeen Lake. Sentinel fish will be monitored, and if major stress or mortality is observed, a rotenone deactivation protocol will be implemented

Deactivation

Chemically induced deactivation, accomplished through the application of potassium permanganate, is the only procedure allowed for the deactivation of rotenone. Potassium permanganate will be applied in liquid form via hand applicators. Deactivation is a complex process that will require onsite observations and analysis to determine the appropriate amount and rate of application. Potassium permanganate distribution can be easily monitored due to the dark purple color of the liquid compound. There is no practical field procedure to determine the actual rotenone concentration once it is applied, and organic material and electrolytes will inhibit the potassium permanganate application. Potassium permanganate deactivates rotenone in a 1:1 ratio, but high levels of organic matter in a stream could require application concentrations above this ratio to ensure total deactivation. Potassium permanganate is toxic to fish species in low concentrations, and sentinel fish will be used to help prevent concentrations from rising above 1 ppm. Sentinel fish will be placed at the contact zone, point of application, and further downstream. Thirty minutes of contact time is needed to deactivate rotenone, and complete deactivation cannot be determined until multiple fish survive thirty-minute contact zones. A potassium permanganate deactivation station will be established upstream of the waterfall at the base of Hozomeen Creek.

Figure 1.1.0 Eastern brook trout, non-native to Washington State.

Summary of Alternative Actions

Alternatives

This section describes alternatives for the management of eastern brook trout in Hozomeen Lake. A "No action" alternative and one other eradication alternative are presented. Two other alternative actions were presented, but dismissed. Removal of eastern brook trout strictly through mechanical methods was deemed infeasible due to both the spatial complexity of Hozomeen Lake, and the unfavorable timeframe associated with removal. The second alternative action dismissed was a biological control. YY male brook trout introduction was considered, but uncertainty in potential hybridization with bull trout, coupled with an unfavorable timeframe prompted its dismissal as an alternative action.

Alternative Action: No Action

The no action alternative will exclude any biological, mechanical, or chemical means to suppress the eastern brook trout populations, and Hozomeen Lake would be managed in its current state. The aquatic organisms in Hozomeen Lake would continue to experience the same minor to moderate effects from eastern brook trout predation. Phytoplankton

and zooplankton populations would continue to be minimally affected by the eastern brook trout population. Amphibian species, particularly those listed as Washington State and federal species of concern, will continue to be negatively impacted by eastern brook trout, and their populations will continue to be repressed or decline further. Waterfowl and migratory birds will experience no adverse effects to their populations. The most impacted species will be bull trout and other native fish. Hozomeen Lake serves as a source of eastern brook trout for the entire Upper Skagit Core Area. Loss of spawning habitat and hybridization are distinct threats to bull trout populations in the Ross Lake area. The no action alternative would fail to address site specific suggestion made for the Upper Skagit Core Area in the United States Fish and Wildlife Service (USFWS) Coastal Recovery Unit Implementation Plan for bull trout (CRUIP).

Alternative Action: Biological Control

Tiger Muskellunge introduction

This alternative action would implement biological control, in the form of tiger muskellunge, for Hozomeen Lake. Tiger muskellunge predation would serve to dramatically reduce eastern brook trout populations. Tiger muskellunge will be stocked in a density of two tiger muskellunge every five acres (40 total). Tiger muskellunge are a sterile hybrid offspring of muskellunge (*Esox masquinongy*) and northern pike (*Esox Lucius*). The inability of tiger muskellunge to reproduce make the species an ideal predator fish to consider for this project. No documented cases of reproduction in introduced tiger muskellunge populations have ever been reported (Satterfield et al. 1994). Idaho Fish and Wildlife has been stocking tiger muskellunge to control brook trout and other invasive fish species populations in alpine lakes since the early 2000's (Idaho fisheries management plan 2007). Idaho's tiger muskellunge stocking success was noted in WDFW's 2004 mountain lake fishery management plan, and similar Washington State pilot projects were initiated in 2005 (Uehara 2005). Introduction of a sterile predator fish eliminates the potential of hybridization, but still presents inherent risk. The primary concern with tiger muskellunge introduction is escapement into Ross Lake. Tiger muskellunge are generally observed to demonstrate the same "lie and wait" littoral predation as the northern pike and muskellunge, but recent research by WDFW indicates that daily and seasonal migration is much greater than initially thought (Osborne et al. 2012). Established tiger muskellunge populations in Hozomeen Lake could possibly enter Ross Lake via Hozomeen Creek. Predation by tiger muskellunge on bull trout may occur since tiger muskellunge show preferential predation on fish that feed low in the water column, such as channel catfish and carp. Bull trout have sub-terminal mouths, an evolutionary niche that allows them to feed on macroinvertebrates and other fish on the stream bottom. The bull trout's low water column feeding behavior

makes them highly susceptible to tiger muskellunge predation, if interaction were to actually occur. Changes in the tiger muskellunge fisheries and eastern brook trout populations in Hozomeen Lake will be monitored and adjusted to meet management needs.

Figure 1.1.1 Tiger muskellunge, the sterile hybrid of muskellunge and northern pike.

Mechanical Removal/Netting

The management philosophy of the National Park Service is the preservation of unimpaired natural and cultural resources. The introduction of a non-native hybrid species is in direct conflict with this management philosophy. Consequently, removal of tiger muskellunge, once brook trout populations are eradicated, is a central component in this alternative action removal plan. The small size of brook trout, 200-300 mm, and the relatively large surface area and moderate depth of Hozomeen Lake, makes mechanical removal of brook trout ineffective. The average size of a mature tiger muskellunge is 750-850 mm, making mechanical removal of tiger muskellunge a reasonable option compared to mechanical removal of brook trout. Years of successive electrofishing and gillnetting will accomplish major reduction of the tiger muskellunge population. The inability of tiger muskellunge to reproduce, coupled with the fifteen-foot water barrier, will insure that Hozomeen Lake reaches a fishless status within two decades. Based upon the success of eastern brook trout reduction via tiger muskellunge predation, additional stocking may have to occur. Tiger muskellunge have a life span of 9-13 years, so die off would have to considered in a tiger muskellunge management proposal (Satterfield 1994).

Decision Matrix

Element	Proposed Action	Alternative Action	No Action
Earth			
Geology	0	0	0
Soils	0	0	0
Topography	0	0	0
Air			
Air Quality	0	0	0
Odor	0	0	0
Climate	0	0	0
Water			
Surface Water*	0	0	0
Runoff/Absorption	0	0	0
Floods	0	0	0
Groundwater	0	0	0
Public Water Supplies	0	0	0
Plants and Animals			
Vegetation	0	0	0
Birds and Mammals*	0/-	0/-	0
Macroinvertebrates and Amphibians*	+/-	+	-
Fish*	+	+/-	-
Migration Routes	0/-	0/-	0
Energy and Natural Resources			

Amount Required/Rate of Use/Efficiency	0	0	0
Source/Availability	0	0	0
Nonrenewable Resources	0	0	0
Conservation and Renewable Resources	0	0	0
BUILT ENVIRONMENT			
Environmental Health			
Noise	0	0	0
Risk of Explosion	-	0	0
Release of Toxic/Hazardous Materials	-	0	0
Land and Shoreline Use			
Relationship to existing land	0	0	0
Housing	0	0	0
Light and Glare	0	0	0
Aesthetics	-	0	0
Recreation	-	-/+	0
Historic and Cultural* Preservation	+	+/-	-
Agricultural Crops	0	0	0
Transportation			
Vehicular Traffic	0	0	0
Waterborne, Rail, and Air Traffic	0	0	0
Parking	0	0	0

Movement of People or Goods	0	0	0
Traffic Hazards	0	0	0
Public Services and Utilities			
Fire	-	0	0
Police	0	0	0
Schools	0	0	0
Parks and Other Recreational Facilities	-	+	+
Maintenance	0	0	0
Communications	0	0	0
Water/Stormwater	-	0	0
Sewer/Solid Waste	0	0	0
Other Government Services or Utilities	0	0	0

Key
Positive Impact +
Negative Impact -
No impact 0

*Indicates that an action may have both a positive and negative impact on the element. These positive/negative benefits are the cause of short-term and long-term effects. The decision matrix disclaimer clarifies these conflicting ratings.

Decision Matrix Disclaimer

Surface Water

Initial treatments of rotenone and potassium permanganate will create toxic conditions

for all gill breathing organisms. However, rapid degradation of rotenone into its corresponding by-products can occur as quickly as a day, or take as long as week. Regardless of the timeline, the toxicity is short lived and its impact on surface water was considered negligible in our decision matrix.

Birds and Mammals

The alternative and preferred action were given both a no impact and negative impact rating. Birds and mammals feeding on eastern brook trout in Hozomeen Lake will be negatively impacted by the removal of a food source, but mitigation measures should prevent migratory birds from being negatively affected from eastern brook trout removal. Any mammals, or other bird species foraging on eastern brook trout have the ability to exploit foraging opportunities in other nearby lakes.

Macroinvertebrates and Amphibians

The prefered action is listed as having both a negative and positive effects on macroinvertebrate and amphibian population in Hozomeen Lake and Creek. Initial rotenone application will eradicate macroinvertebrate and amphibian species currently in a gill breathing portion of their life cycle. Although macroinvertebrate and amphibian populations will initially be depressed, population rebounds will occur over the next five years. The rebound potential of these populations after rotenone application was deemed to be a larger positive impact, than the initial depression caused by the application.

Fish

Positive and negative impacts on the fish populations were determined by considering the given actions relationship with native species, such as the rainbow trout and ESA listed bull trout. The alternative action is given both a positive and negative rating, because possible predation on bull trout by tiger muskellunge could occur while eastern brook trout populations are simultaneously decreased by tiger muskellunge predation.

Historical and Cultural Preservation

The alternative action was given a negative impact rating with regards to historical and cultural preservation, because although it serves to decrease a population of reproducing invasive fish, it is in direct conflict with the national parks management philosophy. The introduction of a nonnative fish species, even as a means of biological control, is a strong departure from insuring that the North Cascades National Park is managed in a way that promotes only natural and historical ecosystems.

Glossary of Figures and Tables

Figures:

Tables:

Glossary of Technical Terms

Sources of definitions: Merriam-Webster Dictionary and corresponding ecological literature

Active Metabolism: The amount of metabolic activity of an organism at a maximum level of activity.

Allopatric: Related species or populations occurring in separate non geographically overlapping areas.

American Cordillera: North American portion of the American Cordillera which is a mountain chain (cordillera) along the western side of the Americas.

Baseflow: Portion of streamflow that comes from "the sum of deep subsurface flow and delayed shallow subsurface flow". The amount of water in a stream or lake during the driest portion of the year.

CFT Legumine™: Least toxic liquid mixture of rotenone available.

Conductivity: Conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water.

Endangered: Any species that is in danger of extinction throughout all or a significant portion of its range.

Epilimnetic: Referring to the layer of water above the thermocline.

EPT: Abbreviation for three orders of macroinvertebrates: Ephemeroptera, Plecoptera, and Trichoptera

Heterotrophic: An organism that cannot manufacture its own food, and instead obtains its food and energy by taking in organic substances, usually plant or animal matter.

Hybridization: The act or process of organisms mating from different varieties or species.

Hydrolysis: A chemical reaction in which water is used to break down a compound.

Hypolimnetic: Referring to the layer of water in a thermally stratified lake that lies below the thermocline, is non circulating, and remains perpetually cold.

Littoral zone: Near shore area where sunlight penetrates all the way to sediments and allows macrophyte growth.

Macroinvertebrates: Term used for invertebrate fauna that can be captured by a 500--µm net or sieve. This includes insects, mites, scuds, crayfish, snails, limpets, mussel, clams, segmented worms, nematodes, roundworms, and flatworm.

Mesotrophic: A body of water having a moderate amount of dissolved nutrients.

Metamorphs: A change in the form and often habits of an animal during normal development after the embryonic stage.

Metabolism: The sum of chemical process within living cells which provide energy for a living organism.

Mitochondria: An organelle found in large numbers in most cells, responsible for the biochemical processes of respiration and energy production occur.

Oligotrophic: Body of water with relatively low in plant nutrients, and containing abundant oxygen in the deeper parts.

Periphyton: The combination of algae, cyanobacteria, microorganisms, and detritus that adheres to underwater surfaces

Photolysis: The decomposition or separation of molecules by the action of light.

Photorespiratory Cycle: Refers to a process in plant metabolism where the enzyme RuBisCO oxygenates RuBP.

Phytoplankton: Photosynthetic small organisms that drift, float, or weakly swim in aquatic habitats.

Potassium Permanganate: A purple colored crystalline solid, used to deactivate rotenone.

Rotenolone: Less toxic byproduct of rotenone produced via oxidation.

Rotenone: A toxic crystalline substance obtained from the roots of derris and related plants, widely used as an insecticide and piscicide.

Salmonid: Belonging or pertaining to the family Salmonidae, including the salmons, trouts, chars, and white fishes.

Scope of Activity: Active metabolism-standard metabolism. The maximum amount of energy that can be used for metabolic activity.

Standard Metabolism: The minimum amount of metabolic activity required to sustain an organism at a specified temperature.

Terrane: A fault-bounded area or region with a distinctive stratigraphy, structure, and geological history.

Thermocline: A steep temperature gradient in a body of water such as a lake, marked by a layer above and below which the water is at different temperatures.

