Prepared in cooperation with Kalispel Tribe of Indians

Risk Assessment for Bull Trout Introduction into Sullivan Lake and Harvey Creek, Northeastern Washington

Open-File Report 2022–1032

U.S. Department of the Interior
U.S. Geological Survey

Risk Assessment for Bull Trout Introduction into Sullivan Lake and Harvey Creek, Northeastern Washington

By Jill M. Hardiman, Rachel B. Breyta, and Carl O. Ostberg

Prepared in cooperation with Kalispel Tribe of Indians

Open-File Report 2022–1032

U.S. Department of the Interior
U.S. Geological Survey

U.S. Geological Survey, Reston, Virginia: 2022

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment—visit https://www.usgs.gov or call 1–888–ASK–USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit https://store.usgs.gov/.

Suggested citation:
Hardiman, J.M., Breyta, R.B., and Ostberg, C.O., 2022, Risk assessment for bull trout introduction into Sullivan Lake and Harvey Creek, northeastern Washington: U.S. Geological Survey Open-File Report 2022–1032, 26 p., https://doi.org/10.3133/ofr20221032.

Associated data for this publication:
Hardiman, J.M., Breyta, R.B., and Ostberg, C.O., 2022, Information tables associated with a risk assessment for bull trout introduction into Sullivan Lake, northeastern, Washington including population donor sources and resident species, April 2021: U.S. Geological Survey data release, https://doi.org/10.5066/P9XCQEZ1.

ISSN 2331-1258 (online)

Acknowledgments

We thank the U.S. Geological Survey (USGS) Ecosystems Mission Area which contributed funding to support this project and the Kalispel Tribe for funding and selecting the USGS to partner with them on this risk assessment. We thank Joe Maroney, Jason Connor, and Jason Olson, fishery biologists of the Kalispel Tribe, for their extensive contributions throughout the risk assessment process. We thank all the members of the risk assessment workgroup and their associated agencies (Avista; British Columbia Ministry of Forests, Lands, Natural Resource Operations; Idaho Fish and Game; Montana Department of Fish, Wildlife, and Parks; Pend Oreille Public Utility District; Seattle City Light; U.S. Fish and Wildlife Service; U.S. Forest Service; Washington Department of Fish and Wildlife). We also thank the following individuals for contributing additional time and information into the process: Andy Dux, Eric Oldenburg, and Will Warnock. We would like to thank William Baker (Washington Department of Fish and Wildlife), Erin Britton Kuttel and William Gale (U.S. Fish and Wildlife Service), Al Solonsky (Seattle City Light), and Jason Dunham (USGS) for providing reviews and comments to improve the final version of this report.

Contents

Acknowledgments iii
Executive Summary 1
Introduction......2
Study Area......3
Risk Assessment Approach 5
    Resident Species 6
    Ecological Interactions 7
    Pathogen Risks......7
    Genetics Risks 8
    Donor Sources......8
    Donor Source Attributes......9
    Decision Framework......9
        Donor Source Population Attributes 9
            Migratory Life History 9
            Abundance......10
            Population Viability 10
            Feasibility......10
            Environmental Match 11
        Ranking Criteria......11
            Life History 11
            Abundance......11
            Population Viability 11
            Feasibility of Collection 12
            Environmental Match 12
Results and Discussion......12
    Resident Species 12
    Ecological Interactions 12
    Pathogen Risks......14
    Genetic Risks 15
    Donor Source Populations and Rankings......16
    Next Steps and Administrative Pathways for Bull Trout Introduction 20
Conclusions......20
References Cited......22
Appendix 1. Bull Trout Risk Assessment Work Group Meeting Attendees 26

Figures

1. Map showing study area in northeastern Washington, including Sullivan Lake and Harvey Creek, with inset map study area in reference to the states of Idaho and Washington and the border of British Columbia, Canada......4
2. Map showing bull trout Columbia Headwaters Recovery Unit Core Areas, excerpted from U.S. Fish and Wildlife Service, Columbia Headwaters Recovery Unit Implementation Plan for bull trout, September 2015 5
3. Decision framework diagram for bull trout donor source selection showing donor source population attributes and weights used to rank donor sources......10

Tables

1. Aquatic pathogens, and the clinical diseases they cause, that are important to fish health in the Columbia River Basin, from surveillance conducted by the U.S. Fish and Wildlife Service's National Wild Fish Health Survey for the years 1994–2014 following American Fisheries Society Fish Health protocols 7
2. Summary of donor source population attribute scores and ranking by region and tributaries, subbasins within these regions for potential donor populations 17

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	0.004047	square kilometer (km^2)
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	10.76	square foot (ft^2)
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$°F = (1.8 \times °C) + 32$.

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1983 (NAVD 83). Altitude, as used in this report, refers to distance above the vertical datum.

Abbreviations

BKD	Bacterial Kidney Disease
CHRU	Columbia Headwaters Recovery Unit
FERC	Federal Energy Regulatory Commission
IDFG	Idaho Department of Fish and Game
IHN	Infectious hematopoietic necrosis
IHNV	Infectious hematopoietic necrosis virus
KT	Kalispel Tribe of Indians
LPO	Lake Pend Oreille
Mc	*Myxobolus cerebralis*
MFWP	Montana Department of Fish, Wildlife, and Parks
NWFHS	National Wildlife Fish Health Survey
POPUD	Pend Oreille Public Utility Department
PRM	Pend Oreille River mile
RM	River mile
Rs	*Renibacterium salmoninarum*
SCL	Seattle City Light
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish and Wildlife

Risk Assessment for Bull Trout Introduction into Sullivan Lake and Harvey Creek, Northeastern Washington

By Jill M. Hardiman, Rachel B. Breyta, and Carl O. Ostberg

Executive Summary

The Kalispel Tribe of Indians (KT), U. S. Fish and Wildlife Service, and Washington Department of Fish and Wildlife are engaged in conservation of bull trout (*Salvelinus confluentus*) in the Lake Pend Oreille (LPO) Core Area. The LPO is a complex habitat core area which falls within three states (Montana, Idaho, and Washington) and a tribal entity. As part of the conservation process, KT worked in cooperation with the U. S. Geological Survey (USGS) to complete a risk assessment for introduction of bull trout into Sullivan Lake and Harvey Creek watershed, northeastern Washington State. The assessment was conducted following guidelines of other, similar risk assessments; built on previous work for reintroduction of bull trout; and engaged regional stakeholders, biologists, and managers throughout the process. The risk assessment was designed to evaluate potential risks to resident fish species, to bull trout introduced into Sullivan Lake, and to bull trout donor source populations. This risk assessment describes the potential risks associated with pathogens (introduction of pathogens and increased pathogen burden), genetics (such as risk to donor sources, straying and breeding with native bull trout, and introduction of bull-brook hybrids), and ecological interactions (such as predation and competition). Potential donor source populations were identified and evaluated using a qualitative approach based on expert opinion and a decision framework.

Literature reviews were completed for fish species composition and abundance in Sullivan Lake watershed to assess potential ecological interactions and risks to these populations and to the introduced bull trout. The USGS assessed pathogen risks through two major questions: (1) whether introduced bull trout might bring pathogens into the Sullivan Lake watershed that were not previously present and (2) whether the health of introduced bull trout could be adversely affected by pathogens already present in the watershed. Assessment of genetic risks included demographic risks to donor source populations, potential for hybridization with native bull trout, and the risk of introducing bull-brook hybrids. Literature reviews were used in conjunction with discussions among regional biologists to identify potential donor source populations and their population attributes. A decision framework was developed by USGS in collaboration with KT biologists that identified desirable population attributes (life history behavior, abundance, population viability, feasibility of collection, and environmental match) associated with donor source populations and established ranking criteria. The population attribute information was used with the (1) decision framework, (2) established ranking criteria, and (3) expert opinion of regional biologists, to assign scores for overall ranking of donor source populations.

Several donor source populations within the Columbia Headwaters Recovery Unit were identified as being suitable for a bull trout introduction program into Sullivan Lake watershed, through the risk assessment and stakeholder engagement. The decision selection framework allowed for consideration of multiple population attributes in identifying the highest-ranking source populations. The LPO source population was the highest ranked and is considered a robust and stable population. The risk of introducing pathogens from LPO into Sullivan Lake via a bull trout introduction program seems low, and indirect pathogen burden risks to resident species can be mitigated using established pathogen surveillance methods. The likelihood that bull trout, introduced into Sullivan Lake, stray and spawn with native bull trout is low. Nearest-neighbor donor source populations, such as LPO, could minimize negative fitness impacts that might occur from straying and interbreeding of individuals that become entrained and help maintain natural patterns of genetic diversity in native populations. The ecological risk that a bull trout introduction presents to resident species seems to be low but with some uncertainty. Pygmy whitefish (*Prosopium coulterii*), a Washington State Sensitive species, is likely most vulnerable to extirpation with increased predation pressure with introduction of an additional piscivore into the ecosystem. The status of the pygmy whitefish in Sullivan Lake is unknown. The ecological risks most likely to reduce the viability of introduced bull trout are predation by burbot (*Lota lota*) and an adequate forage base in Sullivan Lake.

With any new species introduction into an ecosystem, there is always uncertainty. However, uncertainty may be mitigated by establishing a rigorous monitoring program for fish species composition, food web analysis, and fish metrics (such as survival, growth, and abundance) to inform adaptive management decisions and future introduction programs. Further, documentation of all planning stages and processes throughout the introduction program, consistent monitoring,

and identifying outcomes (such as changes in native species abundance, pathogens, habitat use by bull trout, and genetic diversity of the introduced bull trout population) will help to inform other introductions.

Introduction

The Kalispel Tribe of Indians (KT), U. S. Fish and Wildlife Service (USFWS), and Washington Department of Fish and Wildlife (WDFW) are in the process of assessing risks associated with a proposed introduction of bull trout (*Salvelinus confluentus*) into Sullivan Lake and Harvey Creek, northeastern Washington as a conservation strategy in the Lake Pend Oreille (LPO) Core Area. The USFWS has listed all populations of bull trout within the coterminous United States as a threatened species pursuant to the Endangered Species Act of 1973 (64 FR 58910; November 1, 1999). Recovery and restoration actions are ongoing for this species, including many habitat improvements and actions to restore bull trout connectivity within the LPO Core Area. The most recent recovery plan for bull trout (USFWS, 2015a) has recognized that artificial propagation and translocation of bull trout into areas where they were extirpated or suitable habitat exists, are strategies that may help establish viable local populations to improve core area population status. However, such strategies need to consider appropriate precautions to minimize introduction of fish pathogens and unintended consequences on resident species (Dunham and others, 2011, Perez and others, 2012; International Union for Conservation of Nature [IUCN], 2013; USFWS, 2015a).

Introduction and translocation programs require thoughtful planning to increase the likelihood of success and to understand the benefits, risks, and constraints of such programs (Dunham and others, 2011; Perez and others, 2012; IUCN, 2013; Anderson and others, 2014; Hardiman and others, 2017). It is important to identify and address the underlying causes for population declines in the first place: habitat loss, habitat degradation, overharvest, fragmentation, among others. An additional important aspect is to engage regional managers and stakeholders to identify the goals of an introduction program (such as establishing a self-sustaining population, increasing spatial and genetic diversity, enhancing population resiliency, and conservation), identify factors that influence success or failure and how to address them, and identify any long-term unexpected impacts or uncertainties associated with introduction (such as disease, reduced fitness from inbreeding depression, introduction of maladaptive alleles [outbreeding depression]) or other unintended impacts into the ecosystem (Perez and others, 2012). These actions may be accomplished through feasibility and risk assessments.

The feasibility of reintroduction of bull trout into the lower Pend Oreille River has been addressed by earlier investigators (Dunham and others, 2014; Benjamin and others, 2019; Mims and others, 2019). One feasibility assessment evaluated the efficacy of establishing a self-sustaining bull trout population into the lower Pend Oreille River (between Boundary Dam, Pend Oreille River mile [PRM 17.0] and Albeni Falls Dam [PRM 90.1]) through restored connectivity of fish passage at Boundary Dam, as a fundamental goal to support bull trout recovery in the Upper Columbia River Headwaters Recovery Unit (Dunham and others, 2014). To accomplish this evaluation, the study assessed historical occupancy and connectivity in the reintroduction area, possibility of natural recolonization, habitat suitability in the face of a changing climate, interactions with brook trout (*Salvelinus fontinalis*) in the reintroduction area, and availability of suitable donor sources. Dunham and others (2014) concluded that natural recolonization through connectivity of fish passage at Boundary Dam was not biologically justifiable. However, the authors did suggest that an active reintroduction (translocation of bull trout) was feasible. This suggestion was based on the likelihood that self-sustaining bull trout populations were historically present in tributaries within the Lower Pend Oreille River, the existence of suitable habitat that is likely to persist within stream networks, and the availability of donor population sources within the LPO Core Area (Dunham and others, 2014). However, a more comprehensive evaluation was warranted to further address donor source selection (including a pathogen assessment, selection of appropriate life-history stage and strategy, and potential genetic effects), habitat suitability (now and into the future), and impacts of nonnative species in recipient systems (Dunham and others, 2014).

