Kootenai Tribe of Idaho

P.O. Box 1269
Bonners Ferry, ID 83805
Ph# (208) 267-3519
Fax (208) 267-2960

June 21, 2010

Mr. Tony Grover
Fish and Wildlife Division Director
Northwest Power and Conservation Council
851 SW 6th Avenue, Suite 1100
Portland, Oregon 97204

Dear Mr. Grover,

On behalf of the Kootenai Tribe of Idaho, I am submitting the revised *Kootenai River Native Fish Conservation Aquaculture Master Plan*. The Tribe received approval to develop a Master Plan during the Northwest Power and Council's 2007-2009 Fish and Wildlife Program project review process. A Master Plan was developed and submitted to the Council in August 2009, prompting some very helpful requests for clarification and specific recommendations from the Independent Science Review Panel (ISRP). The Tribe has addressed each of the ISRP's comments and incorporated of the majority of their recommendations into a revised Master Plan. To meet the Step 1 requirements of the Council's Three-Step Review Process, we are submitting our responses to the ISRP's comments and a revised aquaculture Master Plan.

Kootenai River white sturgeon and burbot are species of immeasurable cultural value to the Kootenai Tribe and once sustained a vital cultural fishery, as well as a significant recreational fishery. The Tribe views the Kootenai sturgeon and burbot conservation aquaculture programs as essential to supporting the Tribe's overarching vision of a healthy Kootenai River ecosystem that fully supports traditional Tribal uses and other important societal uses.

The 2006 USFWS Biological Opinion Regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout, and Kootenai Sturgeon Critical Habitat specifically acknowledges the need for continued operation of the Tribe's sturgeon aquaculture program in Reasonable and Prudent Action Component 4. It also directs the action agencies to provide funding to expand adult holding and spawning capability for the Tribe's Kootenai sturgeon conservation aquaculture program (USFWS 2006, clarified in 2008).

As described in this Master Plan, the Tribe is proposing critical facility upgrades to the existing Tribal Sturgeon Hatchery near Bonners Ferry for the ongoing Kootenai sturgeon program. In addition, a new hatchery is proposed at the confluence of the Moyie and Kootenai rivers to produce native Kootenai sturgeon and burbot. The new Twin Rivers Hatchery is proposed on land owned by the Kootenai Tribe.

The goals of the Kootenai sturgeon aquaculture program are: 1) to prevent extinction of Kootenai sturgeon by preserving the locally adapted genotypes, phenotypes, and associated life history traits of the population; and 2) to restore a healthy age class structure to enhance demographic and genetic viability and persistence of the population. The goal of the Tribe's burbot aquaculture program is to reestablish a native burbot population in the lower Kootenai River capable of future subsistence and sport harvest once the population reaches sustainable levels.

Upgrades proposed at the Tribal Sturgeon Hatchery include a new spawning room that would eliminate the need to relocate large fish from one building to another, provide a safer means to transport large adult sturgeon to and from the river, and other measures to improve fish culture practices and worker safety.

Because there is no physical capacity to expand the Tribal Sturgeon Hatchery, the Tribe is requesting approval for construction of the new Twin Rivers Hatchery. It will address the need for additional rearing space to produce Age 1+ Kootenai sturgeon, which Tribal studies indicate have much higher survival rates at release than younger fish. The new hatchery will also accommodate the Tribe's burbot conservation aquaculture program. In addition, the Twin Rivers location may also help to extend the river reaches where Kootenai sturgeon imprint and ultimately home. The Twin Rivers site offers high quality ground and surface water needed to support the aquaculture objectives for both species. Proposed facilities include dual water supplies and filtration, incubation rooms, juvenile rearing tanks and ponds, spawning channels, administrative/ biological support facilities and staff housing. The Tribe is also proposing the experimental use of remote streamside incubation and early rearing facilities to imprint Kootenai sturgeon upstream of the new hatchery site.

The relentless decline of both Kootenai sturgeon and burbot underscores the urgency to implement effective actions to restore these native populations to their ecologically and culturally important roles in the region. Because of the critical role of habitat in the restoration of both native populations, the Tribe is also committed to implementing a suite of ecosystem restoration projects as essential companions to the conservation aquaculture program.

The Tribe respectfully requests that the Council and ISRP expedite review and approval of the revised Step 1 *Kootenai River Native Fish Conservation Aquaculture Master Plan* so that the project may proceed without delay. Please do not hesitate to contact our Fish and Wildlife Program Director, Sue Ireland, 208 267-3620; ireland@kootenai.org, with any questions. We look forward to working with you and thank you for your consideration of our proposed program.

Sincerely,

Jennifer Porter
Tribal Council Chairperson
Kootenai Tribe of Idaho

cc:
Mark Fritsch, Erik Merrill, NPPC
Lee Watts, BPA

Enclosures: Kootenai River Native Fish Conservation Aquaculture Program Master Plan and Responses to the ISRP Comments

Kootenai River Native Fish Conservation Aquaculture Program

Master Plan

Prepared by the Kootenai Tribe of Idaho

Revised June 2010

Document Citation:

KTOI (Kootenai Tribe of Idaho) 2010. Kootenai River Native Fish Aquaculture Program Master Plan. Bonners Ferry, Idaho. June 11, 2010. 297 pp.

Cover photos courtesy of Ernest Keeley and the Kootenai Tribe.

Contents

APPENDICES

List of Figures

List of Tables

Executive Summary

Kootenai River white sturgeon (*Acipenser transmontanus*) and burbot (*Lota lota*) were keystone species in the Kootenai River and are species of immeasurable cultural value to the Kootenai Tribe of Idaho (Kootenai Tribe or Tribe). These native species once sustained a culturally Tribal important fishery as well as a valued recreational fishery. A precipitous decline in both populations resulting from river corridor modifications worsened when Libby Dam operations began. The decline eventually resulted in the elimination of he Tribe's ability to exercise its Treaty-reserved fishing right, which continues today despite efforts to manage flow to create somewhat more natural flow and temperature regimes. The relentless decline of both species underscores the urgency of implementing effective actions to restore these native populations to their ecologically and culturally important roles in the region.

The Kootenai Tribe has long recognized the need to protect Kootenai River white sturgeon (Kootenai sturgeon) and native Kootenai River burbot (burbot). In 1989, the Tribe initiated a Kootenai sturgeon conservation aquaculture program near Bonners Ferry in an effort to preserve an adequate demographic and genetic base for a healthy future population while waiting for ecosystem-based habitat restoration activities to be developed and implemented. The Tribe also participates actively in a beneficial partnership with the British Columbia Ministry of Environment (BC MoE) and the Freshwater Fisheries Society of British Columbia to sustain the Kootenai sturgeon population in the cross-boundary Kootenai River subbasin.

Similarly, the Tribe has advocated and supported successful efforts at the University of Idaho to rear burbot to a juvenile life stage in a laboratory setting, paving the way for the more extensive culture and reintroduction program proposed in this Master Plan.

The goals of the Kootenai sturgeon aquaculture program are to 1) prevent extinction of Kootenai sturgeon by preserving the locally adapted genotypes, phenotypes, and associated life history traits of the population; 2) restore a healthy age class structure to enhance demographic and genetic viability and persistence of the population; and 3) reestablish a sturgeon population capable of future Tribal Treaty subsistence and cultural harvest.

The goal for the Tribe's burbot aquaculture program is to reestablish a native burbot population in the lower Kootenai River capable of future Tribal Treaty subsistence and cultural harvest and sport harvest once the population reaches sustainable levels.

The Kootenai sturgeon and burbot aquaculture programs proposed in this Master Plan would:

- Upgrade the Kootenai sturgeon production facilities at the existing Tribal Sturgeon Hatchery near Bonners Ferry
- Develop a new artificial production facility for Kootenai sturgeon and burbot at the confluence of the Moyie and Kootenai rivers (Twin River Hatchery)
- Establish two remote streamside incubation and early rearing facilities to imprint Kootenai sturgeon at upstream locations where more favorable spawning, incubation and early rearing habitats appear to currently exist
- Collect native Kootenai sturgeon broodstock from the Kootenai River

- Collect native burbot broodstock from within basin sources (i.e., Moyie Lake stock from British Columbia)
- Spawn, incubate, and rear Kootenai sturgeon and burbot
- Refine aquaculture apparatus and techniques for sturgeon and burbot
- Release Kootenai sturgeon and burbot at appropriate developmental stages to suitable habitat in the Kootenai River
- Support operation and monitoring at both facilities

Through this Master Plan, the Kootenai Tribe is proposing to construct a new hatchery on Tribal-owned land at the confluence of the Moyie and Kootenai rivers. A new facility at this location will address current physical space limitations that make expansion of the existing Tribal Sturgeon Hatchery infeasible. The Twin Rivers site offers high quality ground and surface water needed to support the program's aquaculture objectives for Kootenai sturgeon and burbot. This location may also help to extend the river reaches where Kootenai sturgeon imprint and ultimately return to reproduce. Proposed facilities include dual water supplies and filtration, incubation rooms, juvenile rearing tanks and ponds, spawning channels, administrative/ biological support facilities and staff housing. The Tribe is also proposing the experimental use of remote streamside incubation and early rearing facilities to imprint Kootenai sturgeon upstream of the new hatchery site.

The improvements the Tribe is proposing for the existing Tribal Sturgeon Hatchery near Bonners Ferry would enhance sturgeon handling and rearing capabilities. A new spawning room would eliminate the need to relocate large fish from one building to another. A safer means to transport large adults to and from the river would be provided, in addition to a number of measures to improve fish culture practices practices and program efficiency and success.

The Kootenai Tribe has long understood that restoring Kootenai River habitat conditions capable of supporting all life stages of Kootenai sturgeon and burbot is critical to the long-term survival of both populations. Until suitable habitat conditions have been restored, the Tribe's ongoing and proposed aquaculture programs will remain essential tools to preserve and manage remnant Kootenai sturgeon and burbot populations. Because suitable habiat is required for natural production and population persistence, the Tribe, with cooperation from multiple agency partners, is aggressively pursuing implementation of a broad suite of ecosystem-based habitat restoration efforts in the Kootenai River and its tributaries. Specifically, in addition to this Master Plan and the Kootenai Tribe's ongoing habitat projects, the Tribe has prepared a Master Plan for the Kootenai River Habitat Restoration Project (BPA project 200200200) that presents a framework for a broad-scale ecosystem restoration effort designed to address factors limiting self-sustaining populations of Kootenai sturgeon and burbot.

The Kootenai Tribe is submitting this Kootenai River Native Fish Conservation Aquaculture Programs Master Plan (BPA project 198806400) to fulfill the Council's requirement that all entities seeking funding for artificial propagation projects involving new construction and/or programs that will produce fish for reintroduction, submit plans and documentation consistent with the Council's Step-Review Process.

Acknowledgements

The Kootenai Tribe of Idaho would like to thank the following individuals without whom it would not have been possible to develop this Native Fish Conservation and Aquaculture Master Plan: Gary Aitken, Jr., Paul Anders, Dave Bangle, John Barco, James Barron, Ray Beamesderfer, Scott Bettin, Ken Cain, Justus Cree, Sheree Faulk, Jason Flory, Mark Fritsch, Bill Hill, Greg Hoffman, Genny Hoyle, Sue Ireland, Kevin James, Nate Jensen, Ray Jones, Boyd Kynard, Chris Lewandowski, Brian Marotz, John McGlenn, Matt Neufeld, Joan Nichol, Vaughn Paragamian, Patty Perry, Mark Polinski, Dan Portman, Mark Reiser, Sarah Richardson, Shannon Riper, John Siple, Colin Spence, Alison Squier, Rod Thompson, Eric Wagner, Dan Warren and Lee Watts.

The Tribal staff and consultants also wish to express our appreciation to the Tribal Elders and Tribal Council for providing an inspiring vision, direction and guidance.

Glossary

Abundance:	An ecological concept referring to the relative representation of a species in a particular community, assemblage or ecosystem, usually measured as the mean number of individuals per sample or unit area
Adaptive management:	A structured, iterative decision-making process to reduce uncertainty over time via empirical experimentation, monitoring and program adjustment
Adaptive Multidisciplinary Conservation Aquaculture Plan:	Refers to the Kootenai Tribe's native fish conservation aquaculture (hatchery) program that addresses program uncertainties by implementing adaptive management among a series of disciplines such as fish health, reproductive and population biology, and genetics among others
Adaptive plasticity:	The ability of an organism with a given genotype to change its phenotype, behavior, or life history trait expressions in response to changes in the environment to benefit the fitness, performance, or survival of the organism or population
Age class:	The set of individuals in a population that are all of a particular age or that fall within a specified age group
Alluvium:	Soil or sediments deposited by a river or other running water
Anadromous:	Fish that hatch and rear in fresh water, migrate to the ocean to grow and mature, and return to fresh water to spawn
Anthropogenic:	Effects, processes, objects, or materials that are derived from human activities
Apex predator species:	Species that, as adults, are not normally preyed upon in the wild in significant parts of their range
Aquatic biomonitoring:	Inferring the ecological condition of water ecosystems by examining the organisms that live there
Artificial production:	A fish that is produced in a controlled environment such as a hatchery (*contrast* natural production)
Artificial propagation:	Breeding and raising organisms in captivity

Assemblages:	A number of characteristic species which together form the feature and usually share similar ecological or habitat requirements
Asymptomatic carrier state:	Condition in which organisms that have contracted an infectious pathogen display no clinical symptoms
Backwater effects:	Physical, biological, and ecological effects of impounded or off-channel waters; refers to the upstream effect of Kootenay Lake on the Kootenai River
Bioaccumulation:	Occurs when an organism absorbs a toxic substance at a rate greater than that at which the substance is lost
Biodiversity:	The variation of life forms within a given ecosystem
Biological Opinion (BiOp):	A written product resulting from interagency consultation pursuant to section 7(a)(2) of the U.S. Endangered Species Act and implementing regulations found at 50 CFR Part 402.
Biomass:	The mass of living biological organisms in a given area or ecosystem at a given time
Broodstock:	Adult fish used by hatcheries to propagate the next generation of fish
Catch rates:	An estimate of numbers of fish caught per specified unit of time or effort (e.g. number of fish per day, hours per fish, or numbers of fish per hook hour)
Channelization:	The process of reconstructing the natural course of a stream in order to make it flow into a restricted path, or the confinement of a river channel by levees or dikes
Connectivity:	The aquatic connection among various in-channel and off-channel habitats allowing the multidirectional flow of organisms and physical, biological, and ecological functions and processes among various habitats
Conservation aquaculture:	Hatchery programs designed to conserve locally adapted genotypes, phenotypes, behaviors and other life history traits of populations that are usually applied to threatened, endangered, or imperiled populations. (*contrast*: supplementation hatcheries)
Critical Functional link species:	Species that are the only ones that perform a specific ecological function within a community

Cryopreservation:	A process where cells or whole tissues are preserved by cooling to low sub-zero temperatures, typically down to −196 °C
Cytopathic:	Of, relating to, characterized by, or producing pathological changes in cells
Demographic stock limitation:	Insufficient numbers of breeders in a population as required for short or long-term population persistence
Demographic viability:	A condition of adequate numbers of animals in a population for population persistence in the face of short-term or long-term environmental change and stochastic events
Density-dependent mortality:	Factor that causes a varying degree of mortality in a population as a function of population density
Distinct Population Segment (DPS):	Subgroup or population of a species that is treated as a species for purposes of listing under the Endangered Species Act that must be separable from the remainder of and significant to the species to which it belongs
Diversity:	Measure of variation or variability of a biological parameter (e.g. genetic or habitat diversity; degree of heterozygosity)
Domestication selection:	A process of selecting or altering behaviors, life history traits, or genes for fitness in the hatchery environment rather than for fitness in the wild environment
Downramping:	Rapid reductions in streamflow downstream of hydropower or flood control dams
Ecosystem:	A natural unit consisting of all plants, animals, and micro-organisms in an area functioning together with all of the non-living physical factors of that environment
Egg:	A female gamete of a sexually reproducing organism
Embryo:	A fertilized egg
Empirical:	Information gained by means of observation, experience, or experiment (*contrast*: theoretical)
Endangered Species Act (ESA):	The most wide-ranging of the dozens of United States environmental laws passed in the 1970s designed to protect critically imperiled species from extinction as a "consequence of economic growth and development untendered by adequate concern and conservation"

Environmental Assessment (EA):	A document required by the National Environmental Policy Act for federal government agency actions to determine if they may affect the quality of the human environment
Environmental Impact Statement (EIS):	A document required by the National Environmental Policy Act for federal government agency actions "significantly affecting the quality of the human environment"
Environmental province:	A component of the Northwest Power and Conservation Council's Columbia Basin Fish and Wildlife Program, environmental provinces are geographic areas that contain ecologically related or similar watersheds or subbasins, distinguished primarily by hydrologic, climatic, geological and biological patterns of similarity.
Enzyme linked immunosorbent assay (ELISA):	A biochemical technique used mainly in immunology to detect the presence of an antibody or an antigen in a sample
Epizootic:	A disease that appears as new cases in a given animal population, during a given period, at a rate that substantially exceeds what is "expected" based on recent experience (i.e. disease outbreak).
Exogenous feeding:	Feeding on orally ingested external food items following complete absorption of a yolk sac (contrast: endogenous feeding)
Extensive aquaculture	Rearing aquatic animals under highly controlled conditions (e.g., recirculation aquaculture with high densities and feed rates) (contrast: intensive aquaculture)
Extirpation:	Local extinction; a case in which a species or a population ceases to exist in the chosen area of study, but still exists elsewhere
Fingerling:	A small fish, typically up to one year of age
Fitness:	The capability of an individual of certain genotype to reproduce, and usually is equal to the proportion of the individual's genes in all the genes of the next generation
Fitness depression:	Reduction in biological or physiological condition that negatively affects an individual's or a population's ability to contribute to the next generation
Floy tags:	Color coded, individually numbered external fish marking tags

Focal species:	The species identified as being most sensitive to a threat in a changing environment
Free embryo:	An early sturgeon life stage immediately following hatch but preceding the larval stage
Functional specialist:	Species that have only one or a very few number of key ecological functions
Functionally extinct:	A population condition characterized by too few individuals to successfully reproduce, or a small population of breeding individuals unable to sustain itself
Gametes:	A cell that fuses with another gamete during fertilization (conception) in organisms that reproduce sexually
Gas supersaturation:	When water becomes supersaturated (> 100%) with atmospheric gases through various means, often associated with spill conditions in the tailrace of dams
Gene flow:	Spatial and temporal patterns of alleles or gene transfer from one generation to the next within a population or from one population to another
Gene pool:	The complete set of distinct alleles in a species or population
Genetic diversity:	A level of biodiversity that refers to the total number of genetic characteristics in the genetic makeup of a species
Genetic viability:	A population genetic condition of avoiding the problems of inbreeding by having a certain amount of genetic diversity, and consequently a certain minimum number of members
Genotypes:	The genetic constitution of a cell, an organism, or an individual
Germ plasm:	Collection of genetic resources for an organism
Glacial till:	Material directly deposited from glacial ice, including a mixture of undifferentiated material ranging from clay size to boulders
Headwaters:	Place from which the water in a river or stream originates
Hydraulic regime:	All aspects of flow and their distribution in time and location in any given watershed or river system
Hydrograph:	A graph showing the stage, flow, velocity, or other water-related properties in relation to time

Hydrology:	Study of the movement, distribution, quantity and quality of water
Imhoff cones:	Fish egg incubating jar optimized for burbot culture; a one liter cone-shaped plastic container with the side of the cone graduated in milliliters, about 14" tall
Impoundment:	Body of water confined by a dam or other structure
Inbreeding:	Breeding between closely related individuals (*contrast*: outbreeding)
Index sampling:	Typically refers to sampling with limited rigor or replication to confirm presence or absence of some event (e.g., a small number of egg mats were deployed to confirm natural spawning of white sturgeon during a given year in a general area)
Infectious hematopoietic necrosis virus (IHNV):	Pathogen that infects many Pacific salmonid stocks
Infectious Pancreatic Necrosis Virus (IPNV):	Pathogen of salmonid fish with a worldwide distribution
Intensive aquaculture	Rearing aquatic animals with limited outside input into a system (e.g., natural pond with no supplemental feeding); (contrast: extensive aquaculture)
Inter-generational gene flow:	Reproductive model or mating strategy in which mating results in gene flow between or among individuals from more than one generation, as observed in white sturgeon
Introgressed:	Movement of a gene (gene flow) from one species into the gene pool of another by backcrossing an interspecific hybrid with one of its parents
Iridovirus:	Diverse array of large icosahedral viruses that replicate in the cytoplasm of infected cells (e.g., white sturgeon iridovirus)
Larvae:	Newly hatched fish, typically with full fin complements and a fully developed digestive track
Life history:	Key developmental, anatomical, functional, or physiological characteristics that define the life course
Life history traits:	Traits that have a clear and direct bearing on fitness, such as age at first reproduction, number and size of offspring, and reproductive lifespan and ageing

Limiting factor:	Factor that controls a process, such as organism growth or population size or distribution of a species
Mark-recapture analysis:	Method commonly used to estimate population size and population vital rates, by which a group of individuals are trapped, marked and released back into the population. A second sample of organism are then recaptured, and the ratio of marked to unmarked animals in the second sample can be used to estimate population size
Mating protocol:	Spawning or breeding matrix or set of rules for fish breeding in a hatchery; could also refer to fish spawning techniques
Mesic:	Type of habitat with a moderate or well-balanced supply of moisture
Metapopulation:	A group of spatially separated populations of the same species that are connected by some level of gene flow
Micro-flocculation:	The process of using chemicals to coagulate suspended colloidal particles into larger particles (floc) which have a higher specific gravity that allows them to settle out or be removed more readily by mechanical filtration.
Microsatellites:	Polymorphic loci present in nuclear and organellar DNA that consist of repeating units of 1-6 base pairs in length; a commonly used genetic marker for population delineation or individual identification
Mitochondrial DNA (mtDNA):	DNA located in cellular organelles called mitochondria; mtDNA is non-recombinatory across generations and is maternally inherited
National Environmental Policy Act (NEPA):	Environmental law signed in 1970 establishing a national policy to protect the environment in consultation with the public; it set up procedural requirements for all federal agencies to prepare environmental assessments (EAs) and environmental impact statements (EISs)
Natural production:	Progeny produced by parents spawning in a stream or lakebed, as opposed to a controlled environment such as a hatchery (*contrast* artificial production)
Natural recruitment:	Process of population renewal that depends on the ability of the reproductively active part of the population to produce sufficient offspring to permit future harvest; spawning occurs in a stream or lakebed, as opposed to a hatchery

Niche partitioning:	Process by which natural selection drives competing species into different spatial or temporal patterns of resource use or different niches
Normative:	Often used to describe altered river conditions and the effort to mimic or restore ecological function; i.e. normative river conditions
Nutrient cycling:	All the processes by which nutrients are continuously transferred from one organism to another in an ecosystem
Outbreeding:	Interbreeding of individuals or stocks that are relatively unrelated (*contrast*: inbreeding)
Outbreeding depression:	Offspring from crosses between individuals from different populations have lower fitness than progeny from crosses between individuals from the same population (*contrast*: inbreeding depression)
Outplanting:	Placing hatchery fish into a river or stream
Outwash:	Deposition of sand, gravel and other substrate material or bedload carried by running water
Periphyton:	Complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems
Phenotypes:	Any observable characteristic of an organism that results from the expression of an organism's genes as well as the influence of environmental factors and possible interactions between the two
Piscivorous:	Fish-eating
PIT-tag:	Passive integrated transponder (PIT) tags are used to identify individual fish or other animals for monitoring, research, or identification purposes; this miniaturized tag consists of an integrated microchip that is programmed to include specific fish information; the inert tag is inserted into the body cavity of the fish and decoded at selected monitoring sites
Plasticity:	Ability of an organism with a given genotype to change its phenotype, behaviors, or life history trait expressions in response to changes in the environment
Primary productivity:	Production of organic compounds from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis

Ramping rates:	Rate of change in flow, either up or down, of water released from a dam
Recruitment:	Process of population renewal that depends on the ability of the reproductively active part of the population to produce sufficient offspring for population persistence
Recruitment failure:	Inability of the reproductively active part of the population to produce sufficient offspring for population persistence
Relative abundance:	Proportion of individuals among species in a community
Remnant population:	A small population that occupies only a fraction of its historic range, and may be geographically and genetically isolated from other populations of the same species
Resident fish:	Non-migratory fish that spend their entire lives in freshwater
Secondary productivity:	Living matter produced by consumers and decomposers in a given time
Sediment transport:	Movement of solid particles (e.g., sediment) due to the movement of the fluid in which they are immersed
Species composition:	Percentage of each recognized species comprising the organisms in a given area
Stochastic:	Random events whose behavior is non-deterministic in that a state's next state is determined both by the process's predictable actions and by a random element
Stock limitation:	A population condition characterized by too few reproductive adults to perpetuate a population or to compensate for cumulative mortality pressures in the short-term or long-term
Substrate:	The earthy material that exists in the bottom of an aquatic habitat, such as dirt, rocks, sand, or gravel
Tailwater:	Area immediately downstream from a dam or waterpower development where water is released
Thermograph:	Graph showing temperature in relation to time
Tiered flow releases:	Prescriptive methods of determining water release volume and timing from a dam in proportion to forecasted inflow volumes

Transboundary population:	Population whose range crosses administrative, geographic, or political boundaries
Trophic levels:	Feeding position of an organism in a food chain, such as primary producers, herbivore, or primary carnivore
Trophic structure:	Feeding relationships within an ecosystem, such as predator-prey, parasite-host and plant-herbivore relationships
Ultraoligotrophic:	Ecosystem or environment with very low nutrient levels
UI-ARI	University of Idaho, Aquaculture Research Institute
Volitional spawning:	In fish, the natural or unaided release of gametes into the water column in natural or captive (hatchery) settings.
Volumetric turnover rate:	Amount of time required for a specified volume of water to evacuate and be replaced in a reservoir or tank
Wild fish:	Fish spawned and reared in the wild
Xeric:	Type of habitat that is deficient in water

Abbreviations and Acronyms

BC MoE	British Columbia Ministry of Environment
BiOp	Biological Opinion (part of ESA)
BOG	Budget Oversight Group
BPA	Bonneville Power Administration
BW	Body weight
CA DFO	Department of Fisheries and Oceans Canada
CBFWA	Columbia Basin Fish and Wildlife Authority
CFS	Cubic feet per second
CSI	College of Southern Idaho
CWA	Clean Water Act
EA	Environmental Assessment
EDT	Ecosystem Diagnosis and Treatment
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
FFSBC	Freshwater Fishery Society of British Columbia
GCCM	General contractor/construction management firm
HGMP	Hatchery Genetic Management Plan
IDFG	Idaho Department of Fish and Game
IKERT	International Kootenai/y Ecosystem Restoration Team
IPNV	Infectious Pancreatic Necrosis Virus
ISAB	Independent Scientific Advisory Board
ISRP	Independent Scientific Review Panel
ITC	Introductions and Transfers Committee of British Columbia
JPA	Joint Powers Agreement
KTOI	Kootenai Tribe of Idaho
KVRI	Kootenai Valley Resource Initiative

M&E	Monitoring and Evaluation
MAFF	Ministry of Agriculture, Fisheries and Foods (BC)
MFWP	Montana Fish Wildlife & Parks
msl	mean surface level
mtDNA	Mitochondrial DNA
NEPA	National Environmental Policy Act
NPCC	Northwest Power and Conservation Council
PVA	Population viability analysis
QHA	Qualitative Habitat Assessment
RPA	Reasonable and Prudent Action (part of ESA consultation)
SARA	Species at Risk Act (Canada)
TDG	Total dissolved gas
UCD	University of California Davis
UCUT	Upper Columbia United Tribes
USFWS	U.S. Fish and Wildlife Service
VARQ	Variable discharge flood control
WSIV	White Sturgeon Iridovirus

1 Introduction

The Kootenai Tribe of Idaho (Kootenai Tribe or Tribe) is submitting this Master Plan for the Kootenai River Native Fish Conservation Aquaculture Program (BPA project 198806400) to the Northwest Power and Conservation Council (NPCC or Council) to fulfill the Council's Step-Review requirements for artificial propagation projects involving new construction and/or programs that will produce fish for reintroduction. The Bonneville Power Administration (BPA) funded the development of this Master Plan through the Council's Columbia River Basin Fish and Wildlife Program (NPCC 2009).

The Kootenai River Native Fish Conservation Aquaculture Programs are designed to ensure the preservation and continued survival of two native fish species of immeasurable cultural and economic significance to the Tribe, Kootenai River white sturgeon (*Acipenser transmontanus*) and burbot (*Lota lota).*

Kootenai Tribe elders pass down the history of the beginning of time, which tells that the Kootenai people were created by Quilxka Nupika, the supreme being, and placed on earth to keep the Creator-Spirit's Covenant – to guard and keep the land forever. The Kootenais have never lost sight of their original purpose as guardians of the land.

Today, the Kootenai Tribe seeks to fulfill this purpose by developing and implementing innovative approaches to guardianship of the land that are holistic, based at the watershed scale, based on defensible science, inclusive of social and economic considerations, collaborative, supported by the local community, and that incorporate adaptive management principles.

In 1989, recognizing the need for immediate protection of Kootenai River white sturgeon (Kootenai sturgeon), the Tribe initiated its sturgeon conservation aquaculture program as a stopgap measure designed to ensure preservation of an adequate demographic and genetic base for a healthy future population. This program currently provides the only significant source of recruitment for the Kootenai River population.[1]

Similarly in 2003, the Kootenai Tribe initiated investigations of burbot aquaculture methods in collaboration with the University of Idaho. These efforts have yielded significant advances in aquaculture techniques for a species that has historically received little such attention. This work has demonstrated that captive rearing of burbot is feasible.

This Master Plan identifies critically needed upgrades and expansions to the Tribe's ongoing Kootenai sturgeon aquaculture program that will help to prevent population extinction, preserve the existing gene pool, and continue rebuilding healthy age classes of endangered Kootenai sturgeon using conservation aquaculture techniques with wild native broodstock.

The proposed burbot program is designed to reintroduce this native species into the lower Kootenai River and begin rebuilding the population using genetically and behaviorally similar stock from within the Kootenai subbasin. Kootenai River burbot are functionally extinct, a status

[1] The U.S. Fish and Wildlife Service Biological Opinion regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout and Kootenai Sturgeon Critical Habitat (Libby Dam BiOp) specifically acknowledges the essential role of the Tribe's sturgeon aquaculture program in Reasonable and Prudent Action (RPA) Component 4, and directs the action agencies to provide funding to expand adult holding and spawning capability at the Tribal Sturgeon Hatchery (RPA Action 4.2) (USFWS 2006).

that occurs when populations are so small they are unable to recover on their own. If sufficient native brood from the remnant lower Kootenai population can be captured and preserved, a captive broodstock program could be initiated.

Successful restoration of Kootenai sturgeon and burbot will depend on the Tribe's Kootenai River Native Fish Conservation Aquaculture program as well as timely implementation of ecosystem-scale habitat improvements. Therefore, in addition to this Master Plan and the Kootenai Tribe's ongoing habitat projects, the Tribe has completed the Kootenai River Habitat Restoration Master Plan (BPA project 200200200), which presents a framework for a broad-scale ecosystem restoration actions designed to address factors limiting self-sustaining populations of Kootenai sturgeon and burbot as well as broader ecosystem restoration objectives[2]. The Kootenai River Habitat Restoration Project is designed to address long-term negative impacts associated with river and floodplain management, altered river and floodplain morphology, disturbances and destruction of riparian habitat, and alterations to aquatic habitat (e.g., depth, velocity, substrate conditions). The Tribe believes these complimentary efforts, once fully implemented, will restore healthy habitats to sustain not only Kootenai sturgeon and burbot, but also many other important species native to the Kootenai River system. The Tribe looks to the future with the hope that native fish and wildlife may once again inhabit the Kootenai watershed in abundance.

This document describes the proposed conservation aquaculture programs and associated facilities for Kootenai sturgeon and native burbot. Although the distinct biological requirements of each species necessitate some independent facility components, the Tribe believes significant efficiencies are possible by combining these programs, through the use of shared facilities, operations and monitoring efforts.

1.1 NPCC Step Review Process

The NPCC is directed by the Northwest Power Act of 1980 to develop a program to protect, mitigate and enhance the fish and wildlife that have been affected by the development of hydropower dams in the Columbia River Basin. The resulting Columbia River Basin Fish and Wildlife Program is the basis upon which the NPCC makes funding recommendations to the Bonneville Power Administration (BPA). In February 2009, the Council adopted a revised Columbia Basin Fish and Wildlife Program that incorporates the Step-Review as part of the project review process.

The NPCC originally implemented a Three-Step Review process in 1997 for all "artificial production initiatives". An artificial production initiative qualifies for the review process if the project proposes to construct new production facilities, plant fish in waters where they have not been planted before, significantly increase the number of fish being introduced, change stocks or the number of stocks, or change the location of production facilities.

The step review includes a thorough review by the Independent Science Review Panel (ISRP) and the Council at three phases: master or conceptual planning, preliminary design and final design. Projects do not move forward from one phase to another without a favorable review. The 2009 revised Fish and Wildlife Program states, "The Council intends the Step-Review process to be flexible and cost-efficient. Depending on the nature and status of the proposed project, the

[2] The Kootenai River Habitat Restoration Project Master Plan is available for download on the Tribe's website at http://www.kootenai.org/fish.html.

Council may allow for a review that combines two or more steps in a single submission and review, or for a submission and review that addresses just part of a step of the review process."

Table 1-1 illustrates the Council's Three-Step Review requirements for new aquaculture facilities.

Table 1-1. NPCC Three-Step review requirements for new aquaculture facilities.

NPCC-defined Steps	Objectives
Step 1	Develop conceptual engineering design to an accuracy level varying from +/-35 to 50%
	Prepare and obtain NPCC approval of conceptual program in the form of a Master Plan
Step 2	Develop preliminary engineering design and cost estimates to an accuracy level varying from +/- 25 to 35%
	Prepare an Environmental Impact Statement or Environmental Assessment in compliance with NEPA. Prepare a Biological Assessment in compliance with the Endangered Species Act.
	Obtain NPCC approval of preliminary design
Step 3	Develop final design and engineering cost estimates for construction bidding to an accuracy level varying from +/- 10 to 15%
	Prepare all permit applications for project construction
	Obtain NPCC approval of final program design and operational conditions

Step 1 is the master plan or conceptual phase of the process. Project proponents identify all major development components, how they could be arranged on the selected site, and how the facility will be operated. Planning level facility sizing, configurations, and costs are estimated to a confidence level of +/- 35 to 50%. In addition, project proponents assess their proposal's consistency with review elements identified by the Council, which include: consistency with the Council's eight scientific principles; links to other projects and activities in the subbasin; defined biological objectives with measurable attributes that define progress, provide accountability and track changes through time; defined project benefits; descriptions of implementation strategies; relationship to Fish and Wildlife Program habitat strategies; review of cost-effective alternate measures; identification of alternates for resolving the resources problem; historical and current status of anadromous and resident fish and wildlife in the subbasin; current and planned management of fish and wildlife in the subbasin; consistency of proposal with fishery management plans and recovery plans; status of environmental assessment; description of the monitoring and evaluation plan; description of cost estimates for 10 Fiscal Years for planning and design, construction, operation and maintenance and monitoring and evaluation; and the artificial production policies of the Columbia Basin Fish and Wildlife Program (NPCC 2009).

The Kootenai Tribe completed the Step 1 Master Plan in August 2009 and submitted it to the NPCC and Independent Scientific Review Panel (ISRP) for approval. In October 2009, the ISRP offered a number of specific recommendations and sought clarification of aspects of both the Kootenai sturgeon and burbot programs. Among their recommendations was that this Master Plan be revised to 1) incorporate responses to their comments, and 2) reduce integration of sturgeon and burbot program components so that the program for each species could be evaluated independently. Responses to the ISRP comments are compiled in a separate submittal and are being delivered to the NPCC and ISRP along with this Master Plan. The substance of many of the responses has been incorporated into this Master Plan. In addition, the document has been reorganized to independently address the culture of burbot and Kootenai sturgeon at the proposed Twin Rivers Hatchery. Responses to the ISRP comments are compiled in a separate submittal and are being delivered to the NPCC and ISRP along with this Master Plan.

While the Tribe understands the ISRP's rationale for wanting to see the Kootenai sturgeon and burbot programs presented separately, separating them entirely is contrary to the Tribe's overarching vision for the Conservation Aquaculture Program, and would also result in a number of inefficiences and additional costs in terms of planning and design. Additionally, separating the basic infrastructure components required for each program would so significantly alter the facility designs, costs of construction, and operations requirements that it might render the program unfeasible. In this revised Master Plan we've tried to address the spirit of the ISRP's guidance regarding presentation of the program while also retaining the design and construction and operational effeciencies that are integral to the proposed design and vision for the program.

In a full Three-Step Review, following NPCC approval of the Step 1 Master Plan, development plans are advanced to a confidence level of +/- 25 to 35% in the Step 2 submittal. At this stage, design is advanced to a degree that allows completion of a full environmental review. While Step 2 design is still considered preliminary, technical detail is sufficiently refined to identify implementation constraints, costs and configurations that will subsequently change in only minor ways. Step 2 submittals will include a summary of the completed Environmental Impact Statement or Environmental Assessment, and preliminary design documents. The Tribe intends to supplement these requirements with the results of a value engineering review.

Step 3 is the final design review prior to construction. Development plans are advanced to a confidence level of +/- 10 to 15% and are ready for bid. A 100% cost estimate accompanies this submittal along with details on all operational plans.

The Tribe proposes, and respectfully asks that the Council consider the following steps to accelerate post-Step 3 project implementation. Rather than starting a bid process and contracting a successful bidder for construction following Step 3 approval (which can take up to a year for a major project), the Tribe proposes to adopt a design/build approach. Following completion of the Step 2 preliminary design, the Tribe, in collaboration with BPA, would initiate a competitive solicitation to select a general contractor/construction management firm (GCCM) to work in partnership with the design engineers and fish culturists to develop the Step 3 final design. GCCM selection would be based on the firm's estimated costs, experience, approach and other critical considerations. The GCCM would provide a representative to work with the Tribe's design engineers to complete the Step 3 final design, resulting in a constructible and cost effective design.

This approach would provide the NPCC with the most realistic construction cost estimate possible in Step 3. Because of contractor pre-selection, it would also allow the Kootenai Tribe and BPA to begin construction immediately after formal NPCC approval of the Step 3 design submittal and the acquisition of necessary permits. This approach could compress the overall timeline for implementation, resulting in significant cost savings and reduced risk without altering the Council's requirements for the Step 3 submittal or approval, while also helping to ensure that these vitally needed upgrades and new facilities are adequately reviewed and completed at the earliest possible juncture.

The Tribe hopes that this Step 1 Master Plan will meet the approval of the Council and the Independent Science Review Panel and that the project may proceed without delay to Step 2.

1.2 Master Plan Organization

This revised Master Plan is intended to fulfill the Step 1 requirements of the NPCC and to address the specific comments and recommendations of the ISRP in their review of the previous Step 1 submittal. Because the Kootenai Tribe views the proposed aquaculture program as integral to its multi-species ecosystem restoration efforts, both burbot and Kootenai sturgeon are addressed in this Master Plan. Each program is described in a separate chapter. Other chapters are relevant to both species (e.g., local and regional context, environmental compliance, etc.) so to reduce redundancy, are not segregated by species.

Following this introductory chapter, Chapter 2 summarizes the proposed Kootenai sturgeon and burbot aquaculture programs, and expresses the vision of the Kootenai Tribe for their implementation.

Chapter 3 describes the Kootenai subbasin and the current status of fish and wildlife resources, and current and planned management actions. This chapter also includes a description of aquatic management and resource issues at regional and local scales, and presents the relationship of the proposed aquaculture programs to other activities and projects in the subbasin.

Chapter 4 describes the proposed Kootenai sturgeon aquaculture program, including the biological objectives, alternatives considered and the conceptual design of the preferred alternative. Monitoring and evaluation programs are outlined, as is the framework to adaptively manage the sturgeon program. A summary of costs associated with the Kootenai sturgeon component of the program is included in this chapter with more detailed discussion presented in Chapter 8. The Step 1 requirement to assess consistency with the NPCC's Fish and Wildlife Program eight scientific principles is addressed for sturgeon, as are other Step 1 requirements.

Chapter 5 describes the current state of burbot aquaculture, the proposed burbot program and addresses the same components as outlined for sturgeon in Chapter 4.

Chapter 6 describes basin-wide adaptive management efforts, of which this program will be a part.

Chapter 7 identifies the environmental compliance steps that will be undertaken in subsequent phases of the project.

Chapter 8 provides cost estimates for facility planning and design, construction, capital equipment, environmental compliance, operations and maintenance, monitoring and evaluation, and projections of ten-year future costs. Costs for reasonably separable components of the program are presented.

Chapter 9 is a summary of the Tribe's proposed approach to this native fish conservation effort.

Appendix A is the Hatchery and Genetic Management Plan for Kootenai Sturgeon.

Appendix B presents various Kootenai sturgeon recruitment failure hypotheses.

Appendix C is the Hatchery and Genetic Management Plan for burbot.

Appendix D provides water quality testing results from the Twin Rivers Hatchery site.

Appendix E presents detailed cost tables from which the Chapter 8 summary tables are derived.

Appendix F is an excerpt from the 2006 USFWS Biological Opinion for Operation of Libby Dam. Reasonable and prudent alternative component 4 is presented, describing the role of the Kootenai sturgeon aquaculture program in species preservation and recovery.

Appendix G is the USFWS 1999 Kootenai River White Sturgeon Recovery Plan.

2 Overview of the Kootenai River Native Fish Conservation Aquaculture Program

This chapter provides an overview of the history of the Kootenai sturgeon and burbot programs as well as a summary of the facility upgrades and program expansions proposed through this Master Plan.

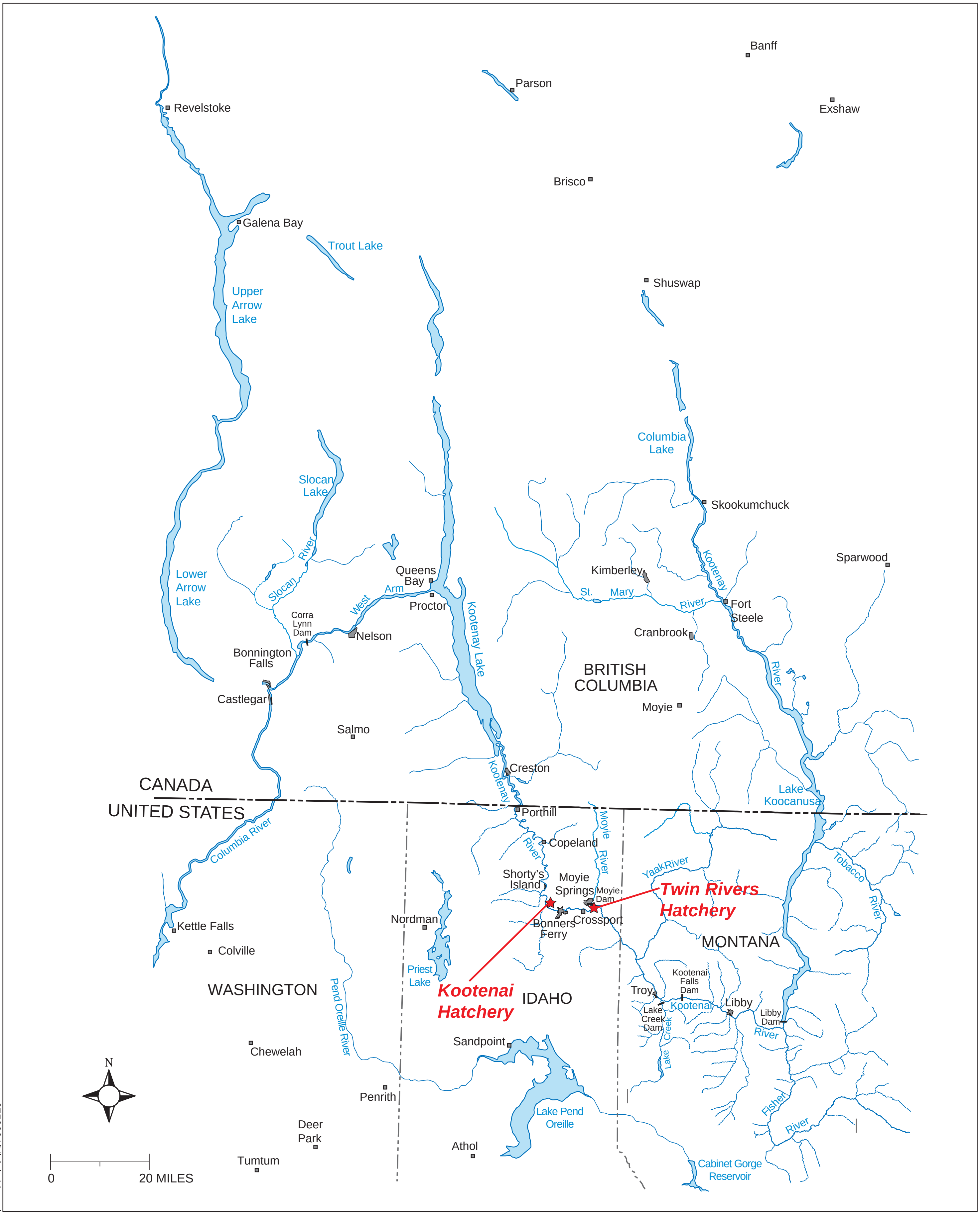
In 1988, the Kootenai Tribe established a Fish and Wildlife Department. This department was developed to help achieve the Tribe's vision of a healthy ecosystem with clean, connected terrestrial, riparian and aquatic habitat that fully supports traditional Tribal and other important societal uses and values, including the restoration, protection and enhancement of the Tribe's ability to exercise its Treaty-reserved hunting, fishing and gathering rights. The earliest identified need targeted by this nascent program was an interim conservation aquaculture program to stem the decline of the Kootenai sturgeon, a responsibility that the Tribe continues and proposes to expand as described in this Master Plan.

This Master Plan addresses two imperiled native species, Kootenai sturgeon and Kootenai River burbot and the history of conservation aquaculture programs to date. This information is provided to help reviewers understand the progress that has been made in both of these programs and to help illustrate the need for, and purpose of new facilities and upgrades presented in this Master Plan.

This chapter will orient the reader to the overall Kootenai sturgeon and burbot programs and lessons learned up to this point. A subsequent chapter describes the relationship of the proposed expanded and new conservation aquaculture programs to other activities in the Kootenai subbasin (Chapter 3) and the proposed Kootenai sturgeon and burbot programs (Chapters 4 and 5). The general project area is illustrated in Figure 2-1.

2.1 Vision for the Program

The Kootenai Tribe envisions the Kootenai River and its floodplain as a healthy ecosystem with clean, connected terrestrial and aquatic habitats, which fully support traditional Tribal and other important societal uses. This ecosystem vision includes healthy, productive populations of Kootenai burbot and sturgeon, both priority species for the Tribe. Accordingly, the facilities proposed in this aquaculture Master Plan are designed to support the requirements of both species in a manner that is cost effective, biologically sound, efficient and sustainable. Separating the sturgeon and burbot programs, as recommended by the ISRP, would increase cost, decrease efficiency, and would be inconsistent with the Tribe's short- and long-term program goals.



3750004/VicinityMap.ai

TETRA TECH
1420 Fifth Avenue, Suite 600
Seattle, Washington 98101
Tel 206.883.9300 Fax 206.883-9301

Kootenai Tribe of Idaho
Kootenai River Native Fish Conservation and Aquaculture Programs
DRAFT MASTER PLAN

Figure 2-1.
PROJECT VICINITY

In developing and implementing approaches to the Kootenai River Native Fish Conservation Aquaculture Programs, the Tribe will continue to emphasize a collaborative approach that considers the needs and values of the region. The Kootenai Tribe believes that cooperation among all groups with a stake in the region is the only way to ensure the sound and prosperous future of the Kootenai subbasin and its biological resources.

Restoration of the Kootenai River ecosystem and self-sustaining populations of Kootenai sturgeon and burbot is a complex and long-term undertaking. Program success will depend on the ongoing cooperation and collaboration of a broad community of individuals and entities. The conservation aquaculture upgrades and expansions proposed in this Master Plan, in concert with implementation of the Tribe's Kootenai River Habitat Restoration Project, and other complementary habitat projects, will be important steps toward achieving the Tribe's vision.

2.2 Summary of the Kootenai Sturgeon Program

Kootenai sturgeon culture activities address interim and long-term recovery goals and objectives that chart a pathway to population recovery. Recovery goals and hatchery objectives have evolved over the last ten to twenty years based on new information and experience. The Tribe's proposed hatchery facilities are an adaptive response to developments and new information collected since the Kootenai River White Sturgeon Recovery Plan was adopted in 1999 (USFWS 1999).

The 1999 Kootenai River White Sturgeon Recovery Plan identified objectives and criteria reflecting the best available information at that time. The plan described initial steps for preventing extinction and initiating recovery, focusing on the first 5 to 10 years of recovery efforts. At the time of listing (1994), it was believed that flow regulation associated with Libby Dam operations (post 1974) was the primary factor responsible for natural recruitment failure at the spawning and early life history life stages.

Because restoring natural recruitment by modifying Libby Dam operations involves considerable uncertainty, the conservation aquaculture program was included as a second key element in the Recovery Plan. The Kootenai River White Sturgeon Conservation Aquaculture Program was initially designed as a temporary "bridge" to fill in a gap of missing year classes until effective flow measures could restore natural recruitment. The 1999 Recovery Plan also recognized substantial uncertainty about limiting factors and action effectiveness, and emphasized research, monitoring, and evaluation to address and reduce these critical uncertainties. Subsequent experience has demonstrated the wisdom of this precautionary, adaptive approach in preventing extinction of the endangered Kootenai sturgeon population.

Initial hopes for a relatively simple water management solution to the recruitment problem have not been realized. Although a variety of measures have been implemented since completion of the Recovery Plan, all efforts to date have failed to increase or restore natural recruitment or to identify an effective remedy for restoring natural recruitment (Paragamian and Beamesderfer 2004). It is now understood that recruitment failure results from much more pervasive changes in the Kootenai River ecosystem related to upstream hydro operations, watershed-scale land use impacts, Kootenai Valley floodplain development, river channel confinement, Kootenay Lake level management, and the cascading trophic effects of these factors (Anders et al. 2002).

Refinements in aging methods indicated that recruitment failure pre-dates Libby Dam completion by 10-15 years (Paragamian and Beamesderfer 2003). Decades of post-release monitoring suggests that the earliest recruitment bottlenecks occur during embryo incubation in the wild (Anders et al. 2002; Kock et al. 2006) and during the young-of-the-year life stage for hatchery released fish (Justice et al. 2009). Given that manipulations of flow conditions to date have not provided suitable conditions for effective reproduction, it is clear that other ecological limitations must also be addressed. It is now apparent that ongoing recruitment failure cannot be expected to be resolved by slight increases of nutrient deficient water from Libby Dam that remain a fraction of average annual historic freshet volumes. This is why the Tribe has also developed, and will soon begin implementing, the complementary Kootenai River Habitat Restoration Master Plan (KTOI 2009).

Recent information suggests that recovery will be more difficult, take longer, and be more expensive than initially anticipated. Although the Tribe's conservation aquaculture program was initially designed as a short-term, stop-gap measure, it now appears that the next generation of Kootenai sturgeon will most likely come from the aquaculture program (Paragamian et al. 2005). Effective flow or habitat remedies have not yet been achieved, and population recovery by natural production is uncertain. At this point, even if some measure of restoration is achieved, natural production alone may not be adequate to produce enough fish or capture enough of the dwindling population to avoid future genetic founder effects and ensure the long-term population viability and persistence.

These realizations have led to a careful re-examination of recovery goals, recovery criteria, and aquaculture objectives in the context of current information and risks. A longer term perspective on the role of the conservation aquaculture program is now required, which in turn led to refinements in the Tribe's program objectives. The new facilities identified in Section 4 are designed to meet the essential role and long-term requirements now deemed necessary for conservation aquaculture.

2.2.1 1999 Recovery Plan Goals and Criteria

The Recovery Plan adopted by the U. S. Fish and Wildlife Service in 1999 identified a long-term goal of downlisting and delisting Kootenai white sturgeon when the population becomes self-sustaining. Short-term objectives included reestablishing natural recruitment and preventing extinction through conservation aquaculture. The plan suggested that down-listing would be appropriate when short-term criteria are achieved. Three criteria for reclassification or downlisting were identified:

1. Natural production occurring in at least 3 different years of a 10-year period. A naturally-produced year class was defined as when at least 20 juveniles were sampled at more than 1 year of age.

2. Stable or increasing population. This includes juveniles released from the conservation aquaculture program each year for a 10-year period in numbers large enough to produce 24 to 120 sturgeon surviving to sexual maturity.

3. A long-term flow strategy adequate to produce natural recruits.

To date, only the second criterion (stable or increasing population due to hatchery production) has been met.

The plan noted that recovery will not be complete until there is survival to sexual maturity, which may take upwards of 25 years for females and possibly late teens for males. However, specific long-term goals or delisting criteria were not identified due to substantial uncertainties in population status, life history, biological productivity, and effects of flow augmentation.

2.2.2 Updated Recovery Goals and Criteria

A clear understanding of current recovery goals and criteria is needed to articulate the objectives of the Tribe's conservation aquaculture program. The need to revise and update the 1999 Recovery Plan has been widely recognized (Paragamian et al. 2005). Plans for a revision are under discussion by the Kootenai River White Sturgeon Recovery Team but have not been implemented. In the interim, a series of working goals and criteria[3] have been identified by the Tribe from a review of essential elements common to other sturgeon and salmon recovery plans (Dryer et al. 1993; UCWSRI 2002; LCFRB 2004; NMFS 2007; CDFO 2009; NMFS 2009).

The long-term recovery goal for the Kootenai River white sturgeon population is unchanged – it is to restore the population to a level where sturgeon are no longer threatened with extinction. Downlisting and then delisting may occur when a species is naturally self-sustaining, where normal variation in abundance does not reduce numbers to a level from which recovery is unlikely or uncertain. Many recovery plans also include "broad sense" goals that recognize critical functions of a species within the ecosystem as well as social benefits related to opportunities for beneficial uses such as fishing.

The current working recovery goal for Kootenai sturgeon is to ensure the persistence and viability of a naturally-reproducing population as an essential element of a functional ecosystem and a resource supporting traditional beneficial uses. In many salmon recovery plans, viability/delisting levels are specifically defined as having a <1 percent risk of extinction within a 100 years (approximately 20 generations). Corresponding standards have not been established for sturgeon where criteria must consider the unique life history and address a much longer time frame consistent with sturgeon longevity, delayed onset of first maturity/reproduction and mulit-year spawning periodicity.

Current recovery criteria related to long-term viability/delisting of Kootenai sturgeon are based on four population attributes: abundance, productivity, distribution/spatial structure, and diversity. The technical basis relating viability to these four attributes is adapted from salmon conservation, as reflected in the Viable Salmonid Population concept (McElhany et al. 2000). Population attribute criteria applicable to sturgeon are identified in Table 2-1. Explanations of the biological basis for these criteria are summarized in the following subsections.

Table 2-1. Working criteria established to guide the development of conservation aquaculture program objectives for Kootenai sturgeon.

Abundance

- A minimum adult population size of 2,500 (for downlisting) and a target adult population size of 8,000-10,000 (for delisting).

Productivity

- Naturally-produced recruitment and juvenile population sizes sufficient to support the desired adult population size.
- Stable or increasing trends in adult and juvenile numbers.
- Representative and stable size and age structure.

Distribution

- Distribution and use of habitats throughout the majority of the historical range.

[3] Criteria identified in the 1999 Recovery Plan have not been formally revised to address current status and information. Working criteria are being used to guide hatchery planning and implementation but have not been formally adopted into the Recovery Plan.

- Breadth of distribution such that population is not vulnerable to any single human-caused catastrophic event (chemical spill for instance).

Diversity

- Stable genetic diversity (including frequencies of common and rare alleles).
- Effective population sizes adequate to allow for normal genetic and evolutionary processes.

Use

- Numbers (consistent with above) adequate to support significant subsistence harvests and recreational fishery uses.

2.2.2.1 *Abundance*

Long-term abundance objectives for conservation are generally based on minimum viable population sizes that are naturally self-sustaining. A viable population is large enough to: 1) survive normal environmental variation, 2) allow compensatory processes to provide resilience to perturbation, 3) maintain genetic diversity, and 4) provide important ecological functions (McElhany et al. 2000).

Other white sturgeon recovery plans have identified abundance objectives ranging from 1,000 per population with multiple populations (NRTWS 2009) to a single population value of 2,500 (UCWSRI 2002). Historical numbers also provide a useful reference point for establishing goals, and are presumed to be consistent with historical levels of ecological function. For planning purposes, 2,500 was used (IUCN 2001; UCWSRI 2002) as a downlisting objective and estimates of historical population sizes of 8,000-10,000 (Paragamian et al. 2005) as a delisting objective.

2.2.2.2 *Productivity*

Productivity refers to a population's ability to replace itself and rebound from a low level to a viable equilibrium population level. Productivity objectives for sturgeon obviously include natural recruitment in numbers sufficient to support adult abundance objectives. Net recruitment is a function of annual spawner numbers or population fecundity, frequency of suitable environmental conditions, and the magnitude of annual or individual recruitment success. No specific annual recruitment objective is identified for sturgeon because adult objectives can be achieved by a variety of combinations of these factors. However, diversity objectives discussed below will require significant recruitment contributions from multiple parents during multiple years to maintain inherent or desirable population characteristics. Stable or increasing trends in juvenile and adult numbers are clearly related to long-term population viability. For long-lived species such as sturgeon, size, age, and sex ratios are particularly powerful indicators of long-term productivity patterns. Viable sturgeon populations are characterized by a broad distribution of sizes and ages. Size and age distributions are stable over the long term in a population at equilibrium.

2.2.2.3 *Distribution/Spatial Structure*

Spatial structure refers to the amount of habitat available, the organization and connectivity of habitat patches, and the relatedness and exchange rates of adjacent populations. Large habitat patches or a connected series of smaller patches are generally associated with wider species distribution and increased population viability. In a highly viable species: 1) the number of habitat patches is stable or increasing; 2) exchange rates among metapopulations are stable; 3) marginally suitable habitat patches are preserved; 4) refuge source populations are preserved, and 5) uncertainty is taken into account (McElhany et al. 2000).

In Kootenai sturgeon, there is only one extant population and limited opportunity to establish an additional population within the historical range[4]. Spatial structure objectives for this population would be met by the broad distribution of sturgeon among river, delta, and lake habitats, the diversity of habitat types accessible within the historical range, and the relative stability and resilience of the Kootenay Lake habitat where a large portion of the adult population spends a majority of its time.

2.2.2.4 *Diversity*

Diversity refers to individual and population variability in genetic-based life history, behavioral, and physiological traits. Genetic diversity is related to population viability because it allows a species or population to use a wider array of environments, protects against short-term spatial and temporal changes in the environment, and provides the raw material for surviving long-term environmental changes (McElhany et al. 2000). Loss of diversity is thought to reduce productivity by reducing physiological and life history variability that is adaptive in a diverse and variable environment (NRC 1996).

Diversity objectives for Kootenai sturgeon are based on genetic criteria. These include maintaining adequate abundance to protect existing diversity and to allow for normal genetic and evolutionary processes. Genetic risks are related to effective population size (N_e), which is based on an idealized population where every individual has an equal chance of mating with every other. Small N_es increase the likelihood of genetic drift, founder effects from managed populations, and inbreeding depression. Genetic considerations are a primary driver for the abundance and conservation aquaculture objectives identified for Kootenai sturgeon.

2.2.2.5 *Use*

Specific use-related objectives are not identified for Kootenai sturgeon but working objectives recognize the need for broad sense use objectives to determine when conservation objectives are met. Natural production rates sufficient to provide harvest or withstand other fishery impacts recognize a desire to restore historical fishing opportunities and the Tribe's ability to exercise Treaty-reserved fishing rights. Reproductive rates that provide a harvestable surplus within the limitations of current system capacity also provide an additional safety factor from long-term risks to population viability.

2.2.3 Conservation Aquaculture Objectives

Conservation aquaculture objectives were developed to support long-term recovery goals and criteria consistent with the essential role of the Tribe's program in light of continuing natural recruitment failure. "Long-term" takes on a special meaning for species like sturgeon for which planning horizons must be expressed in decades or even centuries. Developing an effective conservation aquaculture strategy is, in effect, an optimization exercise in balancing a number of time-sensitive risks (Table 2-2).

[4] A guidance document for evaluating an experimental, non-essential (ESA 10(j)) Kootenai River white sturgeon population was provided to the USFWS (Anders 2007).

Table 2-2. Conservation risks for Kootenai sturgeon: wild population risks that the aquaculture program is designed to address and hatchery-related risks that the aquaculture program is designed to avoid.

Risk	Summary
Demographic	
Depletion	Population declines in response to reduced annual reproduction or recruitment
Depensation	Collapse of normal population processes at low numbers resulting in a spiraling slide toward extinction (the "extinction vortex")
Functional extinction	Too few fish for effective reproduction or to provide hatchery broodstock
Genetic	
Loss of diversity	Founder effect in next generation that results from failure to include adequate numbers of fish in the spawning broodstock
Inbreeding depression	Unbalanced contribution of only a few fish to the next generation that accrues deleterious recessive traits and reduces fitness
Selection	Directional change in genetic composition due to domestication or inadvertent selection over time in the hatchery
Ecological	
Intraspecific competition or predation	Depression of wild recruit survival, growth, maturation, etc.
Disease magnification	Increased incidence of disease and associated effects resulting from transmission in the hatchery
Uncertainty	
Measurement	Many activities are scaled to uncertain estimates of survival, etc. Hatchery fish may also confound detection of natural recruitment
Process	Fundamental lack of understanding of limiting factors and population dynamics

Near- and long-term objectives are identified for the aquaculture program in order to address conservation-related risks over time (Table 2-3). It is helpful to organize objectives by sturgeon generation. Near-term objectives focus primarily on the current generation that includes the declining remnant wild population. Long-term objectives involve future generations, including fish produced primarily in the hatchery from the remnant wild generation, and any natural recruits in the interval until the last wild fish dies or becomes senescent.

Table 2-3. Period-specific objectives[1] of the conservation aquaculture program to protect and restore Kootenai sturgeon.

Near Term

1. Prevent demographic extinction by replacing failed natural recruitment.
2. Establish an increasing trend and broad distribution of ages and sizes in the wild population in order to ensure future sustainability.
3. Preserve native genetic and life history diversity by capturing and spawning significant numbers of representative broodstock.
4. Provide contingencies for uncertain future availability of wild broodstock and prospects for restoring natural recruitment.
5. Inform recovery strategies by using hatchery fish to identify limiting life stages and habitat capacity.

Long Term

6. Avoid annual spawning stock limitation where too few fish might be available to capitalize on favorable

natural spawning conditions in any year (or to continue to provide hatchery broodstock).

7. Minimize, to the extent possible, the time interval between the functional extinction of remaining wild adults and maturation of the first hatchery generation.
8. Maintain an effective population size in the wild adequate to avoid genetic bottlenecks that risk loss of diversity or inbreeding depression in the next generation.
9. Avoid significant detrimental impacts of hatchery fish on natural production due to competition, predation, or disease magnification.
10. Avoid hatchery selection or domestication that might reduce future fitness or viability.

[1] Periods describe the interval during which related risks are manifested

Questions regarding sturgeon conservation aquaculture objectives often focus on long-term outcomes – e.g., how many juveniles need to be released in order to meet adult abundance objectives (or to seed the available habitat to capacity). However, both near-term and long-term risks warrant careful consideration in the design of an effective conservation program. Short-term objectives help plot a course forward from a population's current demographic and genetic condition to future desired conditions. Long-term objectives provide a vision of the ultimate destination. Short-term objectives establish a sound foundation for meeting the long-term objectives. Proposed changes to the ongoing aquaculture program, including new facilities, are designed to address these important near-term and long-term risks.

Forestalling demographic extinction is an essential near-term objective of the Tribe's program. Simple demographic objectives are both a function of fish quantity and quality, as reflected by the amount of genetic and life history trait diversity they represent. They are also met by producing fish in numbers adequate to reverse the declining population trend. Given ongoing, long-term natural recruitment failure, long-term commitment to propagation is necessary to sustain population growth in a long-lived species like sturgeon. Consistent regular production rebuilds the broad size and age structure that is typical of a healthy sturgeon population. Avoiding demographic extinction was a primary focus of the 1999 Recovery Plan and previous program activities when the immediate objective was replacement of a 20-year period of missing year classes (Kincaid 1993; Duke et al. 1999; USFWS 1999).

Since the Kootenai River White Sturgeon Recovery Plan was completed, aquaculture objectives have evolved from replacement of a few year classes to the replacement an entire sturgeon generation, which must now serve as the basis for all subsequent generations. This fundamental shift in project purpose now requires preserving the entire array of native genetic and life history diversity of the current population and propagating this material for the future. At best, the hatchery can only perpetuate the native genetic material represented in the broodstock. Failure to collect adequate and representative numbers of broodstock will reduce genetic diversity in the next generation even if no artificial selection or domestication occurs within the rearing facility. This objective generally requires maximizing the number of different wild adult spawners and the corresponding number of families produced, both within and among years by maximizing the distribution of collections across the spatial and temporal extents of annual spawning seasons.

Considerable uncertainty remains regarding the status of the remnant wild population and how long significant numbers of adults will remain available for hatchery broodstock or to take advantage of proposed habitat improvements. Recent analyses suggest that the population may be somewhat larger than previously estimated (Beamesderfer et al. 2009). However, the remaining adult population continues to decline each year. Many adult-sized fish do not appear to be spawning as frequently as was previously estimated, and it is unknown if or when reproductive senescence might occur. The Tribe's hatchery objectives therefore require and include contingencies for future uncertainties such as "front-loading" current production while broodstock remain available.

Similarly, there is uncertainty about current habitat capacity for sturgeon and related constraints on recovery in the Kootenai River. Monitoring hatchery fish will continue to provide useful information regarding recovery prospects and alternatives (e.g., Ireland et al. 2002a; Beamesderfer et al. 2009; Justice et al. 2009). Hatchery releases provide an experimental basis for evaluating habitat capacity and potential limiting factors. Very few wild juveniles have been produced over the years (Anders et al. 2002), system productivity has declined and current habitat capacity for sturgeon is unknown[5]. Recent analysis of post-release hatchery fish survival suggests there may be size-related density-dependent limitations during the first year of age Justice et al. 2009). Additional information on the habitat capacity for larger juvenile and subadult sturgeon will be provided by future monitoring and evaluation, including information that will be gained through implementation of the Tribe's nutrient restoration program, habitat restoration program (KTOI 2009) and related monitoring and evaluation. Hatchery fish are also being used to evaluate habitat suitability for early life history in areas upstream from Bonners Ferry and to assess the feasibility of imprinting fish to upstream areas with more suitable spawning habitat. The Tribe recognizes that evaluation objectives require carefully- structured experimental designs, tests, and controls.

Long-term recovery objectives address the viability of the next sturgeon generation in the wild. Long-term population abundance objectives are established in part to avoid genetic bottlenecks that risk loss of diversity or inbreeding depression in the next generation. Even if bottlenecks are avoided in the current generation, failure to release enough families or enough fish per family could simply postpone the problem until the hatchery-produced cohort matures and spawns. This objective requires propagation of a diverse population consisting of large numbers of unrelated individuals[6]. The ideal strategy is to produce many families with sufficient releases from each family to ensure that representative numbers survive to adulthood, without swamping the contributions from other families.

Fisheries researchers typically make no mention of a naturally produced year class being too large because its size will be naturally regulated by ecological mechanisms (competition, predation, finite resource and habitat availability); however, these same ecological regulating mechanisms must be assumed to operate on hatchery-produced year classes. This diminishes the relevance of the demographic and genetic swamping argument. Concerns of demographic or genetic swamping are further reduced by the sheer number of release groups within a sturgeon generation, greatly increasing the genetic diversity and thereby reducing the individual contribution of any particular family release group.

Adequate numbers of mature males and females must be spawned each year to capitalize on future natural spawning conditions that may only periodically be favorable. If natural production continues to fail, numbers will need to be sufficiently large to ensure that adequate hatchery broodstock can continue to be collected in a cost effective manner. This risk is of particular concern during the time between the disappearance of the remnant wild cohort and the first maturation of hatchery fish from releases that began in the 1990s. Thus, another program objective is to minimize, to the extent possible, the time interval of potential spawning stock

[5] The Tribe, along with the IDFG and BC MoE, is successfully implementing river and lake fertilization to mitigate cultural denutrification.

[6] In a remnant, post-glacially re-founded, isolated population (one that receives no incoming gene flow), outbreeding depression is not expected to be a concern).

limitation. Future spawner availability is a function of release numbers, years of release, and time required for adequate numbers of released fish to reach sexual maturity and reproduce. Interestingly for sturgeon, larger annual releases can reduce the interval until hatchery fish begin to mature because individual variation in growth rate is large and greater release numbers produce more fast-growing individuals. However, tradeoffs also exist between release numbers and the potential for density-dependent reductions in growth rates (Justice et al. 2009).

Hatchery objectives include avoiding significant detrimental impacts of hatchery fish on natural production due to factors such as competition, predation, or disease magnification. Increased competition is of particular concern due to the potential for large numbers of hatchery fish to reduce growth or survival of natural-origin fish. This was a significant concern in the initial years of hatchery operation when it was hoped that restoration of natural recruitment was imminent. However, given the continued lack of natural recruitment since the late 1950s and 1960s (Paragamian et al. 2005), the choice at this time is now clear: this program must produce enough fish to ensure that the next generation of endangered Kootenai sturgeon is demographically and genetically fit, because the program must provide all the genetic diversity required for the long-term viability of the population in all future generations.

Finally, hatchery objectives include avoiding selection or domestication that might reduce future individual and population level fitness or viability. Impacts of selection or domestication will likely not be manifested until the next (hatchery-produced) population begins to spawn in the wild. Failure to adopt non-selective spawning and rearing practices would likely have long-term irreversible consequences. This objective is addressed by maximizing family sizes, minimizing rearing density, rearing mortality and selective culling.

2.2.4 History of the Tribal Sturgeon Program

The Kootenai Tribe formally launched the Kootenai River White Sturgeon conservation aquaculture program in 1988 in response to the declining abundance and recruitment failure of Kootenai sturgeon. The program has subsequently been expanded and adapted in response to the increasing realization of the hatchery's increasingly critical role in Kootenai sturgeon conservation (Table 2-4).

Table 2-4. Key benchmarks in development of the Kootenai sturgeon conservation aquaculture program.

Year	Benchmark
1979	▪ Sturgeon aquaculture studies initiated at University of California-Davis
1980	▪ Population problems first reported for Kootenai sturgeon (Andrusak 1980)
1983	▪ Recruitment failure reported in Idaho portion of Kootenai River (Partridge 1983)
	▪ Estimated adult population size of 8,000-9,000 fish
1984	▪ Idaho Kootenai sturgeon fishery closed to harvest; catch and release fishery remained open
1987	▪ Northwest Power Planning Council Fish and Wildlife Program recommends Kootenai sturgeon measures
1988	▪ Kootenai Tribe Fisheries Department is established
1988	▪ Kootenai Tribe initiates Kootenai sturgeon studies and program planning
	▪ UC Davis publishes white sturgeon hatchery manual (Conte et al. 1988)
1990	▪ First Kootenai sturgeon is spawned in makeshift river-bank hatchery and eggs are flown to College of Southern Idaho to incubate and hatch
1991	▪ Construction of Kootenai Tribe experimental Kootenai sturgeon hatchery completed
	▪ First successful production of progeny from wild Kootenai River broodstock at hatchery
1992	▪ First release of hatchery-produced fish into the Kootenai River
1993	▪ Breeding plan developed for Kootenai sturgeon (Kincaid 1993)

Year	Benchmark
1994	▪ Kootenai sturgeon listed as federally endangered under ESA. ▪ Hatchery production stopped while under federal review ▪ Catch and release Kootenai sturgeon angling prohibited in the Kootenai River in ID and BC ▪ U.S. Fish and Wildlife Service (USFWS) Kootenai River White Sturgeon Recovery Team formed
1995	▪ Hatchery program reinitiated following ESA listing
1996	▪ Draft Sturgeon Recovery Plan identifies use of Kootenai Tribe hatchery to prevent extinction (USFWS 1996) ▪ Adult population abundance estimated at 1,700 fish
1997	▪ Entire year class lost due to hatchery equipment failure and inadequacy of initial low cost experimental facility design
1998	▪ Funding request was approved by NPPC and BPA to bring the facility and equipment up to standard
1999	▪ Sturgeon Recovery Plan completed and signed by USFWS Regional Director (USFWS 1999; Duke et al. 1999); hatchery upgrades completed ▪ Kootenai Tribe provides funding and coordinates use of the Kootenay Trout Hatchery in British Columbia to be developed as fail-safe Kootenai sturgeon facility and to provide limited additional Kootenai sturgeon rearing
2000	▪ Large-scale annual releases of Kootenai sturgeon begins ▪ Data collection and river modeling for habitat restoration project begins ▪ Kootenai Hatchery Genetic Management Plan completed ▪ Initial genetic analyses (mtDNA) of wild and broodstock groups completed
2002	▪ Adult population abundance estimated at 620 fish
2003	▪ Mark-recapture studies reveal high wild survival rates of hatchery fish
2004	▪ Updated demographic study puts extinction without intervention on the calendar ▪ Program goals revised to maximize broodstock numbers and releases from dwindling wild population (KTOI 2004) ▪ Initial microsatellite genetic analysis completed (> 94% of wild alleles represented by broodstock to date; Rodzen et al. 2004) ▪ Comprehensive Adaptive Conservation Aquaculture Plan completed by Kootenai Tribe and subcontractors ▪ Kootenai Hatchery program incorporated into Regional NPCC Subbasin Plan
2005	▪ Adult population abundance estimated at approximately 500 fish ▪ Experimental nutrient addition begins in Kootenai River
2006	▪ Release size (age) increases after monitoring identified poor survival of earlier life stages ▪ Importance of Kootenai Tribal Hatchery in maintaining population acknowledged in Libby Dam BiOp RPA Component 4
2007	▪ Stocking goals are met with larger fish (age 1+) at release to provide favorable survival rates ▪ Experiments are implemented with fertilized egg and larval fish releases in high quality habitat upstream from existing spawning sites
2008	▪ Planning begins for additional Kootenai sturgeon hatchery to address critical uncertainty regarding imprinting and need for additional spawning and rearing space.
2009	▪ Kootenai River Habitat Restoration Project Master Plan completed. ▪ Kootenai River Native Fish Conservation Aquaculture Program Master Plan completed and submitted to NPCC

About the same time that Kootenai sturgeon population problems were first recognized, the University of California at Davis was using sturgeon hatchery techniques to develop a commercial sturgeon culture industry in California. Additionally, development of sturgeon culture techniques was fueled by a budding sturgeon aquaculture industry motivated to respond to increased worldwide demand for caviar in the face of declining supplies from wild sturgeon in Europe and Asia. Development of effective techniques for spawning, incubating, and rearing white sturgeon (Conte et al. 1988) made instigation of a Kootenai sturgeon conservation program possible.

Experimental Program: 1988 -1997

The initial program was designed to use a very basic and low budget hatchery, laboratory and research facility to address critical ecological and biological uncertainties, identify possible factors limiting natural production of Kootenai sturgeon, and identify possible population restoration strategies. Some of the key uncertainties the Tribe successfully resolved in this early experimental phase included Kootenai sturgeon gamete viability, whether natural recruitment failure occurred before or after spawning (or both), and whether spawning and rearing wild Kootenai sturgeon in a hatchery might be a suitable tool for demographic and genetic conservation and recovery.

Artificial spawning of wild Kootenai sturgeon first occurred in 1990 in a makeshift facility on the banks of the Kootenai River (Apperson and Anders 1991). Construction of a low cost experimental hatchery was completed in 1991 on Tribal land near Bonners Ferry (Figure 2-1). Offspring from wild Kootenai sturgeon broodstock were successfully produced at this hatchery in four of the next five years. The first release of a small number of hatchery-reared juveniles (128) into the river occurred in 1992. Broodstock were released unharmed shortly after being spawned in the hatchery. These early efforts demonstrated that eggs could be successfully spawned, fertilized, incubated, and hatched. Results confirmed that gamete viability was not a major limiting factor for natural recruitment in the Kootenai sturgeon population. Table 2-1 summarizes key benchmarks in the Kootenai sturgeon conservation aquaculture program.

The Tribe's Kootenai sturgeon program generated some regional controversy during the early to mid-1990s. At that time, some fisheries co-managers were concerned that hatchery fish might overwhelm and reduce fitness of the wild population or that the hatchery program would divert attention away from implementing changes in flow from Libby Dam that were believed necessary to help restore a self-sustaining wild population. These concerns were addressed with a breeding plan that included immediately implementing hatchery production to prevent extinction and continuing flow augmentation to address perceived Kootenai sturgeon spawning needs (Kincaid 1993), while continuing to investigate other habitat-based actions to support the population's survival over the long term. The hatchery program has since gained widespread support among the co-managers as other recovery options attempted to date have failed.

As the Tribe's experimental program evolved, the capabilities and potential of the hatchery outgrew the original facility. Initial facilities and equipment were inadequate to meet the conservation aquaculture program requirements identified in the breeding plan (Kincaid 1993) and recovery plans (USFWS 1996 and 1999). Critical facility limitations were underscored by the loss of the entire 1997 year class when the hatchery chlorine filtration system failed.

Program Maturation: 1998 – 2008

With the support of the USFWS Kootenai River White Sturgeon Recovery Team, the Tribe's sturgeon hatchery program objectives, activities, and protocols were incorporated into the USFWS Kootenai River White Sturgeon Recovery Plan, which emphasizes the need for a multifaceted approach to recover Kootenai sturgeon (USFWS 1996; USFWS 1999; KTOI 2004) (Appendix F).

A series of upgrades to the Tribal Sturgeon Hatchery were completed in 1998, 1999, and 2007/2008 to address Tribal objectives and USFWS recovery plan objectives. After the loss of a year class in 1997 due to facility inadequacy, the Tribe entered into an agreement with BC MoE to develop a fail-safe facility for off-site hatching and rearing. A fail-safe Kootenai sturgeon facility was developed at the Kootenay Trout Hatchery in Fort Steele, British Columbia to provide a backup site to avoid repeating a year class loss. Family groups were initially split for rearing at the each facility, and to increase the program's production capacity. This fail-safe program has operated successfully since 1999[7].

Analysis of annual mark-recapture data in 2001 confirmed excellent survival rates of hatchery fish in the wild (approximately 60% during first year at large and ~90% during all subsequent years) (Ireland et al. 2002a). Justice et al. (2009) confirmed that this survival rate has been sustained in releases of age one and older fish; however, experimental releases of young-of-the-year sturgeon had poor survival rates.

By the late 1990s, following nearly a decade of annual experimental flow measures at Libby Dam, it was evident that this approach was failing to restore natural recruitment and that the next generation of Kootenai sturgeon was likely going to be produced predominantly, if not entirely, by the hatchery program. This realization led to further refinements in hatchery objectives and protocols (KTOI 2004).

The initial hatchery purpose was to reduce long-term population risks by ensuring a balanced contribution of hatchery broodstock in the next spawning generation and avoiding competition with wild juveniles. Following updated demographic analysis, production objectives were modified to address near-term genetic risks of lost diversity from the remnant wild population, continuing loss of mature adults to sustain production, and demographic risks of too few spawners in the next generation. Remedies included increased broodstock use in years when available, increased release group sizes, and decreased culling of fish from large family groups. Revised hatchery objectives were reported in an Adaptive Multidisciplinary Conservation Aquaculture Plan (KTOI 2004) and the 18-year Kootenai Hatchery Report (KTOI 2008).

In 2006, the USFWS Biological Opinion Regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout, and Kootenai Sturgeon Critical Habitat was published (Libby Dam BiOp) (USFWS 2006, clarified in 2008). The Libby Dam BiOp specifically acknowledges the need for continued operation of the Tribe's sturgeon aquaculture program in Reasonable and Prudent Action (RPA) Component 4 (see Appendix E), and directs the action agencies to provide funding to expand adult holding and spawning capability at the Tribal Sturgeon Hatchery (USFWS 2006, clarified in 2008).

The Tribal Sturgeon Hatchery upgrades implemented to date have allowed for significant increases in annual releases and give the Tribe, Idaho Fish and Game (IDFG), and BC MoE the ability to collect more hatchery-produced fish under the Tribe's updated Conservation Aquaculture Plan (KTOI 2004). However, the existing facilities are currently at capacity, the additional upgrades and new facilities proposed in this Master Plan are necessary to expand production and genetic preservation and to acclimate and imprint young sturgeon on the waters of upstream reaches of the Kootenai River.

In summary, the Tribe has long supported and advanced native Kootenai sturgeon conservation and restoration efforts. Since the late 1980s, numerous reports and peer-reviewed publications have documented the progress made through the Tribe's Kootenai sturgeon conservation aquaculture program (Anders 1988; Drauch and May 2007, 2008, 2009; Drennan et al. 2006,

---

[7] As part of this Master Plan, the Tribe proposes continued use of the B.C. Kootenay Trout Hatchery facilities (now operated by the Freshwater Fisheries Society of B.C.) for fail-safe operations because: 1) it is a successfully operating off-site program, 2) physical facilities are proven and functional, 3) no additional capital investments are required for continued operation and 4) international permitting and logistics can be continued efficiently.

2007a, 2007b; Ireland et al. 2002a, 2002b; Kootenai Tribal annual hatchery reports 1993-2008; Rodzen et al. 2004; Beamesderfer et al. 2009; and Justice et al. 2009).

2.3 Summary of the Kootenai Burbot Program

2.3.1 Purpose of the Proposed Burbot Program

The Kootenai Tribe is dedicated to the conservation and restoration of a healthy ecosystem that supports traditional Tribal and societal uses. Burbot were a keystone species in this native ecosystem and are a high priority of the restoration effort. An expanded burbot culture facility is an essential element to achieve restoration objectives developed under the NPCC's Fish and Wildlife Program and the local Kootenai Valley Resource Initiative. The Tribe is also undertaking a comprehensive ecosystem restoration program in cooperation with multiple government and non-governmental parties, consistent with shared goals, to aid in restoring Tribal ability to exercise Treaty-reserved fishing rights and to assist the federal (U.S.) government in fulfilling tribal trust responsibilities.

Kootenai burbot have been subject to almost two decades of research and monitoring that has documented the population collapse but failed to prevent or slow its extirpation (Paragamian et al. 2000; 2008). Too few wild burbot now remain to support an effective research and monitoring program to identify factors limiting survival and impediments to restoration. Too few remain to take advantage of other ecosystem measures including tributary habitat improvements, kokanee rebuilding, lake and river fertilization, and mainstem habitat improvements.

A conservation aquaculture program provides the best prospect for timely diagnosis of the root causes of the burbot population failure, to identify effective remedies and to evaluate restoration feasibility. The Tribe's burbot culture program and proposed facilities are based on an experimental, incremental, and adaptive approach to restoration. Phase 1 of this program is complete and established that aquaculture is feasible (see Section 2.3.3). Phase 2 is based on post-release monitoring of burbot produced at the University of Idaho-Aquaculture Research Institute (UI-ARI). These fish will serve as research subjects to evaluate distribution, movements, habitat use, food habitats, and effective sampling methods by life stage. Phase 3 will involve producing and releasing sufficient burbot to support population-level research and monitoring of survival, growth, and maturation. Experimental releases of burbot of various sizes will identify life stage limitations and provide information necessary to guide habitat restoration efforts. Estimates of survival, growth, and maturation will provide the needed quantitative basis to estimate the appropriate scale of production to meet long-term population restoration objectives.

The Phase 3 objectives drive the need for additional burbot production facilities. Potential survival schedules and statistical power analyses demonstrate that current production levels are unlikely to provide the precision necessary to assess burbot survival with any degree of confidence. In the long term, more limited releases may result in too few fish surviving to adulthood to determine if hatchery-reared fish might ultimately contribute to natural production. Scaling up to make a proper experimental evaluation provides the best possible position to get definitive answers in a reasonable amount of time. The NPCC Fish and Wildlife Program consistently identifies the value of an adaptive experimental approach to conservation and restoration. The burbot restoration strategy is designed to do exactly that (KVRI 2005).

2.3.2 Program Goals and Objectives

The Kootenai Subbasin Plan (KTOI and MFWP 2004) and the Burbot Subcommittee of the Kootenai Valley Resource Initiative (KVRI 2005) identified conservation objectives and restoration strategies for this imperiled burbot population. These objectives are:

- Restore consistent natural recruitment in at least three different spawning areas with a juvenile population of sufficient size to support the adult burbot population goal
- Establish a stable-sized population with sufficient age distributions to assure long-term population viability and persistence
- Produce and stock burbot at rates and frequencies to sustain a target population of 2,500 to 9,500 adults in the Kootenai River and South Arm of Kootenay Lake (Paragamian and Hansen 2008)

An important goal for the Kootenai Tribe is to reestablish a healthy sustainable population of native burbot in the lower Kootenai River capable of supporting future Tribal Treaty subsistence and cultural harvest and sport harvest. Harvest opportunities will be appropriate only when monitoring reveals natural reproduction and recruitment is sufficient to restore fishing opportunities.

Like the Tribe's approach to Kootenai sturgeon conservation and recovery, the KVRI Burbot Conservation Strategy has aquaculture and habitat components. Burbot are one of the focal fish species for which habitat improvements are targeted in the proposed Kootenai River Habitat Restoration Project. Long-term recovery cannot be achieved without both programs. Section 5.1.2 identifies biological objectives for burbot, along with measurable attributes that will reflect hatchery program success.

Proposed burbot plans are informed by 20 years of lessons learned from the sturgeon aquaculture program. The sturgeon program demonstrated that failure to develop effective programs and facilities at the outset was much more costly and less efficient in the long run. Up-front investments in a well-designed aggressive adaptive experimental approach are likely to produce significant long-term cost savings and resolve uncertainties more quickly and cost effectively than implementing a more mechanistic, sequential research program.

The only way to effectively evaluate many actions will be through carefully controlled experimental implementation, which is the Tribe's proposed approach. Since the late 1980s, the Kootenai Tribe has consistently provided cost-effective, well-staged experimental research and conservation production of sturgeon. The proposed approach for burbot intentionally provides phases, safeguards, flexibility, and an adaptive management approach to maximize the chances of program success and identify problems and failures early on and adaptively improve and modify the program.

2.3.3 History of the Tribal Program

Unlike sturgeon, previous efforts to culture burbot have been minimal. Other groups encountered difficulty in captive rearing primarily due to temperature sensitive embryo development and the existence of a larval life stage (Taylor and McPhail 2000; Wolnicki et al. 2001, 2002; Harzevili et al. 2003). In 2003, the Kootenai Tribe, BC MoE and the UI-ARI initiated a collaborative project to develop and assess burbot aquaculture feasibility and methods. The goal was to develop and establish methods for captive propagation of burbot for a conservation aquaculture program. The first wild broodstock for this project were collected in 2003 from Duncan Reservoir in British Columbia and were provided to the Kootenai Tribe by the BC MoE. These fish were successfully acclimated and spawned in 2004 at the UI-ARI facility, leading up to the Tribe's first small-scale experimental release to the wild in the fall of 2009.

As part of the effort to develop burbot culture techniques, adult spawning behavior was monitored and the use of exogenous hormone analogs to induce female ovulation was evaluated in 2004 and 2005. These trials showed that volitional (in tank) spawning occurs in this species and the use of hormones can shorten the ovulation period for females, thus minimizing overall spawning time (Jensen et al. 2008a). An evaluation of egg incubation techniques showed that upwelling conical-shaped incubators ≤ 2 liters in volume significantly improved embryo survival compared to larger cylindrical incubators (Jensen et al. 2008b). Larval feeding trials established a basis for the successful culture of this species and demonstrated the feasibility of transitioning burbot to a commercial diet. These trials showed that feeding live prey (rotifers and *Artemia*) for 30 days was required and that extended live prey feeding improves survival and fish health (Jensen et al. 2008b). The ability to successfully cryopreserve burbot semen was investigated in 2005 and 2006. These efforts demonstrated that methanol concentration ≥10% significantly improves motility and fertilization (Jensen et al. 2008c). Such small-scale experiments demonstrated that captive burbot spawning, incubation and larviculture are feasible, establishing conservation aquaculture as a legitimate conservation tool for burbot.

In recent years, burbot production has been expanded at the University of Idaho. Improvements in culture techniques continue to be made and fish are being produced for ongoing research projects. One project is investigating burbot disease susceptibility and establishing fungal control methods for eggs to improve embryo survival. Egg fungus control experiments showed the efficacy of two fungicides (formaldehyde and hydrogen peroxide) (Polinski et al. 2010). To obtain baseline disease susceptibility, laboratory challenge experiments focused on five specific pathogens of concern. These experiments were repeated and expanded in 2008 (Polinski et al. 2009). Success of the burbot program up to this point enabled the Tribe's first experimental release to occur in the fall of 2009 (Jensen et al. 2010).

Numerous reports and peer-reviewed publications document the progress of the Tribe's burbot program (Cain et al. 2008; Hammond and Anders 2003; KVRI 2005; and Jensen 2008a, 2008b, 2008c). Table 2-5 illustrates scientific advances made by the Tribe toward a conservation aquaculture program. A chronology of benchmark achievements is compiled in Table 2-6. Collectively, these efforts and publications provide the needed quanitiative rigor to justify the currently proposed program expansion.

Table 2-5. **Burbot culture experiments and production feasibility by life stage.**

Critical Burbot culture components	Burbot culture activities	Progress to date	Immediate experimental needs	Future experimental needs	Production feasibility status	Comments
Adults	Collection	Good	None	None	Requirements met	Adult stage activities do not currently limit production
	Holding	Good	None	None	Requirements met	
	Spawning	Good	None	None	Requirements met	
Egg stage	Incubation	Good	None	None	Requirements met	Egg stage activities do not currently limit production
Larval stage	Holding (pre-mouth development)	Good	None	None	Requirements met	System design has been improved
	Feeding (intensive – live prey)	Good	None	None	Requirements met	Intensive methods established and do not limit production
	Feeding (extensive/semi-intensive- outdoor ponds)	Good	None	Confirm production potential	Repeat study 2010	Graduate student project underway
Juvenile stage	Grow-out	Good	None	Analyze feed trial experiments and continue to optimize feed transition	Requirements nearly met	Transition to artificial feed successful. Improved survival desired but not essential for production
Burbot health	Assessment of formalin and H_2O_2 for fungal control on eggs	Good	None	None	Requirements met	Published in North American Journal of Aquaculture (Polinski et al. 2010a)
	Disease susceptibility	Good	None	None	Requirements met	Paper in press: Diseases of Aquatic Organisms
	Pathogen screening (develop cell line as diagnostic tool)	Good	None	None	Requirements met	Paper in press: Journal of Fish Diseases

Table 2-6. Key benchmarks in development of the Kootenai burbot conservation aquaculture program.

Year	Benchmark
2001-2004	▪ Adult burbot trapped, acclimated and spawned in captivity
2004	▪ Adult burbot successfully spawned in captivity and progeny reared ▪ Methods to enumerate eggs and estimate fertilization rates were developed.
2004-2005	▪ Exogenous hormone analogue effective used to induce ovulation
2004-2009	▪ Fertilization rates of over 90% achieved (fertilization rates vary from 0-90% each year)
2005-2006	▪ Cryopreservation trials verified techniques to preserve semen ▪ Methanol concentrations tested that resulted in improved motility and fertilization ▪ Larval feeding trials conducted
2007	▪ Incubation trials demonstrated Imhoff cones and pelagic egg hatching jars significantly ($p \leq 0.05$) improve egg survival when compared to a McDonald-type jar ▪ Larval burbot feeding experiments demonstrated that feeding nutritionally enriched live prey resulted in the highest survival and growth rates among treatments. ▪ Larval survival and growth were shown to improve significantly with a live prey diet compared to commercial dry diet.
2007-2008	▪ Egg fungus control experiments tested the efficacy of two fungicides ▪ Burbot aquaculture determined to be a viable management option for reestablishing a burbot population in the Kootenai River.
2009	▪ 247 hatchery-reared burbot acclimated and then released to the Kootenai River

The Tribe proposes to dedicate a portion of the Twin Rivers Hatchery to burbot conservation. The biological objectives of this program are defined by the KVRI burbot conservation strategy (KVRI 2005) for population protection and restoration. Table 5-6 outlines the objectives, hypotheses, duration and timing of a phased program to achieve these objectives. The feasibility stage has been successfully completed. Phase 2 is underway - monitoring the first small release of hatchery-produced fish into the wild began in 2009. Because of facility limitations at the University of Idaho and the Tribe's existing hatchery facility, this and future phases cannot be fully realized without increasing production capacity of the Twin Rivers Hatchery.

The Tribe's burbot program is using a within-basin brood source from Moyie Lake in British Columbia, as described in Section 5.1.2. Following spawning, eggs will be incubated and hatched at Twin Rivers using techniques refined through research by the UI-ARI. Various life stages of burbot will be reared simultaneously year round up to Age 3, when they will be released into the Kootenai River (see Section 5.1.3.4). Prior to release, a non-invasive mark is applied to each fish for monitoring purposes. Older year class fish will be implanted with radio transmitters when feasible. Future research will evaluate tagging methods and retention and the biological and habitat requirements of each life stage.

The proposed burbot monitoring and evaluation program will follow the same fundamental framework and standardized approaches as the Kootenai sturgeon aquaculture program. Basic elements are genetics, fish health, cryopreservation, and water quality. Another important monitoring objective will be to identify habitat factors that are limiting this burbot population– by tracking hatchery-produced fish, these limitations will be identified. Details concerning burbot monitoring and evaluation are presented in Section 5.4.

3 Local and Regional Context for the Proposed Conservation Aquaculture Programs

Chapter 3 presents the local and regional context within which the proposed Kootenai River Native Fish Conservation Aquaculture Programs described in this Master Plan will occur. This chapter includes an overview of the Kootenai River subbasin (subbasin) including its physical characteristics, the historical and current status of its fish and wildlife populations, and factors limiting self-sustaining Kootenai sturgeon and burbot populations. This chapter also includes a summary of the relationship of the proposed conservation aquaculture programs to the Kootenai Subbasin Plan, Recovery Plans, local and regional management activities, and other projects and activities in the subbasin. An overview of the coordination and collaboration that occurs in support of various project and activities is also described.

3.1 Kootenai River Subbasin

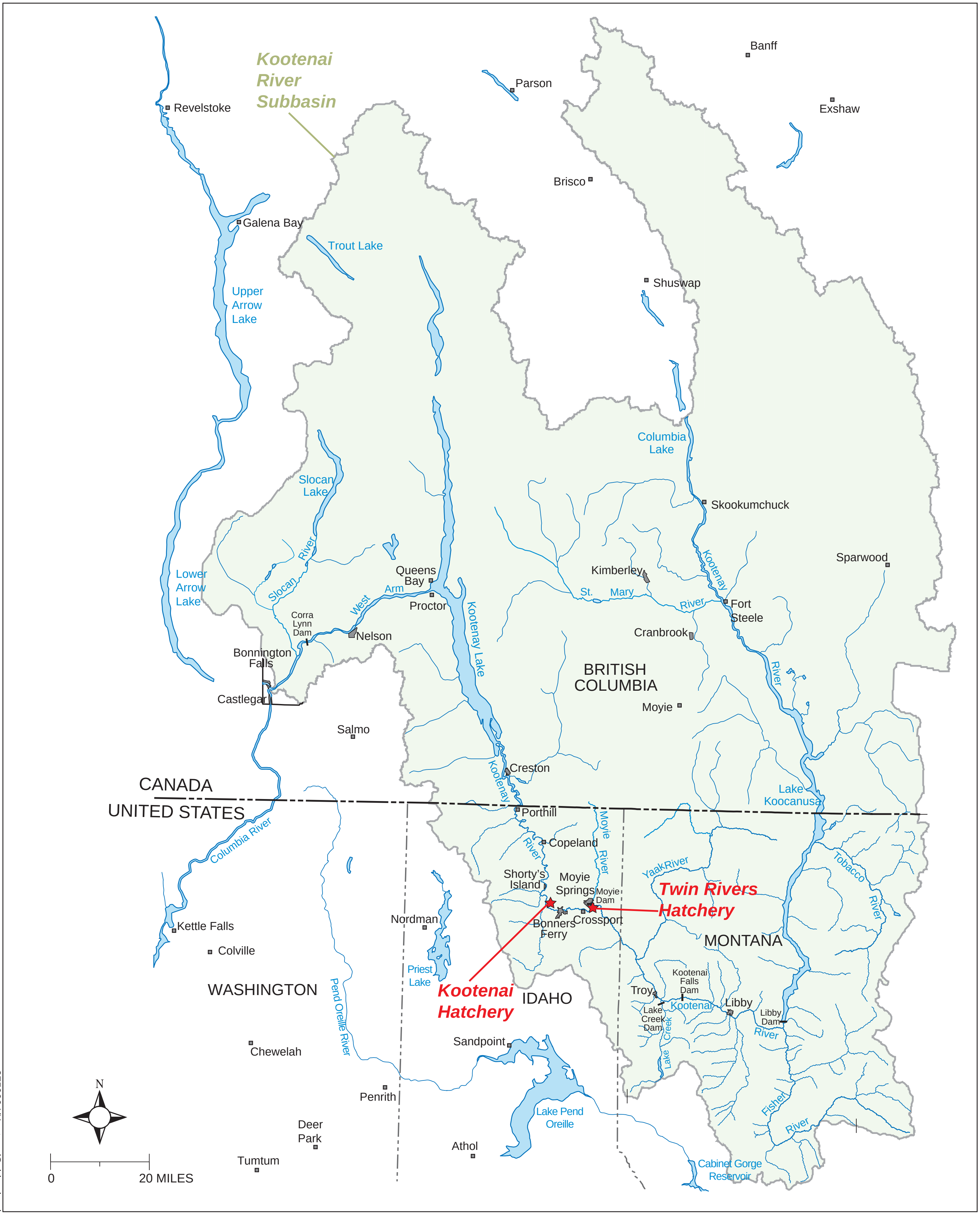
The Kootenai subbasin is an international watershed located primarily in the province of British Columbia, Canada, with smaller portions of the subbasin in the states of Montana and Idaho (Figure 3-1). The Kootenai River is the second largest Columbia River tributary in terms of runoff volume and the third largest in terms of watershed area (10.4 million acres; approximately 16,180 square miles) (Knudson 1994). Nearly two-thirds of the Kootenai River's 485-mile-long channel and almost 70% of its watershed is located within British Columbia. The Montana portion of the subbasin makes up about 23% of the watershed, while the Idaho portion is about 6.5% (Knudson 1994).

From headwaters in southeastern British Columbia the Kootenai River[8] flows southward into northwestern Montana where Libby Dam, forming Lake Koocanusa, impounds it. Downstream from Libby Dam, the river flows into Idaho, and then turns north, entering British Columbia and Kootenay Lake. The river exits the West Arm of Kootenay Lake at the town of Nelson and flows westward to its confluence with the Columbia River at Castlegar, British Columbia.

The Kootenai River white sturgeon population and the lower Kootenai burbot population are completely contained within the geographically isolated Kootenai subbasin. Because of this physical isolation, no out-of-subbasin actions directly affect the Tribe's proposed aquaculture programs for sturgeon and burbot. Cooperative flow management practices in the Kootenai subbasin do, however, influence hydraulic conditions downstream in the Columbia River in both countries.

The majority of information and the programs presented in this Master Plan deal most directly with the Idaho portion of the subbasin, although the Tribe has consistently sought to, and continues to, coordinate with co-managers, communities and stakeholders in British Columbia and Montana in their efforts to restore Kootenai sturgeon and burbot and their complex habitats.

[8] Canadian reaches of the river are spelled "Kootenay"; U.S reaches are spelled "Kootenai". For standardization in this document, the U.S. spelling is used.



375004/KootenaiSubbasin.ai

TETRA TECH

1420 Fifth Avenue, Suite 600
Seattle, Washington 98101
Tel 206.883.9300 Fax 206.883-9301

Kootenai Tribe of Idaho Kootenai River Native Fish Conservation and Aquaculture Programs MASTER PLAN	Figure 3-1. KOOTENAI RIVER SUBBASIN

3.1.1 Aboriginal Territory and the Kootenai River Subbasin

The Kootenai aboriginal territory extended throughout and well beyond the Kootenai River watershed. Fish and wildlife in the diverse Kootenai River ecosystem were once abundant and relied upon by the Kootenai people. Over the last century, those once abundant fish and wildlife resources have declined and a number of the threads of the complex ecosystem tapestry that supported those resources have been systematically shortened, damaged, or removed altogether.

During the last century, the Kootenai subbasin has been modified by agriculture, logging, mining, flood control. The Kootenai and Duncan rivers have been impounded by Libby and Corra Linn dams, respectively. Conversion of more than 50,000 acres of floodplain to agricultural fields has resulted in loss of riparian and wetland plant and animal species, and the related functions that historically supported a healthy ecosystem. The lowermost 120 km of the Kootenai River upstream from Kootenay Lake have been chanelized by levees. Some levees were built on top of natural sand levees for flood control, limiting the hydrologic connection between the Kootenai River and its floodplain.

When Libby Dam became operational in 1972, it reduced annual peak flows by half, thus significantly disrupting the natural hydrograph and thermograph. These modifications resulted in unnatural flow fluctuations in the Kootenai River and its floodplain, which no longer provide suitable habitat to support all life stages of many native aquatic and riparian species. Although major habitat alterations such as levee construction and the regulation of the natural flood regime by Libby Dam benefited agriculture and local communities, they also reduced the Kootenai Tribe's access to traditional resources previously relied upon for subsistence and cultural uses. Today, the Kootenai subbasin no longer supports many aspects of the traditional lifestyles it sustained historically and the ability to exercise Treaty-reserved fishing for most fish species has been prevented entirely.

3.1.2 Climate

The climate in the Kootenai subbasin is affected by both maritime and continental weather patterns. Maritime influences moderate the harsher continental climate. Winters are neither as wet nor as warm as Pacific coastal areas, but generally are not as cold and dry as areas to the east. Weather patterns are complex, with local variations stemming from differences in elevation. The average temperature at Bonners Ferry is 46.9°F, reaching or exceeding 90°F on half the days in July and August, and averaging 22°F in January. Mean annual precipitation in the Idaho portion of the subbasin is 30 inches, approximately 70 to 80% of which falls as snow between November and March.

3.1.3 Geology, Soils and Land Types

The Kootenai subbasin lies within ranges of the Rocky Mountains, trending north to northwest, that are separated by long straight valleys. These valleys tend to be relatively broad and flat. The subbasin is underlain by quartzite-based and granitic rocks. Soils derived from the quartzite deposits are significantly more stable and resilient on hill slopes and in stream channels than the coarse weathered granitic sands. Bedrock in the subbasin is typically covered with glacial till. Till derived from quartzite rocks is medium-textured with a moderate amount of rock fragments. That derived from granite is usually sandier and varies more in its rock-fragment content. The top portion of the glacial till is loose and permeable, while the lower part can be dense and impermeable. The dense layer can restrict water movement and root penetration. Deposits of outwash and alluvium transported by streams are found in valley bottoms. A layer of volcanic ash that is 0.5 to 1.5 feet thick covers most of the glacial material. The ash usually has a silt-loam texture with little gravel, cobble, or rock fragments. It normally has a high infiltration rate, high permeability, and a high water- and nutrient-holding capacity. Ash, however, is easily compacted and displaced by heavy equipment.

Upstream reaches of the Kootenay River in British Columbia flow through the Purcell Range, the southern Rocky Mountain Trench, and the southern Rocky Mountains. The Purcell Trench, which the Kootenai River enters at Bonners Ferry, is perhaps the most pronounced structural feature of the lower part of the subbasin. Lying between the Selkirk and Purcell mountains, it is a glacially-enlarged, asymmetric, fault-bounded valley. The Purcell Trench also holds Kootenay Lake. The bottom of the trench, the lower slopes of the valley and alluvial terraces are covered with deposits of glacial debris and older sediments. Other major structural features created by faults in this part of the subbasin include the Moyie River corridor and the Kootenai River valley between the Purcell and Cabinet mountains (Daley et al. 1981).

3.1.4 Water Quality

The Kootenai River downstream of Libby Dam was listed by the Montana Department of Environmental Quality as partially impaired for aquatic life and coldwater fisheries under Section 303(d) of the Clean Water Act (CWA). Operation of Libby Dam has altered flows and thermal regimes, contributing to this designation.

During the past 50 years, the trophic status of the Kootenai River system changed from naturally oligotrophic to culturally eutrophic by the late 1960's (Daley et al. 1981), then to its current ultraoligotrophic condition.

Prior to construction of Libby Dam, high levels of phosphorus were discharged from a fertilizer plant in Kimberly, British Columbia, resulting in large algal blooms in the river. By the mid-1970s, nutrient levels dropped substantially, due in part to decreases in fertilizer dumping and the presence of Libby Dam. Currently, chlorophyll levels and primary productivity are very low in the river downstream of the dam. In an attempt to remedy this situation, a five-year nutrient addition experiment was initiated in Idaho reaches of the Kootenai River in 2005. The Kootenai Tribe, IDFG and BPA added nutrients to the river at the Montana state line. Measurements found that primary and secondary production and species richness increased significantly in the river downstream from the nutrient addition sites compared to upstream reference conditions (Holderman et al 2009a, 2010; Hoyle et al. 2010; Shafii et al 2010).

Contaminant levels are generally low in the Kootenai River. In the mid-1990s, levels of mercury, lead, and selenium were almost high enough to cause chronic effects to aquatic life (Kinne and Anders 1996). By 2003, water quality sampling detected low levels of these constituents. Possible sources of pollution include tailings from mining operations, runoff from municipalities and agricultural areas, and forestry operations. There are approximately 1,000 privately held parcels adjacent to the river between the mouth of the Fisher River (RKm 351) and the Idaho border (RKm 277). Two-thirds of these parcels are currently developed. In addition to contributing to contaminant runoff, many of the developed parcels have private drinking water wells, often shallower than 60 feet. These systems access subsurface aquifers and have an unknown degree of impact on the river.

Water spilled from Libby Dam increases total dissolved gas (TDG) downstream from the dam. High TDG levels can harm or kill aquatic organisms and may persist many miles from the source. In Montana and Idaho, the TDG standard is 110% saturation. High levels of TDG may have detrimental consequences, depending on a number of conditions ranging from duration of exposure, species and life stage of fish, water temperature, and other stressors. TDG from Libby Dam outflow is generally at or below 110% saturation, but spill releases via the low elevation sluiceway outlets generally produce TDG levels higher than state standards at any release rate. Releases from the dam appear to fully mix within about eight miles downstream. TDG saturation in the Idaho portion of the river is not affected by Libby Dam operations due to the distance from the dam and the effect of Kootenai Falls.

Spill from Libby Dam also affects downstream water temperatures, typically causing warmer temperatures in the winter and colder temperatures in the summer. Post-impoundment winter water temperatures in the Kootenai River downstream from Libby Dam averaged 3°C warmer than pre-impoundment values (Partridge 1983). Summer water temperatures in the same river reaches during the same years were consistently lower than pre-impoundment values, due to hypolimnetic withdrawal from Libby Dam (Partridge 1983; Snyder and Minshall 1994). Solar radiation, air temperature and wind affect river temperatures, factors magnified by low river flows at certain times of the year.

Flow releases for Kootenai sturgeon spawning usually occur in May when the water temperature is approximately 50°F (10°C) at the Tribal Sturgeon Hatchery. Libby Dam operators attempt to provide the warmest water temperatures possible in May and June to assist Kootenai sturgeon spawning. Dam operators have been working to withdraw water from closer to the reservoir surface to achieve desired temperatures; hhowever, to date, all flow tests since the early 1990s failed to produce any observable effects for nautral recruitment.

3.1.5 Hydrology

The Kootenai River has a mean annual discharge of nine million acre-feet and a flow rate at its confluence with the Columbia River of about 30,650 cubic feet per second (cfs). Mountains in the subbasin receive about 70-80% of their precipitation as snow; spring and summer melting produces a characteristic snowmelt hydrograph peaking between April and June. The lowest flows typically occur from November to March.

Under the terms of the Columbia River Treaty, in 1973 the U.S. Army Corps of Engineers (USACE) constructed Libby Dam, the primary purposes of which are power generation and flood control. Libby Dam has a generating capacity of 525 megawatts. Koocanusa Reservoir, formed by Libby Dam, is 90 miles long, has a maximum surface area of 46,500 acres, and spans the Canada-US border (Figure 3-1). The maximum discharge through the turbines at Libby Dam is about 26,000 cfs. An additional 1,000 cfs can be passed over the spillway without exceeding TDG standards (USACE 2002).

Libby Dam operations are dictated by a combination of power production, flood control and recreation objectives. Operations are further managed to reduce negative effects on Kootenai sturgeon and bull trout in the Kootenai River, as well as salmon in the lower Columbia River. Other smaller water control structures in the lower Kootenai subbasin are on the Moyie River and Smith and Lake creeks.

Koocanusa Reservoir is normally drafted to elevation 2,411 feet mean surface level (MSL) by the end of December in accordance with the International Joint Commission (IJC) treaty. Flood control procedures set end-of-month target elevations through the winter months based on inflow forecasting, with the intent of storing water for Kootenai sturgeon and salmon flow augmentation from May through August. Typical Kootenai sturgeon augmentation flows entail releases of approximately 25,000 cfs for two weeks or more in May or June, with a total release volume determined in accordance with the Libby Dam BiOp (USFWS 2006, clarified in 2008). The Kootenai sturgeon releases are followed by a receding or flat hydrograph through the summer that targets a reservoir elevation of 2,449 feet by the end of September in compliance with the NOAA-Fisheries 2008 Columbia River BiOp. Outflow from Libby Dam during the fall and early winter typically is 4,000 to 6,000 cfs until mid-November when flows are increased and shaped to produce power benefits. This is accomplished by drafting the reservoir to 2,411 feet by the end of the year. The variable discharge flood control (VARQ) procedures allow the Koocanusa elevation to remain as high as 2426.7 feet if the spring inflow forecast is lower than 5,500 acre feet.

