Kootenai River Burbot
5-Year Operational Research Plan
(2006-2010)

March 9, 2009 Working Draft

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Introduction

In 2001, the Kootenai Valley Resource Initiative (KVRI) was formed out of a realization that a collaborative community based approach to addressing local natural resource issues had the best chance success (Ireland and Perry 2008). Part of this approach under the KVRI mandate, and led by the Kootenai Tribe of Idaho was to develop an innovative and collaborative process for burbot recovery in the Kootenai River. This approach resulted in the formation of the KVRI Burbot Sub-committee in 2002 to help address burbot recovery under the KVRI collaborative approach (Ireland and Perry 2008). This committee was tasked with developing a conservation strategy to help restore the Kootenai burbot population. The Kootenai Burbot Conservation Strategy was finalized in 2004 and a memorandum of understanding that formalized commitments in the conservation strategy was signed in 2005 by 16 agencies and entities (Ireland and Perry 2008; KVRI 2005). This 5-year plan builds on the Kootenai Burbot Conservation Strategy to provide a detailed implementation schedule and an adaptive management framework for burbot recovery.

Specifically, the objectives of this burbot 5-year research plan are two-fold, to:

1. Build on the Kootenai Burbot Conservation Strategy (KVRI 2005) and provide structure and a coordinated implementation schedule for ongoing and future efforts to conserve Kootenai River burbot; and

2. Provide an adaptive management framework to monitor effects of changes resulting from projects in this plan and other projects at the broad ecosystem-scale to identify any specific impacts that can be reasonably addressed such as specific temperature and flow changes as a result of Libby Dam.

This 5-year plan focuses on identifying and addressing survival limitations in this population and builds on current and past research completed over the last decade. The plan deals specifically with burbot in Kootenay/i River in Idaho and British Columbia (BC) as well as the south and west arms of Kootenay Lake (Figure 1).

There are two major components to the plan. First, a “Core Program” has been identified in recognition of the need for annual stock status monitoring; key projects to evaluate the success of recovery measures. Second, the plan outlines a program to reverse the population decline through habitat alteration, a conservation aquaculture program as well as research to identify and address gaps in our understanding of the specific causes of population decline.

On the Kootenay River, these steps are currently being completed and typically, the design of management experiments becomes a key second step in the adaptive management process. The current empirical understanding and research in this operational plan will help establish the framework for these management experiments. Such experiments include: 1) interim short-term steps to increase population numbers and
avoid extinction, and 2) longer-term plans for the identification and reversal of the specific causes of population declines.

Although this plan addresses specific causes of population decline to inform and prioritize restoration actions, it does not detail all ongoing Kootenai burbot research. It is anticipated that new hypotheses regarding the Kootenai burbot population decline may evolve over the period covered by this plan. Legitimate testable hypotheses developed during this 5-year period (2006-2010) should be considered for inclusion as part of this plan’s progressive adaptive management scheme. Depending on funding constraints, it may not be possible to complete all the work identified in this plan. Depending on results and end-of-phase reviews, each phase may take more or less time than initially listed; variability that should be accommodated by planning schedules.

**Background**

In Idaho, burbot *Lota lota* are endemic only to the Kootenai River (spelled Kootenay for Canadian waters) (Simpson and Wallace 1982) (Figure 1) but this population is now functionally extinct, with virtually no recruitment and an estimated abundance in 2006 of about 50 fish greater than 350 mm total length in 2003 (Pyper et al. 2008; Paragamian et al. 2008). Burbot are much more widespread in much of British Columbia (McPhail 1997), however many of these populations have also declined in the last century (Prince 2007). Burbot once provided an important winter fishery on the Kootenai River in Idaho and British Columbia, as well as providing a substantial fishery on Kootenay Lake, British Columbia (BC), Canada (Paragamian et al. 2000; Ahrens and Korman 2002). Some anglers reported catching up to 40 burbot per night during winter setline fishing (Paragamian 1994a). The annual harvest of burbot from the Kootenai River by sport and commercial fisherman in Idaho prior to 1972 may have been in the tens of thousands of kg. Three commercial anglers alone harvested an estimated 2,150 kg in 1958 (Idaho Department of Fish and Game [IDFG] Regional Archives, unpublished). Burbot caught during the winter fishery were thought to have been part of a spawning migration from the lower river and Kootenay Lake in BC, Canada. However, after construction and operation of Libby Dam by the U.S. Army Corps of Engineers (USACE) in 1972, the fishery rapidly declined and closed in 1992. Concomitant to the collapse in Idaho was the collapse of the burbot fishery in Kootenay Lake, British Columbia where anglers harvested more than 26,000 burbot in some years during the 1960’s (Martin 1976; Paragamian et al. 2000; Ahrens and Korman 2002).