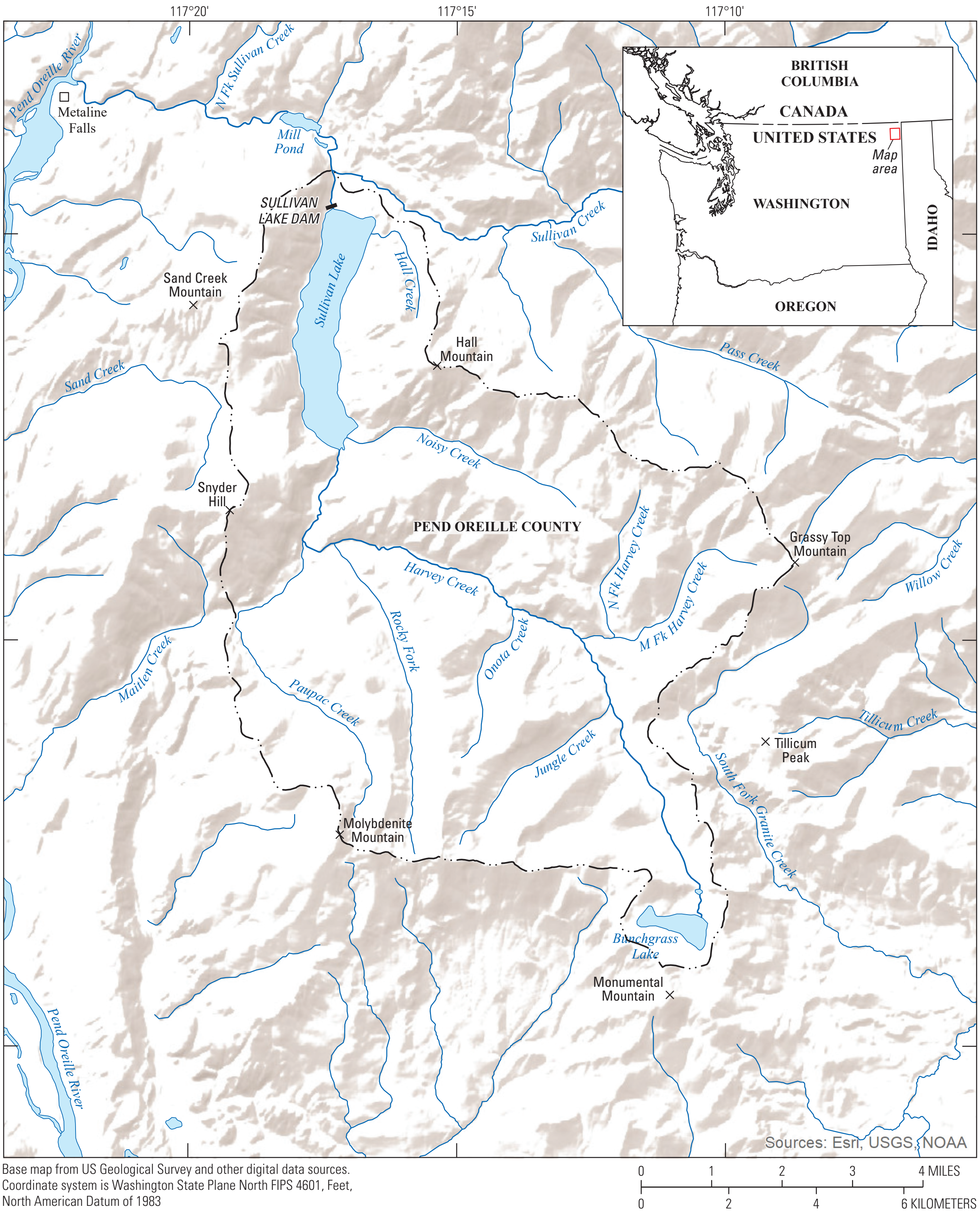
Stakeholder engagement is an important part of project planning, allowing a broad and invested consortium to establish project goals and metrics for evaluating success (Dunham and others, 2011; Benjamin and others, 2019). A structured decision analysis for reintroduction of bull trout into the lower Pend Oreille River was recently completed (Benjamin and others, 2019). The decision analysis involved input from regional resource managers and engaged stakeholders and identified fundamental objectives, feasible reintroduction decisions, and introduction sites. Sullivan Lake and Harvey Creek watershed was identified as the optimal recipient location in the lower Pend Oreille River area for bull trout introduction, with the primary objective of maximizing the abundance of adult bull trout (Benjamin and others, 2019). Sullivan Lake and Harvey Creek watershed contains habitat that is conducive for the bull trout life cycle, including spawning and rearing in headwaters and connectivity to feeding and overwintering habitat in the lake.

The current project focused on risk assessment for bull trout introduction into Sullivan Lake and Harvey Creek watershed. The project approach followed guidelines of other risk assessments and builds on previous work for reintroduction of bull trout (Dunham and others, 2011, 2014; Marcot and others, 2012; Galloway and others, 2016; Hardiman and others, 2017; Hayes and Banish, 2017; Brignon and others, 2018; Benjamin and others, 2019; Mims and others, 2019). Potential risks assessed included introduction of pathogens, genetic consequences (such as demographic risk to donor source, straying and breeding with native bull trout, and introduction of bull-brook hybrids), and ecological impacts (such as predation and competition) between resident species and introduced bull trout. We also identified potential donor source populations and described population attributes (such as migratory behavior, abundance, population viability, among others). A series of work group meetings and email communications were held to engage with regional stakeholders and resource managers to present information and solicit additional information and concerns during the risk assessment process. A decision framework was developed to use the donor source population attributes for scoring and ranking donor sources to determine the best selection for introduction into Sullivan Lake and Harvey Creek watershed. This work supports bull trout recovery efforts in northeastern Washington State and the Columbia Headwaters Recovery Unit (CHRU; USFWS, 2015a).

Study Area

Sullivan Lake is about 11.3 kilometers (7 miles) east of the town of Metaline Falls, northeastern Washington State (fig. 1) and is part of the Sullivan Creek Project. Sullivan Lake is at an altitude of 787 meters (m) at full pool, with a surface area of 5.6 square kilometers (km^2) (Nine and Scholz, 2005) and an average depth of 58.8 m and a maximum depth of 101.2 m (Baldwin and McLellan, 2005). The lake is fed by three tributaries: Harvey, Noisy, and Hall Creeks, with Harvey Creek being the only perennial tributary. Harvey and Noisy Creeks enter at the south end of the lake (fig. 1). The lake's water elevation is controlled by Sullivan Lake Dam, which was originally constructed in 1909 by the Inland Portland Cement Company and reconstructed in 1922 without upstream fish passage facilities (https://popud.org/projects/sullivan-creek-project/). The Sullivan Creek Project generated power until 1956, when a portion of a wooden flume collapsed. The Pend Oreille Public Utility District (POPUD) obtained a license from the Federal Energy Regulatory Commission (FERC) in 1958 to operate the dam as a water storage project for downstream hydroelectric power generation until 2013. In 2005, the POPUD decided not to renew the FERC license and opted to apply to surrender the license and obtain U. S. Forest Service (USFS) authorization for the facilities that occupied the federal land. In 2008, the POPUD entered negotiations with the USFS and other federal, state, tribal, and local agencies, and stakeholders, to develop a plan for the project. The FERC approved a surrender agreement in 2013 that included a plan to maintain Sullivan Lake, remove Mill Pond Dam on Sullivan Creek (completed in 2018, a collaboration by POPUD and Seattle City Light [SCL]), and complete the Sullivan Lake Cold Water Release Project (completed in 2015). Cold water is drawn from the bottom of Sullivan Lake through a 274.32-meter, 1.37-meter diameter pipe into Outlet and Sullivan Creeks to lower water temperatures in these creeks to support native fish habitat. Annually from June to September, 14,000-acre feet of water is released from Sullivan Lake into Outlet Creek on the north end, which then merges with Sullivan Creek and eventually drains into the Pend Oreille River, in the town of Metaline Falls. Sullivan Lake is classified as oligotrophic owing to its water clarity and low concentrations of total phosphorus and chlorophyll a (Washington Department of Ecology, 1997). The steep bathymetry of the lake, coupled with clear water and low nutrients, is typical of oligotrophic lakes. The primary land ownership in the Sullivan Lake area is the USFS. The downstream hydroelectric project Boundary Dam (PRM 17.0), owned by SCL, impounds the Pend Oreille River, creating about a 28.2 kilometers (km) reservoir that Sullivan Creek flows into. The top of this reservoir is bounded by Box Canyon Dam (PRM 34.5), which is owned by POPUD.

Sullivan Lake is within the CHRU, which includes parts of western Montana, northern Idaho, and northeastern Washington (fig. 2; USFWS, 2015a). The CHRU comprises 5 geographic regions (Kootenai, Flathead, Upper Clark Fork, Lower Clark Fork, and Coeur d'Alene), encompassing the major river drainages and 35 core areas (fig. 2) for bull trout. Within the CHRU, 15 of the core areas are referred to as "complex" and represent large, interconnected habitat areas with multiple spawning streams, contain most of the bull trout in the CHRU, and are designated as critical habitat (USFWS, 2010). The remaining 20 core areas are referred to as "simple" and represent single, local populations that are typically isolated. Many of the populations within the "simple" core areas have persisted despite small populations and isolation, and collectively these areas are estimated to contain less than 3 percent of the total bull trout core area habitat within the CHRU (USFWS, 2015a). Donor source populations considered for introduction were primarily from within the CHRU, with the exception being the consideration of adjacent populations within British Columbia, Canada.



Base map from US Geological Survey and other digital data sources.
Coordinate system is Washington State Plane North FIPS 4601, Feet,
North American Datum of 1983

Figure 1. Study area (delineated by dashed line) in northeastern Washington, including Sullivan Lake and Harvey Creek, with inset map study area in reference to the states of Idaho and Washington and the border of British Columbia, Canada.

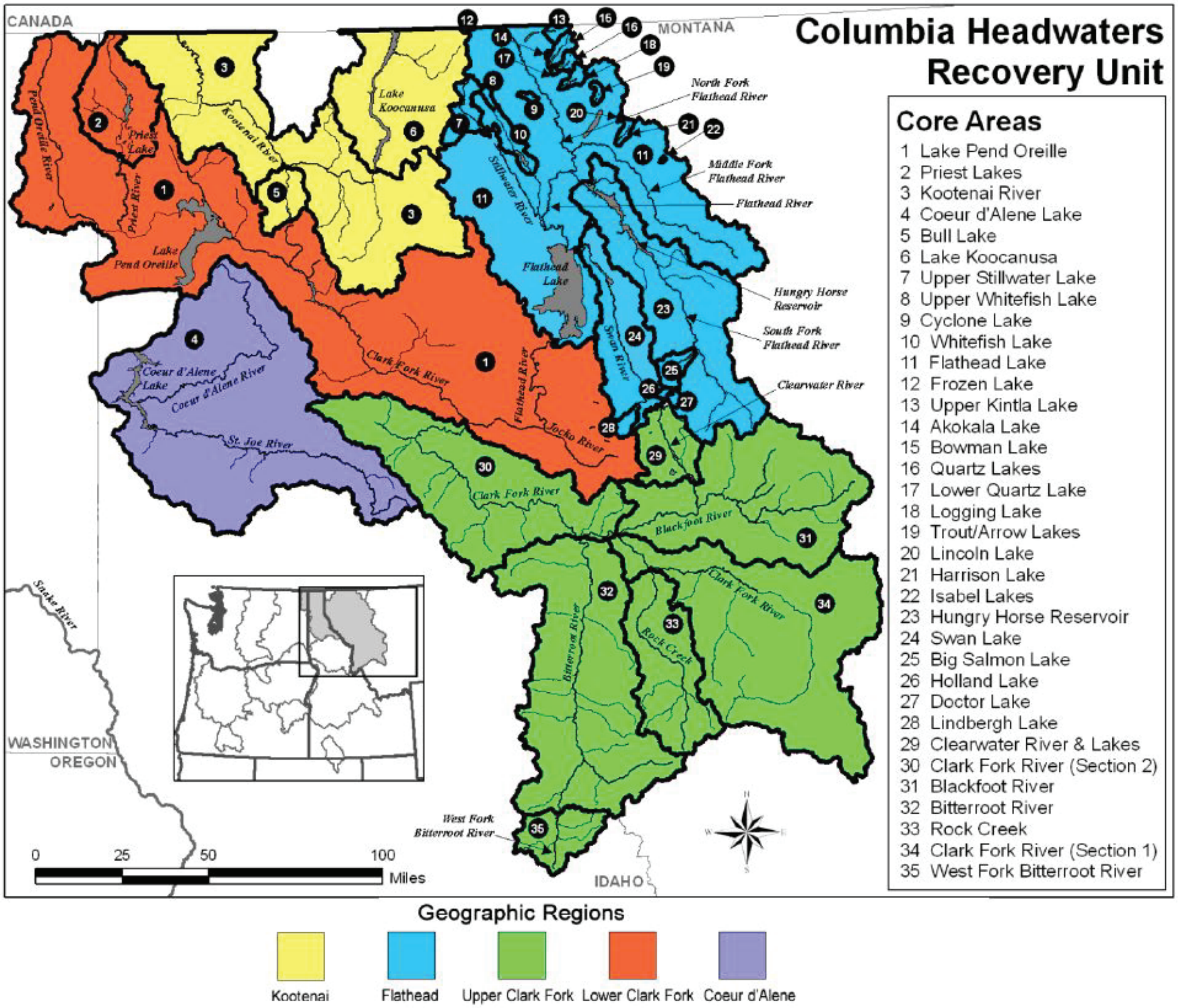


Figure 2. Bull trout Columbia Headwaters Recovery Unit Core Areas, excerpted from U.S. Fish and Wildlife Service (USFWS), Columbia Headwaters Recovery Unit Implementation Plan for bull trout (*Salvelinus confluentus*), September 2015 (USFWS, 2015b).

Risk Assessment Approach

The USGS worked with KT to develop a risk assessment to identify and evaluate potential risks and donor source populations associated with an introduction of bull trout into Sullivan Lake and Harvey Creek watershed. The risk assessment was designed to evaluate potential risks to (1) resident fish species, (2) to bull trout introduced into Sullivan Lake, and (3) to bull trout donor source populations. The risk assessment identifies and describes the potential risks associated with pathogens (introduction of pathogens, increased pathogen burden), genetics (demographic risk to donor source, straying and breeding with native bull trout, and introduction of bull-brook hybrids), and ecological interactions (such as predation and competition) between resident fish and introduced bull trout. To evaluate donor source selection (including demographic risk) a qualitative approach was used based on available data for donor source populations, expert opinion, and a decision framework. The decision framework was developed by USGS in collaboration with KT biologists, which identified desirable population attributes associated with donor source populations and established ranking criteria. A qualitative approach, including expert opinion, has been used in previous assessments, in which quantitative data may be sparse or inconsistent across donor sources (Dunham and others, 2011; Marcot and others, 2012; Galloway and others, 2016; Hardiman and others, 2017). Two primary workshops were held to present the framework and associated information tables to regional stakeholders and resource managers (collectively referred to as the work group) to solicit (1) feedback on the risk assessment approach and framework, (2) additional information regarding resident species and donor source populations, and (3) other concerns. The work group included individuals from Federal, Tribal, First Nations, State, Consulting, and Public Utility groups (appendix 1).

Risk assessment workshops were held on August 13 and September 17, 2020, where subject-matter experts, biologists, and stakeholders presented, reviewed, and discussed current information and provided additional information and concerns that further informed the risk assessment process and final decision framework. The goal of the initial work group meeting (August 13, 2020) was to engage regional experts and stakeholders in the risk assessment process to:

- Review and provide information,
- Identify potential donor sources,
- Describe disease and pathogen risks,
- Describe potential genetic risks,
- Describe potential ecological risks,
- Review donor source selection framework, attributes, and ranking criteria process.