Downstream from Libby Dam, the Kootenai River is free-flowing for approximately 105 miles to Kootenay Lake. This lake extends 66 miles and inundates a 150.5-square-mile area. Since this natural lake was enlarged by construction of Corra Linn Dam, the water surface has fluctuated approximately 10 feet throughout the year, influencing river stage upstream for about 57 miles to Bonners Ferry. In this zone of influence, water levels are higher until Kootenay Lake is drafted in accordance with the IJC Order of 1938 (described in KTOI and MFWP 2004). Kootenay Lake levels are generally highest during May, June and July and lowest during the drawdown period from January through April. The IJC Order requires drafting of the lake according to a rule curve beginning in early January and extending through early April, at which point the lake is allowed to refill through the summer. Kootenay Lake stage is reduced to a maximum elevation of 1743 feet by the end of August, and then is limited to a maximum elevation of 1745 feet through the remainder of the year (until January 7th).

3.1.6 Vegetation

Vegetation in the Kootenai subbasin is typical of the Northern Rocky Mountain Forest-Steppe-Coniferous Forest-Alpine Meadow Province (Bailey et al. 1994). Engelmann spruce, subalpine fir, and lodgepole grow at higher elevations, giving way to forests of mostly Douglas-fir, lodgepole, and western larch, at mid to low elevations. Other common tree species include mountain hemlock, western hemlock, western red cedar, grand fir, ponderosa pine, western white pine, and grand fir. The river floodplains support ponderosa pine, Douglas-fir, black cottonwood, aspen, paper birch, willow, chokecherry, serviceberry, alder, dogwood, rose, and snowberry. Willows, alder, aspen, dogwood, cattails, meadow grasses, and sedges dominate local wetlands. Over 90% of the valley bottom in the floodplain along the river from Bonners Ferry to Kootenay Lake has been converted to agricultural production.

Human activities have caused significant losses in riparian and wetland areas or substantially impaired riparian, wetland and overall floodplain functions along the lower Kootenai River since the early 1900s (USEPA 2004). Some of the most serious impacts have come from: water impoundment and diversion; river diking, flood control and channelization; dam construction and operation; wetland draining and associated reduction of native species dependent on wetlands (including beavers); livestock grazing; urban and suburban development; land clearing for agriculture; road building; and recreation. This degradation impaired key riparian and floodplain wetland ecological functions, including sediment filtering, streambank building, water storage, aquifer recharge, dissipation of stream energy, nutrient retention, and fish and wildlife habitat.

3.1.7 Land Management

The Kootenai River subbasin extends into Canada, Idaho and Montana (Figure 3-1). The upper portion of the watershed in Montana encompasses 3,718 square miles, largely in USFS management (Figure 3-2). The portion identified as the lower Kootenai watershed, located entirely within Idaho, is where the existing and proposed aquaculture facilities are sited. The lower watershed (all of the Idaho portion of the subbasin except the Moyie watershed) encompasses 889 square miles, 76.7% of which is managed by the USFS. Another 23.3% is in private ownership or is managed by other public entities. The Moyie River watershed occupies 208 square miles and 99.7% of the land is managed by the USFS. The majority of lands within the 500-year floodplain downstream from the Moyie River confluence with the Kootenai are managed as private or commercial agricultural land or residential.

3.1.8 Socioeconomics

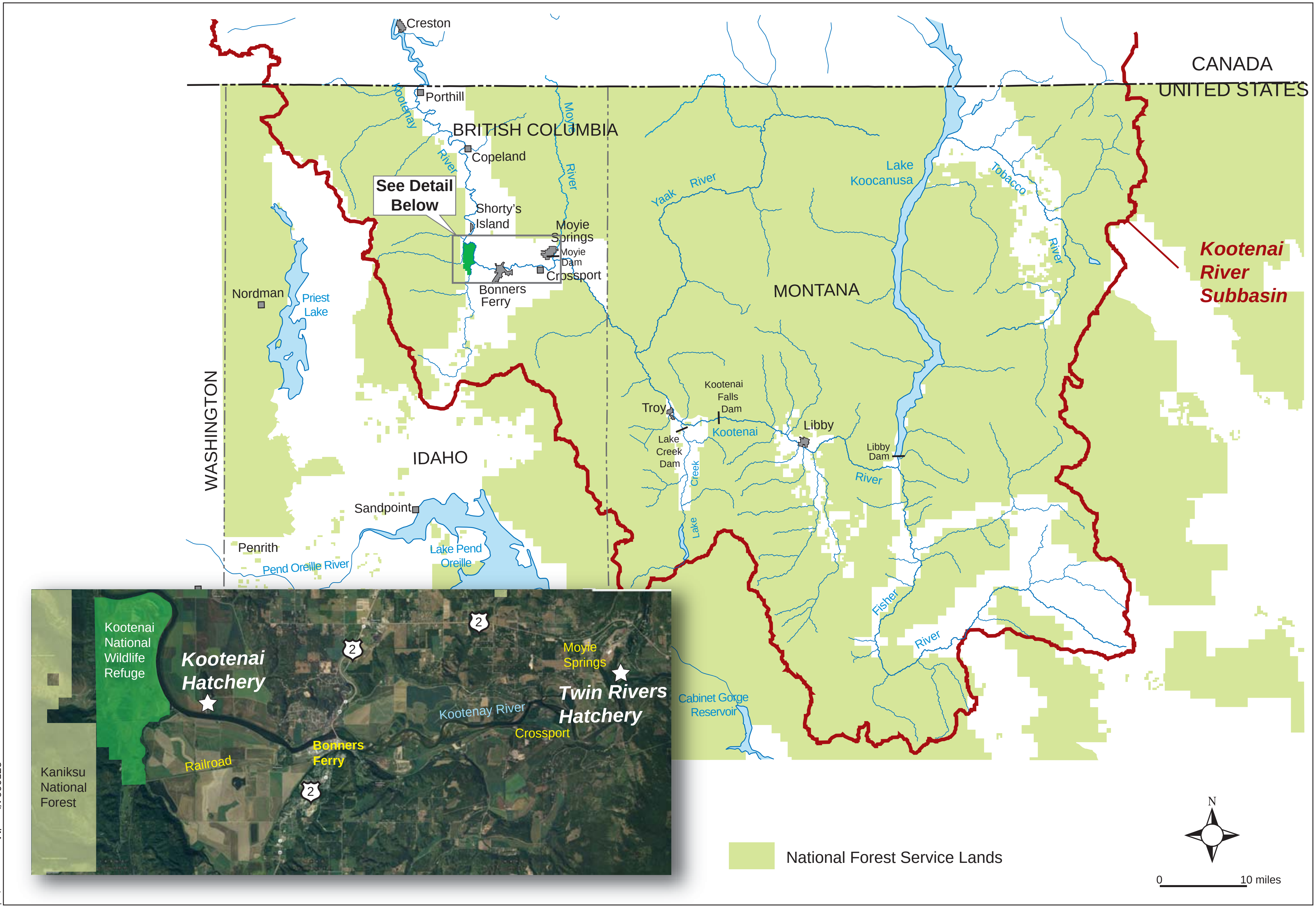
Land ownership in the Kootenai subbasin is largely within Federal and Provincial forestlands including the Kootenai, Panhandle and Flathead National Forests in the U.S. and the Kootenay National Park and Purcell Wilderness in Canada. Historically, the economy of the area was natural resource-based, including timber and mining industries and their associated communities. With the decline of these industries in recent years, other sectors such as tourism have increased.

The proposed aquaculture facilities would be developed in Boundary County, Idaho, which in 2006 had a population of approximately 10,831. Bonners Ferry, the community nearest the project sites, reported 2,647 people in 2006. Primary employment in the county during the same year was in the following sectors: government- 20%, retail- 11.5%, construction- 10.4%, manufacturing- 8.3%, agriculture- 7.5%, and professional services- 6.6 % (www.pnreap.org. Accessed on August 21, 2008). Agriculture is a significant land use in the non-forested regions of the county, occupying about 76,000 acres that produce wheat, beef and milk cows, hay, alfalfa and oats/barley.

3.1.9 Historical and Current Status of Fish and Wildlife

In developing the Kootenai River Subbasin Plan, the Kootenai Subbasin Technical Team selected bull trout, westslope cutthroat trout, Columbia River redband trout, kokanee, burbot, and Kootenai sturgeon as focal fish species in the subbasin because of their population status and ecological and cultural significance (KTOI and MFWP 2004).

No anadromous fish populations currently occupy the Kootenai subbasin and were unlikely to have been present since before the most recent regional glacial period (some 10,000 to 15,000 years ago). A natural upstream migration barrier at Bonnington Falls historically precluded access. Today these falls are inundated by hydropower facilities downstream of Nelson, British Columbia. Four dams without fish passage provisions currently maintain this separation between Kootenay Lake and the Columbia River.



3750004/LandManagement.ai

TETRA TECH
1420 Fifth Avenue, Suite 600
Seattle, Washington 98101
Tel 206.883.9300 Fax 206.883-9301

Kootenai Tribe of Idaho
Kootenai River Native Fish Conservation and Aquaculture Programs
MASTER PLAN

Figure 3-2.
KOOTENAI SUBBASIN
LAND MANAGEMENT

The current abundance of various aquatic species, as a percent of their historical population level, was reported in the Kootenai River Subbasin Plan (KTOI and MFWP 2004):

▪ Bull trout	60% of historic levels
▪ Westslope cutthroat trout	20% of historic levels
▪ Columbia River redband trout	10% of historic levels
▪ Kokanee	40-50% of historic levels
▪ Kootenai sturgeon and burbot	0-10% of historic levels
▪ Focal wildlife species	50-70% of historic levels

The declines associated with all of these species are attributed to habitat loss, and in the case of aquatic species, habitat losses including those associated with altered flow and thermal regimes.

For the terrestrial environment, the Subbasin Technical Team took a multi-species approach instead of identifying individual focal species. The selected assemblage includes species that: 1) were designated as Federal endangered or threatened species or have been otherwise designated a priority species for conservation action; 2) play an important ecological role in the subbasin (e.g., as a functional specialist or as a critical functional link species); or 3) possess economic or cultural significance to the people of the Kootenai subbasin.

More detail about current status of focal fish species and wildlife target species is presented in the sections that follow.

3.1.9.1 White Sturgeon

Life History

Several white sturgeon populations in western North America are anadromous (e.g., Fraser, Lower Columbia (U.S.), and Sacramento river populations). Only the Kootenai River supports a naturally landlocked population. Kootenai Falls, Montana, and Bonnington Falls, British Columbia, are thought to have been migration barriers that isolated white sturgeon in a 270 km reach of the Kootenai River in Montana, Idaho, and British Columbia after recolonization following the most recent Pleistocene glacial period (Wisconsin), approximately 12,000 years BP (Alden 1953; Northcote 1973; Partridge 1983). During this glacial period, the outlet of the West Arm of Kootenay Lake was blocked by ice. This blockage formed glacial Lake Kootenai, which extended south into the area currently occupied by the Lake Pend Oreille system. It is believed that this connection with the large glacial lakes to the south permitted recolonization of the Kootenai region by fish species whose subsequent migration was blocked by Kootenai and Bonnington Falls (Alden 1953).

Consequently, this population adapted to specific local conditions in the Kootenai River headwater system. Kootenai sturgeon are active at cooler temperatures, spawn in different habitats (Paragamian et al. 2001), and have lower genetic diversity than other populations in western river systems (Bartley et al. 1985; Setter 1988; Setter and Brannon 1992; Anders et al. 2000; Anders 2002; Anders et al. 2002; Rodzen et al. 2004). The range of this population extends from Kootenay Lake upstream 190 km to Kootenai Falls, but primarily they are found in the low gradient reach downstream from Bonners Ferry and in Kootenay Lake.

The longevity of Kootenai sturgeon (up to 100+ years), lengthy maturation period (approximately age 30 in Kootenai females), and spawning periodicity (5 or more years in females) suggests that white sturgeon populations can persist through extended periods of unsuitable spawning conditions. This adaptation is particularly well suited to large, dynamic river systems where suitable combinations of habitat, temperature, and flow may not occur every year (Beamesderfer and Farr 1997). However, a lapse in natural recruitment for over 40 years is unprecedented in a self-sustaining natural white sturgeon population. The robust population in the Columbia River downstream from Bonneville Dam spawns successfully every year (McCabe and Tracy 1993, DeVore et al. 1999). This annual production of wild year classes may be attributed to the unnaturally consistent suitable spawning conditions in the vicinity of the Bonneville Dam tailrace. Sturgeon populations, which have been able to persist in some Columbia and Snake river reaches fragmented by dam construction, typically recruit at least some juveniles during some years, with periodic strong year classes when conditions are optimum. Healthy sturgeon populations are characterized by age-frequency distributions that include large percentages of juveniles and sub-adults. Age and length distributions in such populations are stable and are skewed toward young fish. The lower Columbia River white sturgeon population is composed of > 95% sexually immature fish and this population also sustains an annual harvest of 50,000 fish (DeVore et al. 1999). The age and length of the Kootenai population are heavily skewed toward older fish; approximately 90% are age 25 and older (BPA 1997; Paragamian et al. 2005) (see Section 4.1.1.1).

Population Status

The Kootenai sturgeon population was listed as endangered on September 6, 1994 (59 FR 45989) under the Endangered Species Act (ESA) and a recovery plan was completed in 1999 (UWFWS 1999). The USFWS Recovery Plan can be downloaded at: http://ecos.fws.gov/docs/recovery_plan/990930b.pdf.

Within Canada, white sturgeon occur only in British Columbia and are divided into six populations based on geography and genetics: the lower, mid and upper Fraser River, Nechako River, Columbia River, and Kootenay River. All populations were listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), but only the latter four are legally listed under the Canadian Species at Risk Act (SARA). Kootenay sturgeon are included in this group and are listed as endangered under SARA. A recovery plan for white sturgeon is currently being developed under SARA and is scheduled for release in early 2010.

Modeling in 2002 revealed the increasingly imperiled demographic status for the population, suggesting 90%, 75%, and 72% reductions in abundance, biomass, and annually available spawners, respectively, from 1980 to 2002, and a current population "halving time" of 14 years. Recruitment failure continues to drive the decline of the population. A few wild juveniles are periodically captured (0-11 annually). Of 659 white sturgeon juveniles captured between 1995 and 2000, 620 were hatchery-reared and 39 (~6 %) were wild, confirming very low natural recruitment (Ireland et al. 2002a). Augmented flows from Libby Dam have not stimulated recruitment to date as hoped; thus, prospects for restoring natural production remain uncertain (Anders et al. 2002) and the role of the Kootenai sturgeon conservation aquaculture program remains critical to recovery of the population in at least the near term.

Recent status assessments (Beamesderfer et al. 2009) indicated that current population numbers are greater than previously estimated; however, the endangered condition remains unchanged: meaningful natural recruitment has not occurred in 40-50 years. Knowing that the rate of population decline is less than previously estimated suggests that prospects for broodstock availability are good in the foreseeable future. If hatchery-reared fish survive to maturity, an extended gap in adult numbers may be avoided between the demise of wild fish and the availability of hatchery-origin adults.

The Kootenai sturgeon population may be recruitment habitat limited, stock limited or both (Anders et al. 2002). River regulation and related and unrelated habitat alterations (e.g., changes in river morphology, loss of floodplain connectivity, loss of riparian habitat) have significantly compromised the quantity and quality of available habitat. Among the early life mortality factors are unfertilized eggs; egg suffocation; egg predation; fry, fingerling predation; food limitations; and first over-winter mortality (Duke et al. 1999; USFWS 1999; Anders et al. 2002).

Although a number of factors are thought to account for the Kootenai sturgeon population's decline, ongoing recruitment failure is generally recognized as the first bottleneck to survival and a range of recruitment failure hypotheses are most commonly cited as the reason for the endangered status of Kootenai sturgeon.

Decades of study have consistently indicated that recruitment failure most likely occurs during the embryo (incubation to early life) stages (Partridge 1983; Duke et al. 1999; USFWS 1999; Paragamian et al. 2001; Anders et al. 2002; Paragamian et al. 2005; KTOI 2008). Several hypotheses have been advanced to explain the relationship between river system changes and ongoing recruitment limitation and failure of Kootenai sturgeon.

These hypotheses are aggregated into time periods to delineate potential failure mechanisms prior to and after the completion of Libby Dam in 1972. Although Kootenai sturgeon recruitment failure hypotheses may operate sequentially or simultaneously, they are listed below separately:

Pre-Dam Hypotheses

- Ecosystem Degradation Hypothesis: Recruitment failure is due to direct and indirect trophic cascading effects of habitat alteration and loss in the mainstem and in the natural floodplain (e.g., reduced nutrient and food availability, altered competition and predation, and reduced habitat quality and availability during which time population abundance and fecundity has continued to decline) (Anders et al. 2002).
- Imprinting/Homing Failure Hypothesis: Kootenai sturgeon no longer migrate upstream from Bonners Ferry into what appears to be suitable spawning, incubation, and early rearing habitats, because fish that historically spawned in these reaches (possibly as far upstream as the "sturgeon hole" at the base of Kootenay Falls) no longer exist.
- Riparian Habitat Loss Hypothesis: Widespread collapse of resident white sturgeon populations is due primarily to the loss of flooded riparian vegetation, which might provide critical incubation and early rearing conditions (Coutant 2004).
- Stock Limitation Hypothesis: Insufficient broodstock remain in the population to produce enough early life stages to compensate for total additive mortality in the post-development Kootenai River (Anders et al. 2002).

Post-Dam Hypotheses

- Flow Reduction Hypothesis: Recruitment failure has resulted from the effects of flow regulation on spawning and early rearing conditions (Paragamian et al. 2001).
- Sand Invasion Hypothesis: Post-Libby Dam hydraulics and erosion contribute to sand invasion and accumulation in the braided and meander reaches (known to be detrimental to spawning, incubation and possibly survival of free embryos[Koch et al. 2006]).

- Lack of Scour Hypothesis: Spawning historically occurred in present spawning locations; however, reduced floods and stream power resulting from operations of Libby Dam have generally failed to clean the hard substrates of sediment or sand cover as would have occurred under historical flow conditions.

- Upstream Migration Barrier Hypothesis: Some number of Kootenai sturgeon historically migrated upstream past Bonners Ferry to spawn in the braided and/or canyon reaches, but post-dam habitat features now restrict or prohibit that historical upstream migration.

- Shifted Hydraulic Cue Hypothesis: Prior to levee construction and dam operation, hydraulic conditions that served as spawning cues may have existed further upstream (in the braided reach). Today, similar hydraulic conditions may now exist downstream (in the meander reach) in the current spawning reach due to channel constriction from the enhanced levees.

- Olfactory Spawning Location Shift Hypothesis: Pheromones and chemical odorants produced by females (held in captivity to spawn at the Tribal Sturgeon Hatchery) are released into the river via hatchery effluent and may be influencing the location where Kootenai sturgeon currently spawn (i.e., influencing the sturgeon not to migrate further upstream to spawn).

The breadth of these recruitment failure hypotheses suggests that the Kootenai sturgeon population is affected by multiple factors rather than a single or relatively small number of conditions. Due to the range of possible factors contributing to population decline, addressing recruitment failure within the urgent timeframe dictated by the population's decline will require an ecosystem-level approach that goes beyond merely modifying how Libby Dam is operated or focusing restoration actions on single habitat components such as depth, flow or spawning substrate. More detail about recruitment failure is presented in Section 4.1.1.1 and Appendix B.

3.1.9.2 Burbot

Life History and Distribution

The burbot is the only true freshwater representative of the cod family, Gadidae (Scott and Crossman 1973). Their life history is illustrated in Figure 3-3. Burbot inhabit cold rivers and lakes throughout their distribution and exhibit fluvial or adfluvial life histories (Sorokin 1971). They occupy many major rivers and lakes within the Columbia Basin (McPhail and Carveth 1992), although in Idaho, burbot are native only to the Kootenai River and its tributaries (Simpson and Wallace 1982). They are also native to the Kootenai River and Kootenay Lake in British Columbia. The lower Kootenai River adfluvial burbot population spends a portion of its life in the South Arm of Kootenay Lake then migrates up the Kootenai River during winter to spawn in the mainstem river or tributary streams in British Columbia or Idaho (KTOI and MFWP 2004). The burbot population found upstream of Libby Dam, exhibited a lacustrine life history strategy. A fluvial life history strategy is exhibited by the population occurring upstream of Kootenai Falls; these fish migrate within river to tributary streams to spawn.

Adult burbot are thought to be relatively sedentary although they are also reported to migrate over great distances. Lengthy migrations have been documented in the late fall/early winter and again in late winter/early spring that coincide with spawning (Evenson 2000; Paragamian 2000;

Schram 2000). These migrations often correlate temporally with changes in water temperatures, although movement appeared to be minimal immediately prior to spawning (Evenson 2000).

Burbot are coldwater spawners with highly synchronized spawning periods. Optimal spawning and incubation temperatures are at or below 0 to 4°C (Evenson 2000). They spawn in rivers, streams and lakes. Eggs are thought to drift in the water column and lodge in interstitial spaces in the substrate.

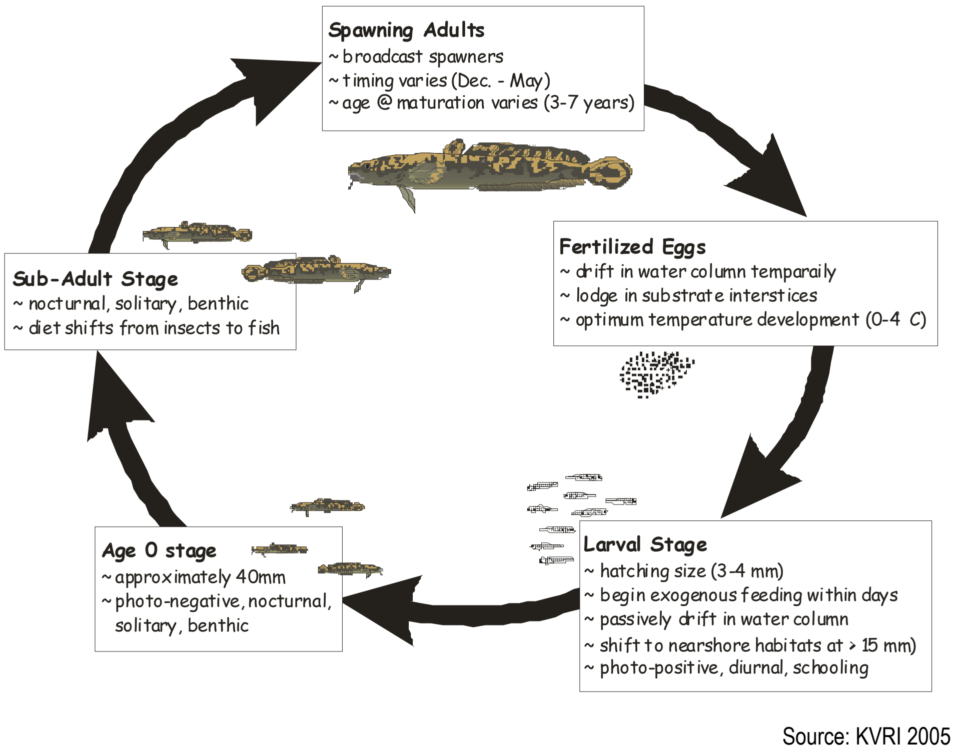


Figure 3-3. **Schematic diagram of burbot life history.**

Population Status

The historical abundance of Kootenai River and Kootenai subbasin burbot populations is largely unknown, although burbot provided the primary winter fishery for the Kootenai Tribe and many non-tribal anglers. Kootenai subbasin burbot supported numerous and varied fisheries between Bonnington Falls and Kootenai Falls. Native Americans traditionally targeted burbot during the winter spawning period as a source of fresh meat when other food resources were limited. Recreational burbot fisheries subsequently developed throughout the subbasin, primarily focused on local spawning aggregations. Numerous credible, independent accounts of significant burbot harvest suggest that Dustbowl immigrants to the Idaho portion of the subbasin were responsible for significant and unregulated burbot harvest during the 1930s (KVRI 2005).

A significant winter burbot fishery persisted into the 1950s and 1960s in the Idaho portion of the subbasin. Partridge (1983) reported that local residents harvested and canned burbot during the winter months to supply their personal needs or for sale in local stores. Burbot were still reported to be abundant during the 1950s, with one angler selling 380 kg (838 lbs) in 1951, and a Bonners Ferry market handling 1,800 kg (3,940 lbs) of burbot during 1957. Three additional fishermen harvested over 2,000 kg (4,409 lbs) of burbot from the Kootenai River during 1958 (IDFG unpublished data). Anglers reported catching as many as 40 burbot per night during winter setline fishing trips in the Kootenai River, where past annual burbot harvest was estimated at approximately 22,700 kg (50,053 lbs) (Paragamian and Whitman 1996; Paragamian et al. 2000). This annual harvest weight represents just over 10,000 five-pound fish, or 16,684 three-pound fish, which does not appear to be sustainable.

A very popular recreational burbot fishery also occurred in the West Arm of Kootenay Lake during late spring and early summer in the 1960s and 1970s. Catches peaked at over 20,000 burbot per year around 1970, a rate that substantially exceeded optimum sustained yield levels estimated for the population (Martin 1976). Catches declined rapidly after 1975 and the fishery disappeared by 1986 (Redfish Consulting Ltd. 1998).

Such overexploitation resulted in reduced creel limits and fishery closures, measures that were not successful in rebounding the fishery (Paragamian et al. 2000). The IDFG has monitored the movement, habitat use, and spawning behavior of burbot since 1993 and has not found evidence of successful spawning or recruitment in Idaho. Native burbot in the Kootenai River in Idaho have been petitioned for ESA listing, are Red Listed in B.C., and are a designated Species of Special Concern in Idaho. In Montana, burbot are listed as a Species of Special Concern. Burbot are identified as a focal species in the Kootenai River Subbasin Plan (KTOI and MFWP 2004).

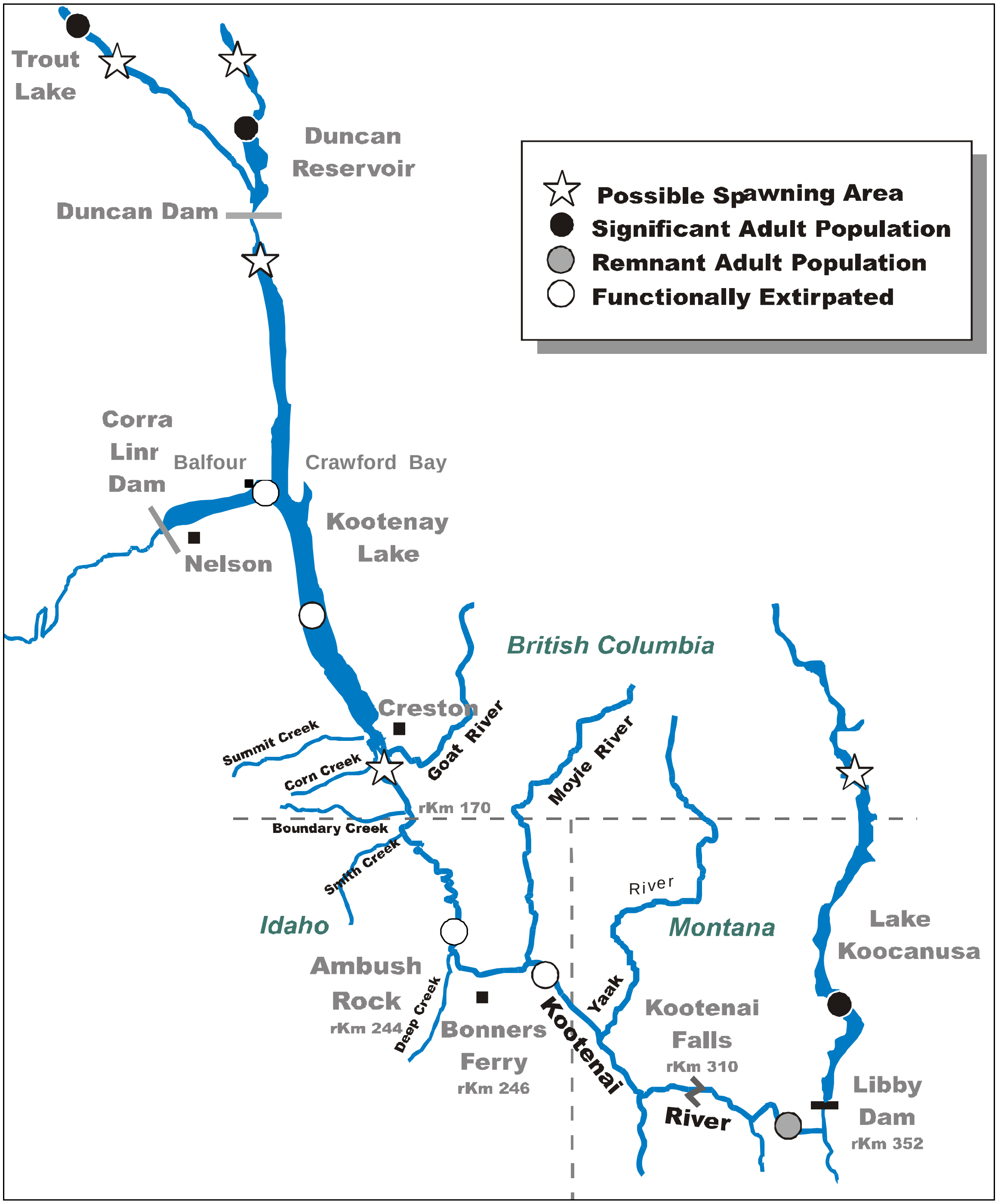
Adult burbot populations in the Kootenai subbasin currently are found in Koocanusa Reservoir and Trout Lake, with remnant populations between Libby Dam and Kootenai Falls and in the South Arm of Kootenay Lake (Figure 3-4). Burbot are functionally extinct in the riverine portion of the Kootenai subbasin in Idaho and extirpated in the West Arm of Kootenay Lake (Ahrens and Korman 2002). The very few burbot remaining between Kootenay Lake and Kootenai Falls are concentrated near and in the Goat River, British Columbia. Recent extensive sampling captured very few adult burbot in Kootenay Lake and the Kootenai River, and juvenile burbot were scarce (Redfish Consulting 1998; Spence 1999; Paragamian et al. 2001; Baxter et al. 2002a, 2002b). Recent demographic analysis of lower Kootenai River burbot habitat indicates that approximately 50 fish remain in this population; the 95% confidence interval on this estimate ranged from 25-100 fish (Pyper et al. 2004). Without substantive management actions, native Lower Kootenai River burbot are expected to disappear completely.

As with Kootenai sturgeon, no single factor appears responsible for the collapse of burbot in the subbasin. Rather, a combination of overharvest, habitat alteration, and ecosystem degradation contributing to recruitment failure appears to be the cause (KVRI 2005). More specifically, reported factors in this collapse included increased winter flow, elevated winter water temperature, environmental degradation, floodplain loss, over-harvest, changes in primary and secondary productivity, Kootenay Lake flood control practices, and the altered composition of the ecological community. As with all populations, eventually, small size becomes the critical limitation or final cause of extinction (i.e., the extinction vortex; Gilpin and Soule 1986).

Burbot mtDNA Clades and Their Distribution

The widespread distribution and persistence of burbot was the subject of two recent studies comparing Palearctic and Nearctic post-glacial dispersal (Van Houdt et al. 2003; 2005). Based exclusively on mitochondrial DNA (mtDNA), these authors reported two distinct burbot lineages in North America; *L. lota maculosa* (Hubbs and Shultz 1941) south of the Great Slave Lake, Canada and *L. lota lota* (Hubbs and Shultz 1941) in the remainder of the Nearctic region and all of Eurasia. They reported that L. lota maculosa consisted of three mitochondrial clades (Van Houdt et al. 2003; 2005); two of these North American clades were observed east of the Continental Divide (Mississippi and Missouri clades).

In the Kootenai River of Idaho, Montana and British Columbia, Paragamian et al. (1999) described statistically significant clinal variation using restriction fragment length polymorphism (RFLP) analysis with mtDNA. A significant difference in burbot mtDNA haplotype frequency distributions was reported between samples collected above and below Kootenai Falls, Montana. Subsequently, Powell et al. (2008) examined 372 burbot collected from 28 sample locations across its range in the Pacific Northwest. Three distinct haplogroups of burbot were observed which correspond to the Pacific, Mississippi, and Missouri clades.



Source: KVRI 2005, updated by Cramer Fish Sciences

Figure 3-4. Distribution of burbot in the Kootenai River / Kootenay Lake subbasin.

Powell et al. (2008) reported that burbot in the Kootenai River of Idaho and British Columbia represented a mixture of Pacific and Mississippi River clades. Moyie Lake burbot were exclusively composed of Pacific clade fish. Although these clades were clearly delineated, the mtDNA provides only comparative information on evolutionary phylogenies of these groups or clades and does not involve adequate resolution to distinguish recent fine-scale divergence among populations or stocks. Higher resolution spatial and genetic data are needed to guide decisions about small scale and recent divergence issues associated with Kootenai program broodstock selection. These mtDNA analyses should be supplemented with higher resolution nuclear microsatellite analyses that are more appropriate for evaluating future decisions about local burbot stock or population comparisons. The Tribe will coordinate with IDFG to determine if they have appropriate samples for this analysis and whether such an analysis is planned.

Ecology of Burbot and Survival Factors

Until recently, burbot have received relatively little management or research attention for a species with such wide distribution. Three international symposia recently focused on burbot. Two peer-reviewed proceedings have been published, including 38 papers on the biology, management, ecology, genetics and culture of burbot. A third proceeding will likely be available in 2010.

Kootenai burbot conservation and research efforts have made significant contributions to the scientific literature. Since 2006, numerous scientific articles have been produced by the project collaborators (Ireland and Perry 2008; Jensen et al. 2008a, 2008b, 2008c; Jensen and Cain 2009; Polinski et al. 2009a, 2009b, 2009c; Paragamian et al. 2008; Zuccarelli et al. 2007). Spawning and semen cryopreservation methods were developed, followed by incubation methods, and larval and juvenile feeding strategies involving intensive, semi-intensive (fertilized and zooplankton enhanced ponds) and extensive (unaided pond culture) methods. In addition, research to characterize burbot disease susceptibility and to establish burbot cell lines for diagnostic purposes was recently completed.

With these fundamental methods in place, the Tribe's program was able to move forward with the first experimental release of cultured burbot in British Columbia and Idaho. During October and November 2009, 247 burbot cultured at the University of Idaho were released into the Kootenai River system in four different locations in Idaho and British Columbia (Jensen et al. 2010). These releases represent a milestone for the program, the species and the subbasin, as the first time burbot have been artificially propagated and released jointly into U.S. and Canadian waters for conservation purposes. Research to address in-river critical uncertainty and limiting factors is now underway to examine post-release survival, growth, and condition of hatchery produced burbot. Thirty of the 247 burbot released were two years old - large enough to be implanted with ultrasonic transmitters. These sonic tagged fish are expected to provide valuable information about habitat preferences, seasonal movement patterns, spawning habitat selection, and reproductive behavior.

3.1.9.3 Bull Trout

In the final ESA listing rule for bull trout, five subpopulations were recognized within the Kootenai River subbasin (USFWS 1994). Three occupy portions of the mainstem system: 1) Upper—upstream from Libby Dam, 2) Middle—from Libby Dam downstream to Kootenai Falls, and 3) Lower— downstream from Kootenai Falls through Idaho to the United States/Canada border. Two disconnected subpopulations (referred to as disjunct by the Montana Bull Trout Scientific Group), are found in Bull Lake (MBTSG 1996a) and Sophie Lake (MBTSG 1996b). At the time of listing, all Kootenai River bull trout subpopulations were considered to have unknown status and population trends, and the Sophie Lake subpopulation was considered to be at risk of stochastic extirpation (USFWS 2002).

The Kootenai Subbasin Technical Team concluded that habitat attributes most limiting to bull trout in the mainstem Kootenai River are altered flows, riparian condition, fine sediment, and channel stability. Subbasin-wide, bull trout have been significantly affected by dams, forest practices, grazing, agricultural practices, roads, mining, residential development, and past fisheries management actions.

3.1.9.4 Westslope Cutthroat Trout

Westslope cutthroat occur in about 1,440 miles of stream habitat in the U.S. portion of the Kootenai River subbasin. Abundance data for 1,051 of those miles indicates that approximately 70% support stocks that are considered abundant. Shepard et al. (2003) reported that among the streams surveyed in the U.S. portion of the subbasin, populations of cutthroat trout with no record of stocking or contaminating species occupied only 142.5 miles. Stocks that are less than 10% introgressed with non-native rainbow trout occupied 29.5 miles; stocks between 25% and 10% introgressed occupied 86.3 miles; and stocks greater than 25% introgressed occupied 576.5 miles.

Cutthroat trout are declining for four primary reasons: over-exploitation, genetic introgression, competition from nonnative fish species, and habitat degradation. Habitat attributes considered most limiting for westslope cutthroat trout across the subbasin are riparian condition, fine sediment, channel stability, and habitat diversity, in that order.

3.1.9.5 Columbia River Redband Trout

The status of Columbia River redband trout populations in Montana is presumed to be stable, although it is listed as a species of special concern by the State of Montana (personal communication with J. Dunnigan, MFWP, 2004). In the Idaho reaches of the Kootenai, their status is described by the USFS as "presence unknown", "present but the population status is unknown", and "present but depressed" depending on the survey location. PWI (1999) reports that the rainbow trout population in the Kootenai River downstream of Kootenai Falls may be the strongest stock of all the salmonids, but that the genetic integrity of native interior redband trout has been compromised through stocking of non-native rainbow strains and hybridization with cutthroat trout.

The most limiting habitat attributes for Columbia River redband trout in the mainstem Kootenai River are the altered hydrograph below Libby Dam, riparian condition, low temperature, and fine sediment. In British Columbia reaches, the primary limiting habitat attributes are riparian condition, channel stability, fine sediment, and habitat diversity. Biologically limiting factors in river habitat include non-native species, system productivity, and connectivity to tributaries.

3.1.9.6 Kokanee

Native kokanee runs in lower Kootenai River tributaries in Idaho have experienced dramatic population declines during the past several decades (Ashley and Thompson 1993; Partridge 1983; Ericksen et al. 2009). Kokanee that historically spawned in these tributaries inhabited the South Arm of Kootenay Lake in British Columbia. Native kokanee are considered an important prey item for Kootenai sturgeon and also provided an important fishery in the tributary streams (Partridge 1983; J. Hammond, British Columbia MELP, 2000, personal communication).

Kokanee runs into northern Idaho tributaries of the Kootenai River that numbered into the thousands of fish as recently as the early 1980s have now become "functionally extinct" (Anders 1993; Ericksen et al. 2009[9]). Since 1996, visual observations and redd counts have been conducted in five tributaries. In 2007, over 100 kokanee spawners were observed in Ball Creek, 300 in South Trout Creek, 20 in Parker Creek, and 150 in Long Canyon.

The Kootenai Subbasin Technical Team concluded that the habitat attributes most limiting for kokanee are low flow, channel stability, and fine sediment, in that order. In British Columbia reaches, limiting factors are channel stability, fine sediment, riparian condition and habitat diversity.

3.1.9.7 Target Wildlife Species

The Kootenai River Subbasin Plan (KTOI and MFWP 2004) identifies 78 species as target wildlife species, including several listed as threatened or endangered: gray wolf, woodland caribou, grizzly bear, and Canada lynx. Other species identified include native and migratory birds, amphibians and reptiles, and 24 mammals, including beaver, mink, mule deer, raccoon and big game species. The subbasin plan examined wildlife by habitat type, not by species, in order to examine the ecosystem as a whole.

The Kootenai Subbasin Plan examined the current condition of terrestrial habitat and identified key limiting factors by habitat type. On the regulated mainstem of the Kootenai River, the chief factors limiting wildlife populations in wetland and riparian habitats are altered hydrographs and diking. In wetland areas throughout the subbasin, roads, land conversion, grazing, forest management, impoundments, and reductions in nutrients/productivity limit wildlife populations. Wildlife use of riparian areas is limited by forest management, land conversion, introduced species, human/wildlife conflicts, impoundments, and reductions in nutrients/productivity. In grassland/shrub areas, the primary limiting factors are forest encroachment, land conversion, grazing, urban and rural development and non-native species. In the xeric (ponderosa pine) habitat, the chief limiting factors are fire exclusion, forest management, and introduced species, while in mesic forest areas, forest management, fire exclusion, introduced species (noxious weeds), roads, and forest insects and diseases limit wildlife.

3.2 Relationship to Subbasin Plan and Other Recovery Plans

3.2.1 Relationship of Proposed Conservation Aquaculture Program to Kootenai River Subbasin Plan

The Kootenai River Native Fish Conservation Aquaculture Program is a critical component in a suite of projects and actions that collectively will help achieve the Kootenai River Subbasin vision of: "the establishment and maintenance of a healthy ecosystem characterized by healthy, harvestable fish and wildlife populations, normative and/or natural physical and biological conditions, and sustainable human communities".

[9] Kokanee spawning returns increased during 2007 and 2008 by up to three orders of magnitude following the first four consecutive years of simultaneous nutrient addition in Kootenay Lake's north and south arms, and the Kootenai River, along with tributary habitat enhancements and higher numbers of eyed-egg plants in westside tributaries to the Kootenai River in Idaho (Ericksen et al. 2009).

The Kootenai sturgeon and burbot aquaculture programs address the following Urgent and High Priority Aquatic Objectives identified in the Kootenai Subbasin Plan (KTOI and MFWP 2004) (Pages 58-59, 62-64 and Page 68 of the Aquatic Objectives Section [White Sturgeon and Burbot]) of the Kootenai Subbasin Management Plan and listed in the Table 10.5 on page 123 (Table of Priority Codes and Description of Habitat and Biological Objectives):

- **Restore White Sturgeon – Conservation Aquaculture**: Subbasin Plan (SBP) Objectives WST 2 and 3a. Achieve an estimated white sturgeon population that is stable or increasing with juveniles reared through a conservation aquaculture program available to be added to the wild population each year for a 10-year period. Achieve natural production of white sturgeon in at least 3 different years of a 10-year period. Prevent extinction, preserve genetic variability, and restore demographic viability of the Kootenai River white sturgeon population through the propagation and release of progeny produced from wild white sturgeon from the Kootenai River (Recovery measure 2; BiOp RPA 4a and 4b).
    - ***WST2 and WST3a strategies*** - Develop and implement conservation aquaculture for white sturgeon using adaptive breeding plan as a guide/restore natural recruitment (Page 62-63 – SBP Management Plan).

- **Restore Burbot – Conservation Aquaculture:** SBP Objectives BUR 3a and 3b and BUR 4. Achieve consistent natural recruitment in at least three different spawning areas. Achieve stable size and age distributions as determined by an upward trend in a 6-year moving average of population abundance. Achieve a minimum number of 2,500 adults per burbot population (KVRI Burbot Conservation Strategy Measure 9.5).
    - ***BUR3a and 3b; BUR 4 strategies*** - Develop and implement a conservation aquaculture program for Kootenai River/Kootenay Lake burbot using the locally developed Burbot Conservation Strategy and SBP as a guide (Page 68-69 – Management Plan).

- **Coordination, Outreach and Information Exchange:** SBP Objectives AP2, AP3, AP4, and AP5. Develop and maintain adequate regional and international coordination. Pursue and support independent peer review and scientific counsel. Support locally recognized stakeholder group to improve coordination and implementation. Provide for and support distribution of information.
    - ***AP2- AP5 strategies*** - Develop and maintain international, regional and local coordination to successfully implement project objectives. Support and enhance existing coordination forums to efficiently and successfully implement the subbasin plan. Support and enhance outreach and information exchange. Involve community stakeholder groups. Use SBP strategies as a guide. (Page 90-92– SBP Management Plan).

- <u>**Kootenai Subbasin Plan Priorities:**</u> The Kootenai River Native Fish Conservation Aquaculture Program meet all Tier 1 criteria and the following Tier II criteria (1, 3, 5, 6, 7, 8, and 9) found in Section 10.5 (starting on Page 125) of the Kootenai Subbasin Plan. The Subbasin Plan also states, " after applying and meeting Tier I criteria, ongoing projects that address urgent objectives will be afforded the highest priority for funding" (Page 126 - paragraph after Tier I criteria). The Tribe's proposed Kootenai sturgeon and burbot programs fall in the above- mentioned category.

3.2.2 Relationship to Recovery Plan

The USFWS published a recovery plan for Kootenai sturgeon in 1999 (USFWS 1999). The plan outlined three priority actions that needed to be implemented concurrently: 1) flow augmentation to support sturgeon spawning requirements, 2) restoration of habitat to restore recruitment, and 3) conservation aquaculture to prevent extinction and provide recruitment while the other actions were being developed and implemented. Due to uncertainty associated with recruitment failure hypotheses and the difficulty in determining which actions will restore recruitment, the Tribe's conservation aquaculture program plays a critical role in sturgeon recovery.

Because burbot are not listed as threatened or endangered under the ESA, a recovery plan has not been prepared by the USFWS. However, in 2005, the KVRI published its Burbot Conservation Strategy which initiated a collaborative project to develop methods to culture this species (see Section 2.1.2). The Kootenai Tribe, University of Idaho and other research scientists have made significant progress in this effort.

3.2.3 Consistency with Other Watershed Plans

The Tribe's sturgeon aquaculture program is consistent with and complementary to the NPCC's Fish and Wildlife Program and artificial production guidelines, as well as with other fishery management plans, watershed plans and activities. Specifically, the Libby Dam BiOp acknowledges the need for continued operation of the Tribe's sturgeon aquaculture program in RPA Component 4 (USFWS 2006, clarified in 2008). The Federal Columbia River Power System Operations plan in 2000 recommended mitigation for operational effects of Libby Dam on Kootenai sturgeon.

Ongoing and proposed burbot activities are consistent with the international, multi-agency Lower Kootenai/Kootenay River Burbot Conservation Strategy (KVRI 2005). Because Lower Kootenai burbot are an international transboundary population, ongoing and proposed research, monitoring and evaluation of burbot culture is closely integrated with other investigations of Kootenai fisheries and ecosystem projects by the IDFG, Montana Fish Wildlife and Parks, and the BC MoE. The Kootenai Tribe also collaborates with universities and researchers throughout the United States and Canada to ensure that the aquaculture program is consistent with and integrates current research findings.

3.3 Local and Regional Management Context

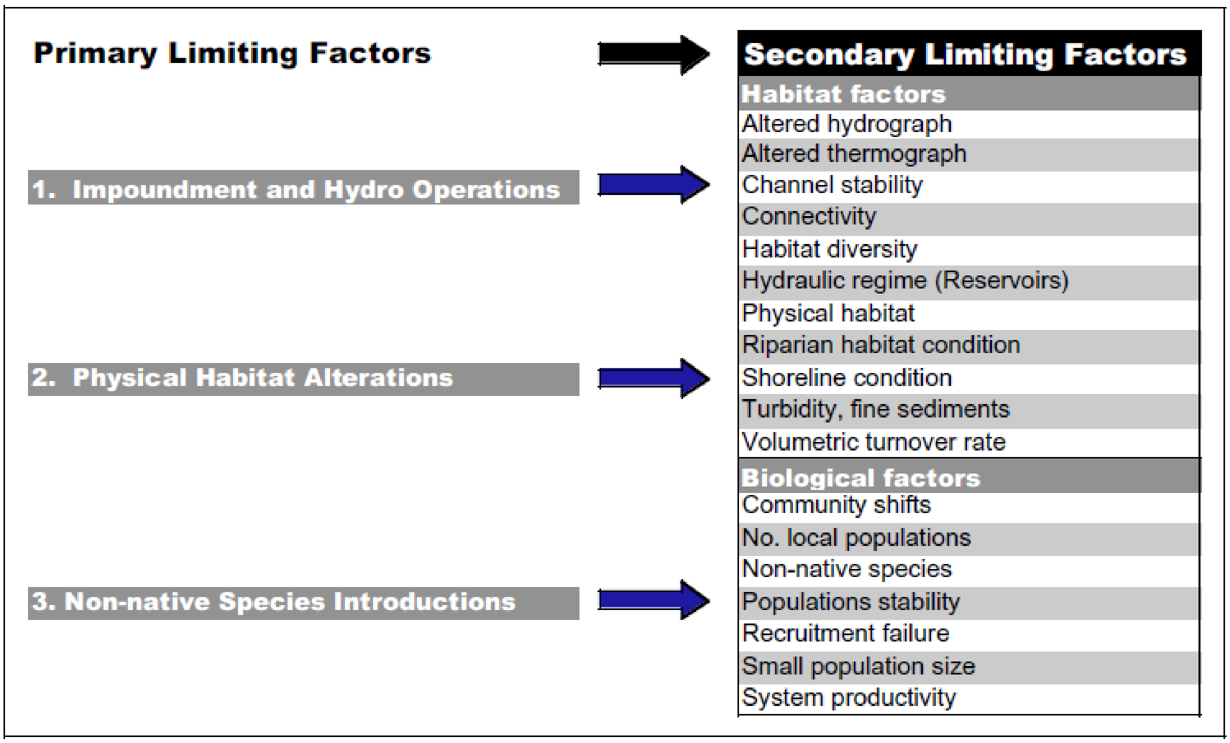
This section expands the presentation of the context within which the Kootenai sturgeon and burbot aquaculture programs would be implemented, by looking at subbasin-scale management activities related to habitat, hydropower, hatcheries and harvest. In addition, this section briefly examines broader environmental factors including development within the Columbia River Basin, climate change and population growth.

3.3.1 Habitat

Historically, the Kootenai River corridor was a dynamic river floodplain with connected backwater habitats, floodplain channels supporting diverse riparian communities. Spring freshets inundated off-channel areas and exchanged organic materials and sediment between the river and floodplain. Delivery of nutrients, sediment and wood created a mosaic of diverse habitats. Riparian forests and extensive wetlands occupied the broad, low gradient floodplain. Sediment deposits formed natural levees paralleling both tributary streams and the Kootenai River, creating topographic high points that sustained upland vegetation.

Dams, dikes, diversions, groundwater withdrawals, road building, channelization, logging, agricultural and grazing practices, the introduction of exotic species, developments, and other human developments subsequently altered habitats and their naturally functioning ecological processes. Consequently, water quality, stream flows, bank stability, sedimentation, channel diversity and other habitat attributes have degraded and native fish populations declined. Current aquatic habitat conditions in the subbasin range from moderately altered to highly altered.

The Kootenai River Subbasin Plan (KTOI and MFWP 2004) identified three primary factors limiting aquatic resources: 1) impoundment and hydropower operations, 2) physical habitat alteration, and 3) the introduction of non-native species. These three factors have resulted in at least 18 important secondary aquatic limiting factors that negatively affect habitat, fish, and wildlife (Figure 3-5). The subbasin plan identifies management strategies to address these limiting factors in both mainstem and tributary habitat.



(Source: KTOI and MFWP 2004)

Figure 3-5. Primary and secondary limiting factors in the Kootenai River ecosystem.

The Tribe in coordination with co-managers and other agencies continues to develop and implement projects to address secondary limiting factors in order to more effectively address primary limiting factors. The response of the biological communities to the Tribe's habitat restoration and nutrient addition actions is expected to be positive. For example, nutrient enhancement in the Kootenai River and in Kootenay Lake has resulted in a significant production response at multiple trophic levels. The large-scale habitat restoration efforts proposed by the Tribe are expected to restore greater ecosystem function (e.g., complexity, floodplain connection, development of more riparian habitat, side channels, etc.) with corresponding changes in the available food web and food supply. Kokanee restoration efforts have significantly increased annual returns to the Kootenai River and tributaries. Kokanee are believed to have been a very significant food resource for the historical sturgeon population. The net effects of all these changes on system trophic dynamics and habitat capacity are extremely difficult to predict. These limitations are why an empirical monitoring and evaluation approach to identifying sturgeon and burbot habitat capacity is being implemented using releases of hatchery-reared fish.

Section 3.4 provides a summary of the various projects that have been, and are being, implemented in the Kootenai subbasin to address these limiting factors.

3.3.2 Hatcheries

As previously outlined, the Tribal Sturgeon Hatchery was constructed in phases between 1990 and 2007 and now includes a hatchery and incubation building, two rearing sheds, water treatment facilities, storage sheds and an administration building. The Kootenay Trout Hatchery in Fort Steele, British Columbia, operated by the Freshwater Fisheries Society of British Columbia, is funded by BPA through the Kootenai Tribe to provide a limited fail-safe rearing facility to back-up the Tribe's Kootenai sturgeon aquaculture program.

Currently there are no burbot facilities in the Kootenai River subbasin.

Other aquaculture programs in the region include the Murray Springs Trout Hatchery operated by Montana Fish, Wildlife & Parks (MFWP) in the Kootenai River subbasin. MFWP operates three other hatcheries in adjoining subbasins. Washoe Park Trout Hatchery in the Clark Fork subbasin provides Montana's westslope cutthroat trout broodstock and historically has produced rainbow trout, arctic grayling, brook trout, golden trout, lake trout and brown trout. Jocko River Trout Hatchery and the Flathead Lake Salmon Hatchery are located in the Flathead subbasin. Jocko River produces rainbow trout broodstock. Flathead Lake Salmon Hatchery produces kokanee and arctic grayling, and rears and releases rainbow trout and westslope cutthroat.

The Canadian portion of the Kootenai River is stocked with westslope cutthroat trout, brook trout, and rainbow trout from the Kootenay Trout Hatchery in Fort Steele. There are no anadromous fish hatcheries in the province because Bonnington Falls (now inundated by Kootenay Lake in British Columbia) has been a natural barrier to fish passage for the last 10,000 years.

3.3.3 Hydropower

Seven hydroelectric projects operate within the U.S. portion of the Kootenai subbasin. In addition, there are six dams within the Canadian reaches of the Kootenai River, all constructed for hydroelectric power production and flood control. The largest in the Kootenai subbasin is Libby Dam, located about 70 miles upstream from Bonners Ferry (Figure 3-4). It was built in 1972 and impounds the 90-mile-long Lake Koocanusa. The nearest downstream dam that may play a part in the regulation of the Kootenai River is Corra Linn Dam. Grohman Narrows and the Kootenay Canal projects between Nelson and Castlegar, British Columbia affect upstream Kootenay Lake and Kootenai River hydrologic and hydraulic conditions.

Libby Dam began regulating flows in the Kootenai River in 1974, reversing the natural hydrograph by storing the spring freshet for flood control purposes and releasing water during winter months for power production. This has resulted in warmer downstream water temperatures during the winter and cooler temperatures during the spring and summer months, opposite of the pre-dam river thermal regime.

Since the early 1990s, Libby Dam operations have been modified to help restore Kootenai sturgeon and burbot migration, spawning, and recruitment. These changes included ceasing spring power peaking operations (load following), creating more normative spring flows and temperatures for Kootenai sturgeon, and more normative winter flows and temperatures for burbot.

Daily load-following has largely been eliminated from winter and spring operational strategies since the early 1990s, primarily due to the ESA listing of Kootenai sturgeon and bull trout, and associated ramping rates specified in USFWS Libby Dam Biological Opinion (USFWS 2006). However, weekly load shaping still occurs during the winter months (i.e., varying flow during the week to generate power during high-demand periods) and follows established ramping rates. To date, none of these efforts have provided any tangible benefits for sturgeon or burbot populations.

Corra Linn Dam at the outlet of Kootenay Lake produces a hydraulic backwater effect that extends upstream to Bonners Ferry, altering natural hydrologic and hydraulic characteristics and functions in the lower Kootenai River ecosystem (Burke et al. 2008).

The City of Bonners Ferry operates the Moyie River Hydroelectric Project at Moyie Dam, 1.5 miles upstream from the confluence of the Moyie and Kootenai rivers. A 92-foot-high dam forms an 11-mile-long reservoir used to generate less than four megawatts. This is a run of river project, so inflow to the reservoir matches outflow. The average annual flow in the lower Moyie is 885 cfs, ranging from 40 to 11,000 cfs. Moyie Falls, within the project's bypass reach, historically was a natural barrier to upstream migrating fish.

3.3.4 Harvest

The Kootenai Tribe of Idaho harvested Kootenai sturgeon, burbot, kokanee, rainbow trout and other fish species in the Kootenai subbasin since time immemorial and the right to do so was reserved by the Treaty of Hell Gate of 1855. Non-Kootenai settlers and others also recreationally harvested these fish species within the Kootenai subbasin.

Sport harvest of Kootenai sturgeon was closed in Montana in 1979 and Idaho in 1984. Tribal Treaty harvest was also voluntarily halted in the 1980s in recognition of the species' danger of collapse. Catch-and-release fishing was closed in 1994 in Idaho when the Kootenai sturgeon were listed as endangered under the ESA. Due to their perilous condition, late maturation and longevity, and their federal listing status in the U.S. and Canada as endangered, no recreational harvest of Kootenai sturgeon is anticipated for many years, potentially until two generations of females mature.

Burbot populations were reported to be abundant as late as the 1950s, but due to habitat alterations and heavy harvest (often targeting spawning aggregations), the numbers have dwindled. In 2000, the Idaho Conservation League and American Wildlands petitioned to have the lower Kootenai River burbot population listed as endangered under the ESA. It was determined that the population did not meet ESA listing requirements because it is not a Distinct Population Segment. In both Idaho and Montana, burbot is listed as a Species of Special Concern, and the Canadian population has been Red Listed. Because of the remnant status of this population, harvest is not possible in Idaho.

Similarly, without natural production, no future burbot harvest is envisioned for at least 10-20 years (1-2 generations). Offsetting such predictions would require restoration of habitat and ecological functions. Ecosystem-based habitat restoration actions are the focus of a number of the Tribe's projects including the Kootenai River Habitat Restoration Project.

Kokanee salmon historically inhabited the South Arm of Kootenay Lake in British Columbia and spawned in tributaries to the Kootenai River in Idaho and British Columbia. As recent as the early 1980s, kokanee catches were as high as 25 fish/hour (Partridge 1983). Catch rates dropped dramatically and by 1990, the population was considered functionally extinct. Although the population has experienced some modest improvement recently through Kootenai tribal efforts, it remains very depressed and can't contribute to a sustainable harvest.

Westslope cutthroat trout, bull trout, and redband rainbow trout also occur in the subbasin. Westslope cutthroat are common in the headwaters of the Lake Koocanusa in Canada, but have been designated as a Species of Special Concern in Montana due to recent population declines. Cutthroat trout are not common in the Idaho reach of the Kootenai and provide minimal harvest. Bull trout, listed as threatened by the ESA, occur in low numbers in the U.S. reaches of the Kootenai River and are not harvested. While the population below Libby Dam cannot be considered stable, the bull trout metapopulation in the British Columbia headwaters of Lake Koocanusa is one of the strongest in existence. Redband trout are common in Idaho and the population still provides the most important salmonid fishery in the Kootenai River in Idaho. The Montana population, however, has been found in only isolated tributaries and is listed as a state Species of Special Concern.

3.3.5 Columbia River Basin Development

Industrial, agricultural and population growth in the Pacific Northwest resulted in development of numerous hydroelectric projects on the Columbia River and its tributaries. Roughly half of the region's electrical energy is supplied by hydroelectric power. In addition to providing an inexpensive source of power, the dams also regulate water flow to prevent flooding and to irrigate vast croplands. While the significance of these benefits to the region cannot be underestimated, their local and regional impacts on natural resource values continue to challenge the region. Three major regional dams likely have contributed to the need for the proposed Kootenai River Native Fish Conservation Aquaculture Programs.

Corra Linn Dam, located on the West Arm of Kootenay Lake (Figure 2-1), was built by West Kootenay Power and Light in 1932 to provide electricity for a local fertilizer plant. Kootenay Lake was used to temporarily store fall runoff until 1938 when downstream flooding, mainly in Idaho, instigated the use of the lake as a permanent reservoir. Corra Linn Dam controls Kootenay Lake fluctuations, which range about 10 feet annually and influence the river hydraulics with backwater effects upstream for more than 120 km to the Bonners Ferry area.

Duncan Dam, constructed in 1967, controls the flow of the Duncan River (a tributary to the North Arm of Kootenay Lake). In conjunction with Libby Dam on the Kootenai River, the two dams assure operational water levels for facilities at Corra Linn Dam and the Kootenay Canal. Duncan Dam, an earthfill dam with no generators, impounds Duncan Lake, which is 28 miles long and fluctuates approximately 98 feet in elevation annually.

Libby Dam spans the Kootenai River in Montana approximately 112 rkm upstream from Bonners Ferry. It was constructed and is operated by the USACE for hydropower and flood control (see Sections 3.1.5 and 3.3.3).

Construction of these and other impoundments in the Columbia River Basin induced significant changes to fish and wildlife and their habitats. Effects include modified riparian, wetland, and aquatic habitats, nutrient trapping, blocked fish passage, and altered river hydrology. Stream channels were altered and critical fish habitats, such as those used for spawning, rearing, and over-wintering, have been inundated. The dams also create physical barriers to the downstream flow of nutrients. Phosphorous and nitrogen erode from mountains and sink to the bottom of reservoirs, effectively removing them from the food web. With nutrients exhausted, reservoirs may become oligotrophic due to upstream dams and changes in water velocity when streams flow into reservoirs. As nutrients and sediment sink to the bottom, water clarity increases. Changes in water clarity can directly affect a number of fish species. Piscivorous species, like rainbow and bull trout, benefit from greater water clarity in their ability to see their prey. The reverse is true for species such as kokanee that need to elude the predator fish. Decreasing water levels associated with downramping events or spill can detrimentally affect fish species that live in the reservoir fringes. As water levels decrease, these fish may be stranded in disconnected side pools or on the shore. Stranding provides easy access for predators and may expose fish to waters fatally deficient in oxygen.

Dam operations also affect downstream water temperature and the level of dissolved gases. Water temperatures below reservoirs are strongly correlated with the elevation from where the released water is extracted. If the water is withdrawn from the reservoir's sun-warmed surface, downstream temperatures may increase. If the water is taken from the reservoir's deeper levels, downstream temperatures can be lowered. As water is released from a spillway or turbines, it comes into contact with the air and traps nitrogen and oxygen. These gases can cause a potentially fatal bubble disease in the blood vessels of fish.

3.3.6 Climate Change

The potential effects of climate change are becoming increasingly critical to long-term natural resource management decisions. Global effects may have significant localized implications, affecting the range of management options, and species responses to restoration efforts (ISAB 2007). For example, hydrologic changes in the Columbia Basin could dictate operational regime changes at Libby Dam, directly affecting the aquatic environment in the reach occupied by Kootenai sturgeon and burbot.

Increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising mean sea level are evidence of global climate warming. Records show that the Pacific Northwest has warmed about 1.0°C since 1900, about 50% more than the average global warming over the same period. These changes in temperature, coupled with projected regional precipitation changes, may increase precipitation in the form of rain instead of snow, decrease snow pack, change inflow forecasts, reservoir refill probabilities, and increase water temperatures. Changes in air temperature and climate have already altered the ranges of some animals. Some insects, birds, and trees have been found to move their ranges polewards and elevationally upward to find suitable habitats.

Changes in hydrology and temperature have the potential to negatively affect aquatic ecosystems. Projections suggest that temperature increases alone will lead to 8-33% of current trout habitat in the Pacific Northwest becoming unsuitable by the year 2090 (ISAB 2007).

Smaller future snow packs confined to higher elevations would reduce stream flows and cause higher stream temperatures during the summer and fall, and potentially higher flows in the winter and spring. These effects may alter the frequency of floods and wildfires and the ecology of streams, riparian areas, and wetlands, potentially affecting every life stage of species in the aquatic ecosystem.

Climate change is expected to occur concurrently with other impacts in the Columbia River Basin. Along with habitat fragmentation and harvest, climate change may cause a decline in fish and wildlife populations much more rapidly when the three factors occur simultaneously. A study using laboratory microcosms showed that populations decrease up to 50 times faster when the three factors occur together (Mora et al. 2007). Such results imply increased extinction probabilities for listed stocks or other species that experience land use and resource use impacts simultaneously with climate change effects.

Although global strategies for reducing the emission of greenhouse gases won't completely address the effects of climate change on habitats in the Columbia Basin, local efforts based on individual habitat needs may help offset some negative effects. In its 2007 recommendations, the ISAB suggests that priorities should be to protect biodiversity and critical habitats sensitive to climate change. Any mitigation focused on minimizing water temperature increases or stream flow augmentation in summer and autumn may reduce the local contribution to climate change. The ISAB recommends that priority be placed on protecting cold-water refugia for migrating salmon and restoring riparian habitats in stream headwaters.

3.3.7 Population Growth

Human population growth and its potential to affect fish and wildlife populations in the Columbia River Basin was a topic addressed by the ISAB in a recent publication (ISAB 2007), which is summarized in this section.

Human population growth has significantly affected both the landscape and the fish and wildlife that live there. The United States population tripled in number and doubled in density during the 20th century; Canada's growth rate was slightly higher. Population increases in the four Columbia Basin states (Washington, Oregon, Idaho, and Montana) and British Columbia are projected to be three to sevenfold by the year 2040. Densities are greatest west of the Cascade Mountains and around the major eastside urban areas of Spokane, Boise, and Bend. Since the 1970s, there has been rapid population growth in rural, sparsely populated areas, especially those with recreation and scenic values, amplifying the demand for land, water, and hydroelectricity.

With the population boom in rural areas of the northwest, new development is occurring on land that was previously forested or used for agriculture and/or ranching. Development is largely low density residential. This form of development tends to degrade habitat for fish and wildlife through direct habitat conversion and loss, secondary changes associated with roads and buildings, and landscape fragmentation. This type of development has led to decreased species diversity and abundance, the local extirpation of some species, as well as increased conflict between wildlife and people.

Such development requires water for domestic, irrigation, wastewater assimilation, recreational, commercial, and industrial supply. Although changing land uses from agriculture to rural residential may decrease water used for irrigation, it increases overall water use and wastewater created by single family homes and industry. Combined with this increased demand, future effects of climate change may decrease snow-pack, leading to water shortages in the summer and fall low flow seasons.

Increasing paved and impervious surfaces increases the amount of surface runoff and prevents soil saturation. These man-made modifications are designed to move water downstream as rapidly as possible, contributing to an increase in peak flow and the frequency of discharge events of sufficient magnitude to cause sediment transport and habitat disruption.

Incorporating human population growth into fish and wildlife planning requires stakeholder involvement; spatial modeling of critical resources and development patterns; investigating alternative development scenarios; and evaluating and monitoring to enable adaptive management. Offsetting the effects of population growth will require adjusting habitat mitigation plans according to future settlement patterns. Mitigation measures should focus on protecting the highest quality environment for fish and wildlife and implementing measures to stop the spread of invasive species. Healthy aquatic population strongholds should be protected before they become threatened by development and by providing an anchor upon which future restoration efforts may be based. Additional tools may include providing incentives for water conservation, modifying irrigation withdrawals, and community planning for sustainable groundwater and surface water.

3.4 Coordination with Other Entities, Programs and Projects

Because of the scale and duration of perturbations to the Kootenai subbasin, it is not possible for any single entity or single project to address all of the cumulative impacts. The following section provides an overview of efforts by the Tribe and others to coordinate Kootenai subbasin fish and wildlife management, project implementation, monitoring and evaluation, and adaptive management. This section also presents a summary of how the various projects that have been implemented to date are intended to address limiting factors in the Kootenai subbasin and contribute to the recovery of naturally self-sustaining populations of native fish and wildlife.

3.4.1 Coordination and Collaboration

In developing and implementing approaches to Kootenai sturgeon and burbot recovery, and ecosystem management as a whole, the Kootenai Tribe embraces a collaborative approach that takes into consideration the needs and values of the local community and region. The Tribe believes that cooperation among groups with a stake in the region is the only way to ensure the sound and prosperous future of the Kootenai River subbasin. The following sections provide an overview of some of the major coordination and collaborative activities occurring in the Kootenai subbasin.

3.4.1.1 Kootenai Valley Resource Initiative

The Kootenai Valley Resource Initiative (KVRI) was formed under a Joint Powers Agreement (JPA) between the Kootenai Tribe, the City of Bonners Ferry, and Boundary County, dated October 2001. Under the JPA, the KVRI is empowered to foster community involvement and development to restore and enhance the resources of the Kootenai Valley. The mission of KVRI is to act as a locally based effort to improve coordination, integration, and implementation of existing local, state, and federal programs that can effectively maintain, enhance, and restore the social, cultural, and natural resource bases in the community. The KVRI membership and its partners include the Kootenai Tribe, who initiated the process, federal, state, and provincial fisheries and water regulatory agencies, regional city and county governments, private citizens, landowners, environmental advocacy groups, and regional representatives of business and industry.

The KVRI Burbot Subcommittee was formed as a subset of the KVRI to pursue coordinated burbot conservation and management. Congressional appropriations in 2003 and 2005 helped fund the coordination and development of a Burbot Conservation Strategy. Burbot are the subject of great interest to the local community, where they historically supported subsistence and popular recreational fisheries (KVRI 2005). The KVRI also provides a forum for local input and stakeholder involvement for subbasin plan implementation in the lower Kootenai Subbasin.

3.4.1.2 Cooperative Management Coordination with Idaho Department of Fish and Game, Montana Department of Fish, Wildlife, and Parks, and British Columbia Ministry of Environment

The Kootenai Tribe and the State of Idaho operate in close collaboration to manage Kootenai River fishes. These efforts include monitoring and evaluating the sturgeon conservation culture and preservation stocking program, monitoring the wild white sturgeon population and researching limiting factors, and conducting other Kootenai River investigations. For instance, the IDFG is conducting an evaluation of natural spawning of white sturgeon. IDFG assists in broodstock collection each spring, as it coincides with the sampling to collect adults for sonic monitoring. Monitoring of hatchery fish by the IDFG is augmented by tribal crews using different gear types, sampling in areas not previously sampled, and sharing information. BC MoE collects information and data about white sturgeon, burbot, and kokanee in Kootenay Lake. The Kootenai Tribe, IDFG, BC MoE and MFWP have a successful data sharing agreement. All field data collected on white sturgeon and Lower Kootenai burbot are compiled in a single database coordinated by IDFG. Data are compiled to provide the most accurate and current information concerning many crucial aspects of this project (e.g., broodstock collection, capture of wild sturgeon for sonic tracking, and locations of fish fitted with transmitters).

3.4.1.3 Transboundary Coordination

Because Kootenai sturgeon and lower Kootenai River burbot occupy a transboundary watershed, important ongoing partnerships have been formed between the Kootenai Tribe and the BC MoE. Since 1999, the Kootenay Trout Hatchery in Fort Steele, British Columbia has provided a small but reliable ,fail-safe component to the Tribe's production of Kootenai sturgeon, rearing five family groups collected from broodstock at Bonners Ferry. The Tribe also contracts with BC MoE to capture and assess white sturgeon from Kootenay Lake and other Canadian waters to assist in species restoration. The BC MoE is also responsible for monitoring movements, habitat use, growth and survival of the Tribal hatchery progeny and wild progeny and adults in Canada. Additional cooperative components include telemetry projects to monitor adults and juveniles, tagging subjects in Canada for telemetry projects completed in Idaho, larval sampling, and other monitoring related to white sturgeon conservation aquaculture and recovery. Data and databases are successfully shared, and personnel from the Ministry, Kootenai Tribe, and IDFG freely communicate and work together in the field to ensure coverage and cooperation in all aspects of Kootenai sturgeon research, monitoring, and evaluation. These efforts support SARA and ESA objectives to sustain a population native to both nations.

3.4.2 Relationships of Ongoing and Proposed Projects in the Kootenai Subbasin

The Kootenai Tribe's Native Fish Restoration Conservation Aquaculture Program represents one component of a group of interrelated projects that are addressing the goals and objectives identified by the agencies, the Tribe, and other co-managers and stakeholders involved in the restoration of native fish and wildlife and their habitats in the Kootenai Basin. This section summarizes the relationship of ongoing and proposed projects to Kootenai River Subbasin Plan objectives, other projects and conservation actions.

All Kootenai Tribe and Kootenai River subbasin projects are interrelated to varying degrees. They are complementary by design and are integrated at multiple levels including:

- All Kootenai Tribe and the Kootenai subbasin projects share and collectively address the vision of the Subbasin Plan to: "establish and maintain a healthy ecosystem characterized by healthy, harvestable fish and wildlife populations, normative and/or natural physical and biological conditions, and sustainable human communities (KTOI and MFWP 2004).
- All of the projects are related by their complementary inclusion into the draft Kootenai Ecosystem Adaptive Management Plan (Walters et al. 2005), which the Tribe will be updating in the near term (see Section 6.1). Within this international multidisciplinary Adaptive Management Plan, all component projects address certain aspects of the Kootenai River ecosystem (e.g., aquatic, riparian or terrestrial management, research, and restoration). Thus, the integration of all Kootenai subbasin projects collectively addresses the Subbasin vision, biological objectives, and strategies in the Subbasin Plan.
- All of the projects are also interrelated to varying degrees by design in order to address the inherent interrelatedness of ecology and ecological restoration activities. Unlike funding opportunities within separate scientific or management disciplines, ecological functions and processes are not segregated along programmatic lines. Projects are designed to be implemented as complimentary pieces in order to bridge programmatic gaps between disciplines by ensuring that aquatic, riparian and terrestrial issues are collectively addressed by aquatic, riparian, and terrestrial projects despite their being funded as separate projects.

The following BPA-funded projects are ongoing in the Kootenai subbasin (note the project names tend to evolve as the projects are adaptively managed over time):

- Project Number 198806400: Kootenai River Native Fish Conservation and Aquaculture Program (Kootenai Tribe). This Master Plan is funded under this project.
- Project Number 198806500: Kootenai River Fisheries Recovery Investigations (IDFG).
- Project Number 199404900: Kootenai River Ecosystem Improvements (Kootenai Tribe)
- Project Number 199500400: Mitigation for the Construction and Operation of Libby Dam (MFWP)
- Project Number 200200200: Assess the Feasibility of Enhancing White Sturgeon Spawning Substrate Habitat, Kootenai River, Idaho (Kootenai Tribe). This project has been retitled, "Kootenai River Habitat Restoration Project," and a Master Plan describing the project was published by the Kootenai Tribe in July 2009.
- Project Number 200200800: Determine the Feasibility of Reconnecting Floodplain Slough Habitat to the Kootenai River (Kootenai Tribe).

- Project Number 200201100: Implement Floodplain Operational Loss Assessment, Protection, Mitigation and Rehabilitation on the Lower Kootenai River Watershed Ecosystem (Kootenai Tribe).

- Project Number 200715200: Evaluation of the Biological Effects of the NWPCC Mainstem Amendment on the Fisheries Upstream and Downstream of Hungry Horse and Libby Dams (MFWP).

In addition to the BPA-funded projects listed above, during development of the Kootenai Subbasin Plan, participants identified over 100 additional fish and wildlife restoration and conservation projects funded by a variety of other agencies and programs (KTOI and MFWP 2004). These projects ranged from removing fish-passage barriers to restoring degraded riparian areas.

Table 3-1 below summarizes the main actions taken by each project and how the Kootenai subbasin habitat and biological objectives are addressed differentially by the series of Kootenai River projects (project listed vertically by project number in the center of the first row). Objective titles in Table 3-1 were shortened for inclusion in this table; objective codes, full objective titles and supporting strategies can be found in the objectives and strategies tables in the Kootenai Subbasin Plan.

Table 3-2 presents a summary of BPA funded habitat projects (and one non-BPA project) being implemented in the Kootenai subbasin that complement and will enhance the benefits derived from the proposed Kootenai sturgeon conservation aquaculture program.

Table 3-3 summarizes the relationship of burbot conservation measures to other actions (e.g., fish management, habitat restoration, etc.) that are occurring in the Kootenai subbasin, the time frame within which measures will occur, and identifies the lead and cooperating agencies involved in these efforts.

3.4.3 Coordinated Research, Monitoring and Evaluation Activities

Research, monitoring and evaluation efforts (RM&E) that have management implications for Kootenai sturgeon, burbot and other key aquatic species are being conducted in the subbasin by the Kootenai Tribe, MFWP, IDFG and the BC MoE. Table 3-4 identifies these RM&E efforts, many of which are funded by BPA under the Columbia River Fish and Wildlife Program (NPCC 2009). Sections 4.4 and 5.4 present the proposed conceptual monitoring and evaluation program for the Kootenai sturgeon and burbot conservation aquaculture programs.

These basin-wide RM&E actions are being conducted under the framework of several planning efforts, particularly the Kootenai Subbasin Plan (KTOI and MFWP 2004). Objectives are incorporated that ensure consistency with ESA recovery plans, the Clean Water Act, and other federal requirements. The linkage of these actions to adaptive management frameworks is described in Chapter 6.

Table 3-1. Priority, code, and description of habitat and biological objectives, BPA-proposed projects that address these objectives, and whether they address ESA and CWA responsibilities.

Priorty Score (U,H,R)	Objective Code	Prioritized Kootenai River Subbasin Objectives (Habitat and Biological)	198806400 Kootenai River Native Fish Restoration and Conservation Aquaculture	198806500 Kootenai R White Sturgeon Inve	199404900 Kootenai River Ecosystem Improvements Project	199500400 Libby Mitigation Program	200000400 Monitor, Protect, and Rehabilitation of Bull Trout and Westslope Cutthroat Trout Habitat in the Upper Kootenay River Subbasin	200200200 Restore Natural Recruitment of Kootenai River White Sturgeon	200200800 Reconnect Kootenai River with the historic floodplain	200201100 Kootenai Floodplain Operational Loss Assessment	200721800 Development of single nucleotide polymorphism (SNPs) genetic markers diagnostic between coastal rainbow trout and interior redband trout	200710900 Aquatic Nuisance Species monitoring and outreach program for the Mountain Columbia province (Montana portion) of the Columbia River Basin	Addresses ESA	Addresses CWA
U	M1, RP2, WB1 R3	Restore normative mainstem hydrograph				X		X		X			X	X
U	BT4 RBT3 WCT3 WB3 RP1 RP5 GS3 XF3 MF4	Suppress and remove non-native species				X				X			X	
U	BT4 RBT3 WCT3 WB3 RP1 RP5 GS3 XF3 MF4	Reduce and prevent non-native introductions								X		X	X	
U	T1	Protect Class 1 Habitat		X	X	X						X	X	X
U	BT5 KOK1 WST 1 BUR1 WB1 RP2	Restore productivity rates and nutrient concentrations to pre-dam levels		X	X				X	X			X	
U	BT5 RBT2 WCT2 KOK3 WST 3 BUR4	Restore/maintain population size required for populations to persist	X	X		X			X		X		X	
U	BT3	Restore/maintain population stability		X		X	X							
U	WST2 BUR3	Restore natural recruitment	X	X				X	X				X	X
U	M5 WB2 RP1 RP5 M1 M3 GS4 XF, XF2	Restore habitat conditions req'd for recruitment			X	X		X	X	X			X	X
H	M1	Alter hydrograph to remove tributary deltas						X					X	
H	T7	Restore tributary hydrographs		X					X				X	
H	M2 T2 R2 RP1 RP4 RP5	Restore riparian habitat to reference condition							X	X			X	
H	M3 T3	Reduced fine sediment input			X	X		X					X	X
H	M3	Coordinate TMDL with req'd boil. productivity			X								X	X
H	T5	Restore normative thermal regime in tributaries			X	X							X	
H	M5 T6 WB2 RP1 RP4 GS2 MF1 MF2 XF1	Increase habitat diversity to reference levels			X	X			X	X			X	
H	R2 RP1 RP4	Protect and revegetate riparian areas			X	X			X	X			X	X
H	M6 T4	Improve channel stability to reference levels			X	X							X	X
H	M3 T3 RP1 WB2	Restore appropriate turbidity levels			X								X	X
H	T8 WB2 RP1 RP3 GS1 XF2	Improve habitat connectivity							X	X			X	
H	R1 R3	Increase Libby Reservoir retention time				X								
H	R2	Revegetate top 10 feet of Libby Res. varial zone												
H	R1 R3	Reduce refill failure rate to top 5' of Libby Res.				X								
H	WST4 BUR5	Evaluate contaminant effects	X										X	X
R	WST4 BUR5	Seek remedies for contamination											X	X
R	M4 T5	Restore normative thermal regime in mainstem				X								
R	KOK2 BUR2 R2 R4	Rehabilitate native community composition		X									X	
H	BT 1 RBT1 WCT2	Number of local populations		X		X	X				X		X	

Source: KTOI and MFWP 2004
Priority Scores: U = Urgent; H = Highly Recommended; R = Recommended Action.

Table 3-2. Habitat projects and restoration activities in the Kootenai River that complement the Kootenai sturgeon aquaculture program.

BPA Project Number	Project Title	Project Sponsor	Relationship to Sturgeon Aquaculture
198806500	Kootenai River Fisheries Investigations	IDFG	Assists the Kootenai tribal hatchery program (198806400) with brood capture, monitors and evaluates spawning in the wild and post-release juvenile sturgeon performance in the wild.
199404900	Kootenai River Ecosystem Improvement Project	KTOI	Implements biomonitoring, data analysis, research, and adaptive management projects (i.e. nutrient restoration and stream rehabilitation) to identify best management strategies to enhance aquatic biota in the Kootenai River ecosystem to recover native species assemblages across multiple trophic levels.
199500400	Libby Reservoir Mitigation Planning	MFWP	Implements watershed-based enhancement and fish recovery actions in the Montana portion of the Kootenai subbasin to mitigate losses caused by hydropower development.
200200200	Enhance White Sturgeon Habitat	KTOI	Designs, implements, and evaluates habitat improvement and creation actions and altered hydro operations, monitors responses, and refines physical and hydraulic models to characterize sturgeon recruitment requirements and implement actions to restore recruitment.
200200800	Reconnect Kootenai River Floodplain	KTOI	Assesses the feasibility and options for reconnecting slough habitat that has been isolated from the Kootenai River by flood control and dikes to benefit white sturgeon, burbot, rainbow trout, kokanee, waterfowl and invertebrate species.
200201100	Lower Kootenai Floodplain Assessment	KTOI	Assesses ecological function and habitat diversity losses due to Libby Dam construction and operation in order to conduct long-term mitigation, protection, enhancement, and rehabilitation in historic floodplain habitats in the lower Kootenai River.
NA	Kootenai Valley Resource Initiative	KTOI, City of Bonners Ferry, Boundary County	Locally based effort to improve coordination, integration and implementation of existing local, state and federal programs that can effectively maintain, enhance and restore the social, cultural, economic, and natural resource bases in the community. KVRI is the forum for local Subbasin Plan implementation, as well as burbot restoration in the lower Kootenai subbasin.

Table 3-3. Relationship of Kootenai River burbot conservation measures to other actions in the Kootenai River subbasin.

Conservation Measure Description	Time Frame*	Lead Agency	Cooperating Agencies
Fish Management			
Continue current restrictions on burbot harvest in the Kootenai River, and Kootenay Lake, and their tributaries.	O-L	IDFG, MFWP, BC MoE	IDFG, MFWP, BC MoE
Continue to monitor and limit incidental impacts and prohibit illegal harvest of burbot.	S-L	IDFG, MFWP, BC MoE	IDFG, MFWP, BCMOE
Integrate aspects of Conservation Strategy into the multi-agency Kootenai River Adaptive Management Program, using IKERT as an annual review and input forum	O-L	All Agencies	All agencies
Consider resumption of subsistence and recreational fisheries after Conservation Strategy targets are met.	L	IDFG, MFWP, BC MoE	Kootenai Tribe
Habitat Restoration			
Seek opportunities to reestablish lost natural river functions in the lower Kootenai River, including hydrograph cycles, habitat diversity, and floodplain connectivity and function.	M-L	Kootenai Tribe, IDFG, MFWP, BC MoE, USFWS, KVRI	KVRI Burbot Committee, IDEQ, NRCS
Continue to implement tributary habitat improvement projects that address instream, riparian, and upland conditions that affect stream discharge, water quality, and habitat diversity and complexity.	M-L	Kootenai Tribe, IDFG, MFWP, BC MoE, USFS	KVRI Burbot Committee, IDEQ, IDL, USFS, NRCS
System Productivity, Aquatic Communities			
Continue annual fertilization of Kootenay Lake (North Arm fertilization began in 1992, South Arm began during 2004) and expand the program to include the Kootenai River in Idaho, near the Idaho-Montana border (2005) to increase the forage base available to burbot.	S	BC MoE, BC Hydro, Kootenai Tribe, IDFG	IKERT
Continue efforts to restore and maintain other components of the native fish community including kokanee and Kootenai sturgeon through approved habitat and population enhancement measures.	S-O	USFWS, Kootenai Tribe, IDFG, MFWP, BC MoE, USACE	IKERT, BEF
Endorse potential benefits to the burbot population and food base of ongoing efforts in other forums to assess and remedy sources of environmental contaminants.	S-L	USFWS, Kootenai Tribe, IDFG, MFWP, BC MoE	All agencies
Conduct controlled and in-situ laboratory bioassays to determine the physiological effects of temperature, contaminants, predation, nutrients and other potential environmental stressors on different life stages of burbot.	S-M	USFWS, Kootenai Tribe, IDFG, MFWP, BC MoE	UI-ARI, USGS, and other labs
Hydro Operations			
Develop an experimental Kootenai River flow/water temperature operation to evaluate the effectiveness of restoring natural spawning, and recruitment by reducing winter temperatures and velocities. Implement experi-mental operations when conditions allow to evaluate burbot spawning requirements while preserving flexibility in needed hydropower production and flood control operations.	S-M	USACE, BPA, BCHydro	IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee
Document specific temperature and flow requirements that provide for natural spawning, incubation, rearing, recruitment, and survival of Kootenai River burbot.	S-L	IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS	USACE, BPA, BCHydro, KVRI M&E and Hydro Operations Subcommittee

Conservation Measure Description	Time Frame*	Lead Agency	Cooperating Agencies
Investigate existing hydrological models based on historic temperature, flow, and velocity data, and modify if necessary to evaluate effects of operational alternatives on conditions required for completing various burbot life stages.	S-L	BPA, USACE, USGS, BC Hydro	IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee
Evaluate use of selective withdrawal during migratory pre-spawning periods to affect thermograph near Bonners Ferry and downstream to benefit burbot. Monitor water temperature at Porthill.	S	USACE	IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee
Develop a long-term process to recommend annual Libby Dam operations for burbot, while providing for other project uses consistent with Endangered Species Act and other statutory and regulatory responsibilities. The multi-year plan may explore opportunities for experimental operations to evaluate burbot response to the operations.	L	BPA, USACE, USFWS, BC Hydro	IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee
Culture, Supplementation & Reintroduction			
Develop effective methods to successfully hold, spawn, fertilize, and rear burbot in a hatchery. Develop these techniques using burbot from other regional populations to avoid impacts to remnant Kootenai River, Kootenay Lake, and Duncan Reservoir populations.	S	Kootenai Tribe, BC MoE, UI-ARI	KVRI Burbot Culture Subcommittee
Evaluate donor stock suitability using a multidisciplinary broodstock evaluation template that incorporates: genetic, evolutionary, biological, ecological, and management parameters for fish in receiving and donating waters. In the short term, complete burbot microsatellite analysis to identify stock structure and guide decisions regarding stock source for conservation aquaculture.	S	Kootenai Tribe, UI-ARI IDFG, MFWP, BC MoE, CFS	KVRI Burbot Culture Subcommittee
When effective burbot culture techniques have been identified, and if natural recruitment sufficient to meet recovery goals has not been restored, implement an experimental burbot stocking program to: 1) identify life cycle bottlenecks in burbot survival, 2) determine whether hatchery-produced burbot can effectively survive in the wild, and 3) contribute to demographic and genetic vigor of remnant or re-introduced populations.	S-L	Kootenai Tribe, UI-ARI IDFG, MFWP, BC MoE	KVRI Burbot Culture Subcommittee, CFS
Design, evaluate, and implement a fish culture strategy with strict genetic guidelines, fish health protocols, and rigorous M&E components to assess and balance benefits and risks of natural production, while recognizing the need for significant conservation measures.	S-L	Kootenai Tribe, UI-ARI, IDFG, BC MoE	KVRI Culture Subcommittee, CFS
Identify subsequent hatchery roles in burbot conservation, based on monitoring and evaluation of post-release fish performance and responses of any natural recruitment to other recovery measures, and to the performance of experimental releases of hatchery fish.	S-L	IDFG, MFWP, BC MoE, Kootenai Tribe	UI-ARI, WSU, IDFG
Research, Monitoring, and Evaluation			
Periodically conduct standardized assessments of burbot status in the Kootenai River from Montana downstream into Kootenay Lake contingent on availability of appropriate sample numbers, and on donor source brood stock populations.	S-L	IDFG, BC MoE, MFWP, Kootenai Tribe (w/ hatchery progeny)	KVRI Burbot Committee

Conservation Measure Description	Time Frame*	Lead Agency	Cooperating Agencies
Periodically conduct standardized assessments of wild larval and juvenile abundance.	S-L	IDFG, BC MoE, MFWP, Kootenai Tribe (w/ hatchery progeny)	KVRI Burbot Committee
Identify essential habitats and conditions by monitoring burbot movement and habitat use.	S-L	IDFG, BC MoE, MFWP	KVRI Burbot Committee
Evaluate current use and suitability of the mainstem Kootenai River and its tributaries for burbot spawning.	S-M	IDFG, Kootenai Tribe, MFWP, BC MoE	KVRI Burbot Committee
Evaluate the contribution of entrainment from Libby Dam to the downstream Kootenai River burbot population.	S-L	MFWP, IDFG, BC MoE	KVRI Burbot Committee
Identify burbot behavior in Kootenay Lake to determine whether special habitat limitations or biological interactions affect effectiveness of the burbot Conservation Strategy.	S-M	BC MoE	KVRI Burbot Committee
Monitor burbot responses to specific conservation measures, and modify projects/operations to meet biological performance targets.	S-L	IDFG, Kootenai Tribe, MFWP, BC MoE	Relevant KVRI Sub-Committees
Design, implement and evaluate natural production experiments.	S-L	IDFG, Kootenai Tribe, MFWP, BC MoE	Relevant KVRI Sub-Committees
Information and Education			
Increase public awareness of the need for Kootenai River burbot conservation by developing and distributing informational and educational materials and by hosting periodic public meetings.	S-L	KVRI I&E Committee	KVRI Burbot Committee
Pursue opportunities to link Kootenai River burbot conservation activities with other ongoing fish management, fish and wildlife recovery activities, and habitat and ecosystem restoration efforts via the multi-agency Kootenai River Adaptive Management Plan.	S-L	IDFG, Kootenai Tribe, BC MoE, USFWS, MFWP	All agencies
Prepare and distribute annual monitoring, evaluation and research reports.	S-L	IDFG, Kootenai Tribe, BC MoE, USFWS, MFWP	All Agencies
Continue to involve a broad coalition of stakeholders in burbot conservation through the Kootenai Valley Resource Initiative Process.	S-L	KVRI Burbot Committee	All Agencies
Planning, Implementation, and Coordination			
Maintain a standing technical committee to coordinate and adapt implementation of this Conservation Strategy.	S-L	KVRI Burbot Committee	All Agencies
Review and update this Conservation Strategy annually; formally update it every five years or less as necessary.	S-L	KVRI Burbot Committee	All Agencies
Continue to build regional and international program coordination and participate in timely data sharing.	S-L	KVRI Burbot Committee	All Agencies

*L=long term (>10 years); S=short term (<5 years); M= medium term (5-10 years); O-L=ongoing to long term; S-L=short to long term; M-L=medium to long term; S-O=short term, ongoing; S-M=short to medium term

Table 3-4. On-going Kootenai River subbasin research, monitoring and evaluation activities.

Agency	Research, Monitoring or Evaluation Action
MFWP	Monitor permanent stream form and maintain sediment monitoring stations in the Wigwam River (B.C.) and in Grave Creek (MT).
	Evaluate the effectiveness of remote site incubators (RSI) and artificial redd construction as a means of increasing recruitment of age-2 or greater westslope cutthroat trout into tributary populations. MFWP will monitor the spawning population and strength of emigration through the operation of the permanent weir on Young Creek to capture upstream migrant adult trout and downstream migrant juvenile trout. It will monitor the effects of RSI's and artificial redds by conducting electrofishing population estimates in historically sampled reaches, and it will monitor the effectiveness of westslope cutthroat trout at displacing non-native eastern brook trout by deploying RSI's in Barron Creek in conjunction with physical habitat inventory, beginning in 2001.
	Monitor and assess trout populations pre- and post-project implementation in stream reaches where enhancement activities will/have been implemented. Either population estimates or CPUE will be monitored. Aquatic insect response, temperature response, and in some cases, vegetative response, will also be monitored. The biological and hydrological effects of lake rehabilitation will be evaluated by monitoring zooplankton recolonization and fisheries growth in chemically treated lakes.
	Monitor spawning and rearing of fluvial burbot and cutthroat and bull trout in the mainstem Kootenai River and principal tributaries. Monitor burbot spawning activity in the stilling basin below Libby Dam by continuing hoop-netting operations during December and February. Monitor tributary use of fluvial bull trout in the Montana portion of the Kootenai River. Conduct bull trout redd counts in core-area tributaries in the U.S. and Canada.
	Continue counting rainbow trout redds below Libby Dam between Alexander Creek and the Fisher River.
	Monitor bull trout movement and habitat use of mainstem Kootenai River and tributaries. Collect adult bull trout in the Kootenai River via electrofishing and from Bear Creek via migrant trapping and surgically implant radio tags. Track fish from boats and planes on a bi-weekly basis annually, and weekly during spawning season.
	Document entrainment of fish through Libby Dam during flow events greater than 20,000 cfs. Monitor entrainment of fish through Libby Dam; measure draft tube velocities and determine relationships to discharge and reservoir elevation; incorporate >20 kcfs entrainment data into the existing entrainment model (Skaar et al. 1996). Estimate forebay kokanee densities using hydroacoustic technology and equipment.
	Monitor zooplankton and gamefish populations in Koocanusa Reservoir and monitor zooplankton and game fish populations in Libby Reservoir. MFWP will monitor seasonal and annual changes in fish abundance in near-shore zones with seasonal gillnetting, conduct annual estimates of population numbers of each age class of kokanee (hydroacoustics) with FWP Regional Fisheries Program, and monitor zooplankton populations in the reservoir.
	Assess bull trout food habits in Koocanusa Reservoir and the Kootenai River.
Kootenai Tribe	Monitor fish community dynamics at index sites on selected tributaries of the Kootenai River. Derive fish community composition and relative abundance by snorkeling and backpack electrofishing.
	Monitor fish community dynamics at index sites on the mainstem Kootenai River. In cooperation with IDFG, the Tribe will conduct late summer, night-time electrofishing of near-shore feeding-zone habitats, gillnetting of deepwater habitats, and beach seining of shallow water habitats.
	Monitor macroinvertebrate community dynamics within the mainstem Kootenai River as part of a pre-nutrient enhancement decision. Sample sites within representative reaches of the Kootenai River from Libby Dam to Porthill, Idaho.
	Monitor primary productivity, algal community composition, and test nutrient addition effects on these parameters.
	Monitor key water-quality parameters at mainstem Kootenai River sites. Take monthly water quality samples during the biologically productive months within key reaches of the Kootenai River in Montana and Idaho, and British Columbia.
	Monitor and evaluate genetic variability and diversity of hatchery Kootenai sturgeon juveniles produced and wild broodstock spawned in the Kootenai Hatchery. Optimize and use nuclear and mitochondrial DNA marker analyses (sequencing, RFLP's, and microsatellites) to document existing variability and diversity of wild broodstock and hatchery progeny, compare genetic variability and diversity of hatchery progeny and wild broodstock with that of the wild population to assess genetic representation in hatchery progeny and refine breeding matrix if necessary.

Agency	Research, Monitoring or Evaluation Action
	Monitor and evaluate biological condition and related population dynamics of Kootenai sturgeon in the Kootenai River. The Tribe and IDFG will determine existing empirical range and variation of growth and condition values of white sturgeon in the Columbia and Kootenai Basin; identify, develop, and rank techniques to determine biological condition as it relates to carrying capacity and associated population dynamics; and evaluate cumulative effects of incremental annual stocking of white sturgeon on growth, condition, and behavioral responses of the hatchery-origin and wild population components in the Kootenai River.
	Monitor and evaluate flora and fauna biological condition on habitat mitigation projects. The Tribe will implement baseline Habitat Evaluation Procedures (HEP), using Habitat Suitability Indices (HSI), to measure enhancements, variation of flora growth and condition values on habitat mitigation projects in the Columbia and Kootenai Basin; identify and develop appropriate HSI models to determine changing biological conditions as they relate to management activities, carrying capacity and associated ecological functions; and evaluate cumulative effects of management activities on vegetative growth, condition, and wildlife responses in the Kootenai River.
IDFG, BC MoE and Kootenai Tribe	Monitor and evaluate survival, condition, growth, movement, and habitat use of hatchery-reared juvenile Kootenai sturgeon released into the Kootenai River. In cooperation with IDFG and B.C. Ministry of Environment, the Tribe will sample juvenile Kootenai sturgeon to collect information pertaining to life history characteristics using gillnets, hoop-nets, and angling. It will conduct sonic tracking studies to determine movement and habitat use of juvenile Kootenai sturgeon. It will evaluate habitat characteristics in areas used by Kootenai sturgeon and identify habitat improvements opportunities and monitor and evaluate juvenile and adult Kootenai sturgeon and burbot in Kootenay Lake, B.C.
	Evaluate burbot movement, spawning, and recruitment through the use of hypothesis tests using scientific designs approved by the Kootenai River Burbot Recovery Committee. Evaluate the effect of winter hydro operations on the rate and timing of burbot spawning migration. IDFG will continue with a cooperative program with BC MoE sampling the Kootenai River and portions of Kootenay Lake in evaluation of the status of burbot.
IDFG	Monitor and evaluate the size structure of the burbot population in the Kootenai River and Kootenay Lake, including periodic estimates of population size of adult and juvenile burbot.
	Monitor and evaluate the blood levels of testosterone, plasma chloride, and Estradiol-17Β with respect to reproductive failure of burbot and compare their levels to a control population from Columbia Lake, B.C.
	With radio and sonic telemetry, monitor the timing of movement of adult Kootenai sturgeon each spring and measure response to flow augmentation and temperature. This effort will also collect information pertaining to life history characteristics.
	Deploy artificial substrate mats and monitor Kootenai sturgeon spawning events, locations, habitat (substrate, mid-column velocity, depth, and temperature), and intensity in response to experimental flows.
	Monitor and evaluate larval Kootenai sturgeon abundance/year class strength in response to experimental flows.
	Use small-mesh gillnets to monitor and evaluate wild and hatchery Kootenai sturgeon year class abundance, growth, relative weight, and survival in the Kootenai River.
	Conduct a creel survey on the Kootenai River in 2001 to determine species composition of the angler catch, harvest, and trout exploitation.
	Use radio telemetry to monitor the timing of movement and habitat preferences of adult redband and bull trout and document spawning locations in the mainstem Kootenai river and tributaries.
	Monitor and evaluate sources (tributary and main-stem) of redband, cutthroat, mountain whitefish, and bull trout recruitment with screw traps, drift nets, and by snorkeling.
	Using hypothesis testing, evaluate the availability of redband and bull trout spawning habitat and test the use of spawning habitat cribs to determine if habitat is a limiting factor to recruitment.
	Monitor the fish community, species composition, relative abundance, biomass, and trophic structure by electrofishing two, key large-scale index sites between rkm 246 and 276 and develop a database for future ecosystem rehabilitation studies.

Source: KTOI and MFWP 2004

4 Proposed Sturgeon Conservation Aquaculture Program

Chapter 4 provides a detailed description of the proposed sturgeon component of the Kootenai River Native Fish Conservation Aquaculture Program. Section 4.1 describes the current Kootenai sturgeon program components; Section 4.2 summarizes alternative program approaches that were considered by the Tribe; Section 4.3 describes the conceptual design of the proposed program; Section 4.4 lays out the Tribe's monitoring, evaluation and research program; Section 4.5 presents the fundamental components of an adaptive management plan; Section 4.6 summarizes program costs; and Section 4.7 assesses the consistency of the sturgeon program with the eight scientific principles of the NPCC Fish and Wildlife Program and other review criteria.

4.1 Description of Proposed Sturgeon Program

As described in Section 2.2, the Tribe's Kootenai sturgeon conservation aquaculture program was originally envisioned as a limited duration program to reestablish age classes absent in the natural population. The Tribe readily acknowledges that achieving long-term recovery of a naturally self-sustaining Kootenai sturgeon population will depend on restoration of habitats and an ecosystem capable of sustaining a natural population. In the short term, given the continued failure of all measures to restore natural recruitment, the hatchery program represents the sole demonstrated effective alternative for forestalling the otherwise imminent extinction of Kootenai sturgeon.

4.1.1 Purpose of and Need for Proposed Program

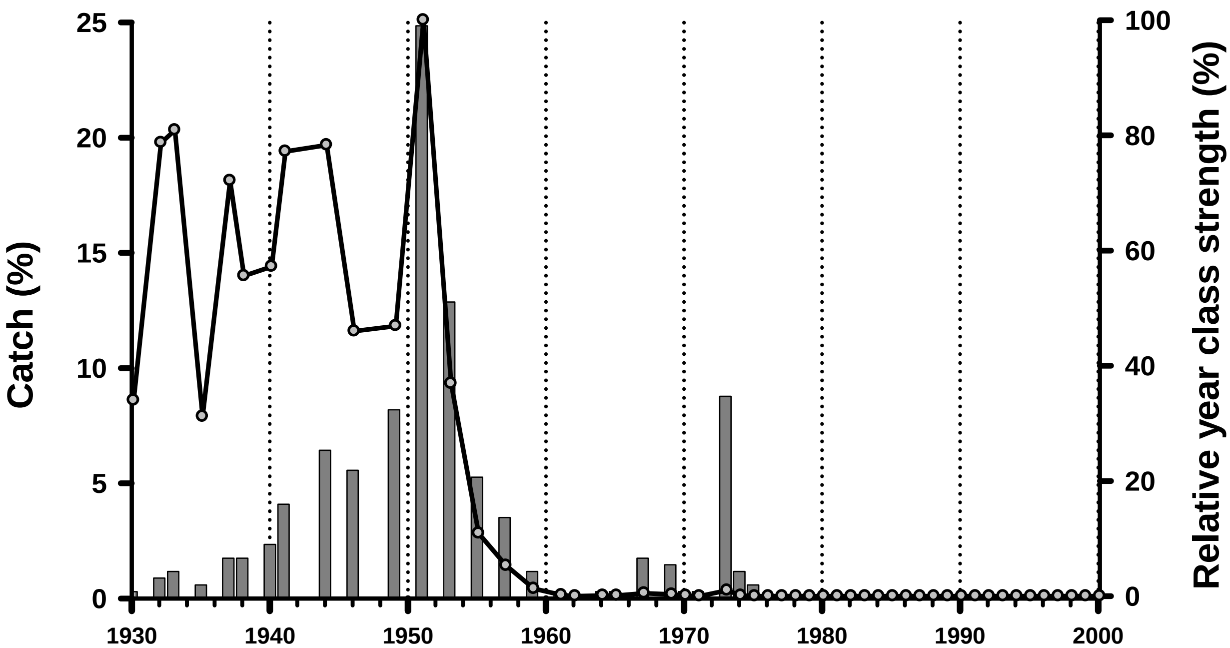
The purpose of the Tribe's Kootenai sturgeon aquaculture program is to prevent extinction, preserve the existing gene pool, and continue rebuilding a healthy age class structure for this endangered population using conservation aquaculture techniques with wild native broodstock. This program is intended to compliment other ecosystem-based habitat restoration activities in the Kootenai subbasin and is a necessary stop-gap measure while those restoration activities are designed, implemented, and have a chance to take effect.

Several factors support the need for the proposed program expansion and upgrades. These include: 1) the anticipated ongoing long-term need for the conservation aquaculture program in light of continued failure of natural recruitment; 2) biological and research objectives of the program; and 3) specific facility needs related to effective and efficient operations of the conservation aquaculture program.

4.1.1.1 Ongoing Need for Kootenai Sturgeon Conservation Aquaculture Program

Kootenai sturgeon were listed as endangered under the ESA in 1994. The USFWS recovery plan for Kootenai River white sturgeon, published in 1999, calls for implementation of conservation aquaculture to prevent extinction and provide recruitment. The Libby Dam BiOp also specifically acknowledges the need for continued operation of the Tribe's sturgeon aquaculture program in Reasonable and Prudent Action Component 4, and directs the action agencies (BPA and the USACE) to provide funding to expand adult holding and spawning capability at the Tribal Sturgeon Hatchery (USFWS 2006, clarified in 2008).

Healthy sturgeon populations are characterized by age-frequency distributions that include large numbers and percentages of juvenile and sub-adult fish, as well as stable age and length distributions that are skewed toward young fish. The lower Columbia River white sturgeon population (downstream from Bonneville Dam) is composed of >95% sexually immature fish and this population also sustains an annual harvest of 50,000 fish (DeVore et al. 1999). The age and length distributions of the Kootenai population are heavily skewed toward older fish. Approximately 90% of the fish are age 25 and older (BPA 1997; Paragamian et al. 2005). Limited year classes were produced during the early 1970s, but these were insufficient for population viability and persistence. Ongoing annual monitoring since the 1990s has confirmed that insufficient recruitment continues to threaten this population (Figure 4-1).



Source: Paragamian et al. 2005; KTOI 2008.

Figure 4-1. **Year-class frequency distribution (bars and left scale) and relative year-class strength (dots connected by lines and right scale) of Kootenai sturgeon captured from 1977-2000.**

The next 10-20 years will be a critical period for the future of sturgeon in the Kootenai River. There will be a significant bottleneck in spawner numbers as the wild population declines but hatchery fish are not yet mature (Figure 4-2). The remnant wild population is declining 4% per year with an approximate 14 year abundance halving time (Beamesderfer et al. 2009). Female Kootenai sturgeon begin maturing around 30 years of age and so the first hatchery-reared fish from releases in the early 1990s will begin reaching maturity around 2020. In the interim, the wild population will reach critically low levels where normal population processes begin to break down on the final slide into extinction (i.e., the "extinction vortex" described by Gilpin and Soule 1986).

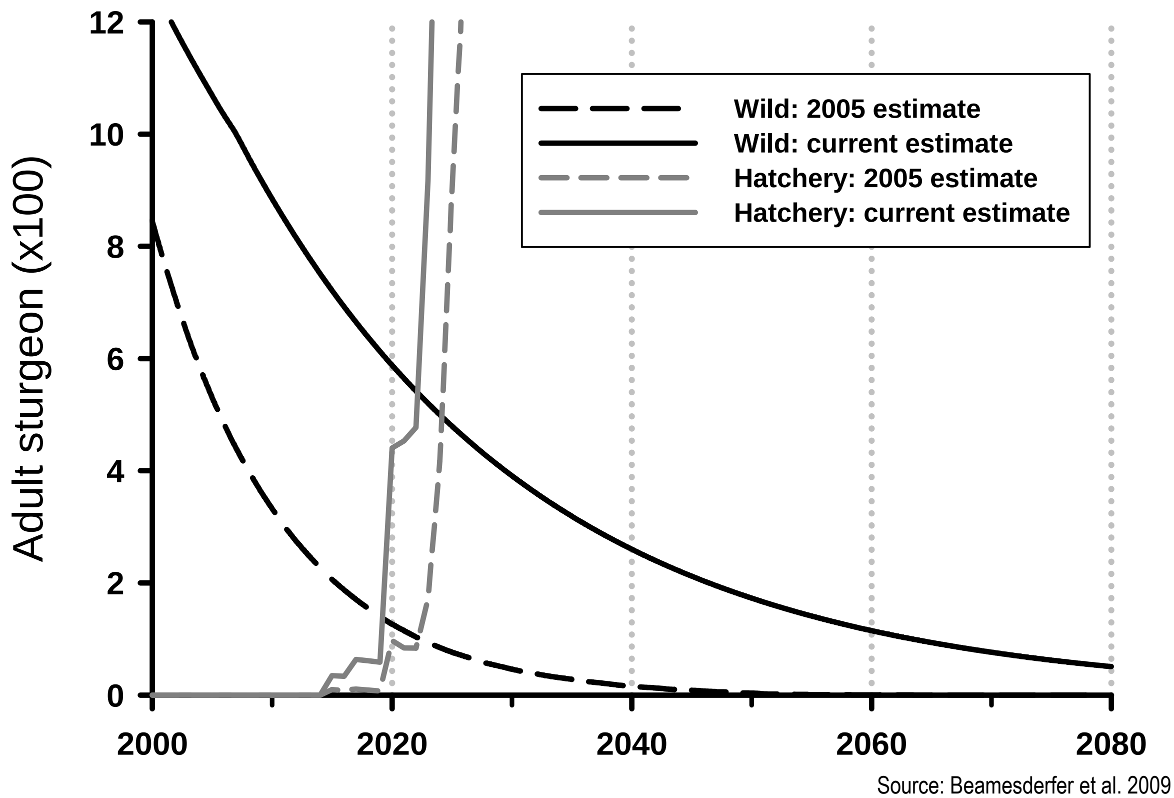


Figure 4-2. Model-projected estimates of wild and hatchery adult Kootenai sturgeon population sizes based on 2005 and 2009 analyses.

Based on these data, it is clear that some combination of limiting factors from pre- and post-Libby Dam periods appears to be responsible for natural recruitment failure (Section 3.1.9 includes a brief summary of recruitment failure hypotheses, Appendix B provides additional discussion). The Tribe acknowledges that prospects for achieving long-term recovery of a naturally self-sustaining population remain uncertain and that the ultimate success of recovery efforts requires restoration of habitats and an ecosystem capable of sustaining a natural population. Meanwhile, given the continued failure of measures to restore natural recruitment, the conservation aquaculture program represents the sole demonstrated effective alternative for forestalling extinction of Kootenai sturgeon.

4.1.1.2 Need for Program Expansion and Facilities to Meet Biological and Research Objectives

While it is uncertain which recruitment failure hypothesis may underlie the current demographic condition of Kootenai sturgeon, the proposed aquaculture program will continue to contribute to restoring and protecting the remaining population's genetic and demographic variability.

Given the demographic trends and the severity and spatial extent of degraded habitat, the proposed conservation aquaculture program may also be needed in the medium and longer term. If the genetically effective size of the Kootenai sturgeon population is enhanced and environmental limitations are resolved, natural production may contribute to a restored population.