Threatened: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

YY Brook Trout Male: Brook trout raised in hatcheries feminized with hormone exposure via diet.

Zooplankton: Heterotrophic plankton consisting of small animals, and the immature stages of larger animals.

Abbreviations

ADFG: Alaska Department of Fish and Game

ANP's: Artificial Nesting Platforms

CRUIP: Coastal Recovery Unit Implementation Plan

ESA: Endangered Species Act

IOC: Index of Connectivity

IDFG: Idaho Department of Fish and Game

MRA: Minimum Requirements Analysis

NOCA: North Cascades National Park

NEPA: National Environmental Policy Act

NPS: National Park Service

NRCS: Natural Resources Conservation Service

RCW: Revised Code of Washington

SEPA: State Environmental Policy Act

USFWS: United States Fish and Wildlife Service

USGS: United States Geological Survey

WAC: Washington Administrative Code

WDFW: Washington Department of Fish and Wildlife

SECTION TWO: IMPACTS TO THE NATURAL ENVIRONMENT

The following section will describe the existing conditions of the natural environmental elements of Hozomeen Lake. For each element, there will be a discussion of the implications of the proposed action, the alternative action, and the no action alternative.

2.1: EARTH

2.1.1: Geology

Existing Conditions

The North Cascades mountain range is a small portion of the American Cordillera. Deep ocean sediments, basaltic ocean floor, pieces of old continents, submarine fans, and deep subcrustal mantle of the earth are the source of rocks and minerals around the Hozomeen Lake area (USGS 2016). Glacial deposits surround Hozomeen Lake with crops of dark green volcanic terrane, composed of biotite and hornblende, scattered throughout the landscape (Haugerud 1999). Chert and related sedimentary rocks are also present in isolated areas around the vicinity of Hozomeen Lake. Hozomeen Lake was glacially carved and the nearby peaks of Hozomeen mountain and two cairns directly adjacent to the lake contain large amount of schist, phyllite, and gabbro (Figure 2.1.1) (Staatz et al. 2006).

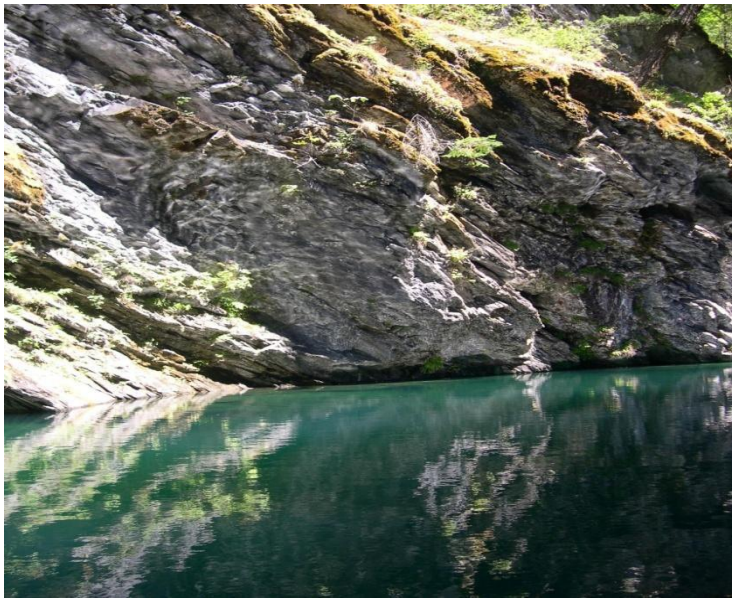


Figure 2.1.1 Common geology of the Hozomeen Lake area including gneiss, granite, andesite, and mica schist rock types.

Effects of Proposed Action

Removing eastern brook trout from Hozomeen Lake would have no long-term or short-term effects on the geology of the Hozomeen Lake area. Transportation of equipment and personnel into the Hozomeen Lake area would have a negligible effect on the geology of the surrounding landscape. Neither rotenone nor potassium permanganate will interact with substrate in Hozomeen Lake or Hozomeen Creek and are thus not expected to have any effect on the geology of the area.

Effects of Alternative Action

Removing the eastern brook trout from Hozomeen Lake with tiger muskellunge would have no effect on the geology of the area. Transportation of equipment and crews into and out of Hozomeen Lake would have no long-term effect on the geology.

Effects of No Action Alternative

The no action alternative would have no effect on the geology of Hozomeen Lake because the trophic web that eastern brook trout have altered is not a driving factor of the geology of Hozomeen Lake.

2.1.2: Soils

Existing Conditions

Multiple combinations of soil types exist throughout the Hozomeen Lake area (Figure 2.1.2). All types are characterized by a surface layer of decaying organic matter, underlain by layers of well-drained material (NRCS Web Soil Survey 2017). The soil beneath the lake is likely similar in character to the surrounding soil types but low dissolved oxygen levels and cooler temperatures will decrease decomposition rates of internal and external inputs, promoting higher levels of organic material.

Map Unit Symbol	Map Unit Names	Depth to Restrictive Feature	Dominant Profile Texture	Natural Drainage Class
6014	Thornton-Ragged-Ledeir complex, 15-65% slopes	>80 in	Gravelly sandy loam	Well-drained
6015	Tricouni-Ragged-Easy complex, 5-50% slopes	>80 in	Gravelly sandy loam	Well-drained
7003	Damnation-Ragged-Rock outcrop complex, 35-100% slopes	10-20 in to lithic bedrock	Cobbly ashy sandy loam	Well-drained
7015	Thornton-Ragged-Damnation complex, 35-100% slopes	>80 in	Gravelly sandy loam	Well-drained
8009	Chilliwack-Perfect-Terror complex, 15-65% slopes	>80 in	Gravelly sandy loam	Well-drained
9999	Water	N/A	N/A	N/A

Table 2.1.2. Soil types surrounding the Hozomeen Lake area as listed on the NRCS Soil Survey (2017).

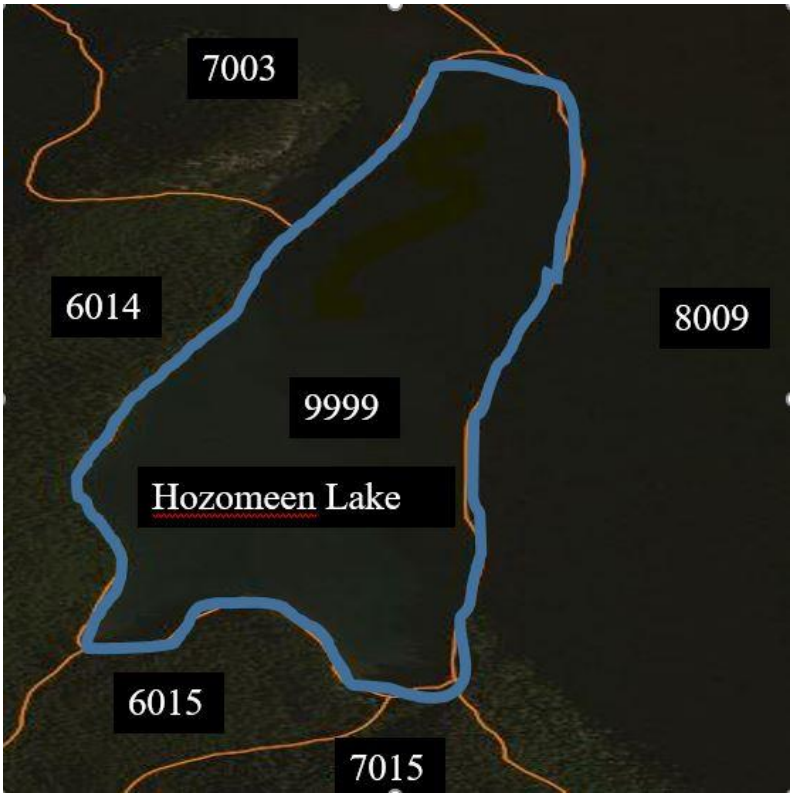


Figure 2.1.2 Map of Hozomeen Lake showing boundaries of soil types. Information on map unit symbols can be found in Table 2.1.2.

Effects of Proposed Action

The soil types surrounding Hozomeen Lake are characterized by an upper layer of decomposing organic matter, underlain by well-drained material (NRCS Web Soil Survey 2017). Highly permeable soils have the potential to promote rotenone infiltration into the underlying soil, but penetration would not exceed more than three inches (Hisata 2002). Rotenone easily binds to sediments and naturally degrades at a rate that would prevent lateral movement in the water table due to several factors. Temperature, sunlight, and organic matter influence the detoxification rate of rotenone. Rotenone degrades more quickly under warmer, high-sunlight conditions. Furthermore, the organic surface layer will contribute to degradation as research has found rotenone to break down more readily in organic-rich sediments than mineral soils (Cavoski et al. 2007). The sediments in the deeper areas of Hozomeen Lake would likely detoxify at a slower rate than shallower areas such as those within the littoral zone. However, the half life of rotenone in soils without sunlight exposure is about 8 days in 20°C water and 25 days at 10°C (Cavoski et al. 2008). Lastly, rotenone is not expected to impact soil microorganisms. Overall, the effects of rotenone application on soils will be negligible and short-term.

Effects of Alternative Action

Introducing tiger muskellunge to Hozomeen Lake will not adversely impact the surrounding or underlying soils because of the minimal interaction the between tiger muskellunge and the soils of Hozomeen Lake and Hozomeen Creek.

Effects of No Action Alternative

The soils beneath Hozomeen Lake and Hozomeen Creek would not be adversely affected by the persistence of eastern brook trout.

2.1.3: Topography

Existing Conditions

Hozomeen Lake is a low elevation mountain lake. Resting at 2873 feet above sea level, it offers accessibility to recreationists and NOCA employees for extended periods of the year, because it is one of the last mountain lakes to accumulate snow. Hozomeen Lake has multiple trailheads with well-maintained trails. Relatively easy accessibility serves to make eastern brook trout eradication from Hozomeen Lake a feasible project. The trailhead from the north-eastern bank of Ross Lake has a 1000-foot elevation gain over four miles. A twenty mile access trail begins at the southern portion of the lake.

Figure 2.1.3. Topographic map of Hozomeen Lake (Topozone 2017).

Effects of Proposed Action

Equipment used for baseline data collection, eastern brook trout removal, and post-treatment surveying equipment can easily be transported via hand crew and helicopter. Watercraft and rotenone application equipment will need to be transported to Hozomeen Lake, but transportation of the equipment to Hozomeen Lake will have no effect on the topography. Crews accessing Hozomeen Lake by foot will have little effect on topography because well-maintained trails are already established, and increased foot traffic during the end of the visitor season would do little to promote wear or erosion that could change topographic conditions around Hozomeen Lake.

Effects of Alternative Action

Transportation of tiger muskellunge for stocking Hozomeen Lake can occur either via hauling fish in backpacks or in containers in a helicopter. Access to Hozomeen Lake via boat transportation on Ross Lake, Silver Skagit Road from Ross Lake Campground in British Columbia, or hiking from Hozomeen trailhead, presents a low-cost alternative to using a helicopter for stocking. Stocking of tiger muskellunge, regardless of technique, will have a negligible effect on topography.

No Action Alternative

The no action alternative would have no effect on Hozomeen Lake topography or surrounding topography. The no alternative action will neither decrease or increase activity around the lake and any changes in topography around the lake will occur naturally or be due to recreational use of the Hozomeen area.

2.1.4: Unique Physical Features

Existing Conditions

With an elevation below 3,000 feet, Hozomeen Lake is a relatively low mountain lake when compared to other North Cascades lakes. The low elevation of Hozomeen Lake helps to promote a moderate level of productivity, relative to low productivity often exhibited by higher elevation lakes. The low elevation also helps to create a high diversity of aquatic and terrestrial organisms.

Effects of Proposed Action

Rotenone application and subsequent eastern brook trout eradication will have no effect on unique physical features of Hozomeen Lake. Eradication of eastern brook trout may cause an increase of nutrients that could alter the productivity of Hozomeen Lake. However, the long-term unique physical feature that is Hozomeen Lake itself will not be significantly impacted by the removal of eastern brook trout.

Effects of Alternative Action

Introduction of tiger muskellunge into Hozomeen Lake will have no effect on unique physical features of Hozomeen Lake. Tiger muskellunge presence will not promote an increase or decrease in productivity.

Effects of No Action Alternative

The no action alternative will have no effect on the unique physical features of Hozomeen lake.

2.1.5: Erosion/Accretion of the Land

Existing Conditions

Landslides are not common surrounding Hozomeen Lake and erosion is primarily aeolian and gravity driven. The mostly-intact forested area encompassing Hozomeen Lake helps to insure direct erosion into the lake is minimal.

Effects of Proposed Action

Rotenone application and resulting eastern brook trout eradication will have no effect on erosion and accretion of the land surrounding Hozomeen Lake.

Effects of Alternative Action

The introduction of tiger muskellunge will have no impact on erosion and accretion around Hozomeen Lake.

Effect of No Action Alternative

The no action alternative will have no effect on the erosion and accretion of land around Hozomeen Lake.

2.2 AIR

2.2.1: Air Quality

Existing Conditions

The National Park Service works closely with USGS to monitor pollutants and assess their impacts on the ecosystem. The entirety of the North Cascades National Park is designated, by U.S. Congress, as a Class I area under the Clean Air Act Amendments of 1977. A Class I designation provides the maximum amount of air quality protection afforded by the Federal government. In NCNP windborne pollutants from the urbanized areas surrounding Puget Sound are transported by prevailing westerly winds and deposited in NOCA as they move up and over the mountains. Particulate matter, ozone, acid deposition, mercury and pesticides have all been detected in NOCA. The data acquired from monitoring these pollutants and the assessments of are used to inform strategies for NOCA management.