A timeline was established to submit comments on the risk assessment process (decision framework, population attribute selection, ranking criteria) and initial information tables of resident species and donor sources (described further in sections below) prior to the next work group meeting. New information and table edits were incorporated into the resident species and donor source tables (Hardiman and others, 2022) and distributed to participants for discussion in work group meetings. Donor source population attributes were scored using established criteria, available data, and expert opinion by regional biologists and natural resource managers (primarily State [IDFG], Tribal [KT], Canadian, consultants [Avista], and Federal [USGS]) with knowledge of donor source populations. Attribute scores were submitted to USGS biologists, who compiled and summarized them. Donor source populations were ranked using the decision framework, based on the highest cumulative and weighted scores. During the September 17, 2020, meeting, a summary of participant concerns and the approach to address these concerns were presented, all updates to the resident species and donor source tables were summarized, and initial ranking scores were provided to the work group for review and discussion. A final work group meeting was held on February 10, 2021, when a preliminary report was presented, and the scores and ranks assigned to donor source populations were provided to solicit additional comments and concerns. Work group participants were given two weeks to submit their final concerns and comments to be addressed prior to initializing the USGS peer review process of the report and associated tables. Additional review and discussions, by regional biologists and managers, were sought out as needed to address discrepancies or concerns over donor source ranking scores during this review process and prior to finalization of donor source attribute scores and rankings.

Resident Species

A literature review was completed for fish species composition and abundance in Sullivan Lake to assess risks to these populations and to introduced bull trout. Literature on past fish surveys were used as the primary sources of information on species abundance (Baldwin and McLellan, 2005 and 2008; Nine and Scholz, 2005, Andersen and Witte, 2020). A resident species table was designed to summarize general information to aid in assessing the type (such as predation, competition, prey) and frequency of interactions between resident species and introduced bull trout (Hardiman and others, 2022). Species of concern were determined on the basis of a variety of criteria including conservation, recreation value (established and valued fishery), competition with bull trout, and predation on bull trout. Habitat use by resident species (such as Sullivan Lake and Harvey Creek) were identified by life stage where known. Population status metric scores were assigned by USGS on the basis of a review of the data on past fish surveys and were shared with multi-agency work group members for additional information, comments, or concerns. Population status metrics (abundance, trend, distribution) were assigned ranking scores between 1 and 5 for the relative species composition. Some species were assigned an unknown (Unk) status if they were previously detected in surveys but were not detected in the most recent 2018 survey (Andersen and Witte, 2020). The abundance rank scores were assigned as: 1 for low-, 3 for moderate-, and 5 for high-abundance. Population trend scores were assigned as: 1 for decreasing, 3 for steady, and 5 for increasing trend. Species distribution scores were assigned: 1 for rare, 3 for narrow or limited, and 5 for wide distribution or habitat use range within the Sullivan Lake and Harvey Creek watershed. Pathogen concerns were addressed by using the U. S. Fish and Wildlife Service National Wild Fish Health Survey data for years 1994—2014 (J. Bader, USFWS, written commun. March 23, 2022, data available upon request from Fish Health Centers Laboratory Information Systems, joel_bader@FWS.gov) to search for fish populations within the Columbia River Basin and Sullivan Lake region found to be positive with pathogens (table 1). Fish surveillance data were collected using standardized protocols (American Fisheries Society, 2014). Species specific high-risk pathogens were also identified for each resident species (Hardiman and others, 2022). Additional information is presented in the table on stocking history, ecological interactions among species, and population status in the general information column (Hardiman and others, 2022). The information needs column provides notes on where information may be lacking, such as current species abundance or the need for targeted surveys with specialized sampling techniques in the

Table 1. Aquatic pathogens, and the clinical diseases they cause, that are important to fish health in the Columbia River Basin, from surveillance conducted by the U.S. Fish and Wildlife Service's National Wild Fish Health Survey for the years 1994–2014 following American Fisheries Society Fish Health protocols.

[Bull trout sampling was limited; available data came from the Pend Oreille River Basin (top of table) and as a proxy of what pathogens may be present in unsampled bull trout, from salmonid samples queried in the Columbia River Basin above the confluence of the Snake River, (lower part of table). Data from the U.S. Fish and Wildlife Service's National Wild Fish Health Survey (J. Bader, USFWS, Fish Health Centers Laboratory Information Systems, written commun. March 23, 2022, data available upon request, joel_bader@FWS.gov) using American Fisheries Society (2014) Fish Health Section protocols.]

Pathogen	Disease
Detections in bull trout sampled from the Columbia Headwaters Recovery Unit	
Renibacterium salmoninarum	Bacterial kidney disease
Myxobolus cerebralis	Whirling disease
Detections in any salmonid in the Columbia River Basin above confluence of the Snake River, including Columbia Headwaters Recovery Unit	
Renibacterium salmoninarum	Bacterial kidney disease
Myxobolus cerebralis	Whirling disease
Flavobacterium psychrophilum	Bacterial coldwater disease
Infectious hematopoietic necrosis virus	Infectious hematopoietic necrosis
Aeromonas salmonicida	Furunculosis
Flavobacterium columnare	Columnaris
*Ceratonova shas*ta	Ceratomyxosis
Yersinia ruckeri	Enteric redmouth disease
Infectious pancreatic necrosis virus	Infectious pancreatic necrosis

example of pygmy whitefish. This table was provided to work group members prior to meetings for review and comment and was updated as needed throughout the risk assessment process. Information was compiled and presented at work group meetings to regional stakeholders and experts to solicit additional information and concerns that could be further addressed.

Ecological Interactions

Ecological interactions were primarily assessed through literature review, discussions between USGS and KT biologists, and use of information from the resident species table (Hardiman and others, 2022). The resident species table was designed to summarize general information to aid in assessing the type (such as predation, competition, prey) and frequency of interactions between resident species and introduced bull trout. To better understand the potential ecological interactions between introduced bull trout and resident species, the resident species table (Hardiman and others, 2022) was developed following Pearsons and Hopley (1999) to (1) identify population status, (2) life stage-specific habitat use, (3) primary locations of resident species (Sullivan Lake, Harvey Creek, or both) and (4) disease and pathogen concerns. The likelihood of species interactions was considered on the basis of overall species composition, abundance, distribution (habitat use overlap), and interaction patterns from other ecosystems where species co-exist. Other considerations were food web interactions, diet overlap, spawning behavior, and habitat preferences.

Pathogen Risks

The USGS assessed pathogen risks associated with introduction of bull trout in terms of two major questions. The first examined whether introduced bull trout might bring pathogens, that were not previously present, into the Sullivan Lake ecosystem. The second was whether bull trout might suffer health problems due to pathogens already present in the Sullivan Lake watershed. Either scenario could increase pathogen burdens on resident species. This form of risk can be thought of as indirect pathogen burden and will be addressed as such in the results section. To address the risk of introduction of new pathogens into Sullivan Lake by translocated bull trout, a fish health database was analyzed for pathogen detection in bull trout populations of either the Columbia River Basin or Sullivan Lake regions. The analyses used the USFWS National Wild Fish Health Survey (NWFHS) data (J. Bader, USFWS, Fish Health Centers Laboratory Information Systems, written commun. March 23, 2022, data available upon request, joel_bader@FWS.gov) and assessed bull trout sampled between 1994 and 2014 as well as sympatric species of fish. All pathogen surveillance data from the NWFHS was collected using standardized protocols (American Fisheries Society, 2014). The pathogens in this survey reflect the current best available knowledge of endemic pathogens that pose health risks to resident or introduced fish species of cultural, sport, or conservation value. The wild fish health survey represents the best balance between resources and surveillance in terms of pathogens monitored and fish species sampled. This means that sampling within the 285,000 square miles of the Columbia River Basin is neither uniform nor comprehensive, but it does provide invaluable insight since without it, only farmed or hatchery fish and their pathogens would be available for sampling and analysis. To address the second question, a literature review was conducted for disease impacts on bull trout in natural settings or within laboratory studies.

Genetics Risks

The USGS identified three genetic risks associated with introduction of bull trout into Sullivan Lake. First, demographic risks may be imposed on donor sources when individuals are removed from the population. Small populations are subject to loss of genetic variation (such as genetic drift and inbreeding) and such effects may be exacerbated by removing individuals from these populations (Rieman and Allendorf, 2001). To facilitate the evaluation of donor sources, we provided spawner surveys, redd counts, and population size estimates for each region and tributary that was considered as a potential donor source, where available within the donor source table (Hardiman and others, 2022). This allowed for individual assessment of each source as well as a composite assessment of sources (metapopulation) within each region. This information was also used in the donor source ranking criteria, where larger donor source populations were ranked higher than smaller populations (see below). The second genetic risk is that naturalized individuals could stray and breed with native bull trout, thereby reducing the fitness of native populations by disrupting local adaptations and co-adapted genes. We assumed that introduced bull trout could be entrained through the outflow of Sullivan Lake Dam and stray into native populations, either downstream into the Salmo River (this requires downstream passage/entrainment at Boundary Dam and currently no fish passage structures exist) or upstream in the Pend Oreille River after completion of proposed fish passage projects at nearby dams. Therefore, we primarily focused on populations within the Lower Clark Fork and Kootenai geographic regions (USFWS 2015b; fig. 2.). The Kootenai geographic region was included with the adjacent areas in British Columbia for potential donor sources in consideration of robust populations available in British Columbia. It was recognized that this region is in a separate drainage than the introduction site, and that gene flow rarely occurs between major river drainages (Ardren and others, 2011). However, bull trout in the Kootenai geographic region are within the interior evolutionary lineage, similar to those in the Lower Clark Fork geographic region (Ardren and others, 2011). The third genetic risk is that donor sources could be hybridized with brook trout, and the introduction of bull-brook hybrids into Sullivan Lake ecosystem would conflict with the goals of bull trout introduction. Areas where brook trout and/or bull-brook hybrids co-exist with potential donor sources were identified (Hardiman and others, 2022).

Donor Sources

The development of a donor source population list began with a literature review and discussions between USGS and KT fish biologists to identify potential donor source populations for translocation of bull trout into the Sullivan Lake watershed (Hardiman and others, 2022). We included populations that were within the Lower Clark Fork and Kootenai geographic regions (USFWS, 2015b) and adjacent areas in British Columbia (fig. 2) that had information available on population attributes for ranking. The Kootenai geographic region was considered due to the potential of robust populations within the British Columbia areas, but with an understanding that these populations are within a separate drainage from the introduction site and historical connectivity was unlikely. Other geographic regions within the CHRU were not considered likely viable options due to low abundance of potential donor source populations, separate river drainage, and conservation threats, such as Coeur d'Alene region. The Flathead geographic region was not considered as a viable source for donor populations due to generally low abundance populations; its remote location in areas designated as wilderness, making access and fish collection difficult; and the distance to transport to the introduction site is far and crosses multiple state boundaries. Although the South Fork Flathead River population above Hungry Horse Reservoir may be considered viable based on population abundance, it was not considered due to reasons already stated. Furthermore, these populations are within a separate core area, which has shown genetic divergence from the LPO/Clark Fork populations (Spruell and others 2003) and could pose higher risk for transport of pathogens between subbasins and state boundaries.

A donor source table was compiled with key information to share with work group members prior to the first meeting along with guidance materials about the development of the risk assessment process (Hardiman and others, 2022). During each work group meeting, the donor source table was presented, and feedback was solicited from members as to its completeness. Regional resource managers and biologists reviewed and provided additional information to the table and updates were re-distributed to work group members prior to the next meeting. Key information on donor source population attributes was provided to natural resource managers and regional biologists for assessment and ranking of potential donor sources. This information included distribution, life history behavior (migratory), population abundance, population trends, viability and conservation threats, and environmental condition considerations at donor population locations (Hardiman and others, 2022). The information was obtained from a variety of sources, including State, Tribal, and natural resource consultant reports summarizing regional redd and adult bull trout survey results, USFWS recovery planning and status assessment documents, peer-reviewed literature, and British Columbia, Ministry of the Environment reports.

Donor Source Attributes

A set of population attributes were identified by USGS and KT biologists to develop a decision framework and ranking criteria guidelines in which potential donor sources could be ranked. These attributes and ranking criteria were developed on the basis of available regional data and review of reintroduction risk frameworks and conservation assessments (Fredenberg and Chan 2005; Fredenberg and others, 2005; Dunham and others, 2011; Hagen and Decker, 2011; Galloway and others, 2016; Hardiman and others, 2017). The set of attributes, ranking criteria, and decision framework were presented and discussed with work group members during regional meetings. Meeting discussions and outcomes contributed to the final selection of population attributes and decisions for weighting of attributes for the donor source ranking framework. Attributes were scored on a scale from 0 to 5, with 0 being the lowest and 5 being the highest score. Scores were provided from fishery resource managers and biologists who have current or historical knowledge of the donor source population and were based on the information provided in the donor source table (Hardiman and others, 2022). One set of scores was provided to represent each entity with working knowledge of that donor source and was generally a consensus of multiple biologists and managers from that entity. The work group agreed that resource managers and fish biologists with the most knowledge of donor source populations should rank the populations, and that regional stakeholders without working knowledge of the populations would not provide attribute scores. This decision resulted in fewer entities providing scores for donor source populations, therefore variation about entity scores was not always available. Individual entity scores generally involved multiple biologists or resource managers providing input for the final consensus score submitted for this assessment. For example, Lake Pend Oreille, Priest Lakes, and the Priest River regions were scored by both IDFG and KT biologists. The rank sum scores between these two entities were similar, even when the attribute scores by individual biologists differed (Hardiman and others, 2022). The KT biologists deferred to the IDFG scores for the final ranking summary on the basis of the IDFG biologists' working knowledge of the populations. The Lower Clark Fork region was scored by Avista biologists, with review and input by regional biologists from MFWP and USFWS. The Salmo River region was scored individually by KT and British Columbia biologists, with the final attribute scores representing an average of the scores by these two entities. The Kootenai River region included scores by the British Columbia Ministry of Forests, Lands, and Natural Resource Operations, primarily focused on populations in British Columbia, and a combination of input from IDFG, MFWP, USFWS, and USGS; final attribute scores represent the average values of the scores from those individual entities if more than one entity provided scores for populations within this region. All scores were reviewed by the work group and additional information or review, was sought out to address concerns among work group members before scores were finalized for this assessment.

Decision Framework

The decision framework consisted of five population attributes that were summed for each donor source population, and the highest sum score was ranked as the preferred choice (fig. 3). Summed scores, that resulted in tied ranks, were assigned the same rank number, and the next highest score was assigned a rank corresponding to the next population donor count including all tied populations. For example, if donor source population ranks were assigned as follows: 1, 2, 2, 2, then the next highest sum score was ranked a 5. Weights were added to some attributes to emphasize or lessen the importance of an individual attribute as determined during work group meetings. The attribute sum scores were used to determine preferred donor source populations.