Absent natural recruitment and the loss of the remnant wild spawner population, it will be at least 20 years before more spawners are available (from the 1990 Tribal sturgeon hatchery releases). Empirical population data suggest that female Kootenai sturgeon require up to 25 or 30 years to become sexually mature, while males mature at 15 to 20 years of age. This prolonged period for recruitment into the adult population is reflected in the modeled abundance curves for hatchery-produced juveniles (Figure 4-2).

Additional rearing space is needed to increase production of Age 1+ fish, which Tribal studies indicate have much higher survival rates at release than younger fish (Beamesderfer et al. 2009; Justice et al. 2009). Space is limited at the Tribal Sturgeon Hatchery where there is no capacity for expansion. Additionally, the Twin Rivers Hatchery site, approximately 15 miles upstream of Bonners Ferry, is located closer to spawning and incubation habitat that currently has more suitable attributes. The Twin Rivers location would allow fish to imprint on and home to waters near this higher quality habitat, thus addressing one of the possible causes of Kootenai sturgeon recruitment failure. Moreover, this site also offers high quality groundwater and adequate space for adult spawning (including space to test multi-purpose spawning channels), expanded rearing, live feed production and all necessary support facilities.

Figure 4-7 illustrates the need for additional facilities to increase the number of wild broodstock that can be propagated. It shows that adding the proposed facilities would increase broodstock projections from 746 to 986, which is very close to the optimal target of >1,000 spawners. Figure 4-3 illustrates the effects of additional facilities on future numbers of hatchery-origin juveniles and adults. These projections assume that additional facilities would increase juvenile production from the current capacity of about 18,000 to about 40,000 age 1 sturgeon per year for a 10-year period before reverting back to an 18,000 fish-per-year production level. Assumptions used in these projections are that broodstock would continue to be available for an indefinite period to support a base production level of 18,000 fish per year, broodstock would begin to constrain production within 10-20 years, and that broodstock would become unavailable thereafter. A range of survival uncertainties are depicted, from 15% for small fish up to 60% as seen in early years of the program. Example analyses highlight the sensitivity of future population projections to a variety of assumptions.

In addition to preservation/conservation purposes, the proposed program also addresses research needs that directly contribute to restoration, mitigation, and augmentation. The hatchery program provides fish for experimental use in estimating natural production rates and in identifying factors limiting early life survival. Reintroducing Kootenai sturgeon to reaches that currently offer suitable habitat will also be tested using two remote incubation and rearing facilities. Specific locations for deployment will be determined in subsequent planning phases. The basis for site selection will be the presence of high quality habitat that is also accessible for installation of the portable facilities. Operational monitoring will seek to address uncertainties about sturgeon behavior, the effects of hatchery effluent on the selection of spawning sites, and to imprint fish to the waters of little or underutilized reaches. The Tribe's ongoing Kootenai sturgeon program has pioneered methods for producing white sturgeon for release to the wild (KTOI 2008). Lessons learned and methods developed have contributed to other white sturgeon conservation aquaculture programs in the Columbia River Basin and beyond.

Use of the proposed program for augmentation purposes may also be feasible if the Kootenai Tribe's habitat restoration efforts are successful. The NPPC defined restoration as the use of artificial production to speed or "jump-start" recovery of natural populations, especially to achieve a harvestable population size. A restoration program assumes a population is reduced or eliminated by habitat degradation or other effects (e.g., overharvest), but that the problem is being corrected and the existing biological system will be capable of sustaining natural production.

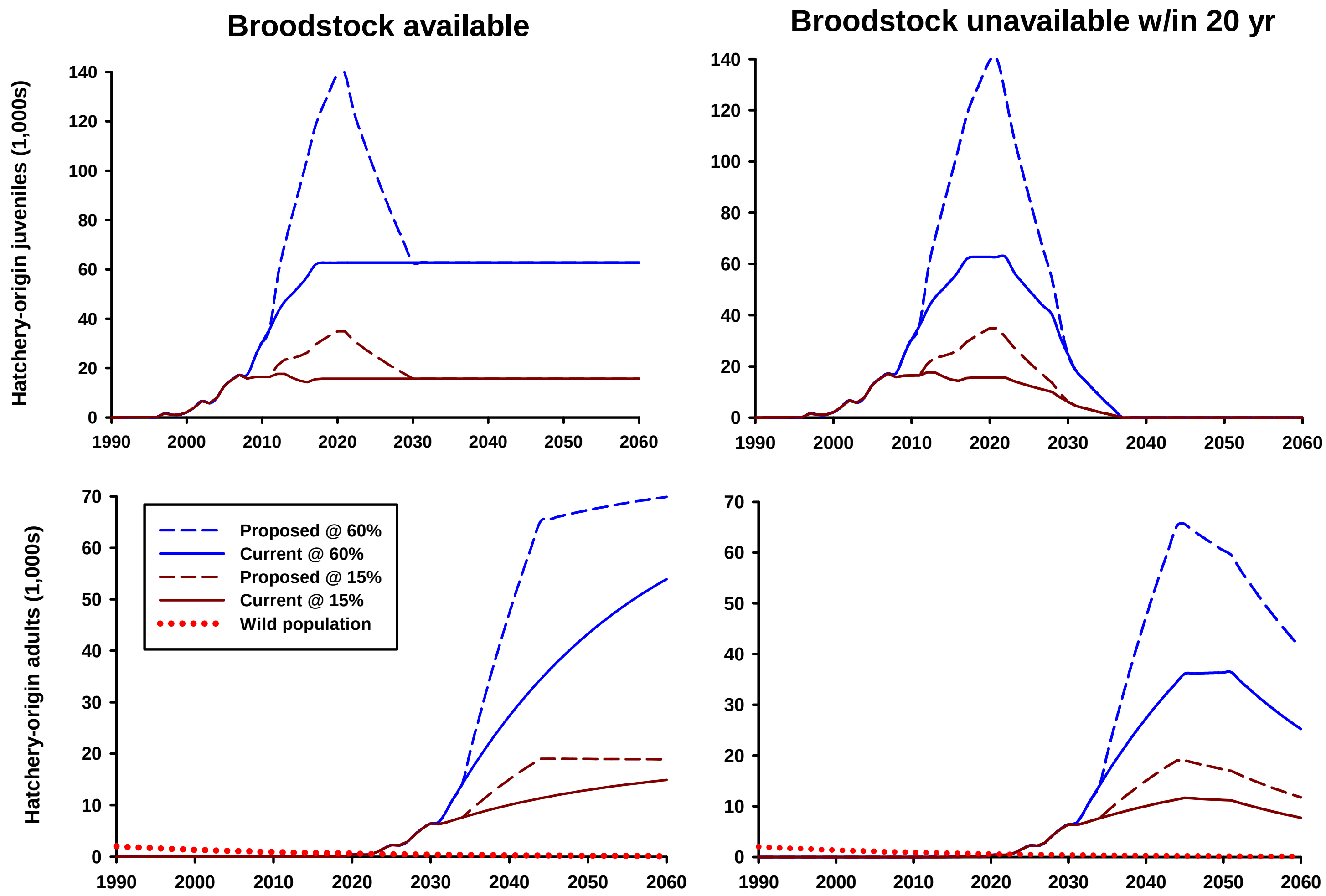


Figure 4-3. **Projected numbers of hatchery-origin juveniles (ages 1-10) and adults (ages 25+) under various assumptions including post-release first year survival (15% or 60%) and the long-term availability of wild broodstock (indefinite or 20 years only).**

4.1.1.3 Need for Facility Upgrades and Program Expansion

The Tribal Sturgeon Hatchery has several significant shortcomings that would be addressed by the proposed improvements and expansion. As described above, facility limitations have hampered the Tribes' ability to meet biological and population objectives.

In particular, the ability to meet production objectives has been limited by available rearing space. In attempting to meet objectives with limited facilities, high rearing densities have contributed to unacceptably high mortality, an effect exacerbated by high summer water temperatures. Assessments of population status (KTOI 2004, Paragamian et al. 2005, Beamesderfer et al. 2009) and release size experiments (Justice et al. 2009) indicated that the current Tribal Sturgeon Hatchery lacks adequate rearing space to meet stocking goals developed to address the current low population size. Facility expansion will enable more fish to be reared to Age 1+ (optimizing survival rates upon release to the river) in temperature and density conditions that optimize in-hatchery survival. Additional rearing space would also improve fish health by reducing density-related pathogen transmission (LaPatra et al. 1994).

Separation of sturgeon progeny groups (families) is needed in the hatchery to maintain distinct family lineages until the fish are large enough to permanently mark with PIT-tags. Markings identify each fish by their family and are a tool to avoid mating siblings in the hatchery when they are recaptured as broodstock for future breeding.

Expansion of the program to a new facility at Twin Rivers would:

- Provide capacity to meet revised program goals and provide flexibility for future adaptive management of the program
- Provide additional space to expand Kootenai sturgeon rearing capacity, while also ensuring low rearing densities, and allowing for greater segregation of fish families
- Encourage fish to imprint and home on waters farther upstream where more suitable spawning and incubation habitat currently exists
- Provide flexible facilities that can accommodate aquaculture research, allow for some adaptive program modification as needed, and provide efficient fish production to support restoration efforts.

An additional consideration for expanding the program to Twin Rivers is water supply. Although recent system upgrades at the Tribal Sturgeon Hatchery have improved sediment and temperature controls, inadequate supply coupled with limited physical space still limits facility expansion here. Adequate high quality ground and surface water is a critical attribute available at the Twin Rivers site, where hydrogeologic investigations indicate there is adequate groundwater to supply the critical life stages of Kootenai sturgeon. Surface supplies from the Kootenai and Moyie rivers together are expected to fulfill the needs of all life stages.

Habitat in the Kootenai River near the confluence with the Moyie and in reaches upstream is thought to offer higher quality spawning and rearing habitat for sturgeon than is present in the vicinity of the Tribal sturgeon hatchery. By rearing fish on waters of the Moyie combined with flows from Kootenai River, it is expected that fish will home to these reaches with more suitable habitat conditions for successful natural spawning and rearing.

There is insufficient physical space to conduct fundamental and basic behavioral and reproductive research on Kootenai sturgeon at the Tribal Sturgeon Hatchery. Such research would be possible with development of the spawning channels and rearing ponds at Twin River Hatchery.

Kootenai sturgeon broodstock being transferred from the river to the Tribal sturgeon hatchery are currently carried on stretchers up a very steep grated walkway. While handling protocols seek to reduce stress on the fish, it is a difficult process for both the fish and their human handlers. Proposed upgrades would include a mechanized transport device that would allow a large fish to be moved in water with less stress and with greater safety for hatchery workers.

4.1.2 Kootenai Sturgeon Program Strategies, Production Targets, and Biological Objectives

4.1.2.1 Production Strategies

Because of their very long life span and late age of maturation, sturgeon conservation work demands a very measured consideration of time. The Tribe's hatchery production strategies therefore take both a near-term and long-term approach. It is not simply a case of establishing annual production targets and protocols, or identifying the future population goals and then backcalculating annual release numbers required to produce that number of fish. Hatchery priorities, strategies, and production targets will change over time based on temporal risk patterns, actions needed to address immediate risks, and actions designed to anticipate future risks.

The definition of production targets is complicated by the need to balance competing risks and objectives over time. Strategies to address specific objectives often provide competing direction. For example, the risk of genetic bottlenecks or founder effects in the current generation is addressed by the strategy of maximizing the number of broodstock incorporated into the program. The need to reduce the coming interval of adult scarcity and risks of having too few broodstock to support production during that interval argues for a front-loaded production strategy of large releases as a contingency for future uncertainty. However, large numbers of broodstock produce large numbers of offspring that potentially exceed the habitat rearing capacity and increase risks of competition with any wild fish that are produced. Numbers might be reduced by culling to a smaller family release target, but any kind of reduction risks inadvertent selection or loss of some of the very diversity that the program is intended to propagate. Consistent releases of small family sizes also increase the likelihood that too few progeny might survive to spawn in the next generation, which would fail to meet program objectives and simply delay the recruitment bottleneck extinction risk.

To address program objectives and future desired population conditions for endangered Kootenai sturgeon, this program is organized into three sequential strategic phases based on program scope and period-specific objectives:

1. **Developmental Phase**. This phase spanned the first two decades of the program from inception in 1988 until about 2008. The program started as a very basic experimental facility designed to address critical uncertainties and limiting factors, to assess gamete viability, and to explore the feasibility of sturgeon aquaculture as a conservation management tool. Program objectives and facilities evolved following the initial success of sturgeon propagation and stocking, and the recognition of the need to artificially supplement ongoing natural recruitment failure.

2. Preservation Phase. This phase began in the last few years with the recognition that the next sturgeon generation will be produced primarily by the hatchery. The preservation phase will extend for the next 10-20 years during which the remnant wild population will gradually dwindle and disappear. Wild broodstock are expected to be available for at least the immediate future to support aquaculture; however, the duration of future broodstock availability is uncertain. During this period, the driving objectives are to capture a representative portion of the native genetic diversity and propagate it in such a manner that can effectively sustain the next generation of adults, whether they may spawn in the wild or in the hatchery. It is these objectives that determine the need for the new facilities identified in this Master Plan. The preservation phase will coincide with implementation of extensive habitat restoration actions in the Kootenai River during the next 10-15+ years.

3. Adaptive Management Phase. The future of the program beyond the next 10-20 years will be determined by events as they unfold and will be adaptively managed. We know that by that time, most of the wild fish will have died, wild hatchery broodstock will become increasingly scarce, and the oldest hatchery fish will begin to reach maturity. We don't know how quickly any of these events will unfold or what other surprises we will encounter along the way. Precautionary actions during the preservation phase are key to providing a firm foundation for the adaptive management phase. The adaptive management phase will coincide and coordinate with adaptive management of Kootenai River habitat restoration actions.

Production targets identified in the Master Plan are designed to ensure that immediate preservation objectives are met while balancing considerations of longer term risks. Targets for total broodstock, family size, fish size at release, and total releases (Table 4-1) are derived from a series of quantitative analyses tailored to address specific short- and long-term risks. The basis for these targets is described in the following sections.

Table 4-1. Production targets of facilities described in the Master Plan.

	Target	Focus
Broodstock Number	>500 (minimum) >1000 (optimum)	Preserve existing diversity
Families produced	Up to 40/year	Near-term precaution for future uncertainty
Fish / family	1,000 - 1,500	Perpetuate diversity through the next generation
Size at release	30 grams (avg.)	Optimize survival/selection balance
Total releases / year	20,000 – 40,000	Balance demographic objectives & risks

4.1.2.1 Broodstock/Family Number

Broodstock and family number targets were established to address the near-term objective of preserving native genetic and life history diversity by capturing and spawning significant numbers of representative broodstock. The future program objective reflected in the Master Plan is to increase the production targets from the current level of 12-18 families[10] per year to up

[10] A family is defined as the offspring from one pair of parents. Families from one female and one male are referred to as full-sibling families. Families from the same female and different males are referred to as half-sibling families. The Kootenai program typically divides the eggs from individual females into separate lots which are fertilized with milt from different males in order to maximize fertilization, survival and genetic contribution.

to 40 families per year to achieve an optimum effective population size (N_e) in the hatchery of at least 1,000 broodstock over a generation.

For hatchery planning purposes, broodstock targets from the current wild population were established at >500 (minimum) and >1,000 (optimum) (Table 4-1). With the typical 1 female: 2 male spawning matrix, the target corresponds to approximately 1,000-2,000 half-sibling families. Minimum and optimum targets are identified because the scientific literature does not provide clear guidance on what effective population sizes are necessary to represent normal population diversity.

Numbers needed to meet long-term genetic conservation objectives are currently uncertain. Most literature values are based on relatively simple genetic population models with unclear transferability to natural populations. The minimum 500 fish target was based on recommendations by Thompson (1991) corresponding to an effective population size adequate to preserve genetic diversity including rare alleles. However, effective population size (N_e) is defined as a theoretical population where every individual has the opportunity to mate with every other. Therefore, significantly greater census population sizes are needed to provide the same level of protection in a natural population where mating is obviously non-random, especially in severely altered ecosystems like the Kootenai River where reduced population abundance and altered habitat conditions further limit natural production. The number of breeders in a population in a given year (N_b) is a subset of the total or census population (N), and the effective population is the successfully reproducing subset of N_b. Furthermore, additional loss of individuals occurs due to mortality between spawning and survival to sexual maturity.

Therefore, this optimum fish target of >1,000 reflects the need for a census population size substantially greater than the theoretical N_e. For context, these targets are only 20-40% of the working recovery goal of 2,500, about 5-10% of the historical population size, but only 50-100% of the current population estimate. It is not possible to capture and spawn every remaining wild fish in the hatchery. However, the proposed precautionary approach will involve propagating as many of these wild fish as possible during the next decade or more to maximize N_e and the amount of genetic diversity available for subsequent generations.

The Tribe's conservation strategy places a very high priority on preserving diversity over the near-term in order to preserve the long-term viability and adaptive potential or plasticity of the population.[11] For the aquaculture program, this involves both capturing representative diversity from the remaining population and ensuring that enough diversity is propagated to prevent a bottleneck in the next generation. In simplistic terms, the effective population size is rapidly reduced in successive generations when only a portion of the adult population is able to spawn effectively (Figure 4-4). Chances of a second generation founder effect would be substantially increased by low initial hatchery numbers, low future broodstock sample rates, or low natural spawning frequencies. The dynamics of actual population genetics are likely much more complicated than this simple example illustrates. On the one hand, many individuals in the population share common alleles. On the other hand, expression of individual variation through recombination and intergenerational and communal spawning work to maintain the spectrum of

[11] It is important to keep in mind that conservation aquaculture is only one component of the overall sturgeon recovery strategy. In light of the failure of flow-only mechanisms to restore natural recruitment, there is increased motivation to implement the Tribe's comprehensive ecosystem-based habitat restoration program, and to continue the efforts of ongoing Tribal programs. These include the Tribe's tributary restoration work and nutrient restoration program. It will take these collective efforts to restore the pervasive habitat degradation that has occurred over the last century in the Kootenai River ecosystem.

traits that helps sustain population viability in the face of habitat and environmental conditions. However, the magnitude, severity, and duration of anthropogenic disturbance in the Kootenai River continues to jeopardize population restoration by natural production.

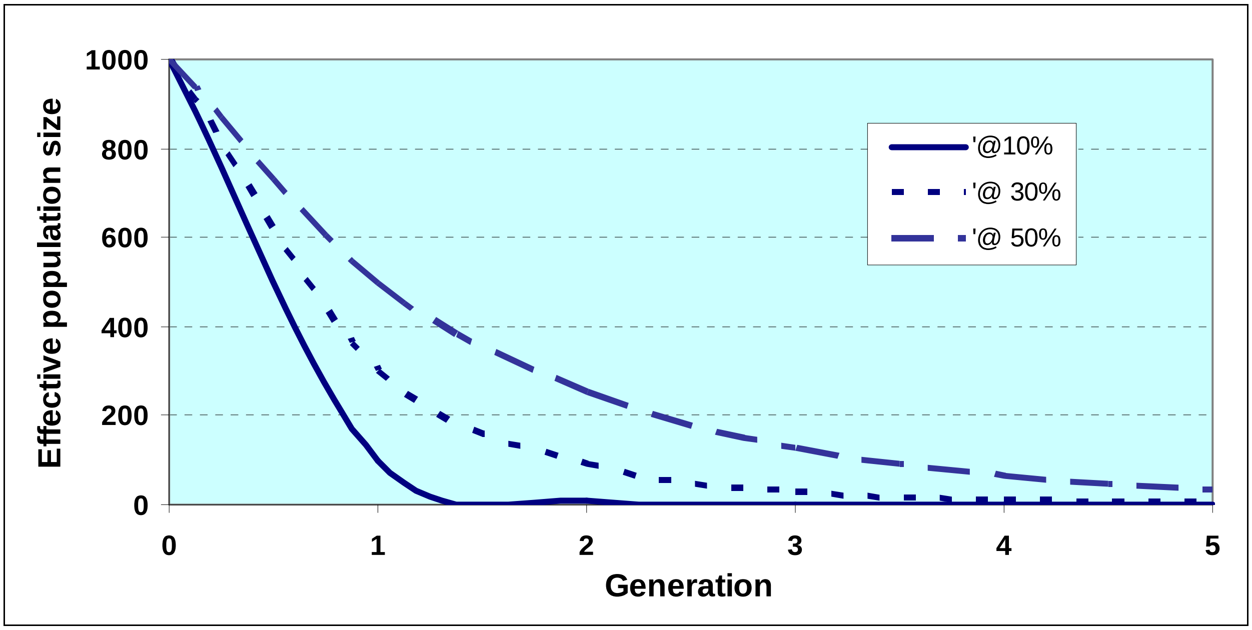


Figure 4-4. **Theoretical reduction in effective population size over generations based on the proportion of the available adults that reproduce effectively.**

Furthermore, because sturgeon genetic population dynamics are still not that well understood, the conservation aquaculture program has elected to take the precaution of targeting a relatively large number of broodstock. Any locally adapted genetic material not incorporated by wild broodstock would be permanently lost because all future populations will be founded by the current contributing wild broodstock. There will be no second chances in this population if we fail to take advantage of opportunity afforded by incorporating the remaining wild spawners into the program.

Another way to look at the multi-generation aspects of the limitations imposed by the hatchery production capacity is to consider the effective population size in relation to sturgeon generation time and annual broodstock numbers. At a sturgeon generation time of 25 years, annual production of 20 adults will result in an effective broodstock population size of just 500 fish during that period (Figure 4-5). Forty spawners would be needed per year to meet a 1,000 fish target within a 25-year period.

Increasing demands of the aquaculture program due to the continuing natural recruitment failure explain the large increases in broodstock and family targets relative to those initially identified by Kincaid (1993). Kincaid developed initial program targets of 3 to 9 females spawned with an equal number of males to produce 4 to 12 families annually for 20 years, targeting an effective population size of 200 fish (10 per year), and an assumption that natural recruitment would be restored during those 20 years (1994-2013). These targets were designed to approximate a normal expanding natural population and to avoid exaggerated genetic contributions of a small fraction of the parent population from the hatchery to the natural population (Kincaid 1993). However, since the conservation aquaculture program was initiated the 1990s, natural recruitment has not increased and annual recruitment failure continues into its fifth decade.

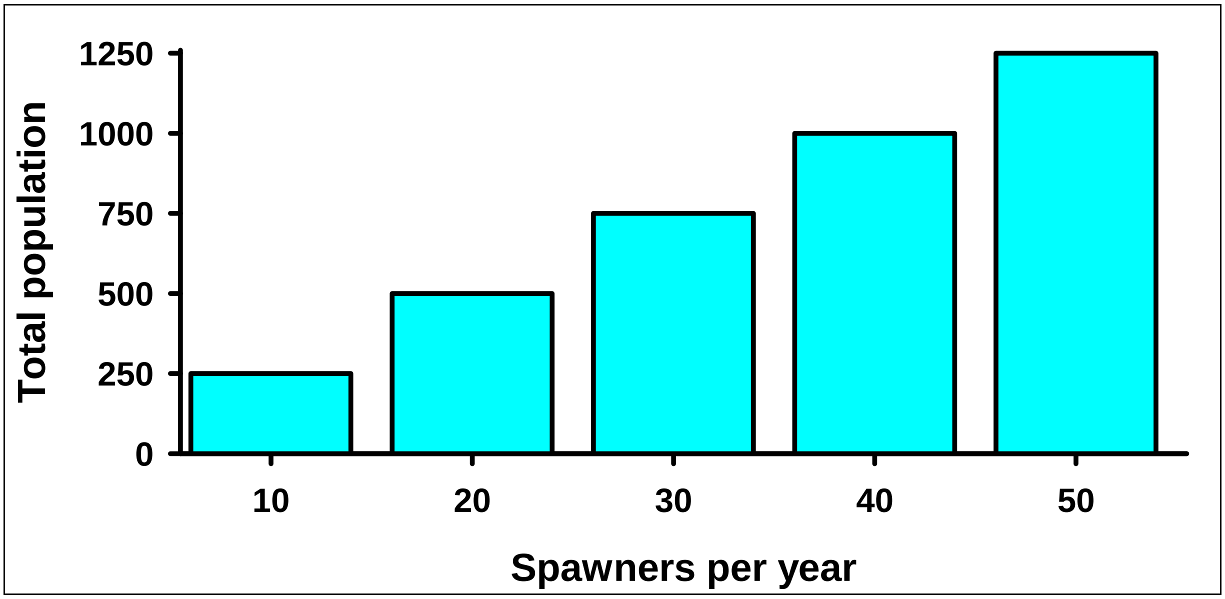


Figure 4-5. **Estimated founder broodstock population size in a 25-year sturgeon generation in relation to annual numbers.**

The need to increase broodstock and family numbers is driven by concerns regarding the limited and dwindling broodstock availability period, uncertainty in the effective reproduction lifespan of the very old fish that comprise the remaining population, and difficulties handling very large fish. The recovery strategy involves front-loading production over the next decade while significant numbers of wild broodstock are available. Front-loading broodstock is a strategy that recognizes the need to provide contingencies against future uncertainties. As the sturgeon population continues to decline, it is likely that it will be increasingly difficult to collect broodstock. Broodstock availability will be further constrained because as more and more fish from the shrinking population are used for broodstock, previously-used broodstock will comprise an increasing proportion of the available catch in annual collection efforts. Current broodstock collection practices use only fish that have not been previously spawned[12]. New individuals are the preferred source for broodstock in order to maximize the number of remaining fish that have contributed via the hatchery to the next generation.

The 40 families per year goal will not be met every year because it depends on the success in capturing ripe fish for spawning. The average family number is expected to be less, particularly beginning 10-20 years hence. However, a front-loaded strategy requires maximum hatchery production rather than average production. This is one of many reasons the proposed new hatchery facility is needed at Twin Rivers.

From 1990 through 2009, 249 wild broodstock have been spawned (171 males and 78 females), producing 156 full or half-sibling families (Table 4-2). Annual broodstock numbers averaged 6.5 per year from 1995-1998 following adoption of the Kincaid plan, 14.8 per year from 1999 to 2004 following the 1999 upgrade of the Tribal Sturgeon Hatchery and the involvement of facilities in British Columbia, and 24.2 per year since 2005 when targets were increased to the capacity of the existing facilities in response to continuing recruitment failure. Current production capacity of the combined Tribal Sturgeon Hatchery and the Kootenay Sturgeon Hatchery in British Columbia

[12] Only one female has been spawned twice in the history of the program. At the point where previously un-spawned ripe females are no longer available, females will be reused by spawning with new males. Ripe males are not typically in short supply.

is 12-18 families per year, with up to 5 families currently produced annually at the B.C. facility. The Master Plan calls for a total production capacity of 40 families per year in the existing Tribal Sturgeon Hatchery and new Twin Rivers facility to maximize use of remnant locally adapted genetic material, including continued production of up to 5 families annually at the Kootenay Sturgeon Hatchery in B.C.

Actual genetic effective population sizes (N_e)[13] of broodstock used to date were estimated in Table 4-2. Annual effective population size ranged from 2 to 24.4 fish from 1990 through 2009 (shaded cells in Table 4-3). Annual N_e values increased as the program and facilities were refined, averaging 2.7 fish for 1990 through 1995, 8.9 fish from 1996 through 2000, and 18.5 fish from 2001 through 2009. The cumulative total of 208 fish was less than the actual broodstock contribution of 249 fish because of the production of half-sibling families.[14]

[13] The effective breeding number (Ne) for a population is the number of individuals in a random breeding population with an equal sex ratio, which would yield the same rate of inbreeding or genetic drift as the population being studied (Falconer 1981; Kincaid 1993): Ne = 4 X (Nm~ x Nf/)/ (Nm +NF). This formula calculates the Ne (effective population size) for populations produced from random mating of Nm male parents and Nf female parents. Ideally, Ne is calculated from counts of the actual number of parents that contribute progeny to the next broodstock generation. Because the actual number of individuals contributing progeny to the next generation and the number of progeny each contributes is unknown in most populations, the number of individuals that spawn and produce progeny is used in the calculation, i.e., the total number of fish spawned of each sex. For animal species with multi-year generation intervals, Ne is calculated using the sum of all males (Nm) and females (Nf) spawning each year for the number of years in the generation interval adjusted by any difference in sex ratio and the number of individuals that spawn more than once per generation. The generation interval is defined as the average age of females at first maturity, or about 20 years for the Kootenai River white sturgeon. The Ne will be the total of all spawners (different fish spawned) over the 20-year generation interval.

[14] While production of half-sibling families marginally reduces the calculated effective population size, it also reduces the chances that the contribution from any given female will be lost due to low fertilization rates from a particular male.

Table 4-2. Summary of broodstock, egg take, and spawning success.

	Males	Females		Families	Egg take (thousands)			Egg-larval Survival		Effective Population	
Year	Brood	Held	Brood	Produced	Total	Mean	Range	Mean	Range	Annual	Cumulative
1990	1	1	1	1	60 [a]	60	--	2%	--	2.0	2
1991	3[e]	2	1	1	69 [a]	69	--	20%	--	3.0	5
1992	3 [f]	2	1	3	142 [a]	142	--	16%	na	3.0	8
1993	2	2	1	2	86 [ab]	86	--	21%	na	2.7	10.7
1994	0[g]	0[g]	0[g]	0[g]	0	--	--	--	--	0.0	10.7
1995	4	2	2	4	143 [b]	71	71–72	28%	--	5.3	16
1996	2	2	1	2	62 [b]	62	--	<1% [h]	--	2.7	18.7
1997 [i]	5	4	3	6	201 [b]	67	40–97	30%	na	7.5	26.2
1998	6	3	3	6	217 [b]	72	60–92	28%	na	8.0	34.2
1999	8	5	4	8	277 [bcd]	69	38–105	63%	40–80%	10.7	44.9
2000	11	6	6	11	306 [bcd]	51	17–112	73%	25–92%	15.5	60.4
2001	10	8	5	10	294 [bcd]	59	51–69	70%	35–86%	13.3	73.7
2002	9	6	3	9	151 [bcd]	50	34–62	86%	50–97%	9.0	82.7
2003	13	8	4	13	246 [bcd]	61	56–74	93%	85–99%	12.2	94.9
2004	11	13	5 [j]	17	369 [bcd]	74	60–98	81%	15–95%	13.8	108.7
2005	14	13	6[k]	16	1,163 [bcd]	108	17–255	78%	15–97%	16.8	125.5
2006	15	11	7	11 [l]	790 [bcd]	113	54-164	88%	66-100%	19.1	144.6
2007	18	8	5	18	289	58	38-85	94%	72-98%	15.7	160.3
2008	19	12	11	17	1,070	97	53-162	89%	60-99%	24.4	184.7
2009	17	11	9	12	1,025	114	70-179	95%	60-99%	23.5	208.2
Total	171	119	78	156	6,960	78	17-255	61%	15-100%		

[a] Eggs collected by c-section
[b] Eggs collected by hand stripping
[c] Portion of egg take incubated at Tribal Sturgeon Hatchery
[d] Portion of egg take used for research purpose
[e] Sperm from 3 males pooled
[f] Eggs fertilized separately from each male
[g] No fish handled due to ESA listing
[h] Low success due to low gamete quality
[i] No survivors to release due to facility failure
[j] 3 females transported upriver, 5 females released unspawned
[k] 5 of 11 females spawned successfully were used only for egg outplants. 5 additional families were produced for experimental river releases
[l] 5 additional families were produced for experimental river releases

Table 4-3. Effective population size (N_e) from annual spawning (1990-2009) of Kootenai sturgeon.

Ne		Number of Female Parents											
		1	2	3	4	5	6	7	8	9	10	11	12
Number of Male Parents	1	2.0 1990	2.7	3.0	3.2	3.3	3.4	3.5	3.6	3.6	3.6	3.7	3.7
	2	2.7 (93,96)	4.0	4.8	5.3	5.7	6.0	6.2	6.4	6.5	6.7	6.8	6.9
	3	3.0 (91 92)	4.8	6.0	6.9	7.5	8.0	8.4	8.7	9.0	9.2	9.4	9.6
	4	3.2	5.3 1995	6.9	8.0	8.9	9.6	10.2	10.7	11.1	11.4	11.7	12.0
	5	3.3	5.7	7.5 1997	8.9	10.0	10.9	11.7	12.3	12.9	13.3	13.8	14.1
	6	3.4	6.0	8 1998	9.6	10.9	12.0	12.9	13.7	14.4	15.0	15.5	16.0
	7	3.5	6.2	8.4	10.2	11.7	12.9	14.0	14.9	15.7	16.5	17.1	17.7
	8	3.6	6.4	8.7	10.7 1999	12.3	13.7	14.9	16.0	16.9	17.8	18.5	19.1
	9	3.6	6.5	9.0 2002	11.1	12.9	14.4	15.7	16.9	18.0	19.0	19.8	20.6
	10	3.6	6.7	9.2	11.4	13.3 2001	15.0	16.5	17.8	19.0	20.0	21.0	21.8
	11	3.7	6.8	9.4	11.7	13.8 2004	15.5 2000	17.1	18.5	19.8	20.6	22.0	23.0
	12	3.7	6.9	9.5	12.0	14.1	16.0	17.7	19.1 2006	20.6	21.8	23.0	24.0
	13	3.7	6.9	9.8	12.2 2003	14.4	16.4	18.2	19.8	21.3	22.6	23.8	25.0
	14	3.7	7.0	9.9	12.4	14.7	16.8 2005	18.7	20.4	21.9	23.3	24.6	25.8
	15	3.8	7.1	10.0	12.6	15.0	17.1	19.1	20.9	22.5	24.0	25.4	26.7
	16	3.8	7.1	10.1	12.8	15.2	17.5	19.5	21.3	23.0	24.6	26.1	27.4
	17	3.8	7.2	10.2	13.0	15.5	17.7	19.8	21.8	23.5 2009	25.2	26.7	28.1
	18	3.8	7.2	10.3	13.1	15.7 2007	18.0	20.2	22.2	24.0	25.7	27.3	28.8
	19	3.8	7.2	10.4	13.2	15.8	18.2	20.5	22.5	24.4 2008	26.2	27.9	29.4
	20	3.8	7.3	10.4	13.3	16.0	18.5	20.7	22.9	24.8	26.7	28.4	30.0

Note: Shaded areas represent the effective population size for each year.

4.1.2.2 *Maintaining Genetic Diversity*

Genetic analysis of wild Kootenai River white sturgeon broodstock and juveniles provides a population-level indicator of how well the program is incorporating wild population genetic attributes into the next generation. Genetic variability (frequency distribution of alleles) and genetic diversity (total number of different alleles) is monitored annually (Figure 4-6). All broodstock spawned and all progeny groups produced in the hatchery are analyzed using microsatellite DNA methods that have become widely used for many conservation and management applications due to their high resolution and highly variable nature (McQuown et al. 2000; Rodzen and May 2002; Rodzen et al. 2004; Drauch and May 2007, 2008, 2009). Recent microsatellite analysis revealed that the wild Kootenai River sturgeon population has 52 alleles, which is approximately 25 to 50% less diverse than eight other North American white sturgeon populations (Rodzen et al. 2004).

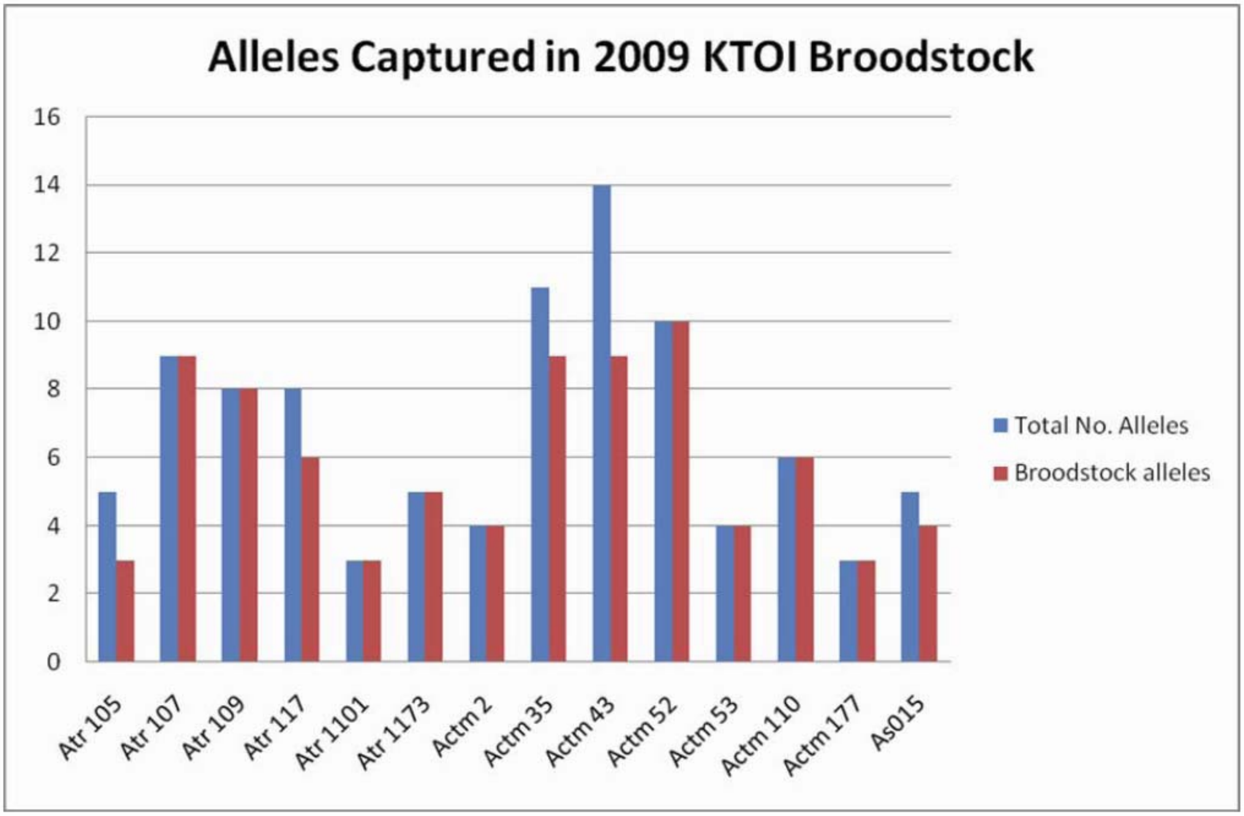


Figure 4-6. Example of the representation of population genetic diversity among Kootenai sturgeon broodstock (Drauch and May 2009).

This is not surprising given that the Kootenai population is a headwater population at the edge of the species' geographic range that has likely experienced a natural loss of rare alleles since post-Pleistocene refounding due to genetic drift. Further artificial loss of native diversity has occurred due to recent anthropogenic demographic and associated genetic bottlenecks. However, from 80 to 90% of all identified extant alleles have been incorporated into the hatchery broodstock groups annually from 2004 through 2009 (Drauch and May 2007, 2008, 2009), with over 95% of all wild population alleles incorporated into the broodstock during the 20 years of program operation (1991 through 2009) (pers. comm. Andrea Drauch, UC Davis Genomic Variation Lab).

Thus, long-term program success and the population's ability to be viable and persistent beyond the next generation depends on whether the remaining variability (i.e., that captured in the current program during the next 20 or so years) is adequate. These questions will ultimately be answered at that time. Meanwhile, incorporating as much of the extant remnant genetic variability as possible during the next 20 years, or until wild broodstock from the current generation are longer available, will maximize the likelihood of future population viability and persistence, and the success of the program.

In order to help illustrate the need for the enhanced hatchery capacity proposed in this Master Plan, we provide a projection of the total wild broodstock numbers at the current hatchery capacity and with the expanded capacity (Figure 4-7). Projections with the current capacity assume that the recent average number of wild broodstock (24 per year) will continue to be available for the next 20 years and that previously-unspawned individuals would continue to be available during this interval. A total of 746 broodstock would be used by 2030 at the current facility capacity. This number exceeds the minimum target of 500 spawners but is substantially less than the optimal target of >1,000 spawners.

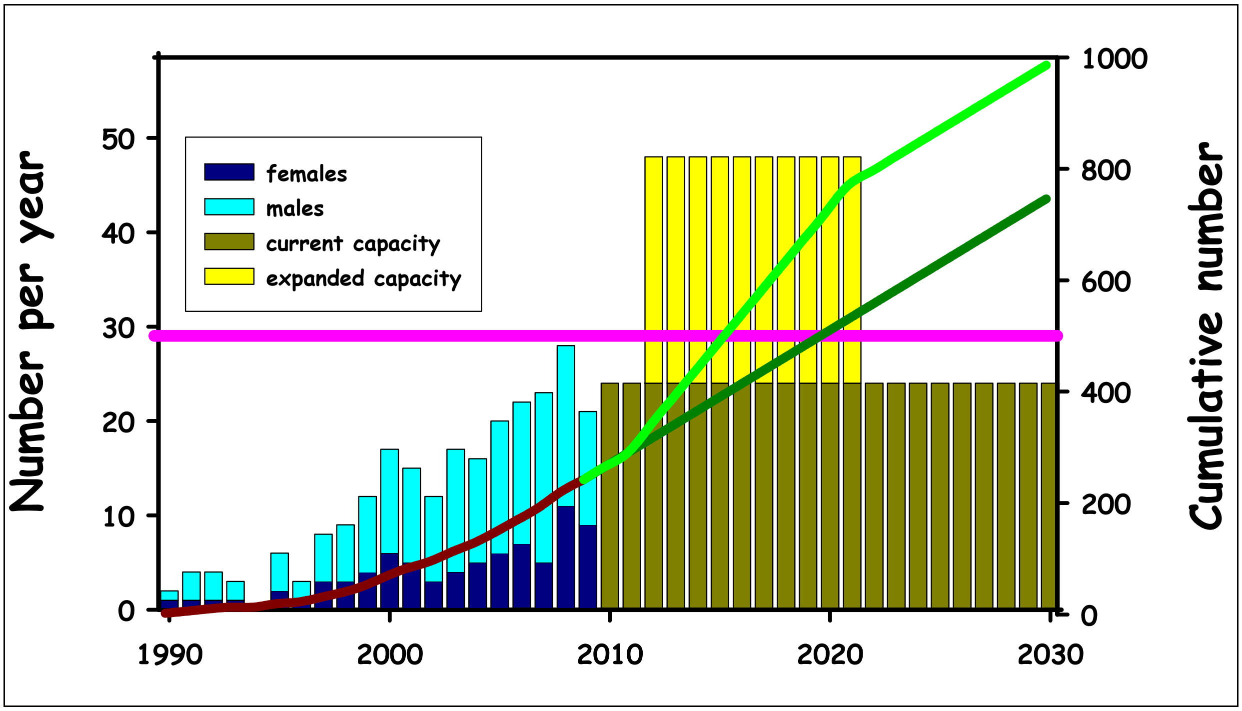


Figure 4-7. Broodstock numbers and projections with and without existing facilities.

Projections with the expanded capacity assume that the number of wild broodstock will double for at least the next 10 years from 24 to 48 per year. Under these circumstances, we project that a total of 986 wild broodstock could be propagated into the next generation, very close to the optimal target of >1,000.

Note that genetic effective population sizes will continue to be less than the actual broodstock numbers because of the unbalanced male and female contributions that result from the difficulty of capturing and spawning ripe males and females, and the sex-specific difference in spawning periodicity (~2-3 years for males, and ~4-5 years for females).

For broodstock collected to date, the total program N_e was approximately 84% of the broodstock total (208 vs. 249). Using this empirical ratio, projected N_es in 2030 would be 626 at the current capacity and 828 with the proposed expanded production capacity. Estimates of the effective population size in the next generation assume that at least some offspring of all broodstock are effectively propagated and survive to adulthood. We already know that some families have fared poorly in the hatchery and that some groups of fish released at small sizes have fared poorly in the wild. Conversely, other families fare well in the hatchery; it is assumed that both genetics and hatchery conditions may be responsible for observed differences. Hence, estimates of effective population size based on broodstock numbers and mating matrices tend to overestimate the actual effective population of hatchery-origin adult spawners in the next generation.

Assessments of broodstock needs and numbers are based on a number of uncertain assumptions. These start with the effective population targets. We identified targets based on the available information; however, this area of science is simply not definitive for a species with complex genetic and reproductive characteristics like sturgeon.

Assumptions regarding the continuing availability of broodstock are also uncertain. Although recent population assessments indicate the remnant wild population is larger than previously thought, numbers continue to decline and the frequency of spawning by many fish estimated to be present in Kootenay Lake appears to be less than that previously estimated from fish sampled in the river (Beamesderfer et al. 2009).

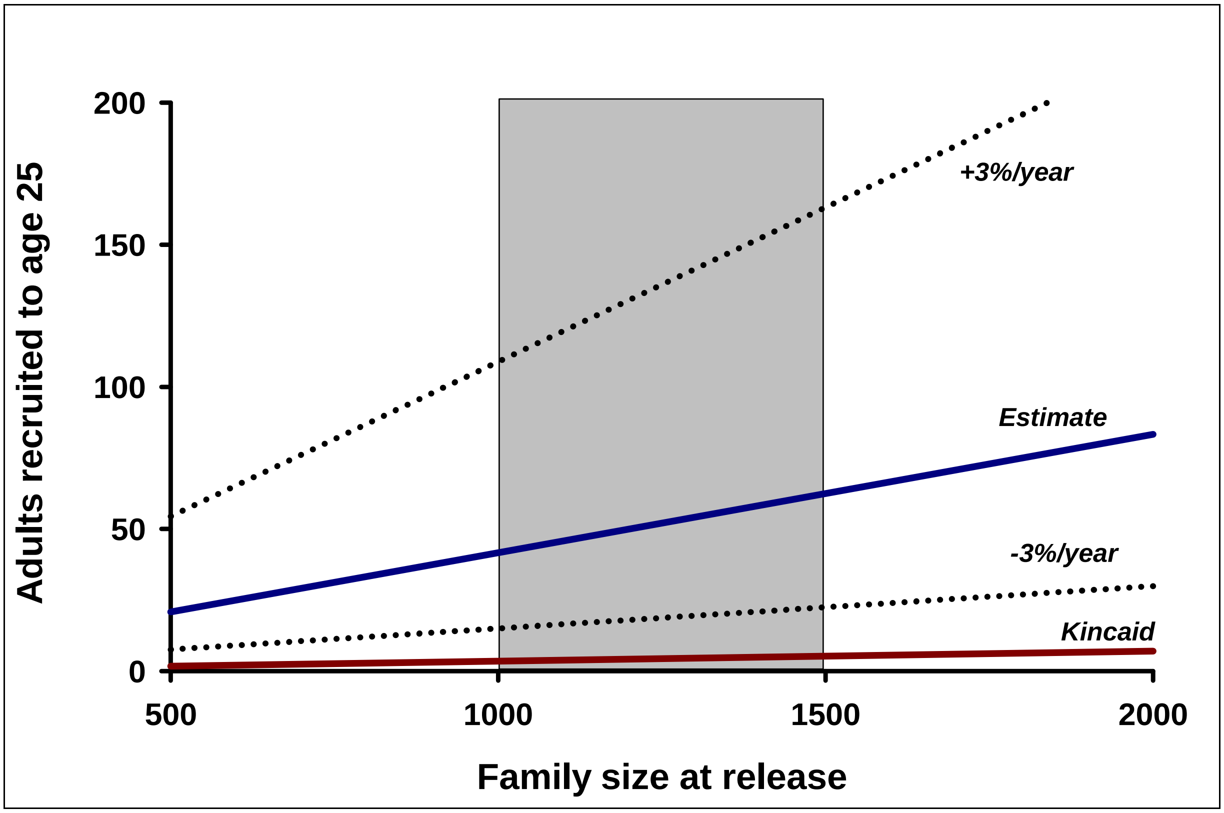
The lifespan and reproductive lifespan of individual fish are also unknown. By 2030, we project that the youngest of the remaining wild fish will be 70-80 years old. There is little information in the sturgeon literature regarding the potential for reproductive senescence and no one has had experience using exclusive very old broodstock as will occur in this program. Old fish are also very difficult to handle as captive broodstock due to their large size. It is also unknown whether mortality rates of very old fish will begin to increase or whether the viability of their gametes or progeny will decrease, and if so, to what degree. The program must contain functional contingencies for such possibilities.

At some point, broodstock availability will be acutely impacted by declining numbers, lack of fish that have not already been spawned, and/or senescence. The Kootenai sturgeon recovery program has elected to address these substantial uncertainties by increasing broodstock numbers now when fish are available, an objective constrained by the capacity limitation of the current aquaculture facility.

4.1.2.3 Family Size

Program targets for numbers per family at release are 1,000 to 1,500 fish at Age 1 or older that weigh about 30 g or more. These targets are the same as those used by the program through 2003 but less than 2004-2008 levels. The original target was established by Kincaid (1993) for a very specific purpose: to avoid an exaggerated contribution of a small fraction of the parent population in less than one generation. In 2004, family size targets were increased to 3,000-4,000 because fish were released at a smaller size. Survival of the smaller fish was very poor relative to previous release groups. Justice et al. (2009) suggested that this could be related to size-specific density dependent effects. In 2009, release targets were changed back to the original family size (1,000 -1,500 fish averaging 30 g) in an attempt to avoid an apparent population bottleneck at the young-of-the-year stage (Beamesderfer et al. 2009; Justice et al. 2009).

Family size targets are established to ensure survival of enough fish from each family to maintain a safe genetic effective population in the next generation, to avoid excessive contributions from any one family that might contribute disproportionately to the population genetics, and to limit total population size in order to reduce intra-specific competition and density-dependent growth and survival limitations. For the purposes of this Master Plan, analyses using current data indicated that family size targets of 1,000 to 1,500 fish should be adequate to ensure that sufficient numbers of each family will be available to: 1) survive for 30-plus years to reach maturity; and 2) produce succeeding generations in which the existing genetic diversity of each parent is represented in all recombinant permutations of offspring. We estimate per family recruitment of 42-62 fish on average to age 25 (Figure 4-8). These projections are extremely sensitive to even small differences in estimated annual survival. For instance, increases of just 3% per year triples the projected number of recruits over the initial maturation period. Decreases of 3% per year reduce the estimate by two thirds. Variability in actual survival and the ability to accurately estimate it clearly limit the value of generating specific population projections of this nature due to additive effects of variability over decades.



Best current estimates are based on first year hatchery survival of 15% (recent average), 88% per year for age 1-3, and 96% thereafter.
The shaded box represents planned family size production targets.

Figure 4-8. Effect of release group size on number of adult recruits from that cohort.

Current projections and targets for adult recruits per family are substantially greater than those originally developed by Kincaid (1993), even though family size targets are similar. Kincaid based the original calculation on an objective of 8 progeny per family at the assumed breeding age of 20. This estimate was based on the best available information at that time and a goal of supplementing natural production to create a "normal expansion" of the population. Since then, post-release survival rates of hatchery fish have been greater than Kincaid initially assumed (net survival of 3% vs. 0.8% to age 20) and age of maturity is older (25 vs. 20 years). Kincaid's original adult targets appear to be much too low to sustain the population in the absence of natural production. This distinction was previously recognized and incorporated into the Tribe's 2004 Hatchery Management Plan (KTOI 2004).

Because of variation in spawning success and survival, family groups range in size from a few hundred to several thousand fish. Orders of magnitude differences among naturally produced families would also be expected, based on variability in genetic and environmental conditions affecting individual families. Jager (2005) found no long-term genetic risk of modest variation in family numbers and hence little benefit of family equalization. Very large differences in family size (e.g., 100,000 vs. 10,000) might be grounds for concern but smaller differences (less than one order of magnitude) are not a concern. Currently, it appears more important to release sufficient numbers from each family group to ensure a next generation than it is to try to equalize release numbers from each family in an attempt to balance the genetic contributions of hatchery fish to the generation after the next generation. This is especially true if such practices equalize release groups down to the size of the smallest family group.

4.1.2.4 Total Releases

The Kootenai Tribe's conservation aquaculture program has reared and released 170,870 Kootenai sturgeon (age 1 or older) from 1992 through 2009 (Figure 4-9, Table 4-4). Significant releases began in 1997 after the hatchery was identified as a critical component of the recovery plan. Hatchery releases prior to 1997 were largely experimental. Full production was reached with the existing facilities in 2003 after hatchery upgrades. Annual releases have ranged from about 3,000 to 37,000 fish per year from 2003-2009 (average 21,000). Past production has averaged about 16,000 yearlings or 33,000 subyearlings. The 2008 release of only 3,254 fish was a transition year from a subyearing to yearling release protocol (fish that would have been released in 2008 as yearlings had already been released in 2007 as subyearlings).

Release numbers consistent with family number and family release number targets designed to minimize genetic risks would be 30,000 to 40,000 sturgeon per year over 10 years[15]. These targets are similar to the maximum release in 2005 of 38,000 fish, but fish would be released as yearlings at a larger size (30 g) rather than as subyearlings in order to increase post-release survival. Annual and total release numbers are largely a function of broodstock number and family size guidelines adopted to balance near-term and long-term genetic and demographic risks.

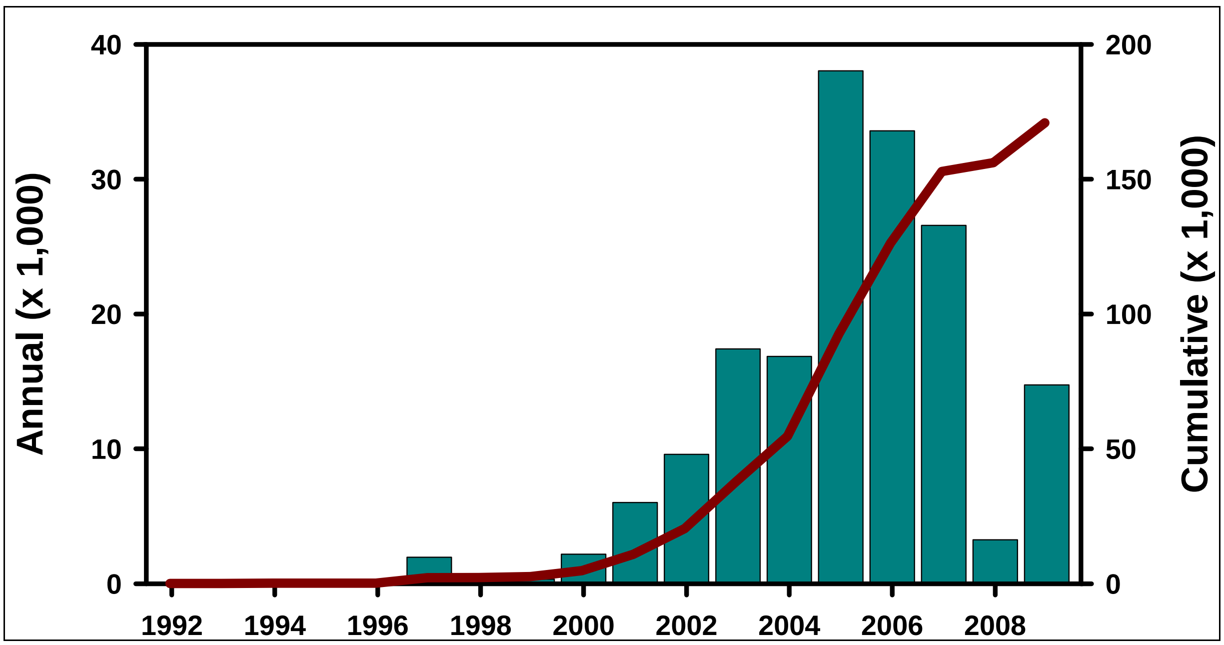


Figure 4-9. Annual (bars) and cumulative (line) numbers of juvenile white sturgeon released into the Kootenai River and Kootenay Lake.

[15] Family number targets are up to 40 per year but actual production likely will vary between 20 and 40 families per year over the next 20 depending on fish variability. Family size targets are 1,000-1,500 fish. We anticipate that smaller family sizes would be released in years with many families and that larger family sizes would be released in years with fewer families (e.g., 20 x 1500 = 30,000, 40 x 1000 = 40,000).

Table 4-4. Numbers of hatchery produced white sturgeon juveniles released into the Kootenai River and Kootenay Lake in Idaho and British Columbia, 1992-2008.

Year Class	Rearing Facility [a]	Release Number		Mean Total Length (mm) (SD[b])	Mean Weight (g) (SD[b])	Release Season & Year
		Tagged	Untagged			
1990	KTOI	14	--	457 (53)	321 (112)	Summer 1992
1991	KTOI	104	--	255 (17)	66 (13)	Summer 1992
1992	KTOI	123	--	483 (113)	549 (483)	Fall 1994
1995	KTOI	1,075	--	228 (27)	47 (17)	Spring 1997
1995	KTOI	884	--	344 (44)	148 (64)	Fall 1997
1995	KTOI	97	--	411 (68)	288 (138)	Summer 1998
1995	KTOI	25	--	582 (40)	863 (198)	Summer 1999
1998	KTOI	309	--	260 (42)	79 (44)	Fall 1999
1999	KTOI	828	--	256 (22)	71 (18)	Fall 2000
1999	KH	1,358	--	248 (33)	67 (28)	Fall 2000
1999	KTOI	491	--	284 (54)	108 (60)	Spring 2001
1999	KH	1,583	--	306 (40)	56 (39)	Spring 2001
2000	KTOI	2,286	--	244 (39)	64 (31)	Fall 2001
2000	KH	1,654	--	240 (23)	58 (16)	Fall 2001
2000	KH	2,209	--	283 (29)	99 (30)	Spring 2002
2000	KH	30	--	365 (14)	195 (20)	Summer 2002
2000	KTOI	214	--	409 (54)	294 (110)	Fall 2002
2000	KTOI	907[c]	--	333 (36)	193 (63)	Jan. 2003
2000	KT	10[d]	--	558 (28)	88 (18)	Feb. 2004
2000	KT	3[e]	--	662 (61)	425 (66)	Summer 2006
2001	KT	2,672	--	200 (38)	33 (16)	Fall 2002
2001	KH	4,469	--	227 (24)	52 (17)	Fall 2002
2001	KH	1,715	--	257 (26)	72 (24)	April 2003
2001	KT	1[e]	--	570	750	Summer 2006
2001	KH	1[e]	--	560[j]	1152	Spring 2009
2002	KH	5,864	--	217 (25)	41 (14)	May 2003
2002	KT	856	--	214 (44)	42 (23)	Oct. 2003
2002	KT	~550[f]	--			Nov. 2003
2002	KT	3,852	--	215 (37)	43 (20)	Winter 2003
2002	KT	3,663	--	214 (55)	43 (27)	Winter 2003-2004
2002	KT	1[e]	--	550	740	Summer 2006
2003	KH	9,020	--	223 (26)	49 (24)	Spring 2004
2003	KH	19[g]	--	230 (27)	52 (19)	Sept. 2004
2003	KT	3,519	--	227(47)	55 (32)	Late winter 2004
2003	KT	3[e]	--	437 (27)	347 (49)	Summer 2006
2004	KT	--	3,000[h]			Fall 2004
2004	KT	--	1,275[h]			Winter 2004-2005
2004	KT	--	17, 723[h]			Spring 2005
2004	KH	1,238	800[i]	196 (28)[j]	57 (33)	Spring 2005
2004	KH	--	3,440[h]			Spring 2005
2004	KT	--	8,637[h]			Summer 2005

Year Class	Rearing Facility [a]	Release Number		Mean Total Length (mm) (SD[b])	Mean Weight (g) (SD[b])	Release Season & Year
		Tagged	Untagged			
2004	KT	1	--	510	490	Winter 2007
2004	KH	5[e]	--	452(23)[j]	563(116.5)	Spring 2009
2005	KT	--	6,200[h]			Fall 2005
2005	KH	14[k]	--	299 (14)[j]	174 (28)	Spring 2006
2005	KH	1,765	--	198 (25)[j]	54 (22)	Spring 2006
2005	KH	--	13,665[h]			Spring 2006
2005	KT	--	3,947[h]			Spring 2006
2005	KT	510[l]	--	171(47)	27 (20)	Fall 2006
2005	KH	1[e]	--	330[j]	225	Spring 2009
2006	KH	--	6,900[h]			Fall 2006
2006	KH	--	600[i]	149 (11)[j]	23 (5)	Fall 2006
2006	KT	--	6,175[h]			Fall 2006
2006	KH	--	5,800[h]			Spring 2007
2006	KH	1,877	1,000[i]	182 (15)[j]	44 (12)	Spring 2007
2006	KT	--	12,973[h]			Spring 2007
2006	KT	4,922	--	171 (30)	22 (11)	Winter 2007
2007	KH	2,167	--	241(24)[j]	92(27)	Spring 2008
2007	KT	884	203[i]	151(36)	20(10)	Fall 2008
2008	KH	9,982	--	198(35)[j]	56(19)	Spring 2009
2008	KT	3,875	882	194(52)	32(19)	Fall 2009
Total		170,870				

[a] Kootenai Tribal Hatchery in Idaho (KT) or Kootenay Hatchery in British Columbia (KH)
[b] Standard deviation
[c] Ten fish from this group held over for later upriver release with transmitters
[d] These 10 fish were released upriver (rkm 306.5) with sonic and radio tags.
[e] These fish were held over for later release (2006-released with Vemco tags).
[f] No measurements available for these fish; exact number not known
[g] These fish were first taken to Kokanee Creek Provincial Park, then released in Sept.'04.
[h] These fish were not given a PIT-tag or measured.
[i] These fish did not have a PIT-tag added and were all given fish #999.
[j] Value given is for mean fork length (mm)
[k] These fish were released upriver (299.0 and 258.7), 6 of them with Vemco sonic tags.
[l] There were 200 fish held over at the Tribal Sturgeon Hatchery for Biopar study.

Current habitat capacity for sturgeon is unknown and cannot be defensibly estimated from existing information. Even if capacity could be estimated, process uncertainty, natural variability and measurement errors in survival rates confound the accurate estimation of release numbers. Even very small differences in annual survival result in vastly different calculations of release numbers needed to establish any given population level. The Kootenai Tribe's restoration and conservation aquaculture program is addressing these limitations by designing for production levels that address the immediate problem of capturing and propagating existing genetic diversity. Habitat capacity is being experimentally estimated by intensive annual monitoring of post-release survival, condition, and growth in relation to juvenile abundance and size distribution. Future hatchery release numbers will continue to be managed adaptively based on feedback from the monitoring program.[16]

Juvenile sturgeon are typically reared for up to 1 to 2 years in the hatchery before release. Fish are released from the Kootenai Trout Hatchery in British Columbia in the spring after reaching suitable tagging size (30 g) and in the fall at Age 1+ and include the faster growing individuals from a brood year cohort. Smaller fish from the same brood year are typically retained in the hatchery and released in the following spring as two-year-old fish.

Monitoring post-release survival of hatchery-reared fish consistently has revealed excellent initial survival in the wild (Ireland et al. 2002b). Survival was estimated at 60% during the first year as hatchery fish adapt to the wild environment and 90% per year thereafter based on analysis of mark-recapture data. Growth and condition within the first 1-3 years after release were often poor (Ireland et al. 2002b). Many fish recaptured within a year or two of release weighed less than when released from the hatchery. However, after several years at large, most recaptured fish exhibited substantial increases in length and/or weight. Fish that initially struggled may have adapted or died, leaving only the successful survivors. Size and condition in the wild were not related to size and condition at release. Thus, how well fish performed in the hatchery did not appear strongly related to how well they survived in the wild. This dynamic illustrates the importance of producing a diversity of individuals across the genetic spectrum on which natural selection can operate (Brannon 1993; Anders 1998). It also highlights the importance of avoiding selective rearing practices that favor fish that do well in the hatchery.

In 2004, concerns about ongoing natural recruitment failure led the Tribe to increase release numbers and family sizes within the constraints of the existing hatchery facilities as a precaution for the coming interval when too few wild fish will remain to provide broodstock. The Tribal Sturgeon Hatchery and the Kootenay Sturgeon Hatchery had the capacity to raise greater numbers of each family if fish were released at a smaller size. Numbers were increased by releasing fish at 10-15g as Age 0+ in fall rather than 30 g at Age 1+ or 2. This avoided the space limitation in the existing hatchery caused by simultaneously rearing multiple overlapping brood years. Minimizing time in the hatchery was also expected to minimize opportunities for hatchery selection effects and unforeseen rearing catastrophes (disease, equipment failure, etc.).

Previous production levels were constrained by the need to raise all fish to sizes suitable for PIT-tag placement and retention, and to rear families separately so that family sizes could be equalized within an order of magnitude upon release. Subsequent evaluations concluded that low population size in the next generation is a much more acute demographic and genetic risk than unequal family contributions in the following generation. Batch marking of fish with scute removal patterns allowed a smaller size at release while preserving a means of distinguishing hatchery-reared fish in the wild. Eliminating the PIT-tag requirement provided the flexibility to release fish at smaller sizes and ages which opened up space for more family groups in the hatchery. Upon release, smaller fish were expected to survive at similar annual rates as those observed in previous groups, although an extra year of natural mortality means that slightly fewer fish from any release group would be expected to survive to a given age. Increased release numbers allowed by this change in use of hatchery space was expected to more than offset this effect.

---

[16] In the longer term, the Tribe is developing a comprehensive adaptive management plan that will incorporate monitoring information from the conservation aquaculture program, habitat restoration efforts, nutrient supplementation program and other efforts, in order to better understand the interrelated effects of these efforts and adaptively manage each program.

However, subsequent monitoring found that survival of the more recent younger release groups has declined substantially from the early estimates (Justice et al. 2009). Where very high recapture rates were observed for the initial release groups, recaptures of later releases occurred at a much lower rate (Table 4-5). The decline was most pronounced among the small hatchery fish (<25 cm) while survival of the larger hatchery fish was similar to previous estimates (Justice et al. 2009). This negative relationship between release numbers and survival suggested that density-related competition or predation may be influencing mortality of juvenile sturgeon during their first year at large. However, this effect appeared limited to the first year at large, as indicated by the relatively stable survival rates for fish recaptured after two or more years following release.

Although larger releases were intended to increase the number of hatchery juveniles in the wild, the release of fish at smaller sizes beginning in 2005 actually had the opposite effect. The benefit of this adaptive experiment was identification of a second life history bottleneck during the first year of life that may affect both hatchery and wild fish. The effect of the Tribe's habitat restoration measures on this first year bottleneck will be one of the outcomes that are monitored. To date, large release numbers have not translated into a large juvenile population size. As a result, the program has now returned to releasing fewer, smaller, older fish (yearling and Age 1) that continue to demonstrate high survival rates (Beamesderfer et al. 2009).

The actual population size of hatchery-reared juveniles in the wild is much smaller than the total release numbers due to significant mortality during the first year post-release adjustment period (Figure 4-10). Only 13% (~16,000) of the 153,000 hatchery sturgeon released into the system from 1992 through 2006 were estimated to have survived until 2007 based on mark-recapture survival estimates. The 2007 population of hatchery-reared fish included an estimated 16,000 sturgeon that had survived at least one year in the wild. Mortality of juvenile sturgeon is significant in the first year following release from the hatchery as individual success in adapting to natural conditions is variable. Similar patterns are observed in many other species including salmon and steelhead. Growth and condition of many sturgeon has also been found to be poor in the first year following release. It is simply a difficult transition to go from the benign hatchery environment where food is readily available to a natural environment where food must be foraged and predators avoided. Some first-year mortality of small fish in release groups appears to be a function of sturgeon densities in the wild; however, survival of the large age 1 or older hatchery fish appears to be density-independent at this time. Early indications are that recent strategies that avoid the release of small hatchery sturgeon have been effective in avoiding the apparent density-dependent bottleneck of the smaller Age 1 sturgeon. Different sizes of sturgeon are able to exploit different food resources and the larger fish may be able to take advantage of a broader diversity of food type.

This large difference between total numbers stocked and total numbers surviving is not viewed as a failure in the program, but rather as reflecting the natural reproductive and life history strategy of sturgeons in the wild. Although individual female sturgeon have high fecundity (produce and spawn large numbers of eggs), very few progeny naturally survive to maturity given no parental care following broadcast communal spawning (i.e., sturgeons are "r-selected" vs. "k-selected" reproductive strategists [MacArthur and Wilson 1967]).

Table 4-5. Release and recapture number of tagged juvenile white sturgeon released by Kootenai hatchery programs, 1990-2006.[1]

Yr	Release					Rkm @ rel.		Number recaptured by year															Individuals[3]	
class	Year	Hat.	Seas.	No.	cm	lower	upper	93	94	95	96	97	98	99	00	01	02	03	04	05	06	Sum	#[2]	%
1990	1992	KT	Sum	14	39	204	243				3		1	1			1	1				7	4	1.6%
1991	1992	KT	Sum	104	22	204	243	1		14	23	9	8	16	8	3	7	6	7		2	104	59	24.3%
1992	1994	KT	Aut	10	61	304	310			4	4	1	2	1	2			1				15	8	2.6%
1992	1994	KT	Sum	113	40	204	246		1	8	12	11	7	8	11	10	10	1	4		5	88	49	19.9%
1995	1997	KT	Aut	884	30	241	245						104	52	64	70	40	12	27	7	9	385	279	113.9%
1995	1997	KT	Spr	1,075	20	243	245					33	62	53	70	61	51	22	31	28	10	421	317	129.4%
1995	1998	KT	Sum	96	36	241	259						1	7	15	12	7	3	1	2		48	37	14.3%
1995	1999	KT	Sum	25	51	241	241							2	3	2	3	1	1			12	8	3.3%
1998	1999	KT	Aut	309	22	230	258								8	15	6	6	2	4	1	42	36	14.0%
1999	2000	KT	Aut	1,358	21	170	200								4	103	46	41	50	33	28	305	259	129.5%
1999	2000	KT	Aut	828	22	200	259								1	37	14	22	14	24	11	123	108	41.7%
1999	2001	KT	Spr	1,583	26	170	200									124	90	43	70	46	61	434	379	189.5%
1999	2001	KT	Spr	491	18	240	245									5	6	7	7	2	3	30	28	11.4%
2000	2001	KT	Aut	1,419	20	170	200										19	29	24	12	12	96	89	44.5%
2000	2001	KT	Aut	2,286	21	170	245										24	18	17	8	9	76	73	29.8%
2000	2001	KT	Win	235	21	170	170										4	6	5	3	3	21	20	11.8%
2000	2002	KT	Aut	214	36	177	240											7	11	2	5	25	25	10.4%
2000	2002	KT	Spr	2,209	24	76	76										1		1		4	6	6	7.9%
2000	2002	KT	Sum	30	31	76	76															0		0.0%
2000	2002	KT	Win	907	29	170	170											19	28	11	12	70	67	39.4%
2000	2003	KT	Win	11	36	301	301															0		0.0%
2000	2006	KT	Sum	3	58	259	298															0		0.0%
2001	2002	KT	Aut	4,469	19	88	101														2	2	2	2.0%
2001	2002	KT	Aut	2,672	17	177	245											25	7	15	14	61	59	24.1%
2001	2003	KT	Spr	1,715	22	88	101														4	4	4	4.0%
2002	2003	KT	Aut	2,239	18	177	244														1	1	1	0.4%
2002	2003	KT	Spr	5,864	18	88	101												1	1	5	7	7	6.9%
2002	2003	KT	Win	6,132	19	170	258												5	1	1	7	7	2.7%
2003	2004	KT	Aut	19	19	75	75															0		0.0%
2003	2004	KT	Aut	324	21	307	307															0		0.0%
2003	2004	KT	Spr	8,501	19	144	151												168	56	77	301	297	196.7%
2003	2004	KT	Sum	519	22	144	144												16	7	3	26	25	17.4%
2003	2004	KT	Win	3,195	19	285	307													1	1	2	1	0.3%
2004	2005	KT	Spr	1,238	20	151	275													2	5	7	7	2.5%
2005	2006	KT	Aut	510	15	170	245															0		0.0%
2005	2006	KT	Spr	1,779	20	151	299														9	9	9	3.0%
2005	2006	KT	Sum	1	39	298	298															0		0.0%
2005	2006	KT	Win	200	15	170	170															0		0.0%
				53,581				1	1	26	42	54	185	140	186	442	329	270	497	265	297	2,735	2,270	4.2%

[1] Actual release groups may have been lumped or split to facilitate analysis. Only a portion of each annual release group is tagged.
[2] Average annual recapture rate based on release number and years where available for recapture.
[3] Number and percentage of individuals from a release group that are recaptured at least once.

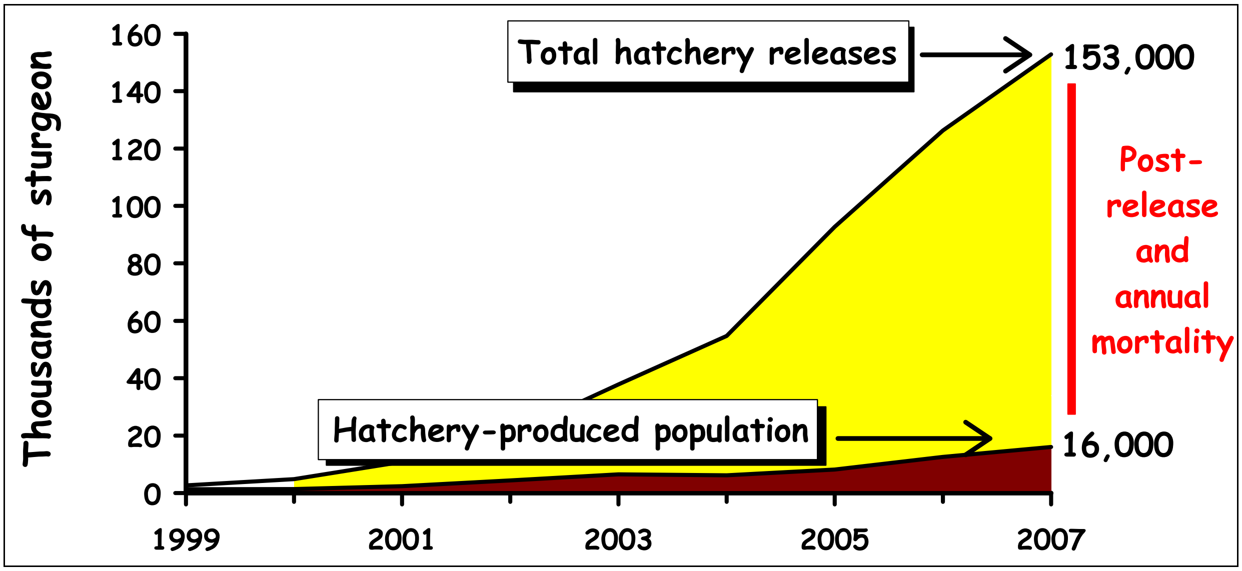


Figure 4-10. Estimated population of hatchery-reared sturgeon one year following release into the Kootenai River from 1999-2007.

Figure 4-11 illustrates the range of values that might be expected based on releases to date and future production targets. First year survival was relatively high (60%) among initial hatchery releases but declined to an average of just 15% in recent years (due to the release of smaller fish [Justice et al. 2009]). Smaller average individual fish sizes in recent years are thought to account for at least some of the decline in survival. It is assumed, but remains to be seen if current plans to increase fish size at release will result in higher first year survival rates.

Figure 4-12 highlights the sensitivity of abundance projections to estimated survival rates due to the compounding effects over the long sturgeon lifespan. Just a ±1% change in annual survival amortized throughout the sturgeon life span can shift projected adult abundance by thousands of fish in either direction. These values are well within the range of error of current empirical estimates of stage-specific survival rates. The sensitivity of abundance to very small variation in survival rates results in low confidence in using release number target back-calculations to accurately predict (and meet) future abundance goals.

Density-dependent effects are possible from releasing large numbers of hatchery fish on natural or hatchery sturgeon populations in the wild. Results of the model sensitivity analysis (Figure 4-12) suggest that even small density effects could have significant implications for target release numbers. Detection of density-dependent effects is a key focus of the ongoing sturgeon monitoring program. Large, diverse, short-term hatchery releases provide the best prospects for the experimental detection of density dependent effects. Results will provide the needed quantitative, empirical basis for subsequent adaptive adjustments to future hatchery production targets.

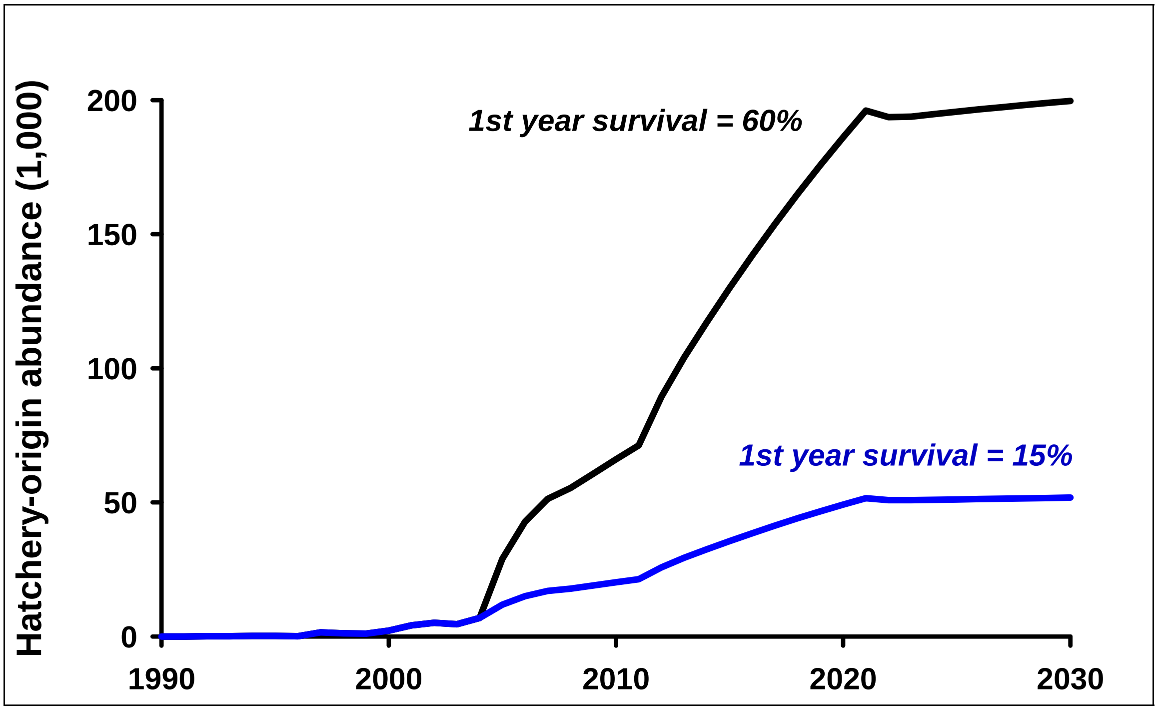


Figure 4-11. **Projected numbers of hatchery-origin sturgeon in the wild based on early (60%) and recent (15%) first year survival rates.**

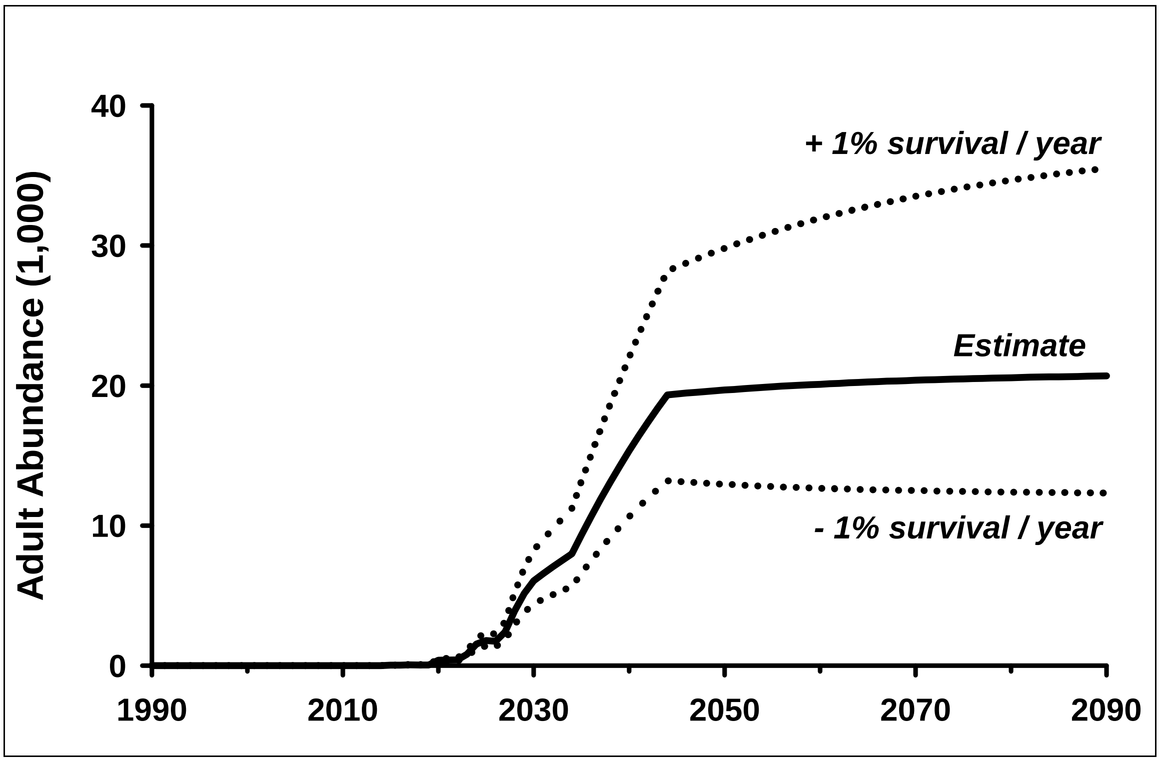


Figure 4-12. **Sensitivity of projected adult abundance to small changes in annual survival rates (based on an actual releases and survival through 2007, annual releases of 40,000 per year from 2012-2021, starting with recent average survival estimates of 0.15 in the first year following release, 0.88 annually through age 3, and 0.96 thereafter).**

4.1.2.5 *Biological Objectives*

The Tribe has identified the following biological objectives for the Kootenai sturgeon conservation aquaculture program. Specific metrics and performance time frames are identified in Sections 4.4 and 4.5 as part of the monitoring and evaluation and adaptive management framework for the program. Summarized below are the Tribe's pre-release and post-release objectives that will guide hatchery operations and production.

Pre-release Kootenai sturgeon conservation aquaculture program biological objectives include:

- **Provide adequate numbers of healthy broodstock.** The biological condition of potential broodstock will be determined through visual observation of health and behavior. Monitoring will occur up to five months each year. Gamete viability will be confirmed by sperm motility, egg germinal vesicle breakdown (GVBD), and polarity Index (PI) values typically generated from April through June.

- **Provide adequate breeding matrices for genetic diversity**. To retain wild sturgeon life history characteristics, each of up to 20 females will be mated with at least one male. The genetic distance of mated broodstock will be tracked.

- **Provide adequate incubation conditions and hatch rates**. Hatch survival will be monitored to achieve a goal of 50-90% survival. Monitoring typically will occur from May through July.

- **Provide adequate fry and larval survival**. The survival goal for each life stage is to exceed 50%. This will be monitored from May through September.

- **Provide adequate young-of-the-year survival**. The survival goal for this life stage is at least 50-90% with no visible signs of health issues and negative Title 50 pathogen test results. This life stage will be observed from September through December.

- **Provide adequate juvenile survival**. Survival, condition and health will be monitored with target survival rates greater than 50-90% and negative pathogen tests. Juveniles will be monitored for up to nine months.

- **Provide adequate fish marking**. Young-of-the-year will be marked with PIT-tags with a target retention rate of over 90%.

Post-release Kootenai sturgeon conservation aquaculture program biological objectives include:

- **Ensure adequate post-release survival, growth, and biological condition to support future mature adults**. Sampling of young-of-year, juveniles and adults will track growth, condition and weight of the fish. The objective is to achieve a survival rate of >60% in the first year post-release and 90% thereafter. Sampling will occur annually or more frequently if needed based on recapture data.

- **Create and maintain favorable age class distribution**. Sampling of young-of-year, juveniles and adults will track age class distribution, recruitment magnitude and frequency. Sampling will occur year round.

- **Maintain adequate individual and population health**. Sampling of young-of-year, juveniles and adults will track external health, fish behavior, and pathogen testing results.
- **Ensure genetic diversity within and among progeny groups**. Sampling of young-of-year, juveniles and adults will track diversity, heterozygosity, genetic distance and inbreeding coefficients. The target is a mean effective population size of more than 20 spawners annually and at least 200 fish per generation.
- **Achieve a sustainable adult population target**. The abundance of adults will be sampled annually to characterize population size and age-class structure. The abundance target is 8,000 to 10,000 adults.

Key uncertainties associated with Kootenai sturgeon aquaculture that will continue to be investigated are:

- Imprinting and homing to upriver spawning, incubation and early rearing habitats
- Success of natural production from mature hatchery progeny

4.1.3 Description of Current and Proposed Kootenai Sturgeon Conservation Aquaculture Program Operations

Operation of the Kootenai sturgeon conservation aquaculture program and the associated hatchery facilities are described below in sequential order: broodstock collection and handling, spawning and fertilization, incubation and hatch, marking and release. A general schematic diagram of Kootenai sturgeon hatchery mating, rearing, and release practices is presented in Figure 4-13. In addition, this section includes a brief discussion of a few critical components of conservation aquaculture programs including water quality and disease management.

Sturgeon culture techniques differ from those used for salmonids because of inherent differences in gonad development, spawning frequency, and sperm and egg structure, physiology, and biochemistry. Given the uniqueness of white sturgeon and the recent use of conservation aquaculture for a long-lived species, methodology has been adopted by Tribal staff by networking with experts in the field, as well as using and refining techniques originally described in the Hatchery Manual for White Sturgeon (Conte et al. 1988). Kootenai Tribal culturists and hatchery staff are in regular contact with white sturgeon reproductive biologists and culture specialists at UC Davis and other facilities to ensure correct application of relevant state-of-the art technology and techniques.

4.1.3.1 Shared Aquaculture Operations

At the proposed Twin Rivers Hatchery site, hatchery designers have sought to maximize shared aquaculture facilities, infrastructure and operations, optimizing efficiency and cost effectiveness. Infrastructure and physical operations for the Kootenai sturgeon and burbot programs will be combined. For example, power supply, support facilities, water sources, supply and temperature treatment will be designed with adequate capacity and flexibility to meet or exceed all water supply and quality needs for all cultured species (burbot, Kootenai sturgeon, and rainbow trout). A shared water treatment and distribution center will provide flows for various aquaculture uses. These functions are described in Section 4.3.2.

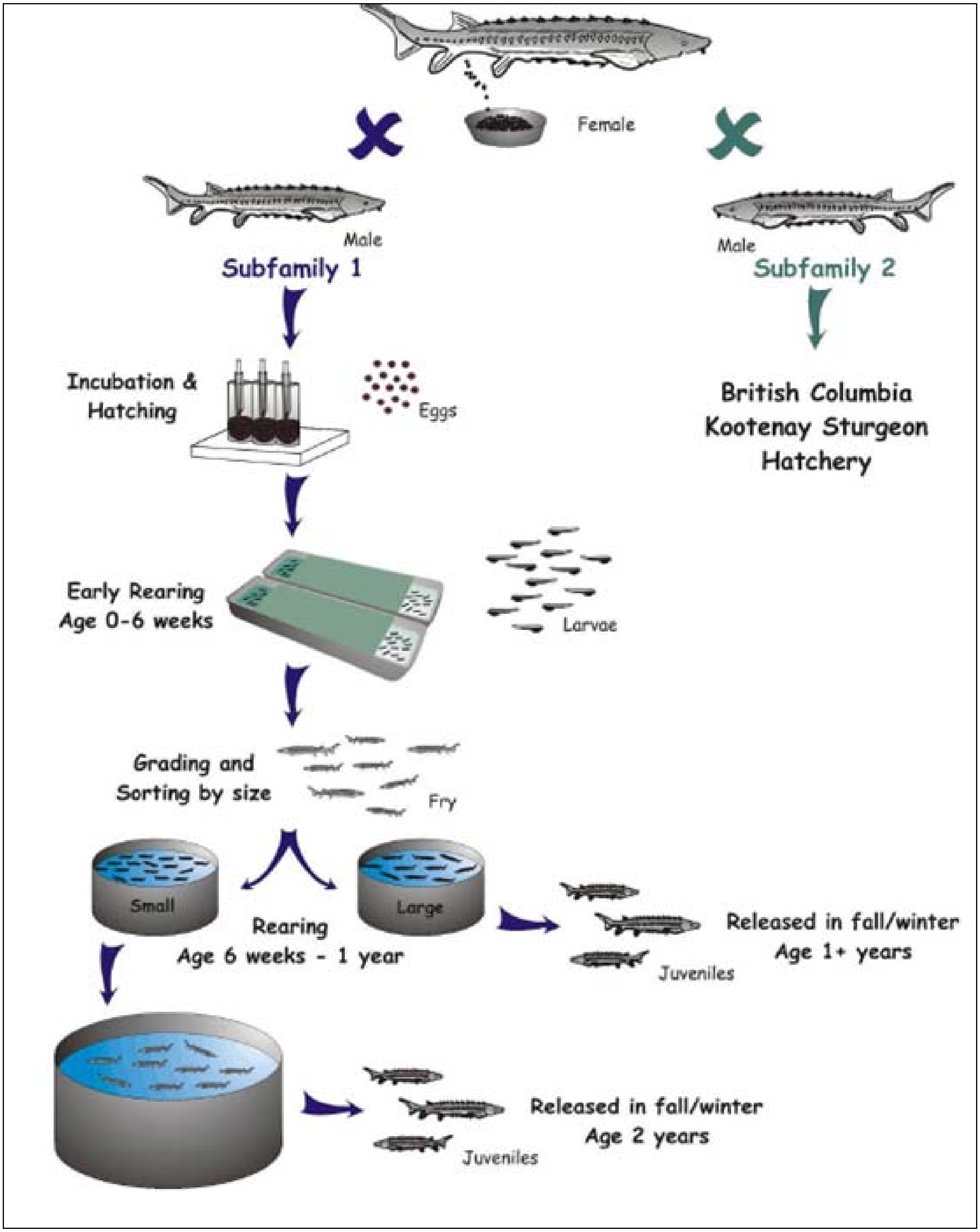


Figure 4-13. **Diagram of Kootenai sturgeon hatchery mating, rearing, and release practices.**

4.1.3.2 *Broodstock Collection and Handling*

All Kootenai sturgeon broodstock are captured from the wild Kootenai River population and released after being spawned. Ripe adult Kootenai sturgeon are captured by angling or set lining from February through June in areas downstream of Bonners Ferry where fish gather prior to spawning. Female broodstock typically average 6 to 8 feet long and males average 5 to 7 feet (Table 4-6). Different candidate female broodstock are brought into the hatchery each year, whereas male gametes are typically collected in the field. Male spawners are released directly back to the river following gamete collection. This broodstock sampling regime is designed to incorporate spawners from the full spatial and temporal extent of the spawning run.

Table 4-6. Average size, age, and fecundity of Kootenai sturgeon.

Total length		Fork length		Weight[a]		Age[a]	Egg take[b]
in	cm	in	cm	lb	kg	(years)	(eggs/female)
24	62	21	54	2	1	10	--
36	93	32	81	8	4	20	--
48	123	42	108	20	9	30	--
60	153	53	135	40	18	45	--
72	183	63	161	69	31	60	40,000
84	213	74	187	111	50	75	70,000
96	244	84	214	169	77	100	130,000

[a]Paragamian et al. 2005
[b]Unpublished Kootenai Tribal Hatchery data

Sex and maturity are checked in the field to identify suitable broodstock candidates. Sturgeon spawn multiple times over their life but do not spawn every year. Kootenai River sturgeon appear to spawn at intervals of 3 to 5 years (females) and 2 to 3 years (males) after first maturity, with age of first maturity estimated at around 15 years for males and 25-30 years for females. Ripe males are readily identified by flowing milt. Ripe females are identified through a one-inch midline belly incision (Conte et al. 1988). Unripe or immature fish are released immediately after being measured, weighed, and PIT-tagged. Recaptured broodstock from prior years generally are not reused, but if they are, they are not mated with the same individuals.

To expedite handling, fish are placed on their back in a hooded water-filled stretcher suspended across the gunwales of the boat. Total handling time in the field is typically less than 10 minutes for each captured fish. Ripe females are transported to the hatchery dock by boat and manually transferred to the broodstock holding facility in a water-filled stretcher. Fish are held separately or with one or two other fish in large circular tanks at ambient Kootenai River temperature and are fed live juvenile rainbow trout produced at the hatchery for this purpose. Brood females are generally held in the hatchery for 2 weeks to 4 months for final maturation and then returned to the river after spawning.

Since 1997, milt has been extracted from ripe males in the field and these fish are then released at their capture location. Because ripe males are captured more frequently than ripe females, milt is collected when females are ready to be spawned. Milt is extracted through the vent using surgical plastic tubing attached to a syringe. Sperm viability and motility are checked upon arrival at the hatchery and again before use to fertilize eggs (Conte et al. 1988). Cryopreservation of white sturgeon sperm is currently being researched and has met with some success, e.g., up to 50% fertilization success (see Section 4.1.2). Cryopreservation techniques for female gametes have been under evaluation since 2006.

Proposed modifications to the Tribal Sturgeon Hatchery would streamline and mechanize broodstock handling. The current transport method is stressful for the fish and very challenging for hatchery staff (Figure 4-14). Proposed upgrades include mechanically transferring large fish from the boat dock to the hatchery and returning large females to the river in a water-filled tank rather than by stretcher.


Photo courtesy of M. Reiser, TetraTech.

Figure 4-14. Transporting female Kootenai sturgeon from the river to the Tribal Sturgeon Hatchery.

4.1.3.3 Spawning and Fertilization

Advances in artificial maturation and spawning techniques are critical to effective hatchery production of white sturgeon (Conte et al. 1988; Van Eennaaneem et al. 1996; KTOI 2004, 2008). Female broodstock are induced to release eggs (ovulate) by hormone injection in the final stages of maturation because captive sturgeon rarely ovulate spontaneously. Eggs are periodically collected and examined for stage of development using metrics of egg size, germinal vesicle breakdown percentage and polarization index values (KTOI 2004).

Prior to spawning induction through hormone injections, females are transferred to a covered rectangular fiberglass spawning tank (7 feet long x 2 feet wide x 2 feet deep) where eggs can be more readily observed once the female begins ovulation. However, in 2007-2008, a different approach was tested at the Tribal Sturgeon Hatchery. Female broodstock were held in 15-foot circular tanks with 4 fish per tank. Prior to injecting hormones, the female was transferred to an empty circular tank where she had more room to move for two days, reducing her stress level

(Figure 4-15). The Tribe conducts such testing to maximize spawning success. Significant numbers of eggs are typically released and are apparent on the bottom of the spawning tank within 48 hours of hormone injection. Egg stage is again confirmed by microscopic examination.

Photo courtesy of A.Squier, Ziji Creative Resources

Figure 4-15. Tribal biologists transferring female Kootenai sturgeon on a stretcher for spawning in another building.

Typical practice in the sturgeon aquaculture industry is to spawn females by caesarian section; however, hand-stripping has been used successfully at the Kootenai Hatchery since 1993 to reduce stress and injury. Fish spawned by hand-stripping (Figure 4-16) can be released into the river directly after the spawning process, whereas fish spawned by caesarian section require two to three months for the sutured incision to heal. From 5,000 to over 100,000 eggs can be collected from each female. Eggs are fertilized with stored sperm collected from males in the field. Sperm viability is verified before fertilization. New developments in low-stress caesarian techniques may enable hatchery crews to maximize egg take from individual fish on a case-by-case basis. This method is being tested in the Tribal Sturgeon Hatchery; preliminary results indicate that hand-stripping generally is as effective as caesarian methods. Targeting ripe fish for the caesarian procedure may have merit, but generally this approach appears unnecessary.

Photo courtesy of A. Squier, Ziji Creative Resources

Figure 4-16. Tribal biologists hand-stripping eggs from a Kootenai sturgeon.

Breeding matrices and protocols have been developed to maximize the effective size of population progeny groups, minimize chances of future inbreeding in the wild and to ensure that hatchery broodstock genetics reflect the wild population genetics (Kincaid 1993; Anders 2002; Ireland 2002b; KTOI 2004). Eggs from individual females are split into separate lots and are separately fertilized with milt from different males to maximize fertilization, survival, and genetic contribution to resulting progeny groups. Usually, eggs from one female are fertilized with sperm from two or more males. Families from one female and one male are referred to as full-sibling families, whereas families produced from the same female parent and different male parents are referred to as half-sibling families. Family identity is maintained through the rearing process prior to release, then fish are PIT-tagged to retain family identity of released individuals.

Modifications proposed to the Tribal Sturgeon Hatchery would eliminate the need to transfer ripe females from holding tanks in one building to spawning tanks in another building. A new spawning room would be added on to the existing holding room, significantly reducing stress for the female broodstock. Heating and chilling controls will allow better management of maturation and spawning of broodstock which has been hampered by unfavorable and fluctuating water temperatures. Temperature regulation in the adult holding facility would enable males to be held at the hatchery until they are in spawning condition.

At the Twin Rivers Hatchery, at least two spawning channels will be developed. Flow patterns and substrate material will mimic natural conditions. This arrangement will allow direct observation and testing of adult spawning behavior that has not been possible in a natural setting.

4.1.3.4 *Incubation and Hatch*

Eggs are incubated in modified MacDonald upwelling jars that drain into fiberglass fry collection tanks. Water piped into the jar gently agitates eggs to prevent clumping and fungus development, and to facilitate gas exchange for proper development. Dead eggs and egg shells are siphoned daily from the incubators and fry collection tanks.

As eggs hatch, the emerged fry tend to move vertically and the water flow carries them to the top of the jar and into the fry collection tank, totally eliminating handling stress. Eggs are incubated with filtered, temperature-controlled river at approximately 56°F (13°C). At this temperature, eggs begin hatching approximately 10 days after fertilization and the hatch is complete approximately 14 days post-fertilization. Embryonic development rates and hatch timing are temperature dependent.

The Tribal Sturgeon Hatchery uses up to 24 hatching jars and 12 tanks to rear separate families. The capacity of each jar is 5,000 to 25,000 eggs. Since 1999, up to 25,000 fertilized, disinfected eggs from up to five families have been shipped to the Kootenay Trout Hatchery in Fort Steele, British Columbia. Egg-to-hatch survival typically averages 70-80%. Approximately 1,920 square feet of the proposed Twin Rivers Hatchery will be dedicated to this hatching process.

4.1.3.5 *Rearing*

Upon completion of hatching, all free embryos within a family are transferred to larger rectangular fiberglass rearing tanks for early larval feed initiation. Tanks are covered since free embryos exhibit a moderate light avoidance response. Fry are transferred to 3- to 5-foot-diameter circular fiberglass tanks approximately 3 weeks after initiation of feeding (Figure 4-17). Circular tanks are easier to clean and provide current for swimming larvae. Fish held beyond Age one are transferred to 9- to 15-foot-diameter circular fiberglass tanks. Reared densities are limited to 0.5 lb/cubic foot of water. All family groups are reared separately to ensure consistency with genetic and program management protocols. This requires many tanks and limits the number of family groups that can be raised at a single facility.

Additional rearing space at Twin Rivers will ensure families can be reared separately. Different families often perform differently in the hatchery during spawning, incubating and/or rearing stages. Survival and growth may vary substantially, even when every effort is made to rear all families under identical conditions. Growth, survival, and biological condition varies within and among families due to inherent genetic and environmental variability. Separate rearing avoids inadvertent selection that can occur if the stronger performing family is favored by rearing conditions or culling practices.

Because sturgeon are a benthically oriented species, the area of tank bottom, not total water volume, dictates rearing space and tank needs. Considerable variation in feeding and growth is apparent among hatchery sturgeon, even within a family group exposed to identical rearing conditions. While some individuals do better in a hatchery environment than others, these same traits did not categorically prove adaptive when fish were released into the wild (Ireland et al. 2002b). Therefore, it is important that hatchery practices do not artificially select for fish that do well in a hatchery environment, for example by grading fish to separate fast and slow growing individuals.

Photo courtesy of K. James, Kootenai Tribe of Idaho

Figure 4-17. Progeny of wild Kootenai sturgeon broodstock in circular rearing tank.

The onset of first feeding is a critical transition period that was a particular problem in early white sturgeon culture efforts. Techniques are now well established and most larvae are successfully converted to artificial feed. First feeding occurs after the yolk sac is absorbed approximately 2-3 weeks post-hatch. Larvae are fed every two hours to enable less aggressive fish to feed successfully and are separated according to size so small fish do not have to compete with larger fish for food.

Fish at the Tribal Sturgeon Hatchery are reared at ambient river temperatures that range seasonally from 33 to 65°F (1 to 18°C). Fish in the Kootenay Trout Hatchery are reared in well water at 43 to 48°F (6 to 9°C) that is heated when needed. The Kootenay Trout Hatchery has warmer water in the winter and cooler water in the summer than the Tribal Sturgeon Hatchery, conditions that result in faster fish growth.

At the Twin Rivers Hatchery, the free embryos and larvae will rear in 36 start tanks. Larvae then will be transferred to the 15 or 16 circular start tanks for the next phase of their growth. These and subsequent life stages will be exposed to waters of the Kootenai and Moyie rivers to imprint them on the water chemistry of this reach of river with higher quality spawning, incubation and initial rearing habitat.

4.1.3.6 Fish Health Monitoring

Reducing rearing densities and using multiple facilities also reduces risks of catastrophic losses due to disease outbreaks or systems failures. Disease outbreaks are a risk in hatchery systems because fish densities and stress are elevated over natural conditions. Uncontrolled outbreaks can cause the loss of an entire brood year production or more likely selected families, both of which impairs propagation of the wild population's remaining genetic diversity.

White sturgeon iridovirus (WSIV) is an endemic pathogen in the Kootenai River and other watersheds in the Pacific Northwest (LaPatra et al. 2004). Although outbreaks of the disease are usually controlled at the Tribal Sturgeon Hatchery by following certain fish culture protocols for water quality, handling, transport and loading densities, recent studies have demonstrated that WSIV is easily transmitted horizontally. Wells at the new Twin Rivers Hatchery will provide a valuable pathogen-free water source for incubation and early rearing.

Prior to reintroducing Kootenai sturgeon into the Kootenai River, all disease testing requirements are satisfied. A minimum of 60 sturgeon from each year class are tested to meet state, federal, and provincial disease testing requirements.

4.1.3.7 Fish Marking

Until 2004, Kootenai sturgeon were reared in the Tribal Sturgeon Hatchery and the Kootenay Trout Hatchery until large enough to be PIT-tagged and released (at least 15 fish/lb). Fish reared at the Tribal Sturgeon Hatchery generally require 12 to 18 months to reach this size while only 6 to 8 months is required for fish reared at the Kootenay Trout Hatchery (due to water temperature differences). Tags are used to distinguish hatchery from wild fish and to monitor and evaluate the numbers and performance of hatchery fish. PIT-tags are the only suitable tag or mark that can persist over the long sturgeon life span.

In 2004, the Tribe, in coordination with the Kootenai Sturgeon Recovery Team made an interim program decision to release smaller and younger fish without tags, although they were marked with a scute removal pattern to identify them as hatchery-produced fish. Follow-up studies showed unacceptable mortality rates with this strategy (Justice et al. 2009); therefore, since 2007, Kootenai sturgeon are reared to Age 1+ and PIT-tagged prior to release. This is one of the factors driving the urgent need for facility expansion since rearing fish to Age 1+ requires more space in order to maintain low rearing densities and keep families separate. One exception to this protocol involves experimental releases of captively-produced progeny of wild parents being used to investigate early life limiting factors. These releases are in addition to the standard population production goals called for in the updated Kootenai Hatchery Plan (KTOI 2004) and in the recovery plan (http://ecos.fws.gov/docs/recovery_plan/990930b.pdf).

4.1.3.8 Release of Hatchery Fish

Juvenile Kootenai sturgeon are typically reared for up to 1 to 2 years in the Tribal Sturgeon Hatchery before release at sizes averaging 6 to 12 inches and 6-15 fish/lb. Release sizes were selected to maximize survival opportunities in the wild, limit the need for hatchery space to simultaneously hold cohorts from several brood years, minimize time in the hatchery that can risk domestication, and allow fish to reach sizes large enough to be individually marked with PIT-tags.

Fish are released from the Tribal Sturgeon Hatchery and the fail-safe Kootenay Trout Hatchery in the spring or fall. Fall releases from the Tribal Sturgeon Hatchery are typically Age 1+ fish and include the faster growing individuals from a brood year. Smaller fish from the same brood year are typically retained in the hatchery and released in the following spring as Age 2 fish. Sturgeon released from the Kootenay Trout Hatchery are typically faster growing and are released at Age 1 in the spring. Releases are distributed from the Creston, British Columbia area to the Montana border. Fish reared at the Tribal Sturgeon Hatchery are released into the Kootenai River in Idaho and Montana and some juveniles migrate downstream into Canada as they grow. Those reared at the Kootenay Trout Hatchery are released in Montana, Idaho and British Columbia.

Age 1 and Age 0 (free embryo) releases are concurrently managed for different but complementary purposes. Age 1 fish are released to build the population, whereas age 0 (embryo and free embryo) releases are small and experimental to evaluate incubation and early rearing habitat suitability as an RPA of the Libby Dam Biological Opinions. Therefore, Age 1 releases are expected to continue (at most annually) and are considered the highest priority until repeatable, adequate natural production is restored, whereas experimental age-0 (free embryo) releases are scheduled to end after 2012. To date, the Age 0 releases have not contributed ot recruitment but remain a mandated part of recovery activities under the Libby Dam operations BiOp. More information is typically provided by controlled replicated studies of early life stage requirements, with results subsequently applied to the field conditions and in-river habitats (e.g., Kynard and Parker 2006a, 2006b; Kynard et al. 2007).

Fish from distinct family groups are divided for release at different sites to ensure that identical genetic material is not concentrated at one site. They are distributed to colonize all suitable habitats, avoid local concentrations that might increase competition and predation, and to reduce initial post-stocking mortality (Figure 4-18). Releases directly into Kootenay Lake have been discontinued because of survival uncertainty (biologists have been unable to recapture released fish). In 2004, releases were expanded to include Montana waters downstream from Kootenai Falls to take advantage of habitat throughout their historical range, and provide opportunities for potential imprinting to upstream areas where more favorable spawning, incubation and early rearing habitats appear to exist.

Photo courtesy of K. James, Kootenai Tribe of Idaho.

Figure 4-18. **Fall release of juvenile Kootenai sturgeon reared at the Kootenai Tribal Hatchery.**

4.1.3.9 *Water Quality*

Although white sturgeon tolerate a wide range of water quality conditions, water temperature ranges for spawning and pathogen-free water during early life stages are critical to successful sturgeon aquaculture. The primary water source for both the Tribal Sturgeon Hatchery near Bonners Ferry and the proposed new Twin Rivers Hatchery will be surface water withdrawn from and discharged back to the Kootenai River. For most of the year, the Kootenai River provides excellent quality water for aquaculture operations. Exceptions occur during high turbidity events and temperature fluctuations. Kootenai River water temperatures are seasonally too warm or too cold for optimum sturgeon culture largely due to Libby Dam operations. Excessively warm temperatures increase juvenile fish mortalities whereas cold water can delay the spawn and reduce growth rates.

High turbidity reduces the effectiveness of filtration and disinfection treatments and makes it difficult to visually monitor fish health. Turbidity is an issue primarily during high runoff periods in the spring when flows in the Kootenai River can exceed 40,000 cubic feet per second (cfs). The U.S. Geological Survey (USGS) water sampling data from 2002, 2005 and 2006 indicates that over 80% of the particulate matter in the water upstream of Bonners Ferry is silty material smaller than 60 microns.

Based on the limited data available, it appears that the peak turbidity events are short in duration, falling by up to 60% in a single day, even when river flows are increasing. This is because the highest sediment loads are associated with the first annual "flush" of high water during spring runoff. A sediment settling pond and drum screen pre-filtration system installed on the water supply system at the Tribal Sturgeon Hatchery in 2007 has proven effective in reducing turbidity to acceptable levels, but still needs refinement for optimal operation.

An existing 60 gpm potable water well at the Twin Rivers site was tested in 2008 and found to be pathogen-free and suitable for aquaculture (results are presented in Appendix D). Due to the high likelihood that there is a productive aquifer contained in the alluvial soils underlying the Twin Rivers site, the Tribe anticipates additional wells can be developed to draw water of similar quality from the same aquifer.

The proposed Twin Rivers Hatchery includes a surface water intake on the Moyie River in addition to well water and Kootenai River sources. The Moyie typically does not experience the high turbidity events seen in the Kootenai.

4.2 Alternatives Considered

The Kootenai Tribe evaluated several strategies to recover endangered Kootenai sturgeon. Four potential strategies are described below. With the exception of Alternative 3, each includes continued use of the Tribal Sturgeon Hatchery.

4.2.1 Alternative 1: Status Quo

The current Kootenai sturgeon conservation aquaculture program would continue under this strategy. Hatchery production at the Tribal Sturgeon Hatchery (and continued support of the fail-safe sturgeon program at the Kootenay Trout Hatchery at Fort Steele, British Columbia) would be maintained at current levels with existing facilities. Manual broodstock collection and handling procedures would continue. Standard maintenance would occur, but no structural and operational improvements would be implemented.

Expected outcomes of adopting this strategy include an inability to accommodate additional broodstock, and capping at current production levels the number of young Kootenai sturgeon available for release. Known operational limitations would suppress production levels (e.g., lack of rearing space, limited spawning space, limited ability to segregate family groups, etc.) and make it difficult or impossible to meet optimal production targets. Inadequate water temperature control and potential high rearing densities could continue to contribute to excessive pre-release mortality. It is unlikely that a sufficient contribution toward recovery of Kootenai sturgeon could be achieved under this alternative due to limited production potential at the existing facility.

