Kootenai River Native Fish Conservation Aquaculture Program

Step 2 Document
Appendix C

Monitoring and Evaluation Plan for Kootenai River Burbot *(Lota lota maculosa)*

August 2012

Monitoring and Evaluation Plan for Kootenai River Burbot

(Lota lota maculosa)

Prepared by the Kootenai Tribe of Idaho for the Northwest Power and Conservation Council and Bonneville Power Administration

August 2012

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The Kootenai Tribe of Idaho (Tribe or KTOI) would like to acknowledge that we produced this document based on the monitoring and evaluation (M&E) plans created for the Chief Joseph Dam Hatchery Program by the Confederated Tribes of the Colville Reservation and their consultant, D.J. Warren & Associates Inc. (Colville Tribes 2009a, 2009b). We believe their approach, which provided a framework for implementing and evaluating hatchery and field monitoring, and a process for multi-agency cooperation and management, with some modification, is well suited to characterize M&E activities associated with the Kootenai River Native Fish Conservation Aquaculture Program, and will help to ensure the program's success.

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1 INTRODUCTION

The Lower Kootenai River burbot (*Lota lota maculosa*) population historically had multiple components inhabiting Idaho, Montana, and British Columbia. These included: 1) fish that reared and spawned in the Kootenai River and tributaries (fluvial), 2) fish that reared and spawned in Kootenay Lake (lacustrine), and 3) fish that used both the river and lake to complete the life cycle (adfluvial). All three life history strategies are currently considered functionally extinct.

In 2001, the Kootenai Valley Resource Initiative (KVRI), led by the Kootenai Tribe of Idaho (Tribe or KTOI), was formed to develop a collaborative community-based approach to addressing local natural resource issues (Ireland and Perry 2008). Under the KVRI mandate, part of this approach included development of an innovative and collaborative process for burbot restoration in the Kootenai River. Since February 2002, the Kootenai Tribe has facilitated a collaborative process through KVRI to implement this project—Restoration of the Kootenai River Burbot Population. In 2002, the KVRI Burbot Subcommittee was formed to evaluate conservation aquaculture for burbot as part of an emerging conservation strategy to help restore Kootenai burbot. The KVRI Burbot Subcommittee, along with the U. S. Fish and Wildlife Service (USFWS) and additional committed stakeholders, proposed the Kootenai River drainage as a "pilot project" to develop, implement, and evaluate a conservation strategy for Lower Kootenai River burbot, in lieu of formal listing under the Endangered Species Act (ESA).

A multilateral conservation agreement was signed to ensure burbot population decline would be addressed. Many people have dedicated their time and energy to this process. There has been committed participation from federal agencies (Bonneville Power Administration [BPA], Corps of Engineers, USFWS); state agencies (Idaho Department of Fish and Game [IDFG], Montana Department of Fish, Wildlife and Parks [MFWP]); local governments (City of Bonners Ferry, Boundary County); Tribal government (KTOI); Canadian federal and provincial governments (BC Hydro, British Columbia Ministry of Forests, Lands, and Natural Resource Operations [BC Ministry]); academia (University of Idaho); congressional delegation staff, Idaho Governor's Office of Species Conservation, KVRI board members and participants, private citizens, and conservation groups (American Wildlands, Idaho Conservation League, The Nature Conservancy).

The KVRI Burbot Subcommittee spent an enormous amount of time discussing issues, learning the biology and habitat requirements of the burbot, and ultimately building consensus among the agencies and stakeholders so that the Burbot Conservation Strategy (BCS) (KVRI 2005) would meet the needs of the species while addressing important social and economic issues. Interviews of local community members with life-long and multi-generational familiarity of historical burbot populations and fisheries provided valuable information to the Burbot Subcommittee during the preparation of the BCS. The BCS outlines a suite of adaptive recovery measures for rehabilitation of the burbot population, including physical habitat restoration, the development and implementation of a conservation aquaculture program and hydropower operations plan, monitoring and evaluation (M&E), and education and outreach. In August

2004, the KVRI Burbot Subcommittee completed the BCS and development of a Memorandum of Understanding (MOU) was begun by the policy representatives of the involved participants. The MOU was successfully negotiated in July 2005 and signed by 16 agencies and entities. It formalizes the commitment of the participants to implement the measures in the BCS, based on their respective authorities and responsibilities (KVRI 2005; Ireland and Perry 2008).

This Monitoring and Evaluation Plan for Kootenai River Burbot (Burbot M&E Plan) is an important component of the Kootenai River Native Fish Conservation Aquaculture Program (KTOI 2010) that provides a framework to guide the use of conservation aquaculture to restore the burbot population as recommended by the KVRI BCS (KVRI 2005). Following the framework and guidance of the BCS, this plan is composed of several research and monitoring elements, including: donor source population, aquaculture production, tagging strategies, sub-adults (release strategy and re-introduction), adults (release strategy and re-introduction), spawning and natural recruitment, and existing monitoring of habitat and biological community. This M&E Plan does not in any way supplant the BCS, but rather expands and elaborates on the implementation framework. This approach is necessary to incorporate achievements and research findings since the BCS inception in 2005. For instance, the collaborative effort has proven that large-scale aquaculture of burbot is a reality, and burbot have been stocked into the Kootenai River since 2009.

Also since 2005, several peer-reviewed publications have been completed which have helped guide development of production levels by life stage (Paragamian and Hansen 2009 and 2011). These and other advancements have provided the rationale for the design and scaling of the Twin Rivers Hatchery.

This M&E Plan identifies program goals and summarizes current data and initial assumptions that are guiding burbot restoration as well as the design and use of the Twin Rivers Hatchery to achieve these goals. The plan will ensure that hatchery operations produce high quality, disease-free fish that can survive in the receiving environment. It will guide the field data collection necessary to evaluate performance of fish in the wild, determine progress toward restoration, and guide production and research at the Twin Rivers Hatchery.

This plan acknowledges the importance of several other large-scale BPA-funded projects that will directly affect burbot restoration. The Kootenai River Habitat Restoration Program has commenced in areas known to have been used by burbot historically, and monitoring of these restored areas will be ongoing to track changes and confirm that habitat actions are effective. Also, long-term biological monitoring of the Lower Kootenai River and Kootenay Lake will provide important information pertaining to the effects of nutrient addition on ecosystem productivity and the aquatic community structure.

This M&E Plan is unusual in the fact that several governmental entities will be responsible for its execution. The Kootenai Tribe will be responsible for general program administration, hatchery production, and the execution of a four-step In-season Management Procedure (ISMP) and Annual Production Review (APR) to guide the restoration effort. The IDFG and BC Ministry will conduct field sampling and management activities within their respective

countries. Also, through the Tribe and IDFG, the University of Idaho – Aquaculture Research Institute (UI-ARI) and the Idaho Cooperative Fish and Wildlife Research Unit (ID-CFWRU) will continue to develop and improve burbot culture and field sampling techniques, respectively, and Cramer Fish Sciences (CFS) will assist by lending expertise upon request.

Program actions will be actively managed using data and information provided from M&E activities described in this plan. The initial hatchery program size outlined herein is anticipated to meet program goals to restore adult abundance and natural recruitment. The ISMP facilitates input and participation from all cooperating agencies to ensure that hatchery production is compatible with conservation goals established for the burbot population in the Kootenai River. Additionally, M&E results will be used to determine whether the program's conservation goals are being achieved over the anticipated time frames.

Section 2 of this M&E Plan summarizes the program goals and objectives for burbot. Section 3 outlines the four-step ISMP. Section 4 identifies the variables and metrics that will be monitored to estimate and update key attributes/parameter values with adequate precision. Section 5 defines and lists initial target values for the program's key attributes used to make decisions concerning the hatchery, conservation, and potential future harvest goals. Section 6 describes the adaptive management platform for the plan. Section 7 provides a list of references.

2 PROGRAM OVERVIEW – BURBOT

This restoration effort is designed to re-establish a stable-sized burbot population with age class distributions sufficient to ensure long-term population viability and persistence. The ultimate program goal is to restore a naturally-reproducing burbot population as close to historical structure and abundance as possible that is in equilibrium with the carrying capacity of the present and future environment, and that can support tribal and non-tribal harvest.

This M&E Plan follows several articles listed in Section 8.0 - Conservation and Restoration Strategies of the KVRI BCS. The following BCS recommendations guide this M&E Plan:

- "Implement an aggressive adaptive program of experimental recovery measures."
- "Employ conservation aquaculture methods as a key near-term component for burbot protection and restoration."
- "Maintain a strong adaptive management scientific monitoring and evaluation program to guide implementation of population conservation and recovery activities."

To achieve these goals, the burbot program will be implemented in four phases, including aquaculture feasibility assessment, initial post-release evaluations, experimental evaluation phase, and a population rebuilding and management phase (KTOI 2010; Table 1). The burbot

aquaculture program is currently in the second phase. Phases 1 and 2 have been guided by 5-year operational plans (Neufeld et al. 2009; 2011b).

2.1 PROJECT HISTORY

The Kootenai Tribal burbot project has been ongoing since the fall of 2001. Efforts began with broodstock and gamete collections conducted by the Tribe and the BC Ministry. Adult fish and gametes were transported to the Kootenai Tribal Hatchery in Bonners Ferry where spawning, egg incubation, and larval rearing were successful; however, no juveniles were produced, due to staff time and facility limitations. In 2003, efforts shifted to the UI-ARI in Moscow, Idaho, where initial work established the feasibility of captive burbot production through a series of empirical life-stage-specific studies examining spawning, semen cryopreservation, egg incubation, and larval and juvenile feeding (Cain et al. 2004; Jensen 2006; Jensen et al. 2008a; Jensen et al. 2008b; Jensen et al. 2008c).

Studies defining specific pathogen susceptibility and carrier status of burbot were also completed and provide a strong background for addressing burbot health concerns (Polinski et al. 2010a; Polinski et al. 2010c). In 2008, F1 progeny from the 2004 brood year successfully spawned and F2 progeny were cultured to the juvenile life stage. In 2009 and 2010, research addressed semi-intensive rearing methods (Barron et al. 2011a), size grading methods to suppress cannibalism during culture of larval and juvenile burbot (Barron et al. 2011b), the effects of temperature on larval and juvenile intensive culture performance (Barron et al. 2011c), and extended (up to 1 year) visible implant elastomer (VIE; Northwest Marine Technology, Shaw Island, WA, USA) tag retention. To date, three graduate students have completed MS degrees with research focused on specific objectives related to burbot culture development (Jensen 2006, Polinski 2009, Barron 2011).

The success of this project has allowed the KVRI Burbot Subcommittee to release progeny produced from a combination of on-site Moyie Lake gamete collections and captive Moyie Lake broodstock. Releases of burbot into the Kootenai River Subbasin (Canadian and US waters) to support conservation efforts have occurred in 2009, 2010, and 2011 and have included age 0, 1, 2, and 3 fish. Notably, 2010 releases included age 1, 2 and 3 burbot carrying both sonic (VemcoTM V9, Amirix Systems Inc. Halifax, Nova Scotia, Canada) and Passive Integrated Transponder tags (PIT; Destron Fearing TM, St. Paul, MN, USA). Jensen et al. (2010a) provides a detailed summary of program releases, and Neufeld et al. (2011a, 2011b) presents a summary of post-release distribution and movements. Releases completed in 2011 represent a milestone for the program, as nearly 50,000 larval burbot and over 21,000-tagged juvenile burbot were released into the Kootenai River.

As mentioned above, the Tribe's burbot conservation aquaculture program comprises four sequential implementation phases. These include: 1) aquaculture feasibility assessment, 2) post-release pilot study, 3) adaptive experimental evaluation, and 4) population rebuilding and management. The program is on schedule, currently implementing Phase 2 (Table 1).

Table 1. Proposed operational phases of the Kootenai River burbot aquaculture program listed in the KTOI Master Plan (2010).