Donor Source Population Attributes

To determine potential donor sources suitable for introduction, the work group considered a variety of population attributes based on previous bull trout reintroduction frameworks and conservation assessments (Fredenberg and Chan 2005; Fredenberg and others, 2005; Dunham and others, 2011; Hagen and Decker, 2011; Galloway and others, 2016; Hardiman and others, 2017). Attributes considered for the final ranking process included life history, abundance, viability, feasibility of collection, and environmental match.

Migratory Life History

An adfluvial life history strategy is likely most compatible with the Sullivan Lake ecosystem. Although migratory distances vary, the adfluvial life history strategy is the dominant life history found in most of the core areas within the CHRU (USFWS, 2015b). Conservation and restoration of the migratory life history form in the CHRU is emphasized (USFWS, 2015b). In some populations (middle and upper Clark Fork), migration has become limited due to habitat fragmentation and barriers such as dams, and in these cases the populations are now considered to express more of a resident life history (USFWS, 2015b). It has been observed that bull trout can be flexible in their life history strategy and that given suitable habitat conditions, resident populations can reestablish their natural migratory pattern (Dunham and others, 2014; Al-Chokhachy and others, 2015).

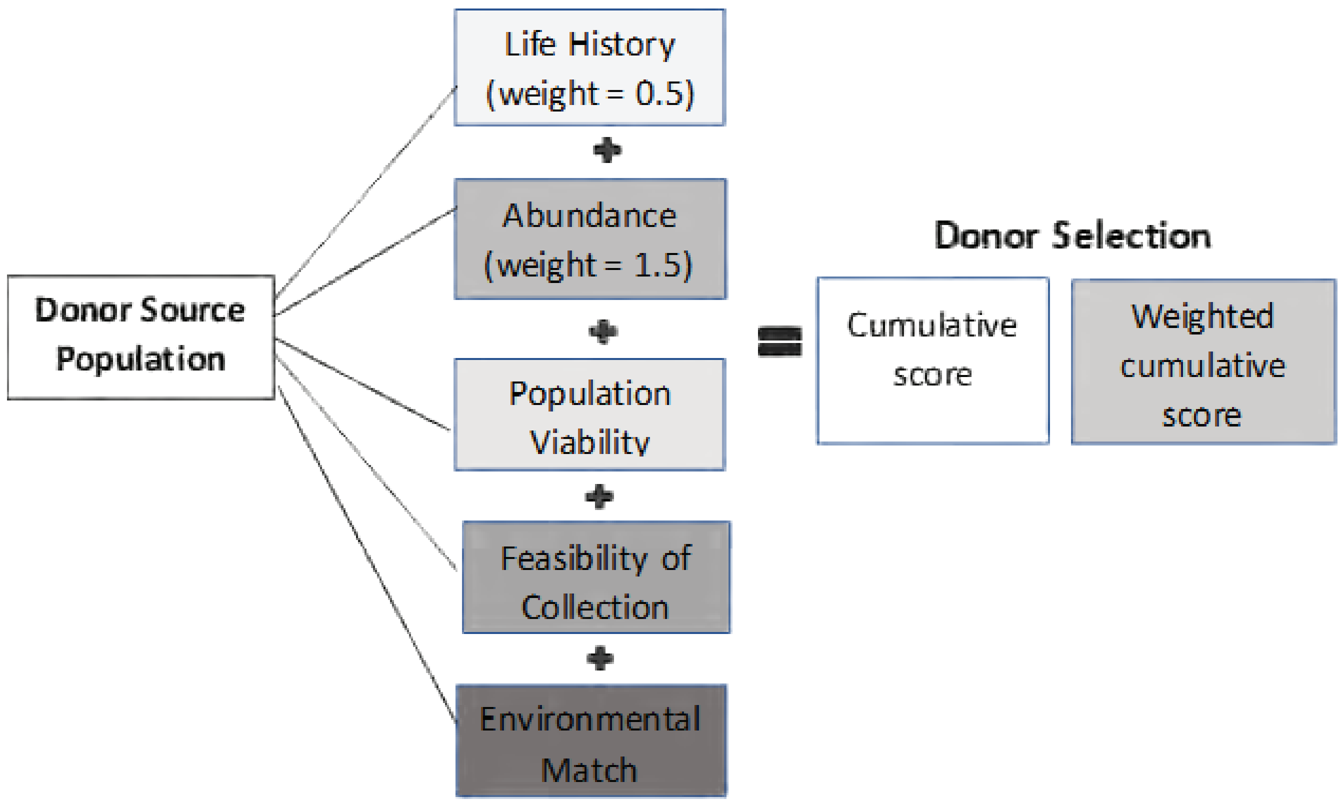


Figure 3. Decision framework diagram for bull trout donor source selection showing donor source population attributes and weights used to rank donor sources. If no weight is specified it is equal to 1.

Abundance

The donor source population abundance is important to consider when assessing the potential demographic risk of removing individuals from the donor population. Criteria for ranking abundance were based on guidelines from previous conservation assessments (Fredenberg and Chan 2005; Fredenberg and others, 2005; Hagen and Decker, 2011). The assumption is that a larger population will be more robust, but many of the populations listed by donor location (individual tributaries) are relatively small and may be considered as part of the larger regional population (or metapopulation). Previous reintroduction assessments have recommended the use of bull trout donor populations with spawner abundances greater than 1,000 spawning adults per year because the demographic risk to the donor population increases as spawner abundance declines below 1,000 individuals (Rieman and Allendorf, 2001; Dunham and others, 2011). Other studies in regions where bull trout populations are present in smaller geographic areas, such as at Glacier National Park, Montana, have used other abundance metrics such as catch per net hour (Galloway and others, 2016). Catch and abundance data are not consistently collected and available throughout the CHRU.

Population Viability

Population viability was included as a ranking attribute to further address minimizing demographic risk of removing individuals from source populations. This attribute takes into consideration population trends, whether decreasing or increasing, area of population occupancy within a larger core area, connectivity, and potential threats to maintaining or recovering a population (Fredenberg and others, 2005). Potential threats may include degradation of habitat by land-use practices (such as forestry, mining, and increased infrastructure, among others), invasive or introduced species (such as brook trout hybridization, competition, and predation), fragmentation of habitat by natural and (or) man-made barriers, and water quality. Considerations include the potential severity, immediacy, and scope of threats (high, imminent, moderate, potential, low, or very low) (Fredenberg and others, 2005).

Feasibility

The feasibility of collecting individuals from a donor population will vary among populations and locations and will influence donor source selection. Considerations include permits (collection and transport across state or international borders), accessible collection locations, methodologies available for collection (efficiency of fish collection or methods already established as feasible), and geographic proximity to minimize distance for transport. For some donor populations, there may be existing recovery or ongoing research and monitoring programs that may allow for easy collection. For example, Kootenay Lake, British Columbia experienced a collapse of kokanee (*O. nerka*) (considered a primary prey source for bull trout) in the system, while the bull trout population remained strong, a program for bull trout removal was under consideration (Will Warnock, British Columbia Ministry of Forests, Lands, and Natural Resources, written commun., September 18, 2020).

Environmental Match

This attribute considers similarity of donor source habitat to that of the introduction site (such as river and lake components and migration distances). Suitability of the Sullivan Lake ecosystem for bull trout introduction was not considered in this risk assessment because it was previously determined to be suitable (Dunham and others, 2014; Benjamin and others, 2019; Mims and others, 2019).

Ranking Criteria

Ranking criteria guidelines for the population attributes were developed from review of reintroduction risk frameworks and conservation assessments (Fredenberg and Chan 2005; Fredenberg and others, 2005; Dunham and others, 2011; Hagen and Decker, 2011; Galloway and others, 2016, Hardiman and others, 2017). For many of the ranking criteria guidelines, the work group relied heavily on the bull trout conservation assessments by USFWS (Fredenberg and Chan 2005; Fredenberg and others, 2005).

Life History

An adfluvial life history strategy is likely most compatible for the Sullivan Lake ecosystem. Life history was assigned to donor source populations through literature review and discussions with regional biologists.

- Resident; Rank = 0
- Unknown; Rank = 1
- Resident, historical fluvial and adfluvial; Rank = 2
- Fluvial; Rank = 3
- Adfluvial and fluvial mix; Rank = 4
- Adfluvial and allacustrine (migratory distance like introduction site); Rank = 5

Abundance

Rank scores were based on conservative estimates for the number of bull trout adults within the donor source population area (tributary or region). Abundance data are not consistently collected or available throughout the geographic area of interest. Data available include adult counts, redd counts, and density estimates (counts per 100 square meters [m^2]). Extrapolation, interpolation of the available data, and expert judgement were used to assign rank scores.

- 1–25 adults; Rank = 0
- 26–50 adults; Rank = 1
- 51–250 adults; Rank = 2
- 251–500 adults; Rank = 3
- 501–1,000 adults; Rank = 4
- > 1,000 adults; Rank = 5

Population Viability

Population trend data are sparsely available and not consistently collected. Therefore, rank scores were based on expert judgement combined with available data and evaluated using the following criteria. Threats to the population considered included environmental (such as habitat changes, timber practices, barriers, and others), biological (nonnative or introduced species), and conservation (very low numbers, disconnected population, narrow distribution).

- High risk—extremely limited and/or rapidly declining numbers, range, and/or habitat, highly vulnerable to extirpation; Rank = 0
- At risk, imminent, substantial—very limited and/or declining numbers, range, and/or habitat, vulnerable to extirpation. Threats are imminent and substantial; Rank = 1
- At risk, moderate—very limited and/or declining numbers, range, and/or habitat, vulnerable to extirpation; Rank = 2
- Potential risk—because of limited and/or declining numbers, range and/or habitat even though bull trout may be locally abundant in some portions of core area; Rank = 3
- Low risk—stable, bull trout common or uncommon, but not rare, and usually widespread through the core area. Not vulnerable at this time, but may have long-term concerns; Rank = 4
- Very low risk—increasing population numbers, few threats or long-term concerns; Rank = 5

Feasibility of Collection

Criteria were established through discussions with KT and regional biologists, recognizing that uncertainties about feasibility of collection will be a factor. Therefore, criteria were scaled from 0 to 5 on the basis of the potential difficulty of collection or the number of uncertainties in abundance, access, and known methodologies proven viable for collection. Thus, nearby populations, without any known collection constraints, and potential for abundant or excess fish available for collection would be ranked the highest.

- Not very feasible—donor source location far from Sullivan Lake, additional permit requirements, collection feasibility (such as location, methodology, efficiency) unknown; Rank = 0
- Unknown feasibility—such as location, methodology, efficiency; Rank = 1
- Potentially feasible—with known constraints (many); Rank = 2
- Limited feasibility—with some constraints; Rank = 3
- Feasible—with very few constraints; Rank = 4
- Very feasible—close geographic proximity, collection feasible (no known constraints), transport possible, potential excess fish availability from existing program; Rank = 5

Environmental Match

Criteria were established through discussions with KT and regional biologists with the understanding that donor source populations currently experiencing environmental conditions similar to those at the introduction site would likely be best adapted for the introduction site and therefore would be considered the most suitable choice for translocation.

- Ecosystem/habitat is different than at introduction site; Rank = 0
- Primary habitat occupancy/use is lacustrine; Rank = 1
- Primarily riverine habitat; Rank = 2
- Habitat has some lacustrine and riverine aspects; Rank = 3
- Ecosystem/habitat mostly matches conditions of introduction site; Rank = 4
- Ecosystem/habitat is a close match to conditions of introduction site; Rank = 5

Results and Discussion

Resident Species

The risks associated with the introduction of bull trout to resident species in Sullivan Lake were evaluated through review of available literature and workgroup discussion. The fish assemblage of Sullivan Lake consists of seven native species, five introduced species, and two hybrid types (rainbow trout [*Oncorhynchus mykiss*] crossed with a westslope cutthroat trout [*O. clarkii. lewisii*], and tiger trout, which are brook trout crossed with a brown trout [*Salmo trutta*]; both introduced) (Nine and Scholz, 2005; Andersen and Witte, 2020). The native species of concern for conservation agreed upon by the work group include: westslope cutthroat trout, mountain whitefish (*Prosopium williamsoni*), and pygmy whitefish (*P. coulterii*) (Hardiman and others, 2022). There is evidence that mountain whitefish captured upstream from the historical Mill Pond Dam (removed in 2017) and in the Sullivan Lake Basin are genetically distinct from the Pend Oreille River, mountain whitefish (Small and others, 2020). Pygmy whitefish are a Washington State sensitive species (Hallock and Mongillo, 1998). Two native species not considered of concern for conservation and found to be abundant in 2018, longnose sucker (*Catostomus catostomus*) and redside Shiner (*Richardsonius balteatus*), will provide a potential forage base for bull trout (Eckmann and others, 2018; Andersen and Witte, 2020). Two other native species are slimy sculpin (*Cottus cognatus*) and speckled dace (*Rhinichthys osculus*); little information is available on the current abundance and population trends for these species in Sullivan Lake (Nine and Scholz, 2005; Andersen and Witte, 2020). However, owing to their regional abundance and widespread distribution, bull trout introduction into Sullivan Lake is not considered a conservation threat to these species.

The introduced species identified as a concern for competition, predation, and recreation value are rainbow trout, burbot (*Lota lota*), and kokanee (Hardiman and others, 2022). Introduced species that are not of concern include tench (*Tinca tinca*), which may provide a forage base for bull trout; brown trout, which are assumed to be low to rare in abundance (Hardiman and others, 2022); and tiger trout, of which one individual, which was estimated to be 11 years old, was present in 2018, thus the population has likely aged out since stocking in 2007 (Andersen and Witte, 2020).