4.2.2 Alternative 2: Expand Aquaculture Production

The Tribe's current conservation aquaculture program would be expanded under this strategy. Existing facilities at the Tribal Sturgeon Hatchery near Bonners Ferry would be upgraded to improve broodstock handling capabilities, water temperatures and operational efficiency. A new hatchery would be constructed at the confluence of the Moyie and Kootenai rivers (Twin Rivers) that would expand the Kootenai sturgeon broodstock holding and rearing capacity. In addition to the expanded production capabilities, this strategy would supply water of reliable quality and temperature and would also allow young fish to imprint on waters closer to more suitable habitat that they would return to as reproducing adults. Infrastructure would be shared with the proposed burbot facilities to be developed at the same location (see Section 5.3). Use of the Kootenay Trout Hatchery as a fail-safe facility would continue. This alternative would also include developing and using portable streamside rearing units, described in Section 4.3.4.

The outcome of this strategy would be expanded rearing areas with reduced density and the associated stress and mortality. Space would be created to separately rear family groups. More reliable water quality at the existing facility and a groundwater-supplemented program at the new facility would reduce the potential for catastrophic losses of year classes, as well as improving overall survival of juvenile sturgeon while in the hatchery. Improving the mechanism by which adults are transported from the river to the hatchery would reduce stress on the fish and improve worker safety. Improved survival would preserve and perpetuate locally adapted genotypes, phenotypes, and life history and behavioral traits. The new hatchery would acclimate and imprint fish on waters of the braided and canyon reaches of the Kootenai River, expanding the reaches to which the Kootenai sturgeon may home.

4.2.3 Alternative 3: Natural Production Only

This strategy would terminate production at the Tribal Sturgeon Hatchery near Bonners Ferry and the fail-safe program at the Kootenay Trout Hatchery. The Kootenai sturgeon population would be left to respond to habitat conditions and other fishery management measures. No fish would be collected for artificial propagation and the existing facility would be converted to other purposes.

The outcome of this approach would be extinction, as predicted from investigations of natural Kootenai sturgeon production in the Kootenai River conducted over many years. Studies to date have shown no measurable success at producing a Kootenai sturgeon year-class, let alone a self-sustaining population. The Tribe believes that natural production could be a viable option in the future if an adequate broodstock population is restored and if significant habitat improvements are successfully implemented and take effect in a timely fashion.

4.2.4 Alternative 4: Introduce Non-Kootenai Subbasin White Sturgeon

Under this strategy, a Columbia River Basin sturgeon stock would be introduced in the Kootenai River. Gametes, embryos or other early life stages would be collected from healthy sturgeon populations elsewhere in the Columbia River Basin and transported for additional rearing or acclimation at the Tribal Sturgeon Hatchery. To maximize production goals and provide state-of-the-art operations, a new facility at the confluence of the Moyie and Kootenai rivers would be constructed.

Although use of a non-native stock for the aquaculture program may be technically and economically feasible, the Council's Fish and Wildlife Program (2000) recommends the use of native species whenever possible:

"Even in degraded or altered environments, native species provide the best starting point and direction for needed biological conditions in most cases. Where a species native to a particular habitat cannot be restored, then another species native to the Columbia River Basin should be used. Any proposal to introduce or release non-native species must overcome this strong presumption in favor of native species and habitats and be designed to avoid impacts on native species."

The native Kootenai sturgeon population evolved in isolation for more than 10,000 years and as a result has diverged from other populations in its spawn timing, habitat selection, spawn periodicity, and age of maturity. The unique selective pressures that enabled the population to thrive for millennia lend uncertainty to the strategy of transplanting out-of-basin stock. In addition, it is unlikely that the provincial Fish Transplant Committee of British Columbia or other management agencies would endorse introduction of non-native stocks into a transboundary river in the presence of a native population at risk.

4.2.5 Basis for Selecting the Proposed Alternative

The Tribe's primary criteria for selecting an alternative are to preserve and perpetuate locally adapted genetic, life history, and behavioral traits. As described above, Alternative 2, Expanded Aquaculture Production, would best meet the goal of restoring natural recruitment in combination with the proposed Kootenai River Habitat Restoration Project and other relevant habitat restoration work in the Kootenai subbasin.

Additional selection criteria include consistency of the alternative with the guiding principles of the Subbasin Plan (KTOI and MFWP 2004). These principles include:

- Recognizing and supporting the basin-wide objectives for resident fish losses in the NPCCs' Fish and Wildlife Program
- Promoting and enhancing local participation in, and contribution to, natural resource problem solving and subbasin-wide conservation efforts
- Using a scientific foundation for diagnosing biological problems, designing, and prioritizing projects, and using monitoring and evaluation to guide management

- Protecting, perpetuating, enhancing, and restoring habitats in a way that will sustain and recover native aquatic and terrestrial species with emphasis on the recovery of ESA listed and native species. Provide adequate protection for unique habitats that may not be abundant but that play an important ecological role.

- Fostering ecosystem protection, enhancement, and restoration that results in the stewardship of natural resources while recognizing all components of the ecosystem, including the human component.

In addition, the guidance provided through the Libby Dam biological opinion (USFWS 2006) is a consideration. Specifically, Reasonable and Prudent Alternative Component 4 stipulates that the conservation aquaculture program is to be continued until otherwise advised by the USFWS. The RPA further directs that funding be provided to expand adult holding and spawning capabilities.

Developing the Twin Rivers Hatchery satisfies the prerogative for local involvement in the Kootenai ecosystem recovery effort and requirements to address treaty trust obligations. Tribal Treaty and Trust obligations are furthered through development of the Twin Rivers Hatchery for a multitude of reasons. First, this aquaculture program has the potential to restore a culturally important Kootenai Tribal fishery and the ability of the Tribe to exercise its Treaty-reserved fishing rights. The federal (U.S.) government's government-to-government relationship with and trust responsibility to the Kootenai Tribe are also furthered through the partnerships developed through this Tribe-led program.

Based on these criteria, the feasibility of Alternative 2 is presented in this Master Plan. The Tribe believes Alternative 2 would provide the approach most likely to succeed in preserving and perpetuating locally adapted Kootenai sturgeon while necessary habitat restoration actions are implemented. The Tribe's analysis shows this strategy to be consistent with the Kootenai River Subbasin Plan and the NPCC's artificial production policies and scientific principles. It also incorporates an existing adaptive management framework within which to perform future program modifications.

4.3 Conceptual Design of Sturgeon Facilities

4.3.1 Overview of Facility Elements

The Kootenai Tribe intends to continue using their existing Tribal Sturgeon Hatchery near Bonners Ferry and to support the small-scale fail-safe program at the Kootenay Trout Hatchery in Fort Steele, British Columbia. To address the need for additional rearing capacity and to imprint Kootenai sturgeon on waters further upstream, as described previously, the Tribe is proposing to develop a new aquaculture facility, the Twin River Hatchery, on Tribal-owned property at the confluence of the Moyie and Kootenai rivers, approximately 10 miles east of Bonners Ferry. In addition, the Tribe is proposing to install two remote streamside rearing and incubation facilities that could be used to imprint sturgeon to waters at other selected upstream locations.

The proposed facility modifications and expansions will allow the Tribe to achieve production goals necessary to preserve sufficient demographic diversity and to provide a hedge against an uncertain future, while habitat restoration actions are implemented and take effect. Upgrades to the existing Tribal Sturgeon Hatchery would include:

- Adding in-water tanks and mechanical means to transfer broodstock from the dock to holding tanks (large broodstock are currently carried on stretchers up a steep bank to holding tanks several hundred feet away)
- Adding a new spawning room (broodstock holding tanks are currently in a separate building from the spawning room, so adult sturgeon must be moved manually between buildings during spawning activities)
- Adding a water supply tempering facility to manage heating and chilling requirements for expanded rearing
- Adding weather protection and de-icing systems to sediment pond to allow year-round operation of the sediment pond and drum filter
- Developing an additional 200 square feet of feed storage and 200 square feet of boat storage
- Replacing twelve existing 10-foot-diameter rearing tanks with twenty-four new 8-foot tanks to allow greater segregation of fish families and to reduce rearing densities

Other proposed Tribal Sturgeon Hatchery modifications include: a new 10 -horsepower water pump, water supply intake screen cleaning system, heated drum screen enclosure, fire protection/alarm system, insulation and lighting upgrades, installation of sanitary wall panels in wet rooms, improved ventilation in rearing sheds, a concrete floor in rearing shed No. 2, and construction of isolation walls for the water treatment electric room.

The proposed new facilities at Twin Rivers would include spawning channels, incubation rooms, rearing ponds, water filtration, two employee houses and administrative/biological support facilities. The Twin Rivers Hatchery site is desirable because it provides high quality pathogen-free groundwater as well as surface water from both the Moyie and Kootenai rivers. The site may provide conditions for white sturgeon free embryos to imprint to and ultimately home to a reach that appears to provide adequate habitat conditions for recruitment. Because of these and other attributes, the Kootenai Tribe purchased this property for hatchery development.

In addition, purchase and deployment of two remote incubation and rearing facilities for sturgeon is proposed as part of the sturgeon program. These facilities would be used experimentally to imprint Kootenai sturgeon at remote locations further upstream than Twin Rivers where more favorable spawning, incubation, and initial rearing habitats also appear to exist.

4.3.1.1 Design Guidelines

Conceptual designs for the various upgrades and new facilities are based on the following Tribal design guidelines:

- Locate the expanded Kootenai sturgeon and burbot programs at a shared site to obtain efficiencies in design, permitting, construction and operations.
- Provide flexible facilities that accommodate aquaculture research, allow for some program modification as needed, and provide efficient fish production in support of restoration efforts.
- Improve the Tribal Sturgeon Hatchery near Bonners Ferry:
    - Improve handling of adult fish during spawning (i.e., develop means to mechanically move broodstock from the boat dock to holding tanks and way to prevent having to manually move adult Kootenai sturgeon to a separate building during spawning)
    - Expand rearing capacity to accommodate larger fish, allow for greater segregation of fish families, and reduce rearing densities
    - Manage hatchery water (from river) temperature fluctuations associated with hydropower operations and climate change
    - Accommodate heating and chilling requirements for expanded rearing operations
    - Increase water supply to meet additional flow requirements for new rearing tanks
    - Protect sediment pond from extreme weather conditions (e.g., ice build-up on pond and drum filter)
    - Provide additional storage capacity for feed and for boats
- Use the Twin Rivers Hatchery to:
    - Expand Kootenai conservation aquaculture program rearing capacity
    - Allow fish to imprint and home on waters farther upstream where potentially suitable habitat exists
    - Allow for greater segregation of fish families
    - Ensure low rearing densities
    - Accommodate aquaculture research needs

4.3.1.2 Design Biocriteria

Preliminary engineering design of fish culture facilities was preceded by development of bioengineering criteria (biocriteria) for each life stage of each cultured species. Program goals were developed and quantified (where possible) and biological requirements of the species were identified. This process resulted in a systematic quantification of life stage requirements organized by the functional or operational areas within the proposed facility. These functional areas include broodstock collection, brood-holding, egg-take, incubation, juvenile life phases, rearing, release, and disease management.

One of the important benefits of developing biocriteria is that it requires facility designers to consider a range of potential future operational scenarios. Neither Kootenai sturgeon nor burbot aquaculture protocols are as highly refined as salmonid programming; therefore, facility planning must be adaptable based on monitoring and evaluation of proposed program activities. By addressing production uncertainties at this early design stage, considerations are incorporated that will accommodate modifications without significant cost increases or space constraints.

In addition to biocriteria, water quality and space requirements were identified and water budgets established. Water budgets (quantities and quality) typically constrain fish production levels. Biocriteria and water budgets for Kootenai sturgeon programs are presented in Tables 4-7 and 4-8.

The Tribe initiated a collaborative process to develop biocriteria early in the design process. The Tribe's contractors hosted an initial meeting with hatchery design team members followed by a formal meeting and interviews of Tribal Sturgeon Hatchery staff. The goal of the interviews was to identify initial needs by area at the hatchery. This was followed by another meeting with design engineers at the Tribal Sturgeon Hatchery in early 2007 that resulted in formulation of initial operations schedules, draft criteria for Kootenai sturgeon and burbot, and live feed assumptions. The Tribe hosted a formal work session with a subgroup at the Kootenai River White Sturgeon Recovery Team meeting on January 22, 2008. Draft criteria were reviewed and detailed requirements identified. From this information, draft biocriteria were produced.

After these initial meetings, basic information was finalized and organized to allow review by a broader technical audience. The biocriteria review included Kootenai hatchery staff, contracted and agency sturgeon biologists, University of Idaho personnel, and IDFG biologists. By late February 2008, the Tribe and their contractors felt that the biocriteria were sufficiently developed for use by the design engineers.

These biocriteria were used to help identify and design specific elements of the facilities including size of tanks, number of tanks, necessary flow, etc. Tables 4-7 and 4-8 provide a summary of the biocriteria developed for the Kootenai sturgeon aquaculture program. Biocriteria were developed for each life stage and organized by the functional or operational areas within the proposed facility. These functional areas include brood collection, brood holding, egg-take, incubation, juvenile life phases, rearing, release, and disease management. Biocriteria for the rainbow trout (used for live forage for sturgeon) are also included in Tables 4-7 and 4-8.

The outcome of these reviews and discussions was a conservation production goal to annually produce up to 40,000 Age 1+ sturgeon for release (up to 1,000 fish per family for up to 40 families, including half-sibling families). Although production of 40 families is not expected to occur annually, facility designs intentionally provide adequate rearing capacity to meet this target while providing optimal rearing densities.

Table 4-7. Biocriteria for Kootenai sturgeon production at the Tribal Sturgeon Hatchery.

Aquaculture Function/Life stage	Broodstock (collection, holding)	Spawning and fertilization	Incubation and hatch	Rearing (fry)	Rearing (on feed, up to 4 months)	Forage fish rearing
General	Separate and adjacent broodstock holding and adjacent spawning areas (improve broodstock transport at boat ramp)	Separate and adjacent egg de-adhesion and fertilization area	Separate and adjacent incubation area	Hatched embryos transferred in water from hatching jars to fry rearing tanks		Rainbow trout
Time / Months	Feb-June	May to June	May into July	July- August	Year round	Feb-June
Water temp range (degrees C)	8 to 16° C	9 to 15° C	14 +/- 2° C	14 +/- 2° C	Ambient river	Ambient
Other WQ Requirements	Silt and pathogen free	Silt and pathogen free	Silt and pathogen free	Silt and pathogen free	Silt and pathogen free	Silt and pathogen free
Densities by life stage	≤ 4 broodstock per 15 ft circular tank	N.A.	10-15K eggs/ jar	Result of hatch success (e.g. 10K fry from 15K eggs)	1,000-1,500 four month-old fish	
Production goals (#)	≤ 12 females X 1 to 3 male each up to 5 males each	Up to 40 family groups from both hatcheries combined	10-15K eggs/ jar	As close to 100% hatch as possible; #s based on above egg numbers	3,000 fish/family X number of families/year	
Survival assumptions by life stage (%)	100%	75-95%	50-90%	50-90%	50%	
Holding units size and description	15 ft dia. X 3 ft dia (4000 gal. ea.)	N.A. to facility design	McDonald jar battery	Rectangular tanks (8'x2'x18" deep)	6 ft. dia x 3 ft. h (500 gal) & 8 ft. dia x 4 ft. h (1,200 gal)	10 ft dia x 4.5 ft. h
Number of tanks and water exchange/flow rates	6 tanks, 6.6 hr exchange	N.A. to facility design	24 jars	24 tanks, R=2, Flow 2 gpm/tank	15- 6 ft dia @ 6 gpm & 24-8 ft dia, @ 8 gpm	(1) 10 ft x 4.5 ft.h tank
Total flow - GPM	60 gpm		48 gpm	48 gpm	6 gpm /tank (282 gpm total)	10 gpm
Water source	Kootenai River		Kootenai River	Kootenai River	Kootenai River	Kootenai River
Water treatment	Sediment filtration, ozone, U.V., heat water, proper fish densities	Egg disinfection (iodophore, formalin)	Sediment filtration, ozone, U.V., proper egg densities, incubator flows	Sediment filtration, ozone, U.V., proper fish densities	Sediment filtration, ozone, U.V., chill, proper fish densities	

Table 4-8. **Biocriteria for Kootenai sturgeon production at the proposed Twin Rivers Hatchery.**

Aquaculture function/ life stage	Spawning channel	Brood-stock (collection & holding)	Spawning and fertile-zation	Incubation and hatch	Rearing (fry)	Rearing (on feed, up to 4 months)	Rearing (YOY)	Rearing (juveniles-Age 1+)	Release	Forage fish - includes burbot program
General	Provide Predator Protection	Separate broodstock holding and adjacent spawning areas (improve broodstock transport at boat ramp)	Separate egg de-adhesion and fertilization area	Separate and adjacent incubation area	Hatched embryos transferred in water from hatching jars to fry rearing tanks		More rearing space needed (each family is reared in its own tank)	Suitable/optimal water quality and densities crucial to maximize survival of all post-hatch life stages	Separate pre-release data collection and work-up area with data logging	Rainbow trout
Time / Months		Feb-June	May to June	May into July	July-August	Sept-Nov	Nov-May	May forward	Variable	Year round
Water temp range (°C)		8 to 16° C	9 to 15° C	14 +/- 2° C	14 +/- 2° C	Ambient river	Ambient river, or heated	<16° during summer, am-bient fall and winter unless heated	Variable	Ground-water for incubation, river water for rearing
Other WQ require-ments		Silt and pathogen free	Silt and pathogen free	Silt and pathogen free	Silt and pathogen free	Silt and pathogen free	Silt and pathogen free	Silt and pathogen free	Thermal tempering	Silt, pathogen free
Densities by life stage		≤ 4 brood-stock per 15 ft circular tank	N.A.	10-15K eggs/ jar	Result of hatch success (e.g., 10K fry from 15K eggs)	1,000-1,500 4 month old fish	500-1,000 YOY	500 Age 1; 100-200 Age 2	NA	75,000 eggs
Production goals (#)		≤ 6 females X 1 to 5 male each	Up to 40 family groups from both hatcheries	10-15K eggs/ jar	As close to 100% hatch as possible; #s based on above egg numbers	3,000 fish/ family X number of families/ye ar	1,500 fish/ family X number of families/year	<1,500 fish/family X number of families/year	<1,500 per family at Age 1	NA

Aquaculture function/ life stage	Spawning channel	Brood-stock (collection & holding)	Spawning and fertile-zation	Incubation and hatch	Rearing (fry)	Rearing (on feed, up to 4 months)	Rearing (YOY)	Rearing (juveniles-Age 1+)	Release	Forage fish - includes burbot program
Survival assumption by life stage (%)		100%	75-85%	50-90%	50-90%	50%	50-90%	50-90%		
Holding unit size and description		15 ft dia. X 3 ft. d (4,000 gal. ea.)	N.A. to facility design	McDonald jar battery	Rectangula r tanks (8'x2'x18" deep)	6 ft dia x 3 ft h (500 gal) & 10 ft dia x 4.5 ft h (1800 gal)	10 ft diam tanks, 1,000 fish per tank	10 ft diam tanks, 750 fish per tank	N.A.	Inc trays, 15 ft dia x 4 ft h & 10' dia x 4.5 ft h
# of tanks and water exchange/ flow rates		3 tanks, 6.6 hour exchange	N.A. to facility design	36 jars	36 tanks, R=2, flow 6 gpm/ tank	15- 6 ft dia & 16-10 ft dia, 1 to 3 hour exchange, 10 gpm/ tank	15- 6 ft dia & 16-10 ft dia, 1 to 3 hour exchange, 10 gpm/ tank	15- 6 ft dia & 16-10 ft dia, 1 to 3 hour exchange, 10 gpm/ tank	N.A.	(2) 8 tray Heath stacks, (1) 15 ft dia. for broodstock and (4) 10 ft.rearing
Total flow - GPM		30 GPM		90 GPM	180 GPM	310 GPM	310 gpm	310 gpm	N.A.	10 gpm groundwater; 50 gpm surface water
Water source		All Sources		Ground-water	All sources (priority Kootenai, Moyie)	All sources (priority Kootenai, Moyie)	All sources (priority Kootenai, Moyie)	All sources (priority Kootenai, Moyie)		Groundwater for incubation, surface water for rearing
Water treatment		Sediment filtration, ozone, U.V., proper fish densities	Egg disinfection (iodophore, formalin)	Sediment filtration, ozone, U.V., proper egg densities, incubator flows	Sediment filtration, ozone, U.V., proper fish densities	Sediment filtration, ozone, U.V., proper fish densities	Sediment filtration, ozone, U.V., proper fish densities			

Seventy tanks at both facilities will provide rearing capacity for up to 42,000 Age 1+ sturgeon to meet annual production goals at a density of 750 fish per 10-foot-diameter tank (Table 4-9). Producing fewer than 40 families in a year will result in lower rearing densities. After 20 years of empirical sturgeon aquaculture, it is apparent that not only does annual variability in broodstock availability occur, but considerable variability in family-specific survival of early life stages also occurs. This variability is thought to arise from a combination of genetic and environmental conditions. Thus, the program's production capacity is designed to capitalize on the rare years in which large numbers of broodstock and high survival across all families occurs, while optimizing conditions during average production years (e.g., rearing density, reduced stress levels during rearing), which could involve considerably fewer fish.

Table 4-9. Production capacity for Age 1+ sturgeon at the upgraded Kootenai Sturgeon Hatchery and the proposed Twin Rivers Hatchery.

Tanks and Production		Annual Number of Fish	Annual Production Capacity by Facility	Total Annual Production Capacity
Twin Rivers				
15- 6 foot diameter	500 fish/tank x 15 tanks	7,500		
16- 10 foot diameter	750 fish/tank x 16 tanks	12,000		
Subtotal			19,500	
Tribal Sturgeon Hatchery[a]				
15-6 foot diameter	500 fish/tank x 15 tanks	7,500		
24-8 foot diameter	625 fish/tank x 24 tanks	15,000		
Subtotal			22,500	
Total Annual Production Capacity				42,000

[a] Production capacity includes the fail-safe program component at the Kootenay Sturgeon Hatchery in B.C.

4.3.2 Tribal Sturgeon Hatchery Modifications

The following section describes the existing Tribal Sturgeon Hatchery site and proposed modifications.

4.3.2.1 Tribal Sturgeon Hatchery Site Analysis

The existing Tribal Sturgeon Hatchery site, shown in Figure 4-19, is located on the Kootenai Tribe of Idaho's Reservation lands, about two miles west of Bonners Ferry. The site is relatively flat bottomland surrounded by agricultural fields that are isolated from the Kootenai River by a 10 to 20-foot-high levee.

Existing facilities include a main hatchery and incubation building, two rearing sheds, an administration building, storage sheds and water treatment facilities that were constructed between 1990 and 2007. The existing hatchery has a reliable surface water supply and good boat access. As a result of emergency upgrades completed in 2008, the facility also has limited water treatment, tempering, and controls systems in place. The incubation and rearing facilities are in good condition and have many years of service life remaining.

The existing facility has several amenities that make it attractive for continued aquaculture operations; however, it also has limitations that prevent it from meeting new program goals as the sole production facility. The primary limitation is lack of space for expansion. Only a small amount of space is available within the existing footprint for additional infrastructure. Other limitations from an aquaculture standpoint are the poor quality of the groundwater and the limited ability to control water temperature.

4.3.2.2 Water Supply

The Tribal Sturgeon Hatchery will continue to use treated Kootenai River water for all fish culture activities. Water supply treatment improvements were completed in 2008 that reduce turbidity and improve temperature and pathogen control, although more temperature control is necessary to meet summer and winter rearing temperature requirements. No increase in water supply is proposed at this site.

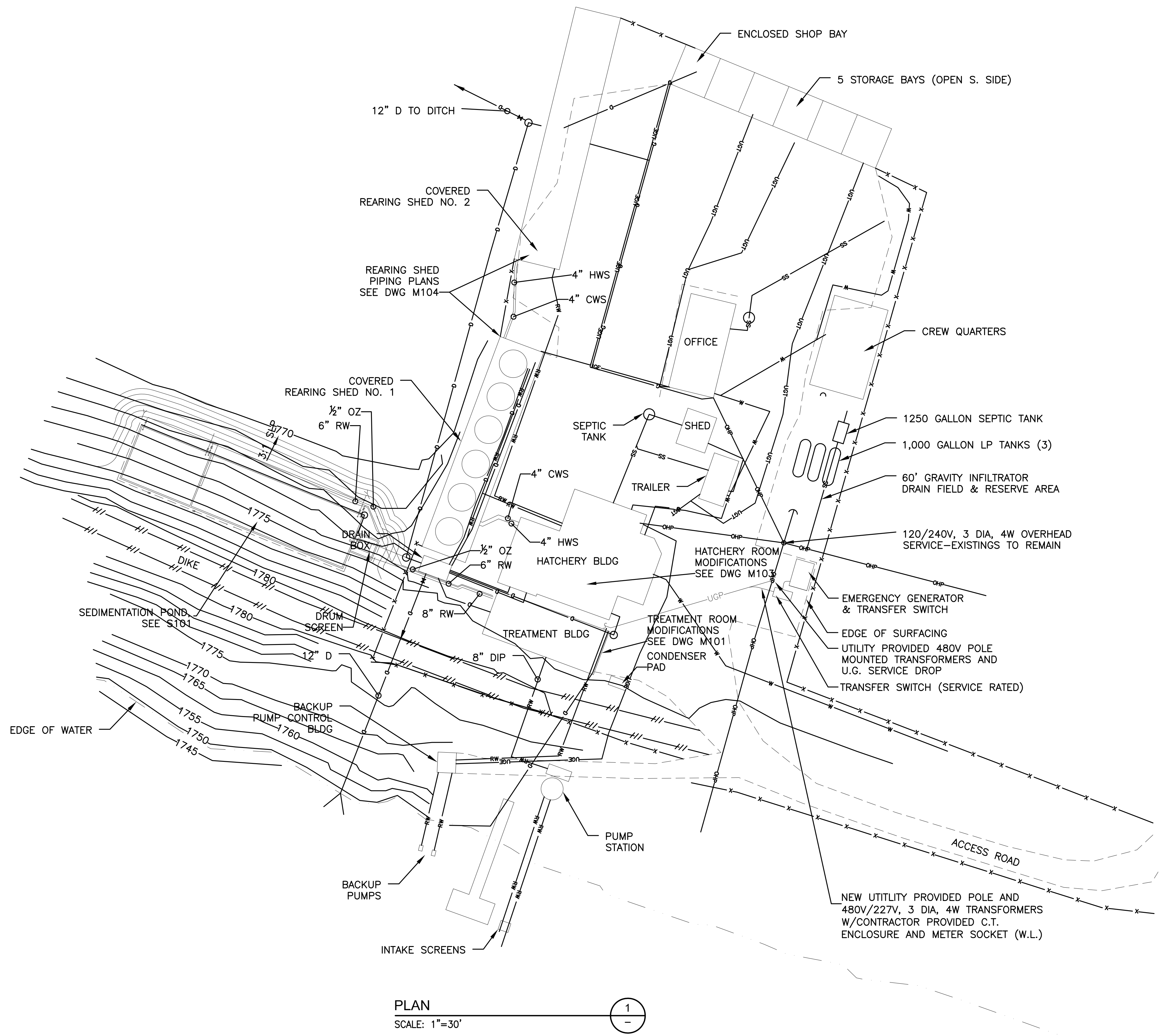
4.3.2.3 Proposed Modifications to Existing Tribal Sturgeon Hatchery Facilities

This section briefly describes the proposed modifications to the existing Tribal Sturgeon Hatchery. Figure 4-20 identifies the specific improvements.

Adult Handling and Transport – Presently, Kootenai sturgeon broodstock are captured in the Kootenai River and transported by boat to a dock. At the dock, the large fish are placed on a stretcher and manually carried from the boat up a steep ramp and over the levee to the holding tanks several hundred feet away. This method of transport is difficult and dangerous for hatchery staff, as well as being stressful for the fish. A means of mechanically moving the fish within in a water-filled tank is an important project need and will significantly enhance the safety of the project for both humans and sturgeons, and the efficiency of spawning operations.

Adult Holding/Spawning – The existing broodstock holding tanks are in a separate building from the spawning room; therefore, large adult Kootenai sturgeon must be moved manually between buildings during spawning activities. The Tribe is proposing adding a new spawning room to the existing broodstock holding shed to improve adult fish handling and spawning efficiency (Figure 4-20).

Water Supply Tempering Facility – The Tribe is proposing an energy recovery heat exchange system to manage water temperatures that are influenced by hydropower operations and climate change, as well as to accommodate the heating and chilling requirements of expanded rearing operations. It will use heated or chilled hatchery effluent to pre-temper the incoming water supply. This will reduce demand on the chiller and boiler, reducing energy consumption. Chiller capacity will also be expanded.



PLAN 1/–

SCALE: 1"=30'

LEGEND

- W — DOMESTIC WATER
- D — DRAIN
- G — GAS
- OHP — OVERHEAD POWER
- RW — RIVER WATER
- SS — SANITARY SEWER
- UGE — UNDERGROUND ELECTRICAL
- UGT — UNDERGROUND TELEPHONE

REV	DATE	DES	CHECK	APPROVALS	REVISION DESCRIPTION

DATE: JUL 2009	CIVIL REVIEW:
DESIGNED:	ARCH REVIEW:
DRAWN:	STRUC REVIEW:
CHECKED:	MECH REVIEW:
APPROVED:	

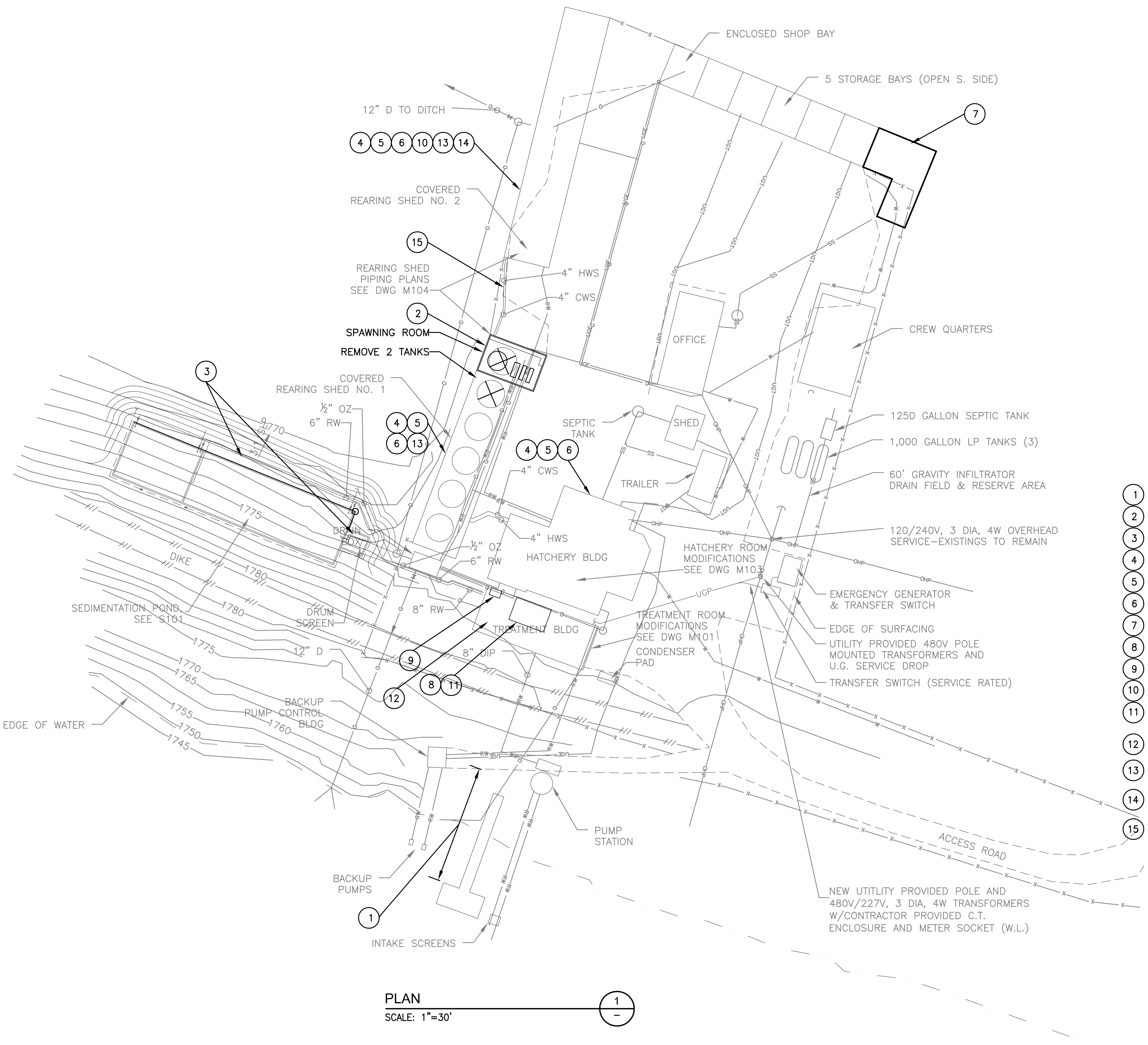
TETRA TECH
www.tetratech.com
7080 SW Fir Loop
Portland, Oregon 97223
Phone: 503-684-9097 Fax: 503-598-0583

KOOTENAI RIVER NATIVE FISH RESTORATION AND CONSERVATION AQUACULTURE PROGRAM

TRIBAL STURGEON HATCHERY
EXISTING SITE PLAN

FILE NO:	
PROJECT NO:	3750004
DWG NO:	FIG 4-19
SHEET:	OF

This drawing is full size when 22"x 34" or is reduced to half size when 11"x17"



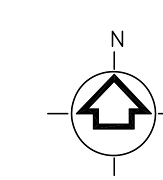
PLAN
SCALE: 1"=30'
1
–

LEGEND

W	DOMESTIC WATER
D	DRAIN
G	GAS
OHP	OVERHEAD POWER
RW	RIVER WATER
SS	SANITARY SEWER
UGE	UNDERGROUND ELECTRICAL
UGT	UNDERGROUND TELEPHONE

LIST OF WORK ITEMS

1. ADULT FISH TRANSPORT IMPROVEMENTS
2. ADULT FISH SPAWING AREA 20'X32' REMODEL
3. DRUM SCREEN HEATER
4. FIRE ALARM AND LIGHTING SYSTEM UPGRADES
5. IMPROVED INSULATION & VENTILATION
6. SANITARY WALL PANELS IN WET AREAS– 8 FEET HIGH
7. FEED AND BOAT STORAGE
8. INTERIOR PARTITION OF ELECTRICAL/CONTROLS IN TREATMENT BUILDING
9. VENTILATION CABINET AND ALARM FOR OZONE GENERATOR
10. ALLOWANCE FOR WATER SYSTEM UPGRADES
11. ALLOWANCE FOR WATER SYSTEM CONTROLS UPGRADES
12. BACKWASH FLOW METER AND THROTTLING VALVE. REPLACE CHECK VALVES
13. CONC. PADS AT DOORWAYS & HOSE BIBBS FOR WASHDOWN
14. REPLACE (12) 10' TANKS WITH (24) 8' TANKS, INSTALL CONC FLOOR & PIPE CHASES
15. EXTEND RIVER WATER SUPPLY FROM SHED #1 TO SHED #2



30' 0' 30' 60'
GRAPHIC SCALE 1"=30'

REV	DATE	DES	CHECK	APPROVALS	REVISION DESCRIPTION

DATE: JUL 2009	CIVIL REVIEW:
DESIGNED:	ARCH REVIEW:
DRAWN:	STRUC REVIEW:
CHECKED:	MECH REVIEW:
APPROVED:	

TETRA TECH
www.tetratech.com
7080 SW Fir Loop
Portland, Oregon 97223
Phone: 503-684-9097 Fax: 503-598-0583

KOOTENAI RIVER NATIVE FISH RESTORATION AND CONSERVATION AQUACULTURE PROGRAM
TWIN RIVERS HATCHERY
PROPOSED MODIFICATIONS

FILE NO:	
PROJECT NO:	3750004
DWG NO:	FIG 4-20
SHEET:	OF

This drawing is full size when 22"x 34" or is reduced to half size when 11"x17"

O:\CAD\CAD\3750004 Kootenai\Prelim Engineering\FIG 5-2.dwg Xref: | 1999 SITE PLAN | XC_DESN | Plotted: May 24, 2010–11:02am

Sediment Pond Weather Protection – A concrete sediment settling pond was constructed as part of the water quality improvements in 2007; however, funds were insufficient to provide a cover for the pond. During an extended cold period in early 2008, the pond and drum filter were incapacitated by ice build-up. Weather protection and de-icing systems are being added to allow year-round operation of the sediment pond and drum filter. Additional adjustments may be required depending on the success of the project during the 2008-2009 winter season.

Feed Storage – An additional 200 square feet of feed storage space and 200 square feet of boat storage space is needed.

Rearing Tanks - Twelve existing 10-foot-diameter tanks in Rearing Shed No. 2 would be replaced with 24 new 8-foot tanks to allow greater segregation of fish families and to reduce rearing densities, which would improve fish health, growth, and survival. The new tanks will be shallower than the old tanks for easier cleaning access and will be installed in a way that better utilizes existing space. Total tank area for fish rearing will increase 50% and water supply requirements will similarly increase.

Water Supply – A ten horsepower booster pump is needed to provide redundant capacity to meet the additional flow requirements of the new rearing tanks.

Other Facilities - Other proposed upgrades include the water supply intake screen cleaning system, heating the drum screen enclosure to prevent icing, adding position indicators on sand filter valves, installing a fire protection/alarm system, improving energy conservation with insulation and lighting upgrades, installing sanitary wall panels in wet rooms for wash down, improving ventilation in the rearing sheds, pouring a concrete floor in Rearing Shed No. 2, and constructing isolation walls for the water treatment electrical room.

4.3.3 Proposed Twin Rivers Hatchery Sturgeon Facilities

This section describes the proposed new Twin Rivers Hatchery facilities for Kootenai sturgeon.

4.3.3.1 Twin Rivers Hatchery Site Analysis

The Kootenai Tribe purchased the land in 2008 for the proposed Twin Rivers Hatchery. A broad flat river delta formed the site that currently is an open park-like setting used as an RV campground (Figure 4-21 and 4-22). Conifers surround much of the perimeter and this is where campsites are concentrated. Much of the site is maintained as lawn, and there is a large swimming hole formed by an embankment placed along the Moyie River. The triangular-shaped property has riverfront on two sites and a steep slope on the third that supports sparse conifers, grass and shrub cover. Site access is available on an unpaved single-lane road traversing the steep slope. This site is suitable for the proposed sturgeon and burbot hatchery because of available high quality water sources, sufficient space to accommodate the proposed facilities without the need for extensive earth work, and low bank shoreline access on two rivers.

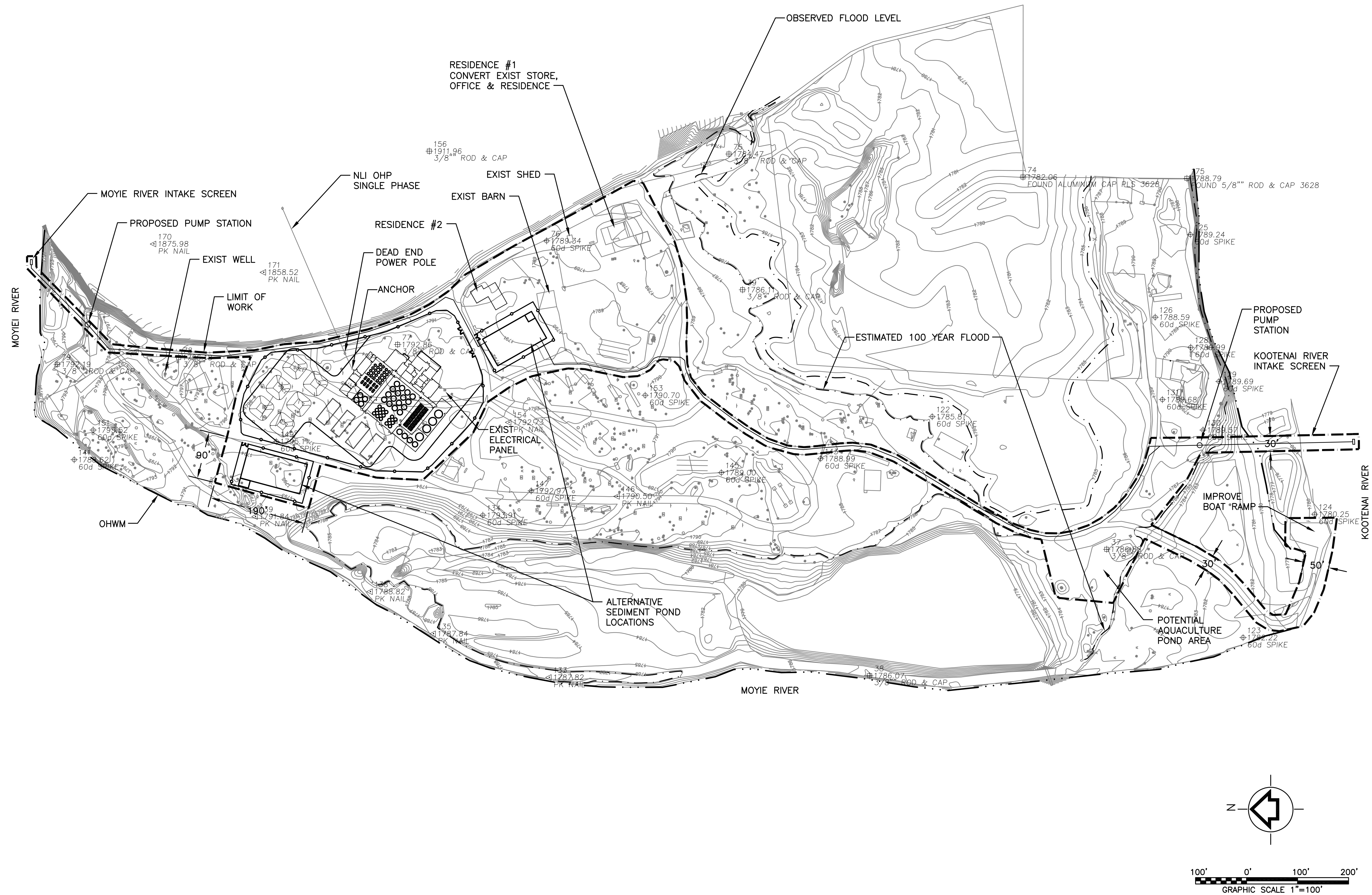
Photo courtesy of M. Reiser, TetraTech

Figure 4-21. Twin Rivers site viewed from access road.

In developing site concepts for the proposed hatchery buildings and support facilities, the following design criteria were emphasized by the Kootenai Tribe:

- Existing resort operations should be preserved to the greatest degree possible without compromising aquaculture functions
- All new facilities should be well above flood elevation (approximately elevation 1786 feet) to prevent water damage and allow gravity drainage of hatchery tanks and ponds
- Mature trees are to be retained to the greatest degree possible
- Available groundwater should be used to provide pathogen-free water
- Hatchery facilities must be secure, with controlled public access and enforced security measures
- Sturgeon culture facilities must be relatively isolated from burbot culture facilities to minimize pathogen vectors
- Operator housing should be available on site or nearby

Based on these criteria, facilities are proposed in predominantly open meadow portions of the site (Figure 4-22), approximately 3 to 5 feet above flood elevation, and will potentially eliminate nine existing RV sites. Building and pond locations potentially could be rearranged within the meadow areas, but there is not much other land available on the property that meets the siting criteria. The proposed layout preserves access to the river and fishing/swimming pond for resort guests.



LEGEND:

- INDICATES POWER POLE
- INDICATES GUY ANCHOR
- INDICATES FIRE PIT
- INDICATES SIGN
- INDICATES PHONE PEDESTAL
- INDICATES POWER PEDESTAL/METER
- INDICATES WATER SPIGOT
- INDICATES SATTELITE DISH
- INDICATES UNDERGROUND POWER & WATER
- INDICATES WELL CASING
- OHWM INDICATES ORDINARY HIGH WATER MARK
- INDICATES PROPANE TANK
- INDICATES SANITARY SEWER CLEANOUT
- INDICATES BASKETBALL HOOP
- INDICATES STUMP
- INDICATES APPROXIMATE BOUNDARY

REV	DATE	DES	CHECK	APPROVALS	REVISION DESCRIPTION

DATE: JUL 2009	CIVIL REVIEW:
DESIGNED:	ARCH REVIEW:
DRAWN:	STRUC REVIEW:
CHECKED:	MECH REVIEW:
APPROVED:	

TETRA TECH
www.tetratech.com
7080 SW Fir Loop
Portland, Oregon 97223
Phone: 503-684-9097 Fax: 503-598-0583

KOOTENAI RIVER NATIVE FISH RESTORATION AND CONSERVATION AQUACULTURE PROGRAM

AQUACULTURE FACILITIES PROPOSED AT TWIN RIVERS

FILE NO:
PROJECT NO: 3750004
DWG NO: FIG 4-22
SHEET: OF

This drawing is full size when 22"x 34" or is reduced to half size when 11"x17"

Plotted: May 24, 2010–11:04am
Xref: | 07-94 TOPO | XC-DESN | XC-BASE |
O:\CADD\CAD\3750004 Kootenai\Prelim Engineering\FIG 5-3.dwg

4.3.3.2 *Water Budget and Supply*

The water supply for the Kootenai sturgeon program at Twin Rivers Hatchery will be shared with the burbot program as described in Section 5.3. Details of annual water budgets for all aspects of Kootenai sturgeon, burbot, and live feed fish (rainbow trout) culture are presented in Table 4-10. A combination of water sources (tempered and ambient river water) are proposed for different Kootenai aquaculture activities. Average monthly flow requirements vary from 55 to about 650 gallons per minute (gpm). Sturgeon rearing flows require mostly ambient river water in addition to some tempered river water during spring and summer. Water budgeted for rainbow trout production is estimated at 70 gpm, while total facility flow rates for Kootenai sturgeon, burbot, and all feed production range from about 170 gpm during winter (December and January) up to nearly 1,250 gpm during June. Water demand projections shown in Table 4-9 are based on using first pass water for all programs and life stages. The potential to reduce heating and chilling energy demands through partial reuse or energy recovery on effluent flows will be studied.

An existing 60 gpm potable water well at the Twin Rivers site was tested in 2008 and found to be pathogen-free and suitable for aquaculture (results are presented in Appendix D). Due to the high likelihood that there is a productive aquifer contained in the alluvial soils underlying the Twin Rivers site, it is anticipated that additional wells can be developed to draw water of similar quality from the same aquifer.

The proposed Twin Rivers Hatchery includes a surface water intake on the Moyie River in addition to well water and Kootenai River sources. The Moyie typically does not experience the high turbidity events seen in the Kootenai because fine sediments are trapped and settled in the reservoir behind Moyie Dam, located about a mile upstream from the Twin Rivers property.

4.3.3.2 *Twin Rivers Hatchery Facilities*

Building Design Criteria and Space Planning

Hatchery production and support spaces will be constructed of cost effective, durable materials designed for the anticipated climactic and industrial conditions of aquaculture operations. Sustainable features will be incorporated into the structures that will be designed to blend with the Twin Rivers setting. Security and fire alarm systems will be incorporated if required. All buildings will be designed to comply with the current standard building codes. Table 4-11 identifies the preliminary square footage estimated for each major Twin Rivers Hatchery building elements.

River Intakes

Intake structures are proposed on both the Kootenai and Moyie rivers to supply aquaculture operations at Twin Rivers (Figure 4-23). While a variety of passive and self-cleaning intake screens are being considered, it is likely that systems similar to those currently in use at the Tribal Sturgeon Hatchery will be selected. This system uses a dual cylindrical tee screen with air-burst backwash. Water will flow by gravity through the screens into the wet well of the pump stations adjacent to the Kootenai and Moyie river intakes. For the Kootenai intake, either submersible or mixed flow pumps will be used to lift the water into a sediment pond in order to remove settleable solids prior to further treatment. The Moyie River water supply is expected have a much lower sediment load than the Kootenai, enabling it to be pumped directly to mechanical filtration in the water treatment building.

At the Twin Rivers Hatchery site, the Kootenai River channel is about 200 feet wide and fairly uniform in cross-section. Near-shore waters are slower moving, with sand and silt deposits over a cobble bottom. Farther from shore, the river is deeper with higher current velocity, resulting in a clean cobble substrate. The intake screen would need to extend at least 50 to 60 feet into the channel where the depth is adequate to assure supply during low flow periods and to avoid hazards to boaters. The preliminary location for the intake piping and pump station is approximately 150 feet upstream of the existing unimproved boat ramp.

Two potential intake sites were evaluated on the Moyie River. One location, at the far north end of the project site, is in slow deep water at the base of a rock outcrop. The other location is a reach of shallow, fast-moving water several hundred feet downstream. It was determined that the water depth at the downstream reach would not be adequate to ensure continuous supply during low flow periods. Additional underwater survey data will be collected prior to developing detailed designs for intake screens and pump stations.

Groundwater

Relatively small amounts of groundwater will be used in the hatchery to provide a pathogen-free supply for incubation, make-up water for the live feed program, and perhaps for temperature control of river water at certain times of the year. As shown in Table 4-9, groundwater demand will range seasonally from 15 to 150 gpm. Two new 150 gpm on-site wells are proposed to provide redundant sources of groundwater. An existing well will continue to be used to supply potable water.

Fish-Rearing Water Supply and Treatment

Figure 4-24 is a schematic diagram of the proposed aquaculture water supply treatment system at Twin Rivers Hatchery. Water pumped from the Kootenai River will first be routed through sediment ponds in order to remove settleable solids. This step may be supplemented by ozone treatment for micro-flocculation, an option to be examined during final design. Ozone can improve settling efficiencies in raw water treatment systems and provide pathogen sterilization as an added benefit. After initial settling, particulates in the river water will be removed through a drum screen pre-filtration followed by booster pumps and high-rate sand filtration. The filtered water will be disinfected with ultra-violet sterilization to destroy any remaining pathogens.

Disinfected water will be routed either directly to the hatchery headbox for use as ambient water or to heat exchangers to adjust the water temperature. All water supplies will be gas-stabilized at the head box prior to use in the hatchery. Groundwater testing is underway to determine if any treatment in addition to standard gas stabilization will be needed.

Table 4-10. Annual water budgets for all aspects of Kootenai sturgeon, burbot and live feed fish culture.

GW	RW	
		Year Zero
		Year One
		Year Two

	Temp Range	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Burbot Program																									
Broodstock Holding Flow	*2-22 C, Amb RW*						65	65	65	65	65	65	65						65	65	65	65	65	65	65
Egg Take	*2-4 C - Chill RW*	65	65	65	65	65								65	65	65	65	65							
Incubation and Hatch Flow	*2-6 C - Chill GW*	7	7	7	7	7	7							7	7	7	7	7	7						
Early Rearing Flow (fry)	*6-10 C - Chill GW*		45	45	45	35	23	10							45	45	45	35	23	10					
Rearing on Feed (age -4mos.)	*10-15 C - Amb GW*					10	23	35	45	45	45							10	23	35	45	45	45		
Extended Indoor Rearing	*10-22 C - H/C RW*									100	100	100	100	200	200	200	200	200	200	200	200	200	200	200	200
Outdoor Rearing	*10-22 C Amb RW*																150	150	150	150	150	150	150	150	150
Summary																									
Tempered River Water Flow		65	65	65	65	65				145	145	100	100	265	265	265	265	265	200	200	200	200	200	200	200
Ambient River Water Flow		0	0	0	0	0	65	65	65	65	65	65	65	0	0	0	215	215	215	215	215	215	215	215	215
Chilled Groundwater Flow		7	52	52	52	42	30	10						7	52	52	52	42	30	10					
Ambient Ground Water Flow						10	23	35	45	45	45							10	23	35	45	45	45		
Backwash Make-up & Overflow		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	50	50	50	50	50	50	50	50	50
Total Flow - Burbot		97	142	142	142	142	143	135	135	280	280	190	190	297	342	342	582	582	518	510	510	510	510	465	465

	Temp Range	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
White Sturgeon Program*																									
Broodstock Holding Flow	*8-16 C H/C RW*			30	30	30	30	30								30	30	30	30	30					
Incubation and Hatch Flow	*12-16 C H/C GW*						90	90	90										90	90	90				
Early Rearing Flow (fry)	*12-16 C - Chill RW*								90	180											90	180			
Rearing on Feed (age-4months)	*Ambient RW*										310	310	310										310	310	310
Rearing (YOY)	*Amb. or Heated RW*													310	310	310	310	310	310						
Rearing (Juvenile Age 1+)	*2-16 C RW*																			310	310	310			
Spawning Channels (2 to 4)	*8-16 C H/C RW*					100	100	100	100									100	100	100	100				
Summary																									
Tempered River Water Flow		0	0	30	30	130	130	130	190	180	0	0	0	0	0	30	30	100	100	130	190	180	0	0	0
Ambient River Water Flow		0	0	0	0	0	0	0	0	0	310	310	310	310	310	310	310	310	310	310	310	310	310	310	310
Tempered Groundwater Flow							90	90	90										90	90	90				
Ambient Ground Water Flow																									
Backwash Make-up & Overflow		0	0	25	25	25	25	25	25	25	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Total Flow - Sturgeon		0	0	55	55	155	245	245	305	205	360	360	360	360	360	390	390	460	550	580	640	540	360	360	360

	Temp Range	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Forage Fish and Live Feed																									
Rotifer and Artemia Culture	*Amb GW makeup*	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
RBT Broodstock Holding Flow	*Ambient - RW*	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
RBT Inc. and Hatch Flow	*Amb GW*	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
RBT Rearing Flow	*Ambient - RW*	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Summary																									
Tempered River Water		40	40	40	40									40	40	40	40								
Ambient River Water Flow		15	15	15	15	55	55	55	55	55	55	55	55	15	15	15	15	55	55	55	55	55	55	55	55
Ambient Ground Water Flow		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Total Flow - Live Feed		70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Facility Summary																									
Tempered River Water Flow		105	105	135	135	195	130	130	190	325	145	100	100	305	305	335	335	365	300	330	390	380	200	200	200
Ambient River Water Flow		15	15	15	15	55	120	120	120	120	430	430	430	325	325	325	540	580	580	580	580	580	580	580	580
Tempered Groundwater Flow		7	7	7	7	7	97	90	90	0	0	0	0	7	7	7	7	7	97	90	90	0	0	0	0
Ambient Ground Water Flow		15	15	15	15	25	38	50	60	60	60	15	15	15	15	15	15	25	38	50	60	60	60	15	15
*Backwash Make-up & Overflow***		25	25	50	50	50	50	50	50	50	75	75	75	75	75	75	100	100	100	100	100	100	100	100	100
Total Flow (Discharge)		167	167	222	222	332	435	440	510	555	710	620	620	727	727	757	997	1077	1115	1150	1220	1120	940	895	895

*Note: Assumes Approx. Half of Sturgeon Broodstock Holding, Spawning and Early Rearing Occurs at Bonners Ferry

** Backwash Flows are Intermittent Higher Flows - Average Flows are used for Programming

Table 4-11. Twin Rivers Hatchery space requirements[1].

Sturgeon	Space Required
Sturgeon Broodstock/Spawning	1,650 SF
Sturgeon Spawning	640 SF
Sturgeon Incubation	1,920 SF
Sturgeon Mechanical/Electrical	200 SF
Sturgeon Rearing	5,400 SF
Sturgeon Subtotal	9,810 SF
Forage Fish	
Forage Fish Broodstock	400 SF
Forage Fish Incubation and Rearing	1,100 SF
Forage Fish Subtotal	1,500 SF
Hatchery Support Space Program	
Entry Vestibule (2)	140 SF
Public Display	400 SF
4-6 Staff Offices (open office)	620 SF
Conference Room	400 SF
Mud Room/Janitor Closet	150 SF
Men's Restroom & Showers	230 SF
Women's Restroom & Showers	230 SF
Misc. Storage	150 SF
Chemical Storage	100 SF
Water Treatment	1,200 SF
Multipurpose Room (Lab)	320 SF
Dry Storage	400 SF
Vehicle Storage/Maintenance	600 SF
Shop	600 SF
Electrical Room	100 SF
Mechanical Room	200 SF
Generator Room	200 SF
Circulation @ 20%	480 SF
Hatchery Support Subtotal	6,520
Outdoor Facilities	
Water Treatment Sediment Pond	8,000 SF
Sturgeon Spawning Channels (4)	12,800 SF
Effluent Treatment	1,000 SF
Sturgeon Outdoor Facility Subtotal	21,800 SF

[1] Space requirements for burbot are listed in Table 5-5.

Water treatment systems will be located in a central room or building in order to simplify operations and maintenance. The sediment pond will be covered to prevent icing. Back-up generators with automated phone alarms will provide emergency power to critical treatment equipment.

According to the water demand projections shown on the operations schedule (Table 4-10), river water demand will gradually increase during the first year of operation. When fully operational levels are achieved, water use will range seasonally from approximately 600 to 1,200 gallons per minute.

Tempered river water and groundwater flow requirements will range seasonally from 100 to 300 gpm, and 10 to 100 gpm respectively. Redundant boiler and chiller systems with automatic set-point controllers will be used to reliably provide appropriate water temperature at each facility. Primary heat exchangers will likely be used to recover energy from heated and chilled hatchery effluent in order to reduce equipment sizes and conserve energy and operating costs.

Incubation and Rearing Facilities

Burbot aquaculture facilities will be separate from the Kootenai sturgeon and forage fish programs as a way to minimize potential pathogen vectors among species. Preliminary site plans place the burbot building and ponds to the north of the sturgeon facilities, with a roadway providing some separation with shared access.

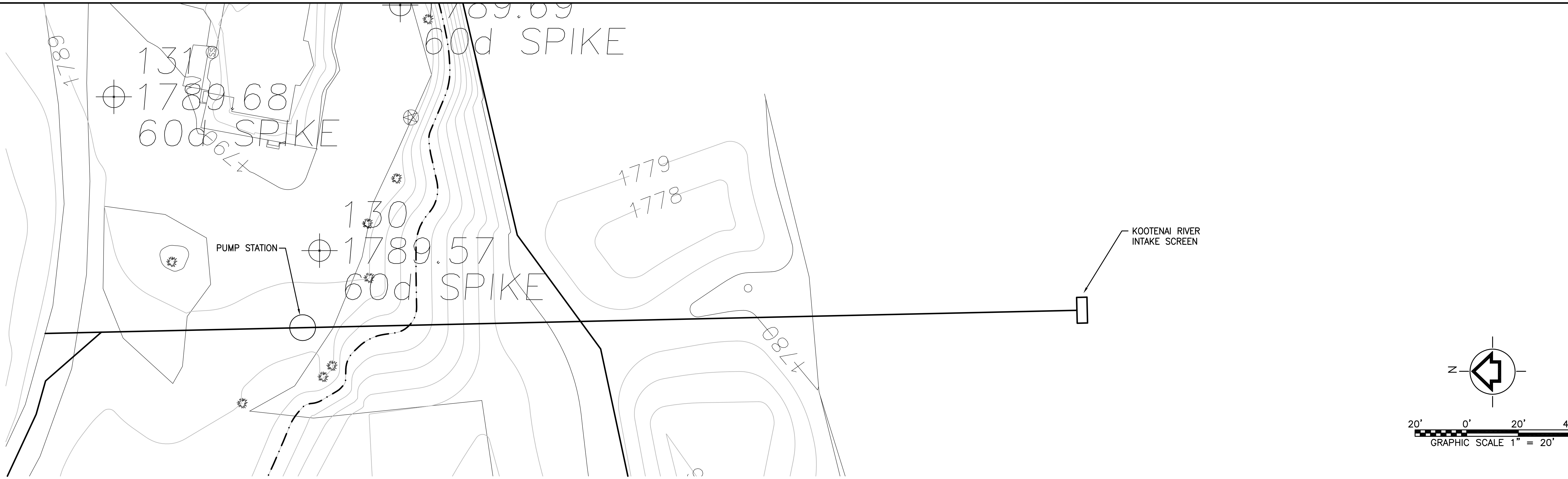
Sturgeon Incubation and Hatch Room

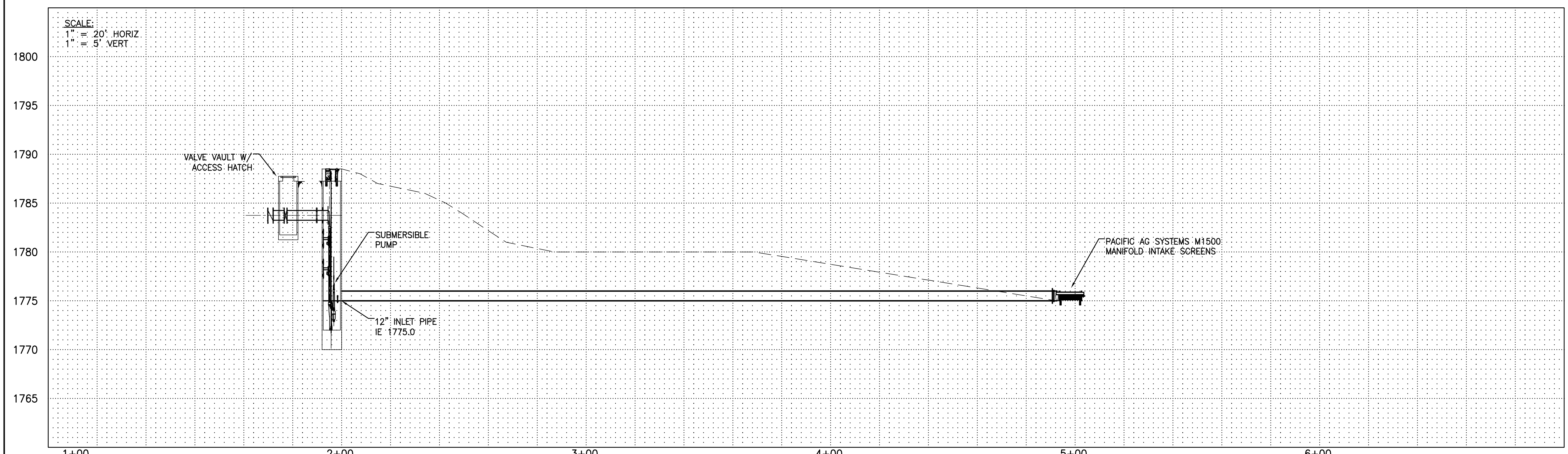
Sturgeon embryos will be incubated in upwelling flow-through jars mounted on fiberglass rearing troughs. Upon hatching, free embryos will follow the flow up and out of the jar and into the trough where they will remain through their early rearing period. Following hatch, free embryos and subsequent life stages will be exposed to Kootenai River water to imprint them to natal water chemistry for future reproductive homing purposes. It will be important to evaluate the role of hatchery effluent as a potential impediment to further upstream migration (i.e., as a result of odorants in hatchery effluent).

The 36 start tanks for free embryo and larval rearing will be 2 feet by 8 feet and 1.5 feet deep. The tanks will be mounted in pairs with access for feeding, cleaning and inspection from only one side. The downstream end of the start tanks will have a short screened-off portion to contain the fish in the tanks. An outlet from each tank will be used to transfer the fish to rearing tanks or to a truck for transport elsewhere. While in the start tanks, larvae will be fed by hand. Target water temperatures for Kootenai sturgeon are from 12 to 16°C.

Sturgeon Rearing

Sturgeon larvae will be transferred from the start tanks to either fifteen 6-foot or sixteen 10-foot-diameter round tanks for the next phase of rearing. Floor trenches with supply and drain piping will be spaced regularly in the concrete slab of this room. Ambient river water typically will be used to supply these tanks, though some provision for tempered water will be included. Baffles and substrate may be included in each tank to mimic natural flow patterns and habitat.





REV	DATE	DES	CHECK	APPROVALS	REVISION DESCRIPTION

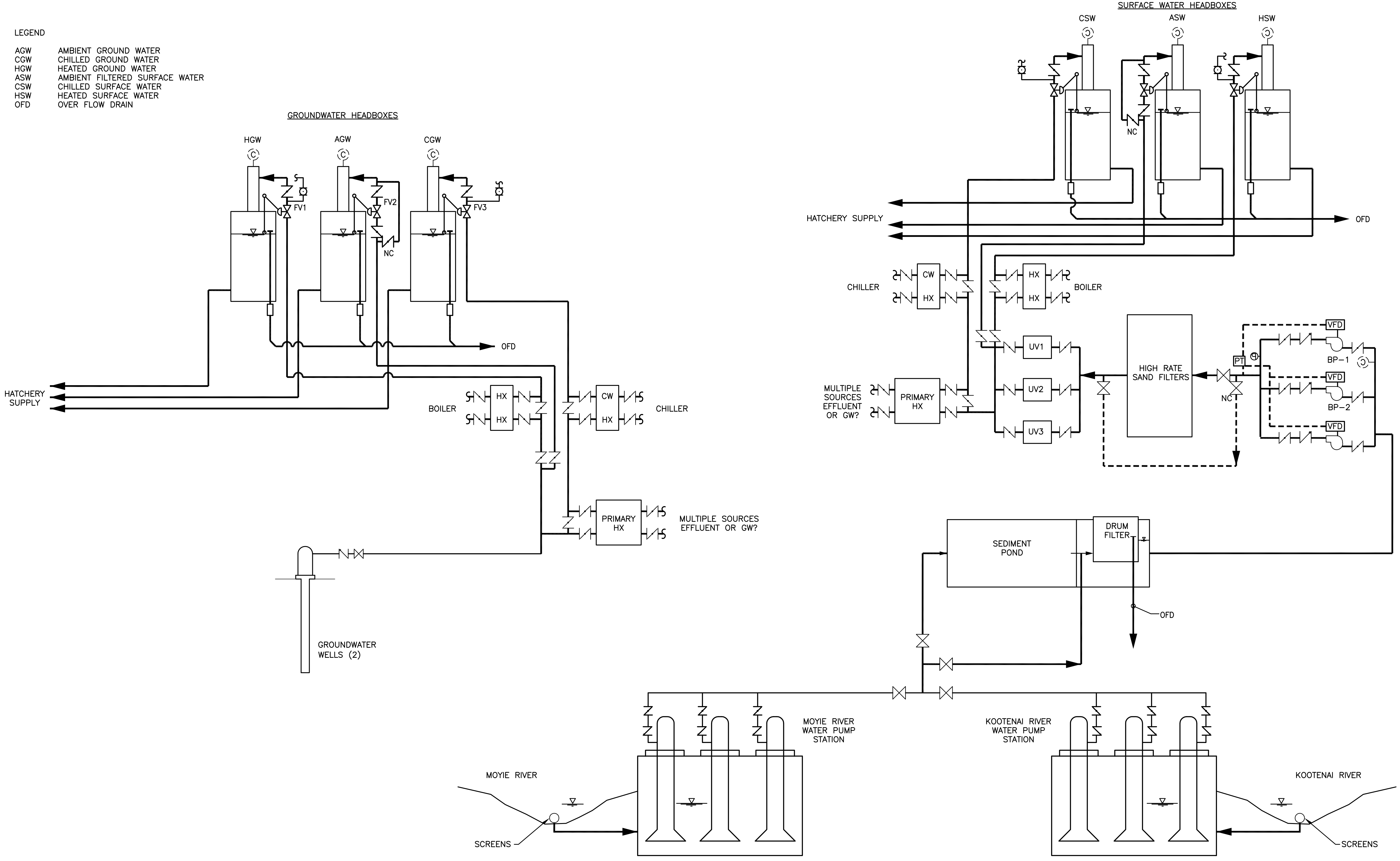
DATE: JUL 2009 | CIVIL REVIEW:
DESIGNED: | ARCH REVIEW:
DRAWN: | STRUC REVIEW:
CHECKED: | MECH REVIEW:
APPROVED:

TETRA TECH
www.tetratech.com
7080 SW Fir Loop
Portland, Oregon 97223
Phone: 503-684-9097 Fax: 503-598-0583

KOOTENAI RIVER NATIVE FISH RESTORATION AND
CONSERVATION AQUACULTURE PROGRAM
TWIN RIVERS HATCHERY
CONCEPTUAL INTAKE PLAN AND PROFILE

FILE NO:
PROJECT NO: 3750004
DWG NO: FIG 4-23
SHEET: OF

This drawing is full size when 22"x 34" or is reduced to half size when 11"x17"



REV	DATE	DES	CHECK	APPROVALS	REVISION DESCRIPTION

DATE: JUL 2009
DESIGNED:
DRAWN:
CHECKED:
APPROVED:
CIVIL REVIEW:
ARCH REVIEW:
STRUC REVIEW:
MECH REVIEW:

TETRA TECH
www.tetratech.com
7080 SW Fir Loop
Portland, Oregon 97223
Phone: 503-684-9097 Fax: 503-598-0583

KOOTENAI RIVER NATIVE FISH RESTORATION AND CONSERVATION AQUACULTURE PROGRAM

TWIN RIVERS HATCHERY
WATER SUPPLY TREATMENT SYSTEM SCHEMATIC

FILE NO:
PROJECT NO: 3750004
DWG NO: FIG 4-24
SHEET: OF

This drawing is full size when 22"x 34" or is reduced to half size when 11"x17"

O:\CADD\CAD\3750004 Kootenai\Prelim Engineering\FIG 4-13.dwg Xref: | Plotted: May 24, 2010-10:41am

Sturgeon Spawning Channels

The spawning channels will be 20 feet wide, with a rearing length of 50 feet and an average water depth of 3 feet, resulting in an individual raceway rearing volume of 3,000 cubic feet. At least two spawning channels will be provided, with space reserved for two to four additional units. Circular flow will be induced in each spawning channel and cobbles will be placed on the bottom to simulate natural conditions. Ambient river water generally will be used to supply the spawning channels. The channels will allow direct observation of adult spawning and early life stage behavior, data that has been unattainable in a natural setting. Adequate space will be available for controlled rearing and other specific research purposes as well.

Forage Fish Facilities

Batches of rainbow trout will be incubated and reared at Twin Rivers Hatchery for use as feed for the Kootenai sturgeon and burbot production programs. Broodstock holding, incubation and rearing operations will be housed in a single large room. Rainbow trout broodstock will be held in one 15-foot-diameter tank. Two stacks of vertical tray incubators will be located adjacent to the brood tank. Three 10-foot-diameter round tanks will be used for rearing to harvest size. Trout eggs will be incubated on groundwater and ambient river water will be used for rearing and broodstock holding.

Effluent Treatment Facilities

Treatment of hatchery effluent is an important water quality protection measure. To accomplish this, effluent will be settled in a dual cell concrete structure (approximately 30 by 60 feet by 3 feet deep) that will receive cleaning waste and backwash from rearing tanks and water filtration equipment. Flow from vacuumed cleaning waste will enter the settling structure at a rate of less than 50 gpm during periodic cleaning. The structure will be split into two cells so that one section can be dewatered and cleaned while the other remains in service. Each cell will have an equipment entry ramp for access to remove solids (sludge). Supernatant (the clear liquid separated from the solids) from the settling process flows directly to an outfall pipe into the Kootenai River in order to maximize dilution. It is expected that solids will be removed from the settling facility once a year and disposed of by land application at an approved site.

Because many fish use odorants or natural chemical signals to locate and home to natal areas, effluent management may be identified as an important parameter in Kootenai sturgeon aquaculture. The role of olfactory cues in white sturgeon homing has yet to be investigated. Recent discussions with the USFWS Kootenai River White Sturgeon Recovery Team and other researchers indicated that the effect of reproductive odorants could have an important effect on the selection of spawning areas by Kootenai sturgeon. Odorants from the Tribal Sturgeon Hatchery effluent may contribute to sturgeon spawning site selection. The implications for future effluent management are uncertain, but may require an adaptive design or operational changes to maximize the success of the programs (Sections 4.5 and 5.5).

Permitting and operational efficiencies will be realized by constructing a single effluent system for both aquaculture programs. Effluent water quality testing and reporting will be centralized at a single location as well.

Biological Laboratory

A small laboratory for all on-site biological and rearing water analysis will be located in the Twin Rivers Hatchery office area. The laboratory area will provide space to store chemicals and equipment needed to perform various required tests and analyses. This area will also facilitate the efficient processing, shipping, and receiving of water quality, live feed, and fish health diagnostic samples, as well as any observational fish health diagnostics as needed. Limited space for small laboratory equipment will also be provided in the burbot spawning area.

4.3.3.3 Infrastructure Components at Twin Rivers

Infrastructure components will be common to the Kootenai sturgeon and burbot programs. These will include the access roads, utilities (power, water, sewer, telephone), an administration building, housing, storage, garage and shop.

Access Roads

The two-mile gravel access road from Highway 2 to the Twin Rivers Hatchery site appears adequate to accommodate the types of vehicles used in hatchery construction and operation. Guardrail will be considered for the steep switchback portions of the roadway. Paving roads and parking areas in the immediate vicinity of the hatchery will be undertaken to reduce dust and dirt tracking.

Administration Building

The main hatchery building will include space for four desks in a common office area. Crew accommodations will include a break/lunch/meeting room, a pair of restrooms with showers and lockers, and a wet gear disinfection and storage area.

Potable Water

An existing well could meet potable water requirements for the aquaculture facilities if, as proposed, current resort occupancy is reduced (the site is a developed campground). If resort use continues at current levels, an additional potable water source or water storage improvements will be explored. A potential back-up connection to one of the two new wells (to be drilled for fish rearing purposes) will be considered during final design.

Power

The site is presently served with single phase power by Northern Lights Power. Three-phase power needed for aquaculture operations is available near Highway 2 and would require a 1.5-mile overhead power line upgrade. Alternatively, it may be possible to obtain power from the City of Bonners Ferry which has a 3-phase power line at the west edge of the Moyie River, less than 100 feet from the hatchery site; however, a service boundary adjustment first would be required.

The new 3- phase power service will supply a new pad-mounted transformer, leading to a main distribution panel in the administration building. This distribution panel will provide power to the Kootenai sturgeon and burbot facilities, the water treatment building, the two river pump stations and branch circuits for site lighting. An emergency generator will be installed in the administration building to provide back-up power to critical aquaculture equipment and facility lighting. During design development, the feasibility and cost effectiveness of installing a separate emergency generator at the Kootenai River pump station will be examined.

Telephone Service

The site has basic telephone service, but does not have DSL or broadband connectivity. Conduits will be installed to provide telephone services for the new facilities. High speed internet service via satellite is available at this location. Telephone and data outlets will be provided in each office and laboratory space.

Sanitary Sewer

The Kootenai Tribe wishes to retain and use most of the existing resort facilities. Any new facilities will require expanded on-site wastewater treatment. Sewage requirements from the hatchery are expected to be relatively low due to the small number of plumbing fixtures. Peak flow rates associated with school bus visitations or conference events will be considered in sizing new wastewater facilities.

Irrigation System

Temporary automated irrigation systems will be used to establish landscape planting for the first year or two after construction. No permanent irrigation systems are planned.

Drainage

Best management practices will be incorporated in the design of stormwater systems for the new facilities. The general approach will be to sheet flow run-off from paved areas into vegetated swales or filter strips to remove pollutants prior to discharge or infiltration. Water from roof drains can be infiltrated or captured for irrigation use.

Storage, Garage and Shop Facilities

The primary feed storage area will be located in the main hatchery building to accommodate pallets of bagged food. Sturgeon broodstock and various life stages of burbot are sustained with live feed or forage fish. Intermediate-size Kootenai sturgeon and trout (to be used as live feed) require pelletized food that will be stockpiled in the dry feed storage area.

The hatchery building will also contain areas to store up to two vehicles, a boat, and other mechanical equipment (approximately 600 square feet), an area to be divided into a carpentry shop and a separate welding shop (approximately 600 square feet), and dry storage (approximately 150 square feet).

Staff Housing

Two houses will be needed at the Twin Rivers Hatchery site for full time employees to be present year-round. The new houses will be constructed on the hatchery grounds as shown on Figure 4-22. Seasonal hatchery staff and visiting researchers will be accommodated in trailers or RVs stationed in the resort area. This will provide flexibility to the Tribe to economically meet changing staffing needs and will reduce transportation costs for the temporary occupants.

4.3.4 Remote Kootenai Sturgeon Incubation, Rearing and Release Sites

In addition to hatchery production, biologists wish to experimentally use remote streamside incubation and early rearing facilities to imprint Kootenai sturgeon at various upstream locations. Holtgren et al. (2007) described a successful remote rearing unit design used to restore lake sturgeon in Michigan. Remote streamside rearing units consist of a portable trailer customized to hold incubation and early rearing tanks, with river water supplied via pumps from selected tributary locations. The units have fully self-sufficient water supply, treatment, temperature controls, aeration, emergency power, and telemetry alarm functions. Site access and security improvements are likely to be needed and are included in project costs, along with supply piping and screening and effluent piping. Specific sites for remote rearing facilities are under consideration. The estimated costs of this program component are separated as an optional item; however, these remote incubation and rearing facilities are a priority to the Tribe and the Tribe plans to move forward with their development. These sites will be important program components for imprinting sturgeon to upstream reaches.

4.4 Sturgeon Monitoring, Evaluation and Research

The conservation aquaculture programs will follow a standard five-part monitoring and evaluation plan to assess water quality, fish health, pre- and post-release performance, genetics, and gamete cryopreservation (KTOI 2004, 2007) (Table 4-12). Water quality monitoring components identified in Section 4.4.1 are the same for both species; other monitoring factors differ between species and are addressed independently in Sections 4.4.4 through 4.4.8 and Section 5.4.

Measurable biological objectives, metrics, and target values for the Kootenai sturgeon aquaculture program are identified in Tables 4-13 and 4-14. Monitoring to be conducted within the hatcheries is summarized in Table 4-13, while post-release monitoring is summarized in Table 4-14. The duration and periodicity of each activity extends over several months per year pre-release to year-round for post-release populations.

Table 4-12. Monitoring and evaluation parameters for Kootenai River white sturgeon and burbot.

M&E Component	M&E Activities	Involved Entities
Hatchery Water Quality	Water sampling	Kootenai Tribe and water quality lab(s)
Fish Health	Standard comprehensive pathogen screening	Kootenai Tribe, USFWS and FFSBC lab(s)
	Fish health research	UI-ARI, FFSBC, and Clear Springs Foods
Performance (Pre-release)	Fertilization, hatch, and survival rates	Kootenai Tribe, FFSBC
Performance (Post-release)	Survival, growth and condition	IDFG, BC MoE, CFS, KTOI
Genetics	Sampling, lab microsatellite analysis	Kootenai Tribe and UC Davis, Genomic Variations lab
Gamete Cryopreservation	Develop and refine white sturgeon cryopreservation techniques	Kootenai Tribe, Univ. of Idaho - Biological Sciences
	Experimental fertilization trials with cryopreserved samples	

Table 4-13. Pre-release biological objectives, metrics and target values to be monitored and evaluated in the Kootenai sturgeon conservation aquaculture program.

Program Aspect	Biological Objectives	Life Stage or Activity	Metrics	Target Metric Values for Sturgeon	Timeframe
Pre-spawning	Provide adequate broodstock	Late vitellogenic, pre-spawning, mature adults	Biological condition	External health and behavior visually suitable	Up to 5 mo. annually, Feb-June
Spawning	Provide adequate broodstock	Spawners	Gamete viability	Water-activated sperm motility > 2 min. Egg GVBD > 80%; PI values < 0.10	Up to 3 mo. annually, typically Feb-June
	Provide adequate breeding matrices for genetic diversity		Effective population size (*Ne*); No. of breeders (*Nb*); fertilization	Up to 18 females mated with at least one male each; fertilization > 80%	
Incubation/ Hatch	Provide adequate incubation and hatch rates	Embryos	Survival (hatch)	Hatching success > 80%	Up to 4 mo. annually, typically May-Sept
Early rearing	Provide adequate fry and larval survival	Fry and larvae	Survival	> 50% for each life stage	Up to 5 mo. annually, typically May-Sept
	Provide adequate YOY survival	YOY rearing	Survival, fish health	Survival > 50 %; no visible signs of fish problems; negative Title 50 pathogen test results if post-release fish tested	Up to 4 mo. annually, Sept-Dec.
	Provide adequate juvenile survival	Juvenile rearing	Survival, condition, fish health	Survival > 50 %; Negative Title 50 pathogen test results	Up to 9 mo. annually, typically Jan-Sept, including fall of previous year for YOY
	Provide adequate fish marking	YOY and juveniles	Mark retention	PIT tag retention > 90%	

GVBD: germinal vesicle breakdown
P1 Value: a metric of sturgeon egg maturity

Table 4-14. Post-release biological objectives, metrics and target values to be monitored and evaluated in the Kootenai sturgeon conservation aquaculture program.

Program Aspect	Biological Objectives	Life Stage or Activity	Metrics	Target Metric Values for Sturgeon	Timeframe
Post-release monitor-ring	Ensure adequate post-release survival, growth, and biological condition to support future mature adults	Juvenile and adult sampling	Survival, annual growth, biological condition (*K*) , relative weight	Survival > 60% first year post-release, 90% thereafter; consistent positive growth; condition factors and relative weights ; consistent, positive trends over years	Annually or periodically based on recapture data
	Create and maintain favorable age class distribution		Age class distribution; recruitment magnitude and frequency	Hatchery-produced year classes annually	Annually, year-round
	Maintain adequate individual and population health		Adequate fish health to support adult target goals	External health and behavior visually suitable; Negative Title 50 pathogen test results	Annually, year-round
	Provide genetic diversity within and among progeny groups		Diversity, heterozygosity metrics, genetic distance and inbreeding coefficients	Genetic diversity targets from mating plan under development	Annually, year-round
All stages	Sustainable adult population target	All life stages	Population abundance (adults)	8,000 to10,000 adults	Annual sampling, periodically update abundance estimates & age class structure characteristics. May occur up to 30 yrs.

4.4.1 Water Quality Monitoring

The quality of incoming water sources and water circulating within the hatcheries is critical to fish health, performance, and the success of any hatchery program. Hatchery effluent also must be monitored for consistency with state, federal, and other relevant quality standards. Criteria for incoming, contained, and effluent waters are critical to the basis of design and a monitoring plan is critical to ensure that water quality is maintained during operations.

Water quality monitoring for each phase of sturgeon and burbot aquaculture is categorized into three broad groups: physical, chemical, and biological. Recommended "no-effect" physical and chemical parameter values for coldwater conservation aquaculture species (Klontz 1991) are presented in Table 4-15. Recommended water quality effluent parameters to be measured include solids (suspended, settleable, and dissolved), nitrogenous waste (ammonia-nitrogen, nitrite-nitrogen, nitrate-nitrogen), dissolved oxygen, organic/inorganic phosphate waste, and temperature (Klontz 1991).

Physical attributes, including temperature, turbidity, and suspended solids, are typically managed through effective facility design, water source choices, and hatchery operations. For example, water temperature is controlled by heating, chilling, or mixing several on-site sources. Suspended solids are removed prior to hatchery use by filtration or settling ponds.

Hatchery water chemistry is also managed through facility design, operations, and hatchery practices. For example, dissolved oxygen can be maintained at optimal levels with agitation towers or by mixing surface and well water. Desired gas saturation levels can be achieved with degassing columns while ammonia levels are controlled by managing appropriate fish densities and feeding and tank cleaning schedules.

Table 4-15. Recommended "no-effect" physical and chemical parameter values supporting cold water conservation aquaculture practices (from Klontz 1991).

Water Quality Parameter	Parameter Value Ranges
Alkalinity	50-200 mg/l as $CaCO_3$
Ammonia (as NH_3)	<0.03 mg/l constant <0.05 mg/l intermittent
Calcium	> 50 mg/l
Carbon Dioxide (CO_2)	< 2.0 mg/l
Copper	< 0.006 mg/l in soft water <0.3 mg/l in hard water
Dissolved oxygen	6-8 mg/l
Dissolved solids	50-200 mg/l
Heavy metals (e.g. Hg, Zn, Cu, Cd)	< 0.1 mg/l
Iron	< 1.0 mg/l
Nitrite-N	< 0.55 mg/l
Nitrogen	< 100 % saturation
pH	6.7-8.5
Suspended solids	< 80 mg/l
Water temperatures	Species dependent
Zinc	< 0.04 mg/l @ pH 7.5

Biological water quality will be monitored to control the presence of bacteria, fungus, and viruses that may affect sturgeon and burbot culture. Pathogens are endemic to most surface water sources, and therefore can be transmitted into a hatchery. Poor hatchery practices can exacerbate fish health conditions, while proper practices in the presence of endemic pathogens can provide disease free fish. Effects of poor biological water quality will be minimized by implementing best management hatchery practices and fish health policies. These will include the use of biofiltration and/or ultraviolet light treatments to reduce the pathogen load in all hatchery waters, reducing the chances for disease outbreaks or pathogen transfer and proliferation. The Twin Rivers Hatchery surface water supplies will be treated similarly to the Tribal Sturgeon Hatchery using settling ponds, screens, sand filters, temperature controls, ultraviolet light and/or de-gassing. Ozonation may also be included in the settling pond for micro-flocculation.

4.4.2 Cooperative Monitoring Efforts

The Tribe and its cooperating partners, IDFG and BC MoE, conduct field investigations that monitor elements specifically related to conservation aquaculture (Table 4-12). These and other broader context monitoring and evaluation programs are identified in the USFWS Recovery Plan, the Tribe's recovery implementation plan (KTOI 2005), and the Kootenai Habitat Restoration Master Plan (KTOI 2009). These strategies and tasks are summarized in Table 4-16. All sturgeon sampling activities are coordinated through the USFWS Recovery Team and through local coordination summarized in the 5-year Sturgeon Implementation Plan provided by the Tribe and cooperating agencies (this plan is currently being updated for 2011-2014).

Table 4-16. Sturgeon recovery and ecosystem monitoring strategy, measures and tasks.

3A. Natural Spawning Assessments	
Measure 3A.1.	Conduct annual assessments of sturgeon spawning activities to index spawning activity, identify spawning periods, and cue sturgeon flow requests.
Task 3A.1.1.	*Implement standardized substrate mat sampling at index sites in known spawning areas.*
Task 3A.1.2.	*Implement standardized D-ring net larval sampling at index sites downstream from known spawning areas.*
3B. Wild Adult Assessments	
Measure 3B.1.	Conduct annual adult sturgeon assessments to estimate population status and obtain spawners for the hatchery program.
Task 3B.1.1.	*Capture adults during spring and early summer in areas of concentration downstream from Bonners Ferry using setlines, gillnets, and angling.*
Task 3B.1.2.	*Biological and mark-recapture sampling to estimate abundance, survival, and other population characteristics.*
Task 3B.1.3.	*Use ripe spawners for hatchery broodstock or other applications as appropriate.*
Task 3B.1.4.	*Tag adults with radio or acoustic and release for monitoring of spawning behaviour and movement patterns.*
Task 3B.1.5.	*Annual wild population and brood stock genetics sampling.*
3C. Juvenile Assessments	
Measure 3C.1.	Conduct periodic juvenile sturgeon assessments to estimate population status, index natural recruitment, and monitor hatchery program performance.
Task 3C.1.1.	*Capture juveniles during summer at standardized, spatially-stratified index sites throughout the U.S. and Canadian portions of the river using gillnets.*
Task 3C.1.2.	*Biological and mark-recapture sampling to estimate abundance and survival.*
Task 3C.1.3.	*Index natural recruitment based on marked-unmarked ratios.*
Task 3C.1.4.	*Evaluate dispersal from release sites, subsequent movements, habitat use, growth and survival of hatchery reared juveniles.*
Task 3C.1.5.	*Incorporate pectoral fin ray sampling from recaptures of large hatchery fish for aging method*

	validation assessment.
3D. Telemetry	
Measure 3D.1.	Monitor distribution and movements of a representative sample of acoustic-tagged juveniles and adults to assess juvenile and adult habitat use and movements and monitor biological response of adult sturgeon to spawning habitat enhancement projects.
Task 3D.1.1.	*Maintenance and operation of Vemco receiver arrays.*
Task 3D.1.2.	*Juvenile telemetry to define dispersal from hatchery release sites and subsequent juvenile habitat use, movements, and migration.*
Task 3D.1.3.	*Adult telemetry to define adult movements and habitat use in current spawning sites and the area of interest for habitat creation above Ambush Rock in Idaho.*
Task 3D.1.4.	*Installation and maintenance of a 3-D telemetry tracking array (acoustic positioning system) to monitor wild adult behavior near enhancement project structures.*
Task 3D.1.5.	*Focused program to monitor the 3D movements of these fish in the small piece of river comprising the Substrate Enhancement Pilot Project.*
3E. Habitat Assessment & Monitoring	
Measure 3E.1.	Measure and monitor physical conditions in critical habitat and potential spawning areas.
Task 3E.1.1.	*Map depth, velocity, and substrate in critical and potential spawning reaches to document baseline conditions.*
Task 3E.1.2.	*Develop detailed computer hydraulic models of current and potential spawning reaches and calibrate to Kootenai River habitat conditions.*
Task 3E.1.3.	*Periodically monitor changes in critical habitat parameters over time.*
3F. Data Management & Reporting	
Measure 3F.1.	Maintain a central repository for data collected by various organizations to facilitate systematic applications.
Task 3F.1.1.	*Annual data storage and management for adult and juvenile index monitoring and tagging programs.*
Task 3F.1.2.	*Periodic updates and reporting of estimates of adult population size and available breeders, population and hatchery genetics, and numbers and survival of hatchery and natural juveniles.*

Source: KTOI 2005.

4.4.3 Fish Health Monitoring, Evaluation and Supporting Research

The standard USFWS Title 50 fish pathogen screen, required to transport and release fish, will be applied to all Tribal aquaculture facilities, supported by a series of cutting edge fish pathology research activities. These pathogen tests will be applied to the broodstock and their progeny produced at the two facilities. Biofiltration and/or ultraviolet light treatments are proposed to reduce the pathogen load in all hatchery waters, thereby reducing the chances for disease outbreaks or pathogen transfer and proliferation. Fish health monitoring and evaluation activities specific to Kootenai sturgeon are described below as well as ongoing research that will inform monitoring protocols.

4.4.3.1 Maintain, Monitor and Evaluate Health of White Sturgeon Broodstock and Progeny

Sturgeon hatchery operations include protocols to monitor and minimize pathogen introduction and transmission in cultured and natural populations. Maintaining optimal rearing conditions (fish densities, temperature, and water quality) can reduce or prevent stress-induced disease in hatcheries. Diseases potentially affecting sturgeon include white sturgeon iridovirus (WSIV) and fish herpes viruses. The history of disease outbreak is mild at the Tribal Sturgeon Hatchery. A WSIV outbreak occurred during 1992 and 1993 in a single overcrowded tank. Hatchery upgrades completed in 1999 substantially reduced disease outbreak and fish loss (Ireland 1999).

All broodstock and at least 30 progeny from each brood year are tested annually for the presence of pathogens. Disease testing includes parasitology, bacteriology, virology, and histology examinations. Fish health is tested one month prior to release and only fish with no diagnostic disease symptoms and less than 10 percent prevalence of endemic pathogens are released. Evaluation protocols were developed by and agreed upon by all involved state, provincial, federal, and tribal management agencies, who also review disease test results annually or more frequently if needed.

4.4.3.2 Investigate Diagnostic Improvements for Evaluating White Sturgeon Iridovirus (WSIV) Status

WSIV is native to the Kootenai River system. Research has been implemented on control methods and mechanisms of host defense and virus transmission. Published research from this project has relieved some concerns about releasing sturgeon into the Kootenai River that test positive for WSIV (LaPatra et al. 1994, 1999; Drennan et al. 2005, 2006, 2007a, 2007b). Study results defined baseline criteria values to limit density-related stress to avoid disease outbreaks, demonstrated that vertical transmission may not be a primary means of viral dissemination, showed that non-lethal sampling could be incorporated for WSIV screening in some cases, and indicated that sturgeon can develop an immune (antibody) response to WSIV and other antigens. Although these findings make significant contributions to sturgeon pathology, further control or diagnostic improvements for WSIV may be required. Several additional investigations are proposed that will guide future WSIV monitoring efforts and are described below.

Identify Genetic Differences Between WSIV Isolates from the Sacramento, Lower Columbia, Snake, and Kootenai Rivers

The Kootenai-isolate of WSIV appears to be different than other WSIV isolates, therefore, this study will define the differences using isolates from different geographic regions. Once differences are identified, specific diagnostic assays can be developed to characterize infections in fish and in the environment. If seasonal virus presence in the water column could be mapped, periods of high risk could be identified and anticipated at the Tribal hatcheries. This diagnostic research is occurring at the University of California (Davis). Once assays are developed, it is proposed that they be validated and tested on field and laboratory samples of infected sturgeon. In addition, water samples containing WSIV would be sampled and analyzed as part of the monitoring program.

Research to Optimize and Validate an Enzyme Linked Immunosorbent Assay (ELISA) for Immunosurveillance of Sturgeon

The ELISA assay developed to detect anti-WSIV antibodies in the serum and mucus of sturgeon will be investigated as a tool to screen fish for prior virus exposure. There is evidence that fish surviving a disease outbreak may have antibodies to WSIV in serum. This will be verified and research expanded to determine if an immune surveillance method could be developed to screen fish at hatcheries or in the wild. Since current diagnostic assays do not effectively detect low levels of infection (possible asymptomatic carrier states), such an assay may provide evidence of WSIV exposure.

This assay would be optimized and the sensitivity characterized using serum and mucus from sturgeon infected with the Kootenai and other WSIV isolates. Serum and mucus would be sampled and the antibodies present in each fish determined. In addition, asymptomatic fish would be sampled to see if the antibody is present.

4.4.4 Genetics

A population genetics monitoring and evaluation plan is essential to guide and track the operations and successes of any conservation aquaculture program. The proposed plan would use recently developed white sturgeon microsatellite techniques[17] (McQuown et al. 2000; Rodzen et al. 2004; Drauch and May 2007, 2008, 2009) to characterize the wild population, the hatchery broodstock population, representative progeny groups, and to track genetic diversity and variability to maximize and maintain both over time. This program is designed to preclude long-term reductions in genetic diversity, mimic natural patterns of gene flow, and assess the effects of program operations on standard population genetic parameters. Monitoring variability and diversity trajectories is ongoing to achieve the objectives mentioned above (Rodzen et al. 2004; Drauch and May 2007, 2008, 2009).

Microsatellite DNA markers have become a popular system for many applications due to their high resolution and highly variable nature. Thirteen white sturgeon microsatellite primer sets have been developed, tested, and described in terms of their inheritance patterns at nine highly variable, polymorphic microsatellite loci (McQuown et al. 2000; Rodzen and May 2002). These primers, plus newly developed primers from a Kootenai sturgeon gene library at UC Davis will be used to evaluate individual, familial, and population genetic aspects of the Kootenai River Conservation Aquaculture Program. These markers are particularly well suited for the wild population and the subset broodstock sample groups due to their high discriminating power.

These loci have been used to assign or exclude unmarked juveniles captured in the river from the hatchery-produced progeny groups, initially with moderate success (Rodzen et al 2004), with a larger suite being currently tested, which are expected to increase the success of these tests (Drauch and May 2007, 2008, 2009). Consideration also will be given to pre-spawning genotyping of all broodstock in the hatchery each year. Although genotyping could occur relatively quickly (days to weeks) and provide benefits under certain situations for the program, other situations, like collecting and using male gamete samples within a day or two would preclude this option. Such information can facilitate intentional outbreeding (the breeding of more distantly related individuals) and the reduction of unintentional inbreeding. The isolated nature of the Kootenai sturgeon population, including total lack of gene flow from outside populations since retreat of the last glacial period (~10,000-15,000 years ago), and recent demographic and genetic bottlenecks in the population suggest that outbreeding depression poses little or no risk.

Since 2007, the Genomic Variation Lab at UC Davis has conducted genetic monitoring of fish from the Tribal Sturgeon Hatchery. In particular, this work involves: 1) genotyping broodstock for parentage analysis (in 2002, and 2005 through 2008); 2) monitoring Kootenai sturgeon genetic diversity; and 3) evaluating parentage analysis. These researchers reported that: 1) the Tribal Sturgeon Hatchery program continues to represent the majority of the genetic diversity (>90%) detected in the wild Kootenai River population; and 2) increasing the number of polymorphic microsatellite loci (markers) is expected to increase the discrimination power and accuracy of parentage analysis (Drauch and May 2007, 2008). Under this project, the Tribe previously sponsored completion of a gene library and the development of a new suite of such markers to characterize and conserve Kootenai sturgeon and other populations.

[17] Microsatellites are polymorphic loci commonly used as genetic markers in the nuclear genome

4.4.5 Gamete Cryopreservation

Cryopreservation techniques for white sturgeon gametes are being developed and optimized for this program in cooperation with the University of Idaho to maintain and preserve genetic variability. Cryopreservation is a process where cells or whole tissues are preserved by cooling to sub-zero temperatures, typically down to –196 °C. Recent progress in cryopreservation techniques may enable this program to contribute to inter-generational gene flow and incorporation of genetic material to further advance genetic and demographic restoration of the Kootenai River white sturgeon population. It is assumed that these developments in sturgeon cryopreservation will also be beneficial for the conservation of other North American sturgeon populations.

4.4.6 Post-release Monitoring

Several ongoing programs monitor the success of hatchery-bred Kootenai sturgeon. A post-release monitoring program was first implemented by IDFG and the Kootenai Tribe in 1993 to annually recapture hatchery-reared Kootenai sturgeon using experimental mesh gill nets, hoop nets, and angling (Marcuson 1994; Paragamian et al. 1997; Ireland 1997; Ireland et al. 2002a). Annual growth and survival data are compiled from this program. An ultrasonic telemetry study, implemented in 1999, is used to determine juvenile Kootenai sturgeon habitat use relative to depth, velocity, substrate and cover (Young and Scarnecchia 2005). Average post-stocking survival rates for the first year and condition factors for each release group are estimated (Beamesderfer 1993; Ireland et al. 2002b; KTOI 2008).

4.4.6.1 Habitat Capacity and Stocking Rates

Habitat capacity is a critical unknown and is being monitored. The implications of differences in year class strength and habitat capacity have been given considerable thought throughout this 20-year program. Justice et al. (2009) reported reduced post-release survival rates of younger life stages (Age 0), and identified evidence for density dependent reductions in survival. Yet there is no indication of density dependent growth or survival among older fish.

The proposed hatchery production levels are part of a purposeful strategy to experimentally identify habitat capacity based on monitoring population response to increasing sturgeon numbers or densities. The recovery program incorporates an intensive hatchery marking and annual monitoring program. Rather than speculating on where capacity lies and artificially limiting production based on assumptions, the experimental approach will provide a real answer with no significant downside risk. Post-release fish growth, condition, and survival are being monitored in the wild in relation to population size and density. Habitat capacity will be identified by a detectable response. Future juvenile, subadult, and adult population levels will be managed adaptively based on continuing monitoring and evaluation.

In weighing tradeoffs among risks and benefits, the Tribe evaluated the down-side risks should this approach be wrong:

- The greatest risks associated with large stocking rates revolve around density-related decreases in survival or growth. Survival feedback would be at least partially self-correcting, as is the case with naturally produced populations. Reduced survival would offset the large initial stocking rates; however, depressed survival could be a problem if it affects different brood years by reducing representation of family groups in the next generation[18]. This risk will be monitored.

- In the extreme case, reduced growth might delay maturation of adults. Because sturgeon growth varies widely among individuals, releasing many diverse individuals may offset this risk by increasing the number of fast-growing fish. Growth and maturation will also be monitored.

- Natural production may be limited or swamped by large numbers of hatchery fish. Prospects for natural production remain uncertain following over 40 years of extreme limitation or failure. Small levels of sporadic natural recruitment since the 1960s is inadequate to sustain a population after such profound recruitment failure. By marking and monitoring hatchery fish, biologists will be able to detect significant natural recruitment if it occurs and accommodations will be made.

The central stocking rate issue is one of balancing the risks of losing genetic diversity versus negative density-dependent responses in the population and the ecological community. The Tribe takes the position that the long-term downside risks of releasing too few fish significantly outweigh those of releasing too many. Failure to conserve remnant locally adapted genetic material from this endangered population would be irreversible. Density-dependent circumstances are reversible and would eventually be self-regulating, albeit at some level of ecological cost. Furthermore, if it turns out that too many fish have been released, empirical recapture data confirm that some could be removed.

The carrying capacity of the system will also be influenced by larger numbers of this apex predator in the Kootenai system food web. Juvenile sturgeon feed on benthic invertebrates, sub-adults consume a variety of benthic organisms, and adults are piscivorous. Because of large size differences over their lifespan, sturgeon may be limited by different components of the aquatic community at different life stages. For example, juvenile productivity could be limited by the availability of benthic invertebrates, but these limitations would relax as the fish grow and can take advantage of more diverse food sources.

4.4.6.2 Habitat Restoration Monitoring

The Tribe's ongoing habitat restoration measures influence the capacity of the habitat to support sturgeon, yet the actions are experimental and outcomes remain uncertain. Biological responses to these measures are a key component of the program-wide adaptive management approach currently under development (Section 4.5). The extent to which sturgeon may benefit from these actions is unknown, but it is likely that improved ecosystem function, habitat complexity, and productivity could be beneficial.

In addition, the Tribe's Kootenai River Habitat Restoration Project is moving forward, with implementation proposed in three phases generally working from upstream (braided reaches) to downstream (meander reaches). Implementation of the first phase is slated to begin in late 2011 or 2012. The restoration project is part of RPA Component 2 in the Libby Dam BiOp. Population monitoring by the Tribe and its cooperating partners will be an important feedback loop to the aquaculture program.

[18] Equal representation among families at maturity should not be assumed relative to genetic and environmental variability, even in wild populations.

4.4.6.3 *Juvenile Sturgeon Monitoring*

A sampling program for juvenile Kootenai sturgeon between the southern end of Kootenay Lake and Bonners Ferry is conducted by the BC MoE in cooperation with the Tribe and the IDFG. This program is: 1) indexing natural recruitment events in the Kootenay/Kootenai River; 2) collecting DNA and WSIV tissue samples from all wild juveniles; 3) determining the age distribution of both wild and hatchery-produced juveniles; 4) describing population trends related to growth rate, size, distribution, survival and abundance of both hatchery and wild juvenile white sturgeon; and 5) determining large scale habitat preferences of wild and hatchery-produced juveniles.

4.4.6.4 *Other Post-release Monitoring*

Additional monitoring under the proposed program would include collection of growth, survival, habitat use, and movement data to evaluate post-release performance. Systematic evaluation of post-release fish and a subset marked with transmitters (e.g., Vemco tags) will also be used to evaluate the success of release strategy components. Historic habitat use by rearing, maturing, and reproducing Kootenai sturgeon is uncertain; therefore, this program will evaluate where fish volitionally reestablish habitat use patterns across the system. Collected data will be used to modify future release protocols as needed.

4.4.7 Ongoing and Potential Research

Analysis is ongoing to assess effects of five years of experimental nutrient addition on condition, growth, and survival of post-release juvenile sturgeon before and after the onset nutrient addition. A significant response has been confirmed by analysis of pre- and post-fertilization nutrient availability, algae abundance, chlorophyll accrual rates, invertebrate biomass, diversity, and richness, and recruitment and size of juvenile mountain whitefish (Holderman et al. 2009a, Holderman et al. 2009b; Ericksen et al. 2009; Holderman et al. 2010; Hoyle et al. 2010; Shafii et al. 2010). Nutrient enhancement in Kootenay Lake has also stimulated a biological response that has been successfully managed since the early 1990s. Most notably, kokanee abundance and escapement has increased from a low in the hundreds of thousands to recent abundance estimates in the tens of millions. Kokanee will be an important part of the food web for the sturgeon population and in addition, provide a general indicator of improving ecosystem health.

Three additional research topics may have future relevance to operation of the Kootenai sturgeon aquaculture program: 1) olfaction as it pertains to spawning location and natal homing; 2) sequential imprinting to natal waters; and 3) habitat needs for embryo, free embryo and larval life stages.

One hypothesis for recruitment failure of Kootenai sturgeon is that their spawning location could be affected by olfactory cues emitted by hatchery effluent. Research with various sturgeon species and other fishes confirms the use of olfactory cues in the form of odorants or pheromones in the selection of spawning location. Studies of olfactory behavior may be considered to minimize unintended consequences of multiple hatchery facility operations on natural spawning and homing in the Kootenai River.

Sequential imprinting is a related mechanism by which early life stages (beginning with post-hatch free embryos) imprint on appropriate river chemistry and associated habitats sequentially over time to develop appropriate spawning behaviors after fish mature. Early life stage releases and lab experiments could provide such information that could trigger adaptive refinements to the Kootenai sturgeon aquaculture program.

Kootenai sturgeon research activities evaluated by the USFWS' Kootenai River White Sturgeon Recovery Team included experimental releases of hatchery-produced embryos, free embryos and larvae, albeit with no tangible results. The Recovery Team has discussed more rigorously and sequentially evaluating free embryo releases for five years to assess the feasibility of this technique to benefit the population, which is thought to be consistent with the natural behavioral and reproductive mechanisms. The Tribal sturgeon program likely will be a participant in these experiments.

The broader-scale Kootenai River Adaptive Management Plan will also play a critical role in terms of post-release monitoring and (Section 6) evaluation.

4.5 Adaptive Management of the Sturgeon Program

Through adaptive management planning, the Tribe and other entities will evaluate the risks and benefits of proposed and ongoing sturgeon and burbot aquaculture programs and will systematically address critical scientific uncertainties using the logic path portrayed in Figure 6-1. An adaptive management workgroup will be established by the Tribe to guide development, implementation, evaluation, and refinement of the plans. Guidance will be sought from research, management, and policy entities to craft efficient implementation, monitoring, and evaluation programs that address and meet success criteria of these programs. The Tribe will build upon the objectives and metrics identified in Table 4-5 to adaptively implement and operate successful Kootenai sturgeon and burbot programs.

4.5.1 Overall Adaptive Management Objectives

The primary purpose of the conservation aquaculture component of the adaptive management plan is to meet the goals defined for the Kootenai sturgeon program by: 1) maximizing the chances of meeting numerical success criteria targets; 2) minimizing risks of short- and long-term adverse effects through monitoring and iteratively refined management; and 3) periodically re-evaluating project success criteria by integrating research, monitoring, and evaluation results. Key uncertainties identified in Section 4.5.2 will be addressed through appropriately designed experimentation where needed. Monitoring components will be refined to ensure that relevant data are being properly collected to evaluate program progress, successes, and failures. Specific biological objectives for the hatchery program are listed in Section 4.1.2.

4.5.2 Key Uncertainties

Because the Kootenai sturgeon program has been operating for over 20 years and has successfully produced year classes in nearly all of those years, uncertainties regarding sturgeon culture are minimal:

- Imprinting and homing to upriver spawning and rearing habitats
- Success of natural production from hatchery progeny
- Habitat carrying capacity

The general process for adaptively addressing uncertainties will include the following steps:

- Determining the relative importance of the uncertainty
- Compiling and characterizing existing data
- Identifying remaining unknowns
- Developing and testing appropriate hypotheses

- Developing and implementing research, monitoring, and evaluation activities to evaluate hypotheses
- Developing, implementing, and evaluating remedial adaptive management actions

4.5.2.1 *Adaptive Decision Framework*

The decision framework for interpreting monitoring data relevant to aquaculture operations will be led by the Kootenai Tribe, along with fisheries management agencies IDFG, BC MoE, and its many collaborating academic and private sectors scientists. This Kootenai River Native Fish Conservation Aquaculture Program Adaptive Management team will be formed to interpret monitoring results and determine if production and population objectives are being achieved or if operational or facility changes are needed in the programs. Interaction will occur regularly with this team to ensure that aquaculture production remains appropriately scaled to habitat and population conditions.

4.5.2.2 *Program Termination*

Program termination or large substantive changes in program objectives and activities will be driven by monitoring and evaluating the program in response to system responses. Termination can be triggered by either success or failure. The program will be terminated when and if:

- Productive naturally self-sustaining populations of white sturgeon are restored in the Kootenai system.

- Conservation aquaculture activities significantly interfere with or otherwise preclude restoration of productive naturally self-sustaining populations of white sturgeon and burbot in the Kootenai system.

- Conservation and restoration objectives cannot be substantively achieved and programs cannot be reasonably adapted to achieve objectives.

- Benefits prove to be marginal and adaptations prove cost-prohibitive relative to program objectives.

Currently (2010), it is difficult to foresee which specific factors, conditions or metrics might trigger a fundamental reconsideration of the conservation aquaculture program for sturgeon. Given this program's rigorous RM&E components and adaptive management platform, it is expected that program objectives and activities will continue to be refined based on evolving conditions and new information.

Key decision points for the sturgeon program might be triggered by the restoration, frequency, and magnitude of natural recruitment, changes in spawning distribution following habitat restoration activities, identification of effective alternatives such as larval releases, unavailable or senile broodstock, strong density-dependent habitat limitations, or delayed maturation of hatchery-origin fish. The Kootenai sturgeon conservation aquaculture program will include checkpoints and evaluations at periodic, scheduled intervals as part of the adaptive management and implementation plans that are overseen by the Kootenai Tribe, as well as the Kootenai Sturgeon Recovery Team led by the USFWS.

4.6 Summary of Sturgeon Program Costs

This section briefly summarizes major costs associated with the Tribe's expanded Kootenai sturgeon aquaculture program. More detailed conceptual costs are presented in Chapter 8. These estimates provide a planning baseline from which to refine costs, evaluate alternatives, and protect against budget expansion as the project progresses through the preliminary (Step 2) and final design (Step 3) phases and implementation.

Estimated conceptual costs for the sturgeon program at the Tribal Sturgeon Hatchery and proposed Twin Rivers facilities are summarized in Table 4-17 and include facility planning and design, construction, acquisition of capital equipment, environmental compliance, research, monitoring, and evaluation, as well as operations and maintenance.

The foundational planning approach taken by the Tribe is to jointly develop sturgeon and burbot aquaculture facilities to achieve design, construction, and operational efficiencies; significantly reduce all associated program costs; and to fulfill ecosystem restoration objectives. All planning and design efforts to date have been based on this precept; however, the Independent Scientific Review Panel requested that the programs be presented separately, so we have made an effort to separate costs specifically associated with each program. The costs reflected in Table 4-17 still contain inseparable program components. Some proposed facilities, as well as staffing and equipment, would be shared between the Kootenai sturgeon and burbot programs. Planning estimates suggest that the operational cost alone of the programs will be at least 30% lower with shared facilities, functions and operational staffing than if two separate, parallel programs were developed and operated; additional savings in construction would also be significant with shared facilities versus separate facilities. Efficiencies are also realized in monitoring and evaluation activities.