Phase	Program Phase	Objective	Test Hypothesis	Status/Duration
1	Developmental aquaculture feasibility analysis	Develop efficient, reliable, and successful aquaculture apparatus and techniques for spawning, incubation, and rearing.	▪ It is feasible to spawn and rear significant numbers of burbot in a hatchery.	~5 years (successfully accomplished) 2004-2008
2	Developmental, post-release pilot study	Initial experimental releases and research to evaluate distribution, movements, habitat use, food habitats, and effective sampling methods by life stage.	▪ Effective sampling methods can be developed to monitor and sample significant numbers of hatchery fish following release. ▪ Some hatchery-produced fish can adapt to natural conditions. ▪ Life stage-specific habitat suitability and limitations can be evaluated using hatchery fish.	~ 5 years (currently on schedule) 2009-2013
3	Adaptive experimental evaluation phase	Implement population-level monitoring to evaluate post-release survival, growth, and maturation to identify restoration feasibility and requirements.	▪ Hatchery fish survive, grow and mature in sufficient numbers to reestablish a significant burbot population in the Kootenai system.	~ 5 years 2014-2018
4	Population rebuilding and management phase	Produce fish, monitor and evaluate success, reevaluate hatchery practices consistent with natural production objectives and outcomes.	▪ A naturally self-sustaining burbot population can be restored through a combination of habitat and hatchery actions.	2019 and beyond

Phase 1 (Developmental Aquaculture Feasibility Analysis) began in 2001. Focused efforts occurred primarily from 2004-2008, and this phase is now complete. Reliable, successful aquaculture apparatus and techniques were developed based on pioneering burbot aquaculture research. The progression of this burbot aquaculture program resembles the early years of the Tribe's successful white sturgeon program, operating since 1989. However, unlike sturgeon culture, burbot culture techniques did not exist prior to this program. Techniques to rear and spawn captive adults, cryopreserve semen, incubate and hatch embryos, intensively feed larval and juvenile burbot, and semi-intensively (fertilized, zooplankton-enhanced) rear fish in ponds have been developed as a result of a series of aquaculture experiments funded by this program (Cain et al. 2004; Jensen 2006; Jensen et al. 2008a; Jensen et al. 2008b; Jensen et al. 2008c; Jensen et al. 2011; Foltz et al. in prep). Additionally, burbot disease susceptibility has

now been well-characterized to circumvent fish health issues that may manifest under intensive conditions (Polinski 2009; Polinski et al. 2010a, 2010b, 2010c). This work continues to demonstrate the feasibility of burbot culture at a significant scale and has laid the groundwork for the next phase of the burbot aquaculture program.

Phase 2 (Developmental Post-release Pilot Study) involves annual releases of limited numbers of juvenile burbot to evaluate distribution, movements, habitat use, food habitats, and effective sampling methods by life stage. This 5-year phase was initiated with the first experimental release of 247 burbot during October and November of 2009. Currently, Phase 2 is nearing completion and is set to expire in 2013 with construction of the Twin Rivers Hatchery. Thirty of the fish released were 2 to 3 years old and implanted with ultrasonic transmitters. Monitoring these and future release groups will provide basic information on the biology and limiting factors for burbot under current river conditions. These pilot-study release groups also provide information regarding the suitability of hatchery-origin fish for larger-scale population rebuilding.

During this 5-year pilot study phase, the UI-ARI facility is being used to address two objectives. One objective is to rear approximately 5,000 Age-0 burbot per year for release and monitoring. Fish are released at 5 to 10 grams, which is the minimum size that can be permanently PIT-tagged with a reasonable potential for post-release survival. The second objective is to continue to develop and refine burbot culture methods and systems. Continued research on propagation methods is expected to pay future dividends in terms of increased effectiveness and reduced cost of burbot aquaculture. This production level and commitment of UI-ARI facilities and staff has reached the maximum extent of its burbot aquaculture efforts, as there are other critical research and developmental functions provided at this facility. These facility and production limitations are an important factor driving development of the proposed Tribal facility at Twin Rivers.

Phase 3 (Adaptive Experimental Evaluation) implements hatchery production and monitoring efforts to determine how well hatchery-produced burbot survive, grow, and mature in sufficient numbers to re-establish a significant population in the Kootenai system. This phase involves population-level monitoring efforts to address in-river questions and critical uncertainties. Phase 3 is distinguished from Phase 2 by the scale and intensity of production and monitoring efforts. Phase 2 involves limited research and monitoring of small-scale pilot-level releases with fish produced at the UI-ARI to provide qualitative assessments of behavior and biology of hatchery-reared fish. Phase 3 involves larger-scale, extensive quantitative monitoring using enough burbot to statistically evaluate post-release survival, growth, biological condition, and maturation. The Twin Rivers facility is needed in Phase 3 to consistently and reliably produce enough fish for a statistically robust evaluation and a phased scaling up of production to meet long-term objectives. One of the objectives of Phase 3 is to estimate key attributes such as post-release survival rates of hatchery-reared burbot with enough precision to maximize benefits of the ISMP to guide future production and to achieve program goals, objectives, and biological targets.

Phase 4 (Population Rebuilding) would implement a full-scale restoration program designed to achieve long-term population restoration goals. The proposed Twin Rivers facility is being designed to provide the flexibility to implement this phased, adaptive burbot restoration program. Hatchery systems will optimize flexibility and allow cost-effective modifications when necessary as the program unfolds. Flexibility will be enhanced by concurrent development of a joint sturgeon and burbot facility.

Based on initial modeling efforts, the program will have the capability to restore a natural reproducing, self-sustaining population if initial assumptions of key attributes and biological targets are realized (Table 2). At present, levels of aquaculture production needed for restoration are feasible if the Twin Rivers Hatchery is constructed. Further, early telemetry results provide survival rates of sub-adults (1-3 years old) used to derive outcomes of this modeling. However, the program has yet to determine if larval survival, 6-month old juvenile survival, and natural recruitment assumptions are feasible; future M&E activities will help define these important program attributes. The average number of burbot released to date during phases 1 and 2, and the number anticipated to be released annually at each life stage are also shown in Table 2.

Table 2. Past, current, and expected outcomes for each phase of the burbot conservation aquaculture program.

	Outcomes	Phase 1 2004-2008	Phase 2 2009-2013	Phase 3 2014-2018	Phase 4 2019 - Beyond
Hatchery	Average egg take	Feasibility	(353,000 – 4,500,000)	6 million	6 million
	Average larval release	Feasibility	(12,355 – 350,000)	TBD	TBD
	Average 6-mo. juvenile release	Feasibility	(247 – 20,183)	20,000 – 100,000	Up to 125,000
	Average Age-1+ release	Feasibility	50 - 100	TBD	TBD
In-river	Average annual Ages 1-3 abundance	Feasibility	6,000 (starting 2012)	32,000	63,000
	Average annual mature adults Ages 4 - 10+	Feasibility	~200	~8,000	17,500
Harvest	Idaho	None	None	None	TBD
	British Columbia	None	None	None	TBD

Note: Future estimates are based upon Age-0 6-month juvenile releases and no contribution from natural recruitment.

2.2 PROGRAM OBJECTIVES

Conservation and management of a naturally producing, self-sustaining burbot population is the primary long-term goal of this program. This goal initially requires the combined implementation of hatchery production and habitat restoration measures, both currently implemented by the Tribe and other collaborating agencies and entities. The proposed Twin Rivers Hatchery will be an integral program component contributing to a population that can once again support harvest at levels consistent with conservation of the species in the Kootenai River.

Program objectives for burbot restoration include the following:

- The interim goal is to produce and stock burbot at rates and frequencies to sustain a *minimum* population of 2,500 - 9,500 adults in the Kootenai River and South Arm of Kootenay Lake (KTOI 2010). This range includes the minimum population goal listed in the BCS and is the minimum abundance also suggested by Paragamian and Hansen (2008; 2011). This interim goal is a starting point to restore a population that once numbered in the tens to hundreds of thousands (Ahrens and Korman 2002; KVRI 2005).

- The long-term goal is to produce and stock burbot at rates and frequencies to sustain a *minimum* population of 17,500 adults in the Kootenai River and South Arm of Kootenay Lake (Paragamian and Hansen 2008; 2011).

- In conjunction with re-establishing adult abundance, the long-term goal is also to restore consistent natural recruitment in at least *three different spawning areas* that results in a juvenile population of sufficient size to support the adult burbot population goal. Initial results from sub-adult burbot telemetry indicate that hatchery-reared burbot are likely contributing to natural spawning, and therefore this is a reasonable goal (Neufeld et al. 2011a; Stephenson and Neufeld 2012).

3 IN-SEASON MANAGEMENT AND ANNUAL REVIEW

3.1 ANNUAL PROJECT REVIEW

Following the recommendation of the KVRI BCS, an APR will be conducted through a workshop sponsored by the Tribe. This workshop will take place prior to making decisions about annual goals for broodstock management, gamete collection, aquaculture production, hatchery release strategies, harvest, and M&E activities. All cooperating agencies and stakeholders will be urged to participate. The purpose of the APR is to implement the four-step ISMP described in Section 3.3 with all stakeholders present to support information sharing, informed decision-making, and management to meet conservation objectives.

The agenda for the APR workshop will follow the steps outlined in the ISMP. The APR is a science-driven process that will result in an annual action plan that will be completed at the workshop. The APR participants will include appointed representatives from the cooperating agencies involved in this project. The workshop and completed action plan constitute the coordinated implementation component of the program.

The APR workshop will be conducted annually in January. At present, a workshop in January allows enough time to complete the previous year's M&E results for use in planning the upcoming year, while arriving at goals for broodstock and gamete collection before the main spawning period, which occurs in February. A facilitator selected by the Tribe will guide the workshop in order to address four fundamental questions:

1. Given the information provided, what are the best estimates for the key assumptions (see ISMP Step 1, Section 3.3.1)?

2. Do the Decision Guidelines need to be changed (see ISMP Step 3, Section 3.3.3)?

3. What are the biological targets for the coming year (see ISMP Step 4, Section 3.3.4)?

4. How can the M&E plan be improved in the coming year?

The first part of the workshop will be devoted to presentations of results from M&E activities related to the key assumptions for the Tribal hatchery program (see ISMP Step 1, Section 3.3.1). There will be sessions covering the following topics: 1) hatchery operations, 2) post-release survival and distribution, 3) habitat, 4) spawning and natural recruitment, and 5) harvest, if and when a fishery may be supported. Prior to the workshop, the Tribe will coordinate with cooperating agencies to ensure the most up-to-date information for each of these subjects will be presented and discussed. The ISMP tool will also be populated with the most recent data and analytical results used to update status and trends (see ISMP Step 2, Section 3.3.2).

In the second part of the workshop, the working group, which consists of policy and technical personnel, will meet to review the implications that conclusions from part one may have on the Decision Guidelines (see ISMP Step 3, Section 3.3.3). Participants will review and confirm conclusions and alternative modifications to the Decision Guidelines (see ISMP Step 3, Section 3.3.3) and finalize a set of biological targets for the upcoming year (see ISMP Step 4, Section 3.3.4). The purpose of the Decision Guidelines is to assure that the long-term goals established in the KVRI BCS, the Tribe's Hatchery Master Plan, and this M&E Plan are met over time. The product of the second part will be an updated action plan for the coming year.

The final step will be a review of parts 1 and 2 to ensure a consensus among the agencies and stakeholders has been reached. Each agency actively implementing the M&E Plan will review how the workshop will guide their respective hatchery and/or field M&E activities/research during the upcoming year. After the workshop, the facilitator will provide a draft summary to all workshop participants, incorporating findings, conclusions and final decisions for review. Workshop participants will confirm (and if necessary correct) the workshop summary and the

facilitator will produce and distribute a final workshop record. A final annual report will then be completed and distributed by Tribal staff. The ISMP database, management tools, Decision Guidelines and other associated products will be retained along with the workshop summary for reference in subsequent APR workshops.

The current Burbot Technical Working Group will continue to communicate routinely throughout the year to coordinate logistics of program activities and reporting requirements.

3.2 BASIS OF THE M&E PLAN

Considerable uncertainty remains regarding future natural production of Kootenai River burbot following decades of habitat loss, natural recruitment failure, and several unsuccessful attempts to modify hydropower operations to reverse the trend. Although habitat restoration activities are expected to increase overall ecosystem productivity, habitat diversity, and fish abundance, specifically when and to what extent these investments will contribute to these outcomes remains somewhat uncertain. The annually updated M&E Plan for Kootenai burbot, which incorporates the APR and ISMP processes, will track program outcomes and guide future implementation.

Activities in this M&E Plan are prioritized based on three criteria:

1. Variables and metrics are needed to implement the four-step ISMP, and will impact management decisions;

2. Variables and metrics are likely to vary from year to year, with uncertainty about the "true" values; and

3. Variables and metrics can be monitored precisely enough to determine whether performance parameters are being achieved.

Variable, metrics, and M&E activities, along with the ISMP process, are presented and described in subsequent sections of this M&E Plan.