The Kootenai River Fisheries Investigation was initiated in 1993 by the IDFG to document burbot abundance, distribution, size structure, reproductive success, and movement, and to identify factors limiting burbot in the Kootenai River. By 1994 this became a cooperative project with MoE. Few burbot were captured between rkm 246 (Bonners Ferry) and the Montana border (rkm 275) from 1993 through 1994 (Paragamian 1994a) and there has been limited evidence of burbot reproduction in the Idaho reach.
Only one juvenile burbot was captured from 1993 through 1998, and only one larval fish was collected. Burbot of different year classes were represented in the catch, indicating that some burbot were reproducing successfully, however, the level of production was insufficient to sustain the population. Previous studies have failed to document a significant spawning run of burbot from the lower river or Kootenay Lake into Idaho, but sampling in the BC reach of the river has documented spawning burbot in the Goat River (Paragamian 2000; Bisset and Cope 2002), and during the winter of 2000-2001 a “spawning ball” of burbot was documented at Ambush Rock (Kozfkay and Paragamian 2002). Since then other potential spawners have been captured in the same location, but their numbers have been low.

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake (Duncan Dam) are in river kilometers (rkm) and are indicated at important access points.
Although little is currently known about the specific causes of decline in the Kootenai River burbot population, a number of impacts/threats are currently viewed as possible contributing factors to declines in the recovery area (Figure 2; KVRI 2005).

Possible impacts/threats include:

- Logging and mining operations beginning in 1880s
- Attempts to dike lower river to claim land for agricultural use beginning in 1892
- Extensive harvest prior to the 1940’s (possible population collapse by 1940s; KTOI 2005)
- Completion of Cora Linn Dam (former natural Bonnington Falls) in 1930
- Fertilizer plant operation (nutrient loading) on St. Mary River from 1953-1970
- Substantial sport and commercial fishery harvest from 1950s to 1970s
- Completion of Duncan Dam in 1967
- Completion of Libby Dam in 1972
- Pollution abatement activities throughout watershed

Many of the above identified habitat impacts that may have contributed to the decline in burbot stocks are ecosystem scale impacts and have also contributed to declines in other native fish species in the Kootenai River. Because of the large scale nature of these threats, there are already a number of research projects currently underway on the Kootenai River to provide remediation plans for some of these ecosystem level impacts. These include measures to improve the Kootenay ecosystem, with an evaluation of nutrient supplementation (Bonneville Project #199404900), assessing, mitigating and rehabilitating floodplain loss (Bonneville Project #200201100), reconnection of lost floodplain (Bonneville Project #200200800), restoration of riverine habitat (Bonneville Project 200200200, as well as numerous tributary restoration and riparian habitat conservation and restoration projects on the Kootenay River. Although agencies involved in burbot recovery efforts provide support for these projects where possible, the project plans will not be included in this document as this planning is completed in other forums. However, this plan details research to monitor the effects of these measures on burbot in the Kootenay River.

In addition to pre-dam habitat changes, Libby Dam is suspected to have contributed substantially. Operation of Libby Dam for hydroelectric power and flood control has created major changes in the river’s seasonal discharge, particularly during the winter when burbot spawn (Figure 2). Post-dam winter discharges are now three to four times greater than they were historically when conditions were relatively stable (Figure 2). Daily differences in discharge now range up to 652 m³/s, a six-fold change. The temperature regime and nutrient supply of the Kootenai River are also thought to be important factors for burbot spawning and recruitment; they too have changed since construction of Libby Dam (Partridge 1983; Snyder and Minshall 1996; Richards 1996). A recent study (Paragamian and Wakkinen 2008) investigated the possible combined
effects of temperature and discharge to help formulate rehabilitation recommendations (KVRI Burbot Committee 2005).

Studies completed to date indicate that discharge management at Libby Dam likely affects burbot spawning migration during winter months (Paragamian 2000; Paragamian et al 2001; Paragamian et al. 2005; Paragamian and Whitman 1999, 2000). The specific effect of increased winter flows and warmer winter temperatures to burbot spawning migration and behaviour is unknown, but it may have reduced spawning fitness and stamina or affected timing of burbot spawning. One or all of these possible factors could have been sufficient to contribute to reduced spawning success and recruitment. Because of the specific nature of this effect, studies to examine this further will be included in this plan.