Even if burbot aquaculture were to be eliminated, the estimated costs of an isolated sturgeon program would not be reduced significantly. Table 4-17 displays the independent costs to expand and operate the sturgeon aquaculture component in one column and the costs of the combined sturgeon and burbot programs in another column. The latter reflects potential efficiencies that may result from sharing facilities and personnel. While efficiencies are gained by sharing staff at the Tribal Sturgeon Hatchery and Twin Rivers, the main efficiencies relate to a more cost effective burbot program because the sturgeon programs at both facilities consume the majority of the operational and monitoring cost efforts (see Table 5-9).

Detailed cost estimates and explanations are presented in Chapter 8 for each major cost area for both the sturgeon and burbot program. A similar tabular summary of project costs is also provided as Table 8-2 and a 10-year summary of all costs projected from fiscal year (FY) 2010 through FY 2020 is presented as Table 8-14. Estimated costs in Chapter 8 reflect the efficiencies of implementing planning and construction of facilities at one time and potential future sharing of operational aspects.

Table 4-17. Key Expenditures by Program Area, Estimate of Costs for Sturgeon Program.

Program Area	Estimated Cost of Implmenting Sturgeon Program Only	Estimated Cost Sturgeon and Burbot Programs	Comments/Assumptions
Planning & Design Step 1 [1]	$490,000	$490,000	Conceptual designs include both sturgeon and burbot programs. To efficiently design and implement the sturgeon-only component, design requirements of future burbot facilities would need to be addressed.
Planning & Design Step 2[2]	$1,046,999	$1,046,999	Assumes completion of preliminary design for both sturgeon and burbot. Additional costs would be incurred for a separate planning and design effort for burbot, if implementation is delayed.
Planning & Design Step 3[3]	$1,017,114	$1,017,114	Assumes completion of final design for both sturgeon and burbot. Additional costs would be incurred for a separate final design effort for burbot if implementation is delayed.
Construction (Base Components)	$11,318,099	$13,997,000	Cost differential assumes delaying construction of a portion of the hatchery building planned for burbot research, assumes cost of water supply for both programs (modification of the sturgeon facility at a later date to accommodate burbot would increase costs over $600,000). A fully separate facility for burbot planned and implemented at a later date would cost significantly more.
Construction (Base and Separable Components, e.g.,sturgeon spawning channels)	$11,847,099	$15,251,000	Includes sturgeon spawning channels and remote rearing units and cost of water supply for both programs (implementation at a later date would increase costs over $600,000). A fully separate facility for burbot planned and implemented at a later date would cost significantly more.
Capital Equipment	$385,512	$423,790	Assumes majority of capital equipment is needed for expanded sturgeon operations; assumes no decrease for delaying burbot program
Environmental Compliance Step 2 (Permitting, NEPA, Other)	$164,546	$164,546	Required environmental compliance would be the same without inclusion of burbot building and support facilities. Implementing a burbot program in the future would incur additional costs.
Land Purchases, Lease & Easements [4]	$0	$0	
Tribal Sturgeon Hatchery Program [5]- Annual Operations and Maintenance	$906,515	$906,515	Assumes O&M costs would not be reduced by addition of the burbot program
Twin Rivers Hatchery Program[5]- Annual Operations & Maintenance	$831,070	$923,411	Assumes O&M costs would increase only 10 to 15% with the burbot program
Monitoring & Evaluation [5]	$561,509	$701,886	M&E costs will not be increased significantly by the addition of the burbot program

Notes and Assumptions:

- Refer to Chapter 8 for detailed notes on escalation of figures shown in this table (generally construction shown as 2012 dollars and O&M and M&E shown as 2010 dollars)
- Construction estimates are conceptual (+/- 35% to 50%), O&M and M&E costs should be considered as (+/- 25%)
- Budget figures assume that work would proceed on the timeline shown in Figure 8-1.

[1] Shows estimated expenditure for FY 2007, 2008, 2009, 2010 (This is an estimated figure from the total project budget for Project No. 198806400)

[2] Shows estimated expenditure from FY 2010 (This is an estimated figure from the total project budget for Project No. 198806400)

[3] Shows estimated expenditure from a projected FY 2010 and FY 2011 budget (This is an estimated figure from the total project budget for Project No. 198806400)

[4] Land Purchases, Leases and Easements (estimated budget is not identified at this time)

[5] Annual Operations and Maintenance and Monitoring and Evaluation costs are based on efficiencies from implementing the new Twin Rivers programs

4.7 Consistency with Eight Scientific Principles of the NPCC Fish and Wildlife Program

This chapter presents a summary of the consistency of the proposed Kootenai sturgeon aquaculture program with the Council's Three-Step process, Step 1 review elements.

4.7.1 Principle 1: The abundance, productivity and diversity of organisms are integrally linked to the characteristics of their ecosystems.

The Tribe's commitment to this principle is demonstrated through ongoing efforts to protect and perpetuate native fish populations and their habitats in the Kootenai subbasin. The Tribe is simultaneously developing and implementing habitat restoration and monitoring projects, including the Kootenai River Habitat Restoration Project, lower Kootenai River mainstem and tributary restoration, experimental river fertilization and native species introduction programs.

The proposed Kootenai sturgeon aquaculture program is necessary because: 1) estimated population persistence without hatchery intervention is shorter than the timeframe required for successful habitat restoration projects, and 2) successful habitat restoration is not guaranteed. Extinction of this unique Kootenai sturgeon population would be all but guaranteed if the Tribe did not continue to intervene via this conservation aquaculture program, which after decades of recruitment failure in the wild has reliably provided the only source of population recruitment during the past 20 years (KTOI 2008).

4.7.2 Principle 2: Ecosystems are dynamic, resilient and develop over time.

Recognizing that natural disturbance and change are part of every ecosystem, the Kootenai sturgeon conservation aquaculture program focuses on mitigating deleterious effects of *unnatural* change. The long evolutionary history of sturgeon attests to the adaptive plasticity and potential of the species and the Kootenai population. Therefore, if ecosystem conditions can be brought back to similar functionality, this inherited plasticity, if not lost during the recent population bottleneck, should enable population persistence through the natural disturbance and change regimes identified in Principle 2.

Nearly a century of ecosystem and habitat changes and their subsequent cascading biological and ecological effects and interactions may in large part have contributed to failed natural production since the 1960s (Anders et al. 2002; Paragamian et al. 2005). Ongoing natural recruitment failure in this population indicates that these environmental and ecological changes may have exceeded the range of adaptive potential for natural recruitment.

Ecosystem and habitat limitations are being addressed simultaneously with this conservation aquaculture program (e.g., the Kootenai River Habitat Restoration Project and other habitat projects). The Kootenai Tribe recognizes that conservation aquaculture programs alone cannot resolve physical habitat problems or limitations. However, preserving the population's remaining genetic diversity and variability with the hatchery program while undertaking critical ecosystem-based habitat restoration activities can help perpetuate the range of genetic and life history expressions that coevolved with historical ecological regimes in the Kootenai River.

4.7.3 Principle 3: Biological systems operate on various spatial and time scales that can be organized hierarchically.

Principle 3 highlights the important multi-scale spatial and temporal nature of ecology. The Tribe fully agrees that to ignore this condition is to contribute to the failure of fish and wildlife mitigation projects. The Kootenai Tribe is developing, implementing, and refining habitat and biological projects in aquatic, riparian, and terrestrial components of the Kootenai subbasin. This project in particular addresses Kootenai sturgeon life cycle completion, with hatchery intervention used for a short period during spawning and early life stages. This apex predator species plays a key role in the food web of the Kootenai River ecosystem (see Section 3.1.9 for a description of sturgeon feeding habits).

The Tribe is continuing to develop their understanding of the ecological hierarchies in the Kootenai River, as reflected in the figure of limiting factors from the Kootenai River Subbasin Plan (Figure 3-5). In addition, a series of finer scale interacting responses and alterations result from secondary limiting factors. The Tribe's Kootenai River Habitat Restoration Project (in concert with other Tribal efforts such as the Tribe's nutrient restoration project, floodplain reconnection project, and Operational Loss Assessment) is designed to address critical limiting factors such as the altered hydrograph, channel stability, connectivity, habitat diversity, hydraulic regime, physical habitat, riparian habitat condition, shoreline condition, turbidity and fine sediments.

4.7.4 Principle 4: Habitats develop, and are maintained, by physical and biological processes.

Libby Dam represents the source of major ongoing ecological perturbations of the type referred to in Principle 4. Other cumulatively significant perturbations affecting the aquatic habitat in the lower Kootenai River include levee construction, agricultural and urban development, and associated infrastructure. In response to problems caused by these continuing impacts, this project specifically focuses on interim Kootenai sturgeon production to preserve genetic variation, prevent extinction, restore year classes and a sustainable year or age class structure, and provide a suitable founding population for future generations. Ongoing and proposed companion habitat restoration projects are consistent with the notion that different effects are produced from different features, as indicated in Principle 4.

4.7.5 Principle 5: Species play key roles in developing and maintaining ecological conditions.

Principle 5 emphasizes the importance of individual species as integral and necessary parts of functioning ecosystems and food webs. This is a primary justification to recover native fish in the Kootenai River, including Kootenai sturgeon. This principle also links and supports the Tribe's ongoing experimental nutrient addition program, intended to restore and maintain species assemblages across trophic levels in order to improve ecosystem functions and biodiversity.

4.7.6 Principle 6: Biological diversity allows ecosystems to persist in the face of environmental variation.

Diversity within and among populations and species is the foundation of ecological processes and functions and of population viability and persistence. The wild broodstock mating strategy and intended gene flow model for the Kootenai sturgeon program is designed to 1) mimic natural patterns, and 2) maximize genetic diversity to hedge bets in favor of conserving adaptive plasticity and survival across a range of environmental conditions. Similarly, the Kootenai Tribe's numerous restoration projects address maintaining and enhancing physical habitat diversity required for a wider range of selective environmental forces that support biodiversity thought niche partitioning and other mechanisms.

4.7.7 Principle 7: Ecological management is adaptive and experimental.

In the developing the Kootenai sturgeon aquaculture program and other projects, the Tribe has incorporated workshop approaches to adaptive management and environmental assessment to characterize uncertainty and to test and evaluate restoration scenarios. The Tribe is committed to implementing all Kootenai subbasin projects within this adaptive management framework.

An example of the use of adaptive management in the Tribe's ongoing Kootenai sturgeon conservation aquaculture program is the sequential set of experimental releases that included various developmental stages or ages. Initially, optimal post-release survival was reached with fish reared to age 1 or 2 in the hatchery. This duration in captivity also ensured favorable PIT-tag retention rates. However, to reduce potential effects of time spent in the hatchery environment (e.g., domestication selection), younger, smaller fish (<20 grams) were released across a period of years with a scute removal pattern to denote hatchery origin. Monitoring and evaluation confirmed that survival decreased due to their small size (Justice et al. 2009). Consequently, the program returned to releasing larger sized fish at age one or older to achieve the higher survival rates reported in 2002 (Ireland et al. 2002b). This example of adaptive management used a pre-planned series of experimental treatments to address an important program metric. The same adaptive approach will be incorporated in the expanded Kootenai sturgeon aquaculture program.

4.7.8 Principle 8: Ecosystem function, habitat structure and biological performance are affected by human actions.

As described in response to Principle 2, one focus of the Tribe's Kootenai sturgeon aquaculture program is to address and mitigate unnatural changes in the Kootenai River ecosystem. Ongoing and proposed hatchery operations are designed to produce minimal negative ecological or environmental impacts. Monitoring and evaluation that leads to adaptive management responses is part of each of the Tribe's fish and wildlife projects, ensuring that each maximizes intended program benefits with minimal negative impacts.

4.8 Link to Other Projects, Activities, and the Desired Endstate

At the subbasin level, the desired endstate is defined by the Kootenai River Subbasin vision statement (KTOI and MFWP 2004): "[To] establish and maintain a healthy ecosystem characterized by healthy, harvestable fish and wildlife populations, normative and/or natural physical and biological conditions, and sustainable human communities". Pursuing and achieving these population- and subbasin-level endstates for the Tribe's proposed Kootenai sturgeon aquaculture program will contribute to the biodiversity and ecological function required for successful restoration and resilience.

The Kootenai Tribe has made a long-standing commitment to coordinate closely with co-managers, transboundary and agency partners, stakeholders and the local community to ensure that program and activities are integrated, non-duplicative, and contribute to the restoration of a functional, healthy ecosystem. As previously stated, the Kootenai sturgeon aquaculture program is currently forestalling species extinction while other projects and activities designed to address the broad range of habitat limiting factors are designed, implemented, and have a chance to take effect. The relationship of this project to other specific program and activities in the subbasin is summarized in Section 3.4.

4.9 Biological Objectives with Measurable Attributes

Biological objectives with measureable attributes are identified below for both pre-release and post-release components of the Kootenai sturgeon aquaculture program.

Pre-release biological objectives include:

Provide adequate numbers of healthy broodstock. The biological condition of potential broodstock will be determined through visual observation of health and behavior.

Provide adequate breeding matrices for genetic diversity. To retain wild sturgeon life history characteristics, the genetic distance of mated broodstock will be tracked.

Provide adequate incubation conditions and hatch rates. Hatch survival will be monitored to achieve a goal of over 80% survival.

Provide adequate fry and larval survival. The survival goal for each life stage is to exceed 50%.

Provide adequate young-of-the-year survival. The survival goal for this life stage is at least 50% with no visible signs of health issues and negative pathogen test results.

Provide adequate juvenile survival. Survival, condition and health will be monitored with target survival rates greater than 50% and negative pathogen tests.

Provide adequate fish marking. Young-of-the-year will be marked with PIT-tags with a target retention rate of over 90%.

Post-release biological objectives for the Kootenai sturgeon conservation aquaculture program include:

Ensure adequate post-release survival, growth, and biological condition to support future mature adults. Sampling will track growth, condition and weight of the fish. The target survival rate in the first year post-release is 60% and 90% thereafter.

Create and maintain favorable age class distribution. Sampling will track age class distribution, recruitment magnitude and frequency.

Maintain adequate individual and population health. Sampling will annually track external health, fish behavior, and pathogen testing results.

Provide genetic diversity within and among progeny groups. Sampling will track diversity, heterozygosity, genetic distance and inbreeding coefficients.

Sustainable adult population target. The abundance of adults will be sampled annually to characterize population size and age-class structure. The target population size is from 8,000 to 10,000 adults.

4.10 Expected Project Benefits

Expanding this Kootenai sturgeon aquaculture program by increasing production capacity would help preserve remaining native genetic and biological diversity and enhance population abundance. This would be accomplished by: 1) preserving locally adapted genotypes, phenotypes, adaptive life history traits and population behavior through breeding matrices; 2) restoring a healthy age class structure; and 3) providing local demographic and genetic stock for natural selection in future generations. Expanding Kootenai sturgeon production to the Twin Rivers Hatchery site and potential remote rearing sites could imprint released fish on the waters of reaches currently thought to provide suitable spawning habitat. The population could benefit if individuals homed to suitable but underutilized spawning habitat. The expansion of the Kootenai sturgeon aquaculture program is also identified as RPA Component 4 in the Libby Dam BiOp (USFWS 2006, clarified in 2008). Other benefits described in the Subbasin Plan (KTOI and MFWP 2004) include restoring/maintaining population stability and rehabilitating community composition.

4.11 Implementation Strategies Relative to Current Conditions and Restoration Potential

The NPCC's Fish and Wildlife Program defines implementation strategies as plans of action to accomplish biological objectives (NPCC 2009). These strategies are formulated around the four key factors affecting aquatic species in the Columbia River Basin referred to as the four "Hs": habitat, hatcheries, harvest, and hydropower. The relationship of each proposed program to these strategies is summarized below.

4.11.1 Habitat

Post-levee and post-dam habitat conditions have been correlated with acutely limited natural production of Kootenai sturgeon. Evidence of this extends back to the 1950s and continuously through the post-Libby Dam years (Partridge 1983; USFWS 1994, 1999; Duke et al. 1999; Anders et al. 2002; Paragamian et al. 2005). The Tribe, in cooperation with other entities, is developing a large-scale ecosystem-based restoration project designed to mitigate habitat limitations for Kootenai sturgeon and other native biota, the Kootenai River Habitat Restoration Project (BPA project 200200200). Habitat restoration work will be implemented over the course of approximately 10 to 15 years:

- Phase 1 actions will take place in the upper portions of the braided reaches and will address significant bank erosion in that is contributing to sediment loading and degradation of habitat downstream. Improving bank structures will also provide benefits to the aquatic habitat by increasing or providing overhanging bank cover, shade and channel margin complexity. Phase 1 actions will also include a substrate enhancement project in the existing sturgeon spawning area in the meander reaches.

- Phase 2 actions will occur in the braided reaches and straight reach and will focus on creating more normative river conditions, including desirable depth and velocity attributes, by establishing channel dimensions that are sustainable given the morphological setting and governing flow and sediment regimes; gradually reducing sediment supply and transport competence in a downstream direction; promoting deposition of sediment on the floodplain; constructing a new floodplain that is connected to the channel during average annual peak flows; and revegetating the floodplain to foster a complex, multi-structured native plant community with a mosaic of age classes and hydrologic regimes.

- Phase 3 actions will occur in the meander reaches where the restoration strategy is based on improving interaction between the river and floodplain. Actions will focus on areas inside the levees adjacent to the river and areas outside the levees that are known to be much lower in elevation and closer to the range of post-levee and post-dam river stage elevations. Opportunities to restore wetlands and riparian plant communities will be explored. Other potential actions may include connecting some low lying areas to create off-channel habitat, removing fish passage barriers in tributaries, and restoring aquatic and riparian habitat along tributary streams.

Because current habitat conditions are inadequate for successful natural production of Kootenai sturgeon, the Kootenai Tribe is implementing a number of habitat restoration activities that complement the hatchery program. Habitat capacity does not appear to be limiting for current release numbers of age 1 or greater hatchery-produced Kootenai sturgeon. Recent analysis of survival rates for hatchery fish released at smaller sizes indicates reduced survival and evidence of density-dependent mortality of this youngest age group. This conclusion is based on 15 years of data collected on hatchery-produced juvenile Kootenai sturgeon released at age 1 or greater that were recaptured and evaluated (Ireland et al. 2002b; KTOI 2008; Justice et al. 2009). Fish typically exhibited 60% survival during the first year at large, followed by over 90% survival during all subsequent years (Ireland et al. 2002a; KTOI 2008). This finding points to habitat limitations for early rearing. A rigorous annual monitoring and evaluation program tracks post-release performance and survival that could be indicative of changes in habitat capacity. The Kootenai sturgeon conservation aquaculture program is managed in an adaptive framework and such changes will be tracked and future release strategies altered accordingly.

4.11.2 Hatcheries

The Kootenai Tribe has operated an aquaculture program for the past 20 years that incorporates ongoing evaluations, modifications and improvements. This is the only program providing any tangible benefits to the endangered Kootenai sturgeon population. Expanding and refining this program is identified in the Libby Dam BiOp (USFWS 2006, clarified 2008). The Libby Dam BiOp specifically acknowledges the need for continued operation of the Tribe's sturgeon aquaculture program in RPA Component 4, and directs the action agencies to provide funding to expand adult holding and spawning capability at the Tribal Sturgeon Hatchery (USFWS 2006, clarified in 2008).

Unlike anadromous salmon hatchery programs with access to genetic material from numerous stocks or populations, this program exclusively uses one unique native population (Kootenai sturgeon). This is consistent with the Council's Scientific Principles for native species use, the ESA, and with the program's objective to use locally adapted stocks. The Tribe's program is focused on replicating and perpetuating the locally adapted biologic traits and gene flow patterns of the Kootenai population, a conservation strategy crucial for success (Brannon 1993; Anders 1998, 2004).

In any population, life history trait diversity is maintained by selection pressures that operate within and across generations. Typically the degree of diversity is positively related to genetic variation, the direction of the selective forces, and requires temporal and spatial variation in environmental and physical habitat conditions. Over time, reduced habitat diversity (and associated reductions in selective forces) can reduce the range of life history types and the breadth of adaptive potential. In implementing this conservation aquaculture program, the Tribe follows a series of protocols designed to maintain a diversity of life history types, including annually: sampling and spawning broodstock across the spatial and temporal ranges of their distribution, replicating natural communal spawning and gene flow with factorial design breeding matrices, never re-spawning the same paired parents, and sampling and spawning broodstock from across all age classes.

Although recent empirical evidence in other sturgeon species (e.g., shortnose sturgeon [personal communication with B. Kynard, BK Riverfish, Inc., 2008, 2009]) revealed that not all spawners may actively spawn due to possible behavioral patterns, the current hatchery program will continue implementing partially factorial matings to meet effect population size targets that incorporate as much of the remnant gene pool as possible. The proposed spawning channels at the Twin Rivers Hatchery can be used to reduce any unintended biases based on previous partial factorial matings.

4.11.3 Harvest

Because of the critically endangered status of Kootenai sturgeon, the first objective of the aquaculture program is to restore a self-sustaining population. While the timeframe for achieving this objective is uncertain, the combined effects of hatchery production and habitat restoration are expected to accelerate population recovery. When multiple years of successful natural reproduction are documented and all life stages of Kootenai sturgeon are present in sustainable numbers, the Tribe's second objective of reinitiating Treaty-reserved ceremonial and subsistence harvests may be realized. Future harvest opportunities are also expected to include a sport fishery if the population achieves the viability and persistence targets necessary to be designated a sustainable population.

4.11.4 Hydropower

Hydropower operations have drastically altered and degraded ecological conditions and fish populations in the Kootenai River system in Idaho, Montana, and British Columbia. Hydropower facilities most directly inducing these effects in the project area are described in Section 3.3.3, while recent operational changes designed to improve ecological conditions are summarized here.

Since the early 1990s, Libby Dam operations have been modified to help restore Kootenai sturgeon and burbot migration, spawning, and recruitment. These changes include ceasing spring power peaking, operational efforts to create more normative spring hydrographs and thermographs for Kootenai sturgeon and more normative winter hydrographs and thermographs for burbot.

Daily load following has largely been eliminated from spring and summer operational strategies since the early 1990s, primarily due to ESA listing of Kootenai white sturgeon and bull trout, and the associated ramping rates in USFWS Biological Opinions (BiOps) (USFWS 2000, 2006). However, weekly load shaping still occurs during the winter months (i.e., varying flow during the week to allow for power generation during high-need periods).

Since the ESA listing of Kootenai sturgeon and preparation of the recovery plan for the species in 1999, experimental hydrographs have been tested at Libby Dam, providing spring freshets to emulate pre-dam conditions. These "sturgeon pulses" initially focused on providing flow to transport sediment from and through river reaches below Bonners Ferry where Kootenai sturgeon currently spawn. USGS data have since indicated that larger substrates are sparse in these areas and that flow of most any magnitude does little to transport sediment or significantly increase velocities through the reaches. Sturgeon flows since the 2006 BiOp have provided more depth in the braided reach of the river near and upstream of Bonners Ferry. In addition, Libby Dam has been operated in a manner that allows, as much as possible, a normatively shaped thermograph through use of a selective withdrawal temperature management structure to "optimize" temperature during the Kootenai sturgeon migration and spawning season.

The 2008 NOAA Fisheries Biological Opinion on the Federal Columbia River Power System modified summer operations at Libby Dam, maintaining a higher reservoir pool for an extended period. The intent is to increase productivity upstream of the dam, and provide a more stable, lower flow in the river below the dam. This will maintain more normatively shaped conditions in the most productive zones of the channel through a greater portion of the growing season.

Despite these combined efforts, ongoing coordination, and changes in Libby Dam operations to date, none of the modified hydropower operations have contributed to natural production of Kootenai sturgeon or burbot. There is evidence, however, of some returned ecological function in riparian areas as a result of more normatively shaped spring freshets as part of Kootenai sturgeon augmentation operations at the dam (e.g., recruitment in cottonwood and other riparian vegetation communities that were not recruiting during years of spring load following operations at Libby Dam).

4.12 Consistency with NPCC Artificial Production Policies

This section summarizes the consistency of the Kootenai sturgeon conservation aquaculture programs with the Council's artificial production strategy. The artificial production strategies are presented below in bold italics, followed by a consistency assessment.

The purpose and use of artificial production must be considered in the context of the ecological environment in which it will be used.

Artificial production is appropriate for Kootenai sturgeon because of the altered ecological environment of the Kootenai River. The program is an interim stop-gap measure to 1) prevent extinction, 2) preserve the existing gene pool, and 3) continue to rebuild a healthy age class structure with wild native broodstock. The altered river environment has rendered natural recruitment inadequate or absent since as early as the 1960s and consistently through the post-Libby Dam decades (Paragamian et al. 2005). The population bottleneck appears to occur in early life stages (Anders et al. 2002), which the hatchery environment has successfully overcome (Ireland 2002b). Hatchery support may be discontinued when reliable natural recruitment is restored.

As described in Section 4.1.2, the carrying capacity of the river system to support the introduction of large numbers of fish is being considered. The proposed stocking rates would initially appear to be greater than needed to produce historical numbers of fish. The value of such projections is compromised by uncertainty in future production and survival. The current carrying capacity is unknown and the only real means of determining capacity is through empirical experimentation to monitor density and post-release fish responses at the individual, cohort and population levels. The ultimate number of sturgeon that can be supported may vary over time and will be determined by the monitoring program (Sections 4.4 and 4.5). The risks of this approach appear to be substantially less in the near term than the risks of failure to propagate genetic diversity into the next generation from which all others will be founded. Ultimately, sturgeon carrying capacity will vary by life stage and will vary over time, as the biological community responds to current and future habitat conditions, nutrient availability, and seasonal environmental variability. Effects of the Tribe's habitat restoration actions and ongoing nutrient addition are intended to increase future carrying capacity.

Artificial production must be implemented within an experimental, adaptive management design that includes an aggressive program to evaluate the risks and benefits and address scientific uncertainties.

An adaptive management framework was used to develop the Kootenai sturgeon aquaculture program. As elaborated in Chapter 6 and in the Tribe's 20 year retrospective hatchery report (KTOI 2008), this ongoing program has successfully applied adaptive management to address uncertainties in conservation aquaculture. The program's multifaceted monitoring and evaluation plans are a crucial part of this adaptive management process (KTOI 2004; 2008).

Hatcheries must be operated in a manner that recognizes that they exist within ecological systems whose behavior is constrained by larger-scale basin, regional and global factors.

The Tribe recognizes that hatcheries cannot be used to resolve habitat problems, but they can play an important role in overall multidisciplinary restoration programs (KTOI and MFWP 2004). The Tribal Sturgeon Hatchery program has continuously operated in a manner that recognizes its role within an ecological system constrained by larger-scale basin, regional and local scale factors. Specifically, this is demonstrated by the array of habitat, ecology, and hatchery-based projects administered and proposed by the Tribe. These programs have been successfully implemented for several native focal fish species depressed by altered habitat conditions and impoundments in the Kootenai River subbasin.

A diversity of life history types and species needs to be maintained in order to sustain a system of populations in the face of environmental variation.

The Tribe uses conservation aquaculture to maintain and protect the genetic basis for life history trait diversity within and among species. The ongoing conservation aquaculture program involving native Kootenai sturgeon confirms this commitment. This approach is doubly important if anthropogenic changes result in environmental conditions outside the range of the adaptive potential of native species, which may have already occurred at least temporarily in the Kootenai subbasin.

Naturally selected populations should provide the model for successful artificially reared populations, in regard to population structure, mating protocol, behavior, growth, morphology, nutrient cycling, and other biological characteristics.

Naturally selected populations and their demographic, age-class, population genetic, and biological structure provide the model for the Kootenai sturgeon conservation aquaculture program. Considerable attention has been paid to characterizing these and other biological conditions and incorporating them into the program design. A paper was written specifically summarizing these issues entitled "Don't save sturgeon with salmon hatcheries: Life history matters" (Anders 2004). The Kootenai Tribe supported numerous other publications on this topic, some specifically addressing this Kootenai sturgeon program (Anders 1998, 2002; Ireland et al. 2003; KTOI 2004, 2008; Beamesderfer et al. 2009; Justice et al. 2009).

The entities authorizing or managing an artificial production facility or program should explicitly identify whether the artificial propagation product is intended for the purpose of augmentation, mitigation, restoration, preservation, research, or some combination of those purposes for each population of fish addressed.

The Tribe's aquaculture program serves mitigation, restoration, preservation, and research purposes. These purposes are addressed earlier in this chapter.

Decisions on the use of the artificial production tool need to be made in the context of deciding on fish and wildlife goals, objectives and strategies at the subbasin and province levels.

Decisions to artificially produce Kootenai sturgeon were made in the context of fish and wildlife goals, objectives, and strategies at the subbasin and province levels. Agreement and collaboration among the Tribal and agency co-managers guides the implementation of this program. This coordination is illustrated in the Management Plan section of the Kootenai River Subbasin Plan (KTOI and MFWP 2004).

Appropriate risk management needs to be maintained when using the tool of artificial propagation.

Adaptive multidisciplinary research, monitoring, and evaluation plans for this program continue to assess the risks of artificial propagation. In the case of Kootenai sturgeon, limited or absent natural production since the 1960s all but precludes any risks to naturally-produced fish from hatchery releases. Furthermore, consistent natural recruitment failure either dictates extinction or use of artificial production to sustain this population.

Production for harvest is a legitimate management objective of artificial production, but to minimize adverse impacts on natural populations associated with harvest management of artificially produced populations, harvest rates and practices must be dictated by the requirements to sustain naturally spawning populations.

Production for harvest is not a near-term option for the Kootenai sturgeon population due to its status under the ESA and SARA and its delayed onset of sexual maturity. Adequate natural production would need to be restored before harvest opportunities could be contemplated.

Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement must be fully addressed.

All federal and other legal mandates for fish protection, mitigation, and enhancement relevant to this project have been met and will continue to be met as demonstrated by its successful ongoing operations since 1990 and since 1994 under terms of the ESA (KTOI 2008).

Implementing the proposed programs would assist the federal government in fulfilling its Tribal Trust responsibilities and would aid in restoring Tribal ability to exercise Treaty-reserved fishing rights.

4.13 Hatchery and Genetic Management Plan

The intent of Hatchery and Genetic Management Plans (HGMPs) is to outline how an artificial propagation strategy will protect a species and assist in recovery. Templates for these plans target anadromous salmonids and have considerable drawbacks and limitations when applying them to programs for primitive resident fish (e.g., Kootenai sturgeon and burbot). The Kootenai Tribe submitted a final draft of the Kootenai sturgeon HGMP to the NPCC on December 12, 2000 as a requirement under the NPPC Rolling Provincial Review Process for the Mountain Columbia Province. The plan is presented in Appendix A.

4.14 Harvest Plan

Because of the endangered status of Kootenai sturgeon, the first objective of the aquaculture program is to restore a self-sustaining population. Although the timeframe for achieving this objective is uncertain, the combined effects of hatchery production and habitat restoration are expected to accelerate population recovery. When multiple years of successful natural reproduction are documented and all life stages of Kootenai sturgeon are present in sustainable numbers, the Tribe's second objective of reinitiating Treaty-reserved ceremonial and subsistence harvests may be realized. Future harvest opportunities are also expected to include a sport fishery if the population achieves the viability and persistence targets necessary to be designated as a sustainable population. Harvest planning will be considered at that time.

5 Proposed Burbot Conservation Aquaculture Program

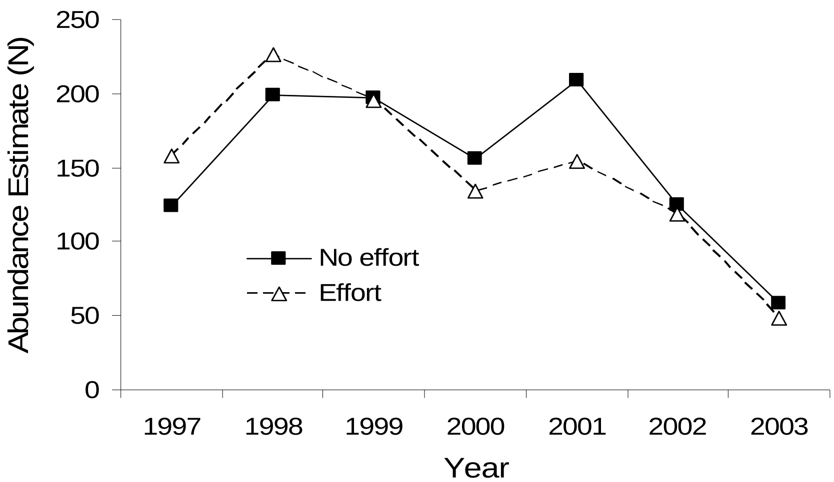
5.1 Description of Proposed Burbot Program

5.1.1 Purpose of and Need for Proposed Burbot Program

Kootenai River burbot are functionally extinct, a status that occurs when populations are so small they are unable to recover on their own, even if suitable habitat conditions exist or were immediately restored. Burbot were proposed for ESA listing in 2000; however, the USFWS determined that this population was not eligible for listing because it did not meet the defining criteria of a Distinct Population Segment. In the meantime, the Kootenai Tribe, in coordination with the USFWS, KVRI, agency partners and additional stakeholders, proposed the Kootenai River drainage as a "pilot project" to develop, implement, and evaluate a Conservation Strategy for Lower Kootenai River Burbot (Conservation Strategy), in lieu of an ESA listing.

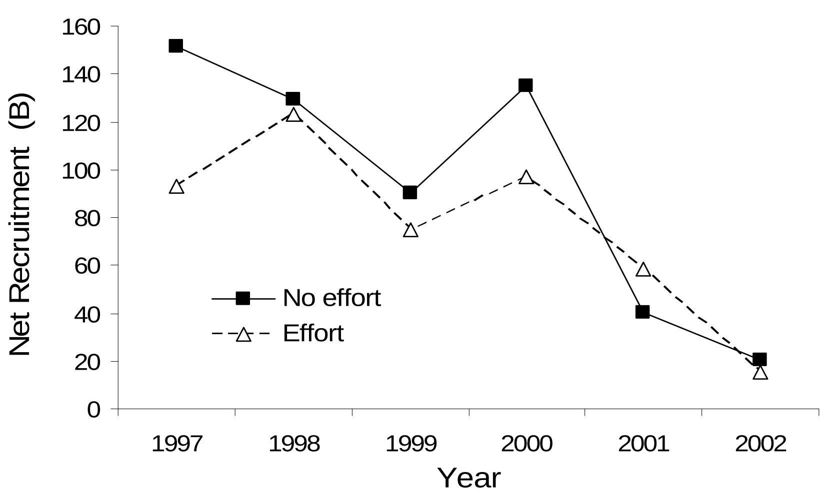
The Kootenai Tribe's proposed aquaculture program would reintroduce burbot into the lower Kootenai River and begin rebuilding the population using genetically similar stock from within the subbasin (from Moyie Lake in British Columbia). It is also possible that native broodstock from the remnant lower Kootenai population could be captured incorporated into the program.

This program is needed in the near term to obtain and incorporate genetic material from the remnant lower Kootenai River burbot population into a conservation aquaculture program. The acutely imperiled status of lower Kootenai River burbot (n<50; Pyper et al. 2004) no longer affords the luxury of an extensive research and evaluation program. Emergency conservation aquaculture appears to be the only short-term approach capable of providing a population in the lower Kootenai River. Too few fish were caught during recent years to accurately calculate more recent population statistics than depicted in Figures 5-1 and 5-2.



Source: Pyper et al. 2004

Figure 5-1. **Estimates of Kootenai River burbot abundance from capture-recapture models.**



Source: Pyper et al. 2004

Figure 5-2. **Estimates of Kootenai burbot recruitment from capture-recapture models.**

5.1.2 Burbot Program Goals, Production Targets, and Biological Objectives

5.1.2.1 Program Goals for Burbot Aquaculture

Since the burbot aquaculture program was initially conceptualized, the Tribe, in collaboration with the UI-ARI, has made notable advances in culturing this previously uncultured species. The initial challenge was the lack of effective methods to spawn, incubate, and rear fish to sizes suitable for release. The UI-ARI, in collaboration with the Kootenai Tribe, has now successfully developed burbot incubation and rearing techniques and has demonstrated the feasibility of large-scale culture of this previously uncultured species (Table 2-5). This work provides the essential foundation for implementing a conservation aquaculture program for burbot.

The next questions about aquaculture effectiveness concern post-release survival rates, effective release sizes and times, cost-effective rearing practices, long -term survival, growth, maturation, and contributions to future wild production. These questions cannot effectively be addressed using existing facilities due to the production limitations of those facilities. The Tribe's current adaptive, step-wise experimental program needs to be expanded to accomplish the next step toward reestablishing a burbot population in the Kootenai River.

The program goal for the Kootenai Tribe's burbot conservation aquaculture program is to:

- Reestablish a native burbot population in the lower Kootenai River capable of future subsistence and sport harvest once the population reaches sustainable levels.

This is consistent with goal of the KVRI Burbot Conservation Strategy to "restore and maintain a viable and harvestable burbot population in the Kootenai River and South Arm of Kootenay Lake" (KVRI 2005) (see Section 2.3.2).

5.1.2.2 Burbot Production Goals

Burbot conservation aquaculture program production goals will be a series of adaptive targets designed to release enough fish to meet survival estimates without swamping the reintroduced population with too many progeny from too few families. The current absence of empirical post-release survival data necessitates this adaptive method[19]. Accordingly, the Kootenai Tribe has developed a step-wise experimental program that includes four phases (Table 5-1). Success in each phase is required to move the program forward to a subsequent phase. Each phase and the associated production goals is described below.

[19] Currently the UI-ARI experimental facilities are able to produce up to 5,000 Age 0 burbot annually at 5 to 10 grams each (a size that can be permanently tagged and with good survival potential).

Table 5-1. Proposed operational phases of the Kootenai River burbot aquaculture program.

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 monitoring 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 2013-2017
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.	2017 and beyond

Phase 1 (Developmental Aquaculture Feasibility Analysis) was initiated in 2001 and has been completed. Reliable, successful aquaculture apparatus and techniques were developed based on pioneering aquaculture research. The progression of this burbot aquaculture program resembles the early years of the successful Kootenai Tribe white sturgeon program, which began in 1989 and has operated successfully for 20 years. 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. Burbot disease susceptibility has now been well characterized to circumvent fish health issues that may manifest under intensive conditions (Polinski et al. 2009; Polinski et al. 2010a). This work continues to demonstrate the feasibility of burbot culture at a significant scale and laid the groundwork for the next phase.

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 phase was initiated with the first experimental release of 247 burbot in October and November of 2009. Thirty of these fish were two 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 habitat and environmental conditions. These pilot study release groups will also provide information on the potential suitability of hatchery-origin fish for larger-scale population rebuilding.

During this 5-year pilot study phase, the UI-ARI facility will be used to address two objectives. One objective is to rear approximately 5,000 age 0 burbot per year for release and monitoring. Fish will be released at 5 to 10 grams, which is the minimum size that can be permanently tagged to provide 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 increased effectiveness and reduced cost of burbot aquaculture. This production level and commitment of UI-ARI facilities and staff is the extent available due to other critical research and developmental functions it provides, which is an important factor driving development of the proposed Tribal facility.

Phase 3 (Adaptive Experimental Evaluation) steps up hatchery production and monitoring efforts to determine how well hatchery-produced burbot survive, grow, and mature in sufficient numbers to reestablish a significant population in the Kootenai system. This phase involves a population-scale monitoring effort 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 to provide qualitative assessments of behavior and biology of hatchery-reared fish. Phase 3 involves larger-scale, extensive quantitative monitoring to provide statistically testable numbers of burbot to statistically evaluate post-release survival, growth, biological condition, and maturation. The Twin Rivers facility is needed in Phase 3 to produce sufficient fish for a statistically robust evaluation[20].

---

[20] The new facility at Twin Rivers is not proposed solely as a burbot facility. It is deemed essential by the Tribe for effective continuation and necessary expansion of the sturgeon program. Therefore, the inclusion of the burbot component is a cost-effective approach and the experimental nature of the program results in a lower risk.

A key objective of Phase 3 is to estimate post-release survival rates of hatchery-reared burbot with enough precision to guide future production efforts and to reach established population and use objectives. Population levels are extremely sensitive to moderate differences in annual survival. For instance, increases in annual survival from 40 to 70% result in a 30-fold difference in projected adult numbers from any given hatchery release level (Table 5-2). Data on annual survival rates of burbot in the Kootenai system are available for adults but not for juveniles. 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 rate of adults in the failed[21] Kootenay Lake burbot population at 71%. These estimates bracket the range of alternatives identified in Table 5-2. Experience with other species suggests that survival rates of hatchery-reared fish will be lower during the first year at large as released fish adapt to natural conditions. For planning purposes, we simply assumed a first year survival rate of half the annual average.

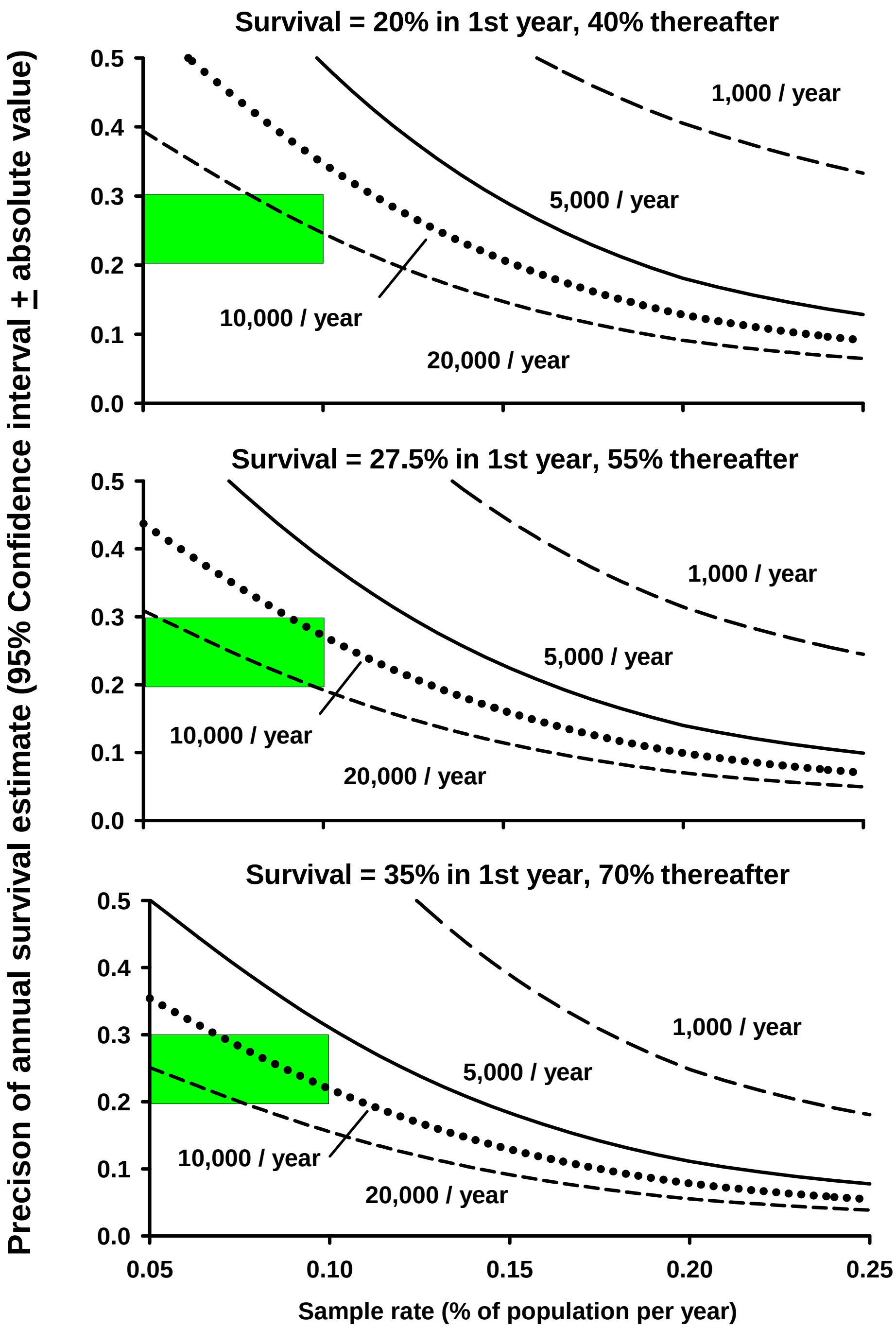
Table 5-2. Sensitivity of burbot population size to production numbers and survival rates.

Age	40% Annual Survival				55% Annual Survival				70% Annual Survival			
Rel no.	2000	5000	10000	20000	2000	5000	10000	20000	2000	5000	10000	20000
1	400	1000	2000	4000	550	1375	2750	5500	700	1750	3500	7000
2	160	400	800	1600	303	756	1513	3025	490	1225	2450	4900
3	64	160	320	640	166	416	832	1664	343	858	1715	3430
4	26	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	294	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	69	138
13	0	0	0	0	0	1	2	4	10	24	48	97
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

Phase 3 annual production targets of 10,000-20,000 Age 0 burbot are consistent with the results of 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%). Power analyses also demonstrated that the current production capacity of 5,000 fish per year is not adequate to provide useful levels of sampling precision, except at very high survival and sampling rates. Statistical power curves (Figure 5-3) 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

[21] Population failure was attributed to over fishing.

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.



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 5-3. Power analysis of the effects of annual release number and sampling rate on 95% confidence intervals for survival under three different survival assumptions.

Phase 4 (Population Rebuilding) would implement a full-scale restoration program designed to meet population and use objectives established in Phase 3. Table 5-2 illustrates Phase 3 production levels are likely to be adequate to meet minimum conservation abundance objectives (2,500) under only the most optimistic of assumptions. This does not mean that conservation objectives will not be met; rather, it underscores the need for implementation of possible program expansion in Phase 4. Although the historical size of the South Arm and Kootenai River burbot population is unknown, we believe that the minimum conservation abundance objectives and planned Phase 3 release levels are substantially less than the historical habitat capacity. Thus the proposed approach protects from indiscriminate, large-scale hatchery production, and allows the program to grow adaptively as necessary.

The only suitable reference point available is from historical harvests of West Arm Kootenay Lake recreational fisheries. Peak harvest levels can be assumed to represent a minimum bound on a population estimate[22]. Peak harvests of 25,930 adult burbot in the West Arm fishery occurred in 1969 (Ahrens and Korman 2002; KVRI 2005). At an average size of approximately 70 cm and an average weight of 1.83 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 5-4). Numbers and biomass of the proposed South Arm/Kootenai River burbot population produced in Phase 3 are clearly much less than 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 and the hatchery program comes nowhere close to that level of production.

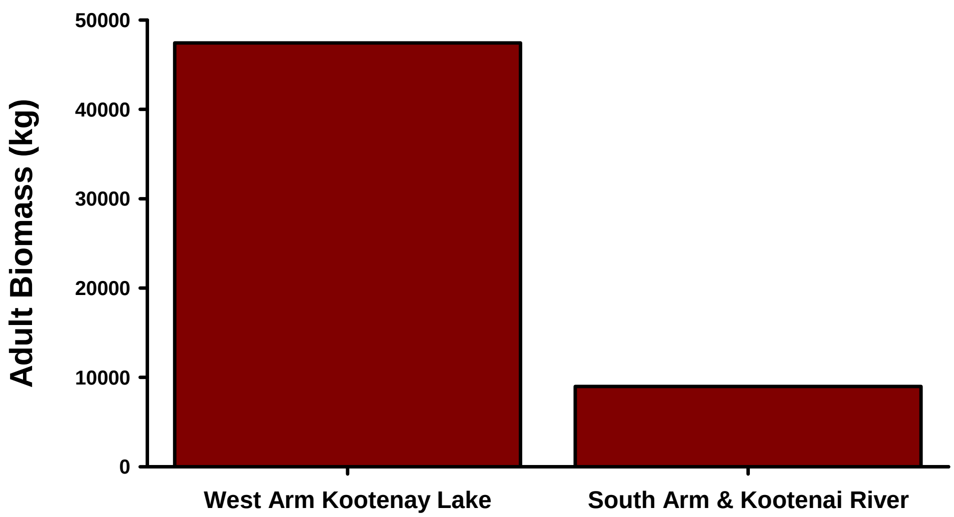


Figure 5-4. Comparison of minimum estimates of population biomass in the West Arm Kootenay Lake burbot population with maximum estimates of population biomass of the hatchery-produced burbot population in the South Arm and Kootenai River burbot population.

---

[22] Of course, total abundance is greater than harvest in proportion to the reciprocal of the harvest rate. Ahrens and Korman (2002) estimated a peak West Arm burbot population size of approximately 200,000 including juveniles and adults. However, the peak catch is used here as a minimum abundance for example purposes because it required no assumptions regarding annual harvest, recruitment rates or sustainability.

Future program expansion may be required if natural production remains limiting and survival rates are relatively low. The proposed Twin Rivers facility is being designed to provide the flexibility to implement a phased, adaptive burbot restoration program. Hatchery systems are being designed to optimize flexibility and to allow cost-effective modifications when necessary as the program unfolds. Flexibility will be enhanced by concurrent development of a joint sturgeon and burbot facility. At this time, it is difficult to accurately estimate the future production demands required by the experimental adaptive approach to both sturgeon and burbot restoration. That is why the current desing allows for optimum flexibility in future operations.

The burbot conservation strategy identifies the need for an aggressive, adaptive implementation approach to burbot restoration (KVRI 2005). In the long run, this approach is likely to produce the only effective, timely, and cost-efficient method of burbot restoration in the lower Kootenai River. The sturgeon restoration program has very effectively demonstrated the success of experimentally releasing sufficient numbers of fish over time to support a robust monitoring, evaluation, and adaptive management design. The same general approach is proposed here for burbot.

There is no significant downside to this aggressive experimental approach. This strategy will clearly establish the feasibility and requirements of burbot restoration within a reasonable time frame. If the facilities are developed as part of the necessary expansion of the Tribe's sturgeon program facilities, the up-front costs of developing suitable facilities needed for an effective experimental evaluation will be more than compensated by the timeliness of the answers that will be obtained (as previously noted, the new hatchery facility is needed for sturgeon program expansion regardless). Nor are there significant biological issues that argue for a slower, more cautious pace. The native population of burbot is essentially gone and the opportunity to capture remnant genetic material is available now. No significant ecological risks to other species are apparent.

The burbot component of the proposed Twin Rivers facilities represents a relatively modest and fiscally responsible investment that capitalizes on many shared sturgeon operational components. Concurrent development of the sturgeon and burbot facilities results in significant cost savings for the burbot program relative to independently constructing new facilities at a later date. Independent construction costs would include separate water supply and treatment facilities, separate effluent treatment and distinct operational infrastructure. Expanding existing facilities or constructing facilities outside of the basin (even if possible and recommended) also would require greater expenditures over the long term.

5.1.2.3 Biological Objectives for Burbot Aquaculture

The Tribe has identified the following pre- and post-release biological objectives for the burbot conservation aquaculture program. These objectives are the foundation of the proposed production objectives that informed preliminary facility design. Specific metrics and performance time frames are identified in Section 5.4 as part of the monitoring, evaluation and adaptive management framework for the program.

Pre-release biological objectives for the burbot conservation aquaculture program include:

- **Maintain health, condition, and reproductive condition of captive broodstock**. The biological condition of broodstock will be determined through visual observation of health and behavior.
- **Provide adequate breeding matrices for genetic diversity**. To retain wild broodstock life history characteristics, 20-30 females will be spawned with one or more male per female.
- **Provide adequate incubation conditions and hatch rates**. Hatching success will be monitored to achieve a goal of 50%.
- **Provide adequate fry and larval survival**. The survival goal for fry is to exceed 2%.
- **Provide adequate YOY survival.** The survival goal for this life stage is 50% on a dry diet with no visible health issues or negative Title 50 pathogen test results.
- **Provide adequate juvenile survival.** Survival, condition and health will be monitored, with target survival rates of 50% when they are transitioned to dry feed.
- **Provide adequate fish marking.** Young of year or juveniles will be PIT-tagged with a retention goal of 90%.

Post-release biological objectives for the burbot conservation aquaculture program include:

- **Ensure adequate post-release survival, growth, and biological condition to support future mature adults.** Sampling will be conducted annually with a post-release survival target of 30-50% in the first year after release and positive survival and health trends observed in subsequent years.
- **Create and maintain favorable age class distribution**. Sampling will be conducted to track age class distribution in the reintroduced population.
- **Maintain adequate individual and population health**. Sampling will be conducted to document external health and visual behavior of released burbot.
- **Provide genetic diversity within and among progeny groups**. Sampling will be conducted to determine diversity, heterozygosity and inbreeding coefficients. Diversity targets are under development.
- **Achieve a sustainable adult population target**. The abundance of adults will be sampled annually to characterize the population size and age-class structure. The abundance target is approximately 2,500 to 10,000 adults.

These objectives are based on guidance in the KVRI Kootenai River/Kootenay Lake burbot conservation strategy (Table 5-3).

Table 5-3. Biological objectives for Kootenai River and Kootenay Lake burbot.

Abundance
▪ A minimum adult population size of 2,500 adults in the Kootenai River and South Arm of Kootenay Lake
Productivity
▪ Consistent natural recruitment in at least 3 different spawning areas with net recruitment and juvenile population size sufficient to support the desired adult abundance

Distribution

- Stable size and age distributions

Use

- Sufficient numbers of burbot to provide a harvest opportunity

Source: KVRI 2005

5.1.3 Burbot Hatchery Operations

Typical annual operational steps at the burbot facility would include broodstock collection and handling, spawning and fertilization, incubation and hatching, rearing, marking and release. The Tribe learned a number of important lessons from the ongoing Kootenai sturgeon program that will be applied to burbot production. For example, because of the initial experimental nature of the Kootenai sturgeon program at the Tribal Sturgeon Hatchery, cautious investments were made in the facility and equipment. The low capital investment in the experimental program proved challenging when production levels needed to be increased to meet Tribal objectives and to support recovery guidance provided by the USFWS' Kootenai River White Sturgeon Recovery Team. The limited facilities and associated equipment proved inadequate, without the appropriate redundancy and operational investment, resulting years of reduced productivity, compromised fish health and condition, and in the loss of an entire year class. Such outcomes will be proactively avoided for burbot through deliberate facility design and programming.

Significant advances continue to be made in burbot aquaculture techniques and processes through the Tribe's collaborative work with the UI-ARI. Still, several critical uncertainties remain that the Tribe will address through its experimental research design at Twin Rivers Hatchery. One of the primary uncertainties is the maximum sustainable level of burbot production. The flexible design of the proposed hatchery facilities will allow the program to be sized appropriately as optimal rearing densities are better understood.

Critical uncertainties concerning post-release survival will be components of the long-term adaptive monitoring program, including tracking the:

- Suitability of river conditions and habitat to provide favorable post-release growth, survival and biological condition, and
- Success of future natural production from mature hatchery progeny

Experimental research will continue at the UI-ARI, including an array of activities designed to synchronize spawning, optimize nutrition for various life stages, improve disease characterization and treatment, and to refine and optimize many aspects of culture for pre-release life stages in the hatchery to maximize production, fish health and condition.

A conceptual site plan showing major hatchery components is presented in Figure 4-22.

5.1.3.1 Broodstock Collection and Handling

The proposed broodstock source population is from Moyie Lake, a Kootenai subbasin water body near Cranbrook, British Columbia (Figure 5-5). This population was selected based on geographic location, connectivity to the Kootenai River in Idaho, management priorities, and logistics. Furthermore, empirical genetic evidence suggests that the Moyie population is closely related to the remnant lower Kootenai River population. Broodstock or gamete collection from Moyie Lake would occur annually, unless facility capacity is met and/or the future captive broodstock population meets or exceeds the proposed production and future genetic diversity targets.

Source: Matt Neufeld, BC MoE

Figure 5-5. Proposed burbot broodstock sources.

For planning purposes, a minimum of 50 adults (25 male, 25 female; 2.5kg average body weight) may be needed. A larger captive population with additional broodstock could be necessary to maintain the proposed number of broodstock and effective population sizes.

To reduce stress, broodstock handling will be minimized. Broodstock will be collected from shallow spawning and feeding areas, an approach that will avoid gas bladder, eye, and common internal injuries caused by retrieving burbot from excessive depths. Multiple capture methods have been tested since 2003, including hand and hoop netting, hook and line fishing and commercial cod traps. All have been used with some level of success and may be adopted.

Broodstock sampling and/or gamete collection occurs through the ice in January and February on Moyie Lake when adults typically congregate to spawn. However, if time constraints or seasonal availability of broodstock limit production goals, broodstock capture could occur during other times of the year. Because adult burbot appear to be vulnerable to abrasion in captivity, they are handled only by hand or with soft mesh netting. Routine inventory of individual fish will occur before and after spawning. Once determined, non-spawning (rest-year) adults will be left alone to feed and condition themselves for the next spawning cycle, likely the following year. Adult fish will be examined before the spawning season by ultrasound to verify and characterize gonadal development (Jensen et al. 2008a). Those with abnormal gonad development or that are injured or ill will be isolated from the healthy broodstock and conditioned accordingly without the handling stress associated with spawning. Broodstock or gamete collection will be coordinated through multiple agencies using transportation equipment and holding facilities already in place.

5.1.3.2 Gamete Production

A broodstock population of 50 adults (1:1 sex ratio) is expected to produce sufficient numbers of eggs to meet the initial objectives of the proposed burbot aquaculture program. Fecundity of burbot maintained at the University of Idaho-ARI experimental burbot facility from 2003 through 2008 averaged approximately 250,000 eggs collected per kg body weight (BW). With 25 females averaging 2.5 kg BW, the potential to produce 15 million fertilized eggs exists[23]; however, both wild and captive burbot have been observed to have rest years where they do not spawn. Furthermore, potential effects of captive holding on spawning periodicity are unknown. Nutritional factors involving broodstock health may affect spawning success but have not been systematically investigated. Key uncertainties in burbot aquaculture will be addressed by the Tribe and its collaborators as described in Section 5.5.2.

5.1.3.3 Incubation and Hatch

Eggs will be maintained in an incubator system designed to keep water temperature near 3° C using recycled water and a series of chiller units. Formalin and hydrogen peroxide will be used to control fungus. Recent studies show that conical upwelling incubators produced higher hatch rates than McDonald type jars (Jensen et al. 2008b) so these will be incorporated into the Twin Rivers Hatchery facility. The proposed incubation system, including 1.2 liter Imhoff incubation cones, has the potential to hold 250,000 incubating eggs at flows of 300 ml/ minute. Hatching typically begins 30 to 40 days after incubator stocking and burbot larvae have been observed to continue to hatch slowly from the egg mass for up to 40 additional days. Larvae hatch from incubators and flow directly into black plastic tanks, which eliminates handling stress at this early developmental stage.

[23] In 2008, 20 females held at the UI-ARI (2-6 years in captivity) produced 7 million viable eggs.

5.1.3.4 *Rearing*

Rearing will occur year-round, with multiple life stages and year classes; however, early summer mortality associated with higher densities of intensive culture may be avoided by spring/summer releases into the river and/or extensive culture grow-out ponds followed by a fall release schedule. Resolution of this timing issue is being pursued with the research being performed at the UI-ARI. After spawning (typically in February-March, but can range from December-April), fry will be reared from March to June, at recommended water temperatures of 6 to 10° C. Rearing densities of < 1000 fry per liter are targeted for <0.1 gram fish. Rearing will occur in insulated, circular 250L (3-foot-dia. x 2.5-foot-deep) tanks using low flows and fine mesh screening for fry containment. Subsequent rearing of exogenously feeding fry will continue from April through September at water temperature ranging from 10 to 15° C at densities of 100 to 250 fish per liter (averaging 0.1 to 1.5 grams). Because age and life stage-specific empirical post-release burbot survival rates are currently unknown, this project will systematically and adaptively test release scenarios at several times of the year, including within year summer and fall releases, and spring releases of Age 0 or 1. All rearing beyond the yolk-sac larvae stage will occur in circular tanks (250 -1000 liter), with experimental self-cleaning apparatus, raceway troughs, and square tanks with external standpipes, insulated when appropriate. Additional information regarding these life stages is provided in Table 5-4.

5.1.3.5 *Fish Health Monitoring*

Prior to reintroducing burbot into the Kootenai River, all disease testing requirements will be satisfied. A minimum of 60 burbot will be tested to meet state, federal, and provincial disease-testing guidelines. Preliminary investigation into disease susceptibility has shown juvenile burbot to be susceptible to *Aeromonas salmonicida salmonicida* (the causative agent of furunculosis). Burbot also showed susceptibility to infectious hematopoietic necrosis virus (IHNV) by immersion in viral solution. To date they have not been shown to be susceptible to *Flavobacterium psychrophilum* (the causative agent of coldwater disease). Studies were also conducted with infectious pancreatic necrosis virus (IPNV), showing that burbot were not susceptible to this virus but could act as carriers (Polinski et al. 2009; 2010a 2010b).

5.1.3.6 *Fish Marking*

PIT-tags, fin clips, or Elastomer tags have been used with varying degrees of success with burbot. Based on lethal and sub-lethal effects of tagging adult burbot with Floy tags, other non-invasive tagging techniques are essential. Additional research on the efficacy of various tags and tagging methods for burbot will be performed as needed at the Twin Rivers Hatchery, the University of Idaho or other facilities.

5.1.3.7 *Release of Hatchery Progeny*

In the hatchery environment, burbot hatch during late winter and early spring. Ideally these fish would be released in the summer or early fall as young-of- year, exceeding 10 centimeters and 5-10 grams. Fish weight and length can be quite variable depending on fish densities, food availability and nutritional quality, and the environmental conditions of the individual extensive grow-out ponds. However, because of the highly voracious and predatory nature of exogenously feeding burbot going into their first winter (including cannibalistic tendencies), burbot aquaculturists at the UI-ARI recommend summer to fall releases after fish have been transitioned to live feed. This timing would reduce mortalities from captive rearing, as well as personnel and rearing costs. It is thought that from 7,000 to 10,000 juveniles could be released annually from the Twin Rivers Hatchery, depending on marking and rearing strategies.

Because the proposed future release strategy for burbot will be adaptive, fish of various ages and life stages will be experimentally released as part of a pre-planned, well monitored strategy during the summer and fall of their first year and the spring and summer of their second year as two-year olds. Adequate groups of different aged fish will be released to identify the optimal release strategies to evaluate survival and cost-benefit ratios. This future release strategy will be detailed in the burbot aquaculture adaptive management plan.

5.1.3.8 Post-release Monitoring

Post-release monitoring will be conducted by the Kootenai Tribe, BC MoE and the IDFG in coordination with various other agencies and programs. Monitoring will include but not be limited to estimates of growth, survival, biological condition, habitat use, and fish pathology. These activities are discussed in greater detail in Section 5.4.4and Section 6.

5.1.3.9 Water Budget

The water budget presented in Table 4-10 includes requirements for burbot aquaculture and the supporting live feed program at Twin Rivers Hatchery. Average monthly flows after the first year of operation will range from approximately 300 to 600 gallons per minute depending on how much extended grow-out culture is conducted. A combination of surface water and groundwater sources are proposed in order to optimize water quality.

5.1.3.10 Water Quality

As with the Kootenai sturgeon program, the primary water supply for burbot aquaculture will be pumped from the Kootenai River and the Moyie River (see Section 4.3.3). While there is little published data regarding optimal water quality for burbot aquaculture, it is known that burbot require very cold water (ranging from 2 to 4° C) for successful spawning and fertilization and 2 to 6° C for incubation. Mechanical chilling will be used to keep the water supply within this thermal range. Juvenile and adult life stages tolerate temperatures typical of the Kootenai River.

Well water will be used at the Twin Rivers Hatchery site to assure a pathogen-free source for incubation and early life stage rearing (water quality testing results are presented in Appendix D). Advanced life stages will be transitioned to a surface water supply that has been filtered and disinfected to control pathogens.

5.2 Alternatives Considered

A range of alternatives for burbot conservation were considered by the Tribe for this planning level evaluation. These included maintaining current flow management measures, developing an artificial production facility, or modifying an existing facility to accommodate production.

5.2.1 Alternative 1: Status Quo

Under this strategy, all ongoing measures would continue. These include: 1) reducing discharge from Libby Dam to the extent possible during the winter months to stimulate reproductive migrations that could lead to natural production; and 2) providing more normative fall and winter thermographs in the Kootenai River to the extent possible through altered operations at Libby Dam.

If Alternative 1 were to be adopted, the expected outcome would be extinction of the native burbot population. Ongoing measures have had no effect on the burbot population over the last decade. Studies indicate that there has been inadequate burbot recruitment over this time period (Pyper et al. 2004, KVRI 2005, Paragamian et al. 2008).

5.2.2 Alternative 2: Implement Conservation Aquaculture at a New Facility

Under this strategy, a new aquaculture facility would be constructed to propagate burbot. Burbot native to the Kootenai River subbasin would be spawned and reared in an effort to rebuild a burbot population in the lower Kootenai River. This facility would be co-located with the proposed Kootenai sturgeon aquaculture program at the Twin Rivers site, resulting in shared infrastructure components and costs and operational efficiencies.

Alternative 2 appears to have a high likelihood of restoring burbot to this reach of the Kootenai River, particularly if combined with the habitat improvement measures proposed by the Kootenai Tribe under the Kootenai River Habitat Restoration Project. The Moyie Lake population is currently proposed for use as the wild donor stock for this program.

5.2.3 Alternative 3: Implement Conservation Aquaculture at an Existing Facility

Artificial propagation of burbot would be accomplished at an existing hatchery in the Kootenai subbasin. Under this strategy, existing facilities would be modified or expanded to accommodate production of this species. Potential locations considered were 1) the Tribal Sturgeon Hatchery near Bonners Ferry, and 2) the Fort Steele Hatchery in British Columbia. Facilities at the UI-ARI currently being used to experimentally propagate burbot are suitable for research programs but cannot be expanded into production facilities, nor can they be used in the long term.

The Fort Steele facilities currently operate at capacity. Producing burbot would occur at the expense of ongoing production commitments (B. Ludwig, BCFFS, pers. comm. with S. Ireland, KTOI, May 18, 2010).

5.2.4 Basis for Selection of Proposed Alternative

The Kootenai Tribe selected implementation of a conservation aquaculture program at a new facility (Alternative 2) for assessment in this Master Plan. In the absence of other viable strategies to rebuild a burbot population, this approach has a high likelihood of preserving and/or restoring burbot in this reach of the Kootenai River, particularly if combined with the habitat measures proposed by the Tribe under a separate action. This strategy is consistent with and specifically included in the Kootenai River Subbasin Plan and is consistent with the NPCC's artificial production policies and scientific principles, and the Burbot Conservation Strategy (KVRI 2005).

In addition, developing the Twin Rivers Hatchery satisfies a prerogative for local involvement in the Kootenai ecosystem recovery effort and requirements to address treaty trust obligations. Local involvement is a mandate of the KVRI burbot subcommittee, operating under a MOU signed by representatives of state, federal, tribal and provincial fishery and river management interests and local governments. Tribal Treaty and Trust obligations would be furthered through development of the Twin Rivers Hatchery for several reasons. First, this aquaculture program has the potential to restore a culturally important Kootenai Tribal fishery and the ability of the Tribe to exercise its Treaty-reserved fishing rights. The U.S. government's government-to-government relationship with and trust responsibility to the Kootenai Tribe also would be furthered through the partnerships developed in this Tribe-led program. Additional detail on the rationale for this decision is presented below.

5.2.4.1 Expand Use of Tribal Stugeon Hatchery, University of Idaho or Fort Steele Facilities

The Tribal Sturgeon Hatchery currently operates at capacity and the option of adding burbot production to the current program would occur at the expense of ongoing production commitments. Reprogramming was not considered to be a feasible option. Expanding facilities at the Tribal Sturgeon Hatchery was determined to be infeasible primarily because the supply of high quality water and land for expansion are limited. The UI-ARI facility is not adequate to meet Phase 3 program requirements for a number of reasons. The primary goals of the University of Idaho program are to develop and refine aquaculture techniques for burbot and to produce juvenile burbot to address a range of experimental biological questions. Their facilities are well suited for much of this small scale work, but are inadequate to fully address the needs of an experimental release and/or population restoration program. The use of the UI-ARI facility in the initial phases of the program has advanced knowledge of this species substantially. Fish produced in the University can continue to be used in the future for experimental releases; however, the scale at which this can be done is limited. The existing University facility cannot be expanded due to water availability, dechlorination capabilities for the existing water supply, and available physical space. Fish produced at the UI-ARI currently meet the out-of-basin requirements for experimental release to the Kootenai River, but few other operations would be capable of this.

Although the Fort Steele facilities provide an important fail-safe function for Kootenai sturgeon production, until the need for such a function is determined for the burbot program, the Tribe does not intend to pursue use of this site with its Canadian partners. Finally, no other suitable existing facilities were identified in either the Idaho or Montana portions of the subbasin that could accommodate a burbot program.

5.2.4.2 Use of Another Out-of-Basin Facility

Best aquaculture practices endorsed by NPCC and others discourage transferring fish out-of-basin for ecological and pathological reasons. Out-of-basin propagation alternatives suffer from a variety of problems that limit their suitability for the burbot aquaculture program.

Pathology concerns are particularly significant in out-of-basin facilities. Inter-basin transfers of fish and water risk introduction and the spread of non-endemic pathogens. This risk greatly complicates aquaculture program implementation. All states, provinces and collaborating agencies and tribes have serious concerns regarding the risks of inter-basin transfers and regulate fish movements. If disease is detected in fish reared out-of-basin, there is little chance that fish would be released due to concerns of introducing non-endemic pathogens or unique strains of a pathogen to new waters. Although extensive measures have been taken to monitor and avoid introduction of non-endemic pathogens, a significant outbreak would preclude fish from being transported and released in the Kootenai and would result in the loss of at least one year class. Due to the reliance on a closed or semi-closed recirculation system for current production of fish at the University of Idaho, detection of a non-endemic pathogen may require the eradication of all fish at the facility and complete disinfection. Disease inspections following USFWS Title 50 requirements are completed prior to release to certify disease free status. Despite these measures, the risk of detecting a non-native pathogen to the Kootenai system cannot be discounted. This is a significant risk that would be minimized by implementing design criteria and rearing fish within basin, as proposed with the Twin Rivers site.

Additional problems with out-of-basin rearing include transportation stress, acclimation requirements, and escapement risks. Long-distance transport increases the potential for stress-related direct and delayed post-stocking mortality. The combined stresses of transport and release into the unfamiliar natural environment could significantly reduce post-release survival. How burbot will respond to significant handling is unknown and it seems prudent to minimize potentially risky practices whenever possible. The significance of acclimation or imprinting for burbot is unknown but may be found to be important in the future. Rearing burbot in close proximity to historical spawning areas will provide the best long-term prospects for successful migration and spawning if imprinting proves to be important.

Finally, local rearing also avoids risks associated with the potential escapement of non-endemic stocks. The UI-ARI facilities are unique in that any effluent drains directly to the Moscow wastewater treatment plant and is fully disinfected. This prevents escapement of burbot (especially larvae) to natural waters where they are not native. Implementing such safeguards at other potential out-of-basin facilities may be difficult and expensive.

5.3 Conceptual Design of Burbot Facilities

5.3.1 Overview of Burbot Facility Elements

The Tribe is proposing to include burbot aquaculture facilities as part of the new Twin Rivers Hatchery. A general site layout is presented in Figure 4-22.

The burbot holding, spawning and rearing tanks would be located in a separate building from Kootenai sturgeon and rainbow trout to minimize potential pathogen transmission. Components specific to burbot aquaculture include:

- **Adult Fish Holding/Spawning.** Round tanks with adequate cover are required to hold adult burbot.
- **Incubation.** Burbot eggs are incubated in one liter Imhoff cones mounted over small circular start tanks.
- **Start Tanks.** Post-hatch burbot volitionally move up through the water column out of the top of the incubators into the start tanks where they will be fed and closely monitored for disease as they grow to a size acceptable for transfer out of the start tank room. Burbot hatchlings require live feed (rotifers and *Artemia*) that will be raised in an adjacent live feed culture room.

- **Rearing Tanks.** Four-foot-diameter indoor circular tanks and eight-foot troughs will be used for burbot dry diet transition and grow-out.
- **Burbot Ponds.** Six 10 by 10 meter outdoor earthen ponds are planned for experimental larval and extended burbot rearing. Each pond will have a concrete harvest and water level control structure, supply, drain piping and predator barriers. Larger ponds for long-term holding of captive broodstock are also being considered.

5.3.1.1 Design Guidelines

Burbot are a challenging species to culture. Researchers have experienced relatively high mortality rates in cultured burbot due to the species' sensitivity to changes in water temperature, chemistry and pathogens and the live feed requirements in their larval stage (Harzevilli et al. 2003, Jensen et al. 2008b). Design guidelines for the proposed facility were derived primarily from the experimental work performed at the UI-ARI, since very little burbot aquaculture occurs in the United States to draw upon for knowledge.

The Kootenai Tribe, University of Idaho, and BC MoE have collaborated since 2003 to successfully bring wild burbot into captivity and to develop rearing systems and hatchery methods[24]. During the last five years, this work has advanced from uncultured to an experimental stage where production of feed-trained burbot wererelease d to the Kootenai River in 2009 (Jensen et al. 2010). This research provides the foundation for design and refinement of the burbot components of the Twin Rivers Hatchery. The design guidelines identified below are based on this recent research:

- Adult gender segregation and hormone analogs used to synchronize and control spawning
- Optimized egg incubator design
- Burbot volitionally spawned in tanks
- Use of defined screening criteria to retain eggs within the adult spawning tanks and embryos in rearing tanks
- Use of defined protocols to wean larvae from live feed to a commercial diet
- Defined live feed criteria using brackish rotifers followed by *Artemia*
- Studied intensive and semi-intensive rearing methods that keep rearing tanks clean when a commercial diet is introduced in order to increase juvenile survival

In addition to informing the conceptual design of the proposed Twin Rivers Hatchery, these pioneering advances in burbot aquaculture will be used to produce the first aquaculture manual for a burbot conservation breeding program and facility operations. These techniques have implications for recovery of burbot populations in the Kootenai River and elsewhere in the world, and may have potential for future commercial production of this species. Other facility design decisions are the same as those described in Section 4.3.3.1.

---

[24] Peer-reviewed publications documenting research results include the following: Hammond and Anders 2003; Ireland and Perry 2008; Jensen 2006; Jensen, Anders and Cain 2008; Jensen et al. 2008a; Jensen et al. 2008b; Jensen et al. 2008c; Jensen and Cain 2009; KVRI Burbot Committee 2005; and Zuccarelli et al. 2007.

5.3.1.2 *Design Biocriteria*

The biocriteria for burbot and live feed aquaculture are based on the experimental burbot program at UI-ARI and the Tribe's experience with the aquaculture program at the Kootenai Sturgeon Hatchery. The process of developing the biocriteria is described in Section 4.3.3, Biocriteria for Kootenai sturgeon. This process requires facility designers to consider a range of potential future operational scenarios, especially important given the absence of models for burbot aquaculture. Facility planning must be adaptable based on tested procedures and monitoring and evaluation outcomes. By addressing production uncertainties at this early design stage, considerations are proactively incorporated that will accommodate modifications without significant cost increases or space constraints.

Table 5-4 identifies biocriteria for various burbot life stages proposed to be cultured. These criteria were used to develop water budgets and treatment requirements, site and space planning, and the related support facilities proposed for the Twin Rivers Hatchery as described in Section 4.3.3.

Live feed, including rotifer and *Artemia* cultures, is needed to support the early life stages (fry) of burbot until they are mature enough to be transitioned to a commercial dry food diet. Burbot broodstock also require live feed in the form of young rainbow trout. Biocriteria for the fry live feed program are shown in Table 5-4.

5.3.1.3 *Water Supply Criteria*

Water supply requirements in burbot aquaculture operations at Twin Rivers Hatchery are described in Section 4.3.3.2 and depicted on Table 4-11. A special requirement of burbot is their need for very cold water (in the range of 2-4° C) during late winter or early spring egg take, fertilization, incubation, and hatch.

Facilities to supply and treat water used in burbot aquaculture will be the same as those described for Kootenai sturgeon in Section 4.3.3.2. Larger chilling capacity will be needed to support the burbot program relative to the Kootenai sturgeon program.

5.3.2 Proposed Twin Rivers Hatchery Burbot Facilities

As previously described, most of the primary Twin Rivers Hatchery structures (buildings, water supply network and utilities) will support both burbot and Kootenai sturgeon culture. Of the total 23,550 square feet of indoor space proposed at Twin Rivers Hatchery, 5,725 square feet will be dedicated to the burbot program (Table 5-5). In addition, six outdoor burbot ponds are proposed that will occupy 20,000 square feet. Operational criteria are described in Section 4.3.3.2. The following section describes the burbot facilities as they are currently proposed as a component of the sturgeon facilities. To describe them as completely stand-alone facilities would require a new design process, increased costs and operational inefficiencies.

Table 5-4. Biocriteria for burbot and live feed.

Aquaculture function/life stage	Broodstock (collection, holding)	Spawning and fertilization	Incubation and hatch	Rearing (fry)	Rearing (on feed, up to 4 months)	Rearing (YOY)	Rearing (juveniles-Age 1+)	Pond or release	Live Feed*		
									Rotifers *B. plicitilis* L-type for master culture	Rotifers for production	Artemia-GSL90+
Time / Months	Collect Oct-Nov, Hold 3 to 12 Months, depend on strategy i.e. hold, spawn, release	Dec to April	Dec to May	Jan to June	April to Sept	Jan to Dec	Jan to Dec	Jan to Dec	All year	Mar-June	May-July
Water temp range (°C)	Year-round range:2-22˚C, (do not exceed 23˚C)	2-4˚C	2-6˚C	6-10˚C	10-15˚C	10-15˚C	10-22˚C	Seasonal, must acclimate	15-25	18-25	28
Other WQ requirements	pH 8-8.5, DO $\geq$ 6ppm, Buffering capacity @ ARI > 150 ppm CaCO3 seems okay	As above	As above	As above	As above	As above	As above		pH7-8, salinity 10-20 ppt	pH 7-8 salinity 15 ppt	pH 7-8, seawater
Densities by life stage	Minimize, 1adult/10L okay in the past	Minimize (1 adult/10L okay in the past). Mix genders in case of volitional spawning - May want capacity to hold pre-spawned broodstock separately by sex on single pass water	Incubator stocking dependant on egg takes and need to separate families. Once hatched, hold at 1000-1500/L; lower recommended	<1000/L Recom-mended	100-250/L	100/L	1-10/L		Variable	Variable	Variable
Production goals (weight)	0.5-1.0Kg fish should be mature			<0.1 g/fish	0.1-1.5 g/fish	1.5-25 g/fish	25-150 g/fish		Maintain 20/ml	Want 10-100 R per ml fed to Larval fish tanks one time per day	Want 10-100 A per ml fed to Larval fish tanks one time per day

Aquaculture function/life stage	Broodstock (collection, holding)	Spawning and fertilization	Incubation and hatch	Rearing (fry)	Rearing (on feed, up to 4 months)	Rearing (YOY)	Rearing (juveniles-Age 1+)	Pond or release	Live Feed*		
									Rotifers *B. plicitilis* L-type for master culture	Rotifers for production	Artemia-GSL90+
Survival Assumptions by life stage	50 - 100%	Fertilize eggs within 1 hour of collection	50%	2%	15%,adding dry diets affects survival	On dry diet - 50%	On dry diet>90%	tbd	Good,variable	Good, variable	Variable
Number of eggs or fish	20 to 30 females-2 kg average	350,000 eggs/kg Bodyweight x 40 kg =14,000,000 eggs	14,000,000 x 50% = 7,000,000 hatchlings	7,000,000 hatchlings x 2% = 140,000 fry	140,000 x 15% = 21,000	21,000 x 50% = 10,500	10,500 x 90% = 9,450 juveniles		Maintain 20/ml	Maintain 2000/ml	Variable
Holding unit size and description	Fiberglass circular tanks 1100-1800L	Use sterile plastic bags (500ml) to collect, activate, and water harden eggs	1 L Imhoff cones	Insulated circular tanks 250L, low flows required, fine mesh screening required	Circular tanks 250-1000L, Will want to experiment with self-cleaning circular tanks, raceway troughs, and square tanks with outside stand pipes. (insulate)			10 M sq. x 1 - 2 M deep ponds with harvest kettles	Variable	Variable	Variable
Holding unit quantity	(4) 6' dia x 3' dia (egg collection provisions?)	NA	50 jars	(20) 3' dia x 2.5' dia			(24) 4' dia x 2.5' dia and/or (12) 2.5 x 10' L x 2.5 d troughs	6 outdoor ponds	20 gal aquarium	Recirculation systems for rearing. Stagnant tanks for acclimation and washing: Rearing 300 L Conical bottom tanks Acclimation 100 L conical bottom tanks Washing 100 L tanks flat bottom tanks	

									Live Feed*		
Aquaculture function/life stage	Broodstock (collection, holding)	Spawning and fertilization	Incubation and hatch	Rearing (fry)	Rearing (on feed, up to 4 months)	Rearing (YOY)	Rearing (juveniles-Age 1+)	Pond or release	Rotifers *B. plicitilis* L-type for master culture	Rotifers for production	Artemia-GSL90+
Water exchange / flow rates	R=2 Max, 16 GPM/tank/ave		500 ml/min ea	R=1 minimum; 0.5-1.0 L/min or ~30-60 L/hr.			R=1; 900L tanks flow need ~15L/min	R=1.5 per day, 25 GPM ea.	5	Rearing system tanks needed-6 (2 per recirc system, Acclimation-4. Washing-2.	
Total flow - GPM	65 GPM	NA	7 GPM	45 GPM		45 GPM	200 GPM	150 GPM	25 GPD needed	Rearing system closed Recirc. Need 2 GPM flow for washing, 1 GPM for acclimation flow. 150 GPD reverse osmosis water	50 GPD filtered water, No flow through
Water source	Kootenai River water		Groundwater	Ground-water			Kootenai or Moyie River water	Kootenai or Moyie River water	Groundwater/ filtered	Groundwater RO, Rearing system recycling 600-800%/d. About 5 GPM per recirc system Acclimating-stagnant-100 L /d Washing-1000 L / d	Ground-water/ filtered

									Live Feed*		
Aquaculture function/life stage	Broodstock (collection, holding)	Spawning and fertilization	Incubation and hatch	Rearing (fry)	Rearing (on feed, up to 4 months)	Rearing (YOY)	Rearing (juveniles-Age 1+)	Pond or release	Rotifers *B. plicitilis* L-type for master culture	Rotifers for production	Artemia-GSL90+
Water treatments	Ambient temps for holding, chill as needed to induce spawning	Filter, disinfect and chill	De-gas and chill	De-gas and chill			Filter, disinfect and chill or heat	Filter, disinfect	Filtered water, LP air	Rearing system Recycling 600-800%/d. About 5 GPM per recirc system Acclimating-stagnant-100 L /d Washing-1000 L / day, Chill or Heat, oxygen supp. and LP air	LP air, salt added
Other				Automated feed delivery and tank bottom wiper				Predator netting	Preferably in room separate from production. In *Artemia* room Okay. Or in lab. Forced air needed	Water storage tank 500-1000 Gal for filtered water plumbed to areas needed. Oversized floor drains needed. Forced air needed	Lighting 2000 lux or 200 ft-candles. Photo-period 16 light:8 dark. In room separate from rotifers. Forced air needed

*Note: Forage Fish tankage and flows are shown under sturgeon water budget

Table 5-5. Spatial requirements for the burbot program.

Proposed Burbot Buildings	
Burbot Broodstock/Spawning	1,125 SF
Burbot Incubation	1,280 SF
Burbot Rearing (Indoors)	1,800 SF
Burbot Mechanical/Electrical	200 SF
Cyro/Freezer/Feed Prep/Lab	720 SF
Burbot Live Feed/Feed Preparation	600 SF
Burbot Subtotal	5,725 SF
Outdoor Facilities	
Burbot Ponds (6)	20,000 SF

5.3.2.1 Burbot Broodstock Holding Tanks

Burbot broodstock will be held in four to six 10-foot-diameter, 3-foot-deep round tanks supplied with ambient river water.

5.3.2.2 Spawning and Egg-Take Facilities

The Twin Rivers Hatchery will include burbot spawning and egg-take areas. This process will occupy an area containing spawning tables and sinks in the same room as the proposed burbot broodstock holding tanks.

5.3.2.3 Incubation and Rearing Facilities

Burbot incubation will occupy 1,125 square feet in a separate room in the burbot building. Burbot eggs will be incubated in jars known as Imhoff cones mounted over three-foot-diameter fiberglass round tanks or troughs that will collect the young as they hatch. The grated floor decking in the incubation area will cover below-grade trenches designed to accommodate different types of tanks, depending on fish culture needs. A fungicide storage and distribution system will be included in this area to allow periodic anti-fungal treatment of the burbot eggs.

Burbot will be reared to release or ponding size indoors in tanks occupying 1,800 square feet in the burbot building. Twenty-four 4-foot-diameter fiberglass tanks are proposed. Water supply and drain piping will be spaced regularly in the floor slab of this room. Typically, ambient river water will supply these tanks, although some provision for tempered water will be included as indicated in Table 4-10. Target rearing water temperatures are 10 to 15° C. Baffles and substrate may be included in each tank to create more natural flow patterns and to simulate habitat.

In order to maximize production capabilities and future program flexibility, the incubation room is slightly oversized to allow the incubation tanks to be replaced with 10-foot by 2.5-foot rearing troughs or larger round tanks.

The burbot rearing program is currently experimental. As the program progresses, the Tribe will assess the need for a fail-safe program similar to that provided for the Kootenai sturgeon aquaculture program at the Kootenay Trout Hatchery in Fort Steele, British Columbia.

5.3.2.4 *Outdoor Ponds*

The Tribe is proposing six outdoor earthen ponds for experimental larval or extended burbot rearing. Each pond will have a water surface area of approximately 1,100 square feet and will occupy a total area of about 20,000 square feet. Predator fencing, netting and/or shade cloth protection will be included.

5.3.2.5 *Live Feed*

Larval burbot from about age 10 to 50 days post-hatch will be fed algae paste, *Artemia,* and rotifers that will be cultured on site in an approximately 600-square-foot area. *Artemia* will be reared in artificial seawater (without flow-through) in small vats or cones. Small temperature-controlled recirculating water systems on 30-inch-diameter tanks will be used for rotifer production, with a master culture maintained in a 20-gallon aquarium. Well water treated with a small reverse osmosis filter will be used for make-up water to the live feed area. A small amount of freezer storage space is needed for the rotifer feed and cold cyst storage of *Artemia*. Special lighting and low-pressure air systems will also be included in the live feed area.

5.3.3 Remote Burbot Rearing and Release

The Tribe and IDFG are temporarily leasing two privately-owned outdoor ponds located in Boundary County to test and develop experimental rearing techniques. At these interim facilities, the Kootenai Tribe, IDFG, and UI-ARI are collaboratively developing and refining burbot pond (extensive) culture until controllable ponds or other extensive culture facilities are developed at Twin Rivers Hatchery. While these remote ponds provide some information on extensive burbot culture, they have some drawbacks, including water management limitations and predation. Furthermore, the replication needed for adaptive experimental trials is not possible. Information gained from operating these temporary ponds is intended to influence final design and operational provisions of the burbot hatchery facilities.

5.4 Burbot Monitoring, Evaluation and Research

A series of research, monitoring, and evaluation activities for burbot are a significant part of this project. Measurable biological objectives and metrics for pre-release and post-release periods are identified in Tables 5-6 and 5-7, including specific monitoring and evaluation activities during pre-spawning, spawning, incubation, and early rearing life stages in the hatchery. Post-release monitoring is especially critical to the burbot program and is the most effective and expeditious method for identifying the suitability or limitations of current environmental conditions for burbot. Too few naturally produced burbot are currently available to identify in-river limiting factors or remedies for restoring for restoring a population through natural production. Burbot produced by this program will tell us where the limitations occur based on an empirical adaptive project implementation design. Understanding burbot population bottlenecks, a prerequisite for long-term restoration success, will only be possible through experimental stocking and monitoring of adequate numbers of cultured fish due to the additive magnitude and severity of habitat loss and alteration.

Table 5-6. Pre-release biological objectives, metrics and target values to be monitored and evaluated in the burbot conservation aquaculture program.

Program Aspect	Biological Objectives	Life Stage or Activity	Metrics	Target Metric Values for Burbot	Timeframe
Spawning	Provide adequate broodstock	Spawners	Gamete viability	Sperm motility ≥ 80%	Up to 3 mo. annually, typically Feb-June
	Provide adequate breeding matrices for genetic diversity		Effective population size (*Ne*); No. of breeders (*Nb*); fertilization	20-30 female broodstock annually, spawned with ≥ 1 male each	
Incubation/ Hatch	Provide adequate incubation and hatch rates	Embryos	Survival (hatch)	Hatching success 50%	Up to 4 mo. annually, typically May-Sept
Early rearing	Provide adequate fry and larval survival	Fry and larvae	Survival	> 2% for each life stage	Up to 5 mo. annually, typically May-Sept
	Provide adequate YOY survival	YOY rearing	Survival, fish health	Survival > 50 %; no visible signs of fish health problems; Negative Title 50 pathogen test results if post-release fish tested	Up to 4 mo. annually, Sept-Dec.
	Provide adequate juvenile survival	Juvenile rearing	Survival, condition, fish health	Survival > 50 %; Negative Title 50 pathogen test results	Up to 9 mo. annually, typically Jan-Sept, including fall of previous year for YOY
	Provide adequate fish marking	YOY and juveniles	Mark retention	PIT-tag retention > 90%	

Table 5-7. Post-release biological objectives, metrics and target values to be monitored and evaluated in the burbot conservation aquaculture program.

Program Aspect	Biological Objectives	Life Stage or Activity	Metrics	Target Burbot Metric Values	Timeframe
Post-release monitoring	Ensure adequate post-release survival, growth, and biological condition to support future mature adults	Juvenile and adult sampling	Survival, annual growth, biological condition (*K*), relative weight	Target survival 30-50% first year post-release; consistent positive growth; condition factors and relative weights ; consistent, positive trends over years	Annually or periodically based on recapture data
	Create and maintain favorable age class distribution		Age class distribution; recruitment magnitude and frequency	Hatchery-produced year classes annually	Annually, year-round
	Maintain adequate individual and population health		Adequate fish health to support adult target goals	External health and behavior visually suitable; negative Title 50 pathogen test results	Annually, year-round
	Provide genetic diversity within and among progeny groups		Diversity, heterozygosity metrics and inbreeding coefficients	Genetic diversity targets from mating plan under development	Annually, year-round
All stages	Sustainable adult population target	All life stages	Population abundance (adults)	From 3 groups of 2,500 to approximately 10,000 adults	Annual sampling, periodically update abundance estimates & age class structure characteristics. May occur up to 30 years

As with Kootenai sturgeon, long-term monitoring efforts have shown that current habitat conditions in the Kootenai River and Kootenay Lake appear suitable for burbot subadult and adult life stages. Population failure appears to occur in the incubation to early rearing stages. Releases of burbot at various sizes and ages will allow the Tribe and its partners to more narrowly identify the limiting life stage and focus restoration efforts on environmental factors that affect that life stage. Carefully monitored releases of hatchery fish are required to evaluate stage-specific habitat requirements.

5.4.1 Fish Health

5.4.1.1 Fish Health Monitoring

The burbot program will include protocols to monitor and minimize pathogen introduction and transmission in hatchery and natural populations. These protocols will be similar to those implemented for the sturgeon program (Section 4.4.2). Research has been aimed at limiting pathogen transmission during egg incubation, developing cell lines for improved diagnostics and assessing burbot susceptibility to pathogens (Polinski et al. 2010b) These efforts, described below, are helping to define optimal treatments to control fungus during egg incubation, to address possible viral diseases through new cell line development, and to establish baseline data regarding burbot susceptibility to a number of fish pathogens.

As part of the proposed monitoring program, all broodstock and at least 30 progeny from each brood year will be tested for the presence of pathogens. As with Kootenai sturgeon in this project, burbot will be subjected to the federal fish health Title 50 pathogen screen. Disease testing may include parasitology, bacteriology, virology and histology examinations. Burbot evaluation protocols have been developed by state, provincial, federal, and tribal management agencies and disease test results will be reviewed by all parties.

5.4.1.2 On-going Fish Health Research

Establishment of Burbot Cell Lines and Characterization of Viral Susceptibility

To screen and monitor burbot for the presence of viral pathogens, an early-larval cell line has been established (Polinski et al. 2009, 2010a, 2010b). This burbot cell line has been maintained in laboratory culture over 3 years and passed nearly 90 times. Although relatively slow growing compared to other established laboratory fish cell lines, increased growth rates have been observed as *in vitro* passage increases. Cryopreservation of this cell line has been achieved with up to 90% viability. Susceptibility of this cell line to multiple viruses and strains has been determined. The line shows a cytopathic effect when exposed during incubation to infectious hematopoietic necrosis virus (IHNV) and viral hemorrhagic speticemia virus (VHSV). If novel viruses affect this species, this burbot cell line will be an important tool in early diagnosis and possible virus isolation. In addition, submission of burbot samples to standard Title 50 pathogen testing (Section 4.4.2) will reveal suitability for future experimental release.

Susceptibility of Juvenile Burbot to Fish Pathogens

Because virtually no information was previously available about the susceptibility of burbot to disease, experiments in 2007 and 2008 at the UI-ARI challenged juvenile burbot with various pathogens. In challenge experiments on progeny from captive broodstock, juveniles were not susceptible to a virulent strain of *Flavobacterium psychrophilum*, the agent that causes bacterial coldwater disease. In addition, disease testing was conducted on mortalities in wild-caught broodstock; generally deaths were not due to disease but associated with factors such as swim bladder rupture linked to collection methods. Fish pathogens were tested on burbot in controlled, replicated pathogen challenges at the UI-ARI: IHNV, IPNV, *Flavobacterium psychrophilum, Renibacterium salmoninarum* (which causes BKD), and *Aeromonas salmonicida* (which causes furunculosis).

Pathology research to date indicates that burbot are: 1) susceptible to IHNV and may be potential carriers; 2) not susceptible to IPNV, although more research is needed; 3) not susceptible to *F. psychrophilum*; and 4) can be susceptible to *Aeromonas salmonicida* (Polinski et al. 2010b). These results, as well as ongoing pathogen investigations, will adaptively inform the burbot aquaculture program.

5.4.2 Burbot Genetics

Genetic analysis was used to inform broodstock choice for this project. A mitochondrial DNA study revealed that the Moyie Lake burbot in British Columbia are closely related to the functionally extinct Kootenai River burbot (Paragamian et al. 1999). The Moyie Lake population is found within the Kootenai subbasin and appears to be large enough to yield up to several dozen broodstock annually for experimental and production purposes if needed.

In addition to stock identification and differentiation issues, genetic analysis also will be used to estimate diversity measures, genetic distance, and population genetic parameters such as effective population size for burbot broodstock and progeny groups as part of this project.

Standard measures of genetic diversity and variability in wild, broodstock and progeny populations will be evaluated. With recent advances in microsatellite analysis techniques, relatedness and genetic distance estimates between and among broodstock can be performed.

5.4.3 Gamete Cryopreservation

The burbot program includes a cryopreservation component to conserve native genetic material in the form of frozen gametes. Subsamples of milt, collected and cryopreserved from Moyie Lake and Duncan Reservoir stocks, have been used to establish a germ plasm repository in the Tribe's cryopreservation unit at the University of Idaho. Cryopreservation of semen from Kootenai burbot was investigated and optimal methanol concentrations determined for a conservation breeding program (Jensen et al. 2008c). The following results support the use of cryopreserved burbot semen to develop germ plasm repositories for imperiled fish stocks:

- Optimal methanol concentrations to provide a permeable cryoprotectant in the semen extender were determined.
- Post-freeze semen motility was evaluated and fertilization rates were determined
- The effect of methanol concentrations in the extender on motility and fertilization percentages was determined.

Techniques derived from this research will be applied to broodstock monitoring and evaluation. The motility and fertility of all cryopreserved burbot semen will be screened for suitability for use as broodstock.

5.4.4 Collaborative Post-release Monitoring of Burbot

Burbot monitoring and restoration efforts during the last decade have been the subject of a cooperative program involving the Kootenai Tribe, BC MoE, IDFG and a variety of other agencies that are signatories to the KVRI Burbot Conservation Strategy (KVRI 2005). The Tribe has ongoing contracts with BC MoE to provide burbot capture and stock assessment services on Kootenay Lake and associated waters in Canada as a component of the burbot restoration process. BC MoE is responsible for these species in Canadian waters and conducts monitoring activities required in that geographic area. The BC MoE also coordinates and oversees annual burbot broodstock and gamete collection at Moyie Lake.

These ongoing contracts with BC MoE include provisions for annual indexing programs for burbot and sturgeon in British Columbia, developing planning documents (5-Year Plan, Stocking Strategy, etc.) as well as maintaining a comprehensive telemetry array to evaluate white sturgeon and the most recent burbot releases from Tribe's hatchery program. These contracts also include projects that provide burbot broodstock for hatchery production from lakes in British Columbia, evaluate the impact of broodstock collection on these native populations, and monitor and evaluate additional mortality factors (angling and other sources) in these locations in order to safeguard broodstock sources for future hatchery program production.

Burbot sampling activities, currently involving only wild fish, are also coordinated among regional agencies under the KVRI Burbot Subcommittee and the MOU. Burbot sampling activities involves the coordinated efforts of the Tribe, IDFG, and BC MoE, as provided in the 5-Year Burbot Implementation Plan (2006-2010). Post-release monitoring of hatchery burbot is a core program element of the current plan. IDFG and BC MoE monitor remnant burbot in the Kootenai River and the annual releases of hatchery-produced burbot from the program that began during 2009. Adult population assessment methods are well established and currently undertaken on an annual basis. Burbot recruit to adult sampling gear at about 3 to 4 years of age and 400 mm in length. The presence of hatchery progeny in the river will also provide the opportunity to develop effective sampling and assessment methods for juveniles. Long-term monitoring plans, to be initiated in 2011, are under development by the program cooperators.

The burbot monitoring strategy builds upon the success of the Kootenai Tribe and its partners with white sturgeon. Sampling white sturgeon life stages in the Kootenai River (wild eggs, embryos, juveniles, and adults), and recapturing hatchery-produced juveniles has been successfully implemented for decades with the IDFG and the BC MoE.

5.5 Adaptive Management of the Burbot Program

Through adaptive management planning, the Tribe and other entities will evaluate the risks and benefits of the proposed and ongoing burbot aquaculture program and will systematically address critical scientific uncertainties using the logic path portrayed in Figure 6-1. An adaptive management workgroup will guide development, implementation, evaluation, and refinement of the plans. Guidance will be sought from research, management, and policy entities to craft efficient implementation, monitoring, and evaluation programs that address and meet success criteria of these programs. The Tribe will build upon the objectives and metrics identified in Tables 5-6 through 5-10 to adaptively implement and operate the burbot program.

5.5.1 Adaptive Management Objectives

The primary purpose of the conservation aquaculture component of the adaptive management plan is to meet the goals defined for the burbot aquaculture program by: 1) minimizing risks of short- and long-term adverse effects through monitoring and iteratively refined management; 2) maximizing the chances of meeting numerical success criteria targets; and 3) periodically re-evaluating project success criteria by integrating research, monitoring, and evaluation results. Key uncertainties identified below will be addressed through appropriately designed experimentation where needed. Monitoring components will be refined to ensure that relevant data are being properly collected to evaluate program progress, successes, and failures. Specific biological objectives for the hatchery program are presented in Tables 5-6 and 5-7.

Key decision points for the burbot program will be triggered by the success of production-scale rearing at Twin Rivers, significant survival of propagated juveniles upon release, and subsequent maturation and spawning success in the wild. The decision framework for interpreting monitoring data relevant to aquaculture operations will be led by the Kootenai Tribe, along with fisheries management agencies IDFG, BC MoE, and its many collaborating academic and private sectors scientists. This Kootenai River Native Fish Conservation Aquaculture Program Adaptive Management team will be formed to interpret monitoring results and determine if production and population objectives are being achieved or if operational or facility changes are needed in the programs. Interaction will occur regularly with this team to ensure that aquaculture production is appropriately scaled to habitat and population conditions.

5.5.2 Key Uncertainties

Because the Kootenai sturgeon program has been operating for over 20 years, uncertainties regarding sturgeon culture are minimal compared to those for the proposed burbot program. Some aspects of burbot culture are still in developmental stages, and uncertainties remain about the species' general biology and how it will affect aquaculture techniques, protocols, and facility design and operations. Key uncertainties for both species are identified in Table 5-8.

Table 5-8. Key uncertainties of Kootenai burbot aquaculture.

Burbot Aquaculture Program	Suitability of river conditions, productivity and habitat to support favorable post-release growth, survival and biological conditions
	Maximum sustainable production levels at the Twin Rivers Hatchery
	Success of natural production from hatchery progeny

The general process for adaptively addressing uncertainties will include the following steps:

- Determining the relative importance of the uncertainty
- Compiling and characterizing existing data
- Identifying remaining unknowns
- Developing and testing appropriate hypotheses
- Developing and implementing research, monitoring, and evaluation activities to evaluate hypotheses
- Developing, implementing, and evaluating remedial adaptive management actions

5.6 Summary of Burbot Program Costs

5.6.1 Rationale for Proposed Approach

The burbot component of the proposed Twin Rivers facilities represents a relatively modest and fiscally responsible investment that capitalizes on many shared sturgeon operational components. Concurrent development of the sturgeon and burbot facilities results in significant cost savings for the burbot program relative to independently constructing new facilities at a later date. Independent construction costs would include separate water supply and treatment facilities, separate effluent treatment and distinct operational infrastructure. Expanding existing facilities or constructing facilities outside of the basin (even if possible and recommended) also would require greater expenditures over the long term.

5.6.2 Summary of Program Costs

This section briefly summarizes major costs associated with the Tribe's proposed burbot aquaculture program. Specific options and comparative cost impacts of phasing the sturgeon and burbot programs are provided in Section 8.3.4.4. These estimates provide a planning baseline from which to refine costs, evaluate alternatives, and protect against budget expansion as the project progresses through the preliminary (Step 2) and final design (Step 3) phases and implementation.

Estimated costs for implementing the burbot program at Twin Rivers are summarized in Table 5-9 and include facility planning and design, construction, acquisition of capital equipment, environmental compliance, research, monitoring, and evaluation, as well as operations and maintenance.

The foundational planning approach taken by the Tribe is to jointly develop burbot and sturgeon aquaculture facilities to achieve design, construction and operational efficiencies, significantly reduce all associated program costs, and to fulfill ecosystem restoration objectives. All design effort to date has been based on this precept; however, at the request of the Independent Scientific Review Panel, we are also separating out the costs associated with the burbot component of the two programs. These estimates only consider options for implementing the program jointly at Twin Rivers. Costs to implement the burbot program at a completely separate site would be significantly more expensive, would not include the combined operational and implantation efficiencies of sharing the planning and proposed Twin Rivers infrastructure.

The burbot program costs shown in Table 5-9 are based on an assumption that the sturgeon program will be implemented; therefore, inseparable components remain. Some proposed facilities, as well as staffing and equipment, will be shared between the Kootenai burbot and sturgeon programs. Planning estimates suggest that the operational cost of these programs will be at least 30% lower with shared facilities, functions and operational staffing than if two separate, parallel programs were developed and operated. Efficiencies are also realized in monitoring and evaluation activities, a cost implication that is significant in an independent evaluation of the burbot program because sturgeon component requires the majority of expenditures.

Table 5-9. Key Expenditures by Program Area, Estimate of Costs for Addition of Burbot Program.

Program Area	Estimated Cost for Addition of Burbot Program	Estimated Cost Sturgeon and Burbot	Comments / Assumptions
Planning & Design Step 1 [1]	$490,000	$490,000	Conceptual designs include both sturgeon and burbot programs. To efficiently design and implement the facility, even with a sturgeon-only approach, planning for future burbot facilities is included.
Planning & Design Step 2 [2]	$1,046,999	$1,046,999	Assumes completion of preliminary design for both sturgeon and burbot. If the burbot program was completely separated, additional costs would be incurred for planning and design in Phase 2.
Planning & Design Step 3 [3]	$1,017,114	$1,017,114	Assumes completion of final design for both burbot and sturgeon. If the burbot program was completely separated, additional costs would be incurred for Phase 3 planning and final design.
Construction (Base Components)	$2,797,926	$13,997,000	Assumes imbedded cost of burbot building if sturgeon program was implemented. Building a stand alone facility would add approximately $600,000. Construction feasibility is currently based on both facilities being built; feasibility issues may arise with a stand alone burbot facility.
Construction (Base & Separable Components such as sturgeon spawning channels)	$3,194,926	$15,251,000	Assumes inclusion of outdoor burbot rearing units. Building these to stand alone would add another $600,000 (based on estimated costs of sturgeon facilities).
Capital Equipment	$38,278	$423,790	Assumes majority of capital equipment is needed for the expanded sturgeon operations
Environmental Compliance Step 2 (Permitting, EA, Other)	$164,546	$164,546	Assumes required EC would be the same with inclusion of burbot building. Additional costs would be incurred if the burbot program was implemented at a later date.
Land Purchases, Lease & Easements [4]	$0	$0	
Annual Operations & Maintenance / Future Tribal Hatchery Program [5]	$906,515	$906,515	Assumes O&M costs would not be reduced. Assumption is that a burbot program cannot be accomplished at the Tribal Sturgeon Hatchery.
Annual Operations & Maintenance / New Twin Rivers Program [5]	$979,647	$923,411	Assumes O&M costs shared and that the sturgeon program is operating. Figure shows costs at Twin Rivers with a combined program in 2012. For a separate facility, O&M costs would be significantly higher.
Monitoring & Evaluation [5]	$140,377	$701,886	Assumes M&E costs would be reduced very little if burbot program is delayed. Critical research would continue.

Notes and Assumptions:
- Refer to Chapter 8 for detailed notes on escalation of figures shown in this table (generally construction shown as 2012 dollars and O&M and M&E shown as 2010 dollars).
- Construction estimates are conceptual (+/- 35% to 50%); O&M and M&E costs should be considered as +/- 25%.
- Budget figures assume that work would proceed on the timeline shown in Figure 8-1.

[1] Shows estimated expenditure for FY 2007, 2008, 2009, 2010. This is an estimated figure from the total project budget for Project No. 198806400.
[2] Shows estimated expenditure from FY 2010. This is an estimated figure from the total project budget for Project No. 198806400.
[3] Shows estimated expenditure from a projected FY 2010 and FY 2011 budget. This is an estimated figure from the total project budget for Project No. 198806400.
[4] Land Purchases, Leases and Easements (estimated budget is not identified at this time)
[5] Annual Operations and Maintenance and Monitoring and Evaluation costs are based on efficiencies from implementing the new Twin Rivers programs.

Detailed cost estimates and explanations are presented in Chapter 8 for each major cost area for both the burbot and sturgeon programs. A similar tabular summary of project costs is also provided as Table 8-2 and a 10-year summary of all costs projected from FY 2010 through FY 2020 is presented as Table 8-14. Estimated costs in Chapter 8 reflect the efficiencies of planning and implementing construction of burbot and sturgeon facilities at one time and the future sharing of operational aspects.

5.7 Consistency with Eight Scientific Principles of the NPCC Fish and Wildlife Program

This chapter presents a summary of the consistency of the proposed burbot aquaculture program with the Council's eight scientific principles, Three-Step process and Step 1 review elements.

5.7.1 Principle 1: The abundance, productivity and diversity of organisms are integrally linked to the characteristics of their ecosystems.

The Tribe's efforts to sustain the native burbot population with a multidisciplinary conservation aquaculture program also support this principle. The Tribe, along with regional partners, is simultaneously developing and implementing multiple habitat restoration and monitoring projects. In this ecological context, the burbot aquaculture program is necessary because entire habitats and ecological functions (i.e., temperature, hydrology, and other ecological conditions) associated with historical burbot production have been altered, degraded, or eliminated completely. The Tribe acknowledges uncertainty about the environmental and ecological conditions required to restore natural production of burbot; nevertheless, the Tribe is actively committed to achieving an optimal combination of ecological and economic benefits in the Kootenai subbasin by implementing a suite of integrated, interdisciplinary population protection and habitat improvement programs. Burbot were, and the Tribe believes, should continue to be an important component of a more functional Kootenai River ecosystem.

5.7.2 Principle 2: Ecosystems are dynamic, resilient and develop over time.

The burbot aquaculture program is focused on mitigating significant deleterious effects of unnatural environmental changes. Nearly a century of largely human-induced ecosystem and habitat changes have contributed to decades of inadequate natural burbot production (Paragamian et al. 2000; Anders et al. 2002; Pyper et al. 2004; KVRI 2005; KTOI 2008).

Numerous independent historical accounts confirm that lower Kootenai River burbot successfully spawned under the ice in the Kootenai River and its tributaries in Idaho, incubated and reared under ambient riverine conditions, reared and developed in off-channel and marsh/backwater habitats, and ate prey that no longer exist (KVRI 2005). Unsustainable historical harvest rates were also reported (KVRI 2005).

It is in this context that the Tribe is proposing reintroduction of a burbot population in the Kootenai River. The Kootenai Tribe is under no illusion that conservation aquaculture programs will resolve physical habitat problems or limitations; however, without hatchery intervention, no burbot population is likely to exist in the Kootenai River, given the magnitude of ecological change and the population's current size (approximately 50 fish, +/- 75) (Pyper et al. 2004).

5.7.3 Principle 3: Biological systems operate on various spatial and time scales that can be organized hierarchically.

As previously noted, the Kootenai Tribe has consistently shown a commitment to multi-scale (e.g., spatial and temporal) ecosystem treatments by developing, implementing, and refining habitat- and biologically-based projects in aquatic, riparian, and terrestrial habitats in the Kootenai River subbasin. The Tribe's burbot aquaculture program in particular addresses restoring a burbot population that was driven to functional extinction by the cumulative impacts of habitat alteration, degradation and loss.

Native burbot likely played a key regulatory role in the Kootenai River ecosystem and food web. Adult burbot are opportunistic, piscivores that prey on a wide variety of aquatic organisms, including insects, macroinvertebrates, lamprey, suckers, minnows, perch and even other burbot (Bailey 1972; Scott and Crossman 1973; McPhail and Paragamian 2000). Diet varies with season, apparently based on prey availability. Being nocturnal and crepuscular feeders, burbot hide among available refugia, such as rocks and fallen logs in epibenthic habitats, and use ambush tactics to capture prey (Kahilainen and Lehtonen 2003). During times of low activity, they congregate in deep holes (Scott and Crossman 1973; Morrow 1980; Riede 2004). Burbot are also quite plastic in their behavior, diet, and habitat use in relation to the available resources.