Air Quality Indicator	Specific Measure	Condition Status/Trend*
Ozone	Human Health: Annual 4th-highest 8hr concentration	
	Vegetation Health: 3-month maximum 12hr W126	
Visibility	Haze Index§	
Nitrogen	Wet Deposition	
Sulfur	Wet Deposition	

Condition Status		Trend		Confidence in Assessment	
	Indicator is in Good Condition		Improving		High
	Warrants Moderate Concern		Unchanging		Medium
	Warrants Significant Concern		Deteriorating		Low

Table 2.2.1 Air Quality Summary for 2015 from the National Park Service for North Cascades National Park. (Data from IMPROVE Monitor ID: NOCA1, WA and NADP Monitor ID: WA19, WA. Human health concentration ranked 4th highest out of all monitored NPS locations.)

Effect of Proposed Action

The proposed action would not emit airborne pollutants to the surrounding areas since the liquid application of rotenone occurs below the surface of Hozomeen Lake.

Effect of Alternative Action

Introducing tiger muskellunge to Hozomeen Lake will not have an adverse impact on the air quality surrounding Hozomeen Lake.

Effect of No Action Alternative

Air quality surrounding Hozomeen Lake will not be adversely impacted by the continued presence of eastern brook trout.

2.2.2: Odor

Existing Conditions

Due to the isolated location of Hozomeen Lake, odors from industry, agriculture, and urban areas are nonexistent. Odors that are uncharacteristic of wilderness environments, i.e. unnatural odors, do not occur at, or near, Hozomeen Lake.

Effects of Proposed Action

The odor from the solvents in liquid rotenone products could last from several hours to several days, depending on air conditions (ADFG 2011). However, the CFT Legumine™ formulation contains less of these odor causing solvents, and have no adverse health effects (Alaska Department of Fish and Game 2011). Rotenone application would not occur until the end of the visitor season, and the lake would be closed to recreationists. The crews administering the application will be wearing full protective equipment, including respirators. The minimal odor created would not have an adverse long-term impact.

The decaying bodies of treated fish could create a pungent odor; however, treated fish that do not naturally sink will have their air bladders punctured so they will sink to the bottom of Hozomeen Lake. Typically, odors of decay emitted by submerged fish are not detectable, but if so, would be short-term during the visitor offseason.

Effect of Alternative Action

Introduction of tiger muskellunge will have no adverse effect on the odor of Hozomeen Lake.

Effect of No Action Alternative

Persistent eastern brook trout populations will have no adverse effect on the odor of Hozomeen Lake.

2.2.3: Climate

Existing Conditions

Hozomeen Lake is isolated from industry, agriculture, and urbanization, but it is likely sensitive to changes in atmospheric temperature and precipitation, especially due to its lower elevation. Mountain lakes have more stable temperature regimes and experience less disturbance events than adjacent mountain streams (Roberts et al. 2015). Projected increasing temperature regimes will cause shifts in abiotic characteristics in mountain lakes and streams that will produce higher turbidity, higher surface temperatures, and

more deep coldwater fish refuge. Shifts in abiotic conditions may change plankton populations and alter mountain lake food web dynamics (Roberts et al. 2015). Changes in mountain lake ecology may serve to promote eastern brook trout reproduction. Increased temperatures will increase the scope of activity for eastern brook trout. An increase in the scope of activity for eastern brook will allow longer feeding periods and result in larger growth. Increased turbidity, although correlated with increased surface temperatures, will create deep water thermal refuges (Roberts et al. 2015). Although these deep water refuges may lack oxygen, they will serve to protect eastern brook trout from potential predators and changing thermal regimes in surface waters (Roberts et al. 2015).

Effects of Proposed Action

Eradication of eastern brook trout from Hozomeen Lake will not impose a significant effect on the climate. Removal of the eastern brook trout population from Hozomeen Lake will reduce predation of native fish and amphibian species. Potential hybridization between eastern brook trout and bull trout within North Cascades National Park will greatly decrease with removal of eastern brook trout. Although no native fish are present within Hozomeen Lake or Hozomeen Creek, the population of eastern brook trout serve as a major source population for Ross Lake. Decreased predation of and hybridization with native species will help to reduce suppression of native amphibian and bull trout populations that may be adversely affected by climate change.

Effect of Alternative Action

Introduction of tiger muskellunge in Hozomeen Lake is not expected to impose any changes to climate. Eradication of eastern brook trout from Hozomeen Lake via tiger muskellunge predation will require more intensive management and monitoring for a longer period to accomplish the same results of rotenone treatment.

Effect of No Action Alternative

The the continued presence of dense reproducing eastern brook trout populations within Hozomeen Lake will not have an effect on the climate.

2.3 WATER

2.3.1: Surface Water

Existing Conditions

Hozomeen Lake is a sub-alpine mountain lake 97.4 acres in surface area with a maximum depth of ~67 feet. Hozomeen Lake is fed by snowmelt from the North Cascades that has exhibited a recent warming trend (Figure 2.3.1) and is situated at a

lower elevation than the majority of the mountain lakes of the North Cascades Complex. The lower elevation results in a relatively longer growing season and warmer average temperatures which contributes to increased biological productivity and a mesotrophic status (Robert Wasem, Aquatic Ecologist, NOCA, unpublished data). Most high-elevation mountain lakes are oligotrophic and the mesotrophic status of Hozomeen Lake requires a unique management strategy. A mesotrophic status implies that nutrients for aquatic primary production are neither scarce nor overly concentrated, likely supporting an abundant but not excessive phytoplankton community. Phytoplankton are microscopic floating plants that make up the base of the aquatic food web.

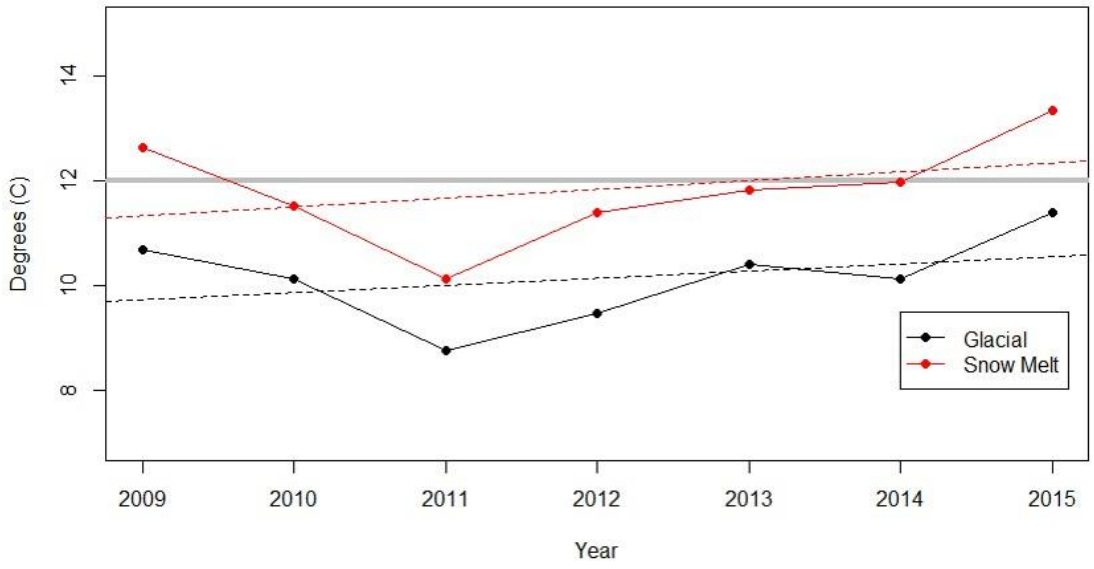


Figure 2.3.1. Mean stream temperatures of glacially and snowmelt sourced Ross Lake tributaries indicating a warming trend (Ashley Rawhouser).

Effects of Proposed Action

Application of rotenone will cause significant short-term water quality impacts to the water of Hozomeen Lake. Before treatment, the physical, biological, and chemical properties of the lake will be monitored according to standard operating procedures as written by Finlayson et al. (2010). The baseline monitoring accomplished prior to the treatment will establish strategies for the timing and dosage of rotenone.

With a median epilimnetic temperature of 17.4°C, Hozomeen Lake may become thermally stratified during the summer season, preventing mixing between the top and bottom layers of the lake (WDFW 2005). If Hozomeen Lake is thermally stratified, a thermocline will be detected during pretreatment monitoring, and stratification will be considered when determining the treatment timing and application methods.

Bathymetry, or underwater topography, may influence the effectiveness of rotenone treatment in lakes. Due to bathymetry, the impacts of rotenone on water quality may not be homogeneous across the lake area.

Pre-treatment assessments in the form of an on-site bioassay, will determine if certain sections should require higher concentrations of the toxicant in an attempt to ensure even distribution and maximum effectiveness.

Despite imposing significant impacts to surface water quality immediately following application, rotenone is short-lived and naturally degrades in water bodies through hydrolysis, photolysis, microbial breakdown, and even physical breakdown through extreme water aeration (EPA 2007). Degradation occurs faster at warmer temperatures as research has found rotenone to decay more than 5 times faster at 23°C than at 1°C (Gilderhus et al. 1986). The half life of rotenone at 15°C is 1.8 days, which is approximately the expected temperature of Hozomeen Lake during treatment (Dawson et al. 1991). The exact water temperature during application will have a strong influence on degradation rates.

Reducing the toxicity of rotenone after application can also occur through dilution by fresh water or deactivation by applying potassium permanganate. There are two small streams acting as a source of fresh water for Hozomeen Lake. These freshwater inputs may serve to dilute Hozomeen Lake during the treatment period, but detoxification will occur primarily through the natural degradation process. Rotenone degradation depends on temperature, pH, conductivity, and exposure to organic matter and sunlight. Rotenone application typically reaches undetectable levels within 2 to 4 weeks in water bodies at 15°C (Dawson et al. 1991).

Rotenone degradation produces a variety of byproducts, including rotenolone, which is also toxic (Cheng et al. 1972). Although rotenolone does not degrade as quickly as rotenone, it is only 10% as toxic as rotenone (CDFG 1991). Rotenolone may persist in low concentrations for several weeks after rotenone application but are not expected to be high enough to adversely impact the surface water of Hozomeen Lake.

Certain concentrations of rotenone pose substantial threats to downstream nontarget organisms during application, so potassium permanganate will be applied to deactivate the rotenone. The details of potassium permanganate application will be determined by personnel assigned to monitor for the presence of rotenone following standard operating procedures (Finlayson et al. 2010). Potassium permanganate is an oxidizing agent that reacts to deactivate rotenone and eliminates the toxicity within 30 minutes of contact. While potassium permanganate itself is toxic to gilled organisms at low concentrations, decreasing concentrations of potassium permanganate during the reaction results in the release of potassium ions and manganese dioxide. Manganese dioxide is a naturally-occurring mineral compound that does not readily dissolve in water and is not available for biological assimilation. If the use of potassium permanganate is required, the water

quality of Hozomeen Lake will not be significantly impacted in the long-term.

The long-term implications of rotenone application to the water quality of Hozomeen Lake are difficult to predict and could follow multiple pathways. Hozomeen Lake may experience a decline in water clarity due to phytoplankton blooms that may result from a release from zooplankton predation following rotenone treatment. Because zooplankton are highly sensitive to rotenone toxicity, zooplankton populations are expected to experience short-term declines in response to rotenone exposure (Almquist 1959). A detailed discussion of the implications of rotenone on zooplankton assemblages can be found in section 2.4.4. Furthermore, phytoplankton respond strongly to increased nutrient inputs, especially phosphorus, which is limiting in freshwater systems. Decaying eastern brook trout carcasses in the lake may act as a source of phosphorus to phytoplankton, further enhancing primary productivity (Fisher-Wold and Hershey 1999). Phytoplankton blooms can pose a substantial threat to water quality by impairing water clarity and by decreasing dissolved oxygen that can arise from the breakdown of dead phytoplankton (Carvalho et al. 2013). However, studies have indicated that nutrients released from decaying fish carcasses were readily taken up by periphyton, benthic macroinvertebrates, and other fish (Claeson et al. 2006). The assimilation of nutrients by periphyton and aquatic invertebrates may buffer the impact of eastern brook trout carcass nutrients on phytoplankton.

Effects of Alternative Action

The stocking of tiger muskellunge would likely not impact the water quality of Hozomeen Lake.

Effects of No Action Alternative

The existing water quality of Hozomeen Lake will not be changed by the continued presence of eastern brook trout .

2.3.2: Runoff/Absorption

Existing Conditions

Hozomeen Lake drains into the northeast portion of Ross Lake via Hozomeen Creek. No data for the runoff or absorption properties of Hozomeen Creek were available at the time of completion of this report.

Effect of Proposed Action

The application of rotenone will not have an impact on runoff or absorption of

precipitation on areas surrounding Hozomeen Lake.

Effects of Alternative Action

Introducing tiger muskellunge to Hozomeen Lake will not have an adverse impact on runoff/absorption surrounding Hozomeen Lake.