Figure 2. Mean monthly discharge of the Kootenai River at Porthill, Idaho from 1962 through 1971 (pre-Libby Dam), and from 1994 through 2000 (post-Libby Dam).

Post-Libby Dam temperature changes may be an additional factor affecting spawning and recruitment of burbot in the Kootenai River (Figure 3). Partridge (1983) found temperature of the Kootenai River is now cooler in the summer and warmer in the winter by several degrees C (Figure 3). Burbot spawn at temperatures of 1-4°C (McPhail and
Paragamian 2000), and even subtle temperature changes in the Kootenai River could have affected the timing and maturation rate of burbot. In addition, temperatures above 6°C have been found to cause egg and larval mortality in burbot (Taylor and McPhail 2000). Thus, it could be valuable to know whether these changes in the Kootenai River and its tributaries have affected burbot spawning migration, rate of maturity (annual gonadal development), spawning synchrony, and possible egg or larval survival. Again, because of the specific nature of this effect, studies to examine this further will be included in this or future plans.

Figure 3. Pre-Libby Dam Kootenai River temperatures at the dam site 1962-1972 and at Copeland, Idaho 1967-1976 and post Libby Dam below the dam from 1993-2003 and at Bonners Ferry, Idaho from 1993-2003 (Data courtesy of Greg Hoffman, US Army Corps of Engineers)
Core Program

The “Core Program” component of this 5-Year Plan includes projects in BC and Idaho required to meet the fundamental, short term (and likely ongoing) tasks of stock status monitoring and restoration planning and implementation. Core program activities will help assess the impacts of ongoing ecosystem scale rehabilitation efforts, specific habitat measures such as dam discharge and temperature recommendations, and future post-release performance of hatchery-reared burbot. Core program activities will contribute to a long-term data set to evaluate the success of restoration activities. The core program is aimed at developing and implementing conservation aquaculture, providing annual monitoring activities to assess wild and hatchery origin adult population stock status, and levels of natural spawning and recruitment.

Along with pre-dam environmental changes temporally correlated with white sturgeon recruitment failure (Anders et al. 2002), altered post-dam temperatures and flows have been reported to negatively affect Kootenai River burbot (Paragamian et al. 2000; Paragamian and Wakkinen 2008). Therefore, the Core Program also includes a task to provide annual temperature and flow recommendations thought to provide suitable conditions for burbot migration and spawning.

Until a hatchery production facility is in place, there may not be enough individual juveniles or adults to warrant all projects in the Core program. In the short term, the effect of monitoring activities in the Core program on the remnant wild population will need to be considered and only activities that pose acceptable risk should proceed. However, recent progress in development of aquaculture techniques at the University of Idaho’s Aquaculture Research Institute (Jensen et al. 2008a and 2008b) and in field applications by IDFG suggests that adequate numbers of experimentally cultured fish could be available for initial experimental stocking as soon as 2009.

Rehabilitation goals for burbot in the Kootenai River were developed using a catchability model for burbot in the Kootenai River and capture rates from two Alaskan rivers (Paragamian and Hansen, in press). Demographic statistics for burbot in the Kootenai River in a stochastic density-dependent population model were used to estimate recruitment rates (Paragamian et al. 2008). An interim abundance target of 5,500 individuals (45 fish/km; 3.0 fish/ha) within 25 years was reported when each adult produced 0.85 recruits per year, along with an ultimate abundance target of 17,500 individuals (143 fish/km; 9.6 fish/ha) when each adult produced 1.1 recruit per year. Time to recovery for both goals could be reduced with the establishment of successful recruitment of stocked fish produced from intensive and extensive culture facilities.
The Core program includes the following projects:

_Burbot Aquaculture Development_
- optimization of spawning and fertilization
- development and refinement of incubation techniques and apparatus
- development and refinement of early rearing techniques and apparatus
- development and refinement of techniques for conversion to live feeds and commercial weaning diets
- development of extensive and semi-intensive (pond culture) techniques to maximize survival and minimize cannibalism in YOY burbot
- determination of minimum stocking numbers to attain the population rehabilitation goals

_Adult Population Assessments_
- annual hoop net trap and tributary sampling at previously established index sites to capture and enumerate adult burbot; and
- sonic telemetry to monitor changes in movements, habitat use and behavior resulting from habitat and dam operational changes, as well as use of tributaries by adult spawners.