Ecological Interactions

The risk assessment of ecological interactions was made on the basis of a literature review of other systems with species assemblages (including bull trout) similar to those in Sullivan Lake. The fish species composition in Sullivan Lake is similar to that in LPO, but with fewer introduced or nonnative species (Hansen and others, 2010; McCubbins and others, 2016). As such, the prey base and ecological interactions among species present in Sullivan Lake may also be similar. Lake trout (*Salvelinus namaycush*), an introduced species, is not present in Sullivan Lake, but is an apex predator in the LPO system. In the LPO system, kokanee dominated the prey species in annual diets of large lake trout, bull trout, and rainbow trout (Clarke and others, 2005). Burbot, not native to Sullivan Lake, is the apex predator and could be of concern for bull trout introduced to Sullivan Lake. Burbot, thought to have been introduced around 1990–92, were first noted in creel surveys in Sullivan Lake in 1992 (Bonar and others, 2000) and since then have become well established, with high recruitment and growth rates (Nine and Scholz, 2005; Andersen and Witte, 2020). Andersen and Witte (2020) found that burbot were 20.8 percent of the species catch composition by weight (35.4 kilograms, 112 individual fish [7.2 percent of total number of catch composition], size range 72–706 millimeters [mm] total length), and it was suggested abundance may have been higher than the electrofishing results indicated (catch per unit effort of 9.7 fish per hr), due to their deep-water preference and cryptic nature. Burbot predation rates on fish is size-related and is influenced by seasonal changes in water temperature (Polacek and others, 2006; Klobucar and others, 2016). Large burbot (greater than 650 mm) are primarily piscivorous and have been observed to consume a higher percentage of salmonids than forage fish in other systems (Klobucar and others, 2016). In Sullivan Lake, burbot are likely to interact with introduced bull trout through direct predation on juveniles and competition via diet overlap.

Bull trout was the top native predator in LPO prior to introduction of lake trout and is considered an apex predator in many lake and riverine systems (Hansen and others, 2010; Lowery and Beauchamp, 2015). In Sullivan Lake, bull trout would be an apex predator and would likely prey upon native species, such as redside shiner (Eckmann and others, 2018), longnose sucker, and whitefish as well as the introduced species (such as kokanee, rainbow trout, juvenile burbot) (Beauchamp and Van Tassell, 2001). During a 2018 fish survey, the most abundant species (based on percentage of total catch number) were redside shiner (37.0%), longnose sucker (25.9%), kokanee (18.0%), burbot (7.2%), and mountain whitefish (5.4%). Trout species (rainbow trout and westslope cutthroat trout) were 4.3 percent of the total catch (Andersen and Witte, 2020). Bull trout would likely encounter and interact with the more abundant resident species, and we would hypothesize that the opportunity for predation rates on these fish would be high. Nine and Scholz (2005) did observe high proportions of both redside shiner and kokanee (35% and 40% of identifiable prey items) in burbot diet samples as well as a high proportion of redside shiner in brown trout diets (68.9% by weight). Redside shiner have been the primary prey item for bull trout in other systems in which they were one of the more abundant species (Eckmann and others, 2018). Bull trout have been observed to feed generally on a variety of species, and this diet varies seasonally (Beauchamp and Van Tassell, 2001; Lowery and Beauchamp, 2015). In Lake Billy Chinook in central Oregon, bull trout become progressively more piscivorous with increasing size where fish are the primary prey item for bull trout greater than 450 mm in fork length. For these larger bull trout, kokanee and other salmonids (primarily rainbow trout and juvenile bull trout) represented the largest fraction of fish prey in the diet, although cyprinids, cottids, and catostomids were present as well (Beauchamp and Van Tassell, 2001). The potential predation impact of introduced bull trout on whitefish is uncertain, but in LPO whitefish species were less than 0.5 percent of the overall biomass identified in the gut content of all piscivore species, except for large lake trout (Vidergar 2000).

Baldwin and McLellan (2005) noted that the relative weight for kokanee in Sullivan Lake was below the national standard and postulated that their abundance could reduce zooplankton abundance in the lake. Andersen and Witte (2020) made similar observations for all species captured, with most fish having relative weights below 100. Sullivan Lake is classified as oligotrophic due to its water clarity and low concentrations of total phosphorus and chlorophyll a (Washington Department of Ecology, 1997). Low levels of nutrients limit zooplankton and macroinvertebrate production, thereby limiting the forage base for primary consumers in the Sullivan Lake food web. Additional predation pressure on kokanee by bull trout could benefit other planktivores by reducing predation pressure on zooplankton in the lake.

Bull trout may also compete for resources (food and space) with westslope cutthroat trout and rainbow trout, and these three trout species have the potential to prey upon eggs, fry, and subadults of the other species, as well as cannibalizing their own species (Beauchamp and Van Tassell 2001). The relative abundance of westslope cutthroat trout and rainbow trout in Sullivan Lake is low (3.5% and 0.8% of total catch number, respectively; Andersen and Witte, 2020). Diet overlap was observed for westslope cutthroat trout and rainbow trout, primarily on aquatic insects and plankton, which also overlaps with kokanee (Nine and Scholz, 2005). Because many species of forage fish are far more abundant in Sullivan Lake than westslope cutthroat trout and rainbow trout and these trout species are often present with bull trout (Beauchamp and Van Tassell, 2001; Hansen and others, 2010; Galloway and others, 2016), it is unlikely that the resident trout in Sullivan Lake system will be a limiting factor for bull trout.

Bull trout and kokanee have the potential to overlap and compete for spawning habitat in Harvey Creek. Kokanee spawn in the lower 600 m of Harvey Creek between mid-October and December (Nine and Scholz, 2005). High densities of kokanee spawning activity could super-impose on bull trout redds and displace eggs, which has been suspected to have occurred with brown trout (Andersen and Witte, 2020). However, in the Deschutes River Basin, the viability of bull trout redds were not observed to be reduced by kokanee spawning and redd superimposition (Weeber and others, 2010). Weeber and others (2010) concluded that kokanee did not scour the stream bed deeply enough to affect bull trout eggs and they found no observed effects on bull trout egg-to-fry survival rates.

Pygmy whitefish, which are native in Sullivan Lake, are a Washington State sensitive species (Hallock and Mongillo, 1998). Factors that threaten their population sustainability include predation by nonnative and introduced species and habitat loss (Hallock and Mongillo, 1998). The population status of pygmy whitefish in Sullivan Lake is currently unknown. During separate fish survey efforts in 2003 by WDFW and Eastern Washington University, one pygmy whitefish was captured by each agency, accounting for less than 1 and 1.5 percent of relative catch abundance (percentage of total fish captured) (Baldwin and McLellan, 2005; Nine and Scholz, 2005). This is a significant decline from survey results in 1994, when pygmy whitefish were about 18 percent of the relative catch abundance (Hallock and Mongillo, 1998). It should be noted that these studies are not directly comparable as different methodologies were used, but the decline in catch numbers remains, as no pygmy whitefish were captured in the most recent fish survey (2018) of Sullivan Lake (Andersen and Witte, 2020). Although fish survey techniques that could capture fish within pygmy whitefish size range were employed in 2018, it is common in a typical fish survey to not capture pygmy whitefish due to their small size (usually under 200 mm) and their tendency to inhabit deeper portions of lake habitat (Hallock and Mongillo, 1998). These deeper areas also provide refuge for pygmy whitefish from predators. Sullivan Lake has an average depth of 58.8 m and a maximum depth of 101.2 m (Baldwin and McLellan, 2005). It is possible that the introduction of burbot and their rapid expansion may have contributed to the decline in pygmy whitefish numbers from 1994 to 2018. The introduction of an additional predator, bull trout, into Sullivan Lake could increase the predation risk to pygmy whitefish but may also apply predation pressure on juvenile burbot. While bull trout predation on pygmy whitefish has been observed (Wyman, 1975), these species often co-exist in many ecosystems (Hallock and Mongillo, 1998; Ardren and others, 2011; Meeuwig and others, 2011), indicating they may co-exist in Sullivan Lake.

Uncertainty about ecological interactions is inherent to the introduction of a new species into a system, such as bull trout into Sullivan Lake and Harvey Creek watershed. Other considerations not yet addressed may be indirect effects on individual species that then in turn affect the overall food web (Ellis and others, 2011). Indirect effects include the potential for zooplankton and macroinvertebrate populations to increase following bull trout predation on kokanee and other smaller forage fish, which feed heavily on zooplankton. Such an effect could have implications for increased growth for zooplanktivores in the system. Increased growth among trout species and burbot could increase competition for resources (space and prey) and increase energetic demands, which could have negative impacts on growth. However, if piscivorous species grow faster, allowing bull trout or burbot to reach size at which fish become their dominant prey item, then more forage fish of a variety of sizes will be available due to decreased gape-width limitations (Beauchamp and Van Tassell, 2001). Thus, the piscivorous species may have a greater predation impact on individual species. Because ecological interactions can be complex and unpredictable, it will be important to monitor food web changes post-introduction to adaptively manage the system and inform future introductions. Further, resource managers will benefit from discussions that focus on acceptable levels of uncertainty and potential risk to individual species, with consideration to the uncertainty around potential ecological interactions and risk management scenarios associated with bull trout introduction.

Pathogen Risks

There is no pathogen survey information for Sullivan Lake and Harvey Creek watershed. The nearest upstream watershed, where pathogen surveillance took place is in the Clark Fork River in 2014 and 2019, above Cabinet Gorge Dam (Cordes, 2020). No bull trout samples were collected in that study. Another report of pathogen surveillance of salmonids in the Lower Clark Fork River and Lake Pend Oreille (Sprague, 2020) included 60 bull trout (from Lake Pend Oreille) for pathogen surveillance in 2018 and found one sample positive with *Renibacterium salmoninarum* (Rs), which cause bacterial kidney disease (BKD); no other pathogens were detected. Due to the limited nature of spatially appropriate pathogen surveillance, the Pend Oreille River Basin was used as a spatial proxy or surrogate for Sullivan Lake for analysis of pathogens detected in bull trout via the USFWS NWFHS data (J. Bader, USFWS, Fish Health Centers Laboratory Information Systems, written commun. March 23, 2022, data available upon request, joel_bader@FWS.gov). Within this region, bull trout were found to be infected with *Myxobolus cerebralis* (Mc), the parasites that cause whirling disease, and Rs between 1999 and 2002 (table 1).

Because of the paucity of bull trout samples for pathogen surveys, the studies in the Clark Fork River tested other salmonids as surrogates, to determine which pathogens might be present in unsampled bull trout (Cordes, 2020). This strategy was also adopted in this study for the analysis of NWFHS data (table 1). Bull trout samples in the NWFHS in general are rare: only 17 of 1,514 (1.1%) fish sampled anywhere within the Columbia River Basin came from bull trout. The majority of the 1,514 fish samples in this area were salmonids, so bull trout is a rarely sampled salmonid species (17 of 1,134 (1.5%) salmonid samples were bull trout). Bull trout samples were found to contain the bacterial pathogen Rs, which causes BKD, and the parasite Mc, which causes whirling disease, but no signs of disease were evident in the fish sampled. The fact that these pathogens are also widely detected in other species in the same region indicate that there is low risk of introducing an unknown pathogen (table 1), and the risk of these two pathogens directly on bull trout is not apparent. However, these two pathogens are known to cause disease in resident species of concern, the most serious of which is whirling disease in trout species. No non-lethal sampling data are available for these two pathogens, so the best method of reducing risk of indirect pathogen burden would be lethal sampling of any bull trout population intended for introduction into the Sullivan Lake ecosystem (American Fisheries Society, 2014 Fish Health Section). The screening of fish populations for known important pathogens before moving the fish is standard procedure in conservation hatchery programs in the Columbia River Basin (American Fisheries Society, 2014 Fish Health Section).

One pathogen of concern is infectious hematopoietic necrosis virus (IHNV). This virus is known to exist throughout the Columbia River Basin in the form of several distinct genetic lineages or genogroups (Breyta and others, 2016, 2017). These genogroups of IHNV are not found in every part of the basin. In watersheds above Grand Coulee Dam (and as far up-basin as the Kootenay River in British Columbia), all IHNV detections are genogroup U, which has been observed to be highly specific for causing acute disease in juvenile kokanee and sockeye salmon (*O. nerka*). The U group IHNV can infect other salmonids but rarely causes disease. Below Grand Coulee Dam, M genogroup IHNV is also present. The M genogroup IHNV is highly specific to steelhead and rainbow trout but sometimes causes disease in Chinook salmon (*O. tshawytscha*), and it is occasionally detected as asymptomatic infections in kokanee and sockeye salmon (Breyta and others, 2016). This means that there is some risk of introducing a form of IHNV via bull trout movement, but the risk to bull trout directly appears less than that of indirect pathogen burden. If bull trout introduced into the Sullivan Lake ecosystem were infected with U group IHNV, it could spread to sympatric kokanee, just as infection with M group IHNV could spread to sympatric rainbow trout and adversely affect the health of those fish. However, as bull trout in natural settings have not been found to be infected with IHNV of any genogroup, and non-lethal sampling for IHNV infection status is being developed to support anadromous salmonid reintroduction by the Confederated Tribes of the Colville Reservation, the risk of this indirect pathogen burden is considered low and easily prevented.

These data indicate that pathogen introduction risk is low, and that indirect pathogen burden risks can be mitigated by using established pathogen surveillance methods. The potential for any detected pathogens to reduce the fitness or viability of introduced bull trout is less clear. None of the pathogen-positive populations recorded in the database described signs of disease, and no reports of clinical or subclinical disease observations in other natural bull trout populations could be found. This finding is not conclusive, because observations of clinical disease are rare for any free-living fish populations. Controlled laboratory studies offer the best way to assess pathogen impacts on animal health for this reason. Published studies of pathogen impacts in bull trout are more limited than for other salmonid species, but they do include three of the most important pathogens of the region. Each pathogen was studied in a single study, and none have been replicated or extended. Each study showed similar results, and although bull trout could be infected by the pathogen of interest, the fish did not develop clinical disease (specifically: BKD; whirling disease; and infectious hematopoietic necrosis [Engelking, 2003; Bartholomew and others, 2003; Jones and others, 2007]). This may indicate that bull trout are unusually refractory to disease compared to other fish species in the region, or it may simply reflect limited resources for pathogen study in bull trout. Therefore, the conclusion for this component of the risk assessment is that it is 'unknown' instead of being present at a ranked threat level. Ongoing pathogen surveillance during the bull trout introduction program would support disease mitigation adaptive management.

Genetic Risks

Among the geographic regions with potential donor source populations, the estimated bull trout abundance was highest in LPO and its tributaries (estimated 2,500–12,000 individuals), followed by tributaries in the Kootenai River Basin (Hardiman and others, 2022). Thus, suggesting these regions would be the most resilient in absorbing negative demographic effects related to the removal of individuals for introduction into Sullivan Lake. Rieman and Allendorf (2001) indicated genetic variation may be maintained in populations that support more than 1,000 spawning adults, subsequently Dunham and others (2011) suggested that donor populations consist of at least 1,000 spawning adults per year. Although no single tributary within a region may contain 1,000 spawning adults, donors could be collected from several tributaries within a region. This would reduce the impact on any single tributary, particularly if the populations function as a metapopulation in which individuals interbreed and exchange genes across spawning tributaries. Mims and others (2019) demonstrated through reintroduction modeling scenarios that demographic risk to source populations was less if riverscape topology (and lack of barriers) allowed for connectivity among populations.