Because burbot occupy upper trophic level positions or niches within the aquatic food web, they are theoretically able to exert top-down regulation on prey item or assemblage abundance and composition. They may play an important regulatory role in shaping or regulating community attributes of prey taxa or assemblages as well as affecting food web dynamics. It is also possible that burbot feeding habits could be regulated by prey availability, rather than simply regulating dynamics of prey populations.

The native burbot populations in Kootenai River and Kootenay Lake likely exploited a wide range of resources including mysids, kokanee, and a variety of native fish species. The availability of many of these resources has changed over time in response to habitat and environmental changes and perhaps changes in the abundance of other species such as burbot and sturgeon. For instance, large kokanee runs into South Arm streams may have been a critical food source for the native burbot populations, but these runs were largely extirpated and have only recently begun to rebound as a result of habitat restoration and related actions undertaken by the Tribe (Ericksen et al. 2009). Ahrens and Korman (2002) identified a shift in the demersal fish community of Kootenay Lake from burbot during the 1960s and 1970s to other species including northern pikeminnow and largescale sucker following the collapse of the burbot population in the lake. An environmentally driven community shift was one hypothesis for the burbot collapse (Ahrens and Korman 2002); however, it is unknown whether the community shift was a cause or effect of the burbot decline, or simply correlated with common factors. In the end, fish community interactions can be very complicated and consist of a variety of positive and negative effects. Without an experimental evaluation using reintroduced burbot, one can only speculate how burbot will affect, limit or be limited by the altered Kootenai ecosystem. The driving hypothesis is that if enough of the historical components of the system can be restored, then some measure of the historical ecosystem function will be achieved as well, which theoretically can improve success of burbot and other native fish restoration programs (e.g., sturgeon and kokanee).

The Tribe has a deeply held understanding of the ecological hierarchies described in Principle 3. These fundamental beliefs have guided the Tribe's proposed restoration designs to address species resiliency.

5.7.4 Principle 4: Habitats develop, and are maintained, by physical and biological processes.

Libby Dam represents the source of major ongoing ecological perturbations of the type referred to in Principle 4. Other cumulatively significant perturbations affecting the aquatic habitat in the lower Kootenai River include levee construction, agricultural and urban development, and associated infrastructure. In response to problems caused by these continuing impacts, this project specifically focuses on interim burbot aquaculture to supplement and rebuild the population for future generations. Ongoing and proposed companion habitat restoration projects are consistent with the notion that different effects are produced from different features, as indicated in Principle 4.

5.7.5 Principle 5: Species play key roles in developing and maintaining ecological conditions.

Principle 5 emphasizes the importance of individual species as integral and necessary parts of functioning ecosystems and food webs. This is a primary justification to recover native fish in the Kootenai River, including burbot. This principle also links and supports the Tribe's ongoing experimental nutrient addition program, intended to restore and maintain species assemblages across trophic levels in order to improve ecosystem functions and biodiversity.

Without implementing the Tribe's proposed burbot reintroduction program, this species will go extinct in the lower Kootenai River. Although burbot culture work focuses on a single species, integrated Kootenai Tribe and other local and regional fish and wildlife programs include restoration of native Kootenai sturgeon and kokanee populations. Making sure that the Kootenai River ecosystem supports a full complex of native species will help restore ecological conditions and may increase the ability of the ecosystem to withstand disturbance and change.

5.7.6 Principle 6: Biological diversity allows ecosystems to persist in the face of environmental variation.

Physical and biological diversity is the foundation of ecological processes and functions and of population viability and persistence. The Kootenai Tribe's pioneering, adaptive approach to refining conservation aquaculture for burbot, a previously uncultured species, operates within this larger ecological context of Principle 6. The Tribe's fish and wildlife habitat restoration projects address physical habitat diversity, consistent with a goal to maintain and enhance physical habitat diversity that is needed to support biodiversity thought niche partitioning and other mechanisms.

5.7.7 Principle 7: Ecological management is adaptive and experimental.

In the developing the burbot aquaculture program and other projects, the Tribe has incorporated workshop approaches to adaptive management and environmental assessment to characterize uncertainty and to test and evaluate restoration scenarios. The Tribe is committed to implementing all Kootenai subbasin projects within an adaptive management framework.

Examples of adaptive management components that have been incorporated into the burbot conservation aquaculture program include: 1) a series of spawning induction methods with and without hormone treatments to maximize spawning success; and 2) a series of incubator design comparisons to determine optimal incubator design. Other planned evaluations include a series of feeding trials to optimize growth, performance and survival of larval burbot. An adaptive feedback approach will link all aspects of burbot reintroduction efforts with aquaculture production.

The Tribe developed the Draft Kootenai Subbasin Adaptive Management Plan in 2005 (Walters et al. 2005) (see Section 6). In the near term, the Tribe plans to further develop and refine this subbasin-wide adaptive management plan which ultimately will link aquaculture and habitat related programs to provide more comprehensive feedback on the complex interactions between biological and habitat-based ecological metrics.

5.7.8 Principle 8: Ecosystem function, habitat structure and biological performance are affected by human actions.

As described in response to Principle 2, one focus of the Tribe's aquaculture program is to address and mitigate unnatural changes in the Kootenai River ecosystem. An important focus of the burbot aquaculture program is to mitigate anthropogenic changes in the Kootenai River ecosystem. The proposed burbot hatchery operations are designed to produce minimal negative ecological or environmental impacts and to have minimal anthropogenic effects on the fish produced by the program. The burbot aquaculture program will be adaptively managed to maximize benefits and minimize negative impacts.

5.8 Link to Other Projects, Activities, and the Desired Endstate

At the subbasin level, the desired endstate is defined by the Kootenai River Subbasin vision statement (KTOI and MFWP 2004): "[To] establish and maintain a healthy ecosystem characterized by healthy, harvestable fish and wildlife populations, normative and/or natural physical and biological conditions, and sustainable human communities". Pursuing and achieving these population- and subbasin-level endstates for the Tribe's proposed burbot aquaculture program will contribute to the biodiversity and ecological function required for successful restoration and resilience.

The Kootenai Tribe has made a long-standing commitment to coordinate closely with co-managers, transboundary and agency partners, stakeholders and the local community to ensure that program and activities are integrated, non-duplicative, and contribute to the restoration of a functional, healthy ecosystem.

The Kootenai burbot conservation aquaculture program is a component of the overall Kootenai River Ecosystem Adaptive Management Program, a basin-wide program that links multiple Kootenai Tribe fish, wildlife and habitat restoration projects (Korman et al. 2005). The aquaculture component contributes to this strategy by protecting and restoring this endangered native focal species. The burbot program is consistent with regional and local habitat strategies including those identified in the:

- Kootenai River Subbasin Plan (KTOI and MFWP 2004)
- The multi-agency, international Lower Kootenai/y River Burbot Conservation Strategy (KVRI 2005)

The proposed burbot conservation aquaculture program is also part of the overall Kootenai River Ecosystem Adaptive Management Program (KTOI 2004; Korman et al. 2005).

The long-term success of the burbot aquaculture program will depend on Kootenai River habitat restoration and ongoing tributary and floodplain, off-channel, and wetland habitat restoration activities that will be accomplished through the Kootenai River Habitat Restoration Project and other complimentary habitat restoration efforts.

In addition to relationships with the projects identified above, in 2003, the Kootenai Tribe initiated investigations into the feasibility of burbot propagation, as is described throughout this section. In collaboration with the UI-ARI, these investigations that have yielded significant advances in the artificial production of a species that has received little such attention.

5.9 Biological Objectives with Measurable Attributes

Section 5.1.2 describes the biological objectives for the burbot aquaculture program. Pre-release biological objectives for the burbot conservation aquaculture program are to:

Maintain health, condition, and reproductive condition of captive broodstock. The biological condition of potential broodstock will be determined through visual observation of health and behavior.

Provide adequate breeding matrices for genetic diversity. Whenever feasible, female burbot will be spawned with multiple males to maximize genetic diversity and retain wild burbot life history characteristics.

Provide adequate incubation conditions and hatch rates. Hatch survival will be monitored to achieve a goal of 50 % survival.

Provide adequate fry survival. The survival goal is 2%.

Provide adequate young-of-year survival. The survival goal for this life stage is 50% with no visible signs of health issues and negative pathogen test results.

Provide adequate juvenile survival. Survival, condition and health will be monitored with target survival rates greater than 50% and negative pathogen tests.

Provide adequate fish marking. Age 0 burbot will be permanently marked with PIT-tags with an expected retention rate of 90%.

Post-release biological objectives for the burbot conservation aquaculture program are to:

Ensure adequate post-release survival, growth, and biological condition to support future mature adults. Sampling will track growth, condition and weight of the fish. The target survival rate after the first year of release is 30 -50%.

Create and maintain favorable age class distribution. Sampling will annually track age class distribution, recruitment magnitude and frequency.

Maintain adequate individual and population health. Sampling will annually track external health, fish behavior, and pathogen testing results.

Provide genetic diversity within and among progeny groups. Sampling will track diversity, heterozygosity and inbreeding coefficients.

Achieve a sustainable adult population target. The abundance of adults will be sampled annually to characterize population size and age-class structure. The target abundance is 2,500 to 9,500 adults.

5.10 Expected Project Benefits

Expected benefits of the burbot aquaculture program include: 1) developing and implementing successful conservation aquaculture techniques for burbot, a previously uncultured species; 2) assessing feasibility of newly developed burbot conservation aquaculture techniques for implementation in the Kootenai River subbasin; 3) restoring and maintaining a viable and harvestable burbot population in the Kootenai River and South Arm of Kootenay Lake; 4) developing over time, subsistence and recreational fishery of an important species; 5) contributing to research objectives; and 6) meeting Tribal trust responsibilities. In short, and most importantly, this program is expected to provide a burbot population in the lower Kootenai River until habitat improvements can successfully support a naturally producing population.

5.11 Implementation Strategies Relative to Current Conditions and Restoration Potential

The NPCC's Fish and Wildlife Program defines implementation strategies as plans of action to accomplish biological objectives (NPCC 2009). These strategies are formulated around the four key factors affecting aquatic species in the Columbia River Basin referred to as the four "Hs": habitat, hatcheries, harvest, and hydropower. The relationship of the proposed program to these strategies is summarized below.

5.11.1 Habitat

Post-levee and post-dam habitat conditions have been correlated with acutely limited natural production of burbot. Evidence of this extends back to the 1950s and continuously through the post-Libby Dam years (Partridge 1983; USFWS 1994, 1999; Duke et al. 1999; Anders et al. 2002; Paragamian et al. 2005). The Tribe, in cooperation with other entities, is developing a large-scale ecosystem restoration project designed to mitigate habitat limitations for Kootenai biota, the Kootenai River Habitat Restoration Project (BPA project 200200200). A Master Plan for that project was completed in 2009 (http://www.kootenai.org/fish.html). Under this project, the Tribe will implement phased habitat restoration actions by 2012. In addition, as noted elsewhere in this document the Tribe has a number of ongoing habitat restoration projects already underway.

5.11.2 Hatcheries

Because burbot have not previously been cultured, conservation aquaculture methods and protocols for burbot are currently being developed and refined. A number of peer-reviewed papers document the Tribe's progress (Table 2-5) (Cain and Jensen 2004; Jensen 2006; Jensen et al. 2008a, 2008b, 2008c). Aquaculture feasibility has been demonstrated through experimental research objectives and many benchmarks have been accomplished by the Tribe and the

University of Idaho (Table 2-6). The developmental, post-release project phase is underway (Table 5-1).

5.11.3 Harvest

Burbot harvest has been prohibited in the Kootenai River in Idaho since 1984 due to long-term declining population abundance trends. The response of the population from this burbot reintroduction program and simultaneous habitat improvements will be monitored to determine changes in species abundance, distribution, and life history trait expression. Tribal treaty rights for ceremonial and subsistence harvests may be exercised when population abundance is adequately restored by hatchery production, natural production, or some combination of both. Potential recreational harvest of burbot may resume at some level in the future when the demographic status is upgraded. Appropriate timing and the magnitude of harvest will be determined by events and population statistics as they unfold.

5.11.4 Hydropower

Winter hydropower operations at Libby Dam were modified in the 1990s in an effort to enhance burbot spawning migration, spawning success, and natural recruitment; however, no positive results have been identified to date. Operational modifications have included lowering flow from November through February, targeting burbot migration and spawning. Flows from Libby Dam have been held to minimal rates or held constant (i.e., less variability) during most years to allow burbot migration to occur. The selective withdrawal structure is used to lower winter water temperature when conditions allow (i.e., when the reservoir is not isothermic).

5.12 Subbasin-wide Risk Assessment

Because burbot are functionally extinct from the lower Kootenai River, and because the expected range of stocked fish from this program is not expected to overlap with any extant burbot populations in the Kootenai River subbasin, the Tribe foresees little or no risk to any other burbot populations in the subbasin from this program.

Furthermore, burbot gametes from within-subbasin broodstock in Moyie Lake are being collected non-invasively in the field instead of removing broodfish from the population, further reducing risk to any subbasin burbot population(s). In the event that gamete collection is not successful during any given year on Moyie Lake, Moyie Lake broodstock are available from initial collection efforts and the program will consider the occasional collection of additional broodfish. Moyie Lake supports a harvestable population of burbot and is monitored extensively by the BC MoE to assess donor stock resilience. Recent annual reports detailing characteristics of the Moyie Lake burbot population are available at the following links:

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=17097

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=16158

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=13484

This work is consistent with the NPCC's eight scientific principles described in Section 5.7.

5.13 Consistency with NPCC Artificial Production Policies

This section summarizes the consistency of the Kootenai burbot conservation aquaculture program with the Council's artificial production strategy. The artificial production strategies are presented below in bold italics, immediately followed by the consistency of the Kootenai burbot program to each of the strategies.

The purpose and use of artificial production must be considered in the context of the ecological environment in which it will be used.
Artificial production is appropriate for this burbot population because of the effect of the altered ecological environment of the Kootenai River. The ongoing research program has developed and refined successful burbot aquaculture techniques and practices that will be instrumental in rebuilding a burbot population in the lower Kootenai River.

The altered river environment has rendered natural recruitment of burbot inadequate or absent during the past several decades (Pyper et al. 2004). For any species negatively affected by habitat limitations, a hatchery program alone cannot resolve the problem. This conservation aquaculture program will provide a future burbot population to respond to proposed habitat improvements in the Kootenai River. Collectively, the Tribe's aquaculture conservation and habitat improvement programs are aimed at providing a naturally reproducing burbot population in the Kootenai River.

Artificial production must be implemented within an experimental, adaptive management design that includes an aggressive program to evaluate the risks and benefits and address scientific uncertainties.
The Tribe's burbot aquaculture program is being developed within an adaptive management structure as elaborated in Section 5.5. A standard template for adaptive management (Figure 6-1) is being applied to the program. In addition, research, monitoring and evaluation plans are a crucial part of this adaptive process to evaluate and refine this pioneering aquaculture effort.

Hatcheries must be operated in a manner that recognizes that they exist within ecological systems whose behavior is constrained by larger-scale basin, regional and global factors.
The Tribe's burbot hatchery program will also operate within an ecological system constrained by larger-scale basin, regional, and global factors. The Tribe has long recognized that hatcheries cannot solve habitat problems, but they may play an important role in overall multidisciplinary restoration programs. These programs have been successfully implemented for several native focal fish species depressed by altered habitat conditions and impoundments in the Kootenai River subbasin (Anders 1998, 1999; La Patra et al. 1999; Ireland et al. 2002b; KTOI 2004, 2008).

A diversity of life history types and species needs to be maintained in order to sustain a system of populations in the face of environmental variation.
The Tribe uses conservation aquaculture to maintain and protect the genetic basis for life history trait diversity within and among species. The ongoing conservation aquaculture program for native Kootenai sturgeon, as well as the proposed burbot aquaculture program using native stocks from within the drainage, are evidence of this commitment.

Naturally selected populations should provide the model for successful artificially reared populations, in regard to population structure, mating protocol, behavior, growth, morphology, nutrient cycling, and other biological characteristics.

Naturally selected populations and their demographic, age-class, population genetics, and other biological structure data will provide the model for the burbot conservation aquaculture program to the extent it is available. Empirical life history trait information and population genetic mechanisms (e.g., gene flow models and mating systems) will guide development of burbot program components.

The entities authorizing or managing an artificial production facility or program should explicitly identify whether the artificial propagation product is intended for the purpose of augmentation, mitigation, restoration, preservation, research, or some combination of those purposes for each population of fish addressed.

The Tribe's burbot program serves mitigation, restoration, preservation, and research purposes. More specific information on the purposes of this program is presented in Sections 5.1.1 and 5.4.

Decisions on the use of the artificial production tool need to be made in the context of deciding on fish and wildlife goals, objectives and strategies at the subbasin and province levels.

The decision to artificially produce burbot has been made in the context of the fish and wildlife goals, objectives, and strategies at the subbasin and province levels. This objective is identified in the Kootenai Burbot Conservation Strategy (KVRI 2005) and the Kootenai River Subbasin Plan (KTOI and MFWP 2004).

Appropriate risk management needs to be maintained when using the tool of artificial propagation.

Research, monitoring, and evaluation plans for this program are being designed to assess the risks of artificial burbot propagation. Limited or absent natural production for the past several decades precludes any risks to naturally-produced fish. Furthermore, consistent natural recruitment failure either dictates extinction or use of artificial production to support this native species. The Tribe has chosen to pursue the second option of preserving the native population and if necessary, rebuilding it from appropriate local or regional donor stocks.

Production for harvest is a legitimate management objective of artificial production, but to minimize adverse impacts on natural populations associated with harvest management of artificially produced populations, harvest rates and practices must be dictated by the requirements to sustain naturally spawning populations.

The long-term goal includes restoring a population that could sustain subsistence and sport harvest (see Section 5.11.3); however, this would occur only after several burbot generations achieve demographic and ecological goals.

Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement must be fully addressed.

All relevant legal mandates for fish protection, mitigation, and enhancement will be met by this burbot program.

5.14 Hatchery and Genetic Management Plan

The intent of Hatchery and Genetic Management Plans (HGMPs) is to outline how a proposed artificial propagation strategy will protect a species and assist in recovery. An HGMP for the proposed burbot aquaculture program has been prepared and is included as Appendix C.

5.15 Harvest Plan

Although burbot are not formally listed under the ESA as threatened or endangered, based on population trend information, harvest has been prohibited in Idaho since 1984. The response of the population to the reintroduction effort and proposed habitat improvements will be monitored to determine changes to burbot abundance, distribution, growth, distribution and expression of life history traits. When their status rebounds, either as a result of natural production or through sustained hatchery production, Tribal Treaty-reserved ceremonial and subsistence harvests may be restored at some level. Potential recreational harvest of burbot may resume at some level in the future when the demographic status is upgraded. Appropriate timing and the magnitude of harvest will be determined by events and population statistics as they unfold.

6 Adaptive Management

6.1 Kootenai Subbasin Adaptive Management Program

Adaptive management is a framework that incorporates the scientific method to resolve complicated natural resource problems. It is based on the premise that informed, deliberate experimentation is the most reliable means of understanding and addressing complex problems in resource systems. The Tribe is committed to using this framework to adaptively design and manage its aquaculture and ecosystem restoration programs and recognizes the opportunity it has to unify data collection as part of the system-wide Kootenai River Adaptive Management Plan[25]. Some of these ongoing efforts are listed in Table 6-1. Because of the complexity of issues in this system and the degree of scientific uncertainty associated with Kootenai sturgeon and burbot, resource management is challenging. Monitoring various parameters of the aquaculture programs and tracking the response of the species to the receiving habitat will enable the Tribe to adaptively manage production and releases and to make informed decisions that contribute to population restoration. Conceptual design of the Twin River Hatchery incorporates flexible components to enable the Tribe to adjust production to monitoring outcomes.

[25] In 2004, the Kootenai Tribe and a number of scientific and management stakeholders participated in an adaptive management workshop to develop a long-term management framework for the Kootenai River ecosystem. The resulting 20-year adaptive management framework includes aquatic, riparian and terrestrial components and is described in the 2005 Draft Kootenai River Adaptive Management Plan (Walters et al. 2005).

Table 6-1. On-going monitoring projects in the Kootenai subbasin and their contribution to the Kootenai River Ecosystem Adaptive Management Program component(s), and what they address.

Ecosystem Component	Kootenai River nutrient restoration	Transboundary nutrient restoration, kokanee intro-ductions, tributary restoration and enhancement	Kootenai sturgeon and burbot conservation aquaculture	Habitat modification to improve sturgeon spawning and recruitment	Ecosystem restoration flows - winter low, spring runoff peaking, summer stable	Floodplain reconnection and operational loss assessments
Target Benefit	Aquatic, riparian communities, increased growth, survival, and biological condition	Kokanee, burbot, sturgeon, trout; Aquatic, riparian communities	Addresses stock limitation, genetic conservation, demo-graphic safety net	Increase survival of eggs, larvae. Increase in habitat complexity and resiliency	Sturgeon and burbot recruitment, salmonid recruitment, cotton-wood recruitment, natural processes	Lentic, lotic, riparian and terrestrial communities, all trophic levels
Potential Negative Effects	Stimulation of non-target species.	Stimulation of non-target species.	Overstocking could limit wild production	Possible unintended hydraulic consequences	Seepage at higher flows, cooler water temp-eratures inhibit sturgeon spawning, reduced reservoir productivity	Possible unintended hydrologic consequences
Required Time to See Effect(s)	Periphyton -weeks Inverts - months Fish - 2-3 yrs	Kokanee, 1-3 years	Variable depending on life stage and objective	In-season detection of larvae, 2+ yrs to fully recruit to gill nets; 30+ years for population effect for sturgeon	In-season detection of larvae, 2+ yrs to fully recruit to gill nets, 30+years for population effect for sturgeon	Lower trophic levels-In-seasons, higher across years
Monitoring Requirements	All taxa responses in Kootenay Lake and lower Kootenai River	All taxa responses in tributaries and Kootenay Lake; stream and riparian habitat health and condition estimators and metrics	Survival, growth and condition	Recruitment magnitude and frequency. Evaluating ecological and physical parameters in newly created habitat	Recruitment magnitude and frequency. Ecological condition and biological productivity of post-treatment communities and functions	Nutrient availability and habitat heterogeneity contributions. Ecological condition and biological productivity of post-treatment com-munities and functions

Two critical components of adaptive management are a direct feedback loop between science and management, and the use of coordinated research, monitoring, and evaluation to guide and refine management (Halbert 1993). These features differentiate adaptive management from traditional trial-and-error or learn-as-you-go management (Hilborn 1992; Halbert 1993) (Figure 6-1).

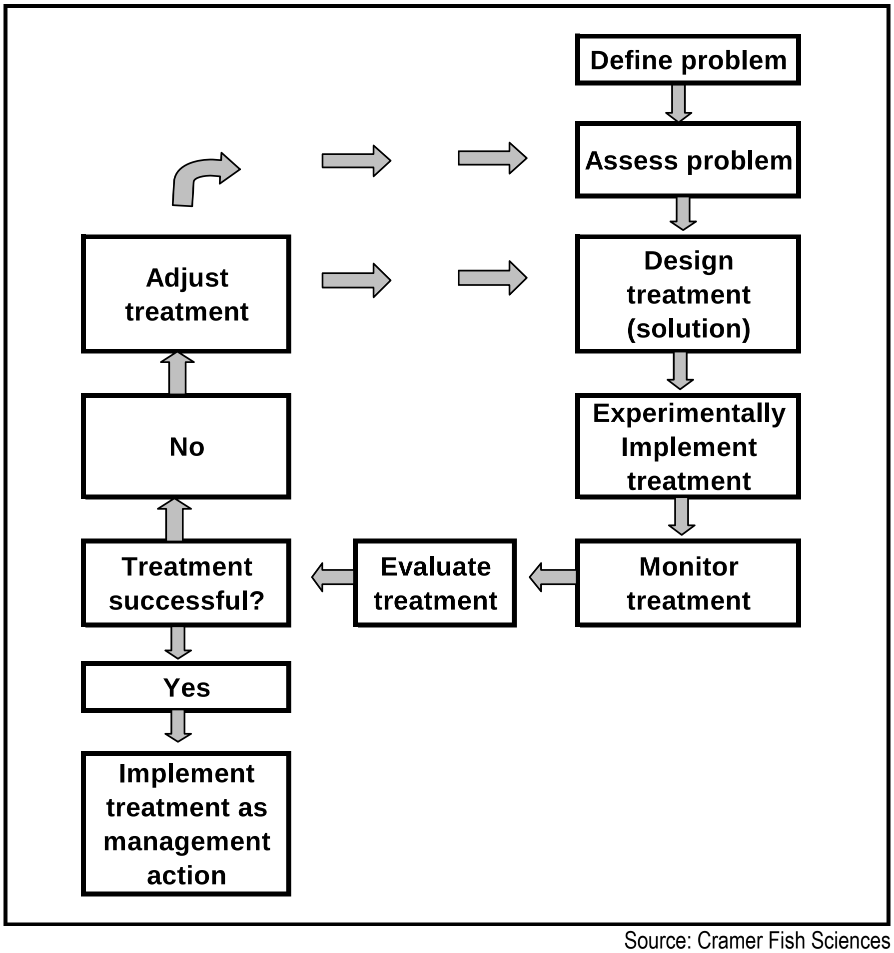
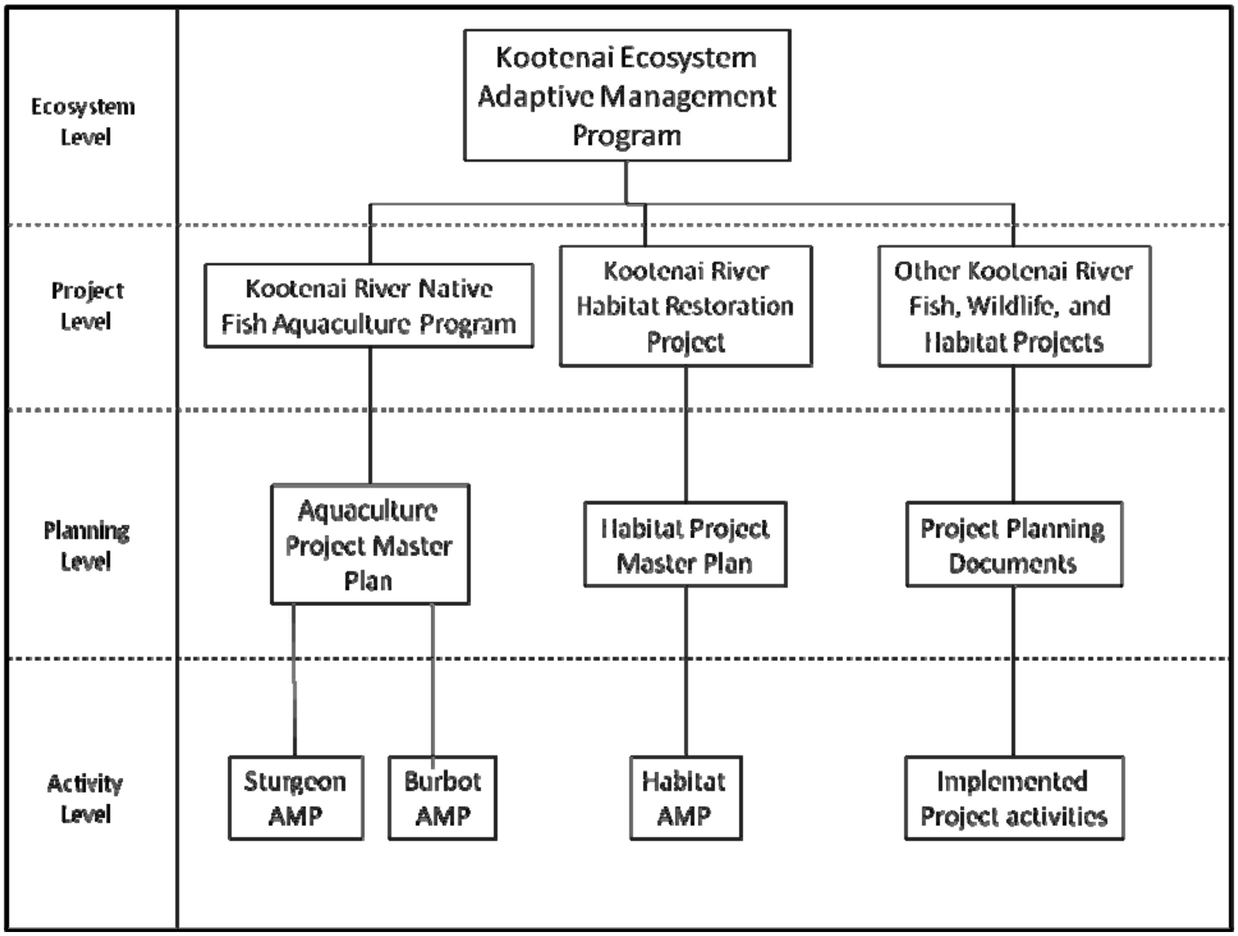


Figure 6-1. The general iterative adaptive management model used in Kootenai Tribe's Kootenai River Native Fish Conservation Aquaculture Program.

Adaptive management plans for the conservation aquaculture programs are a component of a broader effort by the Kootenai Tribe and other state, federal, and provincial co-managers to restore ecosystem functions in the Kootenai River. An ecosystem-level adaptive management program is currently being developed for the Kootenai River that includes all aquaculture, fisheries, and habitat and ecosystem restoration projects as described in Table 6-1. In addition, the process of adaptive management includes a series of hierarchical activities, occurring at the ecosystem, project, planning, and field activity levels. As shown in Figure 6-2, developing this aquaculture master plan is an "activity-level" step (conceptual design) that will then inform "planning level" (facility design) and then "project level" (facility construction and operation) decisions within the context of the Kootenai River ecosystem.



Source: Cramer Fish Sciences

Figure 6-2. Hierarchical organization of adaptive management programs in the Kootenai River subbasin.

An important near-term priority (i.e., within the next 12-24 months) for the Tribe is to update and expand the content and level of detail in the 2005 Draft Kootenai River Adaptive Management Plan in order to more fully support integrated adaptive management of the Tribe's projects and programs in the Kootenai subbasin, and also to support enhanced integration with other activities and programs in the subbasin (e.g., monitoring associated with the Libby Dam BiOp, IDFG and BC MoE projects and programs, etc).

The Tribe anticipates that refining and completing the Kootenai River Adaptive Management Plan will provide additional detail to help support and expand the conceptual monitoring and evaluation program presented in this Master Plan. While some monitoring, evaluation, and adaptive management components are best addressed directly through the Kootenai River Native Fish Conservation Aquaculture Program adaptive management plan (e.g., water quality, fish health, pre-release performance), other components (e.g., post-release performance) require broader integration with other projects and programs. Moreover, as stated throughout this document, the Tribe recognizes that the conservation aquaculture programs are stop gap measures that are necessary while habitat restoration actions are implemented and take effect; therefore, integrated adaptive management will be critical in understanding how the relative role and scale of the aquaculture program may need to change over time.

In particular, completing and implementing the broader scale Kootenai River Adaptive Management Plan will provide vital additional information to: 1) guide review and adaptation of program stocking goals, 2) refine optimal release dates and release numbers, and 3) better understand the nuances of post-release performance.

6.2 Conditions for Ending the Programs

Although the proposed Kootenai sturgeon and burbot aquaculture programs are considered to be stop-gap measures in species restoration, the operational duration is uncertain due to the status of the populations and time required for them to become self-sustaining. Stable, self-sustaining populations would need to be assured before ceasing hatchery supplementation. Biological conditions signaling termination include a genetically diverse population of natural-origin, reproducing adults and age class structure with adequate recruitment to support population persistence and viability. An additional important signal to the Tribe will be the ability of Tribal members to sustainably harvest these culturally important species. Positive outcomes from empirical testing and model simulations (e.g., population viability analysis) would be another important consideration in program termination.

Achieving these conditions may require two subsequent generations (potentially +/- 50 years for sturgeon and +/- 20 years for burbot). Because the Kootenai River white sturgeon population is listed as endangered, down-listing and delisting may be a prerequisite for program termination. Both down-listing and delisting will require increased magnitude and frequency of natural production according to the Kootenai River White Sturgeon Recovery Plan (USFWS 1999). The ultimate goal of this program for the Kootenai Tribe will be achieved when the populations reach a level that allows predictable, sustainable harvest opportunities.

7 Environmental Compliance

Under the NPCC Step-Review process for aquaculture facilities, project proponents are asked to describe the status of their comprehensive environmental assessment. Upon approval of this Step 1 Master Plan, the Kootenai Tribe will initiate preparation of a detailed environmental assessment that meets the criteria of the National Environmental Policy Act (NEPA). This assessment will provide a foundation for compliance with a number of other environmental and regulatory requirements. This chapter provides an overview of the most significant environmental compliance steps to be undertaken during Step 2 of the program.

7.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969, as amended (42 USC 4321 et seq.), requires federal agencies to assess and disclose the effects of a proposed action on the environment prior to funding, approving, or implementing an action.

An Environmental Assessment (EA) that assesses the environmental consequences of implementing the Kootenai River Native Fish Conservation Aquaculture Programs will be prepared to address NEPA requirements. This process will include public outreach to assist the

Tribe in identifying key issues that should be addressed in the environmental analysis. At this time, the Tribe assumes that BPA will be the lead federal agency for the NEPA effort.

7.2 Endangered Species Act

The Endangered Species Act of 1973, as amended (16 U.S.C. § 1531 *et seq.*) requires that federal agencies ensure that actions they authorize, fund or conduct are not likely to jeopardize the continued existence of any ESA proposed or listed species or their designated critical habitat.

Kootenai sturgeon were listed as "endangered" under the ESA in 1994 (59 Federal Register 45989). The USFWS designated the Kootenai River from RM 141.4 to RM 152.6 in Boundary County, Idaho as Kootenai sturgeon critical habitat on September 6, 2001 (66 Federal Register 46548). An additional segment from RM 152.6 to 159.7 was designated as critical habitat on February 10, 2006 (71 FR 6383) with a final ruling issued on July 9, 2008 (73 FR 39506) for a total of 18.3 miles of designated habitat. The lateral extent of critical habitat includes the river channel up to the ordinary high-water lines (as defined by the USFWS in 33 CFR 329.11) on each bank of the Kootenai River.

Burbot were proposed for ESA listing in 2000; however, the USFWS determined that this population was not eligible for listing because it does not comprise a Distinct Population Segment (Federal Register, March 11, 2003 (Vol. 68, No. 47; http://regulations.vlex.com/vid/threatened-findings-lower-kootenai-burbot-22843634). Rather than listing burbot as threatened or endangered under the ESA, the Tribe (previously discussed in Chapter 3), along with the USFWS, agency partners and additional stakeholders, proposed the Kootenai River drainage as a "pilot project" to develop, implement, and evaluate a Conservation Strategy for Lower Kootenai River Burbot (Conservation Strategy), in lieu of an ESA listing. The resulting Burbot Conservation Strategy was developed by the KVRI Burbot Subcommittee and was formalized through a Memorandum of Understanding (MOU) signed in spring 2005 by 16 agencies and entities. This MOU is consistent with the USFWS Policy for Evaluating Conservation Efforts (PECE Policy; U.S. Vol. 65 No. 114, June 13, 2000). Burbot are designated as Species of Special Concern by the states of Idaho and Montana.

7.2.1 Biological Opinion

Section 7 of the ESA directs federal departments and agencies to ensure that actions authorized, funded, and/or conducted by them are not likely to jeopardize the continued existence of any federally proposed or listed species, or result in destruction or adverse modification of critical habitat for such species. Section 7(c) requires that federal agencies contact the USFWS and/or the National Marine Fisheries Service (NMFS) (the Services) before beginning any construction activity to determine if federally listed threatened and endangered species or designated critical habitat may be present in the vicinity of a proposed project. A Biological Evaluation/Assessment (BE/BA) must be prepared if actions by a federal agency or permits issued by a federal agency will result in construction (i.e., actual action on the ground) and if the Services determine that threatened and endangered species may occur in the vicinity of a proposed project. The Service uses this document as the basis of a Biological Opinion that will outline criteria to ensure the project does not further jeopardize an endangered species. The Kootenai Tribe will prepare a BA that addresses the potential effects of the aquaculture programs on aquatic and terrestrial species.

The USFWS, Bureau of Reclamation, Corps of Engineers, and BPA developed a Biological Opinion (BiOp) on Federal Columbia River Power System Operations in 2000 that recommended mitigation for operational effects of Libby Dam on Kootenai sturgeon. Measures for Kootenai sturgeon include implementing flow releases and a flood control approach to lessen the effects on Kootenai sturgeon.

In 2006, the USFWS Biological Opinion Regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout, and Kootenai Sturgeon Critical Habitat was published (USFWS 2006, clarified in 2008). The Libby Dam BiOp specifically acknowledges the need for continued operation of the Tribe's sturgeon aquaculture program in Reasonable and Prudent Action Component 4, and directs the action agencies to provide funding to expand adult holding and spawning capability at the Tribal Sturgeon Hatchery (USFWS 2006, clarified in 2008).

7.2.2 Recovery Plan

The USFWS formed the Kootenai River White Sturgeon Recovery Team in 1994 to provide them with scientific advice in response to the ESA listing. A draft recovery plan was developed in 1996 and in 1999, the final Recovery Plan for White Sturgeon: Kootenai River Population was formally adopted by the USFWS (USFWS 1999). This recovery plan for Kootenai sturgeon, presented in Appendix F, identifies three primary strategies to achieve recovery: 1) flow augmentation to enhance natural reproduction; 2) identification of suitable habitat conditions for survival past the egg/larval stage, and 3) a conservation aquaculture program to prevent extinction and preserve the remaining gene pool (USFWS 1999).

7.2.3 Canadian Species at Risk Act

The Canadian Species at Risk Act (SARA) was proclaimed in June 2003, and is one part of a three part Government of Canada strategy to protect wildlife species at risk. This strategy also includes commitments under the Accord for the Protection of Species at Risk and activities under the Habitat Stewardship Program for Species at Risk.

Within Canada, white sturgeon occur only in British Columbia and are divided into six populations based on geography and genetics: the lower, mid- and upper-Fraser River, Nechako River, Columbia River, and Kootenay River. All populations were listed as endangered by the Committee on the Status of Endangered Wildlife in Canada, but only the latter four are legally listed under SARA. Kootenay sturgeon are included in this group and are listed as endangered under what is referred to as the Red List. These are indigenous species that are critically imperiled either because of extreme rarity or vulnerability to extirpation (http://a100.gov.bc.ca/pub/eswp/speciesSummary. do?id=16164, accessed on July 17, 2009).

A recovery plan for white sturgeon is currently being developed under SARA and is scheduled for release in late 2009 or early 2010. Consistency with SARA provisions and the recovery strategy will be evaluated in Step 2 of master planning.

7.3 Clean Water Act

Consistency of project construction and operation will be demonstrated with Section 401 of the Federal Water Pollution Control Act (Clean Water Act). The authority to review the programs for consistency with Section 401 is the responsibility of the Idaho Department of Environmental Quality.

7.4 National Historic Preservation Act

Funding this project is considered an undertaking within Section 106 of the National Historic Preservation Act of 1966, as amended (P.L.89-665, 16 U.S.C. 470). Section 106 requires that every federal agency take into account how each of its undertakings could affect historic properties. Historic properties are districts, sites, structures and traditional cultural places that are eligible for inclusion on the National Register of Historic Places. The Kootenai Tribe will take all necessary steps to evaluate potential effects on listed properties.

7.5 State Approvals

Developing the proposed aquaculture facilities will require various regulatory approvals from State of Idaho agencies. It is expected that the Kootenai Tribe would lead this effort, which will be based on environmental and engineering analyses of potential project construction and operational effects. Permitting requirements will be verified during Step 2 planning and preliminary design; approvals sought during Step 3, final design. Among the permits the Tribe anticipates will be required, are new water rights for the Twin Rivers Hatchery site, a stream channel alteration permit for construction affecting the Kootenai or Moyie rivers, and potentially a National Pollution Discharge Elimination System permit for hatchery operation if production reaches a regulated level.

8 Cost Estimates

8.1 Approach to Cost Estimation

8.1.1 Basis of Estimates

The costs presented in this chapter are consistent with Council's Step Review, Step 1 Master Plan requirements. These conceptual costs are a planning baseline from which to refine costs, evaluate alternatives, and protect against budget expansion as the proposed project progresses through the preliminary (Step 2) and final design (Step 3) phases, and implementation.

The approach used in this Master Plan to estimate future costs for both operations and capital construction generally follow the principals for inflation and cost escalation described by the Independent Economic Analysis Board (IEAB) in their white paper on Project Cost Escalation Standards (NPCC 2007).

Project costs are based on the proposed programs and conceptual designs presented in Chapters 4 and 5. As described in previous chapters of this Master Plan, the Tribe is proposing to modify facilities at the Tribal Sturgeon Hatchery and construct a new facility at the Twin Rivers Hatchery site (Figures 4-20 and 4-22). Cost estimates for facility planning and design, construction, acquisition of capital equipment, and environmental compliance are presented for each of the hatchery facilities (Sections 8.2 through 8.5). Research, monitoring, and evaluation, as well as operations and maintenance, are also discussed (Sections 8.7 and 8.8). A tabular summary of project costs is provided in Section 8.1.3 and a 10-year summary of all costs projected from FY 2010 through FY 2020 is presented in Section 8.9.

An important aspect of expected costs for the proposed programs involves shared facilities and functions. Some of the proposed facilities, as well as staffing and equipment, will be shared between the Kootenai sturgeon and burbot programs. Planning estimates suggest that the operational cost of these programs will be at least 30% lower with shared facilities and functions than if two separate, parallel programs were developed and operated. Efficiencies are also realized in monitoring and evaluation activities. These facilities will incorporate best management practices, which call for isolating the different fish species to avoid disease problems and ensure efficient operations and activities for each life stage of the cultured species. Due to the experimental nature of some aspects of the proposed programs, it should be noted that conceptual designs for facilities and infrastructure were approached in a manner that accommodates cost effective operational flexibility in each functional area (i.e., eggtake, incubation, rearing, release) to accommodate and adapt for future changes based on new information obtained through experimental work and/or monitoring and evaluation.

Cost estimates are provided for all program areas from FY 2010 through FY 2020. Construction costs can fluctuate significantly from year to year, as shown in the Engineering News Record (ENR) Construction Cost Index (http://enr.com), which has recorded costs since 1913. Since 1978, changes in annual national averages for construction costs have ranged from +11.6% in 1978 to -0.5% in 2001. The fluctuation range of average construction costs from 1997 through 2008 has been between -0.5% and +9.1%.

At the time this Master Plan was finalized, the construction industry was experiencing a downturn; however, it is uncertain how various government programs and other market forces may affect costs over the life of the proposed project. Based on the historical information cited in the ENR, construction cost estimates for the Kootenai River aquaculture programs have been escalated at 4.5%. Cost estimates for operations, maintenance, research, monitoring, and evaluation are escalated at 3% annually from FY 2010 through FY 2020. These types of costs tend to be more stable historically. These estimates may be high or low in any given year depending on the state of the economy, but, at this time, they are considered to be reasonable estimates. Signs of economic recovery are emerging; therefore, deferring or delaying portions of the project could dramatically increase implementation costs of the proposed facilities.

8.1.2 Cost Sharing with Other Organizations and Entities

Cost sharing will be an important aspect of funding the proposed programs. Conceptual costs take into consideration the extensive amount of cost sharing that is occurring in current programs and that is expected to continue in future programs. [26]

Most cost sharing identified for the Tribe's aquaculture conservation programs relates to research, monitoring, and evaluation. Cost sharing includes both direct funding and in-kind

[26] Cost sharing and sharing of facilities and functions are two separate activities and should not be confused with one another. The Kootenai Tribe proposes to combine functions and facilities, to the extent compatible with Best Management Practices, at the two aquaculture sites in an effort to contain costs. Cost sharing involves two or more entities contributing funds or in-kind participation to build and/or operate a particular project.

support. Table 8-1 shows the types and amounts of cost sharing between the Tribe and entities such as BC MoE, Freshwater Fisheries Society of British Columbia, the University of California at Davis, the University of Idaho, and the USFWS Dworshak Fish Health Center. While these cash and in-kind contributions are not shown as direct deductions from the line item budgets presented in this document, they were considered when developing annual operations and M&E cost estimates.

Table 8-1. Summary of cost sharing for Kootenai aquaculture programs.

Funding Source or Organization	Item or Service Provided	Cash or In-Kind?	Status	FY 2010 Estimated Value
BC Ministry of Environment	Kootenay River & Lake Management	In-Kind	Confirmed	$61,800
Freshwater Fisheries Society of British Columbia	Fish culture services	In-Kind	Confirmed	$72,100
University of California – Davis	Information transfer about sturgeon culture issues	In-Kind	Confirmed	$5,150
University of Idaho, Moscow	Research support & oversight for WSIV and Burbot Culture	In-Kind	Under Review	$27,038
USFWS Dworshak Fish Health Center	Disease testing	In-Kind	Confirmed	$10,300
			Totals	*$176,388*

Notes and Assumptions:
- Figures provided are consistent with the FY 2007 - FY 2009 Kootenai Proposal
- Estimates are provided in 2010 dollars
- Estimated cost-share support is accounted for in program areas presented

8.1.3 Program Areas and Major Milestones

Completing the Council's Three-Step process often requires three to five years. During this time, considerable planning, design, environmental compliance and analysis of alternatives will occur. A generalized list of program areas and a preliminary time line linking costs to planning; construction; capital equipment; environmental compliance; operations and maintenance; and research, monitoring, and evaluation is presented in Figure 8-1 for FY 2009 through FY 2020. A cost summary by program area is shown in Table 8-2. Cost estimates for each program are presented in the year in which they are expected to occur and are shown in Table 8-14; costs are escalated from FY 2010.

Table 8-2. Summary of key expenditures by program area.

Program Area	Estimated Cost	Occurrence	Level of Certainty
Planning & Design Step 1 *	$490,000	One Time	Estimated budget from Project budget 198806400 (Step 1 development)
Planning & Design Step 2 **	$1,046,999	One Time	Estimated budget from Project budget 198806400 (Step 2 development not started)
Planning & Design Step 3 ***	$1,017,114	One Time	Estimated budget from Project budget 198806400 (Step 3 development not started)
Construction (Base Components)	$13,997,000	One Time	Concept (+/- 35% to 50%) (escalated to 2012 dollars)
Construction (Base & Separable Components)	$15,251,000	One Time	Concept (+/- 35% to 50%) (escalated to 2012 dollars)
Capital Equipment	$423,790	One Time	Concept (+/- 35% to 50%) (escalated to 2012 dollars)
Environmental Compliance Step 2 (Permitting, EA, Other)	$164,546	One Time	Concept (+/- 35% to 50%) Completed during Step 2 (2011 dollars)
Land Purchases, Lease & Easements ****	$0	One Time, Annual	Budget to be determined
Annual Operations & Maintenance / Future Tribal Hatchery Program *****	$906,515	Annual	Refined concept (+/- 25%), Estimated cost once new Twin Rivers Program is implemented (2009 dollars)
Annual Operations & Maintenance / New Twin Rivers Program *****	$923,411	Annual	Refined concept (+/- 25%), Estimated cost once new Twin Rivers Program is implemented (2010 dollars)
Monitoring & Evaluation *****	$701,886	Annual	Refined concept (+/- 25%), Estimated cost once new Twin Rivers Program is implemented (2010 dollars)

Notes and Assumptions:
* Shows estimated expenditure for FY 2007, 2008, 2009 and 2010. This is an estimated figure from the total project budget for Project No. 198806400.
** Shows estimated expenditure from FY 2010. This is an estimated figure from the total project budget for Project No. 198806400.
*** Shows estimated expenditure from a projected FY 2011 budget. This is an estimated figure from the total project budget for Project No. 198806400.
**** Land Purchases, Leases and Easements (estimated budget is not identified at this time)
***** Annual Operations and Maintenance and Monitoring and Evaluation costs are based on efficiencies from implementing the new Twin Rivers programs.
Budget figures assume that work would proceed on the timeline shown in Figure 8-1.

8.2 Cost Estimates for Facility Planning and Design

The Kootenai Tribe has solicited input from a range of experts during Step 1 conceptual planning in order to avoid significant design and program changes in later planning stages. The Tribe also sought to validate the program, design criteria, and cost estimates to the maximum extent possible through comprehensive early reviews. They intend to continue to solicit input and review by a team of knowledgeable individuals through the Step 2 and 3 processes.

8.2.1 Step 1 Conceptual Planning and Design

The total budget for the conceptual planning and design work is about $490,000 (Table 8-2). This figure is an estimate that includes conceptual planning, engineering, and development of the Step 1 Master Plan and responding to the ISRP review of this Master Plan.

8.2.2 Step 2 Preliminary Planning and Design

The preliminary planning and design stage, intended to meet the Council's Step 2 requirements, is designed to identify any major difficulties or concerns with the program and facility designs. Step 2 design work should provide sufficient detail and specifics to assure that the intent and scope of Step 1 conceptual design work can be met and to further refine the cost estimates. Step 2 will include refinement of scientific information, environmental compliance and ESA reviews. In addition, the Kootenai Tribe may implement a value analysis (also known as value engineering) near completion of the Step 2 planning and design work.

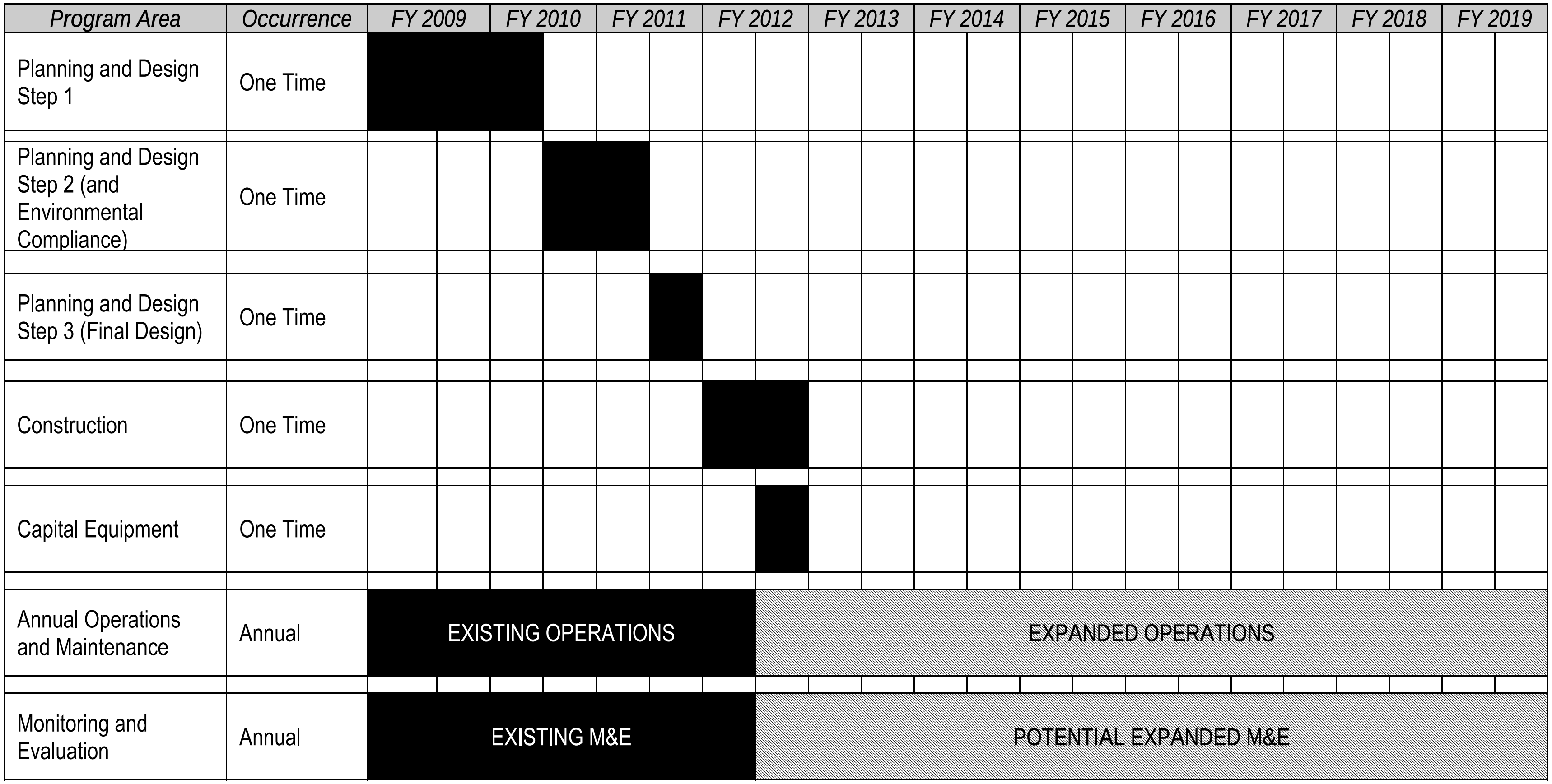
A placeholder of about $1,000,000 has been identified for Step 2 preliminary planning, environmental compliance, site investigations and design. Initiation of this work is proposed in FY 2010 (Table 8-2). This budget includes costs for drilling test wells, surveying and other investigative geotechnical work. The budget may need further refinement depending on the outcome of the Step 1 Master plan approval process.

8.2.3 Step 3 Final Planning and Design

A placeholder of about $1,000,000 (Table 8-2) has been identified for the Step 3 final planning and design stage. It is anticipated that this work will begin in FY 2011. Refinement of the Step 3 budget will occur in Step 2 during development of the preliminary design.

8.2.3.1 Implications of Phasing Facilities for the Sturgeon and Burbot Programs on Planning and Design Expenses

The cost estimates provided for planning and design assume that facilities for both the sturgeon and burbot programs will be developed on the timeline shown in Figure 8-1. Should these programs be separated and/or delayed, costs for planning and design will increase due to required separation of facility designs, construction specifications and planning and design documents. The Tribe's overall proposed approach of sharing and integrating facilities and operations will result in more cost effective planning and implementation for Step 2, Step 3, implementation of construction, and long-term program operations.



Notes & Assumptions:

- Assumes proposed Step 2 and Step 3 funding is available
- Assumes a design / build approach between Step 2 and Step 3.
- Assumes construction starting in early 2012 (one year schedule is dependent on spring 2012 start).
- Assumes all proposed facilities and improvements are built in one construction season (FY 2012).
- Assumes no major environmental compliance issues are identified beyond what is described in Section 7.
- Expanded O&M expenditures will likely start during the last phases of construction allowing for training and handoff of new facilities and equipment.
- Expanded M&E expenditures will likely start after the final phase of construction.

Figure 8-1. Kootenai River Native Fish Conservation Aquaculture Program: general timeline for key milestones and expenditures.

8.3 Construction

8.3.1 Tribal Sturgeon Hatchery

The Tribal Sturgeon Hatchery was originally built in 1991 to conduct experimental programs for Kootenai sturgeon. Facilities have been added over the years and the hatchery currently comprises a main hatchery and incubation building, two rearing sheds, an administration building, storage sheds, and water treatment facilities. Chapters 2 and 4 describe the need for and the conceptual design of the facility upgrades proposed here. Proposed modifications (Section 4.1.1) will allow safer and more efficient handling of Kootenai sturgeon. In addition, improvements would include acquisition and installation of a cover for the existing settling pond, increased water quality and temperature control functions, additional feed storage, improvements to support rearing isolation and disease control, replacement of existing rearing tanks as well as acquisition of new tanks, new water pump, fire protection/alarm system, lighting and insulation upgrades, and improved ventilation.

Construction at the existing Tribal Sturgeon Hatchery site will be confined to upgrading the existing facilities summarized above. Table 8-3 presents the costs associated with these modifications; more detail on construction costs may be found in Appendix E-1. The estimated construction budget for this work is $903,000. These estimates are based on the conceptual design presented in this Master Plan. A 20% contingency has been built into overall costs to accommodate the level of uncertainty associated with conceptual design.

Table 8-3. Estimated construction costs -- Tribal Sturgeon Hatchery.

Description	Total
Critical Upgrades	
Adult Fish Transport Improvements	$20,000
Adult Fish Spawning Area 20' x 32' Remodel	$60,000
Drum Filter Heating System	$15,000
Fire Alarm and Lighting Systems Upgrades	$60,000
Improved Insulation	$30,000
Sanitary Wall Panels in Wet areas – 8 feet high	$26,400
Feed Storage	$16,000
Boat Storage	$16,000
Interior Partition of Electrical/Controls in Treatment Building	$20,000
Ventilated Cabinet and Alarm for Ozone Generator	$4,000
Allowance for Water System/Energy Recovery Upgrades	$50,000
Allowance for Increased Chiller Demand	$75,000
Allowance for Water Systems Controls Upgrades	$10,000
Backwash Flow Meter and Throttling Valve	$7,000
Concrete Pads at Rearing Shed Doorways	$12,000

Description	Total
Rearing Shed #2 – Tank Replacement and Concrete Floor	$120,000
Extend 4-inch River Water Supply from Shed #1 to Shed #2	$16,000
Add 10 hp Booster Pump	$12,000
Construction Cost Subtotal	*$569,400*
Inflation / Escalation to Mid-Point Construction	$82,563
Mob/Demob, General Conditions	$85,410
Subtotal	*$737,373*
Contingency	$147,475
Taxes	$17,697
Total Estimated Cost	$903,000

Notes & Assumptions:
- Estimates are escalated from 2009 dollars at 4.5% annually to an assumed mid-point construction date of June 2012.

8.3.2 Twin Rivers Hatchery

The Twin Rivers Hatchery would be a new facility designed to expand production of Kootenai sturgeon and provide both experimental and future flexible production facilities for burbot. Programs for both species would be conducted at the new facility, resulting in maximum efficiency and cost reductions. As detailed in Section 4.3.3, the shared facilities include:

- Water supply system, including two sources of river water and groundwater from wells
- Water treatment system
- Effluent treatment
- Feed storage and forage fish culture
- Biological laboratory
- Support facilities, including utilities, access roads, storage, garage, and shop facilities, administration building, and staff housing

While the Tribe is seeking efficiencies by combining the Kootenai sturgeon and burbot aquaculture facilities, there are limitations to sharing operations between the two programs due to differences in spawning timing and water temperatures. Best management practices require separation and isolation of the two species for these reasons and for disease control.

Table 8-4 summarizes probable costs for each component of the proposed Twin Rivers Hatchery. Details of these estimates are found in Appendix E-2. The estimated construction budget for Twin Rivers Hatchery (without separable components) is $13,094,000. These estimated costs do not include land purchase or lease as the Kootenai Tribe is using land it purchased in 2008 for this new facility. As with the Tribal Sturgeon Hatchery, these estimates are based on the conceptual design and include a contingency of 20% to accommodate the level of uncertainty at this stage.

Table 8-4. Estimated construction costs -- Twin Rivers Hatchery.

Description	Total
River Water Supply Intakes	$1,554,000
Groundwater Supply	$214,500
Water Treatment Building	$1,355,900
Site Work	$714,600
Process Water Distribution Piping from Headworks	$433,000
Sturgeon and Administration Building (~16,630 Square Feet)	$2,558,820
Burbot Building (~5,570 Square Feet)	$838,880
Effluent / Settling Structure – Dual Cell	$64,329
Hatchery Housing – Add 2 residences	$446,700
Offsite Electrical (3 Phase Feeder)	$80,000
Construction Cost Subtotal	*$8,260,729*
Inflation / Escalation to Mid-Point Construction	$1,197,806
Mob/Demob, General Conditions	$1,239,109
Subtotal	*$10,697,644*
Contingency	$2,139,529
Taxes	$256,743
Total Estimated Cost	$13,094,000

Notes & Assumptions:
- Estimates are escalated from 2009 dollars at 4.5% annually to an assumed mid-point construction date of June 2012.

There are some hatchery components that are identified as "separable." These facilities may be built at the beginning of the project or in later years, however, for the purposes of developing the cost estimate in this Master Plan, these components are being included in cost estimates for the preliminary through final design stages. Table 8-5 shows the estimated costs of these components. Details of the separable component costs are found in Appendix E-3.

Table 8-5. Estimated construction costs –Twin Rivers Hatchery separable components.

Description	Total
Burbot Ponds (6 ponds)	
Construction Cost Subtotal	$250,450
Inflation / Escalation to Mid-Point Construction	$36,315
Mob/Demob, General Conditions	$37,568
Subtotal	$324,333
Contingency	$64,867
Taxes	$7,784
Total Estimated Cost	*$397,000*

Description	Total
Sturgeon Spawning Channels (2) 20' x 50' x 8' d	
Construction Cost Subtotal	$334,000
Inflation / Escalation to Mid-Point Construction	$48,430
Mob/Demob, General Conditions	$50,100
Subtotal	$432,530
Contingency	$86,506
Taxes	$10,381
Total Estimated Cost	*$529,000*
Sturgeon Remote Rearing Units – Two Locations	
Construction Cost Subtotal	$224,000
Inflation / Escalation to Mid-Point Construction	$32,480
Mob/Demob, General Conditions	$11,200
Subtotal	$267,680
Contingency	$53,536
Taxes	$6,424
Total Estimated Cost	*$328,000*

Notes and Assumptions:
- Estimates are escalated from 2009 dollars at 4.5% annually to an assumed mid-point construction date of June 2012.

8.3.3 Summary of Probable Construction Costs

Table 8-6 summarizes the estimated construction costs for the Twin Rivers Hatchery and modifications to Tribal Sturgeon Hatchery. The costs for Twin Rivers Hatchery are broken down into major components. The total construction cost is presented with and without the separable components. The purpose of presenting the burbot ponds, sturgeon spawning channels and remote rearing units as separable components is for clarity of project costs and presentation; however, the Kootenai Tribe considers these components as integral to the overall success of the programs.

Table 8-6. Summary of estimated construction costs.

Area	Estimate *
Twin Rivers Site	
Primary Construction Contract	$13,094,000
Optional Burbot Ponds	$397,000
Optional Sturgeon Spawn Channels	$529,000
Optional Remote Rearing Units (2)	$328,000
Tribal Sturgeon Hatchery Site	
Critical Upgrades	$903,000
Total without Optional Twin Rivers Components	$13,997,000
Total with Optional Twin Rivers Components	$15,251,000

Notes & Assumptions:
* Estimates are escalated from 2009 dollars at 4.5% annually to an assumed mid-point construction date of June 2012.

8.3.4 Implications of Phasing Sturgeon and Burbot Facility Construction

The Kootenai Tribe has investigated several scenarios related to constructing key components of the experimental burbot aquaculture program concurrently with the sturgeon aquaculture facilities. If constructed as an integrated project, the burbot component of the project is estimated to require about 20% of the total cost of the Twin Rivers construction, or about $2.7 million of the proposed $13,000,000 cost (Table 8.5).

The Tribe believes that the experimental burbot aquaculture program proposed at Twin Rivers is critical to species preservation and recovery. Since the cost of burbot-related infrastructure is less than 20% of total project cost, constructing the burbot components from the outset (i.e., at the same time the sturgeon facility is constructed) would significantly reduce the overall cost of the burbot program compared to implementing it as a separate future project. Constructing burbot program components at the same time as the sturgeon components will significantly reduce future funding requests, use resources more efficiently, and minimize site disturbance. In addition to these concerns, protracted construction impacts on Twin River Resort operations is a concern that would be avoided by a single construction event.

8.3.4.1 Twin Rivers Resort Operations

The Twin Rivers site is presently operated as a resort, featuring full RV-hook-up spaces, tent camping, and offering related riverfront recreational opportunities. The resort has become a destination of choice for many vacationers, has a strong base of repeat visitors and is an important site for the Kootenai Tribe and the Bonner's Ferry Community. As such it provides a steady stream of income for the Kootenai Tribe and employment opportunities for local citizens. It is the intent of the Kootenai Tribe to continue resort operations along with the proposed aquaculture operations. The proposed designs will integrate the new fisheries facilities with resort operations. The construction site is immediately adjacent to resort RV and camping spaces, and it will have to share the site access road with construction traffic. A single contractor mobilization and construction period is highly desirable in order to minimize economic, environmental, and aesthetic impacts on the resort. Multiple construction seasons are not considered a viable option.

8.3.4.2 Water Supply and Treatment Concerns

Sections 4.3 and 5.3 describe the bio-programs and conceptual designs of the Kootenai sturgeon and burbot conservation aquaculture programs. According to Table 4-10, the water budget for the burbot program uses roughly 30% of the total process water demand, exclusive of the optional outdoor burbot ponds. The incremental cost of upsizing the process water systems to meet the needs of the burbot program are on the order of 15 to 20% if implemented as part of the original construction. If a separate full capacity process water system were to be added for burbot at a later date, the economies of scale would be lost, and total system costs are likely to be at least 50% higher than if the systems were slightly oversized and constructed under a single contract.

The total cost of the process water systems is approximately $5 million including taxes, contingencies and mark-ups. Applying the 50% cost factor for two separate stand alone process water systems, a value of about $7.2 million results. This rough analysis indicates a premium of ($7.2 million minus $4.8 million) $2.4 million in construction costs alone (not accounting for extra design and administration costs), if the water systems were constructed separately. Therefore, constructing sturgeon and burbot water supply and treatment systems under separate contracts is not considered a viable implementation strategy from a cost perspective.

8.3.4.3 Potential Implementation Strategies for the Burbot Facilities

Based on the recommendations of the ISRP, that the burbot program be separated form the Kootenai sturgeon program, the Tribe has analyzed three options for implementing burbot program facilities at Twin Rivers. These are:

Option 1: Fully build out the burbot building (as originally proposed in this Master Plan), including all process piping, mechanical, electrical and plumbing.

Option 2: Omit the 5,750 square foot burbot wing from the initial project construction contract, and build it two to three years later under a separate contract. Size the river and groundwater supply systems and process water treatment room equipment for the sturgeon program so that it accommodates future burbot program water requirements.

Option 3: Construct the 5,750 square foot burbot building shell and floor slab as part of the initial construction contract. Rough-in mechanical, electrical and plumbing, and process water piping stub-outs.

8.3.4.4 Comparative Cost Analysis of Burbot Implementation Options

Comparative costs for the three burbot facility implementation options described above are provided as three tables (Options 1-3) in Appendix E-4.

Option 1: Costs to construct Option 1, with a full build-out occurring under a single construction contract together with the sturgeon facilities, is depicted in Table 8-4. This Option (also see Appendix E-4) offers the least overall cost totaling $13,000,000.

Option 2: The cost table for Option 2 is presented in Appendix E-4. It reflects construction of the burbot wing two to three years after the initial sturgeon facilities are built. It shows corresponding reductions in the initial project cost for delaying a portion of the site work, process water distribution and the entirety of the burbot wing. The applicable line item costs are increased by a 1.1 multiplier to account for the extra work required to cut, patch and connect to existing infrastructure that would be necessary in this multi- phase option. There is also a 15% inflation escalation and a 5% higher contingency adding for the extra design and administration costs associated with the separate contracting. This option would initially cost $11,300,000, with full build-out reaching $13,600,000. Option 2 is likely to be at least $600,000 higher than Option 1. The Kootenai Tribe considers the $2,400,000 cost of incrementally upgrading these systems for higher flow rates at a later date to be prohibitive and impractical.

Option 3: The cost table for Option 3 is presented in Appendix E-4. It reflects completing the building shell, floor slab of the burbot wing and all site work in the initial construction contract. Installations that would be delayed include installing burbot process piping, tanks, plumbing, mechanical, electrical and controls systems inside the building shell. As with Option 2, applicable line items have been increased by a 1.1 multiplier, a 15% inflation escalator and a 5% higher contingency for design and contract administration. Under Option 3, the initial contract cost would be $12,600,000 million, with a total project cost of $13,500,000. This Option would be about $500,000 higher than Option 1.

8.3.4.5 Preferred Construction Option

The lowest overall cost would be achieved by constructing the sturgeon and burbot facilities under a single contract in one construction season. This approach would also carry the lowest contracting risk because a single contractor would be responsible for complete and functional systems, which is an important consideration for monitoring, alarms and climate control systems. Other benefits of the single inclusive construction contract include:

- Minimizing impacts on Twin Rivers Resort operations and customer satisfaction;
- Eliminating redundant planning, design engineering, permitting and construction administration efforts;
- Reducing environmental impacts by limiting the period of disturbance;
- Incurring single event construction, mobilization and demobilization costs; and
- Requiring a single commissioning and start-up process with full systems integration.

The Kootenai Tribe would prefer to implement all aquaculture components as a single project. In addition to the cost implications identified above, the proposed burbot facility components have been designed to be flexible enough to accommodate both experimental research and future production level programs. Options 2 and 3 (described above) would have an economic impact on the Tribes' programs, and other physical site and social considerations that are unacceptable to the Kootenai Tribe.

8.4 Capital Equipment

Both the Tribal Sturgeon Hatchery and Twin Rivers Hatchery will require acquisition of new equipment. The new Twin Rivers Hatchery will require investment in various types of equipment from office furniture and laboratory equipment to water systems. Less capital equipment will be needed for the Tribal Sturgeon Hatchery since it is an upgrade rather than completely new construction. Table 8-7 lists the potential types of equipment and their probable costs. Note that, in some cases, based on management practices, equipment can be shared by the two facilities, resulting in an overall cost savings. A conceptual estimated budget of $424,000 (escalated from FY 2010 to FY 2012) has been included for capital equipment associated for both facilities.

8.4.1 Implications of Phasing Construction of the Burbot Program on Capital Equipment Expenses

The cost of delaying purchases of capital equipment for the burbot program is not considered to be a significant enough change to warrant documentation at this conceptual stage. The major costs of burbot program implementation are related to the construction costs shown in Section 8.3.

Table 8-7. Capital equipment budget by facility/hatchery functional area.

Description	Total Cost (FY 2010 dollars)	Total Cost (FY 2012 dollars)	Comments
Office Equipment	$4,326	$4,589	Office / administrative at Twin Rivers
Computers / Printers	$11,845	$12,566	Office / administrative at Twin Rivers
Office Furniture and Cabinets	$15,038	$15,954	Office / administrative at Twin Rivers
Communications Equipment	$16,200	$17,186	Twin Rivers
Housing Equipment and Furniture / Permanent Staff Housing	$25,750	$27,318	Two houses / Twin Rivers
Housing Equipment and Furniture / Temporary Staff Housing	$31,518	$33,437	Trailers / Twin Rivers
Shop Equipment	$11,845	$12,566	Twin Rivers
Buildings / Facilities Needs	$8,240	$8,742	Twin Rivers
Transportation	$51,500	$54,636	Trucks not leased
Water System Operation	$10,300	$10,927	Misc. equipment Twin Rivers
Brood Collection / Hatchery and Remote	$31,106	$33,000	Shared Equipment / Twin Rivers and Tribal Hatchery
Eggtake	$5,150	$5,464	Shared Equipment / Twin Rivers and Tribal Hatchery
Incubation	$11,536	$12,239	Shared Equipment / Twin Rivers and Tribal Hatchery
Fish Transport	$52,015	$55,183	Shared Equipment / Twin Rivers and Tribal Hatchery
Rearing at Hatchery	$11,021	$11,692	Twin Rivers
Rearing at Acclimation Ponds	$11,536	$12,239	Remote Rearing Burbot or Sturgeon
Tagging	$47,792	$50,703	Pit tagging and detectors
M&E Equipment	$21,424	$22,729	Shared Equipment / Twin Rivers and Tribal Hatchery
Technical / Lab Equipment	$10,506	$11,146	Twin Rivers
Disinfection Equipment (Other Disease and Pathology Needs)	$10,815	$11,474	Twin Rivers
Other	$0	$0	
TOTAL	$399,463	$423,790	

Notes & Assumptions:
- Costs shown in 2010 dollars
- Expenditures will occur in mid-2012
- Costs should be considered conceptual (+/- 25%)
- Items are not duplicated in the capital construction and operating budgets

8.5 Environmental Compliance

Both the Kootenai sturgeon and burbot programs will incur costs for environmental compliance. Kootenai sturgeon are listed as "endangered" under the ESA; burbot were proposed for listing in 2000, but are not currently listed. Sturgeon are also listed as endangered under the Canadian Species at Risk Act. The proposed programs under this Master Plan will need to comply with NEPA, the ESA and other laws and regulations that are discussed in Chapter 7.

Table 8-8 presents the estimated cost by potential permit or other requirement for the environmental compliance identified in Chapter 7. Costs are estimated to be approximately $165,000 to meet all requirements to implement the proposed project.

Table 8-8. Estimated cost of environmental compliance.

Project Area / Permit / Requirement	Estimated Cost to Complete (2010 dollars)	Estimated Cost to Complete (2011 dollars)
Water Supply / Quality		
NPDES Discharge (EPA/IDEQ)	$5,768	$5,941
Water Quality Certification for Aquaculture (EPA)	$7,416	$7,638
NPDES General Construction Stormwater (EPA)	$4,120	$4,244
Storm Water Pollution Prevention Plan (SWPPP)	$4,120	$4,244
Surface Water Right (Dept. of Water Resources)	$10,918	$11,246
Groundwater Right (Dept. of Water Resources)	$2,678	$2,758
Instream Work		
Corps Section 404/10	$18,540	$19,096
Instream Alteration Permit (ID Dept. Water Resources)	$7,416	$7,638
Navigational Encroachment Permit (ID Dept. of Lands)	$5,047	$5,198
Flood Zone District Approval – Boundary Co.	$3,502	$3,607
Planning Approvals		
Fugitive Dust Control / Idaho DEQ	$0	$0
Boundary County Special Use Permit	$3,708	$3,819
NEPA EA and Record of Decision	$72,100	$74,263
USFWS Concurrence or Biological Opinion	$7,004	$7,214
Section 106 Clearance	$0	$0
Construction		
Boundary County Commercial Building Permits	$4,120	$4,244
Boundary County Road & Bridge Permits	$3,296	$3,395
Total	$159,753	$164,546

8.5.1 Implications of Phasing Construction of the Burbot Program on Environmental Compliance Expenses

All potential costs for environmental compliance would be incurred even if the proposed burbot program was delayed. The Kootenai Tribe does not choose to phase environmental compliance activities at Twin Rivers and would proceed to seek approvals for all potential aquaculture facilities to accommodate experimental investigations and production of burbot and sturgeon.

8.6 Land Purchase Leases and Easements

The Kootenai Tribe purchased property at the confluence of the Kootenai and Moyie rivers in late 2008 and currently holds title to it. A portion of this site will be used for the proposed Twin Rivers Hatchery. The Tribe expects that during the Step 2 preliminary design phase, discussions will be initiated with BPA to review options for leasing or purchasing the portion of this property to be used for aquaculture facilities. Estimates of such costs are too speculative to include in this Master Plan.

8.7 Operations and Maintenance

The following sections present cost estimates associated with operations and maintenance of the existing Tribal Sturgeon Hatchery and the proposed Twin River Hatchery.

8.7.1 Tribal Sturgeon Hatchery

Operating costs for the Tribal Sturgeon Hatchery are shown in Table 8-9. Expenses include such items as payroll, utilities, vehicles, supplies, maintenance, and subcontracted support services. The Tribe estimates that the annual budget for operations and maintenance will be $1,339,000. This budget, which is based on 2010 dollars, would drop to approximately $934,000 (2010 dollars) once the facilities at the Twin Rivers Hatchery come on line in 2012 since sharing of both personnel, services for operations and maintenance between the Tribal Sturgeon Hatchery and Twin Rivers Hatchery is expected to result in about a 30% reduction in the overall budget. If this estimate is escalated from 2009 to 2012 dollars, it can be seen that operations expenses would be $990,000.

8.7.2 Twin Rivers Hatchery

Annual operating expenses for the Twin Rivers Hatchery are shown on Table 8-10 and include payroll, utilities, vehicles, supplies, maintenance, and subcontracted support services. The conceptual estimated budget for operations and maintenance of the Twin Rivers Hatchery is $979,000. Based on the estimates for the Tribal Sturgeon Hatchery (Table 8-9), the Tribe expects that operating the Twin Rivers Hatchery in isolation, e.g., not sharing staff and facilities, would increase costs by about 30%.

Table 8-9. Annual operating expenses – Tribal Sturgeon Hatchery.

Expense Area	Estimated Existing Operations Program (without Twin Rivers) (2010 dollars)	Estimated Existing Cost Tribal Sturgeon Hatchery (Combined with Twin Rivers) (2010 dollars)	Estimated Operations Cost Tribal Sturgeon Hatchery (Combined with Twin Rivers) (2012 dollars)
Payroll / Fringe	$371,067	$378,876	$401,950
Indirect	$218,930	$223,537	$237,150
Travel Costs (Mileage, Lodging, Per Diem)	$14,709	$10,300	$10,927
Professional Services	$7,622	$4,120	$4,371
Vehicles, Boats, Equipment, Transportation (Fuel, Oil, Maintenance, Mileage)	$24,823	$22,627	$24,005
Program Supplies (Office)	$3,748	$3,090	$3,278
Program Supplies (Fish Food, Aquaculture & Facility Chemicals, Hatchery Supplies)	$67,672	$20,085	$21,308
Equipment & Building Maintenance	$208,048	$41,200	$43,709
Utilities (Electrical, Telephone, Natural Gas, Water), Insurance	$64,644	$54,590	$57,915
Subcontracted Services	$357,429	$175,286	$185,960
TOTAL	$1,338,692	$933,711	$990,574

Notes & Assumptions:
- Costs are escalated from 2010 to 2012 dollars at 3% annually.
- Estimated costs for existing operations program do not include M&E costs.
- Estimated costs assume both Tribal Hatchery and planned Twin River Programs are operating in 2012.
- Subcontracted services include; gamete preservation, aquaculture techniques, data analysis and statistics, and public relations.

Table 8-10. Annual operating expenses – Twin Rivers Hatchery.

Expense Area	Estimated Annual Operating Expenses with Existing Tribal Hatchery (2010 dollars)	Estimated Annual Operating Expenses with Existing Tribal Hatchery (2012 dollars)
Payroll / Fringe	$378,876	$401,950
Indirect	$223,537	$237,150
Travel Costs (Mileage, Lodging, Per Diem)	$9,270	$9,835
Professional Services (Data Base, Information System)	$4,120	$4,371
Vehicles, Boats, Equipment, Transportation (Fuel, Oil, Maintenance, Mileage)	$22,627	$24,005
Program Supplies (Office)	$3,090	$3,278
Program Supplies (Fish Food, Aquaculture & Facility Chemicals, Hatchery Supplies)	$20,085	$21,308
Equipment & Building Maintenance	$41,200	$43,709
Utilities (Electrical, Telephone, Natural Gas, Water), Insurance	$45,320	$48,080
Subcontracted Services	$175,286	$185,960
TOTAL	$923,411	$979,647

Notes & Assumptions:
- Estimated costs assume both Tribal Sturgeon Hatchery and planned Twin River programs are operating in 2012.
- Costs are escalated from 2010 to 2012 dollars at 3% annually.
- Subcontracted services include; gamete preservation, aquaculture techniques, data analysis and statistics, and public relations.

8.7.3 Projected Operating Expenses

Operating expenses from 2010 to 2020 are shown in Table 8-11 (these are escalated at 3% annually in all expense areas). The estimated costs of existing operations at the Tribal Sturgeon Hatchery (Table 8-9) are shown from FY 2010 through FY 2012. The combined costs of operating both Tribal Sturgeon Hatchery and Twin Rivers Hatchery programs are shown starting in FY 2012. As noted in Section 8.7.2, costs to operate the Tribal Sturgeon Hatchery could drop as much as 30% if equipment, staff, facilities, and support services are shared between the two hatcheries.

8.7.3.1 Implications of Phasing Construction of the Burbot Program on Operating Expenses

If facilities for the proposed burbot program were delayed at Twin Rivers, it is estimated that operational costs might be reduced by 10 to 15% of the figure shown in Table 8-10 ($980,000) for FY 2012, or about $100,000. This modest reduction can be attributed to efficiencies the Tribe will achieve through shared staffing for the expanded sturgeon program with the burbot program at Twin Rivers. Under the delayed implementation scenario, it is possible that experimental costs could increase due to potentially contracting outside support and facilities for burbot programs; however, it cannot be assumed that delaying the proposed burbot facilities would provide any significant reductions in the conceptual operating cost estimates.

Table 8-11. Operating expenses, Tribal Sturgeon Hatchery and Twin Rivers Hatchery programs, 10-year projection.

	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Expense Area	*Tribal Sturgeon Hatchery / Existing*	*Tribal Sturgeon Hatchery / Existing*	*Tribal Sturgeon Hatchery and Twin Rivers*	*Tribal Sturgeon Hatchery and Twin Rivers*	*Tribal Sturgeon Hatchery and Twin Rivers*	*Tribal Sturgeon Hatchery and Twin Rivers*	*Tribal Sturgeon Hatchery and Twin Rivers*	*Tribal Sturgeon Hatchery and Twin Rivers*	*Tribal Sturgeon Hatchery and Twin Rivers*	*Tribal Sturgeon Hatchery and Twin Rivers*	*Tribal Sturgeon Hatchery and Twin Rivers*
Payroll / Fringe	$371,067	$382,199	$803,900	$828,017	$852,857	$878,443	$904,796	$931,940	$959,898	$988,695	$1,018,356
Indirect	$218,930	$225,498	$474,301	$488,530	$503,186	$518,281	$533,830	$549,845	$566,340	$583,330	$600,830
Travel Costs (Mileage, Lodging, Per Diem)	$14,709	$15,151	$20,762	$21,385	$22,026	$22,687	$23,368	$24,069	$24,791	$25,534	$26,300
Professional Services (Data Base, Information System)	$7,622	$7,851	$8,742	$9,004	$9,274	$9,552	$9,839	$10,134	$10,438	$10,751	$11,074
Vehicles, Boats, Equipment, Transportation (Fuel, Oil, Maintenance, Mileage)	$24,823	$25,568	$48,010	$49,450	$50,934	$52,462	$54,036	$55,657	$57,327	$59,046	$60,818
Program Supplies (Office)	$3,748	$3,861	$6,556	$6,753	$6,956	$7,164	$7,379	$7,601	$7,829	$8,063	$8,305
Program Supplies (Fish Food, Aquaculture & Facility Chemicals, Hatchery Supplies)	$67,672	$69,702	$42,616	$43,895	$45,212	$46,568	$47,965	$49,404	$50,886	$52,413	$53,985
Equipment & Building Maintenance	$208,048	$214,289	$87,418	$90,041	$92,742	$95,524	$98,390	$101,342	$104,382	$107,513	$110,739
Utilities (Electrical, Telephone, Natural Gas, Water), Insurance	$64,644	$66,583	$105,995	$109,174	$112,450	$115,823	$119,298	$122,877	$126,563	$130,360	$134,271
Subcontracted Services	$357,429	$368,152	$371,921	$383,079	$394,571	$406,408	$418,600	$431,158	$444,093	$457,416	$471,138
TOTALS	$1,338,692	$1,378,853	$1,970,220	$2,029,327	$2,090,207	$2,152,913	$2,217,500	$2,284,025	$2,352,546	$2,423,123	$2,495,816

Notes & Assumptions:
- Estimated costs are escalated at 3% annually in all operational areas.
- Cost of existing operations (Tribal Sturgeon Hatchery) shown from FY 2010 through FY 2011 (See Tables 8-9 and 8-10).
- Combined costs of operating both Tribal Sturgeon Hatchery and Twin Rivers Program shown starting in FY 2012

8.8 Research, Monitoring, and Evaluation

This section provides estimated conceptual costs for research, monitoring and evaluation associated with the combined aquaculture conservation programs and associated program elements.

Research associated with the Kootenai sturgeon and burbot programs involves disease investigation, optimizing gamete cryopreservation, early life history research, and chemical odorant investigations. Investigations of white sturgeon iridovirus (WSIV) is a major concern and investigations are proposed to determine diagnostic improvements and the susceptibility of various size fish to the disease. The genetic differences among the WSIV from the Sacramento, Lower Columbia, Snake, and Kootenai rivers is also proposed for investigation. A fourth WSIV-related investigation is aimed at determining if an immune surveillance method for WSIV-exposed fish could be developed to screen fish at hatcheries or in the wild.

Burbot research will also target health issues, including the effects of formalin on egg survival and hatch rates. In addition, establishment of burbot cell lines and their susceptibility to viral diseases as well as the susceptibility of juvenile burbot to fish pathogens will be investigated.

Monitoring and evaluating the hatchery programs is critical to determining their success. Sections 4.4 and 5.4 discuss the proposed monitoring and evaluation programs for Kootenai sturgeon and burbot, respectively. The health of Kootenai sturgeon broodstock and progeny will be monitored as will their post-release performance. Cryopreservation of Kootenai sturgeon gametes will continue.

Burbot will be monitored for transmission of disease between cultured and natural populations. In addition, genetic diversity and performance criteria, e.g., pre- and post-release growth, survival, relative weight, biological condition, age class structure will be tracked. Cryopreservation of burbot gametes will also be conducted.

The costs associated with monitoring and evaluation are summarized in Tables 8-12 and 8-13. Estimated expenses for FY 2010, which are currently being incurred, are $702,000. These expenses are not expected to increase with the addition of the Twin Rivers Hatchery facility. The majority of the current costs are for subcontracted services, which include genetics monitoring, contaminants analysis, gamete preservation, burbot aquaculture techniques, data analysis, and associated statistical analysis. These subcontracted services costs comprise at about 70% of the budget. The use of subcontracted experts in specific areas provides a very efficient way of obtaining needed expertise to support the program. Were the Kootenai Tribe to develop and staff these specific services, costs would be significantly higher than the estimates provided. The current estimated costs are escalated at 3% annually from FY 2010 through FY 2020 (Table 8-13).

8.8.1 Implications of Phasing Construction of the Burbot Program on Monitoring and Evaluation Expenses

If construction of facilities for the proposed burbot programs were delayed, it would not reduce monitoring and evaluation costs. It is possible, however, that experimental costs could increase due to potentially contracting for support and facilities. It cannot be assumed that the delaying the proposed burbot facilities would significantly reduce the monitoring and evaluation costs.

Table 8-12. Annual monitoring and evaluation expenses.

Expense Area	Estimated Annual Expenses (2010 dollars)
Payroll / Fringe	$132,126
Indirect	$77,954
Travel Costs (Mileage, Lodging, Per Diem)	$5,923
Professional Services (Data Base, Information System)	$4,738
Vehicles, Boats, Equipment, Transportation (Fuel, Oil, Maintenance, Mileage)	$3,980
Program Supplies (Office)	$1,185
Program Supplies (Fish Food, Aquaculture & Facility Chemicals, Hatchery Supplies)	$9,476
Equipment & Building Maintenance	$0
Utilities (Electrical, Telephone, Natural Gas, Water), Insurance	$7,107
Subcontracted Services	$459,398
TOTAL	$701,886

Notes & Assumptions:
- Estimates shown in 2010 dollars
- Subcontracted services include; genetics monitoring, contaminants analysis, gamete preservation, burbot aquaculture techniques, data analysis and statistics

8.9 Ten-Year Future Cost Summary

Estimated 10-year costs to operate the conservation aquaculture programs at the Tribal Sturgeon Hatchery and Twin Rivers Hatchery from FY 2010 through FY 2020 are presented in Table 8-14. All estimated costs are allocated to the fiscal year in which the expense will likely occur. As stated in Section 8.1.3, costs for each program area are escalated to the year in which they are expected to occur. This estimated cost summary assumes planning and implementation of new facilities for both the burbot and sturgeon programs would occur in 2010 through 2012.

As previously noted, consistent with Step 1 of the Council's Three-Step process, cost estimates at this stage are conceptual. The Kootenai Tribe will refine these estimates during the Step 2 and Step 3 planning phases. This 10-year estimated cost summary is designed to be a planning tool and will be updated as costs are refined.

Table 8-13. Estimated monitoring and evaluation expenses – 10-year projection.

Expense Area	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Payroll / Fringe	$132,126	$136,090	$140,173	$144,378	$148,709	$153,171	$157,766	$162,499	$167,374	$172,395	$177,567
Indirect	$77,954	$80,293	$82,702	$85,183	$87,738	$90,371	$93,082	$95,874	$98,750	$101,713	$104,764
Travel Costs (Mileage, Lodging, Per Diem)	$5,923	$6,100	$6,283	$6,472	$6,666	$6,866	$7,072	$7,284	$7,502	$7,728	$7,959
Professional Services (Data Base, Information Systems)	$4,738	$4,880	$5,027	$5,177	$5,333	$5,493	$5,657	$5,827	$6,002	$6,182	$6,367
Vehicles, Boats, Equipment, Transportation (Fuel, Oil, Maintenance, Mileage)	$3,980	$4,099	$4,222	$4,349	$4,479	$4,614	$4,752	$4,895	$5,042	$5,193	$5,349
Program Supplies (Office)	$1,185	$1,220	$1,257	$1,294	$1,333	$1,373	$1,414	$1,457	$1,500	$1,546	$1,592
Program Supplies (Fish Food, Aquaculture & Facility Chemicals, Hatchery Supplies)	$9,476	$9,760	$10,053	$10,355	$10,665	$10,985	$11,315	$11,654	$12,004	$12,364	$12,735
Equipment & Building Maintenance	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Utilities (Electrical, Telephone, Natural Gas, Water), Insurance	$7,107	$7,320	$7,540	$7,766	$7,999	$8,239	$8,486	$8,741	$9,003	$9,273	$9,551
Subcontracted Services	$459,398	$473,180	$487,375	$501,996	$517,056	$532,568	$548,545	$565,001	$581,951	$599,410	$617,392
TOTALS	$701,886	$722,943	$744,631	$766,970	$789,979	$813,679	$838,089	$863,232	$889,129	$915,802	$943,276

Notes & Assumptions:
- Estimated costs are escalated at 3% annually in all expense areas
- Assume M&E expenses do not increase with the addition of Twin Rivers in 2012.

Table 8-14. Ten-year summary of future costs, FY 2010 - FY 2020.

Program Area	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
A. Planning and Design											
A.1 Step 1: Conceptual Engineering, Planning											
A.2 Step 2: Preliminary Engineering, Planning & Environmental Compliance	$732,899	$314,100									
A.3 Step 3: Final Engineering, Planning		$1,017,114									
B. Construction											
B.1 Existing Site Estimated Construction Costs			$903,000								
B.2 Twin Rivers Estimated Construction Costs			$13,094,000								
B.3 Twin Rivers Estimated Construction Costs (Separable Components)			$1,254,000								
C. Capital Equipment											
C.1 Capital Equipment			$423,790								
D. Environmental Compliance											
D.1 Environmental Compliance	$65,818	$98,727									
E. Land Purchase and Easements (to be determined)											
E.1 Land Purchases, Leases & Easements	$0										
F. Operations and Maintenance											
F.1 Sturgeon Program (Existing Tribal Hatchery)	$1,338,692	$1,378,853									
F.2 Sturgeon & Burbot Program (Existing Tribal Hatchery & Twin Rivers)			$1,970,220	$2,029,327	$2,090,207	$2,152,913	$2,217,500	$2,284,025	$2,352,546	$2,423,123	$2,495,816
G. Monitoring and Evaluation											
G.1 Monitoring & Evaluation Program	$701,886	$722,943	$744,631	$766,970	$789,979	$813,679	$838,089	$863,232	$889,129	$915,802	$943,276
Total Estimated Capital Costs	$798,718	$1,429,941	$15,674,790	$0	$0	$0	$0	$0	$0	$0	$0
Total Estimated O&M Costs	$2,040,578	$2,101,796	$2,714,851	$2,796,297	$2,880,186	$2,966,592	$3,055,589	$3,147,257	$3,241,675	$3,338,925	$3,439,093
Total Estimated Costs	$2,839,296	$3,531,737	$18,389,642	$2,796,297	$2,880,186	$2,966,592	$3,055,589	$3,147,257	$3,241,675	$3,338,925	$3,439,093

Notes and Assumptions:

A1 Step 1 Planning (based on current expenditures to complete planning)

A2 Step 2 Planning (based on estimate in FY 2010 budget, assume 70% of expenses in FY 2010 and 30% in FY 2011) escalation was included in FY 2010 budget

A3 Step 3 Planning (based on estimates put together for the FY 2010 budget, assumes 100% of expenses in FY 2011)

B.1 Existing site estimated construction costs (escalated from 2009 dollars to mid 2012 dollars)

B.2 Twin Rivers estimated construction costs (escalated from 2009 dollars to mid 2012 dollars)

B.3 Twin Rivers estimated construction costs, separable components (budget shown was escalated from 2009 dollars to mid 2012 dollars)

C.1 Capital equipment, estimated lump sum for equipment items not shown in construction estimate (escalated from 2009 to 2012 dollars)

D.1 Environmental compliance costs (assumes 40% of expenses in FY 2010 and 60% of expenses in FY 2011)

E.1 Land purchases, leases and easements (to be determined)

F O&M costs escalated at 3% annually. Increased costs for expanded production is assumed to start in FY 2012

F.1 Sturgeon and burbot program (existing Tribal Sturgeon Hatchery program, operations sharing with new site starts in 2012)

F.2 Sturgeon and burbot program (existing Tribal Sturgeon Hatchery and Twin Rivers starts in 2012)

G.1 Monitoring and evaluation program (costs escalated at 3% annually, increased costs for expanded production is assumed to start in FY 2012)

9 Summary

The programs outlined in this Master Plan reflect the Kootenai Tribe's vision of an effective recovery strategy for Kootenai sturgeon and burbot and are integral components in the holistic restoration of the watershed envisioned by the Tribe. Over the last century, these once abundant species have declined and the ecosystem that supported them has been significantly damaged. The proposed upgrades and newly developed hatchery facilities would enable the Tribe to continue its efforts to conserve native sturgeon and burbot populations. Conservation aquaculture would provide adequate facilities to address future contingencies for the propagation of these two imperiled species. Implementation timing is critical; both programs must incorporate genetic material contained in remnant populations. Every precautionary biological argument supports this bold and aggressive approach.

The hallmark of the Tribe's efforts to date in developing and improving aquaculture techniques for these species at risk has been its adaptive approach to addressing substantial uncertainties. This experience has demonstrated that surprises and course adjustments are inevitable. Research and monitoring efforts over the last 10 to 20 years have produced a number of surprises, each with significant implications for sturgeon and burbot recovery. The proposed upgraded and expanded hatchery facilities will provide the flexibility necessary to respond to such new information and to maximize operational and program flexibility. Without construction of the proposed Twin Rivers facility, the flexibility of the Tribe's ongoing Kootenai sturgeon program is significantly constrained. Without construction of the proposed Twin Rivers facility, large-scale experimental burbot aquaculture is stymied.

Proposed hatchery facilities ultimately represent an investment in reducing risk. Given the irreversible consequences of failure, the Tribe concludes that the benefits of precautionary investments warrant the costs. Having operated the Tribal Sturgeon Hatchery for years on very modest budgets, the Tribe recognizes that costs versus benefits must always be considered. Expanding hatchery capacity and developing facilities to propagate burbot clearly involves a significant cost. The Tribe's position is that failure to take aggressive action when given this opportunity may have long-term detrimental consequences.

The ISRP expressed hesitation about the proposed burbot program due to a variety of uncertainties. The Tribe suggests that the most expeditious method for identifying the suitability or limitations of current environmental conditions for burbot will be through research, monitoring, and evaluations following reintroduction. Too few naturally produced burbot are currently available to identify limiting factors or remedies for restoring a population through natural production. Hatchery produced fish will tell us where these limitations occur based on an empirical adaptive implementation design. Understanding burbot population bottlenecks, a prerequisite for long-term restoration success, will only be possible by having fish in the river. Currently this can occur only through experimental stocking and monitoring of cultured fish. Available facilities are unable to produce an adequate number of fish to conduct such experiments.

Long-term monitoring efforts have established that current habitat conditions in the Kootenai River and Kootenay Lake are suitable for subadult and adult burbot life stages. Current conditions support migration and spawning. Population failure appears to occur somewhere in the incubation to early rearing stages. Releases of burbot at various sizes and ages would allow the Tribe and its partners to more narrowly identify the limiting life stage and focus restoration efforts on environmental factors that affect that life stage. Carefully monitored releases of hatchery fish are required to evaluate stage-specific habitat requirements. Experimental evaluations of this type require releases of adequate numbers of burbot to provide the statistical sampling power to estimate size-related differences in survival.

Burbot are also an important consideration in the development and design of the Tribe's ecosystem based habitat restoration project. Using the hatchery to jumpstart the population by rearing fish past an apparent recruitment bottleneck will ensure that there are burbot in the river to take advantage of improved conditions when they occur. Once burbot numbers increase in the river, the Tribe will continue to work with its partners on habitat rehabilitation issues that will be guided in the future by increased knowledge of burbot behaviors and habitat requirements within the Kootenai River.

The burbot component of the proposed Twin Rivers facilities represents a relatively modest investment that capitalizes on many shared sturgeon operational components. Concurrent development of the sturgeon and burbot facilities will result in significant cost savings for the burbot program relative to independently constructing facilities at a later date. Independent construction costs would include separate water supply and treatment facilities, separate effluent treatment and distinct operational infrastructure. Expanding existing facilities or constructing facilities outside of the Kootenai subbasin (even if possible and recommended) also would require greater expenditures over the long term.

The next questions about sturgeon and burbot aquaculture effectiveness concern post-release survival rates, effective release sizes and times, cost-effective rearing practices, long -term survival, growth, maturation, and contributions to future wild production. These questions cannot effectively be addressed with the production limitations of existing facilities.

The Tribe is optimistic that the proposed Kootenai sturgeon and burbot facilities will be approved and constructed as proposed in order to ensure the preservation and continued survival of these two native fish species of immeasurable cultural and economic significance to the Tribe.

10 Citations

Ahrens, R. and J. Korman. 2002. What happened to the West Arm burbot stock in Kootenay Lake? Use of an age-structured population model to determine the possible causes of recruitment failure. Report prepared for the B.C. Ministry of Water, Land, and Air Protection, the Habitat Conservation Trust Fund, and the Bonneville Power Administration. 29pp.

Alden, W. C. 1953. Physiography and glacial geology of western Montana and adjacent areas. U.S. Geological Survey, Professional Paper 231. Helena, Montana.

Anders, P.J. 1988. Conservation aquaculture and endangered species: Can objective science prevail over risk analysis? Fisheries. Volume 23(11): 29-31.

Anders, P. J. 1991. White sturgeon (Acipenser transmontanus) movement patterns and habitat use in the Kootenai River system, Idaho, Montana, and British Columbia. MS Thesis, Eastern Washington University. 153 pp.

Anders, P. J. 1993. Kootenai River Fisheries Studies. Annual Progress Report FY93, Report C: Kootenai River tributary kokanee spawning ground survey. Kootenai Tribe of Idaho. Prepared for U.S. Department of Energy, Bonneville Power Administration. Project No. 88-64. Portland, OR.

Anders, P.J. 1998. Conservation aquaculture and endangered species: Can objective science prevail over risk anxiety? Fisheries Vol. 23(11): 28-31.

Anders, P. J. 1999. Pursue integrated fisheries management. Fisheries. Vol. 24 (11):36

Anders, P.J. 2002. Conservation Biology of White Sturgeon. Ph.D. Dissertation, University of Idaho, Aquaculture Research Institute, Center for Salmonid and Freshwater Species at Risk. Moscow, ID. 221 pp. (7 Chapters).

Anders, P. J. 2004. Don't save sturgeon with salmon hatcheries: Life history matters. *In*: Proceedings of 55^{th} Annual Northwest Fish Culture Conference. December 7-9, 2004. Victoria, British Columbia. (http://www.fishsciences.net/reports/2004/anders_2004_sturgeon_salmon_hatcheries.pdf)

Anders, P. 2007. A decision guidance document regarding establishment of an experimental population of Kootenai River white sturgeon under Section 10(j) of the Endangered Species Act. P Kootenai Tribe of Idaho and the Kootenai River White Sturgeon Recovery Team. 8 pp.

Anders, P. J., D.L. Richards, and M.S. Powell. 2000. The first endangered white sturgeon population (Acipenser transmonanus): Repercussions in an altered large river-floodplain ecosystem. In: Proceedings of the 130th Annual Meeting of the American Fisheries Society. August 20-24, 2000. St. Louis, MO. 8.1-8.32 pp.

Anders, P. J., D. L. Richards, M. S. Powell. 2002. The first endangered white sturgeon population (*Acipenser transmontanus*): Repercussions in an altered large river-floodplain ecosystem. Pages 67-82 *In*: W. Van Winkle, P. Anders, D. Dixon, and D. Secor, eds. Biology, Management and Protection of North American Sturgeons. American Fisheries Society Symposium 28.

Andrusak, H. 1980. Kootenay River white sturgeon. British Columbia Ministry of Environment. Nelson, BC.

Apperson, K. A. and P. J. Anders. 1991. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY90. Idaho Department of Fish and Game. Prepared for the U.S. Department of Energy, Bonneville Power Administration. Project No. 88-65. Portland, OR.

Ashley, K. and L. Thompson. 1993. Kootenay Lake fertilization experiment: Year 1 (1992/93) Report. Fisheries Project Report No. RD 32, Ministry of Environment, Lands and Parks, Province of British Columbia.

Bailey, R.G., P.E. Avers, T. King, W.H. McNab, eds. 1994. Ecoregions and subregions of the United States (map). Washington, DC: U.S. Geological Survey. Scale 1:7,500,00. Accompanied by a supplementary table of map unit descriptions compiled and edited by W.H. McNab and R.G. Bailey. Prepared for the U.S. Department of Agriculture, Forest Service.

Bartley, D. M., G. A.E. Gall, and B. Bentley. 1985. Preliminary description of the genetic structure of white sturgeon, *Acipenser transmontanus* in the Pacific Northwest. In: F. P. Binkowski and S. E. Dorshov (eds.) North American Sturgeons. W. Junk Publishers, Dordrecht, The Netherlands

Baxter, J., C. Spence and M. Neufeld. 2002a. Kootenay Lake Burbot Studies Progress 2000-2001. Report prepared for the Ministry of Water Land and Air Protection, Nelson, BC.

Baxter, J., C. Spence and M. Neufeld. 2002b. Kootenay Lake Burbot Studies Progress 2001-2002. Report prepared for the Ministry of Water Land and Air Protection, Nelson, BC.

Beamesderfer, R. C. 1993. A standard weight (W_r) equation for white sturgeon. California Fish and Game 79(2): 63-69.

Beamesderfer, R. C. P., and R. A. Farr. 1997. Alternatives for the management and protection of sturgeons and their habitat. Environmental Biology of Fishes 48: 407-417.

Beamesderfer, R., C. Justice, M. Neufeld, P. Rust, V. Paragamian and S. Ireland. 2009. Kootenai sturgeon population status update, Review Draft. Prepared for the Bonneville Power Administration. July 2009.

Bonneville Power Administration. 1997. Kootenai river white sturgeon aquaculture project: environmental assessment. Bonneville Power Administration, DOE/EA-1169, Portland, OR.

Brannon, E. L. 1993. The perpetual oversight of hatchery programs. Fishery Research, 18:19-27.

Burke, M., K. Jorde, and J. Buffington. 2008. Application of a hierarchical framework for assessing environmental impacts of dam operation: Changes in stream flow, bed mobility and recruitment of riparian trees in a western North American River. Journal of Environmental Management 1-13. 2008.

Cain, K and N. Jensen. 2004. Preliminary Investigations into the Feasibility of Developing Conservation Aquaculture Techniques for Burbot (Lota lota). Annual report prepared for the Kootenai Tribe of Idaho. Bonners Ferry, ID.

Cain, K.D., N. R. Jensen, and P.J. Anders. 2008. Burbot Conservation Aquaculture Progress- 2007. Annual progress report prepared for the Kootenai Tribe of Idaho. Bonners Ferry, ID.

Canadian Department of Fisheries and Oceans (CDFO). 2009. Draft recovery strategy for white sturgeon. Species at risk act recovery strategy series.

Conte, F. S., S. I. Doroshov, P. B. Lutes, and M. E. Strange. 1988. Hatchery manual for the white sturgeon (*Acipenser transmontanus*) with application to other North American Acipenseridae. Publications Division, Agriculture and Natural Resources, University of California, Oakland. Publication 3322.

Coutant, C.C. 2004. A riparian hypothesis for successful reproduction of white sturgeon. Reviews in Fisheries Science 12:23-73.

Daley R.J., E.C. Karmach, C.B.J. Gray, C.H. Pharo, S. Jasper, and R.C. Wiegand. 1981. The effects of upstream impoundments on the limnology of Kootenay Lake, B.C. Scientific Service No. 117. National Water Research Institute, Inland Waters Directorate. Vancouver, British Columbia. 96 pp.

DeVore, D., B. James, and R. Beamesderfer. 1999. Lower Columbia River white sturgeon current stock assessment and management implications. Washington Department of Fish and Wildlife. Report No. SS 99-08.

Drauch, A. and B. May. 2007. Genetic monitoring of the Kootenai Tribe of Idaho White Sturgeon Conservation Aquaculture Program. Reported prepared for the Kootenai Tribe of Idah by the Genomic Variation Laboratory, Dept. of Animal Sciences. Univ of California – Davis. Davis, CA. 8 pgs.

Drauch, A. and B. May. 2008. Genetic Monitoring of the Kootenai Tribe of Idaho White Sturgeon Conservation Aquaculture Program. Davis, CA. University of California at Davis, Department of Animal Science, Genomic Variation Laboratory. November 2008.

Drauch, A. and B. May. 2009. Continued Genetic Monitoring of the Kootenai Tribe of Idaho White Sturgeon Conservation Aquaculture Program. Davis, CA. University of California at Davis, Department of Animal Science, Genomic Variation Laboratory. November 2009.

Drennan, J.D., S. Ireland, S.E. LaPatra, L. Grabowski, T.K. Carrothers, and K.D. Cain. 2005. High-density rearing of white sturgeon *Acipenser transmontanus* induces white sturgeon iridovirus disease among asymptomatic carriers. Aquaculture Research. 36(8): 824-827.

Drennan, J.D., S.E. LaPatra, J.T. Siple, S. Ireland, and K.D. Cain. 2006. Transmission of white sturgeon iridovirus in Kootenai River white sturgeon *Acipenser transmontanus*. Diseases of aquatic organisms. 70(1-2):37-45.

Drennan, J.D., S.E. LaPatra, C.A. Samson, S. Ireland, K.F. Eversman, and K.D. Cain. 2007a. Evaluation of lethal and non-lethal sampling methods for the detection of white sturgeon iridovirus infection in white sturgeon, *Acipenser transmontanus* (Richardson). Journal of Fish Diseases. 30(6):367-379.

Drennan, J.D., S.E. LaPatra, C.M. Swan, S. Ireland and K.D. Cain. 2007b. Characterization of serumand mucosal antibody responses in white sturgeon (*Acipenser transmontanus* Richardson) following immunization with WSIV and a protein hapten antigen. Fish and Shellfish Immunology. 23(3):657-669.

Dryer, M. P., and A. J. Sandoval. 1993. Pallid sturgeon recovery plan. USWFS Region 6, Denver CO.

Duke, S., P. Anders, G. Ennis, R. Hallock, J. Hammond, S. Ireland, J. Laufle, R. Lauzier, L. Lockhard, B. Marotz, V.L. Paragamian, and R. Westerhof. 1999. Recovery plan for Kootenai River white sturgeon (*Acipenser transmontanus*). Journal of Applied Ichthyology. 15(4-5):157-163.

Engineering News Record, McGraw Hill. 2008. Cost Indexes by City. Retrieved July 2008 from http://enr.com/.

Ericksen, R., P. Anders, C. Lewandowski and J. Siple. 2009. Status of Kokanee Populations in the Kootenai River in Idaho and Montana and South Arm Kootenay Lake, B.C. Draft report to Kootenai Tribe. Cramer Fish Sciences, Portland, OR.

Evenson, M. J. 2000. Reproductive traits of burbot in the Tanana River, Alaska. Pages 61-70 in V. L. Paragamian and D. W. Willis, editors. Burbot: biology, ecology, and management. American Fisheries Society, Fisheries Management Section, Publication Number 1, Bethesda, MD.

Falconer, D. 5. 1981. Introduction to Quantitative Genetics, 2nd Edition. Longman Inc., London. 352 pp.

Gilpin, M. E. and M. E. Soule. 1986. Minimum viable populations: processes of species extinction. Pages 19-34 In: M.E. Soule ed. Conservation biology: The science of scarcity and diversity. Sinauer Associates, Sunderland, MA.

Halbert, C. L. 1993. How adaptive is adaptive management? Implementing adaptive management in Washington state and British Columbia. *Reviews in Fisheries Science* 1:261-283.

Hammond, RJ and P.J. Anders. 2003. Population Biology and Population Genetics Reviews of Kootenai Basin Burbot Upstream from Bonnington Falls, B.C. Draft report prepared for the US Dept of Energy, Bonneville Power Administration Division of Fish and Wildlife. Portland, OR. Contract No. 00012146.

Harzevili, A.S., D, De Charleroy, J. Auwerx, J. Van Slycken, P. Dhert, P. Sorgeloos. 2003. Larvae rearing of burbot (*Lota lota*) using *Brachionus calyciflorus* rotifer as starter food. Journal of Applied Ichthyology. 19(2): 84-87.

Hilborn, R. 1992. Current and future-trends in fisheries stock assessment and management. South African Journal of Marine Science. 12:975-988.

Holderman, C., P. Anders, B. Shafii and G. Lester. 2009a. Characterization of the Kootenai River aquatic macroinvertebrate community before and after experimental nutrient addition, 2003-2006. Report to Kootenai Tribe of Idaho and Bonneville Power Administration. 94 pp.

Holderman, C., P. Anders and B. Shafii. 2009b. Characterization of the Kootenai River algae and periphyton community before and after experimental nutrient addition, 2003-2006. Report to Kootenai Tribe of Idaho and Bonneville Power Administration. 76 pp

Holderman, C., P. Anders, B. Shafii, and G. Hoyle. 2010. Characterization of Water Quality in the Kootenai River before and after Experimental Nutrient Addition, 2003-2008. Report prepared for the Kootenai Tribe of Idaho. 72 pp. (In preparation).