Effects of No Action Alternative

Runoff/absorption surrounding Hozomeen Lake will not be impacted by the continued presence of eastern brook trout.

2.3.3: Floods

Existing Conditions

While the input streams to Hozomeen Lake are subject to perennial flash flooding, the lake itself is not prone to flooding (North Cascades National Park Service Complex 2013). Hozomeen Creek and other output streams are not subject to flooding.

Effect of Proposed Action

The application of rotenone will not have an impact on frequency or severity of flooding of the lake, or its outlet.

Effects of Alternative Action

Introducing tiger muskellunge to Hozomeen Lake will not have an impact on flooding surrounding Hozomeen Lake.

Effects of No Action Alternative

Flooding surrounding Hozomeen Lake will not be impacted by the continued presence of eastern brook trout.

2.3.4: Groundwater

Existing Conditions

Groundwater and shallow subsurface flows are important contributions to the habitat of bull trout and other aquatic species in the area. The volume and quality of cold water input from these sources is considered a primary element of critical habitat for bull trout (FWS 2005).

Effect of Proposed Action

The soil types surrounding Hozomeen Lake are well drained (NRCS Web Soil Survey 2016). Infiltration would likely not exceed three inches, and rotenone would readily bind to vegetation and sediments (Dawson et al. 1991). Rotenone naturally degrades at a rate that would prevent rotenone from moving laterally throughout the water table. The lack of rotenone infiltration into groundwater will prevent uptake of contaminated water by shoreline vegetation. The EPA does not expect rotenone applied to surface waters to reach ground water (US EPA 2007).

Effects of Alternative Action

Introducing tiger muskellunge to Hozomeen Lake will not have a significant impact on groundwater surrounding Hozomeen Lake.

Effects of No Action Alternative

Groundwater surrounding Hozomeen Lake will not be impacted by the continued presence of eastern brook trout .

2.3.5: Public Water Supplies

Existing Conditions

Drinking water for the Hozomeen Campground and Winnebago Flats Campground is sourced from Hozomeen Lake.

Effect of Proposed Action

Rotenone application will entail imposing unique chemical conditions to the aquatic environment of the lake in the short-term but these conditions will likely not affect the groundwater used as a public water supply. During the period of rotenone application, the public will be restricted from using Hozomeen Campground in accordance with EPA regulations, preventing withdrawals of rotenone-treated water and potential human consumption.

Effects of Alternative Action

The introduction of tiger muskellunge will not have a significant impact on public water supplies of Hozomeen Lake.

Effect of No Action Alternative

The continued existence of eastern brook trout in Hozomeen Lake will not affect public water sources.

2.4: PLANTS AND ANIMALS

Existing Conditions

General Overview

Hozomeen Lake is a mountain lake resting at just below 3,000 ft. Hozomeen Lake requires a unique management strategy due to its relatively low elevation, northern geographic location, and mesotrophic state as indicated by limnological testing. Mesotrophic lakes have low to moderate levels of nutrients and thus a limited biomass of phytoplankton for supporting heterotrophic aquatic organisms. The land surrounding Hozomeen Lake is 96% forested, composed of both conifers and deciduous trees, 3% meadow, and 2% talus. This combination of mixed forest, small areas of talus, and lack of meadows promotes the establishment of specific set of species. Connectivity of meadows and wetlands is a primary habitat need for a number of amphibian populations found within the park. The lack of meadows around Hozomeen Lake means that the area may harbor less amphibian diversity than other mountain lakes within NOCA (National Park Service Complex 2008). Introduction of highly competitive non-native aquatic organisms can serve to dramatically reduce populations of other organisms that rely on the specific habitat characteristics of Hozomeen Lake. Hozomeen Lake's outlet, Hozomeen Creek, drains into Ross Lake. A fifteen-foot waterfall barrier at the base of Hozomeen Creek allows downstream migration of fish into Ross Lake, but prevents fish upstream migration from Ross Lake to Hozomeen Lake. Eastern brook trout are a member of the salmoninae family, and their natural range includes Eastern Canada, Northern United States, Minnesota, and as farth south as Georgia. Brook trout can live and spawn in both streams and lakes. Eastern brook trout become sexually mature at the age of one, and early sexual maturity, coupled with various feeding tendencies, allows them to often outcompete rainbow and brown trout (E. Marci 2010). Eastern brook trout have an impact, ranging from minor to major, on a number of organisms living in or relying on Hozomeen Lake. Zooplankton, migrating waterfowl, resident bird species, macroinvertebrates, amphibians, and native fish are affected, to some degree, by the continued presence of eastern brook trout.

Due to the size and density of the reproducing eastern brook trout population, macroinvertebrate populations have been moderately impacted, and numbers of trichoptera (caddisflies), ephemeroptera (may flies), plecoptera (stoneflies), and diptera (midges) have been reduced below expected levels (National Park Service Complex 2008).

Even with a dense reproducing population of eastern brook trout, phytoplankton and zooplankton in Hozomeen Lake are still abundant due to favorable physical lake

characteristics.

Amphibian populations have been moderately reduced by dense reproducing populations of eastern brook trout. Although no native char or trout exist in Hozomeen Lake or Creek, reproducing eastern brook trout populations entering Ross Lake via Hozomeen Creek are having major impacts on native fish populations.

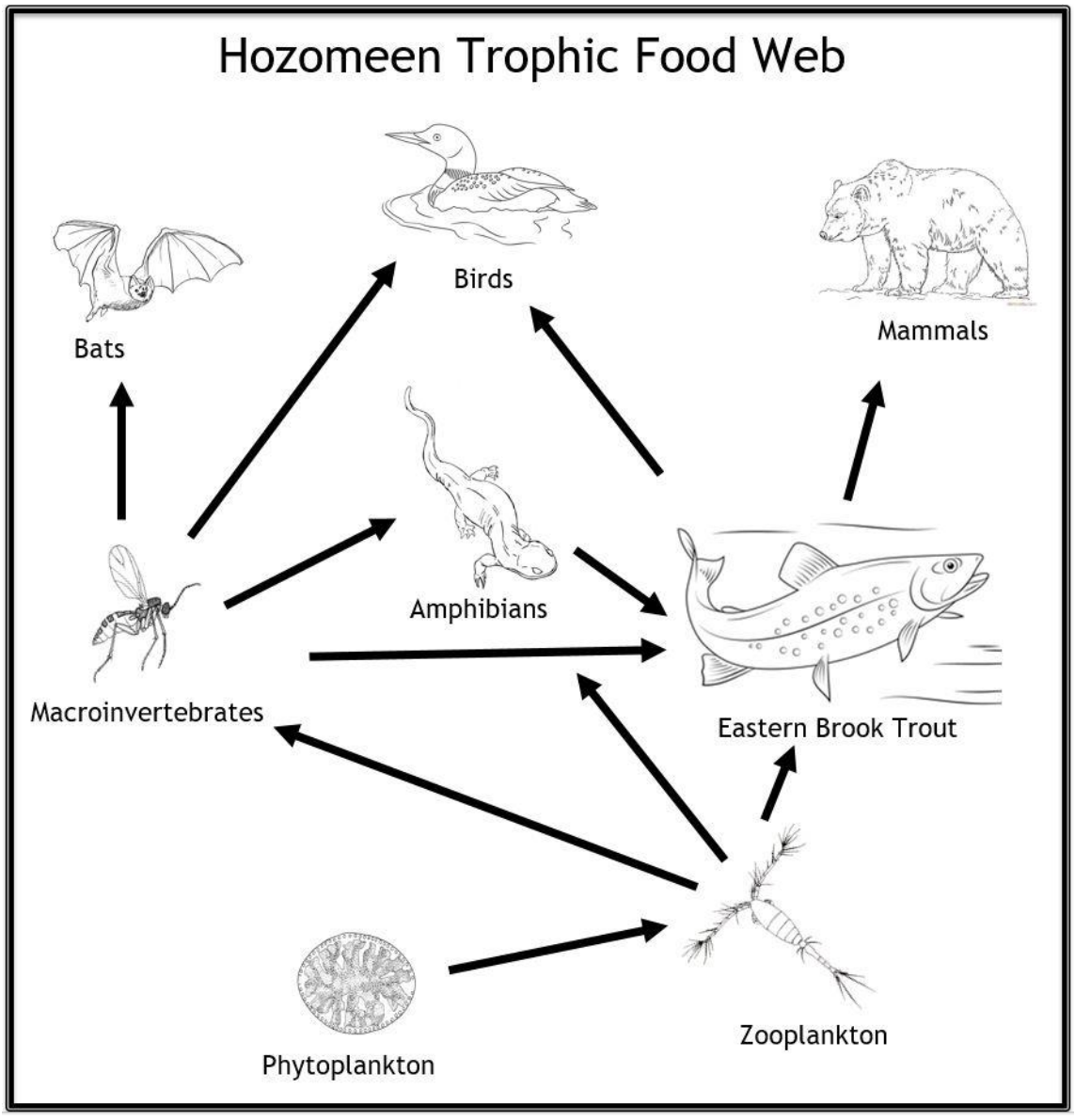


Figure 2.4. Existing trophic food web of Hozomeen Lake showing representative organisms relevant to the proposed action. Arrows represent direction of energy transfer.

2.4.1: Vegetation

Existing Conditions

Hozomeen Lake, and more generally, the expanse surrounding Ross Lake houses a wide diversity of native and nonnative vegetation. Over 1600 different native plant species have adapted to North Cascades habitats over thousands of years (National Park Service 2016). In vegetation surveys surrounding Ross Lake, infestations of the aggressive nonnative plant reed canary grass (*Phalaris arundinacea*) were identified. Reed canary grass thrives in wetland stream outlets with fluctuating water levels (National Park Service 2016). Bull trout and the cascades frog are directly affected by reed canary grass encroachment as it does not provide adequate habitats for aquatic animals. In the area within, and closely surrounding the North Cascades National Park, over 258 exotic plant species have been documented. The low elevation of Hozomeen Lake makes it more susceptible to invasive plant encroachment.

Effects of Proposed Action

While non-aquatic plants are likely to have no exposure to rotenone, various macrophytes within Hozomeen Lake have potential for direct contact. However, rotenone effects on plants are non-existent, because the chemical cannot enter the plant via respiratory pathways as it does in gill-breathing organisms.

Rotenone demonstrates limited vertical and horizontal migration through soils. Plants located at, or near the banks of the lake, are unlikely to absorb the chemical through their root systems (Dawson 1986). Empirical data suggests that mitochondria within photosynthetic tissues of plants contain rotenone-insensitive pathways during glycine oxidation, ensuring the continuous operation of the photorespiratory cycle (Ikuma and Bonner 1967). Studies involving similar respiratory inhibitors, such as antimycin A and cyanide, showed that complete inhibition does not occur, likely due to electron leakage (Ikuma and Bonner 1967). Even when directly exposed to rotenone, plant species have evolved protective barriers that prevent any significant damage.

Effects of Alternative Action

As a piscivorous fish, the introduction of tiger muskellunge will not have any significant impact on macrophytes throughout Hozomeen Lake.

Effects of No Action Alternative

Since eastern brook trout are insectivorous as juveniles and adults, their presence will not have any significant impact on macrophyte presence within Hozomeen Lake.

2.4.2: Birds and Mammals

Existing Conditions

Within the North Cascades, 75 mammal species in 21 families are found throughout the Park. The grizzly bear, the gray wolf, and the Canada lynx are currently listed as either Threatened or Endangered under the Federal Endangered Species Act (National Park Service 2016). Gray wolves were first sighted near Ross Lake in 1984, and Hozomeen Lake in 1991. Three distinct groups of adult wolves with pups represented the first known reproduction of wild wolves in Washington State in the last 50 years (National Park Service 2016). Other documented North Cascades resident species include cougar, bobcat, lynx, river otter, wolverine, and black bear (National Park Service 2016). Also inhabiting the North Cascades are twelve species of bats (further discussed in section 2.4.3), and although seldom seen, they inhabit mature forests such as those surrounding Hozomeen Lake. Hozomeen Campground is home to a large population of bats that draws annual visitors for viewing purposes. The most common ungulates in the North Cascades are mule deer followed by elk, moose, and mountain goats in order of abundance (National Park Service 2016). Rocky outcrops in the North Cascades National Park are commonly inhabited by the American pika and hoary marmots (Burde & Feldhamer 2005).

<u>Birds</u>

See the "Unique Species" section for an analysis of the potential impacts on Common Loon populations.

Effects of Proposed Action

Waterfowl and other mammals that may feed on the decaying corpses of eastern brook trout will be minimally affected by the rotenone treatment. Waterfowl and mammals are not affected by rotenone via ingestion due to enzymes in their stomachs and intestines that neutralize rotenone. Waterfowl demonstrate a higher sensitivity to rotenone than other birds, but in 2007 the EPA presented the following conclusion for birds:

> "Since rotenone is applied directly to water, there is little likelihood that terrestrial forage items for birds will contain rotenone residues from this use. While it is possible that some piscivorous birds may feed opportunistically on dead or dying fish located on the surface of treated waters, protocols for piscicidal use typically recommend that dead fish be collected and buried, rendering the fish less available for consumption."