The likelihood that bull trout introduced into Sullivan Lake stray and spawn with native bull trout is low. Currently, no self-sustaining bull trout populations exist in the Pend Oreille River or tributaries between Albeni Falls Dam and Boundary Dam. In addition, it is unlikely that fish would be entrained through Sullivan Lake Dam based on the outflow configuration (screened intake pipe located at a lower depth on the dam) at and below Sullivan Lake Dam. The nearest bull trout populations are downstream in the Salmo River system in British Columbia, which is separated by two dams without fish passage, Sullivan Lake Dam and Boundary Dam (Pend Oreille River). The nearest upstream populations are LPO and Priest Lakes Core Areas, which are separated by three dams without fish passage: Sullivan Lake Dam, Box Canyon Dam and Albeni Falls Dam. Fish passage facilities are scheduled to be installed at both Box Canyon Dam and Albeni Falls Dam. If bull trout were entrained through Sullivan Lake Dam, they could either (1) migrate downstream, become entrained over Boundary Dam, and spawn with native bull trout in the

Salmo River system, or (2) migrate upstream and spawn with native bull trout in the LPO or Priest River Basin after passage facilities are constructed at Box Canyon Dam and Albeni Falls Dam.

Nearest-neighbor donor source populations could minimize negative fitness effects that may occur from straying and interbreeding of individuals that become entrained, which would help maintain natural patterns of genetic diversity in native populations. For bull trout introduction into Sullivan Lake, a donor source from the LPO Basin is preferred because Pend Oreille and Salmo River populations appear more closely related relative to the Kootenai region (Ardren and others, 2011). A high level of genetic variation has been observed in bull trout in the Kootenai region, but the levels of genetic diversity observed were similar to those observed for bull trout in the LPO and Clark Fork regions (Ardren and others, 2011). There is a high level of genetic variability among populations, even within close proximity, owing to high stream fidelity rates observed in bull trout (Spruell and others, 2003; Ardren and others, 2011).

Brook trout and bull-brook hybrids have been observed in the habitats of numerous potential donor source populations (Hardiman and others, 2022). It is important to avoid introducing bull-brook hybrids along with bull trout into Sullivan Lake because Sullivan Lake bull trout could serve as a brood source for future local supplementation and reintroduction programs. Hybridization between bull trout and brook trout has been identified in habitats where the two species coincide (Leary and others 1993; Kanda and others 2002; Ardren and others 2007; DeHaan and others 2010). First generation hybrids appear to be the dominant form of bull-brook hybrid (Leary and others 1993; Kanda and others 2002; Ardren and others 2007), suggesting bull-brook hybrids may suffer reduced fitness. However, individuals hybridized beyond the first generation are not necessarily uncommon (Kanda and others 2002; Ardren and others 2007; DeHaan and others 2010) and their presence indicates hybrids are capable of reproduction, suggesting brook trout genes may introgress into bull trout populations. The risk of introducing hybrids could be minimized by genotyping individuals prior to their introduction. In addition, brook trout are found below Sullivan Lake Dam. While the risk of entrainment of bull trout through Sullivan Lake Dam is low, entrained bull trout could potentially hybridize with brook trout that occupy habitats below Sullivan Lake Dam. If hybrids were to spread downstream into the Salmo River or upstream after fish passage has been constructed at Box Canyon Dam and Albeni Falls Dam, they may pose an additional risk to bull trout populations through further hybridization.

Donor Source Populations and Rankings

The donor source ranking table, organized by geographic region and donor source population, includes 49 source populations (table 2). It was largely compiled of populations within the Lower Clark Fork and Kootenai geographic regions (fig. 2; USFWS, 2015b) and adjacent areas in British Columbia for which data were available but is not all inclusive (Hardiman and others, 2022). Populations were organized within six primary core areas, including: Lake Pend Oreille, Priest Lakes, Priest River, Lower Clark Fork River, Salmo River, and Kootenai River. Inclusion of these populations was based on discussions with regional biologists. The Kootenai River core area was included after discussion with British Columbia biologists who suggested the potential for British Columbia populations in this geographic region be used as a donor source. Donor source population attributes were assigned scores, using ranking criteria and expert opinion by regional biologists, and summarized using the decision framework (fig. 3) for overall ranking of selection for introduction (table 2). A weight of 0.5 was applied to the life history attribute, recognizing that bull trout exhibit a high level of plasticity when it comes to life history behavior (Shively and others, 2007; Al-Chokhachy and others, 2015). A weight of 1.5 was applied to the abundance attribute, emphasizing more abundant populations to reduce overall demographic risk to donor sources (Rieman and Allendorf, 2001; Dunham and others, 2011). The final rankings were generally consistent between the non-weighted and weighted scores (table 2). The LPO metapopulation (including all tributaries specified in section 1 of table 2) was the top ranked donor source. Granite Creek/Sullivan Springs, South Gold Creek/West Gold Creek, and Pack River Basin (metapopulation of tributaries within), within the LPO region, tied as the second choice for both the non-weighted and weighted ranking. Trestle Creek, Grouse Creek, (also within the LPO region), Upper Kootenai River/Lake Koocanusa and Wigwam River (including areas within the British Columbia portion of the Kootenai River region), ranked next highest for the non-weighted ranking. The Kootenai region populations were ranked higher among the weighted ranks (tie for second highest rank). The next highest-ranking populations included Kootenay Lake (Lower Kootenai River, British Columbia region), Lightning Creek Basin (metapopulation including tributaries within), and Caribou Creek (within the Pack River Basin). Within the Lightning Creek Basin, the East Fork Lightning Creek and Rattle Creek had the highest rank scores (12 for both non-weighted and weighted). The Upper Priest Lake tributaries also ranked 12, followed by Priest River tributaries (which included both Middle Fork East River and Uleda Creek, a tributary of the former) which ranked 15, this was the same rank for Middle Fork East River as a single source donor population. The Lower Clark Fork River and tributaries, and Salmo River were ranked the lowest and would not be considered viable single-source donor populations for an introduction program into Sullivan Lake. These populations scored low due to low abundance, poor viability, and high conservation threats, and unknown or low feasibility of collection. Additionally, many of the Lower Clark Fork source populations had low scores for the life history attribute, suggesting low compatibility with the life history strategy desired for bull trout introduced into the Sullivan Lake ecosystem.

Table 2. Summary of donor source population attribute scores and ranking by region (bold, numbered) and tributaries, subbasins (indicated by the tenth decimal place; tributaries within a subbasin are indicated by the hundredth) within these regions for potential donor populations.

[Attribute rank scores are summarized (rank sum) for each donor source and the highest score is assigned a rank of 1, with consecutively higher numbered ranks representing lower rank sum scores. The weighted rank sum summarized the rank scores with attribute weights applied. Tied scores were assigned the same rank value, with the next highest score being assigned the next consecutive count rank (including tied scores, such as scores of 1, 2, 2, 2, would have the next consecutive rank = 5). **Attribute abbreviations**: LH=Life history; A=Abundance; V=Viability; FC=Feasibility of collection; EM=Environmental match. Other abbreviations: U.S.= United States, B.C.= British Columbia]

Region	Donor source	Attribute weights					Rank sum	Weighted rank sum	Rank	Weighted rank
		0.5	1.5	1.0	1.0	1.0				
		Attributes, ranks 0–5 (low to high)								
		LH	A	V	FC	EM				
1. Lake Pend Oreille	Lake Pend Oreille tributaries	5.0	5.0	5.0	5.0	5.0	25.0	25.0	1	1
	1.1 Trestle Creek	5.0	4.0	3.0	4.0	5.0	21.0	20.5	5	7
	1.2. Johnson Creek	5.0	2.0	2.0	2.0	5.0	16.0	14.5	20	21
	1.3. Strong Creek	5.0	1.0	1.0	1.0	5.0	13.0	11.0	33	34
	1.4. Granite Creek/Sullivan Springs	5.0	4.0	4.0	4.0	5.0	22.0	21.5	2	2
	1.5. North Gold Creek	5.0	2.0	1.0	1.0	5.0	14.0	12.5	29	30
	1.6. South Gold Creek/West Gold Creek	5.0	4.0	4.0	4.0	5.0	22.0	21.5	2	2
	1.7. Pack River Basin (Pack River, Grouse Creek, Caribou Creek, Hellroaring Creek)	5.0	4.0	5.0	3.0	5.0	22.0	21.5	2	2
	1.7.1. Pack River	5.0	2.0	2.0	2.0	5.0	16.0	14.5	20	21
	1.7.2. Grouse Creek	5.0	3.0	4.0	4.0	5.0	21.0	20.0	5	8
	1.7.3. Caribou Creek	5.0	3.0	4.0	3.0	5.0	20.0	19.0	9	11
	1.7.4. Hellroaring Creek	5.0	2.0	3.0	3.0	5.0	18.0	16.5	15	17
	1.8. Lightning Creek Basin (Lightning Creek, East Fork Creek, Savage Creek, Char Creek, Porcupine Creek, Wellington Creek, Rattle Creek, Morris Creek)	5.0	4.0	4.0	2.0	5.0	20.0	19.5	9	10
	1.8.1. Lightning Creek	5.0	2.0	2.0	2.0	5.0	16.0	14.5	20	21
	1.8.2. East Fork Lightning Creek	5.0	3.0	4.0	2.0	5.0	19.0	18.0	12	12
	1.8.3. Savage Creek	5.0	2.0	2.0	2.0	5.0	16.0	14.5	20	21
	1.8.4. Char Creek	5.0	1.0	1.0	1.0	5.0	13.0	11.0	33	34
	1.8.5. Porcupine Creek	5.0	2.0	3.0	2.0	5.0	17.0	15.5	18	18
	1.8.6. Wellington Creek	5.0	2.0	2.0	2.0	5.0	16.0	14.5	20	21
	1.8.7. Rattle Creek	5.0	3.0	4.0	2.0	5.0	19.0	18.0	12	12
	1.8.8. Morris Creek	5.0	2.0	2.0	2.0	5.0	16.0	14.5	20	21

Table 2. Summary of donor source population attribute scores and ranking by region (bold, numbered) and tributaries, subbasins (indicated by the tenth decimal place; tributaries within a subbasin are indicated by the hundredth) within these regions for potential donor populations.—Continued

[Attribute rank scores are summarized (rank sum) for each donor source and the highest score is assigned a rank of 1, with consecutively higher numbered ranks representing lower rank sum scores. The weighted rank sum summarized the rank scores with attribute weights applied. Tied scores were assigned the same rank value, with the next highest score being assigned the next consecutive count rank (including tied scores, such as scores of 1, 2, 2, 2, would have the next consecutive rank = 5). **Attribute abbreviations**: LH=Life history; A=Abundance; V=Viability; FC=Feasibility of collection; EM=Environmental match. Other abbreviations: U.S.= United States, B.C.= British Columbia]

Region	Donor source	Attribute weights					Rank sum	Weighted rank sum	Rank	Weighted rank
		0.5	1.5	1.0	1.0	1.0				
		Attributes, ranks 0–5 (low to high)								
		LH	A	V	FC	EM				
2. Priest Lakes	Priest Lake tributaries (5 local populations: Upper Priest River, Hughes Fork Creek, Gold Creek, North Fork Granite Creek, North Fork Indian Creek)	5.0	2.0	3.0	2.0	5.0	17.0	15.5	18	18
	2.1. Upper Priest Lake Tributaries	5.0	3.0	4.0	2.0	5.0	19.0	18.0	12	12
3. Priest River	Priest River tributaries	5.0	3.0	3.0	2.0	5.0	18.0	17.0	15	15
	3.1. Middle Fork East River	5.0	3.0	3.0	2.0	5.0	18.0	17.0	15	15
	3.1.1. Uleda Creek (Middle Fork East River tributary)	5.0	1.0	1.0	1.0	5.0	13.0	11.0	33	34
4. Lower Clark Fork River and tributaries	Lower Clark Fork River tributaries	2.5	1.0	0.5	2.5	3.0	9.5	8.8	40	39
	4.1. Cabinet Gorge Reservoir/tributaries	5.0	1.5	1.0	3.0	3.0	13.5	11.8	32	33
	4.1.1. Bull River	0.5	0.0	0.0	2.0	3.0	5.5	5.3	45	45
	4.1.2. East Fork Bull River	3.5	0.0	0.0	3.0	3.0	9.5	7.8	40	41
	4.1.3. South Fork Bull River	0.5	0.0	0.0	2.0	3.0	5.5	5.3	45	45
	4.1.4. Rock Creek	0.5	0.0	1.0	2.0	2.0	5.5	5.3	45	45
	4.2. Noxon Reservoir/tributaries	2.0	1.0	1.0	3.0	3.0	10.0	9.5	38	38
	4.2.1. West Fork Trout Creek	0.0	0.0	0.5	2.0	2.0	4.5	4.5	48	48
	4.2.2. Vermillion River	2.0	0.0	0.0	3.0	3.0	8.0	7.0	42	42
	4.2.3. Graves Creek	4.0	0.0	3.0	4.0	3.0	14.0	12.0	29	31
	4.2.4. Cooper Gulch	0.0	0.0	0.5	1.0	2.0	3.5	3.5	49	49
	4.3. Thompson River and tributaries (West Fork Thompson Creek, Fishtrap Creek, West Fork Fishtrap Creek, Beatrice Creek, and Jungle Creek)	2.0	0.0	1.0	1.0	3.0	7.0	6.0	44	44
5. Salmo River	Salmo River and tributaries (including Sheep Creek, Clearwater Creek, South Salmo River, Hidden Creek and others)	4.3	2.3	1.5	2.0	3.0	13.0	12.0	33	31

Table 2. Summary of donor source population attribute scores and ranking by region (bold, numbered) and tributaries, subbasins (indicated by the tenth decimal place; tributaries within a subbasin are indicated by the hundredth) within these regions for potential donor populations.—Continued

[Attribute rank scores are summarized (rank sum) for each donor source and the highest score is assigned a rank of 1, with consecutively higher numbered ranks representing lower rank sum scores. The weighted rank sum summarized the rank scores with attribute weights applied. Tied scores were assigned the same rank value, with the next highest score being assigned the next consecutive count rank (including tied scores, such as scores of 1, 2, 2, 2, would have the next consecutive rank = 5). **Attribute abbreviations**: LH=Life history; A=Abundance; V=Viability; FC=Feasibility of collection; EM=Environmental match. Other abbreviations: U.S.= United States, B.C.= British Columbia]