Holtgren, M. J., S. A. Ogren, and A. J. Paquet. 2007. Design of a Portable Streamside Rearing Facility for Lake Sturgeon. North American Journal of Aquaculture, 69(4): 317-323

Hoyle, G., C. Holderman, P. Anders. B. Shafii, W. Price, and K. Ashley. 2010. A fine-scale evaluation protocol for nutrient restoration in large rivers: Statistical analysis and ecological implications. Report prepared for the Bonneville Power Administration, Portland, OR. Project No. 199404900. 77 pp.

Hubbs, C.L., and L.P. Schultz. 1941. Contributions to the ichthyology of Alaska with descriptions of two new fishes. University of Michigan Museum of Zoology, Occasional Papers 431, Ann Arbor.

IUCN (International Union for Conservation of Nature). 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. http://intranet.iucn.org/webfiles/doc/SSC/RedList/redlistcatsenglish.pdf

Ireland, S.C. 1997. Kootenai River white sturgeon studies and conservation aquaculture. Annual report. BPA Project No. 88-64. Portland, OR.

Ireland, S.C. 1999. Kootenai River White Sturgeon Studies and Conservation Aquaculture. Kootenai Tribe of Idaho. Prepared for Bonneville Power Administration. Progress Report, Contract DE-B179-88BI93743, Project 88-64, Portland, OR.

Ireland, S.C., R. C .P Beamesderfer, V. L. Paragamian, V. D. Wakkinen and J. T. Siple. 2002a. Success of hatchery-reared juvenile white sturgeon (*Acipenser transmontanus)* following release in the Kootenai River, Idaho, USA. Journal of Applied Ichthyology 18: 642-650.

Ireland, S. C., P. J. Anders, and J. T. Siple. 2002b. Conservation aquaculture: An adaptive approach to prevent extinction of an endangered white sturgeon population (*Acipenser transmontanus*). Pages 211-222 *In*: W. Van Winkle, P. Anders, D. Dixon, and D. Secor, eds. Biology, Management and Protection of North American Sturgeons. American Fisheries Society Symposium 28.

Ireland, S. C., P. J. Anders, R. C. P. Beamesderfer, and J. T Siple. 2003. An adaptive conservation aquaculture program for endangered Kootenai River white sturgeon: past, present, and future. *In*: Proceedings of the Cultured Fishes Symposium. Western Division AFS Mtg. Boise, ID. June 2003.

Ireland, S. C., and P. N. Perry. 2008. Burbot restoration in the Kootenai River basin: Using agency, tribal, and community collaboration to develop and implement a conservation strategy. American Fisheries Society Symposium 59:251-256.

Independent Science Advisory Board (ISAB). 2007. Climate Change Impacts on Columbia River Basin Fish and Wildlife. Prepared for the NPCC, Portland OR. May 2007.

Jager, H. I. 2005. Genetic and demographic implications of aquaculture in white sturgeon (*Acipenser transmontanus*) conservation. Can. J. Fish. Aquat. Sci. 62: 1733–1745.

Jensen, N. R. 2006. Development of aquaculture techniques for burbot: Implications for conservation aquaculture and restoration of burbot in Idaho's Kootenai River. MS. Thesis, University of Idaho 135 pp.

Jensen, N.R., P.J. Anders, and K.D. Cain. 2008. Burbot Conservation Aquaculture Progress, 2007. Annual Progress Report prepared for the Kootenai Tribe of Idaho. 37 pp.

Jensen, N. R., S. R. Williams, S. C. Ireland, J. T. Siple, M. D. Neufeld, and K. D. Cain. 2008a. Preliminary captive burbot spawning observations. Pages 155-165 *in* V.L. Paragamian and D.H. Bennett, editors. Burbot: Ecology, Management, and Culture. American Fisheries Society, Symposium 59, Bethesda, MD.

Jensen, N. R., S. C. Ireland, J. T. Siple, S. R. Williams, and K. D. Cain. 2008b. Evaluation of egg incubation methods and larval feeding regimes for North American burbot. North American Journal of Aquaculture. 70: 162-170.

Jensen, N. R., M. D. Zuccarelli, S. J. Patton, S. R. Williams, S. C. Ireland, and K. D. Cain. 2008c. Cryopreservation and methanol effects on burbot sperm motility and egg fertilization. North American Journal of Aquaculture. 70: 38-42.

Jensen, N. and K. Cain. 2009. Burbot: not just another cod. Hatchery International 10(3).

Jensen, N., S. Ireland, M. Neufeld, P. Anders, R. Jones, V. Paragamian, and K. Cain. 2010. Hatchery reared burbot released for the first time in British Columbia, Canada, and Idaho, USA. American Fisheries Society Fish Culture Section, Winter 2010 Newsletter, Pages 11-12.

Justice, C., B.J. Pyper, R.Beamsderfer, V. Paragamian, P,J, Rust, M. Neufeld and S.C. Ireland. 2009. Evidence of density and size dependent mortality in hatchery-reared juvenile white sturgeon in the Kootenai River. Canadian Journal of Fisheries and Aquatic Sciences. 66:1-14. 2009.

Kahilainen, K., and Lehtonen, H. 2003. Piscivory and prey selection of four predator species in a whitefish dominated subarctic lake. J. Fish Biol. 63: 659–672.

Kincaid, H. 1993. Breeding plan to preserve the genetic variability of the Kootenai River white sturgeon. U. S. Fish and Wildlife Service report (Project 93-27) to Bonneville Power Administration. Portland, OR.

Kinne, P. and P. Anders. 1996. Kootenai River water and sediment quality investigation, May 1994-1995-draft. Kootenai Tribe of Idaho. Bonners Ferry, Idaho.

Klontz, G.W. 1991. Fish for the Future: Concepts and Methods of Intensive Aquaculture. Idaho Forest, Wildlife and Range Experiment Station, College of Forestry, Wildlife and Range Sciences. University of Idaho, Moscow, ID. 192 pp.

Knudson, Ken. 1994. Water quality status report: Kootenay (Kootenai) River Basin British Columbia, Montana and Idaho. Kootenai River Network. Libby, MT. and Ecological Resource Consulting, Helena, MT. 57 pp.

Kock, T. J., J. Congleton, and P. J. Anders. 2006. Effects of Sediment Cover on Survival and Development of White Sturgeon Embryos. North American Journal of Fisheries Management 26:134–141.

Kootenai Tribe of Idaho (KTOI). 2004. Ireland, S.C., P. J. Anders and Ray C. P. Beamesderfer eds. An Adaptive Multidisciplinary Conservation Aquaculture Plan for Endangered Kootenai River White Sturgeon. Hatchery Management Plan prepared by the Kootenai Tribe of Idaho with assistance from S. P. Cramer and Associates. 51 pp.

KTOI. 2005. Anders, P., R. Beamesderfer, M. Neufeld, and S. Ireland (eds). Kootenai River White Sturgeon Recovery Implementation Plan and Schedule (2005-2010). Prepared by S. P. Cramer and Associates for the Kootenai Tribe of Idaho, with assistance from the Kootenai River White Sturgeon Recovery Team.

KTOI. 2008. Kootenai River White Sturgeon Conservation Aquaculture Program, 1990-2007 (Version 2). Bonners Ferry, Idaho. Report edited by R. Beamesderfer and P. Anders. 74 pp.

KTOI and Montana Fish Wildlife and Parks (MFWP). 2004. Kootenai Subbasin Plan. A report prepared for the Northwest Power and Conservation Council. Portland, OR. October 11, 2004.

KVRI Burbot Committee. 2005. Kootenai River/Kootenay Lake Burbot Conservation Strategy. Prepared by the Kootenai Tribe of Idaho. 77 pp. plus appendices.

Korman, J, P. Anders, C. Holderman, and S. Ireland. 2005. Draft Kootenai River Adaptive Management Plan. Draft report prepared for the Kootenai Tribe of Idaho. 11 pp.

Kynard, B., Erika Parker, B. Kynard, and T. Parker. 2007. Dispersal Characteristics, Drift Distance, and Wintering Behavior of Young Kootenai River White Sturgeon: A Laboratory Study. Report prepared for the Idaho Department of Fish and Game. 35 pp.

Kynard, B., E. Parker, and B. Kynard. 2006a. Behavior and Habitat of Young Kootenai River White Sturgeon. Report prepared by B.K. Riverfish Inc, Amherst MA. for the Kootenai Tribe of Idaho. 24 pp.

Kynard, B., and E. Parker. 2006b. Ontogenetic Behavior and Dispersal of Kootenai River White Sturgeon Early Life Intervals: A laboratory Study. Report prepared by B.K. Riverfish Inc, Amherst MA. for the Idaho Department of Fish and Game. 35 pp.

LaPatra, S.E., J.M. Groff, G.R. Jones, B. Munn, T.L. Patterson, R.A. Holt, A.K. Hauck, and R.P. Hedrick. 1994. Occurrence of white sturgeon iridovirus infections among cultured white sturgeon in the Pacific Northwest. Aquaculture 126:201-210.

LaPatra, S. E., S. C. Ireland, J. M. Groff, K. M. Clemens, and J. T. Siple. 1999. Adaptive disease management strategies for the endangered population of Kootenai River white sturgeon. Fisheries 24(5): 6-13.

LaPatra, S.E., J. M. Groff, T. L. Patterson, W. D. Shewmaker, M. Casten, J. Siple, and A. K. Hauck. 1994. Preliminary Evidence of Sturgeon Density and Other Stressors on Manifestation of White Sturgeon Iridovirus Disease, Journal of Applied Aquaculture 6(3):51-58.

Lower Columbia River Fish Recovery Board (LCFRB). 2004. Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan.

McCabe, G. T. and C. A. Tracy. 1993. Spawning characteristics and early life history of white sturgeon Acipenser transmontanus in the lower Columbia River. Report A. Pages 18-46 in R. C. Beamesderfer and A. A. Nigro editors. Status and habitat requirements of the white sturgeon populations in the Columbia River downstream from McNary Dam. Vol. 1. Final Report to the Bonneville Power Administration, Project No. 86-50. Portland, OR.

McElhany, P., M.H. Ruckleishaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. NOAA Technical Memorandum NMFS-NWFSC-42.

McPhail, J.D. and R. Carveth 1992. A foundation for conservation: the nature and origin of the freshwater fish fauna of British Columbia. Report to the Habitat Conservation Fund, Ministry of Environment, Lands and Parks. Victoria, B.C. 39 p.

McPhail, J. D. & V. L. Paragamian. 2000. Burbot Biology and Life History. American Fisheries Society: Burbot Biology, Ecology and Management 1: 11-23. In: V.L. Paragamian and D. Wills, editors. Burbot: biology, ecology, and management. American Fisheries Society, Fish Management Section, Bethesda, Maryland.

McQuown, E.C., B. L. Sloss, R. J. Sheehan, J., A. Rodzen, G. J. Tranah, and B. May. 2000. Microsatellite analysis of genetic variation in sturgeon: New primer sequences for *Scaphirhynchus* and *Acipenser*. Transactions of the American Fisheries Society 129:1380-1388.

Marcuson, P. 1994. Kootenai River white sturgeon investigations. Annual Progress Report FY1993. Idaho Department of Fish and Game. Prepared for US Department of Energy, Bonneville Power Administration. Project No. 88-65. Portland, OR.

Martin, A.D. 1976. Kootenay Lake burbot fishery. Unpublished report. British Columbia Fish and Wildlife. Nelson, B.C.

Montana Bull Trout Scientific Group (MBTSG). 1996a. Lower Kootenai River drainage bull trout status report (below Kootenai Falls). Prepared for The Montana Bull Trout Restoration Group. Helena, MT.

MBTSG 1996b. Upper Kootenai River drainage bull trout status report (including Lake Koocanusa). Prepared for The Montana Bull Trout Restoration Group. Helena, MT.

Mora, C., R. Metzger, A. Rollo, and R.A. Myers. 2007. Experimental simulations about the effects of overexploitation and habitat fragmentation on populations facing environmental warming. Proceedings of the Royal Society B 274:1023-1028.

Morrow, J. 1980. The Freshwater Fishes of Alaska. University of British Columbia Resource Ecology Library: University of British Columbia.

NMFS. 2007. Puget Sound Salmon Recovery Plan.

NMFS (National Marine Fisheries Service). 2009. Middle Columbia River Steelhead Distinct population Segment ESA Recovery Plan.

NRC (National Research Council). 1996. Upstream: Salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C.

NRTWS (National Recovery Team for White Sturgeon). 2009. Recovery strategy for white sturgeon (*Acipenser transmontanus*) in Canada. In Species at Risk Act Recovery Strategy Series. Ottawa: Fisheries and Oceans Canada.

Northcote, T.G. 1973. Some impacts of man on Kootenay Lake and its salmonids. Great Lakes Fishery Commission, Technical Report Number 25, Ann Arbor, MI.

NPCC. 2007. Project Cost Escalation Standards, Task 115. Independent Economic Analysis Board. NPCC document IEAB -2007-2. 16 pp.

Northwest Power and Conservation Council (NPCC). 2009. Columbia River Basin Fish and Wildlife Program. http://www.nwcouncil.org/library/2000/2000-19/Default.htm

Pacific Watershed Institute and Resources (PWI). 1999. Kootenai River watershed assessment report. Prepared for the Kootenai Tribe of Idaho. Bonners Ferry, ID.

Paragamian, V.L. 2002. Changes in the species composition of the fish community in a reach of the Kootenai River, Idaho, after construction of Libby Dam. Journal of Freshwater Ecology. 17:375-383.

Paragamian, V.L. and V. Whitman. 1996. Kootenai River fisheries investigations. Idaho Department of Fish and Game. Annual progress report prepared for Bonneville Power Administration Project No. 88-65. Portland, OR.

Paragamian, V.L., G. Kruse, and V. Wakkinen. 1997. Kootenai River fisheries white sturgeon spawning and recruitment evaluation. Annual Report 1997. Idaho Department of Fish and Game and Bonneville Power Administration. Portland, Oregon.

Paragamian, V. L., M. Powell, and J. Faler. 1999. Mitochondrial DNA analysis of burbot Lota lota stocks in the Kootenai River Basin of British Columbia, Montana, and Idaho. Transactions of the American Fisheries Society 128:854-860.

Paragamian, V.L., V. Whitmand, R.J. Hammond, and H. Andrusak. 2000. Collapse of burbot fisheries in Kootenay Lake, B. C. and the Kootenai River, Idaho. Pages 155-164 *in* V.L. Paragamian and D. W. Willis, editors. Burbot: Biology, Ecology, and Management. American Fisheries Society, Fisheries Management Section, Publication Number 1, Bethesda, MD.

Paragamian, V. L., S. Yundt, J. Hammond, C. Spence, S.C. Ireland, J. Laufle, S. Bettin. 2001. An international recovery strategy for burbot in the Kootenai River and Kootenay Lake, Idaho and British Columbia. Presented at the AFS symposium "Practical Approaches for the Conservation of Inland Native Fishes". June 6-8, 2001. Missoula, MT.

Paragamian, V.L., G. Kruse, and V. Wakkinen. 2001. Kootenai River white sturgeon spawning and recruitment evaluation, annual progress report January 1, 1999 to December 31, 1999. Idaho Department of Fish and Game report (01-27) to the Bonneville Power Administration. Portland, OR.

Paragamian, V.L., R.C.P. Beamesderfer, and S.C. Ireland. 2005. Status, population dynamics, and future prospects of the endangered Kootenai River white sturgeon population with and without hatchery intervention. Transactions of the American Fisheries Society. 134:518-532.

Paragamian, V.L. and M.J. Hansen. 2008. Rehabilitation needs for burbot in the Kootenai River, Idaho, USA, and British Columbia, CA. North American Journal of Fisheries Management 29(3): 768-777.

Paragamian, V.L., B.J. Pyper, J. Daigneault, R.C.P. Beamesderfer, and S.C. Ireland. 2008. Population dynamics and extinction risk of burbot in the Kootenai River Idaho, USA and British Columbia, Canada. American Fisheries Society Symposium 59: 213-234.

Partridge, F. 1983. River and stream investigations. Idaho Department of Fish and Game, Federal aid to fish and wildlife restoration, Project F-73-R-5, Subproject IV, Study IV: Kootenai River Fisheries Investigations.

Polinski, M.P., Drennan, J.D., Batts, W.N., Ireland, S.C. and K.D. Cain. 2009a. Establishment of a cell line from burbot Lota lota with characterization of susceptibility to IHNV, IPNV and VHSV. Diseases of Aquatic Organisms (accepted).

Polinski, M.P., Fehringer, T.R., Johnson, K.A., Snekvik, K.R., LaPatra, S.E., LaFrentz, B.R., Ireland, S.C. and K.D. Cain. 2009b. Characterization of susceptibility and carrier status of burbot to IHNV, IPNV, *Flavobacterium psychrophilum, Aeromonas salmonicida,* and *Renibacterium salmoninarum*. Journal of Fish diseases (Accepted).

Polinski, M.P., N.R. Jensen, K.D. Cain, K.A. Johnson and S.C. Ireland. 2009c. Assessment of formalin and hydrogen peroxide use during egg incubation of North American burbot. North American Journal of Aquaculture 72: 111-117.

Polinksi, M.P., N. R. Jensen, and K.D. Cain. 2010a. Assessment of formalin and hydrogen peroxide use during egg incubation of North American burbot. North American Journal of Aquaculture 72:111–117.

Polinski, M.P, T. R. Fehringer, K.A. Johnson, K. R. Snekvik, S. E. LaPatra, B. R. LaFrentz, S. C. Ireland, and K D Cain. 2010b. Characterization of susceptibility and carrier status of burbot, *Lota lota* (L.), to IHNV, IPNV, Flavobacterium psychrophilum, Aeromonas salmonicida and Renibacterium salmoninarum. Journal of Fish Diseases ( ): 1-12.

Powell, M. V.L. Paragamian, and J. Dunnigan. 2008. Mitochondrial variation in Western north American burbot with special reference to the Kootenai River in Idaho and Montana. Pages 3-28, In: American Fisheries Society Symposium 59.

Pyper, B.J., M.J. Daigneault, R.C.P. Beamesderfer, V.L. Paragamian, and S.C. Ireland. 2004. Status and population dynamics of burbot in the Kootenai River, Idaho and British Columbia, Canada. *In* V.L. Paragamian Kootenai River Fisheries Investigation: burbot stock status. Idaho Department of Fish and Game. Bonneville Power Administration. Annual Progress Report, Project 88-65. Boise, Idaho.

Redfish Consulting, Ltd. 1998. Investigation of burbot in Kootenay Lake, 1997. Prepared for British Columbia Ministry of Environment, Lands, and Parks. Nelson, BC.

Riede, K. 2004. Global register of migratory species - from global to regional scales. Final report of the R&D Project 808 05 081. Bonn, Germany: Federal Agency for Nature Conservation.

Rodzen, J. and B. May. 2002. Inheritance of microsatellite loci in the white sturgeon (*Acipenser transmontanus*). Genome 45: 1064-1076.

Rodzen, J. B., P. May, P.J. Anders and S. Ireland. 2004. Initial microsatellite analysis of wild Kootenai River white sturgeon and subset brood stock groups used in a conservation aquaculture program. Report prepared for the Kootenai Tribe of Idaho and the U.S. Department of Energy, Bonneville Power Administration, Portland, OR. Project No. 88-64. 36 pp.

Rust, P. J., V. L. Paragamian, and V. Wakkinen. 2003. Kootenai River white sturgeon spawning and recruitment evaluation. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. IDFG Report Number 03-55, Boise, Idaho.

Rust, P. J., and V. Wakkinen. 2004. Kootenai River white sturgeon spawning and recruitment evaluation. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. IDFG Report Number 04-03, Boise, Idaho.

Schram, S. T. 2000. Seasonal movement and mortality estimates of burbot in Wisconsin waters of western Lake Superior. In Burbot: biology, ecology, and management Paragamian, V. L. and D. W. Willis, editors. eds., pp. 90–95.American Fisheries Society, Fisheries Management Section, Publication Number 1. Bethesda, MD.

Scott, W.B. and E. J. Crossman. 1973. Freshwater Fishes of Canada. Bulletin 184. Fisheries Research Board of Canada.

Setter, A.L. 1988. Stock analysis of white sturgeon in the Columbia River. MS Thesis, University of Idaho, Moscow. 63 pp.

Setter, A.L. and E. Brannon. 1992. A summary of stock identification research on white sturgeon of the Columbia River (1985-1990). Project No. 89-44. Final Report to the Bonneville Power Administration, Portland OR.

Shafii, B., W. J. Price, C. Holderman, C. Gidley, and P, Anders. 2010. Modeling fish length distribution using a mixture model technique. Proceedings of the 22nd Annual American Statistical Association Conference of Applied Statistics in Agriculture. *Accepted.*

Shepard, B.B., B.E. May, and W. Urie. 2003. Status of westslope cutthroat trout (*Oncorhynchus clarki lewisi*) in the United States: 2002. Montana Fish, Wildlife and Parks for the Westslope Cutthroat Trout Interagency Conservation Team. Helena, Montana.

Simpson, J.C. and R.L. Wallace. 1982. Fishes of Idaho. University of Idaho Press. Moscow, ID. 1982.

Snyder, E.B. and G.W. Minshall. 1994. Ecosystem metabolism and nutrient dynamics in the Kootenai River in relation to impoundment and flow enhancement for fisheries management. Annual Report. Stream Ecology Center, Idaho State University, Pocatello, ID.

Sorokin, V.N. 1971. The spawning and spawning grounds of the burbot, *Lota lota* (L.). Journal of Ichthyology 11: 907-916.

Spence, C. 1999. Kootenay Lake burbot study. Report prepared by the B.C Ministry of the Environment, Lands and Parks, Victoria, for the Habitat Conservation Trust Fund and the Columbia Basin Fish and Wildlife Authority.

Taylor, J. L., and J. D. McPhail. 2000. Temperature, development, and behavior in the early life history of Burbot from Columbia Lake, British Columbia. Pages 30-37 *in* V.L. Paragamian and D.W. Willis, editors. Burbot Biology, Ecology and Management. American Fisheries Society, Publication Number 1, Bethesda, Maryland.

Thompson, G. G. 1991. Determining Minimum Viable Populations under the Endangered Species Act. NOAA Technical Memorandum NMFS F/NMC-198, NMFS, Seattle, Washington.

U.S. Army Corps of Engineers (USACE). 2002. Upper Columbia River Alternative Flood Control and Fish Operations Interim Implementation - Libby and Hungry Horse Dams Montana, Idaho and Washington – Final Environmental Assessment.

U.S. Environmental Protection Agency (EPA). 2004. Kootenai River Valley Wetlands and Riparian Conservation Strategy. Kootenai Tribe of Idaho, Bonners Ferry, ID. 76pp.

U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants; determination of endangered status for the Kootenai River population of white sturgeon-Final Rule. Federal Register 59(171):45989-46002. September 6, 1994.

U.S. Fish and Wildlife Service. 1996. Draft Recovery Plan for the Kootenai River population of the white sturgeon (*Acipenser transmontanus*). Region 1, USFWS, Portland, OR.

U.S. Fish and Wildlife Service. 1999. Recovery plan for the Kootenai River population of the white sturgeon (*Acipenser transmontanus*). Region 1, USFWS, Portland, OR.

U.S. Fish and Wildlife Service. 2000. Biological Opinion on Federal Columbia River Power System Operations. U.S. Fish and Wildlife Service. Portland, OR. 97 pp.

U.S. Fish and Wildlife Service. 2002. Chapter 4, Kootenai River Recovery Unit, Oregon. *In*: U.S. Fish and Wildlife Service Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. Portland, OR. 89 pgs.

U.S. Fish and Wildlife Service. 2006. Biological Opinion regarding the effects of Libby Dam operations on the Kootenai River white sturgeon, bull trout and Kootenai sturgeon critical habitat (1-9-01-F-0279R). U.S. Fish and Wildlife Service. Portland, OR. 164 p.

Upper Columbia River White Sturgeon Recovery Initiative (UCWSRI). 2002. Upper Columbia River white sturgeon recovery plan.

Van Eenennaam, J.P., S.I. Doroshov, and G.P. Moberg. 1996. Spawning and reproductive performance of domestic white sturgeon (*Acipenser transmontanus*). *In* Proceedings of Culture and Management of Sturgeon and Paddlefish Symposium, pp. 117-122. American Fisheries Society, San Francisco, CA.

Van Houdt, J. K., B. Hellmans, and F.A.M. Volkaert. 2003. Phylogenetic relationships among Palearctic and Nearctic burbot *lLota lota*): Pleistocene extinctions and recolonization. Molecular Ecology 14: 2445-2457.

Van Houdt, J. K., J. L. De Cleyn, A. Perretti, and F.A.M. Volkaert. 2005. A mitogenic view on the evolutionary history of the Holoiacrtic freshwater gadoid, burbot (*Lota lota*). Molecular Phylogenetuics and Evolution 29:599-612.

Walters C., J. Korman, P. Anders, C. Holderman and S. Ireland. 2005. Draft Kootenai River Adaptive Management Plan.

Wolnicki, J., L. Myszkowski, and R. Kamiński. 2001. The influence of water temperature on the growth, survival, condition factor and biological quality of juvenile burbot, *Lota lota* (L.). Archives of Polish Fisheries. Vol. 9, Fasc. 1, 79-86.

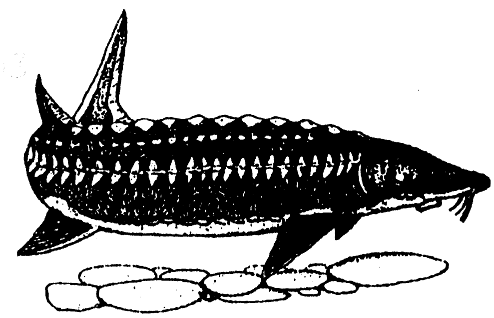
Wolnicki, J., R. Kamiński and L. Myszkowski. 2002. Temperature-influenced growth and survival of burbot *Lota lota* (L.) larvae fed live food under controlled conditions. Archives of Polish Fisheries. Vol. 10, Fasc. 1, 109-113.

Young, W.T. and D.L. Scarnecchia. 2005. Habitat use of juvenile white sturgeon in the Kootenai River, Idaho and British Columbia. Hydrobiologia. 537: 265-271.

Zuccarelli, M.D., N. Jensen and R.L. Ingermann. 2007. Inhibatory effect of osmotic concentration, potassium and pH on motility of the sperm of North American burbot (*Lota lota* maculosa). Journal of Fish Biology. 70:178-189.

Appendix A

Kootenai River White Sturgeon HGMP



APPENDIX A KOOTENAI RIVER HATCHERY: HATCHERY AND GENETIC MANAGEMENT PLAN FOR KOOTENAI RIVER WHITE STURGEON

Hatchery Program:
White Sturgeon Conservation Aquaculture

Species or Hatchery Population/Strain:
Kootenai River White Sturgeon

Agency Operator:
Kootenai Tribe of Idaho

Watershed and Region:
Kootenai / Mountain Columbia

Date Submitted: 12/15/2000

Date Last Updated: 12/15/2000

SECTION 1. GENERAL PROGRAM DESCRIPTION

1.1) Name of hatchery or program.
Kootenai Tribe of Idaho White Sturgeon Conservation Hatchery

1.2) Species and population (or strain) under propagation, ESA/population status.
White sturgeon (*Acipenser transmontanus*) ESA endangered (9/6/94)

1.3) Responsible organization and individuals

Name (and title): ***Susan Ireland Biologist/Administrator (lead contact)***
John Siple Hatchery Manager (on-site operations lead)
Agency or Tribe: ***Kootenai Tribe of Idaho***
Address: ***P.O. Box 1269, Bonners Ferry, Idaho 83805***
Telephone: ***(208) 267-3620***
Fax: ***(208) 267-1131***
Email: ***ireland@kootenai.org***

Other agencies, Tribes, co-operators, or organizations involved, including contractors, and extent of involvement in the program:

The Kootenai Tribe of Idaho (KTOI) administers and operates the hatchery program and conducts monitoring and evaluation studies. Hatchery monitoring and evaluation is closely integrated with other investigations of Kootenai River fisheries and the ecosystem by the Idaho Department of Fish and Game (IDFG), Montana Department of Fish Wildlife and Parks (MFWP), and the KTOI. The KTOI also subcontracts to the University of Idaho (U of I), College of Southern Idaho (CSI), Idaho Department of Fish and Game, U. S. Fish and Wildlife Service (USFWS), U. S. Geological Survey (USGS), and British Columbia Ministry of Fisheries (BCMF) for technical services including disease and genetic monitoring, cryopreservation research, database management, and facility support.

The Kootenai Sturgeon Hatchery is part of a cooperative sturgeon conservation and recovery program being implemented and coordinated through a white sturgeon recovery team that includes members from the U. S. Fish and Wildlife Service, Kootenai Tribe of Idaho, Idaho Department of Fish and Game, Montana Fish, Wildlife, and Parks, University of Idaho, Army Corps of Engineers (ACOE), British Columbia Ministry of Environment, Land, and Parks (BCMELP), and Canada Department of Fisheries and Oceans (CDFO).

1.4) Funding source, staffing level, and annual hatchery program operational costs.

The Bonneville Power Administration under the Resident Fish Portion of the Northwest Power Planning Council's Fish and Wildlife Program funds hatchery construction, operations, administration, research, and monitoring. Cost sharing is also provided by the Upper Columbia United Tribes, U. S. Fish and Wildlife Service, British Columbia Ministry of Fisheries, U.S. Geological Survey, and Clear Springs Foods in the form of cash or in-kind facilities and services.

Current staff includes the biologist/administrator, the hatchery manager, and five hatchery technicians.

Table 1 summarizes program operational costs. Operation and maintenance costs including personnel and facilities typically average $600,000 to $700,000 per year. The program also includes significant planning and monitoring components, which comprise about 2-4% and 10-25% of the annual budget, respectively. Development of the hatchery program has been implemented in phases with the next scheduled capital construction phase scheduled for 2003-2004. Table 2 contains summary of program development and investments.

Table 1. Projected Fiscal Year 2001 – 2005 budgets.

	FY 2001	FY 2002	FY03	FY04	FY05
Planning and design	50,000	95,000	35,000		
Construction/implementation	164,000	184,000	2,000,000	640,000	400,000
Operations and maintenance	622,375	635,000	650,000	650,000	900,000
Monitoring and evaluation	292,193	316,000	314,000	314,000	314,000
Total	1,128,568	1,230,000	2,999,000	1,604,000	1,614,000

Table 2. Past program investments, milestones, and plans.

Year	Budget	Milestones
1988	$117,653	Program initiated
1989	$156,104	Cooperative sampling with IDFG to capture wild white sturgeon adults
1990	$236,430	Experimental breeding program initiated- Artificial spawning of wild broodstock demonstrated gamete viability
1991	$150,000	Experimental hatchery completed
1992	$179,723	First releases of hatchery-spawned juveniles (from 1991 brood year)
1993	$649,573	Genetic breeding criteria completed, hand stripping of eggs proved successful Monitoring program initiated in wild
1994	$378,553	Second experimental release of hatchery-spawned juveniles
1995	$952,387	Recaptures of hatchery-reared juveniles in river provided initial information about habitat use, movement, and growth of white sturgeon juveniles in the Kootenai River.
1996	$67,356	Disease testing protocols initiated
1997	$566,650	Non-lethal iridovirus test and field collection method for sperm developed Loss of 1997 brood from equipment failure reinforced need for improvements; release of 1995 brood year
1998	$750,000	Began Phase I of facility and water supply upgrades
1999	$1,263,692	"Fail-safe" rearing program initiated at BCMF Kootenay Hatchery
2000	$880,193	Phase I facility and water upgrades completed
2001	$1,128,568	
2002	$1,230,000	
2003	$2,999,000	Phase II upgrades to provide for adequate rearing and alternate water source
2004	$1,604,000	Phase II upgrades to be completed
2005	$1,614,000	
⋮	⋮	⋮
2022		Projected completion date*

** USFWS recovery plan calls for conservation aquaculture program to continue until evidence is available to show that natural reproduction is yielding adequate recruits to sustain the genetic variability of the population.*

Unlike most hatchery programs for salmon and trout, which are based on known techniques and practices developed over many years, the Kootenai sturgeon program is an evolving program that must develop new methods of culture and conservation hatchery practices consistent with its focus on sturgeon preservation. Kootenai River white sturgeon studies by the KTOI were initiated in 1988 and the conservation aquaculture program began in 1991 in response to questions concerning water quality, white sturgeon gamete viability and the feasibility of aquaculture as a component to population recovery. Initial investments were relatively small and the program was expanded, as initial efforts were successful.

Progeny from wild broodstock were successfully produced and reared in the Kootenai Tribal Hatchery in 1991, 1992, 1993, 1995, 1998, 1999, and 2000. The Kootenai River white sturgeon was listed as endangered in 1994 and no broodstock capture or spawning occurred. No sturgeon from the 1996 year class were produced due capture and broodstock quality difficulties related to high spring runoff, cold water temperatures, and take limitations on timing of broodstock collection. This problem was rectified through coordination with USFWS and IDFG, which provided the capability to collect broodstock at more appropriate times and locations. The 1997-year class suffered catastrophic mortality in the hatchery due to unforeseen equipment failure. This problem has been rectified by approval and implementation of a hatchery upgrade that brought the facility up to standard and provided for increased water quality, quantity, and equipment redundancy and the addition of a "fail-safe" facility located within the Kootenay drainage in British Columbia, Canada. There is still a need for increased rearing capacity to provide adequate rearing space for up to 12 families per year as the project becomes fully implemented. Each family group must be reared separate from other family groups to ensure proper identification at outplanting and also must be reared at low densities to prevent disease outbreak (LaPatra et al. 1994). Master plan development was planned for initiation in 1999 for another facility within the Kootenai River drainage to provide adequate rearing space and a separate, reliable water source.

Experimental releases of hatchery-produced white sturgeon occurred in 1992 and 1994 and totaled 305 fish from 1990, 1991, and 1992 year classes. During 1995, 25 hatchery-reared white sturgeon were captured using gill-nets (Paragamian et al. 1995). During 1996, 45 hatchery-reared juveniles were captured in the Kootenai River (Paragamian et al. 1996). The experimental releases provided the first habitat use, movement, survival, and growth information for juvenile white sturgeon in the Kootenai River. Since then, the program has received approval from the USFWS White Sturgeon Recovery Team to become fully implemented and approximately 4,879 white sturgeon juveniles representing 36 family groups have been released into the Kootenai River. Data indicates that sturgeon released at age 1+ are surviving in the Kootenai River. Regular annual releases are now a component of the sturgeon recovery plan.

1.5) Location(s) of hatchery and associated facilities.

The KTOI hatchery is located on the Kootenai River mainstem at River Kilometer 241 near Bonners Ferry, Idaho (Figure 1). The British Columbia Kootenay Sturgeon Hatchery at Fort Steele, B.C. is also used to rear five family groups (from fertilized eggs taken from wild broodstock at the KTOI hatchery) to ensure no catastrophic losses of future year classes. The British Columbia Kootenay Sturgeon Hatchery is located at the confluence of the Bull River and Kootenay River, approximately 44 kilometers southeast of Cranbrook, British Columbia and approximately 136 kilometers upstream of Libby Dam. Both hatcheries are located in the Kootenai River basin (HUC 17010101).

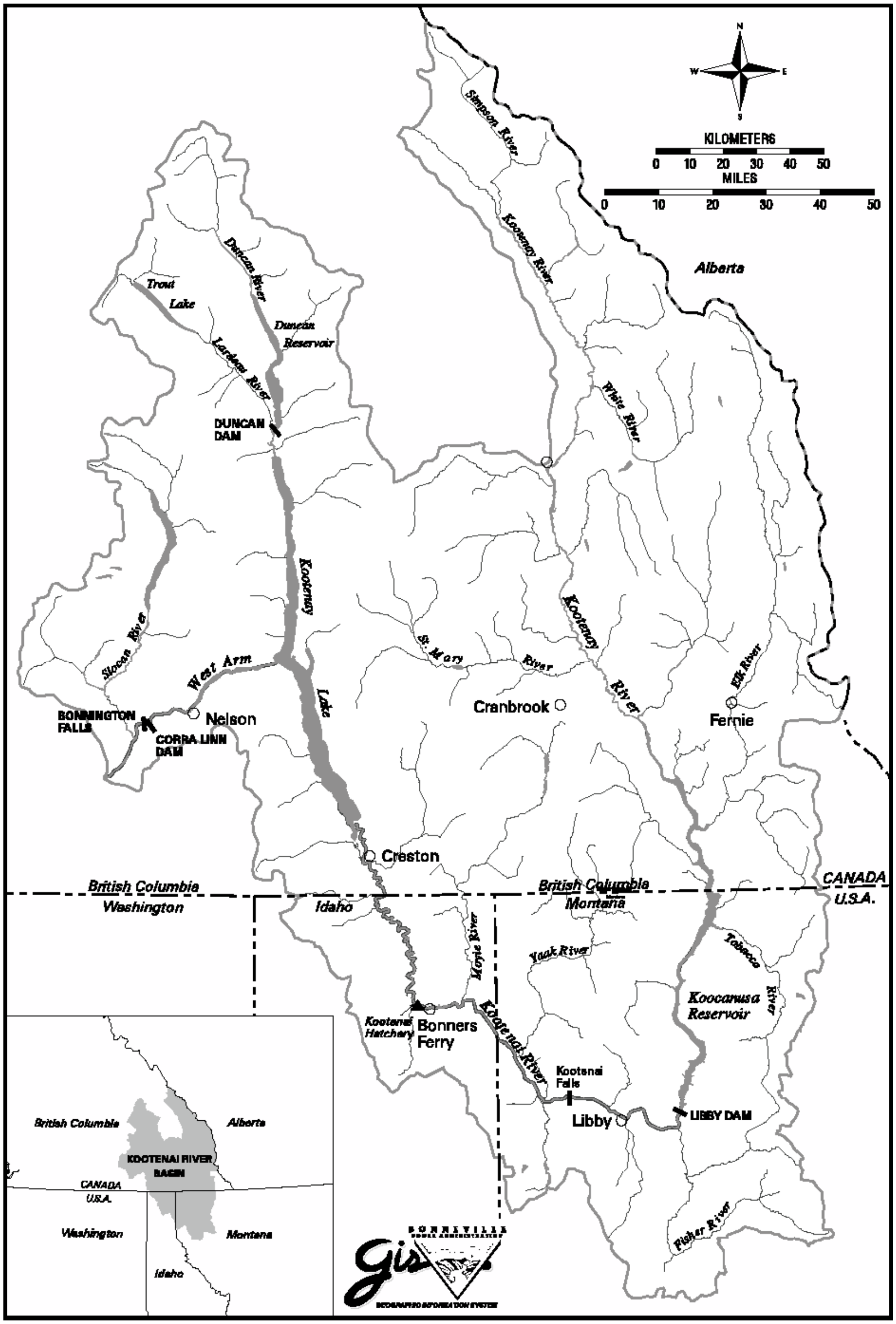


Figure 1. Map of the Kootenai/y drainage.

1.6) Type of program(s).

The KTOI white sturgeon hatchery is an Integrated Recovery Program as defined by criteria prescribed by this template. (*An integrated recovery program is primarily designed to aid in the recovery, conservation or reintroduction of a particular natural population, and fish produced are intended to spawn in the wild or be genetically integrated with the targeted natural population).* This definition for Kootenai River white sturgeon presupposes that natural spawning conditions for the wild population will be restored by habitat measures.

1.7) Purpose (Goal) of program(s).

The goal of the KTOI white sturgeon hatchery program is to prevent extinction, preserve the existing gene pool, and begin rebuilding healthy age classes of the endangered white sturgeon in the Kootenai River using conservation aquaculture techniques with wild broodstock.

This goal is consistent with the Preservation/Conservation purpose identified in Northwest Power Planning Council Document 99-15. The NPPC defined preservation/conservation based on the need to conserve genetic resources of a very small population at a critical late stage in its decline pending future rebuilding. Populations that require preservation/conservation face imminent demise or extirpation and, in most cases, are listed under the federal Endangered Species Act. The NPPC notes the need for immediate intervention in these emergency situations concurrent with the development of a plan for recovery. The NPPC also cautioned that the duration of the preservation/conservation purpose should be minimized because the longer a population is maintained in the hatchery, the less it will resemble the original naturally producing population in regard to genetics and behavior.

The NPPC suggests that a preservation/conservation purpose requires an explicit recovery plan with a compressed time-frame for return of the fish to the wild and an effective plan for dealing with the underlying habitat or management problem so that the preservation hatchery does not become a museum to preserve fish with uncertain connections to the natural population structure. The U. S. Fish and Wildlife Service published a recovery plan for Kootenai white sturgeon in 1999. This plan recognizes the need to restore critical sturgeon habitat in the Kootenai River and the uncertainty in what habitat measures will be necessary. The recovery plan also includes the KTOI conservation aquaculture program as a critical component of recovery actions.

In addition to preservation/conservation purposes, the KTOI white sturgeon hatchery program also serves a research purpose and could evolve toward restoration, mitigation, or augmentation purposes depending on the success of habitat restoration efforts. Research components involve continued evaluations of hatchery practices consistent with the natural biological system within a strict experimental design. The hatchery program also provides fish for experimental use in estimating natural production rates and in identifying limiting factors. The KTOI hatchery is the pioneer hatchery for producing white sturgeon for use in the wild. Lessons and methods developed in the Kootenai will form the basis for consideration and development of other white sturgeon conservation aquaculture programs in the basin.

Potential use of the KTOI hatchery for restoration or augmentation purposes might feasibly be considered if habitat restoration measures are successful. The NPPC defined restoration as the use of artificial production to speed or "jump-start" recovery of natural populations, especially in order to achieve a harvestable population size. A restoration program assumes a population is reduced or eliminated by habitat degradation or other effects (e.g. overharvest), but that the problem has or is being corrected and the existing biological system is now or will soon be capable of sustaining natural production. The NPPC defines an augmentation program as one, which provides fish in numbers beyond the capability of the natural system, to address a social motivation, such as the desire for harvest greater than the existing natural system, can sustain. It operates within an intact natural system that is functioning at or near its natural capacity in the freshwater juvenile life stage, with excess capacity available at other life stages. It augments natural productivity. If habitat restoration measures do not provide suitable spawning and rearing conditions for white sturgeon in the Kootenai River system, a mitigation or compensation purpose of the hatchery may become appropriate.

1.8) Justification for the program.

The KTOI white sturgeon conservation aquaculture program currently provides the only significant source of recruitment by a unique wild population that has been in decline since the 1960’s and has not recruited significant numbers of naturally produced fish since 1974. The naturally produced population now consists almost entirely of mature, older individuals and is gradually declining as fish age and die without replacement. Nearly a decade of augmented river discharge experiments intended to stimulate natural spawning and recruitment have successfully stimulated spawning but have failed to produce natural recruitment (Duke et al. 1999; USFWS 1999; Anders et al. 2000).

The Kootenai River white sturgeon is one of several land-locked populations found in the Pacific Northwest. Their distribution extends from Kootenai Falls, Montana, located 50 river kilometers below Libby Dam, downstream through Kootenay Lake to Cora Linn Dam on the lower west arm of Kootenay Lake, B. C. A natural barrier at Bonnington Falls downstream of Kootenay Lake has isolated the white sturgeon in the Kootenai River from other white sturgeon in the Columbia River since the last glacial age approximately 10,000 years ago (Northcote 1973). This population is believed to have been isolated from other white sturgeon populations in the Columbia River Basin following post-Pleistocene recolonization approximately 10,000 years ago (Northcote 1973, Alden 1953).

The population adapted to natural pre-development conditions of the Kootenai system, which was characterized by frequently large spring freshets, an extensive large-river-floodplain, and delta marshland habitats in the downstream portions of the river upstream from Kootenay Lake. The flood-pulse model of large river-floodplain ecosystems (Junk et al. 1989) suggests that the mosaic of such habitats, as historically present in the Kootenai River, were valuable sources of nutrients required for system productivity. Modification of the Kootenai River by human activities including industrial and residential development, extractive land use practices, floodplain isolation by diking, and construction and operation of a hydropower dam drastically changed the river's natural thermograph and hydrograph (Anders 1991; Anders and Richards 1996; Anders et al. 2000; USFWS 1999; Duke et al. 1999; Apperson and Anders 1991; Partridge 1983). These changes altered white sturgeon spawning, incubation and rearing habitats, changed community structure and species composition across trophic levels, and resulted in depressed biological system productivity (Anders et al. 2000, Anders and Richards 1996; Paragamian 1994; Snyder and Minshall 1996).

The Kootenai River white sturgeon population has been in decline since the mid-1960's (Duke et al. 1999; USFWS 1999). Population size was first estimated to be 4,000 to 6,000 individuals (Graham 1981). Partridge (1983) estimated population size to be 1,148 fish (50-224 cm TL; 95 %CI 907-1503) using tag recovery data from 1979 through 1981,. In 1990, the population was estimated to include 880 individuals (88-274 cm TL; 95% CI 638-1,211; Apperson and Anders 1991). The 1990 estimate was not statistically different from the previous estimate of 1,148, although different sampling areas and protocols confounded interpretation (Giorgi 1993). Most recently, in 1997, the population was estimated to contain 1,468 individuals (95% CI 740-2197, Paragamian et al. 1997).

Natural recruitment failure in this population was first reported in the early 1980's (Partridge 1983). Reconstruction of year-class strength from sturgeon age composition has confirmed that the last substantial year-class was produced in 1974, which was the year prior to operation of Libby Dam. The dam impounds the Kootenai River near Libby, Montana, forming Lake Koocanusa. Construction and operation of Libby Dam has drastically altered the hydrograph, thermograph, and downstream nutrient loading rates in the Kootenai River. Hypothesized causes of natural reproduction and recruitment failure have included post-impoundment thermal and physical habitat alterations, limited gamete viability due to exposure to contaminants in the river, egg and fry mortality due to suffocation, predation and food limitation, and over winter mortality due to habitat loss or food limitation (Anders 1991, Apperson and Anders 1991; Anders 2000; USFWS 1999; Kruse 2000).

Research since 1991 has confirmed natural spawning in eight of the past nine years but juvenile survival has been extremely limited. Hundreds of fertilized and developing eggs have been collected from the Kootenai River under a range of post-impoundment hydrograph and thermograph conditions in all years except 1992 (USFWS 1999). However, nine years of sampling found only 16 naturally recruited white sturgeon (or about 1% of the population) that were 21 years of age or less (Paragamian et al. 1995). Because white sturgeon do not begin reproducing until approximately age 20, this means that the equivalent of one full generation in the white sturgeon life cycle has been lost.

The white sturgeon population in the Kootenai River was listed as endangered on September 6, 1994 (59 FR 45989) under the U. S. Endangered Species Act and a recovery plan was completed in 1999. Recovery will be contingent upon re-establishing natural recruitment, minimizing additional loss of genetic variability to the population, and successfully mitigating biological and physical habitat changes caused by the construction and operation of Libby Dam. The overall recovery strategy for the white sturgeon in the Kootenai River takes a three-pronged approach (USFWS 1998). Priority 1 actions for immediate implementation include: 1) flow augmentation to enhance natural reproduction; 2) the conservation aquaculture program to prevent extinction; and 3) restoration of suitable habitat conditions to increase the chances of white sturgeon survival past the egg/larval stage.

We do not know why white sturgeon recruitment continues to fail or what habitat changes are required to solve this problem. Flow augmentation has not yet created favorable survival conditions, and other habitat bottlenecks may also exist. Barring some unforeseen habitat miracle, the hatchery provides the only means to conserve the native genetic material, begin rebuilding a healthy age class structure, and prevent extinction. If future measures fail to re-establish suitable habitat conditions, the hatchery program may be the only long-term recourse for preserving a segment of this population.

The recovery plan for white sturgeon takes an ecosystem approach by including measures to benefit other resident fish species such as kokanee and burbot. The Kootenai sturgeon hatchery program has contributed the use of its facilities and expertise to these efforts where compatible and consistent with sturgeon activities. These resident fish measures are very small scale and are a value-added benefit of the program rather than a component of the program. For instance, native kokanee are considered an important prey item for white sturgeon and also provided an important fishery in the tributaries of the lower Kootenai River. Native kokanee populations have declined dramatically in the past two decades. Kokanee runs into north Idaho tributaries of the Kootenai River numbering thousands of fish as recently as the early 1980's (Partridge 1983) have now become "functionally extinct". Redd counts from 1993-1999 indicate the South Arm stock of kokanee from Kootenay Lake that migrates into the tributaries of north Idaho has been extirpated (Anders 1995; Ireland 1997; KTOI unpublished data). Program staff used information and expertise from B.C. Ministry of Environment staff to develop instream incubation techniques with eyed eggs in lieu of use or development of a hatchery program while a separate project (Kootenai River Ecosystem Improvement, BPA 94-49) is implementing habitat protection and restoration measures on degraded streams by identifying areas where streams can be restored and working with private landowners. Kokanee restoration activities are more appropriately reviewed in the context of the other projects specific to their restoration.

Similarly, native burbot in the Idaho and Canadian portion of the Kootenai River drainage are at risk of becoming extinct (Paragamian 1996; Paragamian et al. 2000). IDFG has been monitoring the movement, habitat use, and spawning behavior of burbot since 1993 and has not found evidence of successful spawning or recruitment. As with the white sturgeon, conservation aquaculture may play a role in the recovery of this species, as efforts to restore habitat conditions necessary for the survival of burbot continue. Sturgeon aquaculture staff is available to contribute expertise to these efforts but any burbot plans and activities are more appropriately reviewed as an independent effort.

1.9) List of program "Performance Standards."

In their Artificial Production Review, the Production Review Committee of the NPPC defined "Performance Standards" as a set of specific criteria by which progress in achieving the program goal/purpose can be measured.

The goal of the KTOI white sturgeon hatchery program is to prevent extinction, preserve the existing gene pool, and begin rebuilding healthy age classes of the endangered white sturgeon in the Kootenai River using conservation aquaculture techniques with wild broodstock. The performance standards corresponding to this goal as defined in NPPC (1999) are to:

1. Maintain, augment, and restore a viable naturally spawning population using artificial production strategies to reduce the threat of population extinction by providing annual or near-annual year-class production from native broodstock.
2. Conserve genetic and life history diversity of the endangered Kootenai white sturgeon population for a 20 year duration (approximate age at maturity) using wild broodstock to maintain the inherent diversity and mimic the wild population haplotype or genotype frequencies in hatchery broodstock and progeny.
3. Use hatchery-reared fish and facilities to conduct research on factors limiting natural production.
4. Conduct research to improve the performance and cost effectiveness of artificial propagation efforts and to minimize risks.
5. Avoid mortality risks to wild broodstock at capture and spawning.
6. Minimize the detrimental genetic or behavioral impacts of artificial propagation by outplanting fish at the earliest point consistent with survival and evaluation.
7. Avoid disease introduction or increase in disease incidence in the wild population.
8. Avoid risk to the natural population by monitoring parameters that estimate biological condition and related population dynamics as a surrogate for estimating carrying capacity of the natural habitat.

1.10) List of program "Performance Indicators", designated by "benefits" and "risks."

Performance indicators are specific operational measures of fish or hatchery attributes that address each performance standard. They determine the degree to which program standards have been achieved, indicate the specific parameters to be monitored and evaluated, and are used to detect and evaluate the success of the hatchery program and any risks to or impairment of recovery of affected, listed fish populations. Performance indicators must be are measurable, realistic, feasible, understandable, affordable, and time specific. Table 3 lists the specific performance indicators corresponding to each performance standard and indicators are discussed in more detail below.

Table 3. Performance standards and indicators for Kootenai sturgeon hatchery program.		
Performance Standard	***Type***	***Performance Indicator***
1. Maintain natural population	**Benefit**	Gradual increase in population size and age composition as a result of recruitment of hatchery fish: *Proportion of the size/age cohort contributed by hatchery* *Number of hatchery-reared fish by life stage including maturity* *Individual growth rates & condition factors* *Size & age specific survival rates* *Relative distribution and habitat use patterns of wild & hatchery fish based on CPUE & sonic telemetry*
2. Conserve genetic & life history diversity	**Benefit**	Retention of wild sturgeon life history characteristics and genetics by the hatchery reared population *Haplotype and genotype frequencies in hatchery broodstock and progeny* *Separate rearing of family groups* *Fail-safe rearing of each family in separate facilities* *Experimental population established outside current range* *Cryopreservation of sperm if feasible* *Individual and population attributes as in #1 above.*
3. Research natural production limitations	**Benefit**	Understanding of the life history characteristics and factors limiting natural recruitment *Estimated natural cohort size relative to known hatchery release number* *Rearing bottlenecks between YOY and adult* *Effects of contaminants on development, survival, & growth* *Evaluation of sediment transport and pre and post dam conditions in the spawning area*
4. Increase effectiveness & reduce costs	**Benefit**	Adaptive approach to achieve results while reducing process, administrative overhead, & operation costs *Complete planning and review processes and move to multi-year funding schedule with check points* *Adapt size and time of release for maximum benefits and minimum risks* *Marking methods to allow release as subyearlings* *Larval release experiments if appropriate* *Cryopreservation techniques*
5. Avoid broodstock mortality	**Risk**	Additional mortality does not speed population decline *Mortality rate of broodstock in hatchery & after release*
6. Do not exceed carrying capacity	**Risk**	No significant density-dependent trend in growth, condition, or behavior of wild or hatchery sturgeon *Individual and population characteristics as in #1 above*
7. Avoid disease transfer	**Risk**	Minimal incidence of disease in the facility *Appropriate spawning & rearing practices & densities* *Rigorous disease testing protocols* *Rear disease-free trout for bait and broodstock feeding*
8. Minimize behavioral or genetic impacts	**Risk**	See #2 above

1.10.1) "Performance Indicators" addressing benefits.

Benefits of the sturgeon hatchery program include maintaining the natural population through replacement of a lost generation of recruits, conserving genetic and life history diversity, and providing critical information on factors currently precluding significant natural production. The adaptive experimental approach this project has been taken and the involvement of a broad spectrum of tribal, governmental, University, and private participants should also ensure that the program continues to evolve toward a more effective and less costly end.

These performance standards will be addressed by a comprehensive monitoring and evaluation program of fish in the hatchery and in the wild following release. Numbers and mortality of eggs, larvae, and juveniles are tracked throughout the spawning and rearing process. An annual field-sampling program has also been implemented cooperatively with IDFG to recapture and evaluate hatchery-reared fish and any wild-produced fish. Data on numbers, lengths, weights, and marks are used to estimate survival and growth rates. Comparison of wild numbers, if any, with known hatchery release numbers also provide empirical estimates of natural recruitment rate. Growth and condition factors will also provide an index of density dependent effects that could affect productivity of the wild population. An extensive genetic testing program has also been implemented to identify haplotype and genotype frequencies in hatchery broodstock and progeny for comparison with similar data on the wild population. Excess eggs and hatchery-reared fish also provide a source of experimental fish for contaminant assessments, animal health research, in situ hatching experiments, and other research that might provide insight into factors limiting the wild population.

The conserved population will be considered healthy when: 1) a combination of natural and hatchery production has restored a length and age frequency distribution in which all size and ages are represented, 2) numbers of adult spawners are sufficient to produce recruitment which maintains the population size and age distribution at a stable level, 3) habitat improvements are sufficient to allow natural spawning to maintain the population in the absence of hatchery supplementation, 4) population size is sufficient to maintain genetic and life history diversity.

1.10.2) "Performance Indicators" addressing risks.

Risks of the sturgeon hatchery program include accelerating the decline of the wild population if significant mortality of adults resulted from handling, reducing the success of natural spawning and recruitment if hatchery fish over-seed the habitat capacity, increasing mortality or reducing productivity of wild fish if hatchery practices introduced new diseases or increased the incidence of endemic diseases, and reduced genetic or life history diversity if hatchery practices failed to maintain as intended.

These risk performance standards are also addressed by many of the same monitoring and evaluation program indicators used to address benefits. Fish numbers and condition are monitored in the hatchery and in the wild following release. Broodstock capture and spawning methods have been developed and refined to minimize stress and improve artificial spawning success. An intensive genetic and animal health-monitoring program has been implemented. Adjustments have been made throughout the development of this program and will continue to be made based on monitoring and evaluation results consistent with the adaptive management principles recommended by the Artificial Production Review Committee of the ISRP.

1.11) Expected size of program.

The intent of the conservation hatchery program is to approximate a "normal expanding" natural population without exaggerating the contribution of a small fraction of the parent population, as occurs in typical supplementation programs (Kincaid 1993). We estimate that this goal will require an annual production equivalent to 4-10 breeding adults per family for 4-12 families. Theoretically, implementation of this breeding plan each year for the next 20 years using 5 different mating pairs per year would yield an effective population size of 200. About 1,000 age 1 juveniles per family produce target numbers of approximately 8 progeny per family or about 4 breeding pairs per family at age 20, assuming annual survival rates of 50% for years 2 and 3, and 85% for years 4-20 of all fish planted. Natural survival in the river environment during the 18+ years from planting to maturity would result in variability in genetic contribution of families to the next broodstock generation. Number of fish released per family will be adjusted in future years when actual survival rate is known.

Conservation hatchery production numbers were initially developed with an end goal of 10-20 adults per family surviving to female age at first maturity (20 yr.) for two reasons: 1) To represent progeny of Kootenai River wild population genetics; and 2) to avoid over or under-representation of any particular haplotypes or genotypes as a result of the hatchery program. Initial target numbers are the result of Federal Recovery Team negotiations, based on theoretical annual mortality rates presented by Kincaid (1993) in his breeding strategy for this population. The numbers are "loose" because insufficient juvenile white sturgeon (< age 25) exist in the Kootenai River to calculate annual or cumulative survival rates to age at first maturity (approx. 20 yr. for females, males age 12-15). Recaptured juveniles from the conservation aquaculture program, given several years of post-release survival, will allow calculation of empirically based annual and cumulative mortality rates for Kootenai River white sturgeon. These rates in turn will allow calculation of more accurate release numbers to meet target goals and the realistic modeling of the effects of alternative strategies to identify the optimum approach.

1.11.1) Proposed annual broodstock need (maximum number of fish).

The captive breeding program will use 2-8 females and 4-16 males captured from the Kootenai River each spring. Fish are spawned in pairs or in diallel mating designs to produce up to 12 individual families that are reared separately to maintain family identity.

Note that sturgeon are iteroparous spawners. Spawning frequency is estimated at 5 years for females and 2-3 years for males in the Kootenai River system (Paragamian et al. 1996). Males are currently spawned at capture in the field and immediately released at the capture site. Females are transported to the hatchery and released alive after spawning. Typical practice in the sturgeon aquaculture industry is to spawn females by caesarian section. A hand-stripping method of spawning has been developed and used since 1993 in this hatchery program to considerably reduce stress and injury associated with spawning. Hand stripping also reduces the time that broodstock are held in the facility after spawning. Release of broodstock back into the river now generally occurs one week after spawning, while fish spawned by caesarian section were generally held 2-3 months post spawn to ensure adequate recovery time. Since 1991, 19 wild adult sturgeon used for conservation breeding purposes have been subsequently recaptured. One female was spawned by caesarian section on 6/22/1991 and released at Rkm 241 (hatchery location) with a sonic tag on 8/12/1991. She spent the next 31 days swimming downstream to Kootenay Lake, British Columbia. She was tracked for three years in the lake and recaptured at the north end of Kootenay Lake 5 years after the spawning event and original capture. Her health seemed good and although no increase in length was measured, she weighed 7 kg more than at original capture.

Proposed annual fish release levels (maximum number) by life stage and location.

Fish will be marked to identify family and year class before release. Number of fish released will be equalized at up to 1,000 per family for 4-12 families. Releases are made at age 1+ in the fall when fish are large enough to mark. Fish too small to mark are retained in the hatchery and released in the spring or fall as two-year-old fish. Annual releases may average 1,000-12,000 fish per year depending primarily on the availability of maturing females and the number of families produced (and incorporation of survival data to further evaluate stocking goals).

Life Stage	Release Location	Annual Release Level
Eyed Eggs	NA	0
Unfed Fry	Kootenai River	Up to 150,000 may be experimentally released in 2001 (White Sturgeon Recovery Team decision)
Fry	NA	0
Fingerling	NA	0
Yearling/2 year old	Kootenai River	1,000 – 12,000 (up to 1,000 fish per family)

1.12) Current program performance, including estimated survival rates, adult production levels, and escapement levels. Indicate the source of these data.

The Kootenai Tribal conservation program has released 4,879 juvenile white sturgeon into the Kootenai River between 1992 and 2000 (age 1-2 years old) (IDFG database and annual reports; KTOI annual reports; Ireland et al. 2000) and approximately 139,000 larvae (age 3-12 days) in 2000 as an experiment to help determine the bottleneck to survival (KTOI and IDFG progress reports 2000). Through monitoring and evaluation of the hatchery releases, gillnetting for juvenile white sturgeon in the Kootenai River has captured a total of 669 juveniles since 1995 through the 2000 sampling season (includes multiple recapture events) in the Kootenai River in Idaho (IDGF database; IDFG and KTOI reports 1996-1999). A total of 14 juvenile white sturgeon have been captured in Kootenay Lake, British Columbia between 1999 and 2000 (BC. Ministry of Environment, Land, and Parks Progress Reports). Total fork length growth of hatchery reared- reared juvenile white sturgeon released into the river and subsequently recaptured averaged 5.27 cm annually (IDFG reports). Relative weight, W_r, (Beamesderfer 1993) was calculated for 664 hatchery raised white sturgeon juveniles released into the Kootenai River between 1991-1999 and subsequently recaptured between 1995 and October 2000. Mean relative weight, Wr, was 90.638 (S.D. 27.131) (IDFG unpublished data). With five years of recapture data now available, we will be able to estimate survival rates for hatchery-released juveniles this year. Survival estimates will be used to adjust stocking numbers in the future, although we will not have survival to maturity estimates because white sturgeon in the Kootenai River do not become reproductively mature until the age of 22 for females and age 16 for males (Paragamian 1997). We recognize that normal year-to-year environmental variation in precipitation, flooding, flow rates, temperature, predator populations, and food supply can create wide variation in annual and long-term survival. Information gained from monitoring and evaluating biological condition and related population dynamics of white sturgeon in the Kootenai River, as well as information gained about ecosystem productivity (KTOI Project 19944900 – Improve the Kootenai River Ecosystem) will also be incorporated into future decisions concerning stocking rates.

1.13) Date program started (years in operation), or is expected to start.

The current program has developed from an experimental program initiated in 1990 to a Priority 1 Action listed in the Recovery Plan for white sturgeon in the Kootenai River (USFWS 1999). The initial efforts were geared toward research of gamete viability and possible negative effects of exposure to water- and sediment-borne contaminants. Experimental breeding of wild Kootenai River white sturgeon broodstock in 1990 resulted in the first successful artificial propagation of wild Kootenai River white sturgeon (Apperson and Anders 1991). A low cost hatchery facility was built in Bonners Ferry to explore the feasibility of sturgeon aquaculture as a component to recovery, which was then in a developmental stage in North America. Progeny from wild broodstock were successfully produced in 1991, 1992, 1993, 1995, 1998, 1999, and 2000. A significant facility upgrade was completed in 1998-2000 to address hatchery needs consistent with use as prescribed in the ESA recovery plan. A second upgrade is also planned to provide space necessary to rear separate family groups consistent with genetic concerns and to provide a second water source for increased rearing capacity. In 1998, the KTOI entered into a cooperative agreement with BC Ministry of Environment to provide KTOI with a fail-safe facility located in Fort Steele, B.C. in order to have a backup in case of catastrophic loss at the Tribal facility.

1.14) Expected duration of program.

The initial intent of the program was to begin replacing lost sturgeon recruitment. There has not been any measurable recruitment since 1974. This equates to 26 years of missing year classes. The USFWS Recovery Plan calls for conservation aquaculture program to continue until evidence is available to show that natural reproduction is yielding adequate recruits to sustain the genetic variability of the population. The current intent is for continued refinement, implementation, and monitoring of the Kootenai River Conservation Aquaculture Program for a minimum of the equivalent of one generation (20 years), or until repeatable, natural recruitment and subsequent natural production are reestablished.

1.15) Watersheds targeted by program.

Upper Kootenai River basin from Kootenay Lake, British Columbia to Kootenai Falls, Montana (HUC 17010101)

1.16) Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed.

Alternative actions include: 1) no action; 2) more aggressive habitat restoration efforts; and 3) adaptation of other hatchery facilities rather than development of a new facility.

1) No action would probably mean the extinction of this sturgeon population. The longevity of white sturgeon (up to 100 years), delayed maturation (approximately age 20 in females), and spawning periodicity (5 or more years in females in the Kootenai population) suggests that sturgeon populations can persist through extended periods of unsuitable spawning conditions. This adaptation is particularly well suited to large, dynamic river systems where suitable conditions may depend on the right combinations of habitat, temperature, and flow which do not occur every year (Beamesderfer and Farr 1997). However, a lapse in spawning of over 25 years is unprecedented in a sustainable natural white sturgeon population. The robust white sturgeon population in the Columbia River downstream from Bonneville Dam spawns successfully every year (McCabe and Tracy 1992, DeVore et al. 1995). Sturgeon populations, which have been able to persist in Columbia and Snake River reaches isolated by dam construction, typically recruit at least some juveniles during many or most years with periodic big year classes when conditions are optimum. Healthy sturgeon populations are characterized by age-frequency distributions that include large numbers and percentages of juvenile and subadult fish. Age and length distributions are stable and are skewed toward young fish. The lower Columbia River white sturgeon population (downstream from Bonneville Dam) is composed of > 95% sexually immature fish and this population also sustains an annual harvest of 50,000 fish (DeVore et al. 1999). The age and length distributions of the Kootenai population are heavily skewed toward older fish and have been shifting to the right over time. Approximately 90% are age 25 and older fish (Paragamian et al. 1995; BPA 1997). Thus, the key to successful management of threatened and endangered populations must be to apply appropriate conservation measures that minimize risk and maximize benefit before their potential for success is overly compromised by small population size or reduced population viability (Anders 1998).

2) More aggressive habitat actions might result in resumed natural recruitment if the appropriate actions could be identified and implemented but would not replace the 25 years of failed recruitment. The adult population would continue to decline and restored recruitment would lapse as the adult population died before their progeny mature. Significant genetic diversity could be lost in this potentially small population bottleneck even presuming the unidentified habitat measures succeeded immediately. Simultaneous implementation of habitat restoration and conservation culture appears to offer the highest probability of protection and preservation of the Kootenai River white sturgeon.

3) No other hatchery facilities provide a suitable alternative for the sturgeon aquaculture program. Animal health concerns have constrained interbasin movements of fish and hatchery facilities in the Kootenai basin are limited. Sturgeon spawning and rearing requirements are

unique to this species and adaptation of trout or salmon facilities would be a poor substitute for a facility designed specifically for sturgeon. A site on the Kootenai mainstem near fish spawning or staging areas also facilitates the capture and transport of wild broodstock to hatchery in a condition suitable for spawning. The need to capture several mature females with ripe eggs during the spawning season is a critical component of a successful hatchery program.

SECTION 2. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

2.2) List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates.

Kootenai White Sturgeon Recovery Plan: The KTOI hatchery program is a crucial element of the Recovery Plan adopted in 1999 by the U. S. Fish and Wildlife Service for this ESA endangered species. Recovery actions include "Develop and implement a conservation aquaculture program to prevent the extinction of Kootenai River white sturgeon. The conservation aquaculture program will include protocols on broodstock collection, gene pool preservation, propagation, juvenile rearing, fish health, and preservation stocking." The recovery strategy was to implement the conservation aquaculture program for at least the next 10 years. Specific actions related to this objective include:

21. The conservation aquaculture program will follow policies and procedures of the Northwest Power Planning Council's Columbia Basin Fish and Wildlife program and the service's artificial propagation policy.
    211. Obtain necessary local State, Tribe, Federal, and Canadian approval and permits for all conservation aquaculture activities.
22. Develop performance standards for KTOI hatchery facilities.
    221. Determine water quality standards for KTOI hatchery.
    222. Upgrade KTOI hatchery facility to meet aquaculture objectives.
    223. Maintain Kootenai Sturgeon Hatchery as secondary rearing facility.
    224. Implement the conservation aquaculture program.
23. Implement genetic preservation guidelines for broodstock collection and mating designs.
    231. Use adopted white sturgeon broodstock protocol.
    232. Collect adequate numbers of male and female broodstock to maintain the genetic variability.
    233. Annually evaluate the conservation aquaculture program.
24. Develop a release plan for Kootenai River white sturgeon.
    241. Evaluate appropriate production goals.
    242. Develop a fish health plan for hatcheries rearing white sturgeon.
    243. Develop tagging protocol for hatchery reared white sturgeon.
    244. Develop a policy for hatchery white sturgeon in excess of beneficial uses identified in recovery.
    245. Evaluate the feasibility of establishing an experimental white sturgeon population outside of its current occupied range.
25. Release hatchery-reared white sturgeon into the Kootenai River basin.
    251. Adjust white sturgeon releases as necessary, to meet objectives of the Kincaid breeding plan.

26. Monitor ecological interactions between hatchery reared and wild white sturgeon.
    261. Determine factors limiting production (natural or hatchery) and habitat use patterns for each life history stage.

This HGMP is consistent with the recovery plan in all respects.

USFWS Draft Biological Opinion for white sturgeon in the Kootenai River (July 27, 2000). This project is listed as "necessary and appropriate" (in terms and conditions) to implement the reasonable and prudent measures #1 and #3 in the draft Biological Opinion consultation conducted by USFWS Regions 1 and 6 on July 27, 2000. Specifically:

1g. The action agencies shall design and conduct those studies necessary to determine the effects of Libby dam operations and other threats on sturgeon life history, and the causes of sturgeon mortality.

3a. The action agencies shall continue to maintain the preservation stocking program operated by the Kootenai Tribe of Idaho, and associated rearing facilities operated by BC Ministry of Environment, Land, and Parks. This program is described in the 1999 Sturgeon Recovery Plan and shall be operated until deemed unnecessary by the Service.

3b. The action agencies shall maintain the current level of monitoring associated with all stages of natural recruitment and the preservation stocking program.

This HGMP is consistent with the USFWS Draft Biological Opinion in all respects.

U.S. Fish and Wildlife Service Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act (October 20, 2000): This project meets the USFWS policy and intent regarding propagation of endangered species. This HGMP is consistent with the policy in all respects.

Northwest Power Planning Council Fish and Wildlife Program (1994): This project specifically addresses the following measures in the program adopted in 1995:

- 10.3B.11: "In consultation with the Confederated Salish and Kootenai Tribes, the Montana Department of Fish, Wildlife, and Parks, the Kootenai Tribe of Idaho and other appropriate entities, fund the design, operation, and maintenance of mitigation projects in the Kootenai River system and Lake Koocanusa to supplement natural propagation of fish…"
- 10.4B.1: "Operate and maintain a low-capital sturgeon hatchery on the Kootenai Indian Reservation. With Bonneville, explore alternate way to make effective use of the hatchery facility year-round."
- 10.4B.2: "Survey the Kootenai River downstream from Bonners Ferry, Idaho, to the Canadian border to: 1) evaluate the effectiveness of the hatchery, and 2) assess the impact of water-level fluctuations caused by Libby Dam on hatchery operations for outplanting of sturgeon in the Idaho portion of the Kootenai River."

- 10.4B.5: "As part of the Kootenai sturgeon recovery strategy the Kootenai Tribe of Idaho is to: 1) operate the Kootenai Tribal sturgeon hatchery and develop propagation methods to ensure healthy sturgeon are outplanted into the Kootenai River, 2) participate on the water budget team, and 3) conduct monitoring and evaluation to assess the effectiveness of these measures…"
- 2.2G.1: "The Council calls for the development, funding, and implementation of agreements between fish and wildlife managers on both sides of the U.S./Canada border that recognize the mutual benefit of protection mitigation and enhancement for transboundary species…"

This HGMP is consistent with the Fish and Wildlife Program direction in all respects.

Columbia Basin Fish and Wildlife Authority Multi-Year Implementation Plan (1997): The goal of this plan is to promote the long-term viability of native fish in native habitats where possible. The decline of native fish species in the Kootenai River drainage has been attributed to the construction and operation of Libby Dam (USFWS 1998). The following objectives have been listed in the RFM-MYIP for white sturgeon in the Kootenai River drainage: 1) Mitigate and compensate for the decline of white sturgeon in the Kootenai River drainage caused by the construction and operation of Libby Dam; 2) Preserve existing gene pool and re-establish natural age class structure of the population; 3) Restore recruitment produced by naturally-spawning adult sturgeon; 4) Restore this stock of sturgeon to a sufficient abundance and age distribution to allow for ceremonial, subsistence, and recreational harvest by tribal members and recreational harvest by sport anglers; 5) Restore viable native fish populations in historic spawning and rearing areas. This HGMP is consistent with the MYIP plan in all respects.

Genetic Breeding Plan: A plan to preserve the genetic variability of the wild stock (Kincaid 1993) regulates hatchery practices. The breeding plan guides management in the systematic collection and spawning of wild adults before they are lost from the breeding population and includes measures to minimize potential detrimental effects of conventional stocking programs. Details of this plan are described in subsequent sections. This HGMP is consistent with the Genetic Breeding plan in all respects.

Subbasin Summary for the Kootenai Basin prepared for the Northwest Power Planning Council (2000): The summary describes the status of fish and wildlife populations in the Kootenai Basin (including limiting factors) and provides a detailed listing of remedial actions necessary for fish, wildlife, and habitat rehabilitation. This HGMP is consistent with the Subbasin Summary for the Kootenai Basin in all respects.

Cooperative Rearing Agreement with Canada: Kootenai River white sturgeon are a transboundary fish that ranges freely across the international border with Canada. The KTOI, as directed by USFWS and in accordance with Council Measure 2.2G.1, has forged a relationship with Canada concerning the recovery of sturgeon. Beginning in 1999, British Columbia Ministry of Fisheries has provided a "fail-safe" facility for the Kootenai River white sturgeon at the Kootenay Sturgeon Hatchery (KSH) near Fort Steele, B.C. for a relatively low cost. A contract that outlines the terms and conditions of the agreement (spawning, egg incubation, transfers, rearing, fish health management, marking, liberation, and general fish culture) is signed annually by both parties. This HGMP is consistent with the agreement in all respects.

Cooperative Management Agreement with Idaho Department of Fish and Wildlife, Montana Department of Fish, Wildlife, and Parks, and British Columbia Ministry of Environment, Land, and Parks: The KTOI and the State of Idaho operate in close collaboration to manage Kootenai River fishes including white sturgeon, monitor and evaluate the sturgeon hatchery program, monitor the wild white sturgeon population and research limiting factors, and to conduct other Kootenai River investigations. For instance, the IDFG is conducting an evaluation of natural spawning of white sturgeon. IDFG assists is broodstock collection each spring, as it coincides with the sampling to collect adults for sonic monitoring. Monitoring of hatchery fish by the IDFG is augmented by KTOI by using different gear types, sampling in areas not previously sampled, and sharing information. B.C. MELP collects information and data about white sturgeon in Kootenay Lake. The KTOI, IDFG, BC MELP and MDFWP have a data sharing agreeement. All field data collected on white sturgeon is compiled in a single database coordinated by IDFG. Data is compiled to provide the most accurate and up to date information concerning broodstock collection, capture of wild sturgeon for sonic tracking, and locations of fish fitted with transmitters, etc. Monitoring and evaluation efforts are described in further detail in subsequent sections.

2.3) Relationship to harvest objectives.

There are currently no fisheries for this endangered Kootenai white sturgeon population.

2.3.1) Describe fisheries benefiting from the program, and indicate harvest levels and rates for program-origin fish for the last 12 years (1988-99), if available.

Fishing for white sturgeon in Kootenai River fisheries is prohibited and no plans anticipate resumed fishing in the foreseeable future. Fishing has been prohibited on this population since 1979 in Montana, and since 1994 in Idaho and British Columbia. Known fishery harvest or incidental impact rates are zero. Incidental catch of white sturgeon in current fisheries is insignificant because other fisheries occur in times, areas, and with methods and gear to which sturgeon are not vulnerable. Small fisheries for white sturgeon existed prior to closure although effort and catch in these fisheries declined to very low levels concurrent with the decline in the wild population. Fisheries prior to closure were regulated with a combination of bag, possession, size, and gear restrictions (Apperson and Wakkinen 1992). System habitat limitations and productivity are such that the sturgeon fishery will probably not resume in the near future, but an appropriate long term recovery standard should restore population productivity so that target sturgeon fisheries could be contemplated.

2.4) Relationship to habitat protection and purposes of artificial production.

The sturgeon conservation aquaculture program is an interim measure for preventing extinction and maintaining the genetic variability of the existing wild population while habitat restoration measures are identified and implemented. The complete failure of natural production, difficulties in identifying effective habitat measures and the long-term time scale needed to restore habitat in a large river system like the Kootenai result in the need for this interim measure. Habitat recovery measures are identified as a crucial component of the Kootenai River White Sturgeon Recovery Plan and are subject to an extensive evaluation and experimental implementation program currently being implemented by the KTOI, the States of

Idaho and Montana, the Federal government, British Columbia Ministry of Environment, Land, and Parks, the Bonneville Power Administration, and others.

2.5) Ecological interactions.

The Kootenai River ecosystem includes a variety of species including bull trout, interior redband trout, westslope cutthroat, rainbow trout, native kokanee, and burbot. Sturgeon generally occupy a benthic habitat niche and do not interact with most of these species in any significant fashion. Where interactions may occur, they are subtle and beyond our ability to project, measure, or distinguish from interactions with other features of the system. Some species such as spawned-out kokanee were likely a historical food source but are no longer present in significant numbers. Interactions with other sensitive species are minimal or non-existent.

The greatest potential for program impacts is between hatchery and wild sturgeon. Wild sturgeon might negatively impact the program by introducing endemic diseases into the hatchery environment. Disease transfer, genetic effects, or competition effects of a poorly conceived program might negatively impact wild sturgeon. Wild sturgeon positively impact the program by contributing source broodstock. Wild sturgeon will benefit positively from the program addition of fish to the population to prevent extinction until successful habitat recovery measures are implemented.

One of the key interaction concerns related to the hatchery program is the potential for competition between hatchery-reared and naturally spawned sturgeon juveniles. Production of large numbers of hatchery juveniles might swamp natural production and might reduce growth, condition, and survival of the wild fish. For this reason, hatchery releases are carefully limited and a field-sampling program is monitoring the population for indicators of compensatory effects.

Adding hatchery fish to a system that is nutrient limited could increase pressure on wild fish, however, adding naturally recruited wild fish to the same system will also theoretically increase "pressure" on wild fish. For the past 9 years, an attempt has been made to reestablish natural recruitment by using flow augmentation during the spawning season. To date, natural recruitment has not been reestablished. The white sturgeon recovery team has made the decision to use conservation aquaculture in the short term because they believe the risks associated with the "do nothing" approach far outweigh the risks associated with conservation aquaculture.

Interspecific competition of hatchery fish with other species of fish is not expected to be significant. By definition, competition occurs only with the condition of resource limitation. Given the highly speculative nature of potential unwanted side effects of interspecific competition, and the extremely low presence of juvenile white sturgeon in the Kootenai River (wild and hatchery), releasing fish is not rationally viewed as "adding fish to the system." Rather, the conservation aquaculture program is currently the only successful means of compensating for 20+ years of absent recruitment. Presently, the virtual absence of wild juvenile white sturgeon in the Kootenai system appears to present no threat of interspecific competition, based on presumed lack of resource limitation.

2.1) Describe alignment of the hatchery program with other hatchery plans and policies Explain any proposed deviations from the plan or policies.

The white sturgeon hatchery program is and will continue to be operated consistent with all extent plans and agreements including those identified in Section 2.2 and the NPPC annual production report.

Many hatchery reviews and policies were developed for application to anadromous salmon and steelhead programs which were historically geared toward a harvest objective. Specific activities and recommendations in those reviews and policies may not directly apply to the sturgeon conservation hatchery program but the general scientific framework and policies contained in reviews like the NPPC Artificial Production Review are applicable.

The NPPC recommended 10 policies to guide use of artificial production based on a scientific foundation for ecologically sound fish and wildlife management developed as a part of the Multi-Species Framework process, and on a scientific assessment by the Scientific Review Team of how artificial production might fit within that ecological framework. Policies include:

1. The purpose and use of artificial production must be considered in the context of the environment in which it is used.
2. Artificial production remains experimental. Adaptive management practices that evaluate benefits and address scientific uncertainties are critical.
3. Artificial production programs must recognize the regional and global environmental factors that constrain fish survival.
4. Species diversity must be maintained to sustain populations in the face of environmental variation.
5. Naturally spawning populations should be the model for artificially reared populations.
6. Fish managers must specify the purpose of each artificial production program in the basin.
7. Decisions about artificial production must be based on fish and wildlife goals, objectives and strategies at the subbasin and basin levels.
8. Because artificial production poses risks, risk management strategies must be implemented.
9. Production for harvest is a legitimate management objective of artificial production. But to minimize adverse impacts on naturally spawning populations, harvest rates and practices must be dictated by the need to sustain naturally spawning populations.
10. Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement must be fully addressed.

Policy #1 requires artificial production to be used consistent with an ecologically based scientific foundation for fish and wildlife recovery. The Kootenai program recognizes that the ultimate success of the artificial production program depends on restoration the environment in which the fish are released, reared, migrate and return. The program intercedes for the minimum portion (2 years or less) of the sturgeon life cycle needed to compensate for the bottleneck in the natural life cycle. Hatchery sturgeon will exist for almost all of their lives in a larger ecological system where they have access to the available range of riverine and lake habitats and are subjected to environmental factors and variation that we can only partially understand. The success of the program will be evaluated with regard to sustained benefits to the wild sturgeon population over the entire life cycle, rather than by the number of juveniles produced. Hatchery protocols have been specifically designed with the express purpose of avoiding domestication.

Policy #2 requires that artificial production be implemented within an experimental, adaptive management design that includes an aggressive program to evaluate benefits and address scientific uncertainties. The Kootenai white sturgeon program includes an extensive monitoring and evaluation program, which is also included within a comprehensive research and monitoring program of the entire Kootenai ecosystem. The program has demonstrated a ready ability to recognize and integrate new information since it's inception (Table 2).

Policy #3 requires that hatcheries mirror the dynamics and behavior of the larger system. Management and expectations of the KTOI sturgeon program are flexible to reflect the dynamics of the natural environment and large variation in juvenile survival rates are anticipated. Program development and evaluation have been extensively coordinated at the watershed, subbasin, basin and regional levels and are closely integrated with habitat improvement efforts.

Policy #4 requires that a diversity of life history types and species needs to be maintained in order to sustain a system of populations in the face of environmental variation. The entire KTOI program is geared to maintain this unique species and the maintenance of population diversity currently depends on a successful hatchery operation.

Policy #5 requires that artificially reared populations be modeled after naturally-selected populations in regard to population structure, mating protocol, behavior, growth, morphology, nutrient cycling, and other biological characteristics. The KTOI sturgeon program seeks to minimize hatchery involvement in the sturgeon life cycle so that natural processes prevail.

Policy #6 requires an explicit identification of whether the artificial propagation product is intended for the purpose of augmentation, mitigation, restoration, preservation, research, or some combination of those purposes for each population of fish addressed. The preservation and research goal of the KTOI program is clearly and explicitly defined in the Recovery Plan, the NPPC Fish and Wildlife Program, and this HGMP. The underlying habitat decline, which threatens extirpation, is currently being addressed through a series of experimental flow manipulations intended to identify appropriate conditions for natural spawning. Opportunities to restore natural floodplain function and habitat are also being investigated. The propagation program is intended to last until natural production is restored by habitat actions. The program will be evaluated based on the results and schedule of habitat restoration experiments. The hatchery purpose will be re-evaluated if appropriate habitat restoration efforts are deemed a failure or too expensive to implement. Conversely, facility withdrawal or conversion to another identified purpose will be considered in the context of the habitat results.

Policy #7 requires that decisions on the use of the artificial production tool be made in the context of deciding on fish and wildlife goals, objectives and strategies at the subbasin and province levels. The Kootenai sturgeon hatchery program is currently listed as an important component in the context of the basin wide planning process associated with revision of the NPPC Fish and Wildlife program.

Policy #8 requires that appropriate risk management needs to be maintained. The current monitoring and evaluation program is focused on key features that can be measured and program planning has anticipated the effects of factors beyond our capability to measure. For instance, a back-up rearing facility and establishment of an experimental non-essential Kootenai sturgeon population outside the current occupied range (within the subbasin) will provide protection for unforeseen risks.

Policy #9 refers to harvest and is not applicable to the KTOI program at this time.

Policy #10 refers to Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement, which are addressed in detail elsewhere in this plan. This plan anticipates that mandates and obligations can be altered by the appropriate authorities in response to new information or other events.

SECTION 3. WATER SOURCE

3.1) Provide a quantitative and narrative description of the water source (spring, well, surface), water quality profile, and natural limitations to production attributable to the water source.

One of the benefits of the current hatchery location is its proximity to the Kootenai River near the reach used by the wild sturgeon population. The hatchery is located at river kilometer 241 and the main spawning reaches are located between river kilometers 229-238. The primary hatchery water source is the same Kootenai River water used by the naturally spawning population. This is less an issue for Kootenai River sturgeon than it is for an anadromous species where homing and straying are affected by the water source. However, the female broodstock held in the hatchery between capture and spawning (usually between March or April through spawning in June) are exposed to ambient water temperature, enabling timing of gonad maturation to occur as it would in the wild. The wild female broodstock spawning events in the hatchery generally coincide with the timing of sturgeon spawning in the wild. Also, use of the ambient river water exposes the rearing sturgeon to similar conditions to those that would be encountered in the wild.

Since 1999, the source for incubation and hatching of sturgeon eggs at the Kootenai Tribal Hatchery is filtered Kootenai River water. Past attempts of incubation and hatching using ambient unfiltered river water resulted in high mortality rates due to siltation and fungus problems. Prior to the completion of Phase I of the hatchery upgrade in 1999, incubation and hatching used municipal water. The development of a river water filtration system was precipitated in part by the catastrophic mortality of an entire larval year class in July of 1997 when chlorine filtration equipment failed.

The current water intake system at the Kootenai Tribal Hatchery begins at the Kootenai River, where water is withdrawn through a pair of 12” intake pipes coupled to 24” diameter by 24” long stainless steel wedge wire intake screens. Through screen velocity is limited to 0.4 ft. per second. One intake screen is installed 5 feet above the river bottom and the second is installed 15 feet above the river bottom. The three river intake pumps (20 hp) are solids handling submersible type and are located in an on-shore wet well and operate on a active and stand-by mode. Under normal conditions, a single pump will operate to produce 250 gallons per minute, at approximately 125 feet of total dynamic head. Water is delivered to the treatment building through an 8" ductile iron underground pipe. The current system is designed to filter sediment from the river water using Amiad filters and seven 55-inch diameter pressure sand filters. All filtration equipment is designed to automatically backwash. Following the sand filters, the flow passes through a flow control valve to maintain the rearing head tank water level between selected depths. Three ultraviolet disinfection units follow the flow control valve and are piped in parallel, each with the capacity of 250 gallons per minute and a 50,000 microwatt per centimeter squared dosage rate, assuming a 90% ultraviolet transmission efficiency. Following the UV disinfections, a portion of the river water is then diverted through use of a manually adjusted ball valve at a rate of up to 50 gallons per minute to a head tank to feed egg incubation and hatching operations during the spring/summer months. The rest of the water goes directly to the hatchery to provide for rearing of fish from the prior year class. A separate duplex pump system passes the incubation and rearing water through a cooling heat exchanger and a propane fired boiler and heat exchange unit. It is the objective of the heat exchange system to temper river water for use during incubation and hatching, giving a regulated temperature of 12-13 degrees C. This is accomplished using heat exchange and cooling from a well water source. In no case is the tempering water source (well water) blended with the river water. After the eggs are hatched and the larvae have absorbed their yolk sacs and initiated feeding, they are gradually shifted to ambient river water for the duration of their time in the hatchery. Ambient water temperatures range from 1 degree C to 18 degrees C. The incubation and hatching system is in use between June and September.

The Kootenay Sturgeon Hatchery in British Columbia was constructed as an addition to the existing Kootenay Trout Hatchery to accommodate the need for a back-up facility. The water source for the Kootenay Sturgeon Hatchery is an abundant source of high quality groundwater that ranges from 6-9 degrees C. Water is pumped into the facility to a head tank and boilers and heat exchangers provide for heating of water for incubation, hatching, and early rearing. Currently, the hatchery has warmer water in the winter and cooler water in the summer than the Kootenai Tribal Hatchery. The warmer water temperatures have resulted in faster growth than the sturgeon at the Kootenai Tribal Hatchery that are reared on ambient river water. In general, it appears that fish from the Kootenay Sturgeon Hatchery will attain a size appropriate for marking by the age of 12-15 months. Effluent from the Kootenay Sturgeon Hatchery from egg incubation and rearing stages to 120 days post-hatch is sterilized with ozone and piped to ground. Effluent from rearing stages from 121 days to 360 days post-hatch is sterilized with ozone and discharged to surface.

3.2) Indicate any appropriate risk aversion measures that will be applied to minimize the likelihood for the take of listed species as a result of hatchery water withdrawal, screening, or effluent discharge.

Hatchery intake screens conform to NMFS and USFWS screening guidelines to minimize the risk of entrainment of fish species. Screening is described under Section 3.1. Although the USFWS does not have specific screening criteria for bull trout at this time, research is being conducted at the Abernathy facility that will result in criteria specific for bull trout. In the interim, most USFWS field offices are using NMFS criteria.

A National Pollutant Discharge Elimination System permit (NPDES) is not required for the facility because of low production levels. Minimum requirements for NPDES permits are production > 20,000 pounds of fish per year**.**

SECTION 4.   FACILITIES

In response to the Council's 1987 Columbia River Basin Fish and Wildlife Program, BPA funded the construction of the KTOI Experimental White Sturgeon Facility, which began operations in the spring of 1991. The low-capital facility was originally constructed to determine whether artificial propagation was feasible based on existing water quality of the Kootenai River and whether gametes from wild sturgeon in the Kootenai River were viable. Initial culture efforts demonstrated that eggs could be successfully fertilized, incubated, and hatched.

The facility was considered experimental until 1996, when the draft recovery plan called for the full implementation of the conservation aquaculture program (USFWS 1996). The existing facility and equipment was inadequate to meet the new expectations of the conservation aquaculture program as stated in the draft and final recovery plans (USFWS 1996 and 1999) and the breeding plan to preserve genetic variability of the white sturgeon in the Kootenai River (Kincaid 1993). A 1997 funding request was presented to NPPC and CBFWA for approval to bring the facility up to standard in order to provide adequate reliability (Phase I System Improvements – J-U-B Engineering Report 1997). The funding request was approved in time to make the following improvements to the existing facility beginning in 1998: 1) Upgrade the water supply capacity; 2) Improve the water treatment system to assure acceptable water quality; 3) Improve reliability through equipment upgrades and redundancy; and 4) Improve facilities for maintenance and protection of equipment.

Current plans and budget requests include completion of a Phase II upgrade, which is described in further detail in section 4.6.2 below. In no instance, does operation of the hatchery facilities or planned new construction, result in adverse effects to habitat for listed species.

4.1) Broodstock collection, holding, and spawning facilities.

All broodstock used in the Kootenai River Conservation Aquaculture program are captured from the wild population by angling or set lining. Female broodstock are collected from the Kootenai River in areas containing pre-spawning aggregations confirmed by ten years of on-going telemetry (IDFG Annual Reports 1990-1999). Each fish collected is weighed and measured, checked for recapture, and if not recaptured, marked with an individually numbered Floy tag, injected with a PIT tag and biopsied to determine sex and gonad development (spawning periodicity for females is 5 years and 2-3 years for males). Females are captured between February and May and held in the Kootenai Tribal Hatchery during final gonad maturation. After transport to the hatchery (see Section 4.2), each female is held separately or with one other fish in covered, circular fiberglass tanks (3 m diameter x 1.2 m deep) located inside the main hatchery building. An external standpipe maintains water level at approximately 1.14 m inside the tank. Water exchange is provided at 10-15 volumes/day and O_2 is maintained at approximately 5.0 mg/L. The center drain is level with the tank bottom to reduce obstruction and provide for efficient waste removal. Broodstock are held in Kootenai River water pumped into the hatchery and are fed live juvenile rainbow trout that are produced at the hatchery specifically for this purpose.

From 1990-1996, all potential male broodstock were brought to the hatchery, where milt was extracted for use in spawning. From 1997 to the present, milt is collected from flowing males in the field just prior to spawning induction of the female, and held in plastic bags and refrigerated in ice-filled coolers. Oxygen is replaced every 12 hours. Viable sperm can be stored for up to one week using this method. Sperm is checked for viability and motility upon arrival at the hatchery and again before egg fertilization takes place. A minimum water activated motility period of 2 minutes, verified under the microscope, as well as a high ratio of activated to nonactivated sperm, is required to designate viable sperm samples (Conte 1988).

Sturgeon females generally do not ovulate spontaneously in captivity. To induce ovulation, lutenizing hormone (LHRHa) is administered. However, treatment is only effective if the female has reached the responsive stage of final ovarian maturation, which is manifested by the advanced stage of germinal vesicle migration and the oocyte response with germinal vesicle breakdown to a maturation-inducing hormone (Van Eenennaam et al. 1996). Prior to spawning induction, the female sturgeon is transferred by stretcher to a covered rectangular fiberglass spawning tank (2.1 meters long x 0.61 meters wide x 0.61 meters deep), allowing for underwater hormone injection (LHRHa) and observation of eggs once the female begins ovulation.

4.2) Fish transportation equipment (description of pen, tank truck, or container used).

Following sex determination and gonad development by biopsy in the field, potential female broodstock are directly transferred from the boat (in a water-filled stretcher) to a covered fiberglass tank mounted on a truck for immediate transfer to the hatchery. Oxygen is provided by a bottled oxygen system for the short trip to the hatchery. Water for the tank is obtained from the hatchery (Kootenai River) prior to transport. The truck is parked near the sampling area and transfer from the staging area to the hatchery generally takes approximately ½ hour.

The same truck and tank is used for transportation of juvenile white sturgeon for release. Release sites are located between river kilometer 171 and 259 (the hatchery is located at river kilometer 241). Sturgeon are netted out of the rearing tanks into the truck tank containing Kootenai River water. At the release site, fish are netted from the tank truck and released into the river. Some release sites require access by boat, in which case, sturgeon are loaded by net into a live well on the boat, netted out of the well at the release site, and released directly into the river.

Starting in 1999, approximately 5,000 to 20,000 fertilized, disinfected eggs from up to five families are shipped to the Kootenay Sturgeon Hatchery in British Columbia as a "fail-safe" measure to minimize the risk of catastrophic loss. Once the eggs are washed and disinfected, they are loaded into double plastic bags filled with 4-6 liters of water from the Kootenai Tribal Hatchery (ambient river water). The bags are then inflated with oxygen, sealed, and placed in a cooler. Some warming of eggs occurs during transport so that the temperature will be matched with the incubation temperature at the Kootenay Sturgeon Hatchery (15 degrees C). Temperature is monitored during the trip and ice is added if necessary (weather dependant). The coolers are transported to the Kootenay Hatchery by pick up truck, a trip that takes approximately 2 ½ hours.

For release of juvenile white sturgeon from the Kootenay Sturgeon Hatchery, standard trout transportation trucks with insulated, oxygenated 150 to 250 gallon tanks are used. Fish are netted from the rearing tanks into the trucks and then netted out of the tanks at the release site.

4.3) Incubation facilities.

Incubation occurs in modified MacDonald jars (13 liter capacity, round bottom cylinders, 50 cm tall, and 20 cm in diameter), which drain into rectangular fiberglass fry collection tanks (1.2 m x 0.56 m x 0.31m deep). The incubation jars are made of acrylic plastic that allows for direct observation of the eggs and flow pattern. Water enters the jars through water distribution pipes, each equipped with a control valve. The PVC pipe passes through a jar cap screen and is sleeved in a clear acrylic pipe that extends from the jar-cap to about 2.5 cm from the bottom of the jar. This design provides adequate control of water velocity and egg agitation (Conte et al. 1988). The water flows out of the jar, over a lip positioned under the cap, and directly to the fry collection tank. The hatchery uses up to 24 jars and up to 12 tanks to separate all families and half-sib families. The capacity of each jar is 5,000 to 25,000 eggs. Eggs are incubated with filtered water from the Kootenai River held at approximately 13 degrees C during incubation (refer to Section 3.1 for a description of the incubation water system). Eggs begin hatching in approximately 10 days post-fertilization and the hatch is complete at approximately 14 days post-fertilization. As eggs hatch, the emerged fry tend to move vertically and the water flow carries them to the top of the jar and over the lip, directly into the fry collection tank. Eggshells are siphoned daily from the fry collection tanks. The incubation and hatching methodology is adapted from Conte et al. 1988.

As mentioned in Section 4.2, starting in 1999, approximately 5,000 to 20,000 fertilized, disinfected eggs from up to five families were shipped to the Kootenay Sturgeon Hatchery in British Columbia as a "fail-safe" measure to minimize the risk of catastrophic loss. The Kootenay Sturgeon Hatchery incubation and hatching facilities are configured similar to the above description (with capacity for five families rather than twelve and incubation temperatures a few degrees higher (15-16 degrees C rather than 13 degrees C).

4.4) Rearing facilities.

The hatchery piping and drain system is designed for flexibility regarding tank use for different life stages. River water is piped into the main hatchery facility from the treatment room and distributed through a 4" pipe system with valves located approximately every 3 feet so that different tanks can be set up depending upon life stage. Upon completion of hatching, all fry within a family are transferred from fry collection tanks to larger rectangular fiberglass rearing tanks for early larval feed initiation. Each tank is equipped with a PVC spraybar with an attached valve to control flow. A perforated stainless steel screen ($3/16^{\text{th inch}}$) fits into a slot at one end of the tank to separate the clean out standpipe from the larval rearing area. In addition, flexible small mesh fiberglass window screen is used to cover the perforated stainless steel screen to prevent escape of larval fish. Tanks are covered and lights are kept off when staff are not working in the hatchery, since larvae exhibit a slightly phototaxic behavior. The facility uses up to 32 tanks for this life stage, each 2.44 m length x 0.56 m wide x 0.31 m deep. Feed initiation occurs approximately 2-3 weeks post-hatch, after the yolk sac is absorbed. Larvae are fed by hand every 2 hours between 6 A.M. and 8 P.M. and automatic feeders are on 24 hours a day. The hand feeding enables fish that are less aggressive to initiate exogenous feeding. Fry are transferred to circular fiberglass tanks approximately 3 weeks after initiation of feeding. Circular tanks are preferred because they allow for circular water flow, providing current for fry to swim in. Circular tanks are also easier to clean (feces and excess feed collect around the center standpipe for easy removal). Fiberglass circular tank size ranges from 1.02 m diameter x 0.43 m deep to 1.42 m diameter x 0.76 m deep. Because all families and half-sib families are reared separately until release and fry are also separated according to size, up to 32 tanks can be set up and used during this life stage. Fish held beyond age one are transferred to large circular fiberglass tanks (3 to 4.5 m in diameter), and reared in densities below 225-g/cubic foot of water. The facility has two rearing sheds housing 6 - 4.5 m diameter circular tanks (Rearing Shed 1) and 12 – 3 m diameter tanks (Rearing Shed 2). Ambient river water is piped through the main hatchery and then to the rearing sheds. The Kootenay Sturgeon Hatchery rearing facilities are configured similar to the above description (with capacity for five families rather than twelve).

4.5) Acclimation/release facilities.

No specialized acclimation or release facilities are required for sturgeon.

4.6) Describe operational difficulties or disasters that led to significant fish mortality.

In 1997, the entire larval year class was lost as a result of an unfortunate chain of events: 1) In 1996, a proposal was presented to perform some of the necessary upgrades needed at the hatchery. The funding request was not approved; 2) In January 1997, KTOI presented another request for funding in order to upgrade the facility and provide funding for a back-up facility operated by IDFG in Sandpoint. The RFM approved partial funding of the request. The facility in Sandpoint was to be used for back-up but was not available because a broken main waterline had not been repaired. Because the facility was not operational, the KTOI did not have a portion of the 1997 year class in a fail-safe facility; and 3) The use of water from the Northside Water District (de-chlorinated through a charcoal filtration system) to incubate and rear white sturgeon to 3 weeks of age had been the only successful way to produce sturgeon in the past. Incubating in river water has caused fungus problems and egg suffocation because of silt and bacteria present in the flow-through river water system. During incubation in 1997, the North Side Water District replaced some main lines in the water system and flushed them with chlorine. The chlorine filtration system failed, resulting in the overnight loss of the entire 1997-year class. This event confirmed the need for improvements in the water supply system, which was subsequently completed during Phase I of hatchery improvement construction.

4.6.1) Indicate available back-up systems, and risk aversion measures that minimize the likelihood for the take of listed species that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

The KTOI White Sturgeon Hatchery has been constructed with numerous back-up and emergency scenarios in mind. From availability of trained staff seven days a week, 24 hours a day, to power supply, piping, equipment and water supply, operation in unusual or adverse conditions can be accomplished in a variety of ways.

First, the municipal electrical power supply has been improved from an old single-phase river crossing to a new and reliable 3-phase crossing. When the municipal power is interrupted, all of the critical water supply equipment and lighting is automatically switched over to the 100-kilowatt propane-fired generator. The propane generator is currently being converted to natural gas to provide more reliable fuel supply, especially in severe winter conditions when propane and diesel delivery can be difficult.

The new river water delivery system is also backed up through the use of the original river pump station. A 40-kilowatt diesel generator provides stand-by power to the back-up pump station. Multiple pumps are provided in each pump station to allow one unit out of service for maintenance or repair.

Municipal water can also be supplied to the hatchery and rearing facilities. Activated carbon filters are in-line to guard against chlorine in the municipal water. Compressed air and ceramic air diffusers are also available in the hatchery and rearing areas to maintain adequate oxygen content in the water if the river water supply is unavailable for an extended period of time.

The river water supply normally flows through the treatment equipment. However, it can be bypassed directly to the hatchery and rearing head tanks in case of piping or equipment failure in the treatment building. Similarly, each piece of equipment in the treatment building can be bypassed to accommodate maintenance and emergency operations.

An alarm system employs an automatic dialer, audible exterior horn, and interior strobe light to notify operators of an alarm condition. Alarm conditions include low and high incubation water temperatures, pump failure, low head tank water level, power failure, filter system failure, and ultraviolet disinfection system failure. The alarm system is routed through a programmable logic controller (PLC). The PLC receives the alarm signals and sends them on to the audible system, dialer, and light as well as logs them on the hatchery computer. The computer is equipped with PC Anywhere software and a modem to allow the PLC and all the alarm data to be accessed by a technician from a remote location. This interface facilitates rapid response to alarm conditions.

The water discharge system has also been connected with drain connections to the river as well as the Irrigation District drainage ditches. Both systems are designed to operate satisfactorily under the 100-year flood conditions predicted for the Kootenai River. A flood control dike that was designed for the 100-year flood also protects the KTOI site. The primary river pump station is designed to operate under 100-year flood conditions as well.

In the event of a train, roadway, or other accidental spill that may affect water quality, the KTOI hatchery is notified by the Boundary County Sheriff’s dispatch. Since the hatchery staff live in the adjacent village or stay in the crew quarters while on duty, emergency actions can be instituted quickly 24-hours per day and seven days per week.

4.6.2) Indicate needed back-up systems and risk aversion measures that minimize the likelihood for the take of listed species that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

A significant facility upgrade was completed in FY2000 to address hatchery needs consistent with use prescribed by the USFWS recovery plan (1999). Phase I upgrades that have been completed to date at the existing Tribal facility include: 1) 3-phase power crossing and standby generation system; 2) new river intake piping system; 3) water treatment system with three submersible river intake pumps and two types of filtration followed by ultraviolet disinfection; 4) water temperature control system for incubation; 5) crew quarters and boat storage; 5) re-piping and concrete in the main hatchery; and 6) installation of a dock to carry wild broodstock from the boat to the hatchery.

These upgrades bring the existing facility up to standard but there is still be a need to provide adequate rearing space for up to 12 families per year as the project becomes fully implemented. Each family group must be reared separate from other family groups to ensure proper identification at outplanting (USFWS 1999) and also must be reared at low densities to prevent disease outbreak (LaPatra et al. 1994). Presently, the existing facility can house approximately 8 families per year class to the age of 2. The BCMF "back-up facility" in Canada provides space for up to five families per year class to the age of 2 (representing up to five female's progeny). The intention of the back-up facility is to provide replication of families represented in the Kootenai Tribal Facility in case of catastrophic loss at either facility. Although the BCMF "back-up facility" provides an important function (and will contribute fish to the stocking goal when necessary), it does not provide additional rearing space that is necessary to represent up to 12 families per year class, as called for in the USFWS recovery plan (USFWS 1999). For this reason, we have received funding in FY2000 to begin preparing a master plan for a second facility located on Tribal land in the Kootenai River drainage to provide adequate rearing space for white sturgeon.

SECTION 5. BROODSTOCK ORIGIN AND IDENTITY

5.1) Source.

All broodstock used in this program are wild Kootenai River fish which are captured, spawned, and released following spawning. Fish are collected in staging and spawning areas near Bonners Ferry between river km 200 and 245.

5.2) Supporting information.

5.2.1) History.

No broodstock other than wild Kootenai River white sturgeon have ever been used in the program. This ESA endangered stock fails to meet even the most optimistic critical and viable population thresholds (see section 10.2.2 for discussion of thresholds).

5.2.2) Annual size.

Up to 20 wild broodstock are spawned per year. Based on an approximate wild population size of 500 to 2,000 adults, broodstock would comprise 1-4% of the population. Use of wild broodstock does not affect population status relative to critical and viable thresholds because wild spawning is currently unsuccessful and broodstock are released alive after spawning.

5.2.3) Past and proposed level of natural fish in broodstock.

All (100%) of broodstock are wild fish.

5.2.4) Genetic or ecological differences.

Hatchery and natural stocks are identical except that the broodstock in any single year represent a subset of the available population.

5.2.5) Reasons for choosing Broodstock traits

No specific broodstock traits or characteristics are selected.

5.2.6) ESA-Listing status

Hatchery-reared sturgeon are listed as Endangered and are essential for recovery.

5.3) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects that may occur as a result of using the broodstock source.

The risk of among population genetic diversity loss will be reduced by selecting the indigenous white sturgeon population for use as broodstock in the supplementation program.

SECTION 6. BROODSTOCK COLLECTION

6.1) Life-history stage to be collected (eggs, juveniles, adults).

All broodstock are collected as mature adults immediately prior to spawning.

6.2) Collection or sampling design.

All broodstock used in the Kootenai River Conservation Aquaculture program are captured from the wild population by angling or set lining. Male and female broodstock are captured from February through May in areas containing pre-spawning aggregations confirmed by ten years of ongoing telemetry (IDFG Annual Reports 1990-1998). Annual collection of late vitellogenic females from these areas, and subsequent spawning of these fish in the hatchery suggested that fish spawning throughout the entire spawning season congregated simultaneously in the same areas. Thus, our broodstock sampling regime incorporated spawners from the duration of the spawning run.

To identify potential broodstock in the field, all captured fish are biopsied to determine sex and gonad maturation stage (Conte et al. 1988). Captured fish are placed ventral side up in a hooded water-filled stretcher suspended across the gunwales of the boat. Sex and reproductive development is determined by visual observation of gonadal tissues through a 2-3 cm midline incision on the ventral surface of the fish. Reproductive development of males and females is categorized according to criteria reported by Conte et al. (1988). Every fish collected is weighed and measured (mm, FL, TL), checked for recapture, and if not a recapture, marked with an individually numbered Floy tag and injected with a PIT tag. Once sex and reproductive status is determined, fish are either brought to the hatchery for subsequent spawning or released back into the river. Male and female broodstock recaptured in the wild are weighed, measured, and immediately released. Recaptured male and female broodstock that contributed to surviving progeny groups are not spawned more than once.

6.3) Identity.

Only one target population is present. Wild broodstock that have been captured before or have contributed to previous hatchery broods are distinguished with individually-numbered Floy and PIT tags and data regarding all captured fish is provided to field crews on an annual basis in a field notebook organized alphabetically and numerically by PIT tag number (IDFG database). Hatchery origin fish are identified by a PIT tag and a scute removal mark and are also included in the field notebook database.

6.4) Proposed number to be collected:

6.4.1) Program goal (assuming 1:1 sex ratio for adults):

A genetic breeding plan has been implemented to guide management in the systematic collection and spawning of wild adults before they are lost from the breeding population. The implementation of the breeding plan includes measures to minimize potential detrimental effects of conventional stocking programs. The objective of the conservation aquaculture program is to produce 4-12 separate families per year. This will generally require 2-6 females and 4-12 males per year. Actual numbers for any given year generally depends upon the annual number of females available in the spawning population and the success in capturing ripe females. The implementation plan incorporates the expectation that actual annual numbers will vary.

6.4.2) Broodstock collection levels for the last 12 years (e.g., 1988-99), or for most recent years available:

A total of 477 broodstock were captured from 1990 through 2000, of which 68 were spawned (23 females, 45 males), producing 44 families (see following table). For simplicity, all half-sibling families were included in this total of 44 families. Fertilization and hatching success rates ranged from 6 % to > 99% and 1% to 90% respectively among all years.

Year	Adult Males	Adult Females	Jacks	Eggs	Juveniles	No. families produced
1990	1	1	NA	0	0	1
1991	3[a]	1	NA	0	0	1
1992	3[b]	1	NA	0	0	3
1993	2	1	NA	0	0	2
1994	0	0	NA	0	0	0[c]

Year	Adult Males	Adult Females	Jacks	Eggs	Juveniles	No. families produced
1995	4	2	NA	0	0	4
1996	2	1	NA	0	0	2[a]
1997	5	3	NA	0	0	6[e]
1998	6	3	NA	0	0	6
1999	8	4	NA	0	0	8
2000	11	6	NA			11
Total	**45**	**23**	**NA**	**0**	**0**	**44**

a: Sperm from 3 males pooled.
b: Eggs fertilized separately from each male.
c: No white sturgeon handled, due to ESA listing.
d: No survivors to age at release; hatching success 1% due to low broodstock (gamete) quality.
e: No survivors to age at release; hatching success > 80%; larvae died shortly after hatch due to equipment/facility failure.