The EPA also hypothesized the following situation to demonstrate the likelihood of waterfowl dying from rotenone poisoning

> "Whole body residues in fish killed with rotenone ranged from 0.22 µg/g in yellow perch (*Perca flavescens*) to 1.08 µg/g in common carp (*Cyprinus carpio*) (Jarvinen and Ankley 1998). For a 68 g yellow perch and an 88 g carp, this represents totals of 73 µg and 95 µg rotenone per fish, respectively. Based on the avian subacute dietary LC50 of 4110 mg/kg, a 1 kg bird would have to consume 56,300 perch or 43,000 small carp. Thus, it is unlikely that piscivorous birds will consume enough fish to result in a lethal dose."

The biggest concern with rotenone impact to waterfowl and other bird populations is not the potential for lethal dosage, but the decrease in amphibians and macroinvertebrates that may serve as a food source. Migratory birds will be impacted by the loss of food sources, but since they have the ability to migrate to other lakes in the area that offer feeding opportunities, the effects of a diminished food source at Hozomeen Lake will be minimal. Mitigation measures in the form of artificial nest platforms will be used to try and maintain current Hozomeen Lake waterfowl populations.

Standard procedure for rotenone application calls for the removal or burial of all treated fish. In addition to the physical removal of treated eastern brook trout , a majority of the eastern brook trout would also be dumped or sunk into the hypolimnion to decompose, further decreasing any potential risk to threatened migrating waterfowl or mammals that may have tried to fed on the rotenone treated fish.

Effects of Alternative Action

The introduction of tiger muskellunge to Hozomeen Lake will have no adverse effects on local mammals or migratory birds visiting Hozomeen Lake because mitigation techniques utilized in the proposed action will be used in an attempt to maintain migratory waterfowl populations. Tiger muskellunge could also become an additional source of nutrition for birds or mammal species attempting feed on eastern brook trout within Hozomeen Lake.

Effects of No Action Alternative

Local mammal populations will not be adversely impacted by the continued presence of eastern brook trout within Hozomeen Lake.

2.4.3: Bats

Existing Conditions

The most common species of bat at Hozomeen Lake is the long-eared bat (*Myotis*

septentrionalis), which makes up a majority of the bat population. Nesting occurs near Hozomeen Lake and campground, but not specifically at the lake (DeBruyn 2016). Long-eared bats are designated as a state Species of Concern due to a lack of knowledge about their reproduction and hibernation. Long-eared bats forage over water, but are not reliant strictly on aquatic macroinvertebrates as a food source. The primary component of long-eared bats diet has been identified via stomach analysis as species within the moth taxa (Alberdi et al 2012).

Proposed Action Impact

Although bats around Hozomeen Lake feed on emerging insects, they do not rely entirely on them. Insects in Hozomeen Lake have been reduced by eastern brook trout predation, but their reduction has had a minor effect on the bat population because the bats' primary diet is moths (Alberdi et al 2012). Continued suppression of insect populations within Hozomeen Lake will likely continue to have minor negative effects on bats. Rebounds in the macroinvertebrate numbers after rotenone treatment will likely have a positive effect on bat populations (Rawhouser pers comm 2017).

Effects of Alternative Action

The introduction of tiger muskellunge will reduce the eastern brook trout population. This will allow insect numbers to rebound from their currently suppressed sizes. A greater abundance of insects will have a positive effect on bat populations around Hozomeen Lake

No Action Alternative Action

Eastern brook trout presence will continue to suppress macroinvertebrate numbers below carrying capacity in Hozomeen Lake. The suppression of macroinvertebrates will have a minor or negligible effect on bat population around Hozomeen Lake.

2.4.4: Zooplankton

Existing Conditions

Hozomeen Lake likely supports an abundant and diverse community of zooplankton, but baseline monitoring done prior to rotenone treatment will allow more comprehensive analysis of the zooplankton populations within the lake.

Effects of Proposed Action

Zooplankton are highly sensitive to rotenone toxicity. Prior research has found

zooplankton abundance and diversity to significantly decrease in response to rotenone treatments. For example, most of or all zooplankton were killed with exposure to a 0.5 ppm concentration of rotenone (Brown and Ball 1943, Kiser et al. 1963). Significant short-term reductions to the zooplankton of Hozomeen Lake and Hozomeen Creek can be expected as a result of rotenone application. Due to the complexity of ecosystems, the response of the aquatic and riparian food web to zooplankton decreases cannot be predicted with much assurance. Decreased zooplankton abundance has the potential to initiate a phytoplankton bloom because of reduced herbivory. This could enhance the productivity of macroinvertebrate populations such as mayfly nymphs that feed on phytoplankton (eg. diatoms and other algae). However, macroinvertebrates are also susceptible to rotenone exposure and thus, the overall effect of the proposed action to macroinvertebrate assemblages may be negative. See section 2.4.5 for a further discussion of macroinvertebrate responses to rotenone treatment.

Furthermore, zooplankton depletions may adversely impact the status of amphibians such as the long-toed salamander (*Ambystoma macrodactylum)* whose larvae feed on the zooplankton groups of cladocerans and copepods (Anderson 1968). As with macroinvertebrates, the implications of rotenone application for amphibians at Hozomeen Lake are complicated by potential changes to other trophic levels and further explored in section 2.4.7.

Despite significant reductions in zooplankton abundance and diversity following rotenone application, recovery within a few months is anticipated. Even after complete elimination, zooplankton have been found to recover quickly in pond and lake ecosystems, but cladocerans generally recover more slowly than copepods. One study observed all 42 species present before rotenone application had recovered after 5 months (Kiser et al. 1963). The timing of zooplankton recovery is variable, but studies have reported zooplankton abundance to typically reestablish within a few months to a few years after rotenone treatment (Brown and Ball 1943, Kiser et al. 1963, Anderson 1970). In sum, the effects of rotenone treatment on zooplankton in Hozomeen Lake are likely to be species-dependent, moderate to significant in the short-term (months to ~3 years after second treatment), and insignificant in the long-term.

Effects of Alternative Action

Because tiger muskellunge feed on other fish, the introduction of tiger muskellunge to Hozomeen Lake will likely impose no direct effect on zooplankton populations.

Effects of No Action Alternative

Zooplankton populations would not be significantly altered by the persistence of eastern brook trout within Hozomeen Lake.

2.4.5: Macroinvertebrates

Existing Conditions

In freshwater ecosystems, macroinvertebrates serve important functions and are highly diverse having evolved from many phyla over millions of years (Covich et al. 1999). These species are an integral part of freshwater food webs as they support many amphibian and fish species while performing other ecosystem functions. For example, particular benthic species are important for organic matter processing in freshwater ecosystems and may enhance overall primary productivity of lake ecosystems by helping release biologically available nutrients to macrophytes and algae (Palmer et al. 1997, Covich et al. 1999).

Hozomeen Lake, Hozomeen Creek, and the surrounding riparian zone likely support a diverse macroinvertebrate community due to the warmer temperature and increased productivity of Hozomeen Lake when compared to the higher elevation lakes found in NOCA. The macroinvertebrate species composition of the habitats around and within Hozomeen Lake and Hozomeen Creek is currently undocumented but resident species likely include: true flies (Diptera), dragonflies and damselflies (Odonata), caddisflies (Trichoptera), stoneflies (Plecoptera), mayflies (Ephemeroptera), snails and slugs (Gastropoda), segmented worms (Oligochaeta), unsegmented worms (Nematoda), flatworms (Turbellaria), scuds and sandhoppers (Amphipods), woodlice (Isopoda), and beetles (Coleoptera) based on findings from sampling in NOCA by Liss et al (1995). Some invertebrates, such as snails and worms, dwell in benthic sediments within the lake while others inhabit the littoral zone. Many species use the shoreline vegetation as breeding and rearing habitat while some species only spend their larval stages in lake ecosystems.

Aquatic macroinvertebrates are eaten by eastern brook trout and thus numbers of some species are likely reduced due to the presence of eastern brook trout in Hozomeen Lake and Hozomeen Creek.

Effects of Proposed Action

The application of rotenone at Hozomeen Lake and Hozomeen Creek is expected to significantly decrease the abundance and diversity of aquatic macroinvertebrates due to their sensitivity to rotenone toxicity, especially in their larval stages. Several studies have documented notable declines in both species diversity and overall abundance of macroinvertebrates in lake and stream systems (Brown and Ball 1943, Almquist 1959, Darby et al. 2004, Mangum and Madrigal 1999, Koksvik and Aagaard 1984). The toxicity of rotenone to macroinvertebrates varies depending on species, exposure duration, and environmental conditions. Several studies found benthic organisms to be

negatively affected by 0.5 ppm rotenone (Brown and Ball 1943, Almquist 1959) while Koksvik and Aagaard (1984) only detected significant impacts to lake flies/non-biting midges (Chironomidae). Rotenone is most lethal to gill-breathing invertebrates such as mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera), hereafter "EPT", which have experienced large population declines after rotenone treatments (Darby et al. 2004, Mangum and Madrigal 1999).

Despite the toxicity of rotenone to macroinvertebrates, recovery of species abundance and diversity is commonly observed. Mangum and Madrigal (1999) found a third of benthic invertebrate taxa to be resistant to rotenone. Almost half of the pre-treatment macroinvertebrates recovered within one year of rotenone application, but 21% of taxa were still absent 5 years after treatment. The toxicity of rotenone depends on the macroinvertebrate species as some are more tolerant than others (Table 2.4.5.a). Although recovery of macroinvertebrate densities is well documented, rotenone treatments have the potential to alter the dominant species in macroinvertebrate communities (Binns 1967, Whelan 2002).

The application of rotenone to Hozomeen Lake and Hozomeen Creek would initially suppress local macroinvertebrate populations, especially EPT species, but a subsequent recovery in total macroinvertebrate abundance is expected. Macroinvertebrate populations may even surpass pre-treatment levels due to reduced EBT predation. Several years after the treatments have taken place, many of the originally impacted species will reestablish populations similar to pretreatment levels while the overall macroinvertebrate species composition of benthic and littoral communities may be significantly different.

Table 2.4.5.a: Rotenone toxicity for various aquatic organisms. LC50 refers to the concentration of a substance in water that has a 50% chance of killing an organism and thus lower lethal concentrations and test endpoints correspond with higher species

sensitivity. (Ling, 2003).

Effects of Alternative Action

GROUP	SPECIES	TEST ENDPOINT	LETHAL CONCENTRATION	REFERENCE
Flatworm	*Catenula* sp.	LC50 24h	5.10 mg/L	1
	Planaria sp.	LC50 24h	< 0.500 mg/L	2
Annelid worms	Leech	LC50 48h	< 0.100 mg/L	2
Copepod	*Cyclops* sp.	LC100 72h	< 0.100 mg/L	5
Branchiura	*Argulus* sp.	LC50 24h	~ 0.025 mg/L	2
Cladoceran	*Daphnia pulex*	LC50 24h	0.027 mg/L	1
	Daphnia pulex	LC50 24h	< 0.025 mg/L	2
	Diaptomus siciloides	LC50 24h	< 0.025 mg/L	2
Ostracod	*Cypridopsis* sp.	LC50 24h	0.490 mg/L	1
Conchostracan	*Estheria* sp.	LC50 24h	~ 0.050 mg/L	2
Freshwater prawn	*Palaemonetes kadiakensis*	LC50 24h	5.15 mg/L	1
Crayfish	*Cambarus immunis*	LC50 72h	> 0.500 mg/L	2
Dragonfly naiad	*Macromia* sp.	LC50 24h	4.70 mg/L	1
Stonefly naiad	*Pteronarcys californica*	LC50 24h	2.90 mg/L	4
Backswimmer	*Notonecta* sp.	LC50 24h	3.42 mg/L	1
	Notonecta sp.	LC50 24h	~ 0.100 mg/L	2
Caddis fly larvae	*Hydropsyche* sp.	LC50 96h	0.605 mg/L	1
Whirligig beetle	*Gyrinus* sp.	LC50 24h	3.55 mg/L	1
Water mite	Hydrachnidae	LC50 96h	~ 0.050 mg/L	2
Snail	*Physa pomilia*	LC50 24h	6.35 mg/L	1
	Oxytrema catenaria	LC50 96h	1.75 mg/L	1
	Lymnaea stagnalis	LC50 96h	> 1.00 mg/L	2
Bivalve Mollusc	*Dreissena polymorpha*	LC50 48h	0.219 mg/L	3
	Obliquaria reflexa	LC50 48h	> 1.00 mg/L	3
	Elliptio buckleyi	LC50 96h	2.95 mg/L	1
	Elliptio complanata	LC50 96h	2.00 mg/L	1
	Corbicula manilensis	LC50 96h	7.50 mg/L	1

Refs: 1, Chandler 1982; 2, Hamilton 1941; 3, Waller et al. 1993; 4, Sanders & Cope 1968; 5, Meadows 1973.]

Macroinvertebrate populations may increase with the introduction of Tiger Muskellunge to Hozomeen Lake as a result of the removal of eastern brook trout and consequent reduction of predation.

Effects of No Action Alternative

With continued eastern brook trout predation, macroinvertebrate populations will likely maintain their current status.