This M&E Plan provides a framework for open input and participation by all cooperating agencies and a structured process by which agreements can be reached to provide the most efficient implementation and evaluation of population restoration efforts. The ISMP will provide the cooperating agencies and entities with the necessary adaptive management framework. The program goals directly affected by and relevant to the ISMP are: 1) to ultimately restore and maintain a naturally-spawning, self-sustaining burbot population in the Kootenai River, and 2) to provide future harvest opportunities for tribal and non-tribal fishers.

3.3 IN-SEASON MANAGEMENT PROCEDURE AND GOALS

The goal of the ISMP is to provide a structured decision-making framework that will guide hatchery operations, identify M&E needs, and support effective agency cooperation and

communication consistent with the guidelines established each year. The Kootenai Tribe will implement the four-step ISMP (Figure 1) in cooperation with management agencies, research institutes, and stakeholders (as appropriate). The ISMP procedure is formalized in database(s) and a set of management tools, as well as through the APR to assure consistency and accountability. The database will store and document data and assumptions, while management tools will use predictive models and Excel spreadsheets to arrive at outcomes from which decision guidelines and biological targets may be derived. The tools document the basis for these targets and establish expectations for all performance indicators. They also will help simplify the implementation process and document the rationale for recommended annual restoration actions. The Tribe's biologist responsible for implementing in-season management will use these tools to prepare for the APR workshop, where analytical results will be presented and shared with all interested parties. The management tools used in the ISMP will be further refined over time through implementation of the ISMP and APR processes as new information is obtained and analyzed.

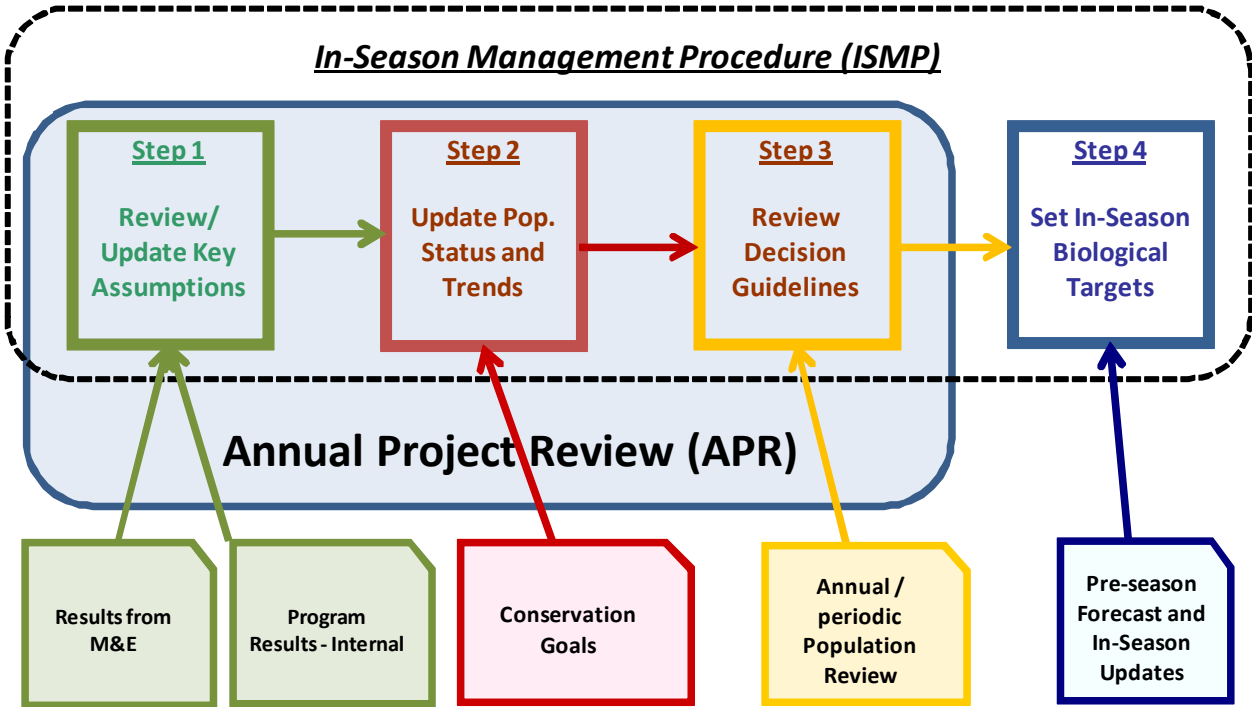


Figure 1. In-Season Management Procedure (ISMP) framework for the Kootenai River Burbot M&E Plan.

Due to inherent uncertainty and expected annual variability in abundance of natural-origin adult burbot returns, the hatchery program is designed for flexible production and operations. This flexibility is reflected in the design and operation of the hatchery facilities and in the Decision Guidelines that will determine the annual hatchery production in balance with the natural population component (Table 6).

3.3.1 Step 1 - Update Key Assumptions

The annual ISMP will integrate newly acquired data and analyses to update a set of key assumptions. Table 3 in Section 5.1 identifies the current and initial estimated future values for each of these parameters in each operational phase. The highlighted column indicates the phase that starts with anticipated start-up of Twin Rivers Hatchery.

3.3.2 Step 2 - Update Stock Status Information

In this step, the most recent stock status information will be entered into the database for both the hatchery and natural components of the population. The initial predictive tool focuses on hatchery production and survival of hatchery-reared burbot. Upon observation of natural recruitment, this tool will be modified to integrate the contribution of natural recruitment to the population. This step will occur at the APR workshop.

3.3.3 Step 3 - Review Decision Guidelines

Once the key assumptions and stock status have been updated, a review of the Decision Guidelines (see Table 6) will be conducted to determine if they need alteration. This adaptive management step will occur at the APR workshop. Although not expected to change frequently, the Decision Guidelines may need to be periodically altered to account for 1) changes in conservation goals in the United States and Canada, 2) unequal goal achievement across the project area, 3) Libby Dam operations/habitat related issues, 4) new scientific discoveries, or 5) other changes in management or environmental conditions in the subbasin or the region.

The purpose of the Decision Guidelines is to assure that hatchery programs and fisheries meet the guidelines for abundance, composition, and distribution to restore and maintain a natural spawning stock. The ultimate goal of the Decision Guidelines is to establish a naturally-reproducing population with a distribution similar to historical records. The Decision Guidelines are based on a set of key assumptions about our capability to accurately detect and respond to the annual abundance of hatchery and natural-origin spawners. This M&E Plan identifies the information needed to update and apply these guidelines and describes how data will be collected to derive this information. The Tribe expects to meet resource goals over time as a result of appropriate in-season management actions.

3.3.4 Step 4- Set Biological Target for the Coming Year

With updated stock status, the data can be used to set biological targets (broodstock needs, release strategy, etc.) for the coming year (see Section 5). The adult-abundance prediction will be updated at the APR. All updates will be entered into modeling and analysis tools (Table 5). The tool(s) then generate expected outcomes that are used to set hatchery production and biological targets for the program, and evaluate progress towards achieving program objectives.

4 DATA COLLECTION

The following metrics are necessary to populate the ISMP spreadsheets to calculate population status and trends, determine biological targets, and evaluate efficacy of Decision Guidelines governing the program. These metrics are essential to assessing the values of the key assumptions and to evaluating the Decision Guidelines. Section 5 defines the initial values for each of the key assumptions (Table 3).

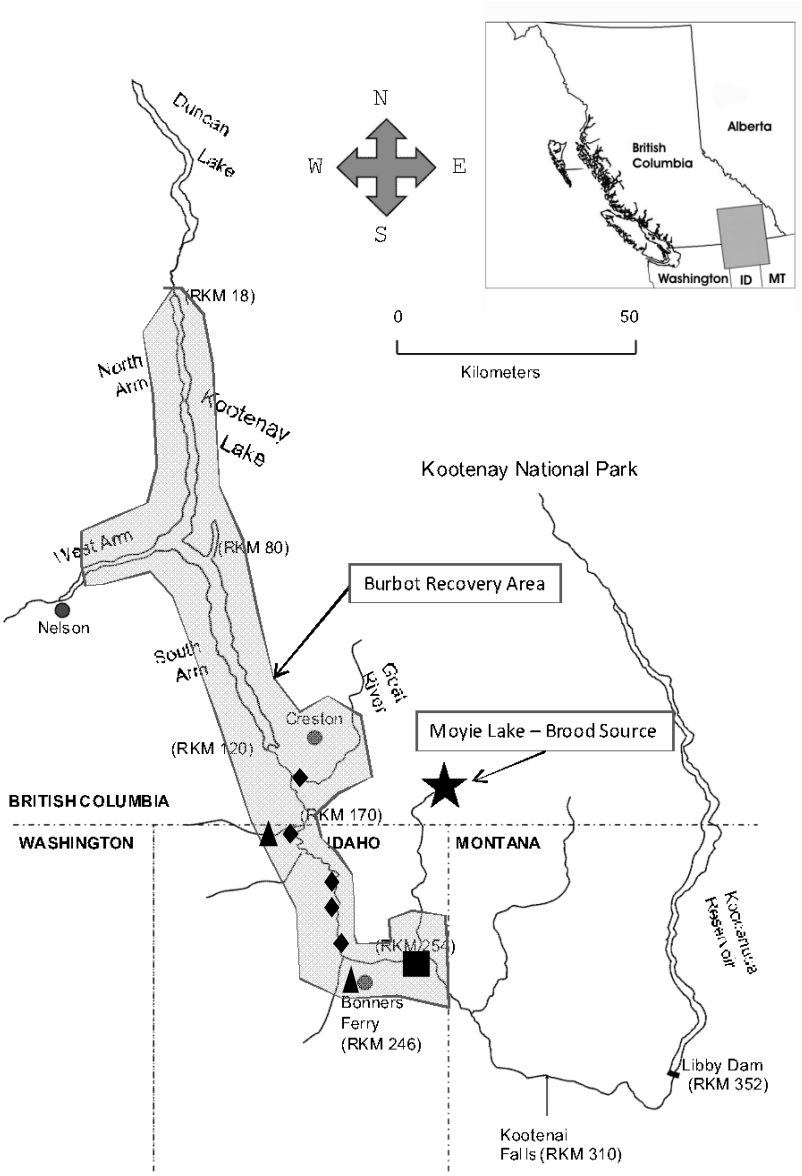
Program data collection is presented under the following headings:

- Metrics Monitored – Donor Source Population
- Metrics Monitored – Aquaculture
- Metrics Monitored – Tagging
- Metrics Monitored – Sub-adults
- Metrics Monitored – Mature Adults
- Metrics Monitored – Spawning / Natural Recruitment
- Metrics Monitored – Habitat
- Existing Kootenai River Monitoring Activities

4.1 METRICS MONITORED - DONOR SOURCE POPULATION

The primary objective for broodstock M&E is to estimate the number of spawning adults that may be available annually for use in the hatchery program without negative consequences to the natural-origin donor population. Currently, Moyie Lake, British Columbia (BC) provides all broodstock and gametes for hatchery production. Future production may use natural-origin progeny from hatchery-reared burbot collected from areas of the Kootenai River and Kootenay Lake where natural recruitment has been restored (Figure 2).

Ongoing monitoring of the Moyie Lake adult burbot population will continue to ensure over-harvest does not occur and that a viable and genetically diverse source remains available to the program. Burbot genetic analyses, population abundance estimates, location of Moyie Lake within the Kootenay River drainage, and recent behavior studies from experimental conservation aquaculture releases all indicate that Moyie Lake is a suitable brood source for reintroduction into the Kootenai River (Figure 2; Powell et al. 2008; Neufeld 2008; Neufeld et al. 2011a and 2011c).



Note: Black star denotes current broodstock collection site. Black square denotes future site of Twin Rivers Hatchery, and the current hatchery-reared burbot release site upriver of Bonners Ferry. Black diamonds denote other current hatchery-reared burbot release sites. Black triangles denote current extensive, natural pond rearing sites.

Figure 2. Location of the Kootenai River burbot recovery area.