_Larval Production Indexing_
- annual larval ½ m net, light trap or other larval sampling techniques on Kootenai River and tributaries.

_Juvenile Assessments_
- development of suitable methods such as juvenile electro-shock and trap sampling to index year class strength and assess growth and survival of wild and hatchery produced progeny; and
- sonic telemetry to evaluate stocking strategy and monitor dispersal from hatchery release sites, or dispersal and behavior of adult donor stocks as well as identifying habitat use and movements of wild and hatchery produced juveniles.
- Develop stocking location and density guidelines based on empirical survival rates

_Flow Recommendations and Monitoring (normative hydrograph – temperature and flow component)_
- annual recommendations for winter flows to facilitate burbot spawning migration and low water temperatures will be provided in a systems operation request (SOR).
- deployment of temperature recorders in the Kootenai River and major tributaries to monitor flow recommendations and provide a post hoc evaluation of temperature and movement patterns of adult burbot.
Research Program

The “Research Program” component of this 5-Year Plan includes the implementation of a conservation aquaculture program to reverse the current population decline and research to identify and address gaps in our understanding of the specific causes of population decline. The long term goal of population restoration includes four phases:

- **Phase I** - Develop burbot conservation aquaculture methods, broodstock options and hatchery facilities suitable for Kootenai River burbot production
- **Phase II** - Initiate adequate experimental hatchery releases with stocking guidelines to measure response, increase population abundance, and identify limiting factors/causes of population declines;
- **Phase III** – Apply conservation stocking in conjunction with experimental ecosystem, flow, and temperature restoration measures to attempt reversal of population decline; and
- **Phase IV** – Implement, monitor, evaluate, and adapt 5-year plan core program and research activities as needed based on analysis of empirical data collected by these activities.

This plan addresses five years of study, and therefore will only cover Phase I and II of the above research program phases. Phase III and IV are set out following goals in a longer term strategic planning document (Kootenai Burbot Conservation Strategy, KTOI 2005).

Phase I – Aquaculture Development, Research and Lab Studies

Initial phases involve the development of fish culture methods and a hatchery facility to provide the production targets for juvenile release. In-river study of adults and lab studies of hatchery juveniles will also be completed.

Year 1 (2006/07)

Safeguard Remaining Kootenai Adults
- First year would involve committee determination of the viability of protecting adults and planning for a facility or monitoring a lake for suitable conditions

Conservation Aquaculture
- Experimental Intensive Techniques
  - Continue refinement of intensive burbot aquaculture techniques, apparatus and protocols (KTOI/U of I)
- Experimental Extensive Rearing techniques
  - Investigate available locations for extensive rearing experiments in a confined lake environment in Idaho (KTOI/IDFG/MoE)
  - Identify specific waterbody(ies) for extensive rearing experiments and acquire necessary federal, state and provincial permits to complete releases in 2007.
  - Develop experimental design for extensive rearing experiments, within bounds of acceptable impacts to wild broodstock population

**Donor Stocks**
- Development and application of screening criteria to select not more than 2 potential donor populations
- Initiate an annual population monitoring program on potential brood source water bodies to help set targets around brood removal.
- Provide fish from donor stock for fish culture trials

**Fish Health Testing**
- Assemble a fish health sub-committee and produce a fish health testing protocol for donor stocks and their progeny
- Initiate design and evaluation of fish health techniques for burbot hatchery production in the lab environment
- Conduct challenge tests, if subjects available, to assess burbot vulnerability to common Salmonid diseases as well as others of interest (IPNV, BKD, Coldwater disease, Furunculosis) as well as experimental hatchery progeny screening for these diseases

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**Year 2 (2007/08)**

**Safeguard Remaining Kootenai Adults**
- N/A in 2007 and beyond - committee decided there are too many uncertainties in this approach and too few remaining adults for make this option feasible.