2.4.6: Unique Species and Migratory Routes

Existing Conditions

Salvelinus confluentus

Salvelinus confluentus (Bull trout) is listed as "Threatened" under the Federal Endangered Species Act (ESA). Historically, bull trout had a geographic range

throughout Washington, Idaho, Oregon, California, and a limited presence in Nevada. Presently, bull trout are extinct in California, and populations in Washington, Idaho, Nevada, and Oregon are in major decline. Bull trout are the most thermally sensitive salmonid species in the Pacific Northwest, and by demonstrating a dependence on high quality habitat, the bull trout is an important indicator of stream condition. Increased stream temperatures from anthropogenic disturbances to the natural landscape, such as agriculture, deforestation, and climate change, threaten the existence of bull trout populations in lowland streams. Populations residing in higher elevation freshwater ecosystems on protected public lands have the advantage of existing outside the realm of negative effects caused by land use. The Upper Skagit Core Area contains a healthy population of bull trout and is one of four areas identified in the United States Fish and Wildlife Service (USFWS) Coastal Recovery Unit Implementation Plan (CRUIP) for bull trout. High quality habitat in the Upper Skagit Core Area has allowed large populations of bull trout to persist. Decades of stocking exotic fish species has put the Upper Skagit bull trout at risk. Introduction of eastern brook trout (*Salvelinus fontinalis*) has helped establish a reproducing population of eastern brook trout in Hozomeen Lake. The lake now has potential to serve as a source population to the entire Upper Skagit Area, which puts bull trout populations at increased risk of extirpation.

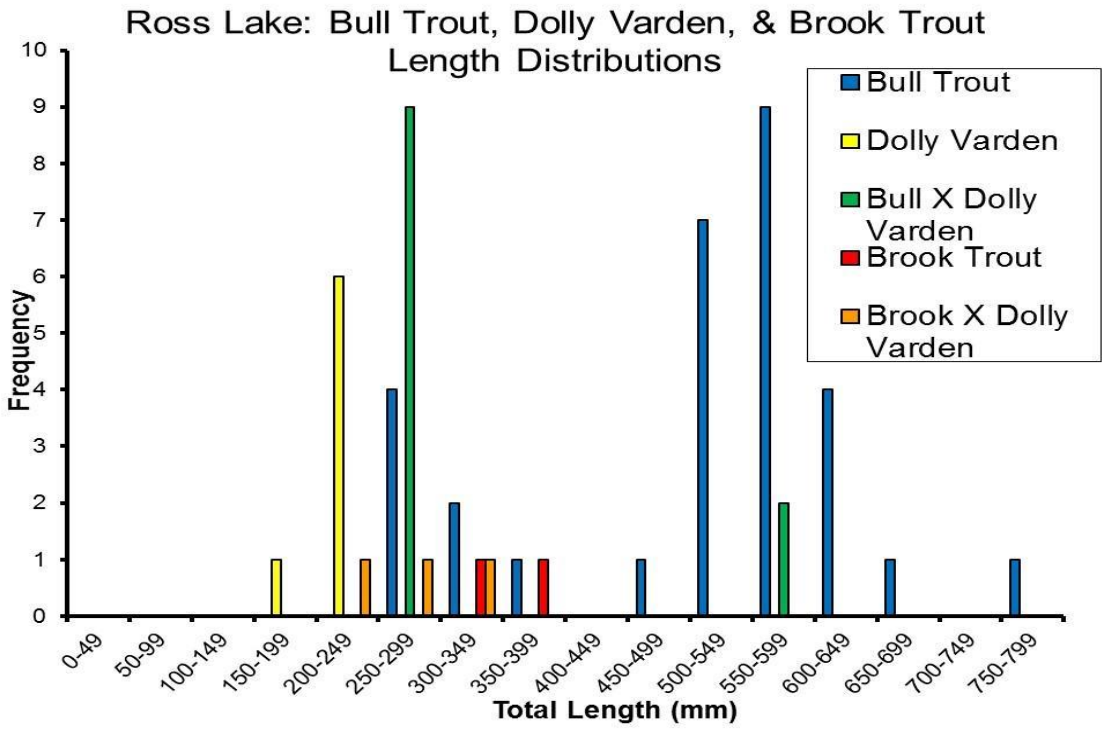
Figure 2.4.6.a. Bull trout and Dolly varden are Washington's native char. Genetic testing is the only way to definitively identify them.

Hybridization and Competition Between Chars

Bull trout and eastern brook trout are related species that evolved allopatrically, and are commonly observed hybridizing when inhabiting the same watershed. When the natural geographic ranges of the two species coincide, they are observed residing in different reaches of the same system, with bull trout occupying headwaters and eastern brook trout residing downstream (DeHann et al. 2009). When introduced into headwater lakes, eastern brook trout become more widely dispersed throughout the entire stream system, and their ability to hybridize and compete for resources with bull trout greatly increases (DeHaan et al. 2009). The greatest barriers to hybridization between bull trout and eastern brook trout are a difference in size of spawning adults and isolation between

spawning areas. Since eastern brook trout were introduced into Upper Skagit Area, they have established themselves in bull trout habitat, removing the spatial barrier to hybridization.

Bull trout are the larger of the two species, with a typical adult size of 500 to 600 mm compared to 250 to 350 mm for eastern brook trout (Raleigh 1982). Dolly varden, a native char closely related bull trout and eastern brook trout and similar in size to eastern brook trout has been documented to hybridize with both bull trout and eastern brook trout in the Ross Lake watershed (figure 2.4.6.b). Because eastern brook trout have a higher optimal temperature range than bull trout (Raleigh 1982), increased stream temperatures from climate change will allow increased eastern brook trout distribution and contact with bull trout. An increase in temperatures will also give eastern brook trout a metabolic advantage, which will continue to increase the existing trend of larger body sizes. Larger eastern brook trout size will favor hybridization with bull trout, and allow eastern brook trout to compete for spawning ground that was once dominated by bull trout. This could increase hybridization occurrence and decrease the bull trout's ability to spawn. Hybridized individuals in other parts of the United States have been found to be sterile, which makes determining the rate of hybridization difficult (Montana



Fish Wildlife & Parks N.D.).

Figure 2.4.6.b. Frequency and size range of char species and char species hybrids within Ross Lake (Ashley Rawhouser unpublished data 2008).

Gavia immer

The common loon, a member of the scientific order Gaviiformes, is a medium-distance migratory waterfowl with a summer breeding geographic range extending from northern Alaska to the northernmost extent of Washington, Montana, and Idaho. Isolated populations have been documented breeding in Yellowstone National Park and Shoshone National Forest (Evers et al. 2010). The common loon is an obligate piscivore. Habitat degradation over the last century has caused a major decline in common loon populations with breeding pairs disappearing completely from Indiana, Illinois, Ohio, Pennsylvania, and Connecticut (Tischler K. 2011). Common loon breeding pairs in the lower 48 states now make up less than 3% of all common loon breeding pairs in North America (Tischler K. 2011). Common loons are protected under the Migratory Bird Treaty Act, but they are not listed under the Endangered species Act, or considered a species of concern in Washington State by the United States Fish and Wildlife Service. Proposal to list the common loon as threatened under Washington state law began in the late 1980's, and the common loon is currently listed as a state sensitive species. Optimal common loon nesting habitat is wooded lakes with offshore hummocks and dense littoral plant populations, such as Hozomeen Lake. Hozomeen Lake is one of only twenty sites throughout Washington State where common loon nesting has been confirmed in the last thirty years. Eastern brook trout serve as a food source for common loons in Hozomeen Lake; therefore, the effects of eastern brook trout removal on the established common loon population must be considered.

Figure 2.4.6.c: Drawing of a Male Common Loon

Effects of Proposed Action

Bull Trout

Elimination of eastern brook trout via rotenone will protect the bull trout in the Upper Skagit Core Area and meet suggestions made in the CRUIP. The primary concern with rotenone application is native fish mortality. This is unlikely because no native fish live in Hozomeen Lake or Creek. A number of mitigation techniques will ensure that no accidental mortality of native fish occurs. Rotenone naturally degrades, and the rate is highly dependent on temperature and pH. To ensure that the rotenone has been administered at the appropriate concentration and stays within the treatment zone, cages containing the target fish will be placed in various depths throughout the lake and downstream of the treatment. These "sentinel fish" will be extensively monitored in order to enable response to changes in the rotenone movement and effectiveness. If downstream flow of rotenone is observed and seen to be a direct threat to native fish populations, potassium permanganate will be administered to neutralize the toxicity (U.S Fish and Wildlife Service 2010).

Common Loon

Although birds are susceptible to rotenone toxicity via fish consumption, the dosage required to intoxicate birds would require infeasible amounts of contaminated fish. Therefore, mortality via rotenone poisoning is of minor concern (EPA 2007). The discovery of common loons makes the removal of eastern brook trout, the primary food source at Hozomeen Lake, a possible negative impact of the proposed action. Although common loons feed on a variety of fish in Ross Lake and other nearby lakes, eastern brook trout in Hozomeen Lake likely serve as a food source for the nesting individuals. Abrupt eradication of eastern brook trout could cause nest abandonment by the common loons at Hozomeen Lake.

Mitigation

Mitigation of nest abandonment will be accomplished by the construction of artificial nesting platforms (ANPs) in Willow Lake and Ridley Lake. Common loon ANPs are simple and inexpensive to build (see figure 2.4.6.d). Willow and Ridley Lakes are heavily forested, with 77-100% forest cover around the lakes. Stocked native rainbow trout could serve as an additional food sources for nesting common loons if nest abandonment occurred at Hozomeen Lake. Studies have found that when displacement occurs, common loons are most likely to establish new nests in lakes short distances away, typically between 4 and 21 km from the area of nest abandonment (Tischler 2011). Willow and Ridley Lakes fall within the range of potential reestablishment. Ross Lake is also well suited for nesting sites for common loons, but mitigation efforts will need to be explored to address changing water levels that could displace or damage ANPs or cause abandonment.

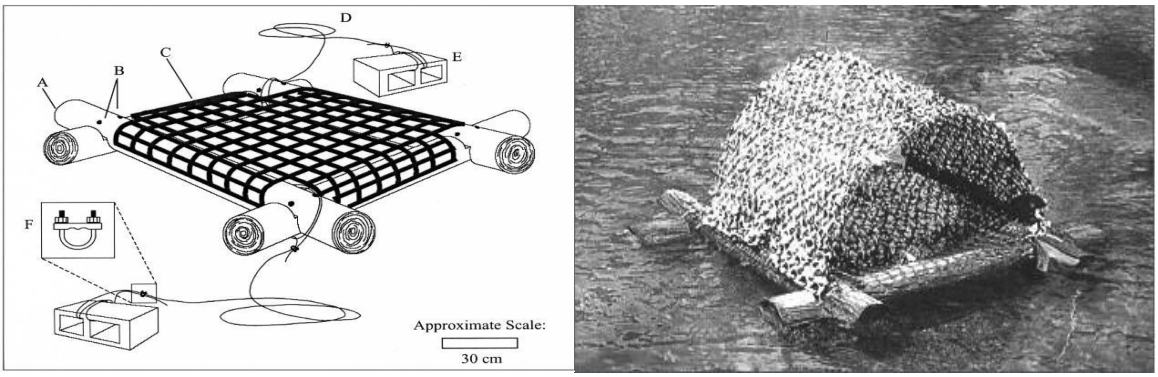


Figure 2.4.6.d Basic artificial nesting platform structure (Left) and completed ANP with additional camouflage and predator protection (Right). Camouflage design depends on habitat type and lake specific characteristics.

No Action Alternative

Bull Trout

The continued presence of eastern brook trout will cause Hozomeen Lake to remain a source of eastern brook trout for the Upper Skagit Core Area. Consequently, the bull trout population in the Upper Skagit watershed may be adversely affected by competition and hybridization. The rate at which the bull trout population will decline is highly dependent on the rate at which environmental conditions change.

Common Loon

The no action alternative will not affect Common Loon nesting in Hozomeen Lake. Nesting populations will continue to return to the lake as long as habitat conditions remain favorable.

Effects of Alternative Action

Bull Trout

Stocking tiger muskellunge into Hozomeen Lake risks introducing a predator to the watershed that may potentially prey on bull trout. Tiger muskellunge may leave the lake through Hozomeen Creek and enter Ross Lake, where they may encounter bull trout. If

this occurs, the likelihood that tiger muskellunge will enter Ross Lake via Hozomeen Creek before and after removal is high. Mechanical removal methods can be used to reduce the number of tiger muskellunge. Tiger muskellunge are sterile, so predation will only occur during the lifespan of the tiger muskellunge. Studies on tiger muskellunge show life span to be highly variable, and thought to be dependent on habitat type. The average lifespan of both northern pike and muskellunge is 7-10 years (Simonson 2012). Since the tiger muskie is a sterile hybrid of the northern pike and muskellunge, it is reasonable to expect a similar life span. A large selection of other prey in Ross Lake and a low stocking density will minimize tiger muskellunge predation on bull trout in the Upper Skagit Core Area. Reduction of the eastern brook trout population by tiger muskellunge predation will decrease hybridization and competition between bull trout and eastern brook trout. This will be a major benefit to the bull trout population in the Upper Skagit Core Area.

Common Loon

A decrease in eastern brook trout populations over the course of five to seven years could cause eventual nest abandonment. Initial stocking of tiger muskellunge may impose a negative impact on the common loons nesting in Hozomeen Lake as tiger muskies could prey on juvenile loons. However, this is not expected to be a significant or long-term impact to the resident common loons. Furthermore, small tiger muskellunge may serve as an additional food source for the common loons in Hozomeen Lake.

Mitigation

The same mitigation efforts outlined in the proposed action will be used to address potential nest abandonment.