Because of the need for the long-term use of Moyie Lake burbot as a broodstock source for recovery efforts, there was a need to evaluate population size and other biological indicators (Prince 2007; Neufeld 2008 and 2010; Neufeld and Spence 2009), the feasibility of capturing broodstock (Neufeld 2008 and 2010; Neufeld and Spence 2009) and the ability to collect and fertilize eggs from natural-origin spawners (Neufeld et al. 2011c). The success of these previous projects implemented since 2007 ultimately led to the first experimental releases of juvenile hatchery fish in the Kootenay River in 2009 (Jensen et al. 2010; Neufeld et al. 2011a and 2011b). Data from these first experimental hatchery releases identified initial survival, movements, and habitat use; high initial survival and dispersal from release locations will likely be suitable for ultimate recovery (Neufeld et al. 2011a).

Each February, Moyie Lake spawning adults are captured via angling, gametes are collected, eggs are fertilized on site, and the fertilized eggs are transported to Tribal facilities and/or UI-ARI for incubation and rearing following methods similar to those detailed in Neufeld et al. (2011c), recognizing that continued method refinements are expected in the future. Also, broodstock will be collected from the Moyie Lake adult burbot population to use as a captive brood source when required (based on facility capacity, breeding requirements and natural-origin population size), following trapping methods outlined in Neufeld and Spence (2004a) and Neufeld (2008). Once the lower Kootenai River adult population is deemed sufficient to support aquaculture objectives, efforts will transition to incorporate these Kootenai River burbot in order to take advantage of their genetic and phenotypic characteristics that allowed survival within the recipient environment. If progeny reared from Moyie Lake adults do not survive and/or reproduce in the lower Kootenai River / Lake, alternative donor populations will be considered.

During sampling efforts at Moyie Lake, all previously untagged adult burbot will be tagged, contributing to the mark-recapture sample used for annual population estimates (Neufeld 2008, Schwarz 2011). The ongoing nature of this work and history of the project will allow enough marked fish for preliminary population abundance estimates in the first year of the Phase 3 of the program (2013). However, there are several critical uncertainties surrounding these preliminary population estimates. A recent statistical review of the program (Schwarz 2011) identified key uncertainties that can be evaluated in the first 3 years of the study. Addressing these key uncertainties entails a telemetry component to evaluate mixing between basins and spawning sites, double tagging (Floy and PIT-tags) to evaluate tag loss, and spawning site tag mixing surveys (visual surveys and telemetry).

Participating agencies and other entities

- BC Ministry
- Kootenai Tribe of Idaho
- University of Idaho Aquaculture Research Institute
- Idaho Department of Fish and Game

Broodstock monitoring and evaluation objectives

- Provide mature adult burbot and fertilized eggs for conservation aquaculture operations;
- Describe donor stock population trends - age, growth, distribution and survival;
- Produce annual donor stock population estimates using mark-recapture;
- Use population indices and mortality factors to determine level of broodstock collection which still allows for successful recruitment and maintenance of fisheries on these systems; and
- Determine the location and general habitat characteristics of burbot spawning locations, and timing of spawning.

Broodstock monitoring and evaluation activities

- Annual fall trapping to provide captive broodstock and provide individuals for sonic tagging;
- Annual winter sampling to provide fertilized eggs for aquaculture operations, mark-recapture sample for population estimation;
- Telemetry system deployment, data collection and analysis (2013-2015); and
- Data analysis, annual reports, and ongoing communications with Technical Working Group.

BPA project(s)

- KTOI "Kootenai River Native Fish Conservation Aquaculture Program"- 198806400

Metrics to be monitored

- Adult abundance
- Mortality
- Growth and condition
- Fecundity and sperm motility
- Behavior and distribution

Variables estimated

- Donor source = Moyie Lake (Continual viability of donor population?)
- Broodstock survival percent (natural-origin)
- Number of broodstock used (Can donor population support aquaculture goals?)

- Number of fertilized eggs (Are female fecundity and male sperm motility adequate and accurately characterized to estimate annual hatchery production?)

ISMP purpose: Will be used to update ISMP Steps 1 – 3.

4.1.1 Methods

Angling will be used to collect spawning adults for on-site gamete collection as described by Neufeld et al. (2011c). Hoop nets may also be used to capture adult burbot for captive broodstock to be held at the hatchery. During sampling for gamete collection, adults will be tagged for mark-recapture population estimates. Telemetry will provide age-specific information on burbot distribution, behavior, and mortality.

4.1.1.1 Mark-Recapture / Population Estimate

During sampling, all previously untagged adult burbot will be tagged with both PIT and floy tags (PIT-tags KRRFM - PIT Tagging (ID: 998)), contributing to the mark-recapture sample used for annual population abundance estimates.

4.1.1.2 Population Structure

During sampling, all burbot will be tagged with an individual identification (PIT tags KRRFM - PIT Tagging (ID: 998)). Weight, length, and sex will be recorded for each burbot captured regardless of whether the individual is used in the aquaculture program.

4.1.1.3 Telemetry / Behavior

Telemetry studies will be conducted to determine mixing between the south and north basins of Moyie Lake as well as mixing of spawners between spawning sites. Spawning site selection and spawning behavior will also be evaluated. Technology used will be similar to other Kootenai River burbot telemetry projects (KRRFM - Sonic telemetry [ID: 996]).

4.2 METRICS MONITORED – AQUACULTURE

Conservation aquaculture for burbot is a critical component for the recovery of this species within the Kootenai River subbasin of Idaho and British Columbia. The quality of the fish produced at hatchery facilities depends largely on the fish husbandry protocols used in hatchery operations. Thus, all rearing phases of the hatchery program will be monitored using best-management practices outlined in a hatchery operations manual that is being developed by UI-ARI and the Tribe. The hatchery will be operated to maximize survival at all life stages by implementing the most current fish health and disease prevention techniques.

In addition to producing adequate numbers of burbot to restore the population, research components will be maintained at Twin Rivers, while future research at the UI-ARI will continue to focus on refinement and improvement of burbot culture methods and applied reproductive biology. Specifically, efforts will focus on addressing ways to improve larval survival and transition to commercial feeds. Also, future research will evaluate the potential to enhance

culture using constructed extensive/semi-intensive ponds. The Tribe, UI-ARI, and others have worked closely to develop burbot biocriteria and facility needs for the Twin Rivers Hatchery. This collaboration will continue as the Twin Rivers facility is constructed, and burbot culture methods are adapted and refined at the new facility.

Participating agencies and other entities

- Kootenai Tribe of Idaho – Twin Rivers Hatchery operation
- University of Idaho – Aquaculture Research Institute – Experimental / research
- Idaho Department of Fish and Game – Pond rearing

Aquaculture research, monitoring and evaluation objectives

- Optimize burbot culture in terms of quantity and quality.

Aquaculture research activities

- Conduct laboratory studies to evaluate and define dietary needs of larvae and juveniles.
- Conduct laboratory studies to optimize feeding rates and rearing densities.
- Conduct laboratory studies to evaluate the role of gut flora to enhance health and survival of intensively reared larval burbot.
- Conduct studies to determine capacity for enhanced rearing of burbot in extensive/semi-intensive ponds at the Twin River's facility through replicated trials.
- Produce larvae to compare hatchery rearing, natural pond rearing, net pen rearing.
- Produce sentinel adults for telemetry studies to determine dispersal, survival, habitat selection, and spawning by hatchery-reared burbot.

Aquaculture monitoring and evaluation activities

- Monitor survival across all life stages in hatchery.
- Identify causes of mortality and factors limiting growth and develop solutions these limitations.
- Monitor growth of fry, juveniles, and sub-adults.
- Kootenai Tribe "Kootenai River Native Fish Conservation Aquaculture Program" 198806400.

Metrics to be monitored during hatchery production

- Survival across all life stages
- Growth / Condition
- Density

Variables estimated

- Broodstock survival in hatchery
- Number of fertilized eggs
- Percent hatch success
- Percent larval survival
- Percent Young-of-Year (YOY) survival (in-hatchery)
- Percent Age-1 survival (in-hatchery)

ISMP purpose: Will be used to update ISMP Steps 1 – 3.

4.2.1 Methods

Each of the metrics listed below will be measured at the beginning and end of the life stage as deemed prudent. Mortality will be recorded daily and reported by hatchery staff in the annual hatchery report. A summary of all hatchery operations and data collection to be conducted as part of hatchery operations will be presented in the Program's Operations and Maintenance Manual (KTOI, in preparation).

- Survival across life stages
- Growth
- Feeding / Diet / Bioenergetics
- Density / Cannibalism

4.3 TAGGING

Use of appropriate tags and tagging methods that do not compromise survival will be essential. Cost-effective batch marks are needed to determine fish origin (hatchery vs. natural). Long-term retention of tags with individual identification that do not compromise survival is also of paramount importance to future M&E efforts. Currently, UI-ARI in collaboration with the IDFG, is developing a genetically-based origin assignment technique based upon collecting genetic information from broodstock and then matching progeny back to parents used in the hatchery program. This will allow determination of fish origin (hatchery vs. natural) without additional tagging requirements. The UI-ARI has also evaluated the use of extended (up to one year) VIE tags (Northwest Marine Technology, Shaw Island, WA), which are currently being used to tag individuals too small for other tags. Color-coded VIE tags enable recaptured individuals to be identified by year class and release site. The UI-ARI has also evaluated surgical implantation of PIT-tags (Destron Fearing, St. Paul, MN) for long-term monitoring of individuals, providing survival, growth, and behavioral data. More important, PIT-tags enable evaluation of release strategies by comparing survival, growth, and reproduction, between and among release locations and seasons. Finally, to date, Age-1, -2 and -3 burbot have been successfully

implanted with sonic transmitters (Vemco, Amirix Systems Inc., Halifax, Nova Scotia) and released into the Kootenai River, providing information about survival and dispersal. The combination of using appropriate tagging methods and employing appropriate field sampling techniques is an essential component of evaluating recovery strategies.

Participating agencies and other entities

- Kootenai Tribe of Idaho
- University of Idaho – Aquaculture Research Institute
- Idaho Department of Fish and Game
- BC Ministry

Tagging research, monitoring, and evaluation objectives

- Develop a genetic-based tagging program.
- Continue evaluation of batch marking techniques for different life stages to accommodate large-scale hatchery production and evaluation of stocking strategy.
- Determine best tagging methods that provide individual identification with the least negative effects on survival, growth, and reproduction.

Tagging research, monitoring, and evaluation activities

- Develop and implement a genetic based tagging program.
- Conduct laboratory studies evaluating tag retention, survival, and growth at different life stages.
- Evaluate artificial batch markers (VIE).
- Evaluate artificial marking techniques for individual identification (PIT-tag).
- Evaluate genetic markers for origin identification and genetic diversity assessments.
- KTOI “Kootenai River Native Fish Conservation Aquaculture Program”-198806400.
- IDFG “Kootenai River Resident Fish Mitigation”- 198806500.

Metrics to be monitored for tagging studies

- Post-tagging survival
- Post-tagging behavior
- Post-tagging growth / condition
- Tag retention

Variables estimated

None; however, this tagging research is an integral part of the program. Without proper tagging techniques, values for numerous parameters will be difficult to estimate with precision.

ISMP purpose: Without proper tagging techniques, much of the information needed in ISMP Steps 1 – 3 will not be available.

4.3.1 Methods

4.3.1.1 Batch Markers – Artificial

Studies will determine retention and negative effects of VIE tags on juvenile and sub-adult burbot.

4.3.1.2 Individual ID

KRRFM – PIT-Tagging (ID: 998)

4.3.1.3 Genetic Based Tagging

Collect tissue samples from all broodstock and a sub-sample of their progeny, and then determine accuracy of parental assignment via genetic techniques. This will allow differentiation between hatchery- and natural-origin burbot without an artificial tag.

KRRFM - Parental based tagging (ID: 1008)

4.4 METRICS MONITORED – SUB-ADULT RELEASES

Restoration of a functionally extinct or extirpated sub-population of fish evolves over time. Progress is predicated by initial survival of hatchery-reared or translocated individuals followed by assessing adaptation to the environment that results in reproduction and recruitment. Currently, hatchery-reared burbot provide research subjects to evaluate distribution, movements, habitat use, food habitats, and to determine effective sampling methods for the different life stages. UI-ARI production and tagging studies will be coupled with IDFG and BC Ministry population-level research and field monitoring of initial survival, growth, and maturation. Telemetry, fixed PIT-tag arrays and year-round sampling with multiple gears will initially provide survival, growth, and behavioral data, and then also recruitment data when natural spawning occurs. KTOI will provide field support if requested, and will participate in data analysis and restoration strategy development. Experimental releases of burbot of various sizes will identify life stage limitations and provide information necessary to guide habitat restoration efforts. Survival, growth, and maturation estimates will provide the needed quantitative basis to estimate the appropriate scale of production and release strategies to meet long-term population restoration objectives.