Region	Donor source	Attribute weights					Rank sum	Weighted rank sum	Rank	Weighted rank
		0.5	1.5	1.0	1.0	1.0				
		Attributes, ranks 0–5 (low to high)								
		LH	A	V	FC	EM				
6. Kootenai River	Includes a region within B.C., Idaho, and Montana (Lake Koocanusa, Kootenai River and tributaries, Bull Lake and Kootenay Lake, B.C.)	4.0	3.0	3.0	2.5	3.0	15.5	15.0	27	20
	6.1. Upper Kootenai River/ Lake Koocanusa (Wigwam River, Gold Creek, Middle and North Forks of the White River, Skookumchuck and Redding Creeks, B.C.)	4.0	5.0	5.0	4.0	3.0	21.0	21.5	5	2
	6.1.1. Grave Creek (U.S.)	4.0	2.0	540	1.0	3.0	14.0	13.0	29	29
	6.1.2. Wigwam River (B.C.)	4.0	5.0	5.0	4.0	3.0	21.0	21.5	5	2
	6.2. Middle Kootenai River and tributaries, downstream of Libby Dam and upstream of Kootenai Falls (West Fisher, Libby, Bear, Pipe, and Quartz Creeks)	3.0	3.0	2.0	1.0	2.0	11.0	11.0	37	34
	6.3. Lower Kootenai River tributaries, downstream of Kootenai Falls (O'Brien and Callahan Creeks. U.S.)	4.0	1.0	1.0	1.0	3.0	10.0	8.5	38	40
	6.3.1 Lower Kootenai River, Kootenay Lake, B.C.	4.0	4.0	5.0	4.0	3.0	20.0	20.0	9	8
	6.4 Moyie Lake (B.C.)	5.0	1.0	1.0	4.0	5.0	16.0	14.0	20	27
	6.5. Bull Lake (Keeler Creek)	5.0	2.0	2.0	2.0	4.0	15.0	13.5	28	28
	6.6. Sophie Lake (Phillips Creek)	4.0	1.0	0.0	0.0	3.0	8.0	6.5	42	43

Next Steps and Administrative Pathways for Bull Trout Introduction

At the completion of this risk assessment, various administrative alternatives are possible for moving forward with the introduction of bull trout into the Sullivan Lake and Harvey Creek watershed. This assessment is only one step in the process of development and implementation of a bull trout introduction program. These administrative alternatives include: Section 6 agreement, Section 7 on a Memorandum of Agreement or Conservation Agreement, Section 4(d) Rule, Section 10(a)1(A) Recovery permits, and Section 10(j) Experimental Population (National Oceanic and Atmospheric Administration, and National Marine Fisheries Service, 2020). Once an administrative pathway has been identified (Dunham and others, 2016), the details of how the introduction project is to be implemented, monitored, and reported, including agency roles and responsibilities would be determined.

Conclusions

Through risk assessment and stakeholder engagement, several suitable donor source populations within the Columbia Headwaters Recovery Unit (CHRU) were identified for a bull trout introduction program into Sullivan Lake and Harvey Creek watershed. The decision selection framework allowed for consideration of multiple population attributes in selecting the highest-ranking source populations. The demographic risk to the donor source population is considered relatively low if higher ranked populations are selected. Using both weighted and unweighted metrics, the Lake Pend Oreille (LPO) source population (metapopulation) ranked as the top choice and is considered a robust and stable population. The individual LPO tributary populations were less abundant and had lower population viability scores with more constraints or uncertainty around the feasibility of sample collection. However, in a metapopulation context, it may be appropriate to use some of these individual tributary sources as part of a pooled selection of individuals (removing small numbers from individual tributaries) for introduction into Sullivan Lake. Connectivity among donor populations will reduce the demographic risk imposed by removing individuals from these populations. The ranking process allows for identification of the tributaries with the highest rank scores as those from which to select donors for the introduction program. The donor source populations within the Kootenai geographic region (Upper Kootenai River/ Lake Koocanusa, Wigwam River, and Kootenay Lake), primarily within British Columbia, also ranked high; but these populations appear to be in a separate genetic cluster from LPO populations, suggesting little to no connectivity with populations adjacent to the introduction site. Consideration of source populations from the Kootenai geographic region may warrant further discussion focusing on genetic diversity and conserving the genetic integrity of regional populations, including the Salmo River population. All the populations within the CHRU are within the interior evolutionary lineage of bull trout and still can have a high level of genetic variability within close proximity populations. Many of the donor source populations within the CHRU region are relatively small, with less than 50 reproducing adults, and thus are more at risk to genetic drift and inbreeding in the absence of connectivity to other stream networks. The introduction of some genetic variation may counterbalance the risk of inbreeding depression in the more geographically isolated populations. Within the Priest Lakes Core Area, the Upper Priest Lake tributaries and Priest River Tributaries would also be viable donor source options.

The risk of introducing pathogens into Sullivan Lake via a bull trout introduction program appears to be low, and indirect pathogen burden risks to resident species can be mitigated by using established pathogen surveillance methods including screening of bull trout prior to translocation. However, the ultimate effect of any introduced pathogens on bull trout health and the success of the introduction program is uncertain owing to the lack of clinical or subclinical disease observations in natural bull trout populations. Routine pathogen surveillance, such as that conducted by the U.S. Fish and Wildlife Service and Washington Department of Fish and Wildlife (both agencies follow American Fisheries Society [2014] Fish Health Section Blue Book guidelines), appears to be an effective method for addressing the unknown impact of pathogens on bull trout. Because pathogen avoidance has been shown to be an effective control strategy, pathogen screening prior to translocation of bull trout is an appropriate pathogen mitigation action. Pathogen screening within Sullivan Lake prior to introduction efforts would also be prudent, with continued, post-introduction bio-surveillance.

The ecological risk that a bull trout introduction presents to resident species appears to be low but with some uncertainty. Sullivan Lake currently supports a mix of native and introduced fish species. Bull trout within the Kootenai, Pend Oreille, and Clark Fork River ecosystems have coevolved with assemblages of westslope cutthroat trout and mountain and pygmy whitefish, suggesting that these species can co-exist in Sullivan Lake. Pygmy whitefish, a Washington State Sensitive species, is likely the most vulnerable species to extirpation with introduction of an additional piscivore into the ecosystem. The status of the pygmy whitefish in Sullivan Lake is unknown, and this population may already be at risk, possibly due to the past illegal introduction of burbot. To better understand the risk bull trout may pose to the resident whitefish species, targeted fish surveys for these species and specifically for pygmy whitefish (Pyle, 2015), would be necessary to determine a baseline abundance prior to a bull trout introduction. Additionally, fish surveys and food web analysis prior to an introduction program would fill data gaps on resident species abundance and provide a baseline for effectiveness monitoring and identifying ecosystem changes post-bull trout introduction. The ecological risks likely to affect viability of introduced bull trout are predation by burbot and maintenance of an adequate forage base in Sullivan Lake. With the introduction of an additional piscivore, many potential changes could occur within the food web, and there is uncertainty about the effects of such changes. Changes in the food web, such as kokanee abundance, could result in higher predation rates on sensitive native species, such as the whitefish, and changes to survival and growth of apex predators. Future planning and implementation phases for bull trout introduction would benefit from consideration of the potential effects of burbot interactions on bull trout and whitefish. It is important to consider the potential for unintended outcomes with the introduction of a new species to the Sullivan Lake ecosystem. As part of the introduction program, fishery managers and stakeholders will need to determine acceptable levels of scientific uncertainty, risk management, and risk containment strategies or adaptive management actions.

With any new species introduction into an ecosystem, there is the potential for unintended outcomes associated with introduction efforts, because introduced species may behave in novel or unexpected ways in a new environment. Establishing a rigorous monitoring program for fish species composition, food web analysis, and fish metrics such as survival and growth, are warranted to inform adaptive management decisions and future introduction programs. Further, documentation of all planning stages and processes throughout the introduction program, consistent monitoring, and identifying outcomes (such as changes in native species abundance, pathogens, habitat use by bull trout, and genetic diversity of the introduced bull trout population) will help to inform other introductions.

A series of work group meetings were held in which briefing materials (including the resident species table and donor source table [Hardiman and others, 2022]), were sent to attendees prior to meeting for review on the risk assessment approach and donor selection framework. Work group meetings were used to present the general risk assessment approach and decision framework and to solicit comments from experts and stakeholders on concerns about the approach. Additionally, all participants were asked to review the information in the resident species and donor source tables for completeness and to provide additional comments and edits as to the completeness of the information presented.

References Cited

Al-Chokhachy, R., Moran, S., McHugh, P.A., Bernall, S., Fredenberg, W., and DosSantos, J., 2015, Consequences of actively managing a small bull trout population in a fragmented landscape: Transactions of the American Fisheries Society, v. 144, no. 3, p. 515–531.

American Fisheries Society, 2014, FHS blue book—Suggested procedures for the detection and identification of certain finfish and shellfish pathogens (2020 ed.): American Fisheries Society, Fish Health Section website, accessed April 2021, at https://units.fisheries.org/fhs/fish-health-section-blue-book-2020/.

Andersen, T., and Witte, B., 2020, Kalispel joint stock assessment annual progress report Project no. 1997-004-00: Usk, Washington, Kalispel Natural Resources Department, 41 p.

Anderson, J.H., Pess, G.R., Carmichael, R.W., Ford, M.J., Cooney, T.D., Baldwin, C.M., and McClure, M.M., 2014, Planning Pacific salmon and steelhead reintroductions aimed at long-term viability and recovery: North American Journal of Fisheries Management, v. 34, p. 72–93.

Ardren, W., DeHaan, P., and Dunnigan, J., 2007, Genetic analysis of bull trout in the Kootenai River Basin—Final report: Longview, Washington, Abernathy Fish Technology Center, U.S. Fish and Wildlife Service and Libby Field Station, Montana Fish, Wildlife, and Parks, 20 p.

Ardren, W.R., DeHaan, P.W., Smith, C.T., Taylor, E.B., Leary, R., Kozfkay, C.C., Godfrey, L., Diggs, M., Fredenberg, W., Chan, J., Kilpatrick, C.W., Small, P.M., and Hawkins, D.K., 2011, Genetic structure, evolutionary history, and conservation units of bull trout in the coterminous United States: Transactions of the American Fisheries Society, v. 140, no. 2, p. 506–525.

Baldwin, C.M., and McLellan, J.G., 2005, Fisheries survey of the limnetic zone of Sullivan Lake, Washington, using hydroacoustics and gill nets, September 2003: Wenatchee, Washington, Washington Department of Fish and Wildlife Report, 29 p.

Baldwin, C.M., and McLellan, J.G., 2008, Use of gill nets for target verification of a hydroacoustic fisheries survey and comparison with kokanee spawner escapement estimates from a tributary trap: North American Journal of Fisheries Management, v. 28, p. 1744–1757.

Bartholomew, J.L., Lorz, H.V., Sollid, S.A., and Stevens, D.G., 2003, Susceptibility of juvenile and yearling bull trout to *Myxobolus cerebralis* and effects of sustained parasite challenges: Journal of Aquatic Animal Health, v. 15, no. 3, p. 248–255.

Benjamin, J.R., Brignon, W.R., and Dunham, J.B., 2019, Decision analysis for the reintroduction of bull trout into the lower Pend Oreille River, Washington: North American Journal of Fisheries Management, 20 p., accessed February 20, 2020, at https://doi.org/10.1002/nafm.10334.

Beauchamp, D.A., and Van Tassell, J.J., 2001, Modeling seasonal trophic interactions of adfluvial bull trout in Lake Billy Chinook, Oregon: Transactions of the American Fisheries Society, v. 130, no. 2, p. 204–216.

Bonar, S.A., Brown, L.G., Mongillo, P.E., and Williams, K., 2000, Biology, distribution, and management of Burbot (*Lota lota*) in Washington State: Northwest Science, v. 74, p. 87–96.

Breyta R., Black, A., Kaufman, J., and Kurath, G., 2016, Spatial and temporal heterogeneity of infectious hematopoietic necrosis virus in Pacific Northwest salmonids: Infection, Genetics and Evolution, v.45, p. 347–358.

Breyta, R., Brito, I., Kurath, G., and LaDeau, S., 2017, Infectious hematopoietic necrosis virus virological and genetic surveillance 2000–2012: Ecology, v. 98 no. 1, p. 283.

Brignon, W.R., Peterson, J.T., Dunham, J.B., Schaller, H.A., and Schreck, C.B., 2018, Evaluating trade-offs in bull trout reintroduction strategies using structured decision making: Canadian Journal of Fisheries and Aquatic Sciences, v. 75, no. 2, p. 293–307.

Clarke, L.R., Vidergar, D.T., and Bennett, D.H., 2005, Stable isotopes and gut content show diet overlap among native and introduced piscivores in a large oligotrophic lake: Ecology of Freshwater Fish, v. 14, no. 3, p. 267–277.

Cordes, R., 2020, Lower Clark Fork River Basin Pathogen Survey 2014 and 2019: Bozeman, Montana, Bozeman Fish Health Center Technical Report, U.S. Fish and Wildlife Service, 17 p.

DeHaan, P.W., Schwabe, L.T., and Ardren, W.R., 2010, Spatial patterns of hybridization between bull trout, *Salvelinus confluentus*, and brook trout, *Salvelinus fontinalis* in an Oregon stream network: Conservation Genetics, v. 11, no. 3, p. 935–949, accessed May 2021, at https://doi.org/10.1007/s10592-009-9937-6.

Dunham, J., Gallo, K., Shively, D., Allen, C., and Goehring, B., 2011, Assessing the feasibility of native fish reintroductions—A framework applied to threatened bull trout: North American Journal of Fisheries Management, v. 31, no. 1, p. 106–115.

Dunham, J.B., Taylor, E.B., and Allendorf, F.W., 2014, Bull trout in the boundary system—Managing connectivity and the feasibility of a reintroduction in the lower Pend Oreille River, northeastern Washington: U.S. Geological Survey Open-File Report 2014–1229, 28 p., accessed April 1, 2021, at http://dx.doi.org/10.3133/ofr20141229.

Dunham, J.B., White, R., Allen, C.S., Marcot, B.G., and Shively, D., 2016, The reintroduction landscape—Finding success at the intersection of ecological, social, and institutional dimensions, *in* Jachowski, D.S., Millspaugh, J., Angermeier, P.L., and Slotow, R., eds., Reintroduction of Fish and Wildlife Populations: Oakland, California, University of California Press, p. 79–104.