2.4.7 Amphibians

Existing Conditions

The Hozomeen Lake area has a number of amphibian species, including the Western toad (*Anaxyrus boreas),* Pacific Tailed Frog (*Ascaphus truei.)*, Cascades frog (*Rana cascadae*), Columbia spotted frog (*Rana luteiventris),* Long-toed salamander (*Ambystoma macrodactylum),* and Northern red-legged frog (*Rana aurora)*. The Oregon spotted frog (*Rana pretiosa)* is a state species of concern and a potential resident of Hozomeen Lake; however, this has yet to be independently verified (Ashley Rawhouser.

Figure 2.4.7 Photograph of a Long-toed salamander (*Ambystoma macrodactylum)* By John P. Clare.

Effects of Proposed Action

Gill-breathing amphibian larvae demonstrate similar sensitivity to rotenone as fish. However, adult amphibians are less sensitive. Laboratory experiments exposing amphibians to high levels of rotenone coupled with post treatment monitoring indicated complete mortality in gill-breathing tadpoles, but strong resistance to intoxication in metamorphs, juveniles, and adults was evident (Billman 2007). Tadpole studies for three successive years after treatment showed tadpole recovery in numbers to be higher than pretreatment numbers (Billman et al. 2011). Additional research by Billman et al. (2011) also found low mortality in the Columbia spotted frog.

Reduction in amphibian abundance will be likely to be short-term due to adult resistance to rotenone. Reduction of macroinvertebrates caused by rotenone intoxication will likely result in less available food for amphibian. To insure the highest possible survival, rotenone will be applied at the end of the summer as to follow the period of metamorphosis by amphibians from larvae to adult. Tadpoles will be least abundant and possibly absent in fall, and treatments will be timed to reduce potential impacts.

Effects of Alternative Action

Introduction of tiger muskellunge would likely promote population rebounds for amphibian populations residing in Hozomeen Lake. Tiger muskellunge are primarily

piscivorous, but predation on amphibians has been noted (Simonson 2012). Tiger muskellunge predation on amphibians was found to only occur in lakes with low fish densities (Simonson 2012). The large reproducing eastern brook trout population of Hozomeen Lake is dense enough to deter tiger muskellunge from preying on amphibian species.

2.5: ENERGY & NATURAL RESOURCES

2.5.1: Nonrenewable Resources

Existing Conditions

Hozomeen Lake does not provide any nonrenewable energy resources to the public or private sector, nor is it likely to in the future.

Effects of Proposed Action

The removal of eastern brook trout from Hozomeen Lake will require the use of fossil fuels to transport personnel and materials to the Hozomeen Lake area.

Effects of Alternative Action

Introducing tiger muskellunge will likely require the use of fossil fuels for transporting personnel and equipment to the Hozomeen Lake area.

Effects of No Action Alternative

The continued existence of eastern brook trout will not result in impacts to nonrenewable resources.

2.5.2: Renewable Resources

Existing Conditions

Hozomeen Lake acts as a freshwater resource to Hozomeen and Winnebago Flats Campgrounds.

Effects of Proposed Action

The removal of eastern brook trout from Hozomeen Lake through the use of rotenone will temporarily limit water resources to Hozomeen and Winnebago Flats Campgrounds. However, these areas will be closed to the public during treatment, and thus there will be no demand for the resource. No impacts to the water resources of Hozomeen Lake are expected to arise from the proposed action.

Effects of Alternative Action

Introducing tiger muskellunge will not affect the availability of water resources at Hozomeen and Winnebago Flats Campgrounds.

Effects of No Action Alternative

The continued existence of eastern brook trout will not result in impacts to water resources.

2.5.3: Scenic Resources

Existing Conditions

Hozomeen Lake acts as a scenic resource for recreational visitors to the area.

Effects of Proposed Action

The removal of eastern brook trout from Hozomeen Lake through the use of rotenone will temporarily limit the public from enjoying the scenery of Hozomeen Lake since public access will be restricted to the public during the treatment periods. However, the treatments will occur during the slow season and thus restrictions of scenic resources should be minimal. Furthermore, the long-term scenic resources of Hozomeen Lake will not be impacted by rotenone application.

Effects of Alternative Action

Introducing tiger muskellunge will not affect the scenic resources of Hozomeen Lake.

Effects of No Action Alternative

The scenic resources of Hozomeen Lake are not expected to be impacted by the persistence of eastern brook trout.

SECTION THREE: IMPACTS TO THE BUILT ENVIRONMENT

The following section describes existing conditions of the built environment elements of Hozomeen Lake. Each element contains a discussion of implications of the proposed action, the alternative action, and the no action alternative.

3.1 ENVIRONMENTAL HEALTH

3.1.1: Noise

Existing Conditions

Hozomeen Lake is a remote site within the designated Stephen Mather Wilderness Area, and is maintained by the Park as a natural soundscape. Thus, no motorized equipment or boats are allowed at the lake (United States Congress 1964).

Effects of Proposed Action

Short-term noise associated with helicopters used for material transport will occur, temporarily disturbing the naturally quiet lake. The proposed action will have no expected long-term impacts on noise levels at the lake.

Effects of Alternative Action

Noise levels will intermittently rise if stocking of tiger muskellunge is conducted using aircraft. The impact of such noise will be short-lived. No adverse impacts are likely in the long-term.

Effects of No Action Alternative

The no-action alternative will have no impacts on existing noise levels at Hozomeen Lake.

3.1.2: Risk of explosion

Existing Conditions

Hozomeen Lake is naturally devoid of concentrated and contained flammable materials. While recreational visitors could potentially cause an explosion by the improper use of fuel canisters for cooking, this risk is negligible.

Effects of Proposed Action

Rotenone is known to be a combustible material if preheated (NCBI 2017). Combustion of rotenone could result in a fire spreading to the surrounding environment, although explosion is not likely. The transport of materials and equipment to the lake will require multiple helicopter flights, which carries an inherent risk of explosion in the event of a crash. The boat used to apply rotenone will be battery-powered, and not require the storage of gasoline at the lake (Ashley Rawhouser, North Cascades National Park, personal communication, February, 2017).

Effects of Alternative Action

The use of tiger muskellunge to eradicate the eastern brook trout population will require the transport of fish stock to the lake either by hand crews or helicopters. Any use of a helicopter to transport materials carries the risk for a crash and explosion.

Effects of No Action Alternative

The no action alternative avoids the use of helicopters and other motorized equipment, thus maintaining a negligible risk of explosion.

3.1.3: Releases or potential releases to the environment affecting public health, such as toxic or hazardous materials

Existing Conditions

Hozomeen Lake is the source of drinking water for the nearby Hozomeen Campground, thus the water supply system provides a route through which toxic or hazardous materials released into the lake could potentially affect public health.

Effects of Proposed Action

Rotenone is a skin and eye irritant, and is toxic if inhaled or ingested (NIOSH 2014). Potential releases affecting public health could occur through the public water supply to Hozomeen Campground. Those conducting the rotenone application could experience exposure via fumes and dust during application. Applicators will use proper personal protective equipment to avoid potential health consequences of rotenone exposure. Park employees will temporarily restrict public access to the lake to prevent exposure to hikers. Access to water spigots at Hozomeen Campground will be restricted to prevent potential exposure to campers.

Potassium Permanganate, a chemical used to deactivate rotenone, is also toxic to humans and could spread downstream from Hozomeen Lake if not carefully applied and controlled. The proposed action will require careful administration of potassium permanganate and proper securing to prevent accidental releases above planned dosages.

Effects of Alternative Action

The use of tiger muskellunge to eradicate the existing eastern brook trout population will not involve the application of toxic or hazardous materials which could affect public health.

Effects of No Action Alternative

The no action alternative will not result in any potential release of toxic or hazardous materials to the environment.

3.2 LAND AND SHORELINE USE

3.2.1: Relationship to existing land use plans and to estimated population

Existing conditions

Hozomeen Lake is a recreational site and has no permanent or seasonal population of residents. The lake is visited by recreationalists and park employees throughout the summer and fall seasons. Shoreline use and development in the area associated with Ross Lake must comply with procedures, policies, and regulations put forth by the Whatcom County Shoreline Management Program; however, the lake is in a federally designated wilderness area and has no plans for development.

Effects of Proposed Action

Chemical eradication of the existing eastern brook trout population through rotenone will affect recreational visitors by temporarily restricting access to the lake throughout the month of October. This action would have no impacts on existing land or shoreline use plans.

Effects of Alternative Action

The use of tiger muskellunge to eradicate the existing eastern brook trout population will have no effects on existing land or shoreline use plans.

Effects of No Action Alternative

The no action alternative will have no effects on existing land or shoreline use plans or the recreational population.

3.2.2: Housing

Existing conditions

Hozomeen Lake is situated in the Ross Lake National Recreation Area, and contains seasonal housing for NPS employees at Hozomeen Lake Campground.

Effects of Proposed Action

The proposed action will have no effects on housing in the area.

Effects of Alternative Action

The alternative action will have no effects on housing in the area.

Effects of No Action Alternative

The no action alternative will have no effects on housing in the area.

3.2.3: Light and Glare

Existing Conditions

Sunlight reflects off the lake, creating a natural glare. No artificial light sources are present at the lake.

Effects of Proposed Action

Temporary discoloration arising from potassium permanganate and rotenone could temporarily alter the glare of the lake, though this will not result in any long-term negative effects.

Effects of Alternative Action

The introduction of tiger muskellunge will have no effect on light and glare in the area because no changes affecting these conditions will occur.

Effects of No Action Alternative

The no action alternative will have no effects on the light and glare in the area because no changes affecting these conditions will occur.

3.2.4: Aesthetics

Existing conditions

The aesthetics of the lake are a primary motivation for recreational visitors, who come to enjoy the pristine natural setting (Swanson and Johnson 2005). The mission of the National Park Service guides it to preserve the scenery of the area.

Effects of Proposed Action

The use of potassium permanganate to deactivate rotenone could result in a temporary purple coloration of the water (ADFG 2011). This discoloration will disappear as dilution of treated water occurs. The eradication of eastern brook trout with rotenone could potentially result in a phytoplankton algal bloom, which would negatively impact the aesthetics of the lake.

Effects of Alternative Action

The use of tiger muskellunge to eradicate the existing eastern brook trout population will have no effects on the aesthetics of the lake.

Effects of No Action Alternative

The no action alternative would have no effect on the aesthetics of the lake because no changes to aesthetics would occur.

3.2.5 Recreation

Existing Conditions

Hozomeen Lake is a popular recreational site, accessible by trail from Hozomeen Campground or Highway 20. Hozomeen Campground is only accessible by road from British Columbia, Canada, or by boat on Ross Lake Reservoir. The campground contains 75 designated campsites, several docks, boat launches, and a trailhead to Hozomeen Lake. An estimated 8,200 people visited Hozomeen Campground in 2002 (Mountain Lakes Management plan Vol 1 2008). Ross Lake Campground is within the Skagit Valley Provincial Park across the Canadian border. This area likely supports similar densities of visitors during the summer season. Hozomeen Lake is closed to access from April 1-May 31 due to the presence of nesting Common Loons (NPS 2017). Trailhead access from Hozomeen Campground is also restricted by a gate on the Canadian side of the border during winter months.

Fishing at Hozomeen Lake is currently an important part of the recreational experience for many visitors to the area. Visitor usage statistics reveal that fishing is the second most frequently listed activity in the area (Swanson and Johnson 2007). This study highlights the importance of fishing to Hozomeen Lake visitors. However, research also indicates that visitors hiking specifically to Hozomeen Lake were primarily motivated by other interests, such as sightseeing, hiking, and exercise (Swanson and Johnson 2005).

Effects of Proposed Action

Given that rotenone causes skin and eye irritation and is toxic if ingested (NIOSH 2014), public access to the lake must be restricted until acceptable levels for human contact are reached. This will reduce recreational opportunities for visitors, but will also result in temporarily lower levels of foot traffic and less potential damage to the natural environment through a reduction of vegetation trampling.

Effects of Alternative Action

The use of tiger muskellunge to eradicate the existing eastern brook trout population will allow for continued fishing opportunities for recreational anglers. This will result in continued visitor usage and associated impacts to the immediate surroundings. Over the long-term, fishing opportunities will decline as the introduced tiger muskellunge will be non-reproducing and eventually become locally extirpated, causing the local fish population to ultimately disappear.

Effects of No Action Alternative

The no action alternative will allow for continued fishing opportunities at Hozomeen Lake. Continued usage of the area for fishing could result in negative environmental impacts, such as vegetation trampling and erosion along the shoreline.

3.2.6: Historic and cultural preservation

Existing Conditions

Historic stocking of Hozomeen Lake has led to recreational fishing for the past few decades and establishment of its reputation within the recreational culture of the park. However, the existence of fish in naturally fishless Hozomeen Lake is at odds with the management philosophy of the National Park Service (NPS), which seeks to conserve the scenery and natural landscape as well as protect wildlife and maintain the natural integrity of the area (United States Congress 1916). The mission of the NPS thus provides impetus for restorative action intended to return Hozomeen Lake to its historically fishless status.

In accordance with park management rules, groups are limited to 12 or fewer people (NPS 2017). The use of motorized equipment and motor boats is also prohibited. According to the National Register of Historic Places, there are no registered historic structures within the immediate vicinity of the lake.