Evaluating reintroduction strategies is another major program objective for burbot. Release sites for hatchery-reared burbot in the Kootenai River extend from the mouth of the Moyie

River at river kilometer (RKM) 260 downriver to the Goat River (RKM 155). The eight release sites currently used were selected based on current and historical distribution and the likelihood that these habitats will optimize survival (Figure 2). Other sites may be used if studies indicate they are necessary to meet objectives. As larval and juvenile production expands, the number of sites will expand to include Kootenay Lake and several additional tributaries.

Participating agencies and other entities

- Idaho Department of Fish and Game
- Idaho Cooperative Fish and Wildlife Research Unit (ID-CFWRU)
- BC Ministry
- Kootenai Tribe of Idaho

Post-release monitoring and evaluation activities

- IDFG - Early life stages of burbot sampling and gear efficacy study using Herzog (Missouri) trawls, electrofishing, and small-mesh traps --- collaboration with the Idaho Cooperative Fish and Wildlife Research Unit (ID-CFWRU; Dr. Michael C. Quist).
- IDFG - Tributary spawning, rearing, habitat selection, and emigration of burbot by using fixed and mobile PIT-tag arrays --- collaboration with the Idaho Cooperative Fish and Wildlife Research Unit (ID-CFWRU; Dr. Michael C. Quist).
- BC Ministry and IDFG - Telemetry of age 1- to 3-year-old hatchery-reared burbot.

Sub-adult monitoring and evaluation objectives

- Survival
- Growth / Bioenergetics
- Ecology
  - Habitat selection by life stage
  - Diet by life stage
- Kootenai Tribe “Kootenai River Native Fish Conservation Aquaculture Program” 198806400
- IDFG “Kootenai River Resident Fish Mitigation” 198806500

Metrics to be monitored for sub-adult burbot (in-river)

- Annual survival
- Growth / Condition
- Bioenergetics

- Density
- Behavior – dispersal and habitat selection

Variables estimated

- Percent Age-0 survival in-river
- Percent Age-1 survival in-river
- Percent Age-2 survival in-river
- Percent Age-3 survival in-river

ISMP purpose: Will be used to update ISMP Steps 1 – 3.

4.4.1 Methods

4.4.1.1 Release Success

Larval, juvenile, and sub-adult burbot are currently stocked at six mainstem locations and in four tributaries. Release sites may expand to include multiple locations in Kootenay Lake.

- Site 1 KR - Mouth of Moyie River (RKM 260)
- Site 2 KR – Mouth of Deep Creek (RKM 240)
- Site 3 KR – Shorty's Island (RKM 230)
- Site 4 KR – Ferry Island (RKM 205)
- Site 5 KR – Mouth of Boundary Creek (RKM 170)
- Site 6 KR – Mouth of Goat River (RKM 130)
- Site 7 Boundary Creek, ID
- Site 8 Deep Creek, ID
- Site 9 Goat River, BC
- Site 10 Corn Creek, ID

Survival and growth will be compared to determine optimal mainstem and tributary stocking locations. All hatchery-origin burbot will be identified as such by genetic parental based tagging. A portion of hatchery-reared burbot will also be released at each site with an individually identifiable tag that will provide recapture data in a non-lethal manner.

4.4.1.2. Telemetry

Telemetry methods are well developed (Neufeld et al. 2011a) and will be used to tag and track hatchery sub-adults after release (for up to 4 years post-release; Neufeld et al. 2011a) as well as to tag hatchery and natural-origin adults captured after release in the wild to further evaluate response to habitat actions (Paragamian et al. 2005, Paragamian and Wakkinen 2008). An array

of receivers was developed in 2004, with funding from BPA, USFWS, and other partners, to cover the entire Kootenai watershed from Kootenay Falls in Montana and downstream through Idaho and BC, including all of Kootenay Lake in BC. Forty Vemco VR2 sonic receivers are currently deployed in Kootenay Lake and River in BC with an additional 41 in the Kootenai River in Idaho and Montana; additional receivers will be deployed into the release tributaries in 2012. Following methods outlined in Neufeld and Rust (2009), receivers in Kootenay Lake are deployed both in lines crossing the width of the lake (gate or curtain system) to record movements past a chosen point, and individually to record fish near a specific location of interest. In the river, individual receivers are deployed at single monitoring locations because the range of a single receiver is great enough to cover the river width and thus create a gate or curtain system. The distance between gates in Kootenay Lake (9-11 km) is greater than in the Kootenai River (0.6-12 km). Development of this telemetry array initially focused on evaluating juvenile dispersal from hatchery release sites as part of conservation aquaculture monitoring and refinement (Neufeld and Rust 2009). However, the utility and cost saving provided by this array for monitoring adult sturgeon and burbot quickly became apparent and current BPA-funded telemetry projects for many species in the Kootenai now rely on this array (e.g., Neufeld and Rust 2009; Neufeld et al. 2011a).

KRRFM – PIT-tagging (ID: 998)
KRRFM - Sonic telemetry (ID: 996)

4.4.1.3. Sampling Gear

Hoop traps of various aperture and mesh sizes along with Herzog (Missouri) trawls, electrofishing, and other small-mesh traps will be used to capture juvenile and sub-adult burbot. Gear efficiency across seasons and time of day will be tested. Traps will be fished un-baited and baited with kokanee (*Oncorhynchus nerka*) spawner carcasses placed in marquisette bait bags. Trap locations will be recorded with a Global Positioning System receiver and depths by means of a recreational grade depth sounder. Captured burbot will be pulled from trapping depth following decompression procedures described in Neufeld and Spence (2004a). Upon retrieval, burbot will be placed in a plastic container filled with water. All burbot will be measured and searched for tags. Any untagged fish will be given a uniquely identifiable PIT-tag. Fish that meet criteria for surgical implantation of telemetry devices will be placed back into the trap and held until experienced personal implant the telemetry device. These fish will subsequently be tagged and released. Also, a fin-clip for DNA will be taken from all recaptured burbot.

KRRFM - Burbot adult and juvenile sampling (ID: 997)
KRRFM - Burbot sampling efficiency graduate research (ID: 1290)
KRRFM – PIT-tagging (ID: 998)

4.4.1.4. Tributary Use / Fixed PIT-Tag Arrays

Tributary spawning, rearing, habitat selection, and emigration of burbot will be evaluated by using fixed and mobile PIT-tag arrays and sonic telemetry.

KRRFM – PIT-tagging (ID: 998)
KRRFM - Sonic telemetry (ID: 996)

4.5 METRICS MONITORED – MATURE ADULTS

Data collected by field M&E of hatchery-reared and natural-origin burbot adults will be a critical component to evaluate program success. As discussed in Section 4.4 (sub-adults), hatchery-reared burbot are being released at eight different locations across a 130 km segment of the Kootenai River in Idaho and BC. Currently this includes four tributaries, Moyie River, Deep Creek, Boundary Creek and Goat River. Boundary Creek historically supported burbot spawning, and Goat River is believed to be the last spawning habitat for the remnant stock in the Lower Kootenai subbasin.

All parties involved in this endeavor are in agreement that the natural-origin stock in the recovery area is now functionally extinct; however, a very small remnant still exists. A very limited amount of natural reproduction may still be occurring in the Goat River, BC, and a few other historical spawning areas such as Ambush Rock (RKM 244.5) on the Kootenai River.

Participating agencies and other entities

- Idaho Department of Fish and Game
- Idaho Cooperative Fish and Wildlife Research Unit (ID-CFWRU)
- BC Ministry
- Kootenai Tribe of Idaho

Adult monitoring and evaluation objectives

- Quantify hatchery-reared, naturally-reared from hatchery-origin, and remnant natural-origin stock.
- Monitor behavior of each possible component.
- Determine whether donor stock sources support recovery goals.
- Provide population assessments to determine production goals.
- Determine if the release strategy has been effective.
- Determine if natural recruitment is occurring.
- Estimate harvest.
- Set management regulations.

Adult monitoring and evaluation activities

- Calculate population estimates using mark-recapture data.
- Population abundance trends and gear efficiency based upon CPUE.
- Annual survival rates
- Spawning / recruitment
- Monitor harvest
- Using these population parameters, future population trajectories may be constructed; these may then guide hatchery production and fisheries management decisions.
- Behavioral studies that focus on habitat selection, and behavioral response to environmental changes, both negative and positive
- The KVRI Kootenai River Burbot Conservation group and the technical working group will evaluate reintroduction strategies based on data.
- Kootenai Tribe "Kootenai River Native Conservation Aquaculture Program" 198806400
- IDFG "Kootenai River Resident Fish Mitigation" 198806500.

Metrics to be monitored for adult burbot (in-river)

- Abundance
- Annual Survival
- Growth / Condition
- Bioenergetics
- Density
- Behavior – movement and habitat selection
- Harvest

Variables estimated

- Percent annual survival Ages 4 – 10
- Number of adults – in river
- Number of adults – in lake
- Natural mortality
- Fishing mortality

ISMP purpose: Will be used to update ISMP Steps 1 – 3.

4.5.1 Methods

4.5.1.1 Adult Monitoring

Adults will be captured primarily using hoop nets (IDFG and BC Ministry). All burbot will be measured, weighed, inspected for batch marks and scanned for PIT-tags to determine origin (hatchery vs. natural), year class, and release site. If not previously tagged with an individual identifier, each captured fish will receive a PIT-tag.

KRRFM - Burbot adult and juvenile sampling (ID: 997)
KRRFM - Burbot sampling efficiency graduate research (ID: 1290)
KRRFM – PIT-tagging (ID: 998)
KRRFM - Burbot demographics analysis (ID: 1022)

4.5.1.2 Telemetry

Telemetry combined with trapping and other capture techniques currently under development will be used to identify movements and habitat use of hatchery-reared and natural-origin Kootenay River burbot to assess general behavior and dam operation modifications aimed at providing suitable conditions for successful recruitment from both natural- and hatchery-origin adult burbot. These projects use Vemco hydro-acoustic technology. A hydro-phone array extends throughout Kootenay Lake upriver to the Montana border.

KRRFM - Sonic telemetry (ID: 996)
KRRFM - Burbot movement response Libby Dam operations (ID: 1046)

4.5.1.3 Mark-Recapture / Population Estimate

All previously untagged adult burbot will be tagged (PIT tags) upon capture, contributing to the mark-recapture sample used for annual population estimates.

KRRFM - Burbot demographics analysis (ID: 1022)
KRRFM - Sonic telemetry (ID: 996)
KRRFM - Burbot movement response Libby Dam operations (ID: 1046)
KRRFM - Burbot adult and juvenile sampling (ID: 997) (Proposed)
KRRFM - Burbot sampling efficiency graduate research (ID: 1290)
KRRFM – PIT-tagging (ID: 998)

4.5.1.4 Harvest

An angler reporting system or a creel survey program will be needed.

KRRFM - Burbot demographics analysis (ID: 1022)

4.6 METRICS MONITORED – SPAWNING / NATURAL RECRUITMENT

All involved parties are in agreement that the natural-origin stock in the recovery area is now functionally extinct; however, a very small remnant still exists. Some natural reproduction may still be occurring in the Goat River, BC, and a few other historical spawning areas such as Ambush Rock (RKM 244.5) on the Kootenai River.

Participating agencies and other entities

- Idaho Department of Fish and Game
- Idaho Cooperative Fish and Wildlife Research Unit (ID-CFWRU)
- BC Ministry
- Kootenai Tribe of Idaho

Spawning monitoring, and evaluation objectives

- Quantify total spawner abundance.
- Quantify contribution of hatchery-reared, naturally-reared from hatchery-origin, and remnant natural-origin stock to the spawning population.
- Monitor spawning behavior of each component.
- Determine number of spawning locations.
- Determine if natural recruitment occurs to larval and juvenile stages.

Spawning monitoring, and evaluation activities

- Spawning population estimates based upon mark-recapture data or enumeration by visual counts or at fish weirs.
- Spawning site and microhabitat selection.
- KTOI "Kootenai River Native Fish Conservation Aquaculture" 198806400.
- IDFG "Kootenai River Resident Fish Mitigation" 198806500.