Eckmann, M., Dunham, J., Connor, E.J., and Welch, C.A., 2018, Bioenergetic evaluation of diel vertical migration by bull trout (*Salvelinus confluentus*) in a thermally stratified reservoir: Ecology of Freshwater Fish, v. 27, no. 1, p. 30–43.

Ellis, B.K., Stanford, J.A., Goodman, D., Stafford, C.P., Gustafson, D.L., Beauchamp, D.A., Chess, D.W., Craft, J.A., Deleray, M.A., and Hansen, B.S., 2011, Long-term effects of a trophic cascade in a large lake ecosystem: Proceedings of the National Academy of Sciences of the United States of America, v. 108, no. 3, p. 1070–1075, accessed April 2020 at https://doi.org/10.1073/pnas.1013006108.

Engelking, J.M., 2003, Fish disease risk study associated with potential anadromous fish passage at the Pelton Round Butte Project—Summary Report 1997–2002: Corvallis, Oregon, Pelton Round Butte Project, FERC No. 2030, prepared by Oregon Department of Fish and Wildlife, Fish Pathology Section, 79 p.

Fredenberg, W. and Chan, J., eds., 2005, Bull trout core area templates—Complete core area by core area analysis: Portland, Oregon, U. S. Fish and Wildlife Service, 660 p.

Fredenberg W., Chan, J., Young, J., and Mayfield, G., eds., 2005, Bull trout core area conservation status assessment: Portland, Oregon, U. S. Fish and Wildlife Service, 662 p.

Galloway, B.T., Muhlfeld, C.C., Guy, C.S., Downs, C.C., and Fredenberg, W.A., 2016, A framework for assessing the feasibility of native fish conservation translocations—Applications to threatened bull trout: North American Journal of Fisheries Management, v. 36, no. 4, p. 754–768.

Hagen, J., and Decker, S., 2011, The status of bull trout in British Columbia—A synthesis of available distribution, abundance, trend, and threat information, Fisheries Technical Report no. FTC 110: Victoria, British Columbia, Ministry of Environment, Ecosystems Protection and Sustainability Branch, Aquatic Conservation Science Section, 104 p.

Hallock, M., and Mongillo, P.E., 1998, Washington State status report for the Pygmy Whitefish: Olympia, Washington, Washington Department of Fish and Wildlife, 20 p.

Hansen, M.J., Schill, D., Fredericks, J., and Dux, A., 2010, Salmonid predator-prey dynamics in Lake Pend Oreille, Idaho, USA: Hydrobiologia, v. 650, no. 1, p. 85–100.

Hardiman, J.M., Breyta, R.B., Haskell, C.A., Ostberg, C.O., Hatten, J.R., and Connolly, P.J., 2017, Risk assessment for the reintroduction of anadromous salmonids upstream of Chief Joseph and Grand Coulee Dams, northeastern Washington: U.S. Geological Survey Open-File Report 2017–1113, 87 p., accessed June 2018 at https://doi.org/10.3133/ofr20171113.

Hardiman, J.M., Breyta, R.B., and Ostberg, C.O., 2022, Information tables associated with a risk assessment for bull trout introduction into Sullivan Lake, northeastern, Washington including population donor sources and resident species, April 2021: U.S. Geological Survey data release, https://doi.org/10.5066/P9XCQEZ1.

Hayes, M.F., and Banish, N.P., 2017, Translocation and reintroduction of native fishes—a review of bull trout *Salvelinus confluentus* with application for future reintroductions: Endangered Species Research, v. 34, p. 191–209.

International Union for Conservation of Nature/Species Survival Commission (IUCN), 2013, Guidelines for reintroductions and other conservation translocations (ver. 1.0): Gland, Switzerland, IUCN Species Survival Commission, 72 p.

Jones, D.T., Moffitt, C., and Peters, K.K., 2007, Temperature-mediated differences in bacterial kidney disease expression and survival in *Renibacterium salmoninarum* – challenged bull trout and other salmonids: North American Journal of Fisheries Management, v. 27, no. 2, p. 695–706.

Kanda, N., Leary, R.F., and Allendorf, F.W., 2002, Evidence of introgressive hybridization between bull trout and brook trout: Transactions of the American Fisheries Society, v. 131, no. 4, p. 772–782.

Klobucar, S.L., Saunders, W.C., and Budy, P., 2016, A *Lota lota* consumption—Trophic dynamics of nonnative burbot in a valuable sport fishery: Transactions of the American Fisheries Society, v. 145, no. 6, p. 1386–1398.

Leary, R.F., Allendorf, F.W., and Forbes, S.H., 1993, Conservation genetics of bull trout in the Columbia and Klamath River Drainages: Conservation Biology, v. 7, no. 4, p. 856–865.

Lowery, E.D., and Beauchamp, D.A., 2015, Trophic ontogeny of fluvial bull trout and seasonal predation on Pacific Salmon in a riverine food web: Transactions of the American Fisheries Society, v. 144, p. 724–741.

Marcot, B.G., Allen, C.S., Morey, S., Shively, D., and White, R., 2012, An expert panel approach to assessing potential effects of bull trout reintroduction on federally listed salmonids in the Clackamas River, Oregon: North American Journal of Fisheries Management, v. 32, no. 3, p. 450–465.

McCubbins, J.L., Hansen, M.J., DosSantos, J.M., and Dux, A.M., 2016, Demographic characteristics of an adfluvial bull trout population in Lake Pend Oreille, Idaho: North American Journal of Fisheries Management, v. 36, no. 6, p. 1269–1277.

Meeuwig, M.H., Guy, C.S., and Fredenberg, W.A., 2011, Trophic relationships between a native and a nonnative predator in a system of natural lakes: Ecology of Freshwater Fish, v. 20, no. 2, p. 315–325.

Mims, M.C., Day, C.C., Burkhart, J.J., Fuller, M.R., Hinkle, J., Bearlin, A., Dunham, J.B., DeHaan, P.W., Holden, Z.A., and Landguth, E.E., 2019, Simulating demography, genetics, and spatially explicit processes to inform reintroduction of a threatened char: Ecosphere, v. 10, no. 2, 24 p.

National Oceanic and Atmospheric Administration, and National Marine Fisheries Service, 2020, Recovery Planning Handbook (ver. 1.0): U. S. Department of Commerce, 246 p. accessed April 4, 2022, at https://s3.amazonaws.com/media.fisheries.noaa.gov/2020-10/NMFS%20Recovery%20Handbook_10-02-2020_final_v1.0_508.pdf?null.

Nine, B.P., and Scholz, A.T., 2005, Fishery and limnology investigation of Sullivan Lake, Pend Oreille County, Washington: Cheney, Washington, Eastern Washington University, Department of Biology, Fisheries Research Center, Contributions of Fisheries Management in Eastern Washington, no. 9, 170 p.

Pearsons, N., and Hopley, C.W., 1999, A practical approach for assessing ecological risks associated with fish stocking programs: Fisheries, v. 24, no. 9, p. 16–23.

Perez, I., Anadón, J.D., Díaz, M., Nicola, G.G., Tella, J.L., and Giménez, A., 2012, What is wrong with current translocations?—A review and a decision-making proposal: Frontiers in Ecology and the Environment, v. 10, no. 9, p. 494–501.

Polacek, M.C., Baldwin, C.M., and Knuttgen, K., 2006, Status, distribution, diet, and growth of burbot in Lake Roosevelt, Washington: Northwest Science, v. 83, no. 3, p. 153–64.

Pyle, C., 2015, Species Fact Sheet: Oregon-Washington, U.S. Forest Service, Bureau of Land Management State, Interagency Special Status/Sensitive Species program website, 15 p, accessed January 12, 2021, at https://www.fs.fed.us/r6/sfpnw/issssp/documents3/sfs-fn-prosopium-coulterii-2015-04-508.pdf.

Rieman, B.E., and Allendorf, F.W., 2001, Effective population size and genetic conservation criteria for bull trout: North American Journal of Fisheries Management, v. 21, no. 4, p. 756–764.

Small, M.P., Kissler, M., and Simmons, R., 2020, Boundary region mountain whitefish genetic report 2020: Olympia, Washington, Washington Department of Fish and Wildlife Molecular Genetics Laboratory, 8 p.

Sprague, L., 2020, 2019 Survey for selected fish pathogens in the lower Clark Fork River and Lake Pend Oreille in Idaho: Orofino, Idaho, Pacific Region Fish Health Program Idaho Field Station, U. S. Fish and Wildlife Service, 8 p.

Spruell, P., Hemmingsen, A.R., Howell, P.J., Kanda, N., and Allendorf, F.W., 2003, Conservation genetics of bull trout—Geographic distribution of variation at microsatellite loci: Conservation Genetics, v. 4, no. 1, p. 17–29.

Shively, D., Allen, C., Alsbury, T., Bergamini, B., Goehring, B., Horning, T., and Strobel, B., 2007, Clackamas River bull trout reintroduction feasibility assessment: Portland, Oregon, United States Department of Agriculture, Forest Service, Mt. Hood National Forest, U. S. Fish and Wildlife Service, Oregon State Office, and Oregon Department of Fish and Wildlife, North Willamette Region, 253 p.

U.S. Fish and Wildlife Service (USFWS), 2010, Endangered and threatened wildlife and plants—Revised designation of critical habitat for bull trout in the coterminous United States—Final Rule: Federal Register, v. 75, p. 63898–64070.

U.S. Fish and Wildlife Service (USFWS), 2015a, Recovery plan for the coterminous United States population of bull trout (*Salvelinus confluentus*): Portland, Oregon, U. S. Fish and Wildlife Service, 79 p.

U.S. Fish and Wildlife Service (USFWS), 2015b, Columbia headwaters recovery unit implementation plan for bull trout (*Salvelinus confluentus*): Portland, Oregon, U. S. Fish and Wildlife Service, 179 p.

Vidergar, D.T., 2000, Population estimates, food habits and estimates of consumption of selected predatory fishes in Lake Pend Oreille, Idaho: Moscow, Idaho, University of Idaho, Master's thesis, 99 p.

Washington Department of Ecology, 1997, Water quality assessment of selected lakes within Washington State, 1994: Olympia, Washington, Washington Department of Ecology, 451 p., accessed January 4, 2021, at https://apps.ecology.wa.gov/publications/documents/97307.pdf.

Weeber, M.A., Giannico, G.R., and Jacobs, S.E., 2010, Effects of redd superimposition by introduced Kokanee on the spawning success of native bull trout: North American Journal of Fisheries Management, v. 30, no. 1, p. 47–54.

Wyman, K.H., Jr., 1975, Two unfished salmonid populations in Lake Chester Morse: Seattle, Washington, University of Washington, Master’s thesis, 53 p.

Appendix 1. Bull Trout Risk Assessment Work Group Meeting Attendees

Table 1.1. List of digital meeting participants for bull trout regional risk assessment work group for introduction of bull trout into the Sullivan Lake region, call on August 13, 2020.

Name, Affiliation
Jill Hardiman, U.S. Geological Survey, Chair
Rachel Breyta, U.S. Geological Survey
Carl Ostberg, U.S. Geological Survey
Joe Maroney, Kalispel Tribe
Jason Connor, Kalispel Tribe
Jason Olson, Kalispel Tribe
Raymond Ostlie, Kalispel Tribe
Erin Britton Kuttel, U.S. Fish and Wildlife Service
Bill Baker, Washington Department of Fish and Wildlife
Chris Donley, Washington Department of Fish and Wildlife
Andy Dux, Idaho Department of Fish and Game
Matt Corsi, Idaho Department of Fish and Game
Scott Jungblom, Pend Oreille Public Utility District
Matt Boyer, Montana Department of Fish, Wildlife, and Parks
Eric Oldenburg, Avista
Al Solonsky, Seattle City Light
Harry Rich, Seattle City Light
Karen Honeycutt, U.S. Forest Service
Lucy Reeves, U.S. Forest Service
James Capurso, U.S. Forest Service
Brendan Naples, U.S. Forest Service
Bill Brignon, U.S. Forest Service
Will Warnock, British Columbia Ministry of Forests, Lands, and Natural Resource Operations

Table 1.2. List of digital meeting participants for bull trout regional risk assessment work group for introduction of bull trout into the Sullivan Lake region, call on September 17, 2020.

Name, Affiliation
Jill Hardiman, U.S. Geological Survey, Chair
Rachel Breyta, U.S. Geological Survey
Carl Ostberg, U.S. Geological Survey
Jason Olson, Kalispel Tribe
Joe Maroney, Kalispel Tribe
Jason Connor, Kalispel Tribe
Andy Dux, Idaho Department of Fish and Game
Brendan Naples, U.S. Forest Service
Karen Honeycutt, U.S. Forest Service
Erin Britton Kuttel, U.S. Fish and Wildlife Service
Scott Jungblom, Pend Oreille Public Utility District
Al Solonsky, Seattle City Light
Ryan Simmons, Seattle City Light
Will Warnock, British Columbia Ministry of Forests, Lands, and Natural Resource Operations
Bill Baker, Washington Department of Fish and Wildlife

Table 1.3. List of digital meeting participants for bull trout regional risk assessment work group for introduction of bull trout into the Sullivan Lake region, call on February 10, 2021.

Name, Affiliation
Jill Hardiman, U.S. Geological Survey, Chair
Carl Ostberg, U.S. Geological Survey
Jason Olson, Kalispel Tribe
Joe Maroney, Kalispel Tribe
Jason Connor, Kalispel Tribe
Andy Dux, Idaho Department of Fish and Game
William Gale, U.S. Fish and Wildlife Service
Erin Britton Kuttel, U.S. Fish and Wildlife Service
Scott Jungblom, Pend Oreille Public Utility District
Troy Jaecks, Seattle City Light
Ryan Simmons, Seattle City Light
Al Solonsky, Seattle City Light
Harry Rich, Seattle City Light
Karen Honeycutt, U.S. Forest Service
Matt Boyer, Montana Department of Fish, Wildlife, and Parks
Christopher Donley, Washington Department of Fish and Wildlife
Bill Baker, Washington Department of Fish and Wildlife

Publishing support provided by the U.S. Geological Survey
Science Publishing Network, Tacoma Publishing Service Center

For more information concerning the research in this report, contact the
Director, Western Fisheries Research Center
U.S. Geological Survey
6505 NE 65th Street
Seattle, Washington 98115-5016
https://www.usgs.gov/centers/wfrc

Hardiman and others—**Risk Assessment for Bull Trout Introduction into Sullivan Lake and Harvey Creek, Northeastern Washington**—OFR 2022–1032

ISSN 2331-1258 (online)
https://doi.org/10.3133/ofr20221032