Effects of Proposed Action

The use of rotenone to exterminate the existing eastern brook trout population will require the presence of Park personnel for a period of roughly three weeks, during two successive years. Four individuals may be in place for a week to set up camps and chemical stations, followed by the presence of 10+ individuals for a continuous week for implementation. The number of individuals may conflict with park rules on maximum group size. This period of heavy use will be followed by the rotation of a small group, which will be in place to monitor lake conditions and break down camps (Ashley Rawhouser, North Cascades National Park, personal communication, February, 2017). This action will require an MRA - a minimum requirements analysis, in order to qualify as an exemption to Wilderness Act and park management stipulations. While the proposed action may temporarily result in impacts to the site, it will ultimately reduce ground impacts from visitors motivated by fishing opportunities, resulting in beneficial effects on the historic and cultural landscape.

Effects of Alternative Action

The use of tiger muskellunge to eradicate the eastern brook trout population could result in continued foot traffic and associated ground impacts by recreationalists motivated by fishing, leading to increased deterioration of the historic and cultural landscape. Ground impacts may include vegetation trampling and bank erosion. Stocking of tiger muskellunge and their eventual mechanical removal could be an ongoing process over a number of years involve annual recurring work by park personnel. As the non-reproducing population diminishes and eventually disappears, foot traffic instigated by fishing will simultaneously diminish. In the long-term, the alternative action will have a beneficial effect on the historic and cultural landscape of the area by resulting in the restoration of the lake to a fishless state.

Effects of No Action Alternative

The no action alternative will allow the existing eastern brook trout population to continue propagating in Hozomeen lake, causing detrimental impacts to both the Upper Skagit watershed and the surrounding historic and cultural landscape.

3.2.7: Agricultural crops

Existing Conditions

The watershed immediately surrounding Hozomeen Lake is not used for the production

of agricultural crops.

Effects of Proposed Action Alternative, and No Action Alternative

The proposed action will not affect agricultural crops as the surrounding watershed in the vicinity of Hozomeen Lake is not utilized for agricultural purposes.

Effects of Alternative Action

The alternative action will not affect agricultural crops as the surrounding watershed in the vicinity of Hozomeen Lake is not utilized for agricultural purposes.

Effects of No Action Alternative

The no action alternative will not affect agricultural crops as the surrounding watershed in the vicinity of Hozomeen Lake is not utilized for agricultural purposes.

3.3 TRANSPORTATION

Existing Conditions

The only transportation system within the proposed site is a trail network, which allows foot traffic to access the lake. These trails originate at the Hozomeen Campground to the northwest and Highway 20 to the south. The East Bank trail runs continuously from Highway 20 to Hozomeen Campground.

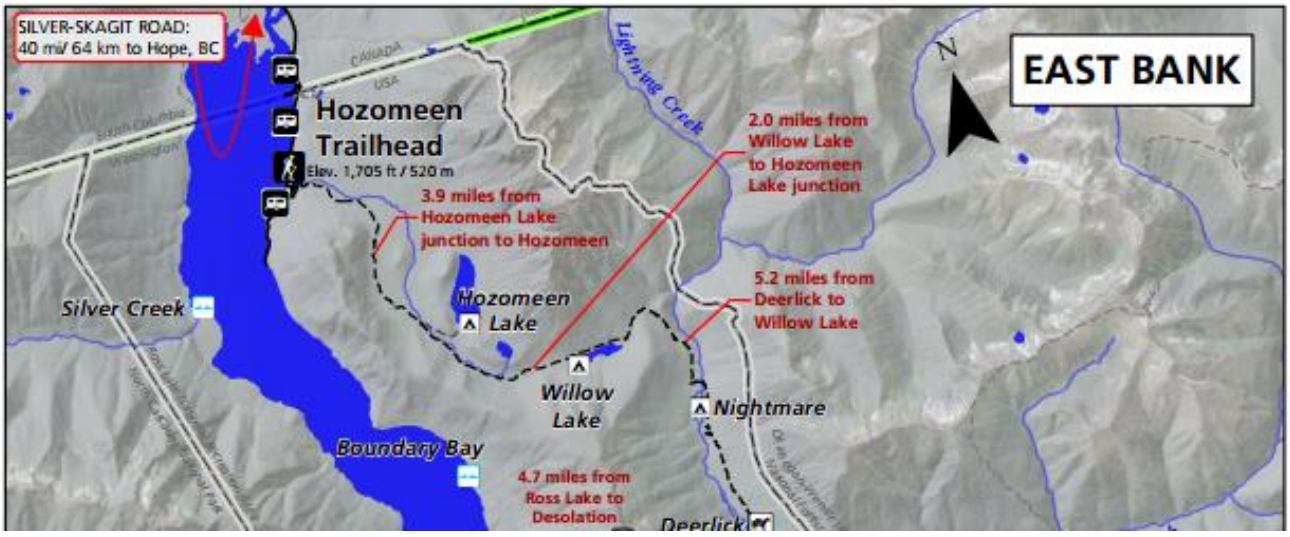


Figure 3.3.1: The trail network surrounding Hozomeen Lake.

Effects of Proposed Action

Public access to Hozomeen Lake will be restricted during the month of October (Ashley Rawhouser, North Cascades National Park, personal communication, February, 2017). This temporary restriction of public access will block the movement of people intending to access Hozomeen Lake from the East Bank trail. The public closure will not impact thru-traffic between Hozomeen Campground and Highway 20.

Aside from direct trail access to the lake, the proposed action will have no effects on other transportation systems, including vehicular, waterborne, rail, and air traffic, and parking and traffic hazards.

Effects of Alternative Action

The alternative action will have no effects on hiking traffic, other transportation systems, vehicular traffic, waterborne, rail, and air traffic, parking, or traffic hazards.

Effects of No Action Alternative

The no action alternative will have no effects on hiking traffic, other transportation systems, vehicular traffic, waterborne, rail, and air traffic, parking, or traffic hazards.

3.4 PUBLIC SERVICES AND UTILITIES

3.4.1: Fire

Existing Conditions

Hozomeen Lake is currently listed a dipping-source for helicopters used to collect, deliver, and apply water in fire suppression activities (NOCA Fire Management Team 2010).

Effects of Proposed Action

The proposed action will require temporary restriction of the lake as a source for dipping and pumping. Using water treated with rotenone for fire suppression will result in the distribution of rotenone across the landscape. The proximity of numerous water sources, particularly nearby Ross Lake, will accommodate a temporary withdrawal restriction at Hozomeen Lake should water be required for fire suppression activities.

Effects of Alternative Action

The alternative action will have no effect on fire suppression activities.

Effects of No Action Alternative

The no action alternative will have no effect on fire suppression activities.

3.4.2: Police

Existing Conditions

Law enforcement personnel in the park are limited to NPS employees. A ranger is stationed near the East Bank trailhead at Hozomeen Campground.

Effects of Proposed Action

The use of rotenone to eradicate the eastern brook trout population will require the cooperation of the ranger at Hozomeen Campground to keep recreational visitors from accessing the lake during the application period.

Effects of Alternative Action

The use of tiger muskellunge to eradicate the existing eastern brook trout population will have no effects law enforcement near or at the lake.

Effects of No Action Alternative

The no action alternative will have no effects on law enforcement at or near the lake.

3.4.3: Schools

Existing Conditions

There are no public or private schools in the vicinity of Hozomeen Lake. Nearby educational institutions, such as the North Cascades Institute, or other universities may utilize the lake for research purposes.

Effects of the Proposed Action

Rotenone application could disrupt educational field trips or academic research conducted at the lake.

Effects of the Alternative Action

The use of tiger muskellunge to eradicate the eastern brook trout population will have no adverse effects on schools. Academic research conducted at the lake could be affected

by the introduction of tiger muskellunge.

Effects of the No Action Alternative

The no action alternative will have no adverse effects on schools.

3.4.4: Parks and other Recreational Facilities

Existing Conditions

Recreational facilities in the vicinity of Hozomeen Lake are limited to basic campsites for recreational visitors. Four campsites are present, with a total capacity for 20 individuals (NPS 2015).

Effects of Proposed Action

The proposed action will result in the permanent loss of fishing opportunities for recreational anglers. It will temporarily block other visitors from accessing the lake. No impacts are expected to existing campsites.

Effects of Alternative Action

The introduction of tiger muskellunge to eradicate the eastern brook trout population will allow continued fishing opportunities for recreational anglers with the addition of fish stock. In the short-term, this will maintain recreational opportunities for visitors. Fishing opportunities will diminish in the long-term as the tiger muskellunge population disappears due to fishing and natural mortality. This action will allow continuous access to the lake by other visitors.

Effects of No Action Alternative

The no action alternative will allow for the continued use of Hozomeen Lake as a site for recreational fishing, sight-seeing, camping, and other recreational pursuits.

3.4.5: Maintenance

Existing Conditions

Maintenance of campsites and the trail to Hozomeen Lake is carried out by park employees.

Effects of the Proposed Action

The proposed action will have no effects on the maintenance of campsites and the trail to Hozomeen Lake.

Effects of the Alternative Action

The alternative action will have no effects on the maintenance of campsites and the trail to Hozomeen Lake

Effects of the No Action Alternative

The no action alternative will have no effects on the maintenance of campsites and the trail to Hozomeen Lake.

3.4.6: Communications

Existing Conditions

No communications facilities or equipment exist in the immediate vicinity of Hozomeen Lake.

Effects of the Proposed Action

The proposed action will have no effects on communications facilities or equipment near Hozomeen Lake.

Effects of the Alternative Action

The alternative action will have no effects on communications facilities or equipment near Hozomeen Lake.

Effects of the No Action Alternative

The no action alternative will have no effects on communications facilities or equipment near Hozomeen Lake.

3.4.7: Water/Storm Water

Existing Conditions

The lack of impervious surfaces surrounding Hozomeen Lake allows for drainage of the Hozomeen Lake watershed into the lake. One culvert beneath Silver Skagit Road in the Hozomeen Campground area exists on Hozomeen Creek. Groundwater from a location nearby Hozomeen Lake is the source of drinking water for Hozomeen Campground.

Effects of Proposed Action

The use of rotenone will not negatively impact the availability of drinking water for Hozomeen Campground because the area will be closed to the public during the treatment periods. Moreover, rotenone readily binds to soil particles and is degraded within sediments. Therefore, the groundwater supply will not be at risk of contamination. The application of rotenone will not impact storm water of Hozomeen Lake or Hozomeen Creek.

Effects of Alternative Action

The introduction of tiger muskellunge will have no effect on water or stormwater as it relates to the built environment.

Effects of No Action Alternative

The continued existence of eastern brook trout will have no effect on water and stormwater as it relates to the built environment.

3.4.8: Sewer/Solid Waste

Existing Conditions

There are pit toilet systems near Hozomeen Lake.

Effects of Proposed Action

The proposed action will not impact pit toilet systems near Hozomeen Lake.

Effects of Alternative Action

The alternative action will not impact pit toilet systems near Hozomeen Lake.

Effects of No Action Alternative

The no action alternative will not impact pit toilet systems near Hozomeen Lake.

Summary of Findings and Recommended Action

After careful analysis of literature regarding rotenone application, relevant RCW codes, and the possible effects on the elements described in WAC 197-11, our team concludes that the proposed action should be implemented in order to remove the eastern brook trout in Hozomeen Lake.

The positive impacts that rotenone application will have on endangered and unique species should be the primary concern when weighing the positive and negative effects of the actions presented in this EIA. Protecting the ESA-listed bull trout in the Upper Skagit Core Area complements NOCA's management philosophy of prioritizing restoration and protection of the parks natural ecosystems. The no action alternative was immediately dismissed because eastern brook trout are non-native and self-sustaining in Hozomeen Lake. Hozomeen Lake has a stunted and dense reproducing population of eastern brook trout that will persist until action is taken to remove them. The major threat that eastern brook trout pose to native trout and char species, as well as macroinvertebrates and amphibians, demands immediate attention. The negative effects that climate change is projected to have on mountain lakes will only serve to exacerbate the impacts of eastern brook trout within the Upper Skagit Core Area.

The most effective method of eradicating eastern brook trout populations is with the treatment of rotenone. The alternative action, although possessing the potential to reduce the eastern brook trout population, fails to adhere to NPS management philosophy. Tiger muskellunge stocking was therefore dismissed as an effective action. Tiger muskellunge stocking could potentially take two decades, and monitoring after introduction could uncover variables that may extend the timeline of the project. The difference in project duration between rotenone application and tiger muskellunge introduction was an additional factor for our decision. Current water temperature monitoring has determined that Ross Lake is warming incrementally, with the warmest portion of the lake being the north eastern portion directly along the Canadian border. This warmer portion is more energetically favorable for eastern brook trout, and subsequently harbors the largest population of eastern brook trout in Ross Lake. As the lake warms, eastern brook trout populations are likely to move southwards (Rawhouser pers comm 2017).

The negative connotation associated with chemical removal of any organism is virtually unfounded in past rotenone application. The specific toxicity to gill breathing organisms and rapid chemical breakdown make rotenone application favorable over any other available methods of fish removal. The plethora of relevant research on the properties of rotenone and its effects on aquatic and terrestrial organisms, coupled with numerous applications done by federal agencies, only helps to demonstrate its reliability as a safe and effective method for invasive fish removal. Although the ecological trajectory of Hozomeen Lake may be permanently shifted, the removal of eastern brook trout will allow an ecosystem that is similar, if not historically exact, to establish itself in this

mesotrophic mountain lake. The potential disturbance to common loons can be mitigated in a cost effective manner, and amphibian and macroinvertebrate population rebounds post-treatment will create a system that mimics its historical predecessor.

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