Metrics to be monitored for adult burbot (in-river)

- Annual spawner abundance
- Composition of spawning population
- Sex ratio
- Fecundity and sperm motility
- Spawning site selection
- Egg fertilization

- Egg hatch
- Larval survival
- Juvenile survival

Variables estimated

- Number of spawners
- Number of spawning locations
- Number of spawners per location
- Natural egg fertilization
- Natural egg hatch
- Natural larval survival
- Natural juvenile survival
- Natural egg abundance
- Natural larval abundance
- Natural juvenile abundance

If this program successfully restores natural spawning but does not rebuild a sustainable population structure, natural-origin adults may be incorporated into hatchery broodstock program. If so, then this section would include additional "Parameters Estimated" similar to Sections 4.1 and 4.2. Further, as long as the restored population is comprised of hatchery and natural production, both will be incorporated into the predictive tools. Natural production attributes and parameters will be similar to hatchery parameters, and then both components will be analyzed separately and in total to characterize the population.

ISMP purpose: Will be used to update ISMP Steps 1 – 3.

4.6.1 Methods

4.6.1.1 Annual Spawning Counts

Hoop nets will be placed at tributary mouths and fish weirs will be implemented at selected tributaries known to historically support burbot spawning. Visual counts will be conducted during day and spotlight surveys at night by foot or by boat at historical spawning locations and at any newly discovered spawning sites.

KRRFM – PIT-tagging (ID: 998)
KRRFM - Burbot adult and juvenile sampling (ID: 997) (Proposed)

4.6.1.2 Spawner Abundance

Optimally, direct enumeration will be employed. Mark-recapture may be employed when and where direct enumeration is not possible.

KRRFM – PIT-tagging (ID: 998)

4.6.1.3 Telemetry

Telemetry combined with trapping and other capture techniques currently under development will be used to identify movements and habitat use of hatchery-reared and natural-origin Kootenay River burbot. These efforts will assess general behavior and behavioral responses to dam operation modifications aimed at providing suitable conditions for successful recruitment from both natural- and hatchery-origin adult burbot. The telemetry projects use Vemco hydro-acoustic technology. A hydro-phone array extends throughout Kootenay Lake upriver to the Montana border.

KRRFM - Sonic telemetry (ID: 996)

4.7 HABITAT

As suggested by the KVRI BCS, addressing habitat needs is critical to burbot restoration. The following passage is found in Section 8 of the BCS:

> **"2. Develop a broad-based habitat restoration program to address altered ecosystem problems that have contributed to the burbot collapse.** Burbot declines are the result of an extended period of pervasive, large-scale changes in the Kootenai River and Kootenay Lake ecosystems. Declines, in some cases were exacerbated by past harvest (e.g. West Arm burbot fishery). The changes extend from physical habitat and ecological function loss to primary and secondary system productivity, nutrient availability, and possible contaminant dynamics. Some factors such as harvest, levee construction, and hydro development are obviously implicated; population collapse resulted from the combined impacts of these multiple factors, rather than from the isolated effect of any single factor. The complex interactions of changes and their relative impacts on burbot are difficult to partition. However, effective long-term persistence and viability of a sustainable, naturally producing burbot population depends on significant conservation and restoration across the current ecosystem. Measures narrowly focused on increasing numbers of one species are likely to fail if by concentrating on the symptom, they overlook the underlying causes. Ecosystem-based approaches are given wide lip service but rarely translated into specific, scale-appropriate activities. In this Conservation Strategy an ecosystem-based approach includes a combination of mainstem habitat protection, tributary and mainstem habitat restoration, fish population protection and recovery measures, conservation aquaculture, fish community and primary productivity improvements, and pollution control. This Conservation Strategy also exists as

part of a larger context of the Kootenai River Adaptive Management Program currently being developed (Anders et al. 2004)."

BPA project(s)

- Kootenai Tribe "Kootenai River Habitat Restoration Project Monitoring and Evaluation" 200200200

Metrics monitored during ongoing ecosystem restoration efforts

- KTOI - Bank erosion monitoring (ID: 1179)
- KTOI - Browse evaluation (ID: 1184)
- KTOI - Cover type mapping (ID: 1182)
- KTOI - Disturbance observation monitoring (ID: 1186)
- KTOI - Floodplain and channel morphology surveys (ID: 1178)
- KTOI - Floodplain herbaceous vegetation composition and cover (ID: 1310)
- KTOI - Floodplain substrate survey: volumetric bar samples (ID: 1180)
- KTOI - Floodplain woody vegetation composition and percent cover (ID: 1183)
- KTOI - Floodplain woody vegetation natural recruitment and regeneration (ID: 1311)
- KTOI - Greenline photo monitoring (ID: 1187)
- KTOI - Groundwater data collection (ID: 1214)
- KTOI - Mainstem stage data collection (ID: 1215)
- KTOI – Percent cover woody vegetation on streambanks (ID: 1312)
- KTOI - Side channel fish assemblage and population study (ID: 1212)
- KTOI - Structure monitoring (ID: 1181)
- KTOI - Substrate survey: underwater videography (ID: 1306)
- KTOI - Survival monitoring (ID: 1308)
- KTOI - Suspended sediment sampling (ID: 1213)
- KTOI - Model development and calibration (ID: 1216)

Variables estimated

None at this time; however, each of the above-listed metrics may directly affect many of the parameters and the associated values. As relationships become apparent, correlations and predictive models may be used to evaluate assumptions and Decision Guidelines for the burbot program.

ISMP purpose: Ongoing monitoring and restoration activities will be used to update and evaluate ISMP Steps 1 – 3.

4.8 EXISTING MONITORING IN THE KOOTENAI RIVER

All parties are in agreement that the natural-origin stock in the recovery area is now functionally extinct. In order to restore a viable population, hatchery-reared burbot from the Moyie Lake donor source, and eventually Kootenai River naturally produced burbot, must adapt to the current altered state of the Kootenai River and Kootenay Lake that has been implicated in the population's decline. Habitat restoration, nutrient addition, and river flow and temperature management are expected to provide an adequate environment that supports survival, growth, sexual maturation, and spawning by hatchery-reared individuals. Then ultimately, natural recruitment may be sustained.

IDFG has been conducting burbot population surveys since 1979 (Partridge 1983), long before functional extirpation occurred. As habitat change appears to have been the main cause for the decline of burbot and other species, the Tribe and IDFG have jointly managed the Kootenai Basin Biological Monitoring and Evaluation Program, assessing the health of the Kootenai system. Also, there are multiple habitat restoration projects within the project area that are expected to benefit burbot restoration efforts. Previously, IDFG investigated the effects of an altered hydrograph and thermograph on burbot behavior; it is likely this topic will be further addressed during restoration of a viable population.

BPA projects

- Kootenai Tribe "Kootenai River Ecosystem Restoration" 199404900
- IDFG "Kootenai River Resident Fish Mitigation" 198806500

Metrics monitored during ongoing ecosystem restoration efforts

- KRRFM- Nutrient dosing BMP (ID: 1103)
- KTOI - Benthic macroinvertebrate sampling
- KTOI - Nutrient addition of N and P (ID: 1175)
- KTOI - Periphyton accrual and biomass sampling (ID: 1107)
- KTOI - Periphyton taxonomic community/density sampling (ID: 1114)
- KTOI - Water chemistry (ID: 1123)
- KRRFM- Fish biomonitoring data (ID: 1007)
- KTOI - Benthic macroinvertebrate analysis (ID: 1137)
- KTOI - Periphyton accrual and biomass sample analysis (ID: 1118)
- KTOI - Periphyton taxonomic community/density analysis (ID: 1117)

- KTOI - Water chemistry analysis (ID: 1136)

Variables estimated

None at this time; however, each of the above-listed metrics will directly affect many of the parameters and the associated values. As relationships become apparent, correlations and predictive models may be used to evaluate key assumptions and Decision Guidelines of the program.

ISMP purpose: Ongoing monitoring and restoration activities will be used to update and evaluate ISMP Steps 1 – 3.

5 METRIC ESTIMATES & HYPOTHESIS TESTING

In general, the purpose of the ISMP is to guide the restoration of the burbot population. More specifically, the ISMP will aid in the transition from experimental phases to population rebuilding phases as the Twin Rivers Hatchery comes on line. Further, the ISMP will be valuable for the working group to adapt M&E results to phasing a hatchery-reared population into a naturally-reproducing population.

This section identifies and defines the variables and metrics used in the four-step ISMP and how they will be used. In Step 1, the key assumption parameters are used to predict how the population will respond to future management actions. In Step 2, the status and trend analysis, outcomes based on empirical data are assembled, the current status of the population is established, and progress toward population goals is analyzed (Section 5.2). From the predicted outcomes, the Decision Guidelines will be annually reviewed in Step 3, although they may not change. The Decision Guidelines set the management controls so that if the key assumptions are accurate, the biological targets set in Step 4 for the population may be met.

At each step in this process the working group will describe any and all analytical results and changes to parameter values and record them in the ISMP database. At the end of the season, this information will be compiled in an annual report developed prior to the APR.

A key element of this plan is that all assumptions and parameters will be reviewed and challenged each year to assure the most current and reliable information is used in the decision-making process.

5.1 KEY ASSUMPTIONS (ISMP STEP 1)

The key assumptions are a set of parameters that relate to future expectations (i.e., the basis for predictions about what will happen). Generally, these assumptions are based on current culture techniques, recent findings, and strategy goals. These form the basis for in-season and long-term restoration decisions. The parameters are grouped into four categories: 1) hatchery

production, 2) natural production, 3) reproduction, and 4) harvest parameters. Each is described below and listed in Table 3.

Table 3. Initial key assumptions for hatchery-reared and natural-origin components of a restored burbot population.

	Variable Name	Phase 1 2004-2008	Phase 2 2009-2013	Phase 3 2014-2018	Phase 4 2019 +
Donor	Broodstock Donor Source	Variable	Moyie Lake	Moyie Lake	Moyie Lake and/or Kootenai R.
	Broodstock Percent Survival (field)	90	90	90	90
Hatchery	Broodstock Percent Survival (in hatchery)	50 - 100	50 - 100	80 - 100	80 - 100
	No. of Broodstock (females:males)	Variable	9 – 20: 18 - 40	30 : 60	30 : 60
	No. of Families (1 female:2 male = 2 families)	Variable	18 - 36	60	60
	Fertilized Eggs (Mean fecundity = 200,000 eggs / kg body weight)	Variable	3.0 – 5.0 million	6 million	6 million
	Percent Hatch	Variable	50 - 70	50 - 70	50 - 70
	Percent Larval Survival	Variable	20 (2012)	20	20
	Percent Fry Survival	Variable	25	25	25
	Percent YOY Juveniles (Age 0 - 6 months) Survival	Variable	20 – 30	20 – 30	20 – 30
	Percent Age-1 Survival in Hatchery	Variable	50 – 90	50 – 90	50 – 90
Natural (in-river)	Percent Egg to 6 Months Survival	-	unknown	unknown	unknown
	Percent Age-6 mo. to Age 1 (assumed)	-	20 - 35	20 - 35	20 - 35
	Percent Age-1+ Survival in Wild	-	40 - 70	40 - 70	40 - 70
	Percent Ages 2 – 10+ Annual Survival	-	40 - 70	40 - 70	40 - 70
	Minimum Number of Adults	-	-	2,500	17,500
	Number of Spawning Areas	-	-	≥ 3	≥ 3
	Number of Spawners per Spawning Area	-	-	TBD	TBD
	Natural Mortality (percent)	-	30 - 60	30 - 60	20 - 50
Harvest	Fishing Mortality (percent)	-	0	0	TBD

5.1.1 In-Hatchery Assumptions

In-hatchery operations will incorporate detailed record keeping and tracking of mortality at each stage from broodstock collection through release. It is important to note that the number of fish collected for broodstock will vary from year to year based on the annually determined biological targets.

The size of the program is measured in terms of broodstock (number and composition), number of families produced, and release numbers.

In-hatchery parameters to be monitored are:

Donor stock

- **Definition**: The population from which broodstock and/or gametes are collected.
- **Assumed Value**: Moyie Lake

Broodstock survival

- **Definition**: Percentage of fish used for broodstock surviving one year post-spawn.
- **Assumed Value**: 90%

Number of females: number of males

- **Definition:** Ratio of females to males used for broodstock.
- **Assumed Value**: 1:2 (30:60)

Number of families

- **Definition:** A cross of one female with one male. On average, each female will be crossed with two males, but individually. Thus, each female should produce two distinct families.
- **Assumed Value**: 60 (Twin Rivers Hatchery)

Eggs/female (fecundity)

- **Definition**: Average number of eggs per female spawned.
- **Assumed Value**: 200,000 (200,000 eggs per kg body weight; mean weight per female = 2.0 kg).