**Conservation Aquaculture**
- Experimental Intensive Techniques
  - Continue refinement of intensive burbot aquaculture techniques, apparatus and protocols (KTOI/U of I)
  - Pursue experimental releases into Kootenai River if necessary permits granted

- Experimental Extensive Rearing techniques
  - Finalize locations for extensive rearing experiments in a confined lake environment in Idaho (KTOI/IDFG/MoE)
  - Acquire necessary federal, state and provincial permits to complete releases in spring, 2007.
  - Release larvae into selected location/s and monitor success
- Pursue experimental releases into Kootenai River if numbers available and necessary permits granted

- **Hatchery Facility Development**
  - Develop conceptual design of proposed production and monitoring facility
  - Conduct pre-acquisition activities for land purchase for aquaculture facility

- **Marking Strategy**
  - Begin development of a marking strategy (PIT tags, genetic, fin clip etc) to allow distinction among hatchery families and year classes, as well as hatchery and wild progeny

**Donor Stocks**
- Use a screening criteria to narrow potential donor populations from two to one,
- Initiate an annual population monitoring program on brood source waterbody to help set targets around brood removal.
- Provide fish from donor stock for fish culture trials

**Fish Health Testing**
- Refine fish health techniques for burbot hatchery production in the lab environment
- Conduct challenge tests if subjects available to assess burbot vulnerability to common Salmonid diseases as well as others of interest (IPNV, WSIV, WS herpes etc.).
- Conduct fish health testing program on adult brood source to assess disease concerns.

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**Year 3 (2008/09)**

**Conservation Aquaculture**
- **Experimental Intensive Techniques**
  - Continue refinement of intensive burbot aquaculture techniques, apparatus and protocols (KTOI/U of I)
  - Pursue experimental releases into Kootenai River if necessary permits granted

- **Experimental Extensive Rearing Techniques**
  - Acquire necessary federal, state and provincial permits to complete releases in 2009.
  - Release larvae/eggs into selected location/s and monitor success
  - Pursue experimental releases into Kootenai River if necessary permits granted

- **Hatchery Facility Development**
  - Based on relative success of intensive and extensive hatchery trials, decide on rearing method/s and proceed with hatchery development
  - Complete conceptual design of proposed production and monitoring facility
  - Complete land purchase for aquaculture facility
  - Complete conceptual cost estimates for hatchery design and construction.
Marking Strategy
- Continue development of a marking strategy (PIT tags, genetic, fin clip etc) to allow distinction among hatchery families and year classes, as well as hatchery and wild progeny
- If hatchery releases are feasible in 2009, implement marking protocol developed in this and previous years

Donor Stocks
- Continue annual population monitoring program on brood source.
- Provide fish and/or gametes from donor stock for fish culture trials

Fish Health Testing
- Complete annual fish health sampling techniques for burbot hatchery production in the lab environment
- Complete challenge tests on burbot vulnerability to common Salmonid diseases

Year 4 (2009/10)

Conservation Aquaculture
- Hatchery Facility Development
  - Complete preliminary and final design of proposed production and monitoring facility
  - Acquire necessary federal, state and provincial permits to complete releases in 2009 and continue experimental release in 2010.

- Hatchery Methods Refinement and Stocking
  - Development of a stocking strategy for hatchery releases including densities, locations, timing, and receiving habitat conditions.
  - Continue refinement of intensive and extensive burbot aquaculture techniques, apparatus and protocols (KTOI/U of I)
  - Acquire necessary federal, state and provincial permits to complete experimental releases in 2009-10 if surplus fish available.
  - Develop stocking guidelines for experimental releases from experimental production into river environment and monitor success if necessary permits granted

Donor Stocks
- Continue annual population monitoring program on brood source.
- Provide fish from donor stock for fish culture trials

Fish Health Testing
- Complete annual fish health sampling techniques for burbot hatchery production in the lab environment
Lab and In River Studies
- TBD in planning meetings

Phase II – Hatchery Production and Identification of Causes of Decline
Initial stages include large scale hatchery production and associated monitoring.

Year 5 (2010/11)

Conservation Aquaculture
- Initiate construction of hatchery
- Design and implement annual fish health monitoring protocols
- If facilities in place, complete first year of hatchery production to test burbot aquaculture techniques, apparatus and protocols and provide limited numbers of progeny for lab studies and river releases
- If facilities in place, initiate annual hatchery production and continue extensive rearing for experimental releases

Donor Stocks
- Continue annual population monitoring program on brood source.
- Provide fish from donor stock for fish culture trials

Fish Health Testing
- Complete annual fish health monitoring for burbot hatchery production in the lab environment
- Implement annual fish health monitoring protocols
Acknowledgements

We would like to thank Colin Spence for his objective review of this plan and Jack Siple and Chris Lewandowski for their technical input. The Bonneville Power Administration provided funding for development of this plan through the Idaho Department of Fish and Game and the Kootenai Tribe of Idaho.

References