Number of fertilized eggs

- **Definition**: Total number of eggs successfully fertilized as determined under microscope.
- **Assumed Value**: 6,000,000 (Twin Rivers Hatchery)

Percent hatch

- **Definition**: Percentage of fertilized eggs that successfully incubate and hatch.
- **Assumed Value**: 50 - 70%

Percent larval survival

- **Definition**: Percentage of fish that survive from hatch until fry stage.
- **Assumed Value**: 20%

Percent YOY survival (to 6 months in-hatchery)

- **Definition**: Percentage of fish that survive from end of larval stage to 6 month juvenile.
- **Assumed Value**: 20 – 30%

Percent Age-1 survival (in-hatchery)

- **Definition**: Percentage of fish that survive from 6 months to 12 months.
- **Assumed Value**: 50 - 90%

5.1.2 Natural Production and In-river Survival for Hatchery-reared Burbot

Data on annual survival rates of burbot in the Kootenai system are available for adults, but not for juveniles. Adult survival of 40 to 70% was derived from historical data. Pyper et al. (2004) estimated an annual natural survival rate of the remnant Kootenai River population at 37%. This unsustainably low survival rate resembles that of over-exploited populations; however, the population experiences no harvest and densities are so low that illegal harvest is not suspected. This low survival rate may be explained by delayed mortality from past trapping efforts (B. Pyper, Cramer Fish Sciences, pers. comm., 2006). Ahrens and Korman (2002) estimated an annual natural survival of adults in the failed Kootenay Lake burbot population at 71%. More recently, Stephenson and Neufeld (2012) reported 63% survival 1-year post-release of transmittered 2- and 3 year-old, hatchery-reared, sentinel sub-adults. These estimates bracket the range of alternatives identified in Table 5.

Experience with other species and general fish population dynamics suggests that survival rates of hatchery-reared fish released at earlier life stages will be lower during the first year at large as released fish adapt to natural conditions. For planning purposes, we assumed the first year survival rate for Age-0 juveniles will be half the annual survival of 2- and 3-year-old sub-adults and adults. Thus, annual survival of hatchery-reared and natural-origin juveniles is assumed to be 20 to 35%. Annual survival for sub-adults (Ages 1-3) and adults (Ages 4+) is assumed to be similar based upon studies discussed in the previous paragraph.

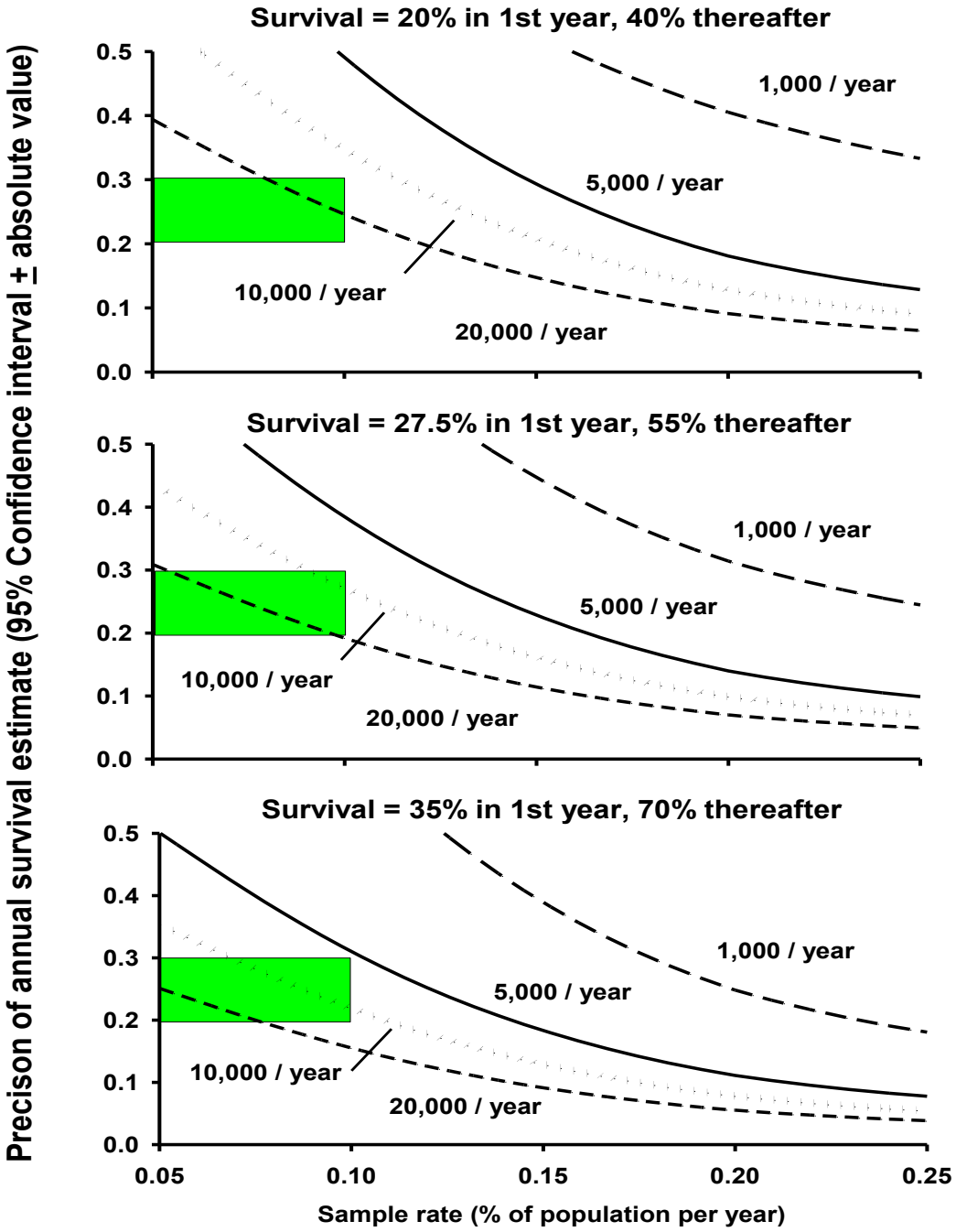
Population levels are extremely sensitive to moderate differences in annual survival. For instance, increases in annual survival from 40 to 70% result in a substantial difference in projected adult numbers from any given hatchery release level (Table 4).

Phase 2 annual experimental production targets of 10,000 to 20,000 Age-0 burbot are consistent with a statistical power analysis of the numbers required to provide reasonable estimates of precision (±20-30%) on estimates of annual survival at sampling (capture rates; 5-10%). Statistical power curves (Figure 3) illustrate tradeoffs between release number and sampling rate at three survival scenarios. This example is based on a simple Cormack-Jolly-Seber mark-recapture model formulation that is consistent with the annual mark-recapture sampling design of the monitoring program. Even moderately precise estimates of survival or trends in survival will require either large release numbers or large sample rates (large numbers of recaptured fish). Release numbers and/or sample rates would need to be increased substantially at lower survival rates in order to provide comparable levels of statistical precision. Release numbers and sampling effort will be adjusted adaptively as data are collected to provide the desired precision to evaluate this program.

Table 4 illustrates that UI-ARI production capabilities may be adequate to meet the very minimum conservation abundance objectives (2,500) under only the most optimistic of assumptions. This underscores the need for the Twin Rivers Hatchery in order to implement program expansion to rebuild and sustain a viable population. Although the historical size of the South Arm and Kootenai River burbot population is unknown, we believe that the minimum conservation abundance objectives at current and planned Phase 3 release levels are substantially less than the historical habitat capacity. Thus, the proposed phased approach protects from indiscriminate, large-scale hatchery production, and allows the program to grow adaptively as necessary.

Table 4. Sensitivity of burbot population size to production numbers and survival rates based on example release numbers of 2,000, 5,000, 10,000 and 20,000 Age-0 burbot.

Age	40% Annual Survival (20% survival age-0+, 40% thereafter)				55% Annual Survival (27.5% survival age-0+, 55% thereafter)				70% Annual Survival (35% survival age-0+, 70% thereafter)			
Rel no.	**2,000**	**5,000**	**10,000**	**20,000**	**2,000**	**5,000**	**10,000**	**20,000**	**2,000**	**5,000**	**10,000**	**20,000**
1	400	1000	2,000	4,000	550	1,375	2,750	5,500	700	1,750	3,500	7,000
2	160	400	800	1,600	303	756	1,513	3,025	490	1,225	2,450	4,900
3	64	160	320	640	166	416	832	1,664	343	858	1715	3430
4	266	64	128	256	92	229	458	915	240	600	1201	2401
5	10	26	51	102	50	126	252	503	168	420	840	1681
6	4	10	20	41	28	69	138	277	118	274	588	1176
7	2	4	8	16	15	38	76	152	82	206	412	824
8	1	2	3	7	8	21	42	84	58	144	288	576
9	0	1	1	3	5	12	23	46	40	101	202	404
10	0	0	1	1	3	6	13	25	28	71	141	282
11	0	0	0	0	1	3	7	14	20	49	99	198
12	0	0	0	0	1	2	4	8	14	35	49	138
13	0	0	0	0	0	1	2	4	10	24	48	98
14	0	0	0	0	0	1	1	2	7	17	34	68
15	0	0	0	0	0	0	1	1	5	12	24	47
Adults	**17**	**43**	**85**	**171**	**112**	**279**	**558**	**1117**	**549**	**1373**	**2746**	**5492**



Note: Estimated using a simple Cormack-Jolly-Seber mark-recapture model (6-year sampling interval). Confidence intervals are approximated based on two times the standard error of the estimate. The shaded box shows target precision and sampling rates

Figure 3. Power analysis of the effects of annual release number and sampling rate on 95% confidence intervals for survival under three different survival assumptions.

The only suitable population abundance reference point available is from historical harvests of West Arm Kootenay Lake recreational fisheries. Peak harvest levels, assumed to represent a minimum bound on a population estimate, occurred in 1969 with the harvest of 25,930 adult burbot in the West Arm fishery (Ahrens and Korman 2002; KVRI 2005). At an average size of approximately 70 centimeters (cm) and an average weight of 1.83 kilograms (kg), this catch translates into a total biomass of 47,400 kg of burbot. The projected adult biomass of proposed Kootenai releases of 10,000 to 20,000 burbot per year ranges from 100 to 9,000 kg at annual survival rates of 40-70% (Figure 4). Numbers and biomass of the proposed South Arm/Kootenai River burbot population produced currently and in Phase 3 do not exceed those of the extinct West Arm population. Although we don't know how the historical West and South Arm populations compared, this example clearly demonstrates that portions of the Kootenai system could produce very large numbers of burbot; thus, hatchery production should not exceed historical carrying capacity.

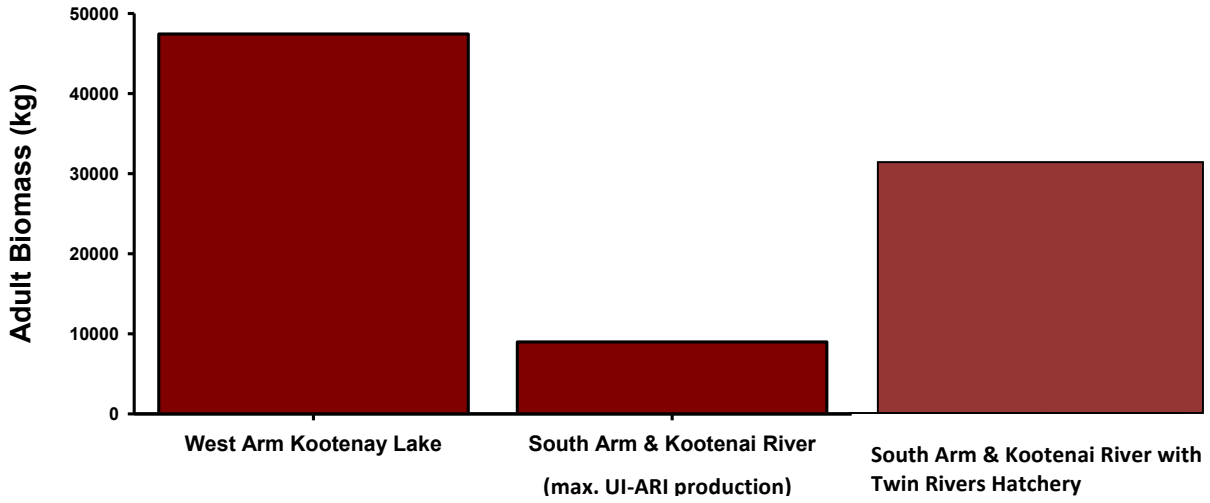


Figure 4. Comparison of minimum estimates of population biomass in the West Arm Kootenay Lake burbot population with maximum estimates of potential population biomass of the hatchery-produced burbot population in the South Arm and Kootenai River burbot population.

The Twin Rivers Hatchery is designed to provide the flexibility to scale up production in Phase 4 to a level of restoration closer to historical natural abundance. Twin Rivers Hatchery will also allow increased production of Age-0+ and Age-1+ burbot, providing flexibility in release strategies. Current release strategies are predicated on survival of Age-0+ juveniles. If post-release juvenile survival is poor, then a transition to releases of Age-1+ sub-adults may be needed for successful restoration. The UI-ARI facility simply cannot meet these challenges.

In-river parameters to be monitored are:

Fertilized egg to 6-month-old juvenile

- **Definition:** Survival from egg to 6-month-old juvenile.
- **Assumed Value**: Unknown

Percent Age-0+6-month-old to Age 1 survival (in-river)

- **Definition:** Survival during from 6 -12 month juvenile stage.
- **Assumed Value**: 20 – 35%

Percent Age-1+ survival (in-river)

- **Definition:** Survival during 12 - 24 months sub-adult stage.
- **Assumed Value**: 40 -70%

Percent Ages 2-10+ survival (in-river)

- **Definition:** Annual survival during 2 – 10 years old
- **Assumed Value**: 40 -70%

5.1.3 Natural Spawning

Number of spawners

- **Definition:** Total number of sexually mature adults per year.
- **Assumed Value**: 100% of adults 4+ years old.

Spawning area

- **Definition:** Any area where spawning behavior is observed. This would entail observation or capture of congregating sexually mature adults.
- **Assumed Value**: At least (1) congregation of mature adults.

Number of adults per spawning area

- **Definition:** Number of sexually mature adults estimated to spawn in a common area.
- **Assumed Value**: 100% of adults estimated in a common area or tributary from mid-January to mid-March.

Spawner per recruit ratio

- **Definition**: Number of F1 progeny surviving to reproductive status per P1 spawning adult.
- **Assumed Value**: 1:2 (spawner to recruit). This ratio is assumed to allow rebuilding and sustaining a natural population in the presence of fluctuating annual mortality and harvest.

Natural mortality

- **Definition**: Percent of population that dies within a given year due to natural causes.
- **Assumed Value**: 30 – 60%

5.1.4 Harvest

Fishing mortality

- **Definition**: Percent of adult population that dies from fishing in a given year.
- **Assumed Value**: TBD

5.2 STATUS AND TRENDS (ISMP STEP 2)

Status and trends represent actual outcomes (i.e., looking back at what happened). This information will be collected and reported annually and incorporated into the historical record of outcomes. These outcomes will be re-analyzed each year as part of the APR that will evaluate key assumptions and parameter estimates. It will also be used to evaluate performance of the ISMP (e.g., Did we meet the biological targets? Were these targets correct?). This information will also be shared with the public and other management entities as part of the accountability responsibility. The attributes involved in status and trend monitoring are arranged into four categories: 1) hatchery production, 2) natural production, 3) reproduction and 4) harvest.

An example of the ISMP predictive hatchery production data is shown in Table 5. This example lists initial parameters and currently known values that result in production of 6-month-old juveniles expected to meet program goals. These data were used to design and scale the burbot program at Twin Rivers Hatchery.

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Table 5. Example ISMP predictive annual hatchery production tool for Kootenai River burbot using empirical life stage-specific survival rates for aquaculture.

1 Family		Survival Rate - Hatchery			
Life Stage	Numbers	Hatch	Larvae	Fry	Age-0 Juv
Eggs	100,000	0.6			
Hatched Larvae	60,000		0.2		
Feeding Larvae	12,000			0.25	
Fry	3,000				0.7
6-mo Juveniles	2,100				

60 Families		Survival Rate - Hatchery			
Life Stage	Numbers	Hatch	Larvae	Fry	Age-0 Juv
Eggs	6,000,000	0.6			
Hatched Larvae	3,600,000		0.2		
Feeding Larvae	720,000			0.25	
Fry	180,000				0.7
6-mo Juveniles[a]	126,000				

[a] Current releases consist mainly of larvae and 6-month old juveniles. This strategy is anticipated for the future.

(1) Year Class		Survival Rate – In-river			
Life Stage	Numbers	Age 1	Age 2	Age 3	Age 4 -10+
6-mo. Juveniles	126,000	0.275			
Age 1+	34,650		0.5		
Age 2+	17,325			0.63	
Age 3+	10,915				0.63
Age 4+	6,876				0.63
Age 5+	4,332				0.63
Age 6+	2,729				0.63
Age 7+	1,719				0.63
Age 8+	1,083				0.63
Age 9+	682				0.63
Age 10+	430				
Total Ages 4 - 10	17,851				

5.3 REVIEW DECISION GUIDELINES (ISMP STEP 3)

All available data will be used to update key assumptions (Step 1) as well as population status and trends (Step 2) before each APR. From this, cooperating agencies must decide whether to proceed with current Decision Guidelines or make adjustments to better address program goals. Moving forward, the cooperating agencies will determine biological targets for the coming year. These biological targets will determine annual hatchery production, harvest, and any needed adjustments to M&E activities. Table 6 displays the initial program Decision Guidelines for each phase.

Table 6. Initial KRNFCAP - Burbot Decision Guidelines for the phases of the program. Twin Rivers is expected to start production in Phase 3 (shaded).

Metrics	Phase 1 2004-2008	Phase 2 2009-2013	Phase 3 2014-2018	Phase 4 2019 +
Donor Source	Moyie Lake	Moyie Lake	Moyie Lake	Moyie Lake
Percent Broodstock from Donor Source	100	100	50-100	0-100
Percent KR Natural-origin Broodstock	0	0	0-50	0-100
Families Produced	-	Up to 36	Up to 60	Up to 60
Larvae Released	-	0 – 350,000	TBD	TBD
Age-0+ 6 mo.-old Juveniles Released	-	5,000 - 20,000	20,000 - 100,000	Up to 125,000
Age-1 Released	-	100 - 500	TBD	TBD
Minimum Number Mature Adults (Ages 4+)	-	-	2,500	17,500
Minimum Number of Spawning Areas	-	-	3	3
Natural Recruitment	-	Possible	Probable	Significant
Harvest				
Fishing Mortality	-	0	0	TBD

5.4 IN-SEASON MANAGEMENT TOWARD BIOLOGICAL TARGETS (ISMP STEP 4)

This information will be determined at the APR. Currently, in-season management takes place once per quarter, typically via teleconference. Most in-season management decisions currently involve hatchery production updates and determination of release strategy. This will change as needed, as the program evolves and as burbot are restored to the system.

5.4.1 Hatchery Production

All hatchery fish will be marked via an artificial tag or via a genetic based parental assignment. Thus, any hatchery-produced fish may be properly assigned to origin and year class. This will allow for determination of program success. Hatchery production targets are as follows:

Donor stock

- **Definition**: The population from which broodstock and/or gametes are collected
- B**iological Target**: Any stock that successfully adapts to the Kootenai River. Ideally, donor stock would be genetically similar or closely related.

Broodstock survival

- **Definition**: Percentage of fish used for broodstock surviving one year post-spawn
- **Biological Target**: 90%

Number of females: number of males

- **Definition:** Ratio of females to males used for broodstock
- **Biological Target**: 30 : 60 (various sizes and ages)

Number of families

- **Definition:** A cross of one female with one male. On average, each female will be crossed with two males, but individually. Thus, each female should produce two distinct families.
- **Biological Target**: 60 (Twin Rivers Hatchery)

Egg take/female (fecundity)

- **Definition**: Average number of eggs per female spawned
- **Biological Target**: 200,000 (200,000 eggs per kg body weight; mean weight per female = 2.0 kg)

Number of fertilized eggs

- **Definition**: Total number of eggs successfully fertilized as determined under microscope
- **Biological Target**: 6,000,000 (Twin Rivers Hatchery)

Hatch

- **Definition**: Percentage of fertilized eggs that successfully incubate and hatch
- **Biological Target**: 3.6 million

Larvae

- **Definition**: Percentage of fish that survive from hatch until fry stage
- **Biological Target**: 720,000

Fry

- **Definition**: Percentage of fish that survive from post- larval metamorphosis to 3-4 months
- **Biological Target**: 180,000

Young-of-Year (YOY) (to 6 months in-hatchery). The current release strategy is based on stocking 6-month-old juveniles.

- **Definition**: Percentage of fish that survive from end of larval stage to 6-month juvenile
- **Biological Target**: 65,000 – 126,000

Age-1 (in-hatchery). Age-1 in-hatchery production should be at the lower levels presented here to minimize density.

- **Definition**: Percentage of fish that survive from 6 months to 12 months
- **Biological Target**: 45,000 – 113,000

5.4.2 Natural Production

Each year, a full accounting of the in-river population will be obtained through stock reconstruction. The biological targets listed below will be estimated each year. Tracking performance of the in-river population and the hatchery- and natural-origin components over time is a primary objective of this monitoring plan.

Fertilized egg to 6-month-old juvenile

- **Definition:** Survival from egg to 6-month-old juvenile
- **Biological Target**: TBD

Age-0+ 6-month-old to Age-1 survival (in-river)

- **Definition:** Survival during from 6 -12 months juvenile stage
- **Assumed Value**: TBD

Ages-1 - 3 (in-river)

- **Definition:** Annual survival during sub-adult stage
- **Biological Target**: TBD

Percent Ages-4 - 10+ (in-river)

- **Definition:** Annual survival during 4 to 10 years old
- **Biological Target** (interim): Minimum 2,500 – 9,000

5.4.3 Natural Spawning

Number of spawners

- **Definition:** Total number of sexually mature adults per year
- **Biological Target** (interim): 2,500

Spawning area

- **Definition:** Any area where spawning behavior is observed. This would entail observation or capture of congregating sexually mature adults.
- **Biological Target**: ≥ 3

Number of adults per spawning area

- **Definition:** Number of sexually mature adults estimated to spawn in a common area
- **Biological Target**: TBD (likely distributed as smaller groups among a particular river and/or lake reach)

Spawner per recruit ratio

- **Definition**: Number of F1 progeny surviving to reproductive status per P1 spawning adult
- **Biological Target**: 1:2 (spawner to recruit). This ratio is assumed to allow rebuilding and sustaining a natural population in the presence of fluctuating annual mortality and harvest.

Natural mortality

- **Definition**: Percent of population that dies within a given year due to natural causes
- **Biological Target**: < 30%

5.4.4 Harvest

Fishing mortality

- **Definition**: Percent of population that dies from fishing in a given year
- **Biological Target**: TBD

6 ADAPTIVE MANAGEMENT

Although no formal adaptive management (AM) plan has currently been prepared for the Kootenai River burbot program, annual reviews of critical variables and metrics as part of the ISMP and APR processes described in previous sections of this M&E Plan provide a solid AM foundation for the burbot culture components of the program. These features will ensure annual review and will appropriately adjust release numbers and modify culture techniques in response to annually updated age-specific survival rates, ages at first maturity for males and females, and spawning frequency or periodicity values for burbot in the Kootenai River. This M&E Plan also provides an array of abundance trajectories based on a range of post-release survival rates, and addresses the precision of mortality estimates as a function of sampling intensity (Figure 3).

The burbot program also includes a phased approach (Table 1), which ensures that the program cannot go forward without quantitative confirmation of suitable success measures. Furthermore, Phase 3 of the burbot program (the Adaptive Experimental Evaluation Phase) implements hatchery production and monitoring activities to determine how well hatchery produced burbot survive, grow, and mature, relative to the numbers needed to reestablish a future sustainable burbot population in the Kootenai River. This threshold-based, phased implementation approach also protects from indiscriminate, large-scale hatchery production, and allows the program to grow as necessary and as warranted by iterative, adaptive evaluations (by implementing program mechanisms described in this M&E Plan). Thus, this suite of direct adaptive feedback loops will continue to serve the program well, as reflected in the program's relatively short but successful history.

7 REFERENCES

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