6.5) Disposition of hatchery-origin fish collected in surplus of broodstock needs.

Unlike most salmon and steelhead hatcheries where hatchery broodstock enter the collection system, sturgeon must be caught one by one in the wild. Broodstock collection activities for sturgeon cease when adequate numbers of mature fish are in hand. In many years, collection activities may continue through the duration of the wild sturgeon spawning season.

6.6) Fish transportation and holding methods.

All broodstock used in the Kootenai River Conservation Aquaculture program are captured from the wild population by angling or set lining between February and June. Female broodstock are collected from the Kootenai River in areas containing pre-spawning aggregations confirmed by ten years of on-going telemetry (IDFG Annual Reports 1990-1999). White sturgeon broodstock are often large, weighing between 45 and 75 kg, and special handling is required to avoid injury to the fish. Each captured fish is placed in a hooded stretcher in the water, prior to placing them aboard the boat. The sturgeon's axial skeleton is cartilaginous, and the stretcher distributes the weight evenly and provides support, preventing injury to the internal organs when the fish is moved (Conte et al. 1988). The stretcher is constructed of smooth nonabrasive fiber-reinforced nylon sheeting attached to two 2.4-meter poles. It has a hood at one end to cover the fish's head, acting as a respiration chamber when water is added. The stretcher and fish are then hoisted into the boat, the stretcher is placed across the gunwales of the boat, the fish is turned on the dorsal side, and water is added to the stretcher. Each fish is measured, checked for recapture, and if not recaptured, marked with an individually numbered Floy tag and injected with a PIT tag, and biopsied to determine sex and gonad development (spawning periodicity for Kootenai River white sturgeon is 5 years for females and 2-3 years for males). Total time in the stretcher is less than 10 minutes.

Following sex determination and gonad development by biopsy in the field, potential female broodstock are directly transferred from the boat (in a water-filled stretcher) to a covered fiberglass tank mounted on a truck for immediate transfer to the hatchery. Oxygen is provided by a bottled oxygen system to provide aeration for the short trip to the hatchery. Water for the tank is obtained from the hatchery (Kootenai River) prior to transport. The truck is parked near the sampling area and transfer from the staging area to the hatchery generally takes approximately ½ hour.

After transport to the hatchery, each female is held separately or with one other fish during final gonad maturation in covered, circular fiberglass tanks (3 m diameter x 1.2 m deep) located inside the main hatchery building. Female broodstock are held in ambient Kootenai River water pumped into the hatchery and are fed live juvenile rainbow trout that are produced at the hatchery specifically for this purpose. An external standpipe maintains water level at approximately 1.14 m inside the tank. Water exchange is provided at approximately 10 to 15 volumes per day and O_2 is maintained at approximately 5.0 mg/L. The center drain is level with the tank bottom to reduce obstruction and provide for efficient waste removal. Female broodstock are generally held in the hatchery for 2 weeks to 4 months for final gonad maturation. Female broodstock are returned to the river approximately one week after the spawning event.

From 1990-1996, all potential male broodstock were brought to the hatchery, where milt was extracted for use in spawning. From 1997 to the present, milt has been collected from flowing males in the field just before spawning induction of the female. Field methodology described above for female broodstock is similar for males except that a surgical biopsy is not necessary during the natural spawning period to determine sex. Instead, flowing males are identified in the field by extraction of milt. Milt is extracted using surgical tygon tubing attached to a syringe and inserted into the vent, and held in plastic bags and refrigerated in ice-filled coolers. Oxygen is replaced every 12 hours. Viable sperm can be stored for up to one week using this method. Sperm is checked for viability and motility upon arrival at the hatchery and again before egg fertilization takes place. A minimum water activated motility period of 2 minutes, verified under the microscope, as well as a high ratio of activated to non-activated sperm, is required to designate viable sperm samples (Conte 1988).

6.7) Describe fish health maintenance and sanitation procedures applied.

Biopsies to assess sex and gonad maturation are completed with sterile surgical methods. Methodology is detailed in Conte el al. 1988. In preparation for surgery, the abdominal area anterior to the genital pore is treated with a 4 percent antibacterial solution of nitrofurazone, administered with a wash bottle. Using a scalpel with a size 10 blade, a 2-3 cm incision is made through the ventral midline, a distance of three to five ventral scutes anterior to the genital pore. The presence or absence of ripe oocytes or testes is then confirmed and the incision is closed and sutured using a cruciate or continuous suture pattern with resorbable sterile sutures. The surgical area is then washed with a 4 percent solution of nitrofurazone.

6.8) Disposition of carcasses.

Not applicable for sturgeon. Broodstock are released alive after spawning.

6.9) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed species resulting from the broodstock collection program.

Adverse genetic or ecological measures by use of wild broodstock are eliminated by the use of a small fraction of the population and the live release of all fish after spawning. Fish capture methods by angling or set lining minimize any size selectivity associated with other capture gears such as gillnets. The fish captured thus represent a random sample from the adult population of potential spawners. Disease amplification risks in capture and handling are eliminated by use of sterile techniques in field biopsies and the isolation of broodstock in the hatchery. Standard hatchery equipment and facility sanitation and fish health maintenance guidelines and procedures are followed.

SECTION 7. MATING

Sturgeon culture techniques differ from those used for salmonids because of inherent differences in gonad development, spawning frequency, and sperm and egg structure, physiology, and biochemistry. A complete description of broodstock evaluation, gamete processing, and incubation of eggs is outlined in the Hatchery Manual for White Sturgeon by Conte et al. (1988). This includes information concerning: 1) assay to determine spawnable females and final oocyte maturation; 2) spawning induction of females including injection schedule for LHRHa, injection procedures, and observation of response; 3) milt and egg extraction overview including checking sperm viability, sperm dilution, egg fertilization, and egg de-adhesion; and 4) incubation of eggs and early life stages.

Given the uniqueness of the species and the new concept of conservation aquaculture for a long-lived species, methodology has been adapted by networking with experts in the field, as well as using and refining techniques described in Conte et al. (1988). Techniques have been refined to suit the purposes of the conservation aquaculture program. For example, surgical removal of eggs was used for 2 years until hand-stripping of eggs proved to be a viable alternative. Hand-stripping of eggs greatly minimizes stress associated with Cesarean surgery and reduces the recovery period of post-spawning adult white sturgeon prior to release back into the wild. Also, we are in the process of refining techniques for field collection and storing of sperm to minimize the number of wild fish brought to the hatchery.

7.1) Selection method.

Breeding matrices and protocols were developed to maximize effective population number and to minimize chances of future post-stocking inbreeding in the wild (Kincaid 1993). The conservation-breeding program uses 2-6 females and 4-12 males captured from the Kootenai River each spring. Fish are spawned in pairs or in diallel mating designs to produce up to 12 individual families that are reared separately to maintain family identity. The field collection of broodstock results in a random selection process for spawners as described previously.

7.3) Fertilization.

Eggs from all potential female broodstock held in the hatchery are evaluated to estimate timing of final maturation. Germinal vesicle breakdown (GVDB, Conte et al. 1988) and Polarization index (PI) values (J. VanEenennaam et al. 1996) are calculated at least twice for at least 20 eggs from each female brood fish prior to spawning. Selection criteria for female broodstock included $\geq$ 80% GVDB and PI values of $\leq$ 0.10. All selected female broodstock receive two doses of synthetic ovulatory (releasing) hormone LHRHa at 0.1mg/kg body weight: 1) an initial dose (10% of total calculated dose), and 2) a resolving dose (90% of total calculated dose) (Conte et al. 1988). Males do not receive LHRHa injections, with the exception of two males that were experimentally injected during 1997. From 1990 through 1996, all male broodstock were removed from the river to the hatchery, where sperm was extracted. Since 1997 all sperm samples have been collected from flowing males in the field, up to several days before fertilization. A minimum water-activated motility period of 2 min, verified under a dissecting microscope, as well as a high ratio of activated to nonactivated sperm, is required to designate viable sperm samples (Conte 1988).

Initially, (1990-1992) eggs were removed by Caesarian surgery (Conte et al. 1988). Since 1993 eggs have been removed solely by hand stripping (Siple and Anders 1993) to minimize the stress experienced by the broodstock. Use of this hand-stripping technique also enables earlier release of post-spawned broodstock back into the river, and reduces the chance for disease or infection associated with complete post-surgery recovery, which took up to several months. Eggs are collected within 48 hours after the LHRHa resolving dose, after ovulation began, characterized by several hundred eggs visible on the bottom of the spawning tank. Eggs are fertilized, volumetrically quantified, de-adhesed with Fuller's Earth, and incubated in modified MacDonald hatching jars (Conte et al. 1988).

7.3) Cryopreserved gametes.

Cryopreservation of sturgeon gametes is not currently practiced. Research is being conducted at the University of Idaho as part of this program in an attempt to determine if cryopreservation is feasible for sturgeon. This method will be considered for incorporation into future activities if a feasible methodology can be identified.

7.4) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme.

A genetic monitoring program has been implemented to assess and potentially minimize genetic risks associated with this hatchery program. The success of the sturgeon hatchery program hinges on accurately representing the wild population's genetic diversity and variation in a subset of broodstock from that population. Failures of other conservation aquaculture programs to restore wild populations may have resulted from under- or over-representing a subset of a wild populations' specific genotypes or haplotypes or from other selection pressures (Hindar et al. 1991; Waples 1991; Waples and Teel 1990). Such failures may have occurred due to design oversight or logistical or economic constraints.

MtDNA and nuclear DNA are being analyzed, including but not limited to D-loop length variation screen (mtDNA) microsatellite analysis (mt and nuclear DNA), and direct sequencing of mtDNA regions. Samples of wild fish are being taken to monitor possible differences between hatchery and wild brood stocks. Genetic analyses of samples from wild broodstock, their progeny groups, and an ongoing but separate analysis of the wild population all address the issues of genetics accompanying this hatchery program. A sub-contract with the University of Idaho's (ARI) Fish Genetics Lab is currently in place to provide this work.

Nucleotide primer pairs for eight separate microsatellite loci are used to PCR amplify the intervening sequences between primers. All microsatellite primers have been used to previously amplify polymorphic loci in white sturgeon samples (May et al., 1997). An approximate 400 bp segment of the hypervariable, non-repetitive portion of the D-loop region will be sequenced from individuals from each family to assess the nucleotide divergence in this rapidly evolving portion of the mitochondrial genome. For methodologies using sturgeon see Brown et al. (1996), Stabile et al (1996), Miracle and Campton (1995), and Buroker et al. (1990). An automated DNA sequencer and nucleotide primers specific for this region will be used in this task. Geneticists include Dr. Madison Powell and consulting geneticist Dr. Don Campton. University of Idaho, ARI Fish Genetics Lab is subcontracted to perform the genetics portion of proposal.

White sturgeon possess a series of length variants in the control region of their mitochondrial genome that have been used to identify maternal lineage. This length variation arises as a consequence of a gain or loss of 1-5 perfectly repeated tandem 78-82 base-pair sequences (Brown et al., 1996, 1992; Buroker et al., 1990). Frequencies of these length variants were reported for 113 wild white sturgeon from the Kootenai system (Kootenai River n=66; Kootenay Lake n=47; Anders and Powell 1998). Length variant frequencies were subsequently determined for 54 wild broodstock brought to the Kootenai Hatchery from 1997 through 1999 (see Powell and Anders 1999 for DNA isolation and PCR protocols). A Monte Carlo simulation for chi-square tests that employed 1000 boot-strap resampling iterations (Roff and Bentzen 1989) was used to compare how length variant frequencies of the 113 wild fish differed from those of the 54 broodstock from the same wild (source) population. Genetic typing of progeny groups is ongoing but incomplete and not reported here. Five mitochondrial control region length variants have been observed among the 113 fish surveyed from the wild population in the Kootenai River and Kootenay Lake (see Table below). Preliminary results from the 54 wild Kootenai River broodstock suggest that all five length variants found in the wild population were represented by the 54 broodstock. Distribution of haplotype (length variant) frequencies were non-significant with standard chi-square analysis (x^2 = 1.64). However, 82.1% of 1,000 boot strap iterations (Roff and Bentzen 1989) exceeded the average chi-square value of 3.97.

mtDNA control region length variant frequency comparison between 113 wild Kootenai River white sturgeon and 54 Kootenai Hatchery broodstock from the same population. Percent of samples having each length variant is indicated parenthetically.

Length variant	Wild population	Broodstock sample group
LV-01	54 (47.8)	26 (48.1)
LV-02	35 (31.0)	14 (25.9)
LV-03	11 (9.7)	6 (11.1)
V-04	6 (5.3)	3 (5.6)
LV-05	7 (6.2)	5 (9.3)
Totals	113 (100)	54 (100)

The feasibility of pedigree analysis is being explored but it has not been implemented to date. Unlike other animal and fish breeding programs, the logistics of spawning wild endangered white sturgeon lacks many of the luxuries of design flexibility these other species possess. For instance, a desirability or dissimilarity matrix approach has been used for salmonids in the Pacific Northwest to reduce the probability of spawning closely related broodstock and associated deleterious effects. In some of these cases, dozens to hundreds of potential broodstock are simultaneously available, along with added flexibility from cryopreservation. All these conditions are unavailable to our sturgeon spawning program.

Although not a comprehensive population assessment, our genetic analysis (mtDNA control region length variant analysis) provided an efficient, low-cost technique to monitor genetic diversity and variation of native broodstock relative to that of the wild (source) population. The relative simplicity and low cost of this analysis makes it possible to genetically type wild broodstock prior to spawning. Provision of this genetic information can provide hatchery managers, biologists, and geneticists with the opportunity to develop spawning matrices to reduce or eliminate unintended mating of highly related broodstock. Implementation of this analytical technique can also help mimic natural within-population genetic diversity and variation, and theoretically improve fitness of progeny groups. Future genetic research should include the use of bi-parentally inherited nuclear markers (RFLP's and microsatellites) at population, broodstock, and progeny levels to further resolve relevant population genetic issues and to address responses of the wild population to continued operation of the Kootenai River Conservation Aquaculture Program.

SECTION 8. INCUBATION AND REARING

8.1) Incubation:

8.1.1) Number of eggs taken/received and survival rate at stages of egg development.

All fertilized eggs are subsequently incubated, hatched, and reared. Starting in 1999, approximately 5,000 to 20,000 fertilized, disinfected eggs from up to five families are shipped to the British Columbia Ministry of Fisheries Kootenay Hatchery in Fort Steele, British Columbia as a "fail-safe" measure to minimize the risk of catastrophic loss at either facility. Incubation and rearing methods at Fort Steele mirror those used at the KTOI facility

Year	Number of Females Spawned*	Number of Families	**Total** and Mean # Eggs Taken (Range)	Estimated Larvae Produced	Average Egg-Larval Survival Rate
1990	1 (1)	1	**60,000** a	1,100	1.8%
1991	1 (2)	1	**68,536** a	14,000	20%
1992	1 (2)	3	**141,984** a	22,700	16%
1993	1	2	**86,326** b	18,100	21%
1994	0 (0)	0	0	0	0
1995	2 (2)	4	**142,700** c Mean-71,350 (70,875-71,825)	39,800	28%
1996	1 (2)	2	**61,805** c	200	<1%
1997	3 (4)	5	**201,480** c Mean -67,160 (39,600-97,080)	60,600	30%

Year	Number of Females Spawned*	Number of Families	**Total** and Mean # Eggs Taken (Range)	Estimated Larvae Produced	Average Egg-Larval Survival Rate
1998	3 (3)	6	**216,526** c Mean 72,175 (60,076-92450)	60,000	28%
1999	4 (5)	8	**277,050** cd Mean 69,262 (37,800-105,000)	174,500	63%
2000	6 (6)	11	**306,085** cd Mean-51, 014 (17,100-112,160)	223,500	73%

*(Number of females in hatchery in parentheses)
a: eggs taken by caesarian section
b: eggs taken by a combination of hand-stripping and caesarian section
c: eggs taken by hand-stripping
d: a portion of the eggs were incubated at the Kootenay Sturgeon Hatchery

8.1.2) Loading densities applied during incubation.

Fertilized eggs are approximately 3-4 mm in diameter. Each MacDonald jar generally receives 5,000 to 25,000 fertilized eggs and flow is adjusted to maintain a 30-40% exchange per minute.

8.1.3) Incubation conditions.

Water flow through the hatching jars provides a gentle rolling of the eggs, which allows oxygen to reach all eggs in each jar. Eggs typically hatch within 10 to 14 days at 13 degrees C. Upon hatching, fry swim up and exit the MacDonald jars with the effluent water and are deposited directly into rectangular fiberglass rearing tanks (1.2 m x 0.56 m x 0.31m deep). A full description of the UV treatment, water filtration system (to prevent silt from suffocating eggs), and incubation water system see Section 3.1 (Water Source).

8.1.4) Ponding.

Upon completion of hatching, all fry within a family are transferred to circular fiberglass rearing tanks for larval and fingerling grow-out. All families and half-sib families were reared separately until release. Sturgeon are reared in the Kootenai Tribal Hatchery for up to 2 years prior to release. Fish held beyond age one are transferred to larger circular fiberglass tanks (3 - 4.5 m in diameter). See Section 4.4 for further details regarding rearing facilities.

8.1.5) Fish health maintenance and monitoring.

Fungus is controlled during incubation by maintaining a water flow that gently rolls the eggs, as well as temporarily reducing the water flow and siphoning out dead eggs. Eggshells are also siphoned from the fry collection tank several daily during hatching.

8.1.6) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to fish during incubation.

Eggs are incubated using filtered river water (with UV treatment) to minimize the risk of catastrophic loss due to siltation or fungus problems caused by river water and potential filtration problems caused by using chlorinated municipal water. Egg densities in MacDonald hatching jars are kept low to minimize mortality risk from fungus and clumping. Additionally, eggs are incubated separately according to family so that parental contribution at stocking age can be identified and genetics can be monitored.

8.2) Rearing:

8.2.1) Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to release) for the most recent twelve years (1988-99), or for years dependable data are available.

Survival data by hatchery life stage is generally not available because routine culling takes place during each life stage. Before 1999, rearing space and water availability was limited and culling was necessary to prevent overcrowding. With full implementation of the program, the number of fish spawned has increased in the past few years. Additionally, with the new upgrades to water quality and quantity, survival during incubation has increased. Rearing space is still a limiting factor and culling to prevent overcrowding is still necessary. High production rates per family are not the focus of this conservation program. Rather, a focus on the breeding plan and an attempt to provide genetic diversity are more important than producing as many fish as possible.

8.2.2) **Density and loading criteria (goals and actual levels).**

Larval, fingerling, and juvenile densities are maintained below 225 g of fish per cubic foot of water as a precaution against density-dependent, stress-induced disease outbreaks.

8.2.3) Fish rearing conditions

Water temperatures for rearing are ambient river water temperatures and range from 1-18^0 C. As part of an ongoing water quality-monitoring program at the KTOI hatchery, monthly water samples are collected at the hatchery inlet (before filtration) and the head tank (after filtration).

Lab analyses of conventional parameters include: Alkalinity, total dissolved solids, total suspended solids, N-Ammonia, NO3 + NO2, and ortho-phosphorus. Lab analyses for inorganics include: Calcium, copper, magnesium, manganese, and zinc. Other parameters monitored include temperature, dissolved oxygen, and bacteria. Quality control analyses are also included in the lab report.

8.2.4) Indicate biweekly or monthly fish growth information (*average program performance*), including length, weight, and condition factor data collected during rearing, if available.

N/A Routine fish growth information is not collected.

8.2.5) Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (*average program performance*).

When larvae are ready to initiate exogenous feeding (2-3 weeks of age), they are started on commercial grade trout starter (soft moist). As they grow, they are fed commercial grade trout food (soft-moist) throughout their time in the hatchery and food size is adjusted for fish size. Feeding rates are decreased as water temperature drops during the fall/winter months.

8.2.6) Fish health monitoring, disease treatment, and sanitation procedures.

A primary goal of any aquaculture program is to minimize introduction and transmission of pathogens in cultured and native populations. Available scientific information should be used to develop conservation and management strategies that minimize the transmission of disease from cultured fish to native populations and the potential severity of disease in the native population (LaPatra et al. 1999). Although asymptomatic infection may be widely distributed within and among wild populations, maintenance of optimal rearing conditions (e.g. optimal rearing densities, temperature regimes, water quality conditions) can reduce or prevent stress-mediated manifestation of disease in the hatchery setting. Development, refinement, and strict implementation of the Program's disease testing protocols for white sturgeon in the Kootenai Hatchery should minimize potential in-hatchery disease outbreak and disease transmission risks to the wild population.

Recent Kootenai Hatchery upgrades completed in 1999 (new water intake system, increased water temperature control for incubation and hatching, sediment filtration systems, pathogen control (UV sterilization), and added rearing capacity) have increased hatching success and survival of early life stages, and minimized disease outbreak and fish loss (Ireland 1999). High fertilization, development, and hatching rates in 1999 and 2000 may be indicative of future benefits to be provided from the extensive hatchery upgrades. The addition of a "fail-safe" facility in British Columbia also helps to ensure success of the program.

From 1992 through 1996, white sturgeon in the Kootenai River Conservation Aquaculture Program were periodically tested for the presence of white sturgeon iridovirus (WSIV), when disease mediated fish loss occurred in the hatchery. Since 1997, all broodstock and at least thirty progeny from each brood year are tested for the presence of pathogens. Disease testing includes parasitology, bacteriology, virology and histology examinations. Since 1997, ovarian fluid and male and female gametes are also sampled and tested for viral pathogens (e.g. WSIV and *Herpes* viruses 1 and 2).

8.2.7) Indicate the use of "natural" rearing methods as applied in the program.

"Natural" rearing methods are currently the subject of experimentation in salmon and steelhead hatcheries in an attempt to identify strategies that produce a fish better adapted for wild conditions they will encounter upon release. These methods include things like natural substrates and structures, cover, and feeding regimens. The unique life history and behavior of sturgeon requires different rearing strategies than for salmon. For instance, sturgeon are deep water, benthic feeders which are not as susceptible to predation by birds and mammals, hence would not benefit by a feeding regimen designed to foster predator avoidance. Current practice is to rear sturgeon in dark, covered circular tanks that provide similar light, water velocity, and water temperature conditions to the natural habitat. Also, the flow through water system in the hatchery provides ambient river water for rearing.

8.2.8) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to fish under propagation.

Fish are currently being reared for release at age 1 or 2. The need to mark all hatchery fish to distinguish from wild production precludes release at a smaller size or age (except for experimental releases of 3-12 day old larvae in 2000). The only suitable tag or mark that can be expected to persist over the life span of these long-lived fish is a PIT tag. In the effort to minimize the risk of domestication effects that may be imparted through rearing to age 1 or 2, we are continuing to research alternative marking methods for smaller fish.

SECTION 9. RELEASE

Describe fish release levels, and release practices applied through the hatchery program.

Prior to 1999, all releases of hatchery-reared Kootenai River white sturgeon were experimental, to assess growth, survival, and habitat use of juveniles in the wild. Annual release numbers are determined each year by the white sturgeon recovery team based on numbers of families, fish available, and the preservation stocking criteria in the breeding plan (Kincaid 1993).

Proposed fish release levels.

Age Class	Maximum Number	Size	Release Date	Location
Eggs				
Unfed Fry	Up to 150,000 (experimental release)		Summer	Kootenai
Fry				
Fingerling				
Yearling	Up to 12,000	> 20 g	Spring/Fall	Kootenai

9.2) Specific location(s) of proposed release(s).

Stream, river, or watercourse: Kootenai River (HUC 17010101)

Release points: Idaho (from downstream to upstream release sites): Porthill - rkm 170 (near Canadian border); Copeland - rkm 199.5; Ferry Island – rkm 205; Rock Creek confluence – rkm 215.5; Shorty's Island – rkm 231; Deep Creek confluence – rkm 240; Hatchery Dock – rkm 241; Ambush Rock – rkm 244.5 (near Bonners Ferry); and Moyie River confluence - rkm 258.5

Major watershed: Kootenai River

Basin or Region: Columbia River Basin/Mountain Columbia Province

9.3) Actual numbers and sizes of fish released by age class through the program.

The Kootenai Tribal conservation program has released 4,879 juvenile white sturgeon into the Kootenai River between 1992 and 2000 (age 1-2 years old) (IDFG database and annual reports; KTOI annual reports; Ireland et al. 2000) and approximately 139,000 larvae (age 3-12 days) in 2000 as an experiment to help determine the early life survival bottleneck (KTOI and IDFG progress reports 2000). Through monitoring and evaluation of the hatchery releases, gillnetting juvenile white sturgeon in the Kootenai River captured a total of 669 juveniles from 1995 through the 2000 sampling season (includes multiple recapture events) in the Kootenai River in Idaho (IDFG database; IDFG and KTOI reports 1996-1999). A total of 14 hatchery produced juvenile white sturgeon have been captured in Kootenay Lake, British Columbia between 1999 and 2000 (BC MELP Progress Reports). Annual growth of hatchery-reared juvenile white sturgeon released into the river and subsequently recaptured averaged 5.27 cm (FL) (IDFG reports). Relative weight, W_r, (Beamesderfer 1993) was calculated for 664 hatchery raised white sturgeon juveniles released into the Kootenai River between 1991-1999 and subsequently recaptured between 1995 and October 2000. Mean relative weight, Wr, was 90.638 (S.D. 27.131) (IDFG unpublished data). With five years of recapture data now collected, post-release survival rates for juveniles in the Kootenai River should be estimated during 2001.

Summary of numbers released and recapture rates of hatchery produced white sturgeon juveniles released into the Kootenai River in Idaho and Montana between 1992-1999. These numbers do not reflect the 173 juveniles recaptured during the 2000-sampling season or the 2,177 juvenile white sturgeon released into the Kootenai River in September – October of 2000 from the 1999-year class (length and weight data for the 1999 year class released in 2000, as well as recapture data from the 2000 sampling season have not been summarized yet). Also not included in the table are the 139,000 3-12 day old larvae released in 2000 as part of an experiment to help determine the bottleneck to survival.

Numbers and recapture rates of hatchery produced white sturgeon juveniles (progeny of wild broodstock) released into the Kootenai River in Idaho and Montana between 1992 and 1999

Year Class	Number Released	Mean Total Length (mm) (S.D.)	Mean Weight (g) (S.D.)	Release year	Percent (#) Recaptured [a]
1990	14	455	321	Summer 1992	25.2 (54) [b]
1991	200	255	64.4	Summer 1992	-
1992	91	-	-	Fall 1994	45 (41)
1995	1,076	229 (27)	47 (16)	Spring 1997	15 (295) [c]
1995	891	343 (43)	147 (61)	Fall 1997	-
1995	99	408 (70)	283.3 (136.8)	Summer 1998	6 (6)
1995	25	565 (71)	805.8 (276.4)	Summer 1999	<1 (2)
1998	306	261 (42)	79.5 (44.4)	Fall 1999	0
Total	2,702				14.7% (398)

a: Percent recaptured during 1993-1999 sampling period for each release year (Excluding multiple recapture events).
b: Includes 1990 and 1991 year class.
c: Includes 1997 spring and fall release.

Analysis of data for release of the 1999 year class and 2000 recapture events was not complete of this writing and is not included in this table.

9.4) Actual dates of release and description of release protocols.

See above table for season of release. See Section 4.2 for description of release protocols. Release dates are generally chosen to coincide with having a majority of any given year class at a size that can be marked. Also, some fish are retained to a larger size in order to attach sonic transmitters for habitat use and movement research.

9.5) Fish transportation procedures, if applicable.

Sturgeon are transported to the release site in an oxygenated covered fiberglass tank filled with ambient river water) mounted on a truck and released from shore or by boat.

9.6) Acclimation procedures.

No acclimation procedures are required for sturgeon. Sturgeon are reared on ambient river water and released into the Kootenai River.

9.7) Marks applied, and proportions of the total hatchery population marked, to identify hatchery component.

Before release, each fish is weighed, measured and marked. Hatchery-produced fish are marked with PIT tags and scute removals. Scutes are removed to denote year class in case of tag loss (e.g. the ninth left lateral and the eighth right lateral scutes were removed from juveniles from the 1998 year class). Due to current limitations of permanent tagging or marking technologies for juvenile white sturgeon, fish are PIT tagged and released at > 20g, since body mass appeared to be a better predictor of PIT tag retention than length or age. In order to determine future post-stocking survival and potential genetic contribution to the next generation, family identification, year class, and release site are included in data records for each fish.

9.8) Disposition plans for fish identified at the time of release as surplus to programmed or approved levels.

The USFWS ESA Section 10 Permit (PRT-798744) authorizes routine culling of hatchery reared fish to maintain low rearing densities (to preclude stress induced disease from overcrowding) and to fulfill the intent of the preservation stocking strategy outlined in the *Breeding Plan to preserve the Genetic Variability of the Kootenai River White Sturgeon* (Kincaid 1993).

9.9) Fish health certification procedures applied pre-release.

One month prior to release, animal health is evaluated using the protocol developed by USFWS, B.C. Ministry of Environment, Land, and Parks, IDFG, and MFWP pathologists and agreed upon by all agencies. Test results are provided to all agencies and a letter of request is written to USFWS from KTOI. After the USFWS concurrence letter is received, a transportation and release permit is obtained from IDFG at the request of KTOI and USFWS. Disease testing results are reviewed by relevant state, provincial, federal and tribal management agencies. Generally, fish with no diagnostic disease symptoms and ≤ 10% prevalence of endemic pathogens are approved for release.

9.10) Emergency release procedures in response to flooding or water system failure.

Refer to Section 4.6.1 for a description of the back-up and emergency system at the Kootenai Tribal Hatchery. Also, risks of system failure have been addressed by incubating eggs at the fail-safe facility. The KTOI program has made a formal international agreement with the British Columbia Ministry of Fisheries to provide off-site "fail-safe" rearing space at the Kootenay Trout Hatchery, Fort Steele, BC. The Kootenai Tribal Hatchery has recently completed exhaustive upgrades to minimize many risks associated with culture facilities.

Emergency release procedures can be implemented in the event that all other back-up systems had failed. This would entail contacting USFWS recovery team representatives for an authorization for emergency release.

9.11) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed species resulting from fish releases.

The intent of the breeding plan and preservation stocking strategy outlined in the *Breeding Plan to preserve the Genetic Variability of the Kootenai River White Sturgeon* (Kincaid 1993) is to minimize risk associated with conventional stocking programs. As stated by Kincaid (1993), "The standard concept of supplemental stocking is that large numbers of fish are reared to the fingerling or yearling stage, then planted on top a "natural" population to expand the production of that fishery. The goal of a supplemental stocking program is typically to expand the population or increase production of a fishery; little attention is given to preservation of the existing gene pool. The term "preservation stocking" is used here to indicate that preservation of genetic variability is the primary objective of the program' as "slow" expansion of population is a secondary goal. Undesirable effects commonly associated with supplemental stocking occur when the hatchery product (1) competes with wild fish for food and rearing space, resulting in reduced survival of the wild fish; (2) competes with wild fish for spawning habitat, resulting in reduced reproduction of wild fish; and (3) interbreeds with wild fish; resulting in the introduction of hatchery-adapted genes, which dilute the genetic attributes and gene complexes that enhance "wild" survival, growth, and reproductive performance. This plan differs from "conventional" supplemental stocking in several ways. First, because the current broodstock has not reproduced successfully since 1974, there is no reproducing population of white in the Kootenai River to compete and interbreed with fish planted under this plan. Second, the number of fish planted will be small compared with conventional supplemental stocking programs. The number of fish planted per family will be equalized at a level designed to produce only 2-5 times broodstock replacement numbers.

The objective of the breeding plan is to preserve the existing gene pool; therefore, number of fish planted will represent equal numbers from all available families and will be only enough to produce 4-10 adults per family at maturity. As individual fish will be used as parents only once every 5 years, the likelihood of inbreeding in future generations will be reduced. Effects of preservation stocking, as outlined under this plan, do not pose a threat to the genetic stocking of the existing gene pool. Conversely, this plan offers an approach for preserving the genetic variability remaining in this seriously threatened, declining white sturgeon population."

SECTION 10. PROGRAM EFFECTS ON ALL ESA-LISTED, PROPOSED, AND CANDIDATE SPECIES (FISH AND WILDLIFE)

10.1) List all ESA permits or authorizations in hand for the hatchery program.

Kootenai River White Sturgeon Biological Opinion (59 FR 45989)
ESA Section 10 Permit No. PRT-798744

All Kootenai Tribe of Idaho activities associated with the backup facility in British Columbia are permitted by a CITES permit issued by the USFWS Office of Management Authority

(Permit number 00US011646/9). A USFWS wildlife inspector authorizes concurrent USFWS Form 3177 export/import permits at the time of shipment. Each release of white sturgeon (preservation stocking) into the Kootenai River is cleared by USFWS through written communication (and necessary state and provincial permits are also obtained before transport or stocking). IDFG fish transportation permits have been issued for all fish transport and releases. Disease testing protocols have been developed and implemented to the satisfaction of all agencies and entities involved.

10.2) Provide descriptions, status, and projected take actions and levels for ESA-listed natural populations in the target area.

10.2.1) Description of ESA-listed, proposed, and candidate species affected by the program.

Information concerning the Kootenai River white sturgeon conservation culture program is listed in the above sections. The Draft biological opinion for Kootenai River white sturgeon and the USFWS ESA Section 10 permit cover all activities of the program.

- Identify the ESA-listed population(s) that will be directly affected by the program.

The ESA-listed population directly affected by this program is the Kootenai River white sturgeon. Information concerning the Kootenai River white sturgeon conservation culture program is listed in the above sections. The Draft biological opinion for Kootenai River white sturgeon and the USFWS ESA Section 10 permit cover all activities of the program.

- **Identify the ESA-listed population(s) that may be incidentally affected by the program.**

Information concerning the Kootenai River white sturgeon conservation culture program is listed in the above sections. The Draft biological opinion for Kootenai River white sturgeon and the USFWS ESA Section 10 permit cover all activities of the program.

10.2.2) Status of ESA-listed species affected by the program.

- Describe the status of the listed natural population(s) relative to "critical" and "viable" population thresholds.

Empirical "critical" population sizes for white sturgeon remain undefined. However, the concept of minimum viable population size (MVP) has been a topic of great interest to conservation biologists (Meffe and Carroll 1994). MVP is defined as the smallest isolated population that has a specified percent chance of persisting for a specified period of time in the face of foreseeable demographic, genetic and environmental stochasticities, and natural catastrophes (Meffe and Carroll 1994). However, it's the unforeseen stochastic and catastrophic events that make accurate predictions difficult.

Nonetheless, Shaffer (1987) reported an MVP that included 500 breeding individuals. The estimated annual number of female breeders in the Kootenai River system (limited relative to males in this population) ranged from 26 to nearly 50 (USFWS, University of Idaho, unpublished data, 2000). Additional male breeders increase this estimate of annual spawners. Thus, relative to Shaffer's 1987 MVP, the viability of the Kootenai River white sturgeon population may be in question.

However, the fact that white sturgeon are iteroparous and possess inter-generational spawning suggests a more optimistic future for the demographics and genetic viability of this population. Proper attention to genotype and nuclear marker frequencies in the wild population, and the broodstock and progeny sample groups should account for maintenance of background variability and within-population diversity.

- Provide the most recent 12-year (e.g. 1988 - present) progeny-to-parent ratios, survival data by life-stage, or other measures of productivity for the listed population. Indicate the source of these data.

During the last ten years of monitoring, only one hatching fry has been found and no free-swimming larvae or young of the year have been captured. Despite extensive monitoring, only 17 naturally recruited juvenile sturgeon associated with experimental augmentation flows between 1991 and 1999 have been captured to date.

- Provide the most recent 12-year (e.g. 1988 - 1999) annual spawning abundance estimates, or any other abundance information. Indicate the source of these data.

The effective breeding number (N_e) for a population is the number of individuals in a random breeding population with an equal sex ratio, which would yield the same rate of inbreeding or genetic drift as the population being studied (Falconer 1981). One important goal of the Kootenai River White Sturgeon Conservation Aquaculture Program is to maximize contribution of a large number of individual male and female broodstock over an initial 10-year period (Kincaid 1993; Duke et al. 1999). This practice will theoretically approach a desirable effective population number, or effective number of breeders. Although a linkage-disequilibrium method of N_e estimation for Kootenai River white sturgeon has not been performed, this program is currently investigating the feasibility of using microsatellite data for an assignment test to potentially estimate numbers of breeders contributing to hatchery-produced and wild-produced year classes.

In addition, based solely on probability theory, the estimated number of spawners to be used during this 10-year period (1999-2008) is predicted to reach or exceed the level needed to represent haplotype frequencies in the broodstock (and hence progeny groups) at levels equal to that of the wild population (P. Anders, University of Idaho, pers. comm). For example, the least common length variant in the D-loop of Kootenai River white sturgeon mtDNA is approximately 5% (University of Idaho, unpublished data, 2000). Thus, based on the probability of representing this least common haplotype, present at 5% in the population, approximately 60 different broodstock should be used. Based on current rates of broodstock collection and spawning in the Kootenai hatchery during the past 5 years (see Section 6.4 and 8.1), this goal is expected to be met, thus achieving the goal of matching the haplotype frequency distribution of the wild population within broodstock and progeny groups.

- Provide the most recent 12 year (e.g. 1988 - 1999) estimates of annual proportions of direct hatchery-origin and listed natural-origin fish on natural spawning grounds, if known.

It will take up to 20 years for hatchery-produced fish to begin contributing to the breeding population.

10.2.3) Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of listed species in the target area, and provide estimated annual levels of take *(see "Attachment 1" for definition of "take")*. **Provide the rationale for deriving the estimate.**

The Draft 2000 Biological Opinion for Kootenai River white sturgeon and the USFWS ESA Section 10 permit cover all activities associated with this program. All activities are also reviewed and approved by the Kootenai River White Sturgeon Recovery Team.

- Describe hatchery activities that may lead to the take of listed species in the target area, including how, where, and when the takes may occur, the risk potential for their occurrence, and the likely effects of the take.

The Draft 2000 Biological Opinion for Kootenai River white sturgeon and the USFWS ESA Section 10 permit cover all activities associated with this program. All activities are also reviewed and approved by the Kootenai River White Sturgeon Recovery Team.

- **Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken, and observed injury or mortality levels for listed fish**.

The Draft 2000 Biological Opinion for Kootenai River white sturgeon and the USFWS ESA Section 10 permit cover all activities associated with this program. All activities are also reviewed and approved by the Kootenai River White Sturgeon Recovery Team.

- **Provide projected annual take levels for listed species by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).**

The Draft 2000 Biological Opinion for Kootenai River white sturgeon and the USFWS ESA Section 10 permit cover all activities associated with this program. All activities are also reviewed and approved by the Kootenai River White Sturgeon Recovery Team.

- Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program.

The Draft 2000 Biological Opinion for Kootenai River white sturgeon and the USFWS ESA Section 10 permit cover all activities associated with this program. All activities are also reviewed and approved by the Kootenai River White Sturgeon Recovery Team.

SECTION 11. MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

11.1) Monitoring and evaluation of "Performance Indicators" presented in Section 1.10.

11.1.1) Describe the proposed plans and methods necessary to respond to the appropriate "Performance Indicators" that have been identified for the program.

Table 3. Performance standards and indicators for Kootenai sturgeon hatchery program.

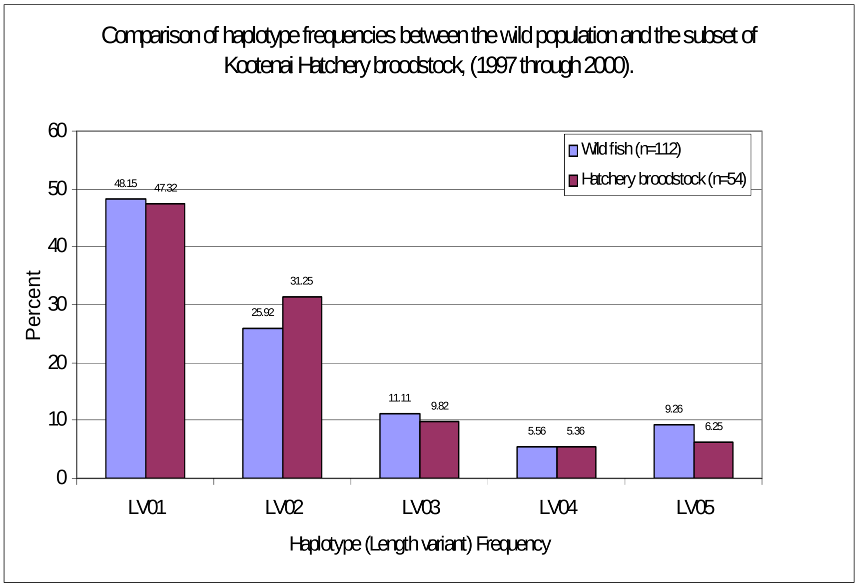
Performance Standard	*Type*	*Performance Indicator*
1. Maintain natural population	**Benefit**	Gradual increase in population size and age composition as a result of recruitment of hatchery fish: *Proportion of the size/age cohort contributed by hatchery* *Number of hatchery-reared fish by life stage including maturity* *Individual growth rates & condition factors* *Size & age specific survival rates* *Relative distribution and habitat use patterns of wild & hatchery fish based on CPUE & sonic telemetry*
2. Conserve genetic & life history diversity	**Benefit**	Retention of wild sturgeon life history characteristics and genetics by the hatchery reared population *Haplotype and genotype frequencies in hatchery broodstock and progeny* *Separate rearing of family groups* *Fail-safe rearing of each family in separate facilities* *Experimental population established outside current range* *Cryopreservation of sperm if feasible* *Individual and population attributes as in #1 above.*
3. Research natural production limitations	**Benefit**	Understanding of the life history characteristics and factors limiting natural recruitment *Estimated natural cohort size relative to known hatchery release number* *Rearing bottlenecks between YOY and adult* *Effects of contaminants on development, survival, & growth* *Evaluation of sediment transport and pre and post dam conditions in the spawning area*
4. Increase effectiveness & reduce costs	**Benefit**	Adaptive approach to achieve results while reducing process, administrative overhead, & operation costs *Complete planning and review processes and move to multi-year funding schedule with check points* *Adapt size and time of release for maximum benefits and minimum risks* *Marking methods to allow release as subyearlings* *Larval release experiments if appropriate* *Cryopreservation techniques*

Table 3. Performance standards and indicators for Kootenai sturgeon hatchery program.		
Performance Standard	***Type***	***Performance Indicator***
5. Avoid broodstock mortality	**Risk**	Additional mortality does not speed population decline *Mortality rate of broodstock in hatchery & after release*
6. Do not exceed carrying capacity	**Risk**	No significant density-dependent trend in growth, condition, or behavior of wild or hatchery sturgeon *Individual and population characteristics as in #1 above*
7. Avoid disease transfer	**Risk**	Minimal incidence of disease in the facility *Appropriate spawning & rearing practices & densities* *Rigorous disease testing protocols* *Rear disease-free trout for bait and broodstock feeding*
8. Minimize behavioral or genetic impacts	**Risk**	See #2 above *Release fish at earliest life stage possible*

A comprehensive monitoring and evaluation program is in place to assess genetic variability, survival, growth, movement, and habitat use of juveniles released into the Kootenai River. The monitoring program was initiated in 1993 to annually recapture post-release hatchery-reared white sturgeon in the Kootenai River (Marcuson et al. 1995, IDFG Annual Reports 1996-1999, Kootenai Tribe of Idaho Annual Reports 1997-1999). Mark-and-recapture techniques using gillnets are used to estimate mean annual growth of post-release hatchery-reared white sturgeon in the Kootenai River, as well as provide data for analysis of individual and population characteristics. Ultrasonic telemetry is used to determine juvenile white sturgeon movement and habitat use in relation to depth, velocity, substrate and cover.

Data collection for monitoring and evaluating the adult population is performed by IDFG and BC MELP and is accomplished using setline and hook and line techniques, ultrasonic telemetry, artificial substrate mats (McCabe and Beckman 1990), D-ring plankton nets (Parsley et al. 1989), and other larval fish sampling gear. All data collected by the agencies are contributed to a database managed by IDFG. Analysis includes population attributes such as population size, sex ratio, spawning periodicity, occurrence of natural spawning and spawning behavior, growth and age composition.

Tissue samples (non-invasive pectoral fin clips) have been collected annually from all broodstock and from each progeny group produced in the Kootenai hatchery. These tissue samples are preserved immediately in tissue lysis buffer and sent to the lab (UI,ARI) for genetic analysis (Anders and Powell 1998). Archived genetic data from 113 wild fish from the Kootenai River and Kootenay Lake allow comparisons of haplotype and microsatellite marker frequencies between the wild population, the entire broodstock group, and all progeny groups (families) produced in the hatchery. The goal here is to produce cumulative genetic marker frequency distributions among the broodstock and progeny groups that most closely resemble those of the wild population. To date this goal is being successfully met (see figure below):



11.1.2) Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program.

Funding and staff for monitoring and evaluation are an integral component of annual contracts with the Bonneville Power Administration.

11.2) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed species resulting from monitoring and evaluation activities.

Risks of monitoring activities are minimal. The proportion of wild fish handled is small and non-lethal sampling methods are employed.

SECTION 12. RESEARCH

The KTOI white sturgeon program has been extensively coordinated with ongoing sturgeon research and recovery. While other project sponsors have proposed supplementation, the KTOI white sturgeon conservation aquaculture project is the only project successfully producing white sturgeon juveniles from wild broodstock in the Upper Columbia Basin. The KTOI staff initially spent time with experts in this particular field (Serge Doroshov and Joel Van Eenennaam, UC Davis, and Terry Patterson, CSI) to learn the intricacies of the sturgeon culture process. With the increasing success of the project, other project managers in the region have spent time with the KTOI staff to learn the complexities of spawning and rearing this species.

While the aquaculture program is essential to the population recovery effort, recovery is also contingent upon re-establishing natural recruitment. Research to determine factors limiting recruitment is an important component of this program and is well coordinated with other research agencies (IDFG, BC Ministry of Environment, MDFWP, and USFWS). In order to determine potential risk associated with limiting factors, the effects of individual and concurrent multiple stressors in the Kootenai River ecosystem must be addressed (Foran and Ferenc 1999). This portion of the program attempts to qualify and quantify these multiple stressors in order to evaluate the total and secondary impacts on resources from anthropogenic disturbances.

12.1) Objective or purpose.

The following is a summary of limiting factors from the Kootenai River Subbasin Summary (2000):

The substantially unnatural change to the flows in the Kootenai River caused by at Libby Dam is considered to be a primary reason for the Kootenai River white sturgeon's continuing lack of recruitment and declining numbers. As a result of original Libby Dam operations (until the initiation of experimental flows in 1992), the natural, high, spring flows thought to be required by white sturgeon for reproduction rarely occurred during the May-to-July spawning season when suitable temperature, water velocity, and photoperiod conditions would normally exist. In addition, cessation of periodic flushing flows has allowed fine sediments to build up in Kootenai River bottom substrates. This sediment fills the spaces between riverbed cobbles, reducing fish egg survival, larval and juvenile fish security cover, and insect production. Acoustic Doppler profiles of the Kootenai River bottom have revealed large sand dunes located in the spawning reaches used by the white sturgeon (IDFG/USGS unpublished data). The effect of moving dunes is unknown but may contribute to egg suffocation and/or prolonged contact with contaminated sediments, further contributing to recruitment failure.

White sturgeon in the Kootenai River spawn within an 18 km reach of river downstream of Bonners Ferry, Idaho (river kilometers 228-246). This spawning reach is comprised of sand substrate, which is thought to be poor habitat for survival of eggs and larva when compared to white sturgeon spawning habitat in the Columbia River (Parsley and Beckman 1994; Paragamian et al., in press). More suitable substrates of cobble and gravel are upstream of Bonners Ferry (Apperson 1991, Paragamian et al., in press). Improved flows for spawning in recent years appears to have resulted in increased spawning as evidenced by the collection of more sturgeon eggs (Paragamian et al., in press). Despite improved spawning, the success for recovery of Kootenai River white sturgeon remains a serious concern. Few wild juvenile white sturgeon have been captured that were produced during flow test years.

Lake spring maximum elevations also appear to be contributing to the decline of white sturgeon. Concomitant to Libby Dam construction, the elevation of Kootenay Lake was lowered 2 m. Although Kootenay Lake is 108 km downstream of the spawning reach, higher lake elevations have a backwater effect on the sturgeon spawning reach. As the lake elevation rose during any given spawning season, sturgeon spawned progressively further upstream (Paragamian et al., in progress). Fifty-nine percent of the variation in spawning location was attributable to Kootenay Lake elevation. A linear regression model indicated higher lake elevations might promote spawning further upstream over cobble substrate.

As a consequence of altered flow patterns, average water temperatures in the Kootenai River are typically warmer (by 3 degrees Celsius) during the winter and colder (by 1 - 2 degrees Celsius) during the summer than prior to impoundment at Libby Dam (Partridge 1983). However, during large water releases and spills at Libby Dam in the spring, water temperatures in the Kootenai River may be colder than under normal, non-spill, spring flow conditions.

Much of the Kootenai River has been channelized and stabilized from Bonners Ferry downstream to Kootenay Lake, resulting in reduced aquatic habitat diversity, altered flow conditions at potential spawning and nursery areas, and altered substrates in incubation and rearing habitats necessary for survival (Partridge 1983, Apperson and Anders 1991). Side-channel slough habitats in the Kootenai River flood plain were eliminated by diking and bank stabilization in the Creston Valley Wildlife Management Area in British Columbia and Kootenai National Wildlife Refuge in Idaho.

The overall biological productivity of the Kootenai River downstream of Libby Dam has also been altered. Libby Dam blocks the open exchange of water, organisms, nutrients, and coarser organic matter between the upper and lower Kootenai River. Snyder and Minshall (1996) stated that a significant decrease in concentration of all nutrients examined was apparent in the downstream reaches of the Kootenai River after Libby Dam became operational in 1972. Libby Dam and the impounded Lake Koocanusa reduced downstream transport of phosphorus and nitrogen by up to 63 and 25 percent respectively (Woods 1982), with sediment-trapping efficiencies exceeding 95 percent (Snyder and Minshall 1996). The Kootenai River, like other large river-floodplain ecosystems, was historically characterized by seasonal flooding that promoted the exchange of nutrients and organisms among a mosaic of habitats (Junk et al. 1989; Bayley 1995). As a result of channel alterations, the Kootenai River has a lowered nutrient and carbon-retention capacity. Wetland drainage, diking and subsequent flood control has eliminated the “flood pulse” of the river and retention and inflow of nutrients. Removal of riparian and floodplain forests has eliminated sources of wood to the channel and potential retention structures.

In relation to reduced productivity, potential threats to Kootenai River white sturgeon include decreased prey availability for some life stages of sturgeon, and a possible reduction in the overall carrying capacity for the Kootenai River and Kootenay Lake to sustain populations of white sturgeon and other native fishes. A limited food supply for young of the year could contribute to increased mortality rates, either through starvation or through increased predation mortality, because young of the year would spend more time feeding, thereby exposing themselves to higher predation risk. The reduction in native kokanee in the South Arm of Kootenay Lake may have also reduced nutrient contributions (deteriorating carcasses from spawners) from tributaries in Northern Idaho and British Columbia flowing into the Kootenai River. Kokanee were also considered an important food source for adult sturgeon to build reserves for the winter and help in final gonad maturation. Growth rates of sturgeon have declined and relative weights in the Kootenai River/Lake population are the lowest in reported sturgeon populations in the Northwest.

In the Adaptive Environmental Assessment modeling exercise performed for the Kootenai River system in 1997, predation on eggs and larvae was identified as a potential threat to successful white sturgeon recruitment. For broadcast spawners like white sturgeon, the mortality rate on eggs and larvae will increase with: 1) an increase in the number of predators; 2) an increase in the vulnerability of eggs or larvae to predation associated with changes in habitat or foraging behavior; and 3) a decrease in the volume or area of water that the eggs/larvae are dispersing into or over (as volume or area decreases, prey concentration to predators in increases). In post-impoundment years, Kootenai River springtime flows have been reduced substantially and vulnerability has increased due to an increase in water clarity and reduced food supply, as well as loss of habitat in the spawning reach.

Georgi (1993) noted that the chronic effects on wild sturgeon spawning in "chemically polluted" water and rearing over contaminated sediments, in combination with bioaccumulation of contaminants in the food chain, is possibly reducing the successful reproduction and early-age recruitment to the Kootenai River white sturgeon population. Results from a contaminant study performed in 1998 and 1999 showed that water concentrations of total iron, zinc, and manganese, and the PCB Arochlor 1260 exceeded suggested environmental background levels (Kruse 2000). Zinc and PCB levels exceeded EPA freshwater quality criteria. Several metals, organochlorine pesticides, and the PCB Arochlor 1260 were found above laboratory detection limits in ova from adult female white sturgeon in the Kootenai River. Plasma steroid levels in adult female sturgeon showed a significant positive correlation with ovarian tissue concentrations of the PCB Arochlor 1260, zinc, DDT, and all organochlorine compounds combined, suggesting potential disruption of reproductive processes. In an experiment designed to assess the effects of aquatic contaminants on sturgeon embryos, results suggest that contact with river-bottom sediment increases the exposure of incubating embryos to metal and organochlorine compounds (Kruse 2000). Increased exposure to copper and Arochlor 1260 significantly decreased survival and incubation time of white sturgeon embryos and could be a potentially significant additional stressor to the white sturgeon population

12.2) Cooperating and funding agencies.

USFWS Recovery Team

All recovery work is coordinated through the white sturgeon recovery team that includes members from the U.S. Fish and Wildlife Service (USFWS), Kootenai Tribe of Idaho (KTOI), Idaho Department of Fish and Game (IDFG), Montana Fish, Wildlife, and Parks (MFWP), University of Idaho (U of I), Army Corp of Engineers (ACOE), British Columbia Ministry of Environment, Land, and Parks (BC MELP), and Canada Department of Fisheries and Oceans (CDFO). White sturgeon in the Kootenai drainage constitute a transboundary population, crossing interstate and international boundaries. This project is a component of many different programs working concurrently on white sturgeon recovery and ecosystem rehabilitation.

Research is funded through BPA, USFWS, and numerous cost-sharing agreements with other agencies listed below:

Upper Columbia United Tribes – KTOI Fish and Wildlife Program Support

BC Ministry of Environment, Land, and Parks – Kootenay River and Lake Management

BC Ministry of Fisheries – Fail-safe facility staffing and expertise

Clear Springs Foods Research and Development – WSIV analyses, animal health consulting, and experiments to further knowledge about sturgeon pathogens

IDFG Fish Health Lab – animal health consulting

USFWS Dworshak Fish Health Center – Disease testing

USGS – Cost share for assessment of feasibility of improving white sturgeon spawning habitat

UC Davis – information transfer about sturgeon culture

College of Southern Idaho – information transfer about sturgeon culture

University of Idaho – Dept of Biology –cost share for developing cryopreservation techniques for sturgeon

University of Idaho Center for Salmonid and Freshwater Species at Risk – genetic analysis, program support, policy support, research (tagging, biological condition)

12.3) Principle investigator or project supervisor and staff.

University of Idaho Center for Salmonid and Freshwater Species at Risk and the Aquaculture Research Institute: Drs. Madison Powell, Ernie Brannon, and Paul Anders – genetics research, analysis of biological condition, permanent-tagging techniques

University of Idaho Biology Department: Dr. Joseph Cloud in cooperation with Serge Doroshov – cryopreservation of white sturgeon gametes

University of Idaho Fish and Wildlife Department: Dr. Dennis Scarnecchia – white sturgeon habitat use and growth

Clear Springs Foods Research and Development: Dr. Scott LaPatra – WSIV analyses, animal health consulting, and experiments to further knowledge about sturgeon pathogens (in cooperation with College of Southern Idaho and U of I Aquaculture Research Institute)

Free Run Aquatic Research: Gretchen Kruse – contaminant analysis and effects on reproductive success

12.4) Status of population, particularly the group affected by project, if different than the population(s) described in Section 2.

Status of population described in previous sections.

12.5) Techniques: include capture methods, drugs, samples collected, tags applied.

Research is conducted in conjunction with the conservation culture program and the on-going monitoring and evaluation program. No research is proposed that requires increased sampling of the population. Capture methods are described in previous sections.

12.6) Dates or time period in which research activity occurs.

Spawning of wild white sturgeon broodstock occurs during May-July. Research activities associated with gametes and larvae occur at this time.

12.7) Care and maintenance of live fish or eggs, holding duration, transport methods.

Care and maintenance of live fish or eggs, holding duration, and transport methods are described in earlier sections.

12.8) Expected type and effects of take and potential for injury or mortality.

No mortality expected for wild white sturgeon or juvenile white sturgeon released into the Kootenai River and subsequently recaptured. Any eggs and larvae used for research experiments are in excess of the conservation culture program needs.

12.9) Level of take of listed species: number or range of individuals handled, injured, or killed by sex, age, or size, if not already indicated in Section 2 and the attached "take table" (Table 1).

The Draft 2000 Biological Opinion for Kootenai River white sturgeon and the USFWS ESA Section 10 permit cover all activities associated with this program. All activities are also reviewed and approved by the Kootenai River White Sturgeon Recovery Team.

12.10) Alternative methods to achieve project objectives.

Research addressing habitat use, genetics, endemic pathogens or contaminants is population specific; therefore it would be difficult to use a surrogate population (other white sturgeon population or commercial stock) to accomplish project research objectives.

12.11) List species similar or related to the threatened species; provide number and causes of mortality related to this research project.

N/A

12.12) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury, or mortality to listed species as a result of the proposed research activities.

All white sturgeon activities have been reviewed by the USFWS white sturgeon recovery team and are conducted in compliance with Federal Guidelines and terms and conditions outlined in the USFWS ESA Section 10 permit

SECTION 13. ATTACHMENTS AND CITATIONS

Alden, W.C. 1953. Physiography and glacial geology of Western Montana and adjacent areas. Geological Survey Professional Paper 231. U. S. Government Printing Office.

Anders, P. J. 1997. The need for objective assessment of conservation aquaculture. Fisheries Vol. 22(5):46.

Anders, P. J., and D. L. Richards. 1996. Implications of ecosystem collapse on white sturgeon (Acipenser transmontanus) in the Kootenai River, Idaho, Montana, and British Columbia. Pages 27-40 In S. Doroshov, F. Binkowski, T. Thuemeler, and D. MacKinlay, eds. Culture and Management of Sturgeon and Paddlefish Symposium Proceedings. Physiology Section, American Fisheries Society, Bethesda, MD.

Anders, P. J., D. L. Richards, and M. S. Powell. 2000. The first endangered white sturgeon population: Repercussions in an altered large River-floodplain ecosystem. In: Proceedings of the 130th Annual Meeting of the American Fisheries Society. St. Louis MO., August 20-24, 2000.

Anders, P.J. 1991. White sturgeon (Acipenser transmontanus) movement patterns and habitat utilization in the Kootenai River system, Idaho, Montana and British Columbia. MS Thesis, Eastern Washington University. 153 pp.

Anders, P.J. 1995. Kootenai River White Sturgeon Studies. Report C: Kootenai River Tributary Kokanee Spawning Ground Survey. Annual Report. BPA Project No. 88-64.

Anders, P.J. 1998. Conservation aquaculture and endangered species: Can objective science prevail over risk anxiety? Fisheries 23(11):28-31.

Anders, P.J. and M. S. Powell. 1998. Preliminary report of mitochondrial DNA diversity and variation of white sturgeon (Acipenser transmontanus) from the Columbia River Basin. Report F. In: Effects of mitigative measures on productivity of white sturgeon populations in the Columbia River downstream from McNary Dam, and Determine the status and habitat requirements of white sturgeon in the Columbia and Snake Rivers upstream from McNary Dam. Annual Progress Report to the Bonneville Power Administration. BPA Project 86-50.

Anders, P.J. and R.E. Westerhof. 1996. Conservation Aquaculture of endangered white sturgeon (Acipenser transmontanus) from the Kootenai River, Idaho. Pages 51-62 in S. Doroshov, F. Binkowski, T. Thuemeler, and D. MacKinlay, eds. Culture and Management of Sturgeon and Paddlefish Symposium Proceedings. Physiology Section, American Fisheries Society, Bethesda, MD.

Apperson, K.A. and P.J. Anders. 1991. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY1990. Idaho Department of Fish and Game and Bonneville Power Administration. Contract No. DE-A179-88BP3497; Project No. 88-65. Portland, Oregon.

Beamesderfer, R. C. P, and R. A. Farr. 1997. Alternatives for the protection and restoration of sturgeons and their habitat. Pages 407-417 in V.J. Birstein, J.R. Waldman, and W.E. Bemis, editors. Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers, Dordrecht.

Bonneville Power Administration. 1997. Kootenai River white sturgeon aquaculture project: environmental assessment. Bonneville Power Administration, DOE/EA-1169, Portland, OR.

Brannon, E. L. 1993. The perpetual oversight of hatchery programs. Fisheries Research (18):19-27.

Brown, J.R. 1992. Mitochondrial DNA length variation and heteroplasmy in populations of white sturgeon (Acipenser transmontanus). Genetics. 132:221-228.

Brown, J.R., K. Beckenbach, A.T. Beckenbach, and M.J. Smith. 1996. Length variation, heteroplasmy and sequence divergence in the mitochondrial DNA of four species of sturgeon (Acipenser). Genetics. 142:525-535.

Buroker, N.E., J.R. Brown, T.A. Gilbert, P.J. O'Hara, A.T. Beckenbach, W.K. Thomas, and M.J. Smith. 1990. Length heteroplasmy of sturgeon mitochondrial DNA; an illegitimate elongation model. Genetics 124: 157-163.

Conte, F.S., S.I. Doroshov, P.B. Lutes, and M.E. Strange. 1988. Hatchery manual for the white sturgeon (Acipenser transmontanus) with application to other North American Acipenseridae. Publications Division, Agriculture and Natural Resources, University of California, Oakland. Publication 3322.

DeVore, J. D., B. James, and R. Beamesderfer. 1999. Lower Columbia River white sturgeon: Current stock status and management implications. Washington Department of Fish and Wildlife. In Press.

Duke, S., P. Anders, G. Ennis, R. Hallock, J. Hammond, S. Ireland, J. Laufle, R. Lauzier, L. Lockard, B. Marotz, V. Paragamian, and R. Westerhof. 1999. Recovery plan for the Kootenai River white sturgeon. Journal of Applied Ichthyology 15(1999): 157-163.

EcoAnalysts, Inc. 1998. Stream Habitat Survey of Long Canyon, Parker, and Trout Creeks: Tributaries to the Kootenai River, Idaho, with Special Consideration of Kokanee Spawning Habitat and Enhancement Potential. Prepared for Kootenai Tribe of Idaho.

Giorgi, A. 1993. The status of the Kootenai River white sturgeon. Report prepared for the Pacific Northwest Utilities Conference Committee. September 1993.

Graham, P.J. 1981. Status of white sturgeon in the Kootenai River. Montana Department of Fish Wildlife and Parks. Kalispell, Montana.

Hindar, K., N. Ryman, and F. Utter. Genetic effects of cultured fish on natural populations. Can. J. Fish. Aquat. Sci. 48:945-957.

Ireland, S. C. 1997. Kootenai River White Sturgeon Studies and Conservation Aquaculture. Annual Report. BPA Project No. 88-64. Portland, Oregon.

Ireland, S. C. 1998. Kootenai River White Sturgeon Studies and Conservation Aquaculture. Annual Report. BPA Project No. 88-64. Portland, Oregon

Ireland, S. C. 1999. Kootenai River White Sturgeon Studies and Conservation Aquaculture. Kootenai Tribe of Idaho. Prepared for Bonneville Power Administration. Progress Report, Contract DE-B179-88BI93743, Project 88-64, Portland, OR.

Ireland, S. C., P. J. Anders, and J.T. Siple. 2000. Conservation aquaculture: An adaptive approach to prevent extinction of an endangered white sturgeon population. Manuscript in prep. Draft in: Proceedings of the 130th Annual Meeting of the American Fisheries Society. St. Louis MO., August 20-24, 2000.

J-U-B Engineers. 1997. Preliminary Engineering Report - Hatchery Improvements for the Recovery of White Sturgeon. Prepared for Kootenai Tribe of Idaho. BPA Project No. 88-64.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river floodplain systems. Can. Spec. Publ. Fish. Aquati. Sci. 106:110-127.

Kincaid, H. 1993. Breeding Plan to Preserve the Genetic Variability of the Kootenai River White Sturgeon. Final Report to Bonneville Power Administration, U.S. Fish and Wildlife Service. Project 93-27. Contract Number DE-AI79-93B002886. Portland, Oregon.

LaPatra, S.E., J.M. Groff, G.R. Jones, B. Munn, T. L. Patterson, R.A. Holt, A.K. Hauck, and R.P. Hedrick. 1994. Occurrence of white sturgeon iridovirus infections among cultured white sturgeon in the Pacific Northwest. Aquaculture Vol. 126:201-210.

LaPatra, S.E., J.M. Groff, T.L. Patterson, W.D. Shewmaker, M. Casten, J. Siple, and A.K. Hauck. 1996. Preliminary Evidence of Sturgeon Density and Other Stressors on Manifestation of White Sturgeon Iridovirus Disease. Journal of Applied Aquaculture. Vol. 6, No. 3 pp. 51-58.

LaPatra, S.E., S.C. Ireland, J.M. Groff, K.M. Clemens, and J.T. Siple. 1999. Adaptive disease management strategies for the endangered population of Kootenai River white sturgeon. Fisheries 24(5): 6-13.

Marcusen, P., V. Wakkinen, and G. Kruse-Malle. 1995. Kootenai River white sturgeon investigation. Idaho Department of Fish and Game. Annual Report prepared for Bonneville Power Administration. Contract No. DE-B179-88BP43497; Project No. 88-65, Portland, Oregon.

May, B., C.C. Krueger, and H.L. Kincaid. 1997. Genetic variation at microsatellite loci in sturgeon: primer sequence homology in Acipenser and Scaphirhynchus. Can. J. Aquat. Sci. 54:1542-1547.

McCabe, G. T., Jr. and C. A. Tracy. 1992. Spawning and life history of white sturgeon, Acipenser transmontanus, in the lower Columbia River. Fishery Bulletin 92:760-772.

McCabe, G.T., and L.G. Beckman. 1990. Use of an artificial substrate to collect white sturgeon eggs. California Fish and Game 76 (4) : 248-250.

Meffe G.K , and C. R. Carroll. 1994. Principles of Conservation Biology. Sinauer and Associates Inc. Sunderland, MA. USA.

MFWP, CSKT, and KTOI. 1997. Fisheries mitigation and implementation plan for losses attributable to the construction and operation of Libby Dam.

Miracle, A.L., and D.E. Campton. 1995. Tandem repeat sequence variation and length heteroplasmy in the mitochondrial DNA D-loop of the threatened Gulf of Mexico sturgeon, Acipenser oxyrhynchus desotoi. J. Heredity 86: 22-27.

Northcote, T.C. 1973. Some impacts of man on Kootenay Lake and its salmonids. Great Lakes Fishery Commission. Technical Report, Number 2.

Northwest Power Planning Council. 1994 as amended in 1995. Fish and Wildlife Program (FWP). Portland, Oregon.

Paragamian, V.L. 1994. Kootenai River Fisheries Investigations. Annual Progress Report FY 1993. Prepared for U.S. Department of Energy, Bonneville Power Administration. Contract No. DE-AI79-88BP93497; Project No. 88-65, Portland, Oregon.

Paragamian, V.L., G. Kruse, and V. Wakkinen. 1996. Kootenai River White Sturgeon Investigations. Annual Progress Report FY 1996. Prepared for U.S. Department of Energy, Bonneville Power Administration. Contract No. DE-AI79-88BP93497; Project No. 88-65, Portland, Oregon.

Paragamian, V.L., G. Kruse, and V. Wakkinen. 1997. Kootenai River white sturgeon spawning and recruitment evaluation. Idaho Department of Fish and Game. Annual Report prepared for Bonneville Power Administration. Contract No. DE-B179-88BP43497; Project No. 88-65, Portland, Oregon.

Paragamian, V.L., V. Whitman, J. Hammond, and H. Andrusak. 2000. Collapse of burbot fisheries in the Kootenai River, Idaho, USA, and Kootenay Lake, British Columbia, Canada. Pages 155-164 in V.L Paragamian and D.W. Willis, editors, Burbot Biology, Ecology, and Management. Publication Number 1, Fisheries Management Section of the American Fisheries Society, Spokane, Washington, USA.

Parsley, M.J., L.G. Beckman, and G.T. McCabe. 1989. Report I in A.A. Nigro, editor. Status and habitat requirements of white sturgeon populations in the Columbia River downstream from McNary Dam. Report to Bonneville Power Administration, Project 86-

Partridge, F. 1983. Kootenai River Fisheries Investigations. Idaho Department of fish and Game. Job Completion Report. Project F-73-R-5, Subproject IV, Study VI, Boise, Idaho.

Powell, M.S., and P. J. Anders. 1999. Assessing genetic variation among Columbia Basin white sturgeon populations. Annual Progress report to the Bonneville Power Administration. BPA Project 99-22.

Resident Fish Manager's Caucus of the Columbia Baisn Fish and Wildlife Authority (RFM-CBFWA). 1997. Multi-Year Implementation Plan for Resident Fish Protection, Enhancement, and Mitigation in the Columbia River Basin. Final Draft, June 3, 1997. Columb

Roff, D. A., and P. Bentzen. 1989. The statistical anlysis of mitochondrial DNA polymorphisms: X2 and the problem of small samples. Molecular Biology and Evolution (6):539-545.

Shaffer, M. L. 1987. Minimum viable populations: Coping with uncertainty. In: M.E. Soule (ed.) Viable populations for Conservation pp.69-86. Cambridge University Press, Cambridge.

Siple, J.T. and G. Aitken. 1991. Annual Kootenai Hatchery Report In: Kootenai River White Sturgeon Studies. Annual Report. BPA Project No. 88-65.

Siple, J.T. and G. Aitken. 1992. Annual Kootenai Hatchery Report. In: Kootenai River White Sturgeon Studies. Annual Report. BPA Project No. 88-65.

Siple, J.T. and P.J. Anders. 1993. Annual Kootenai Hatchery Report. In: Kootenai River White Sturgeon Studies. Annual Report B. BPA Project No. 88-64.

Siple, J.T. and P.J Anders. 1994. Annual Kootenai Hatchery Report. In: Kootenai River White Sturgeon Studies. Annual Report B. BPA Project No. 88-64.

Siple, J.T. and P.J Anders. 1995. Annual Kootenai Hatchery Report. In: Kootenai River White Sturgeon Studies. Annual Report B. BPA Project No. 88-64.

Siple, J.T. and S.C. Ireland. 1996. Kootenai River White Sturgeon Studies. Annual Hatchery Report. BPA Project No. 88-64

Siple, J.T. and T.L. Patterson. 1991. Snake River Sturgeon Report. Information from 1988-1990. Progress Report. Idaho Department of Fish and Game. Boise, Idaho.

Snyder, E.B., and G.W. Minshall. 1996. Ecosystem metabolism and nutrient dynamics in the Kootenai River in relation to impoundment and flow enhancement for fisheries management. Annual Report. Stream Ecology Center, Idaho State University, Pocatello, Idaho.

Stabile, J. J.R. Waldman, F. Parauka, and I. Wirgin. 1996. Stock structure and homing fidelity in Gulf of Mexico sturgeon (Acipenser oxyrinchus desotoi) Based on restriction fragment length polymorphism and sequence analysis of mitochondrial DNA. Genetics. 144:767-775.

U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants; determination of endangered status for the Kootenai River population of white sturgeon-Final Rule. Federal Register 59(171): 45989-46002. (September 6, 1994).

U.S. Fish and Wildlife Service. 1999. Recovery plan for the Kootenai River population of the white sturgeon (Acipenser transmontanus). Region 1, USFWS, Portland, OR.

U.S. Fish and Wildlife Service. 2000. U.S. Policy regarding controlled propagation of species listed under the Endangered Species Act. Federal Register 65 (183) (September 20, 2000).

Van Eenennaam, J.P., S.I. Doroshov, and G.P. Moberg. 1996. Spawning and reproductive performance of domestic white sturgeon (Acipenser transmontanus). Pages 117-122 in S. Doroshov, F. Binkowski, T. Thuemeler, and D. MacKinlay, eds. Culture and Management of Sturgeon and Paddlefish Symposium Proceedings. Physiology Section, American Fisheries Society, Bethesda, MD.

Waples, R. S., and D. J. Teel. 1990. Conservation genetics of Pacific Salmon I. Temporal changes in allele frequency. Conservation Biology Vol. 4(2):144-156.

Waples. R. 1991. Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest, Canadian Journal of Fisheries and Aquatic Sciences 48(Suppl. 1):124-133.

SECTION 14. CERTIFICATION LANGUAGE AND SIGNATURE OF RESPONSIBLE PARTY

"I hereby certify that the foregoing information is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this HGMP is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or penalties provided under the Endangered Species Act of 1973."

Name, Title, and Signature of Applicant:

Certified by: Susan C. Ireland
Kootenai Tribal Fisheries Program Director
December 15, 2000

This page is intentionally blank.

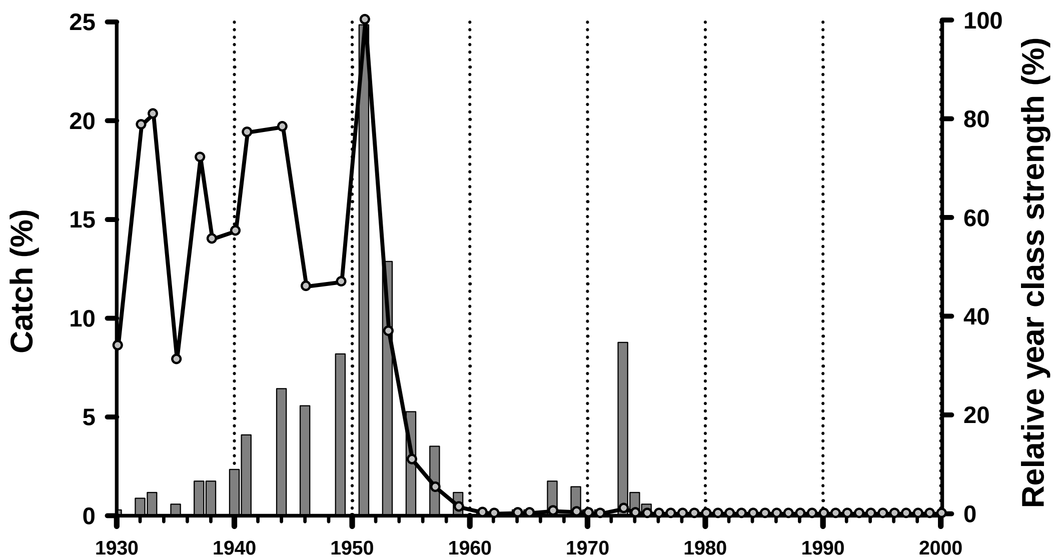
Appendix B

Kootenai River White Sturgeon Recruitment Failure Hypotheses

Appendix B Kootenai River White Sturgeon Recruitment Failure Hypotheses

The proposed program addresses the need created by over 40 years of natural recruitment failure in the Kootenai River white sturgeon population. Empirical Kootenai River white sturgeon data indicate that natural recruitment initially plummeted from about 1950 to 1960 and has been largely suppressed or absent ever since (Figure B-1) (Paragamian et al. 2005). Limited year classes were produced during the early 1970s, but these were insufficient for population viability and persistence. Ongoing annual monitoring since the 1990s has confirmed that insufficient recruitment continues to threaten this population (Figure B-1). Based on these data, some combination of limiting factors from pre- and post-Libby Dam periods appears to be responsible for natural recruitment failure.

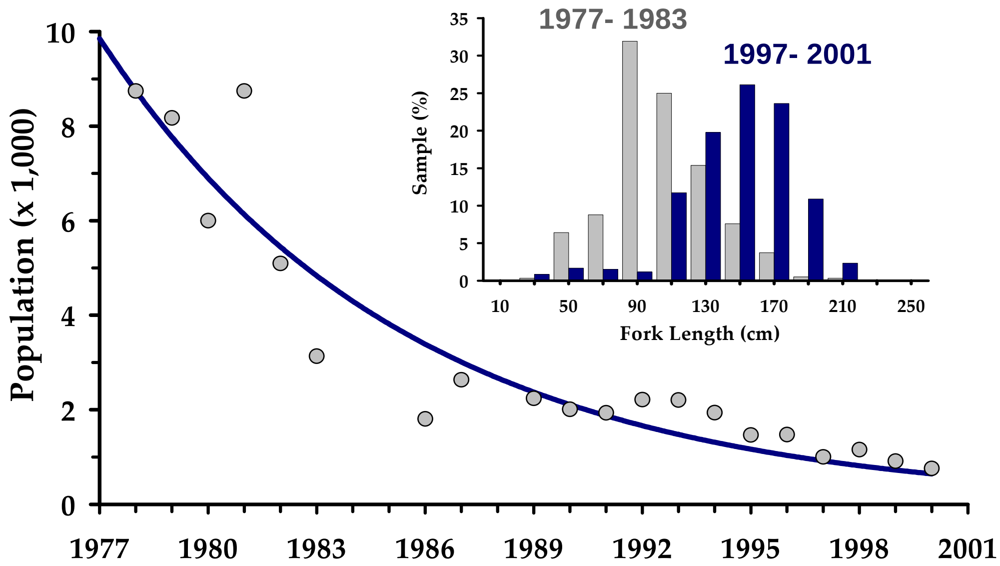
Libby Dam was constructed on the Kootenai River about 70 miles upstream from Bonners Ferry in 1972. Although the onset of natural recruitment failure pre-dated Libby Dam by several decades, construction and operation of the dam drastically changed timing, duration, and magnitude of flows and temperature regimes downstream. Construction and operation of Libby Dam is the subject of many ongoing fish, wildlife, and ecological mitigation programs.



Source: Paragamian et al. 2005, as amended by Cramer Fish Sciences 2008.

Figure B-1. **Year-class frequency distribution (bars and left scale) and relative year-class strength (dots connected by lines and right scale) of Kootenai River white sturgeon captured from 1977-2000.**

Continued natural recruitment failure will ensure population extinction over the next 20 to 40 years without hatchery intervention (Figure B-2).



Source: Paragamian et al. 2005

Figure B-2. Trends in estimated population size, size composition, and numbers of Kootenai white sturgeon (1977-2001).

Kootenai River sturgeon population abundance has declined over 60 percent, from 3,000 fish in 1989 to 1,000 fish in 2007 (Beamesderfer et al. 2009). At an estimated rate of decline of 4 percent per year, the population is estimated to decrease by 50 percent every 17 years. Fewer than 300 adult fish are expected to remain by 2040 under current trends.

Several hypotheses have been advanced to explain potential relationships between ecosystem changes, hydropower operations and ongoing natural recruitment failure (Anders 1991; Duke et al. 1999; USFWS 1999; Anders et al. 2002; Anders 2004; Coutant 2004; Paragamian et al. 2005). These hypotheses can be grouped into two categories, pre-dam and post-dam, although it is likely that some pre-dam factors may continue to limit or prohibit recruitment in the post-dam environment (Table B-1).

Table B-1. Sturgeon Recruitment Failure Hypotheses

Pre-Libby Dam Hypotheses	Post-Libby Dam Hypotheses
Ecosystem degradation	Flow reduction
Imprinting/homing failure	Sand invasion/accumulation
Riparian habitat loss	Substrate scour
Stock limitation	Upstream migration barrier (depth, velocity, light)
	Shifted hydraulic cues

Pre-Dam Hypotheses

Ecosystem Degradation Hypothesis: This hypothesis attributes ongoing recruitment failure to direct and indirect cascading effects of habitat alteration and loss of the natural floodplain. Proposed mechanisms of recruitment failure include reduced nutrient and food availability, altered competition and predation, and reduced habitat quality and availability (Anders et al. 2002).

Imprinting/Homing Failure Hypothesis: The imprinting/homing hypothesis suggests that Kootenai sturgeon no longer migrate upstream from Bonners Ferry into what appears to be suitable spawning, incubation, and early rearing habitats, because fish that historically spawned in these reaches (possibly as far upstream as the "sturgeon hole" at the base of Kootenay Falls) no longer exist. Demographic sampling during 1989 with over 1,800 hours of set-lining captured two sub-adult Kootenai sturgeon in the sturgeon hole (Apperson and Anders 1991). The loss of this potential segment of the population or upstream production would prohibit the opportunity for imprinting in and later homing to natal areas in the upstream reaches.

Riparian Habitat Loss Hypothesis: This hypothesis attributes the widespread collapse of resident white sturgeon populations primarily to the loss of flooded riparian vegetation, which might provide critical incubation and early rearing conditions (Coutant 2004).

Stock Limitation Hypothesis: This hypothesis suggests that insufficient broodstock currently remains in the population to produce enough early life stages to compensate for total additive mortality in the post-development Kootenai River. Proponents of this hypothesis suggest that larger numbers of broodstock may be needed for natural recruitment than were needed in the pre-development river ecosystem.

Post-Dam Hypotheses

Flow Reduction Hypothesis: This general hypothesis suggests that recruitment failure has resulted from the effects of flow regulation on spawning and early rearing conditions (Paragamian et al. 2001). Successful natural recruitment has been associated with spring flows or other general water year measures (Parsley et al 1993; Beamesderfer and Farr 1997), although finer scaled analysis has failed to show linkage between short-term hydropower operations and spawning (Anders and Beckman 1993, Golder 2005).

Sand Invasion Hypothesis: This hypothesis suggests that post-dam hydraulics and erosion contribute to sand invasion and accumulation in the braided and meander reaches. This condition is assumed to be detrimental to spawning, incubation, and possibly survival of free embryos. Based on their expressed concealment behavior (Kynard et al. unpublished data, 2009) and their susceptibility to sediment inundation (Kock 2004; Kock et al. 2006), this hypothesis suggests that use of the current spawning areas fails to produce recruitment due to sedimentation and suffocation. Under pre-dam and pre-levee conditions, sand was deposited out of the channel on the floodplain and finer sediments were transported downstream. The current 120 km of continuous levees, some built on historical natural sand levees, now constrict the channel and prohibit deposition of sand and fine sediments outside the main channel.

Substrate Scour Hypothesis: This hypothesis assumes that spawning historically occurred in present spawning locations. It also assumes that following Libby Dam completion, reduced flood flows and stream power have generally failed to clean the hard substrates of sediment or sand cover, as is assumed to have occurred under historical flow conditions. Clean substrates and interstitial space in spawning, incubation, and early free embryo habitats are thought to be necessary for survival of these early life stages as a prerequisite for natural recruitment.

Upstream Migration Barrier Hypothesis: This hypothesis assumes that some number of Kootenai sturgeon historically migrated upstream past Bonners Ferry to spawn in the braided and/or canyon reaches and that post-dam habitat features restrict or prohibit upstream migration. Post-dam depth, velocity, and incidental light conditions have been cited in federal Biological Opinion as primary factors that might inhibit or block upstream migration (http://www.fws.gov/easternwashington). Recent tracking has confirmed migration of numerous individuals a few kilometers upstream from Bonners Ferry during the spawning season in recent years. However, no signs of successful spawning have been documented upstream from Bonners Ferry.

Shifted Hydraulic Cue Hypothesis: This hypothesis suggests that sturgeon are finding and using suitable hydraulic conditions for spawning that are similar to those conditions that historically contributed to successful year class production. It suggests that prior to levee construction and dam operation, hydraulic conditions that served as spawning cues may have existed further upstream. According to this hypothesis, despite lower flows, similar hydraulic conditions may now exist downstream in the current spawning reach due to channel constriction from the enhanced levees. This hypothesis suggests that the farthest downstream location of suitable hydraulic conditions for sturgeon spawning are now encountered in the meander reach rather than the braided reach.

Olfactory Spawning Location Shift Hypothesis: This hypothesis suggests that pheromones and chemical odorants produced by captively held and spawned females which are then released into the river via hatchery effluent are contributing to: 1) reduced upstream spawning migrations into the canyon reach past the braided reach, 2) observed passing repeatedly upstream and downstream from the hatchery effluent site, and 3) the current spawning reach and locations.

An experiment to asses this hypothesis would involve either: 1) bringing no broodstock into the hatchery and experimentally eliminating this chemical source during one or more years, or 2) routing all sturgeon broodstock effluent away from the river. The latter approach could truck the effluent upstream or release it continuously in large volumes.

Meanwhile, it is important to avoid potential problems associated with chemical guidance and potential migration and spawning location modification caused by reproducing sturgeon tracking the effluent.

Appendix C

Burbot HGMP

KOOTENAI TRIBE OF IDAHO

HATCHERY AND GENETIC MANAGEMENT PLAN
RESIDENT FISH VERSION
(HGMP-RF)

Hatchery Program: Kootenai Tribe of Idaho Native Fishes Conservation Aquaculture Program

Species or Hatchery Population/Strain: Burbot (*Lota lota maculosa*)

Agency/Operator: Kootenai Tribe of Idaho

Watershed and Region: Kootenai River Subbain, Idaho

Date Submitted: June 2010

Date Last Updated: June 2010

SECTION 1. GENERAL PROGRAM DESCRIPTION

1.1) Name of hatchery or program

Twin Rivers Hatchery, Kootenai River Native Fish Restoration and Conservation Aquaculture Program (BPA Project No. 198806400)

1.2) Species and population (or strain) under propagation, ESA/population status.

Burbot (*Lota lota maculosa*), Lower Kootenai River, Idaho

Conservation status / Classification:
Rangewide: Secure (G5)
Statewide (Idaho): Critically imperiled (S1)
ESA: No current or pending status
USFS: Region 1: Sensitive; Region 4: No status
BLM: Regional/State imperiled (Type 3)
IDFG: Game fish; Endangered
(From: http://fishandgame.idaho.gov/cms/tech/CDC/cwcs_appf/Burbot.pdf)

1.3) Responsible organization and individuals

Name (and title): Sue Ireland, Fish and Wildlife Program Director

Agency or Tribe: Kootenai Tribe of Idaho
Address: 242 Hatchery Rd., P.O. Box 1269, Bonners Ferry, ID 83805
Telephone: (208) 267-3620
Fax: (208) 267-1131
Email: ireland@kootenai.org

Other agencies, Tribes, cooperators, or organizations involved, including contractors, and extent of involvement in the program

The Kootenai Tribe of Idaho (KTOI) administers the burbot experimental aquaculture program and the Idaho Department of Fish and Game (IDFG) and the British Columbia Ministry of Environment (BCMoE) conduct burbot monitoring and evaluation studies. The KTOI subcontracts to the University of Idaho's Aquaculture Research Institute (UI-ARI) for burbot aquaculture development and pathology investigations, the University of Idaho department of Life Sciences for development of burbot cryopreservation, Cramer Fish Sciences for project development, reporting and coordination, and the BC MoE for technical services and burbot field investigations.

The Burbot Aquaculture Program is part of a cooperative, multi-agency, international conservation strategy produced as a part of the Kootenai Valley Resource Initiative (KVRI 2005). The KVRI is a community-based, collaborative forum that facilitates communication to restore and enhance the resources of the Kootenai Valley. The KVRI coordinates the Burbot Culture Subcommittee, working to reestablish a burbot population in the Kootenai River. KVRI's conservation strategies delineate reasonable actions that are believed necessary to protect, rehabilitate, and maintain species and populations that have been recognized as imperiled, but not federally listed as threatened or endangered under the US Endangered Species Act. This strategy resulted from cooperative efforts of U.S. and Canadian federal, provincial, and state agencies, Native American Tribes, First Nations, local Elected Officials, Congressional and Governor's staff, and other resource stakeholders.

1.4) Funding source, staffing level, and annual hatchery program operational costs.

The Bonneville Power Administration, under the resident fish portion of the Northwest Power Planning Council's Fish and Wildlife Program, funds hatchery construction, operations, administration, research, and monitoring. Cost sharing is provided in the form of cash or in-kind facilities and services by the Idaho Department of Fish and Game, U.S. Fish and Wildlife Service, British Columbia Ministry of Environment, and the University of Idaho's Aquaculture Research Institute and Department of Life Sciences.

Staff and other resources will be shared between the sturgeon program and the burbot program at both the Tribal Sturgeon Hatchery near Bonner's Ferry and the proposed Twin Rivers Hatchery. Staffing and operational costs provided are based on the assumption of these proposed shared resources. For detailed presentation of potential operational and monitoring and evaluation costs refer to Chapter 8 in the Kootenai River Native Fish Conservation Aquaculture Program Master Plan.

Staffing Levels

It is estimated that inclusion of the burbot program at the proposed Twin River's facility will result in the need for about 4 FTE's. These FTEs are assumed to be Tribal staff and would be utilized for operational activities for both the sturgeon and burbot programs. Specific estimates by staff title are provided in Table 1.

Table 1. Estimated full time equivalent staff for the proposed burbot program

Staff Title	Estimated Annual FTEs for Sturgeon and Burbot Program	Estimate of FTEs for Burbot Program Only
Program Administrator/ Director	0.7	0.3
Program Biologist	0.7	0.3
Hatchery Manager	1.5	0.4
Fish Culture Technicians	7.0	2.0
Maintenance Manager	1.5	0.4
Administrative Assistant	0.5	0.3
Administrative Coordinator	0.5	0.3
Total FTE	**12.4**	**4.0**

Notes and Assumptions:
- Staffing levels are general estimates based on shared staffing with the current and future sturgeon programs at the existing Tribal Hatchery at Bonner's Ferry and proposed program at Twin Rivers
- Does not include labor estimates for subcontracted services
- Monitoring and evaluation costs for the burbot program are not included

Operational Costs

Estimated annual operating costs including labor could range from $180,000 to over $280,000 for the burbot program. Though expenses are interrelated, this doesn't include costs for annual monitoring and evaluation. Detailed costs by area are provided as Table 2.

Table 2: Estimated Annual Operating Expenses, Proposed Burbot Program, Twin River's Hatchery

Expense Area	Estimated Annual Operating Expenses with Existing Tribal Hatchery (2012 dollars)	Estimated Annual Operating Expenses Burbot / Low Estimate (2012 Dollars)	Estimated Annual Operating Expenses Burbot / High Estimate (2012 Dollars)
Payroll / Fringe	$401,950	$80,390	$120,585
Indirect	$237,150	$35,573	$59,288
Travel Costs (Mileage, Lodging, Per Diem)	$9,835	$1,475	$2,459
Professional Services (Data Base, Information System)	$4,371	$656	$1,093
Vehicles, Boats, Equipment, Transportation (Fuel, Oil, Maintenance, Mileage)	$24,005	$3,601	$6,001
Program Supplies (Office)	$3,278	$492	$820
Program Supplies (Fish Food, Aquaculture & Facility Chemicals, Hatchery Supplies)	$21,308	$3,196	$5,327
Equipment & Building Maintenance	$43,709	$6,556	$10,927
Utilities (Electrical, Telephone, Natural Gas, Water), Insurance	$48,080	$7,212	$12,020
Subcontracted Services	$185,960	$44,631	$65,086
TOTAL	$979,647	$183,781	$283,605

1.5) Location(s) of hatchery and associated facilities

Include name of stream, river kilometer, location, basin name, and state. Also include watershed code (e.g. WRIA number), or sufficient information for GIS entry.

The KTOI Twin Rivers Hatchery will be located at the Kootenai and Moyie River confluence (rkm 258.6), about 12 km upstream from Bonners Ferry, Idaho, at GPS coordinates: 559999.38 x 5396591.63 (UTM NAD83, Zone 11) (Figure 1). The Twin Rivers Hatchery site is located in the Kootenai River Basin (HUC 17010101).

1.6) Type of program(s)

Define as either: Integrated Recovery; Integrated Harvest; Isolated Recovery; or Isolated Harvest (see Attachment 1 - Definitions" section for guidance).

The Twin Rivers Hatchery will be an Integrated Recovery Program primarily designed to aid in the recovery, conservation or reintroduction of a natural population. Fish produced are intended to spawn in the wild or be genetically integrated with the natural population.

This recovery objective for burbot in the Kootenai River presupposes that natural spawning conditions for the wild population will be restored by proposed habitat measures.

1.7) Purpose (Goal) of program(s)

The goal of this program is to restore a burbot population in the lower Kootenai River using broodstock and gametes from within-basin native populations.

1.8) Justification for the program

Indicate why the hatchery program is needed and how it will enhance or benefit the survival of the listed population (integrated or isolated recovery programs), or how the program will be operated to provide fish for harvest while minimizing adverse effects on listed fish (integrated or isolated harvest programs).

The Twin Rivers Hatchery Program is needed to reestablish a burbot population in the lower Kootenai River. Decades of sampling the lower Kootenai River have confirmed that native burbot population abundance has declined to about 50 fish (25-100, 95% CI), a level considered to be functionally extinct (Pyper et al. 2004; KTOI and MFWP 2004; KVRI 2005; Paragamian et al. 2008). The program would restore an important biodiversity component of the ecosystem and its food web, which would likely benefit other native species within this system. Burbot are a culturally important species to the Kootenai Tribe, and establishing a sufficiently sized and diverse population capable of future ceremonial, subsistence, and sport harvest is the ultimate long-term goal of this program.

This aquaculture program is needed because there is no current or near-term alternative available for restoring a burbot population in the lower Kootenai River.

1.9) List of program "Performance Standards"

In their Artificial Production Review, the Production Review Committee of the Northwest Power and Conservation Council (NPCC defined "Performance Standards" as a set of specific criteria by which progress in achieving the program goal/purpose can be measured).

The goal of this program is to restore a burbot population in the lower Kootenai River using broodstock and gametes from within-basin native populations. The accompanying performance standards corresponding to this goal as defined in the Artificial Production Review Report (NPCC 1999), are to:

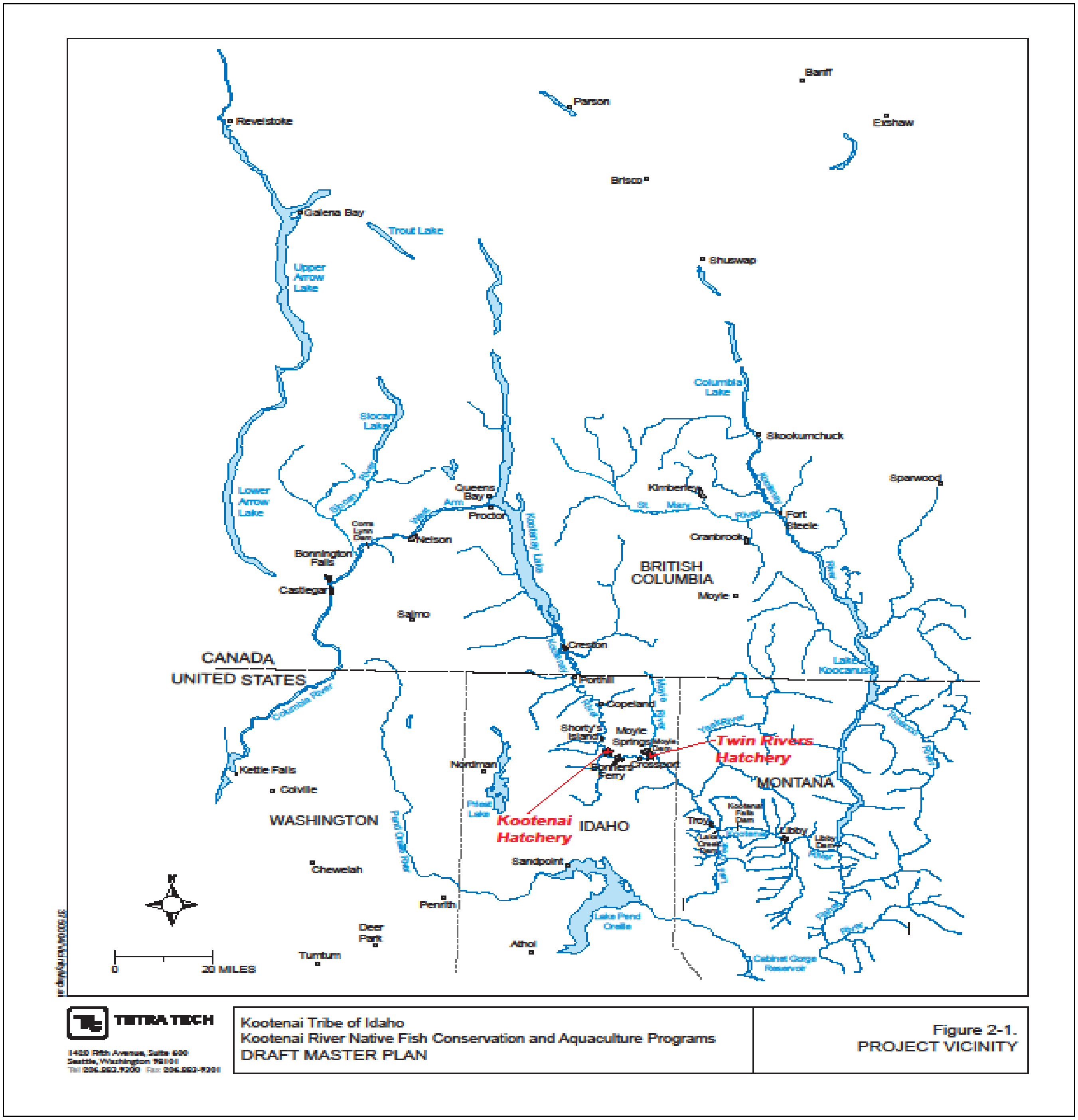


Figure 1. Map of the Kootenai River Basin indicating locations of existing (Kootenai) and proposed (Twin Rivers) hatchery locations.

1. Maintain, augment, and restore a viable naturally spawning population using artificial production strategies.
2. Incorporate genetic and life history trait diversity into a hatchery-produced burbot population for release into the Kootenai River, and life stage-specific habitat use and availability in the Kootenai River and in lab experiments.
3. Use hatchery-reared fish and facilities to conduct research on factors limiting natural production.
4. Conduct research to improve the performance and cost effectiveness of artificial propagation efforts and to minimize risks.
5. Avoid mortality risks to wild broodstock at capture and spawning and other earlier life stages in the hatchery.
6. Minimize the detrimental genetic or behavioral impacts of artificial propagation by stocking fish at the earliest point consistent with satisfactory growth and survival.
7. Avoid pathogen introduction and transfer, and reduce disease incidence in the hatchery produced population in the hatchery and in the river.
8. Avoid risk to the natural population by monitoring parameters that estimate biological condition and related population dynamics as a surrogate for estimating carrying capacity of the natural habitat.

1.10) List of program "Performance Indicators", designated by benefits and risks

"Performance Indicators" determine the degree that program standards have been achieved, and indicate the specific parameters to be monitored and evaluated. The list of "Performance Indicators" should be separated into two categories: "benefits" that the hatchery program will provide to the listed resident fish species, or in meeting harvest objectives while protecting listed resident fish species; and "risks" to listed resident fish species that may be posed by the hatchery program, including indicators that respond to uncertainties regarding program effects associated with a lack of data.

Performance indicators are specific operational measures of fish and hatchery attributes that address each performance standard. They determine the degree to which program standards have been achieved, indicate the specific parameters to be monitored and evaluated, and are used to detect and evaluate the success of the hatchery program and any risks to or impairment of recovery of affected, listed fish populations. Performance indicators must be measurable, realistic, feasible, understandable, affordable, and time-specific. Table 3 lists specific burbot performance standards, indicators, and activities associated with the program.

The first experimental release of cultured burbot from this program occurred during October and November of 2009 and will be repeated in 2010. Subsequent years of experimental, larger scale releases are required to further quantify benefits and risks to listed resident species, and to evaluate benefits and risks of program implementation.

1.10.1) "Performance Indicators" addressing benefits

Benefits of the proposed burbot hatchery program include: 1) creating and maintaining a burbot population with a sustainable age class structure, one dominated by immature juvenile fish that grow to reproductive adulthood; 2) incorporating adequate genetic diversity and life history trait diversity into the hatchery-produced population for viability and persistence; and 3) determining and counteracting natural production limitations to the extent feasible (Table 3).

The adaptive experimental approach being designed for this project involves a broad spectrum of expertise from tribal, governmental, university, and private sector participants. Performance standards will be addressed by a comprehensive monitoring and evaluation program of fish in the hatchery and in the wild following release (see Section 11). Numbers and mortality of eggs, larvae, and juveniles are tracked throughout the spawning and rearing process. An annual field sampling program will be implemented cooperatively with KTOI, IDFG, and BC MoE to recapture and evaluate hatchery-reared fish and any wild produced fish. Data on numbers, lengths, weights, and marks are used to estimate survival and growth rates.

Growth and condition factors will also provide an index of post-release burbot performance. A genetic testing program will be developed to identify gene frequencies in hatchery broodstock and progeny groups for comparison to target desirable population genetic metric values.

Excess eggs and hatchery-reared fish will also provide burbot for contaminant assessments, animal health research, *in–situ* hatching experiments, and other aquatic, biological, and ecological research to provide insight into factors limiting natural production of burbot.

A burbot population in the Kootenai River will be considered healthy when: 1) natural production (or if necessary a combination of natural and hatchery production) has restored a length and age frequency distribution in which all size and ages are represented in a fashion suggesting sustainability; 2) numbers of juveniles and adult spawners are sufficient to produce recruitment that maintains desirable population size and age distribution; 3) habitat improvements are sufficient to allow natural spawning to maintain the population in the absence of hatchery supplementation; and 4) population size is sufficient to maintain adequate genetic diversity and life history trait expression for burbot life cycle completion after release.

Table 3. Performance standards and indicators for the burbot conservation program. Italics indicate program actions or activities associated with performance indicators.

Performance Standard	*Type*	*Performance Indicator*
1. Maintain, augment, and restore a viable naturally spawning population using artificial production strategies	**Benefit**	Increase population size and enhance age composition as a result of hatchery propagation, release, and future recruitment of hatchery-produced fish: *Proportion of the size/age cohort contributed by hatchery* *Number of hatchery-reared fish by life stage including maturity* *Individual growth rates & condition factors*

Table 3. Performance standards and indicators for the burbot conservation program. Italics indicate program actions or activities associated with performance indicators.		
		Size & age specific survival rates
2. Incorporate genetic & life history diversity	**Benefit**	Retain life history characteristics and genetics by the hatchery reared population *Genetic population characteristics of hatchery broodstock and progeny* *Separate rearing of family groups* *Cryopreservation of male gametes* *Individual and population attributes as in #1 above.*
3. Use hatchery-reared fish for research on natural production limitations	**Benefit**	Understanding of the life history characteristics and factors limiting natural recruitment *Sampling to determine habitat use* *Research to assess habitat quality and quantity for all burbot life stages*
4. Conduct research to increase effectiveness & minimize costs	**Benefit**	Adaptive approach to achieve results while reducing process, administrative overhead, & operation costs *Complete planning and review processes and move to multi-year funding schedule with check points* *Adapt size and time of release to maximize benefits and minimize risks* *Marking methods to allow release as subyearlings* *Larval release experiments if appropriate* *Cryopreservation techniques*
5. Avoid mortality risks	**Risk**	Minimize mortality rate of broodstock in hatchery & after release *Modify collection and marking techniques (e.g. No FLOY tags; no sampling at great depths) to reduce mortality*
6. Minimize detrimental effects of artificial propagation	**Risk**	Release fish at youngest age/earliest life stage consistent with satisfactory growth and survival
7. Minimize pathogen transfer and disease risk	**Risk**	Minimal incidence of disease in the facility *Maintain appropriate spawning & rearing practices & densities, rigorous disease testing protocols, and rear disease-free trout for bait and broodstock feeding*
8. Avoid risks to natural population	**Risk**	Monitor parameters that estimate biological condition and related population dynamics as a surrogate for estimating carrying capacity of the natural habitat; modify program appropriately to minimize risks

1.10.2) "Performance Indicators" addressing risks

Performance indicators assessing risks associated with the burbot culture program include: 1) avoiding broodstock and early life stage mortality; 2) minimizing pathology transfer and disease risk; and 3) minimizing negative and behavioral and genetic impacts from breeding matrices and rearing techniques.

These risks are addressed by many of the same monitoring and evaluation indicators used to address program benefits. Burbot numbers and condition will be monitored in the hatchery and in the river following release. Burbot broodstock capture, gamete collection, cryopreservation, spawning, incubation, early rearing and feeding methods have been developed and are being refined to minimize stress and improve success of burbot aquaculture.

Genetic and animal health monitoring programs are being developed and refined, by project-funded efforts at the UI-ARI. Adjustments will be made throughout the development of this program and will continue to be made based on monitoring and evaluation results consistent with the adaptive management principles recommended by the Artificial Production Review Committee of the ISRP.

1.11) Expected size of program

In responding to the two elements below, take into account the potential for increased fish production that may result from increased fish survival rates affected by improvements in hatchery rearing methods, or in the productivity of fish habitat.

1.11.1) Proposed annual broodstock need (maximum number of fish)

The burbot biocriteria developed for this program recommend that a minimum of 25 female and 25 male broodstock (averaging 2 kg body weight) or their gametes will be needed to initiate the breeding program. Subsequent annual needs will depend on adult acclimation to captivity, post-spawn survival, and the final desired breeding matrix complexity to ensure adequate genetic variation in the small breeding population.

1.11.2) Proposed annual fish release levels (maximum number) by life stage and location

Annual release numbers will depend on in-river survival rates. Until these numbers are defined, interim release numbers will be based on population modeling efforts and data obtained from early experimental releases. The first experimental burbot release occurred during 2009 (Table 4). Details of this release, which used experimental, limited facilities, do not reflect attempts to maximize burbot production.

Table 4. Data from first experimental burbot releases in fall 2009.

Life Stage	2009 Release Location	2009 Release Level
Fingerling release 1	Bonners Ferry, Idaho, Ambush Rock Kootenai River (rkm 244.5)	21
Fingerling release 2	Between Bonners Ferry and Naples, Idaho, Deep Creek	177
Fingerling release 3	Snow Creek,	19
Age 2+	British Columbia, Canada. Goat River (UTM's 533131 5437543; rkm 152.5)	30
Total experimental release in 2009		247

In 2009, burbot fry were also stocked in two ponds to evaluate extensive culture. Stocking levels were:

- 4,500 fry in Cow Creek Pond
- 17,000 fry in Fredrick's Pond
- 360 fry in 5 cages in Fredrick's Pond

Proposed release numbers are derived from survival and demographic model simulation procedures using a series of possible post-release survival rate scenarios to establish future production and release numbers. These numbers will be refined based on program operations which will be adaptively managed as the program is implemented and monitoring and evaluation results are analyzed.

Future release locations and levels will depend on efforts to identify suitable habitat, river flow manipulations and future habitat modifications. The impetus for the 2009 experimental release (Table 4) in the Goat River, British Columbia, was to track the movement of juvenile burbot (age 2+) and subsequently identify seasonal habitat use over the next several years and beyond. Annual releases of ultrasonic tagged fish are planned and should provide valuable information on habitat use and potential spawning sites for adult burbot.

An adaptive release and monitoring program for burbot produced at Twin Rivers is being designed based on developing trends from collection and analysis of empirical post-release burbot data. This approach has been successfully implemented as part of the Tribe's white sturgeon conservation aquaculture program over the past two decades.

A series of burbot releases based on projected post-release survival scenarios will generate early survival data that will be used to refine subsequent release numbers. If favorable post-release survival rates and biological condition are observed from juvenile burbot releases (ages 0-2, the youngest age likely to exhibit favorable post-release survival), then a series of trials involving the release of younger or earlier life stage fish will be implemented. Annual release numbers would increase dramatically if younger life stages could be released.

Because empirical post-release survival rates for burbot are not yet available, the information presented in Table 5 is a preliminary order of magnitude estimate of future release strategies.

Table 5. Initial order of magnitude release numbers for burbot by life stage.

Life Stage	Release Location	Annual Release Level
Eyed Eggs	TBD	Millions
Unfed Fry	TBD	Millions
Fry	TBD	Hundreds of Thousands
Fingerling	TBD	Thousands
Yearling	TBD	Hundreds - Thousands
Spawner	TBD	Hundreds

1.12) Current program performance, including estimated survival rates, adult production

levels, and escapement levels. Indicate the source of these data.
Provide data (e.g., CPUE, condition factors) available for the most recent twelve years), or for the number of years of available and dependable information. Indicate program goals for these parameters.

Current program performance is relevant to the specific research objectives and questions identified by the KVRI burbot culture subcommittee as they relate to experimental scale development of fundamental aquaculture methods (e.g., spawning, egg incubation, larval feeding and rearing options). An experimental program is operated with limited labor, space, water resources at the University of Idaho Aquaculture Research Institute (UI-ARI).

This program began in 2003 to assess the feasibility of conservation aquaculture as a burbot population restoration tool. The initial objectives were to: 1) design, construct, and evaluate rearing systems to meet critical thermal parameters, and 2) develop handling and enumeration methods for adults, eggs, and young-of-year in the hatchery.

The first 20 burbot were spawned in 2004 at the UI-ARI; all 20 captive broodstock were successfully spawned. Several million eggs were collected, fertilized, and water hardened. Egg enumeration and incubation methods were developed, as were larval and juvenile feeding strategies. A precipitous decline in survival was observed post-hatch as a result of the delicate nature of burbot larvae (3-4 mm total length at hatch and no mouth or functional alimentary tract). Within 15-30 days post-hatch, >50% of embryos died or escaped through 500 micron mesh screening used to contain them. Following physiological development to a functionally feeding larval form, live feeds were required. Aside from developing methods to propagate burbot, live feed (Algae, Rotifers and *Artemia*) propagation techniques were successfully developed. By the juvenile life stage (post metamorphosis), 19 fingerlings remained and were transitioned to commercial dry feeds. This was the first time cultured burbot were successfully transitioned to a commercial dry diet and the first time burbot had been successfully propagated in the US from egg to juvenile stages.

By 2005, 50% of the original adults remained. Adult mortality was attributed to distended swim bladders during capture and handling when spawning. During 2005 (January and October), additional wild broodstock were collected. All January adult captures perished from infections caused by external Floy tagging and ruptured or distended swim bladders. Subsequently, capture, transportation and handling methods were refined to reduce trauma and these sources of mortality are now avoided.

During 2006, 73 juvenile burbot were produced past the larval diet transition stage in a limited trial. Juvenile survival and full transition to larval diets has improved each year, representing the project's exponential production success curve (Figure 2).

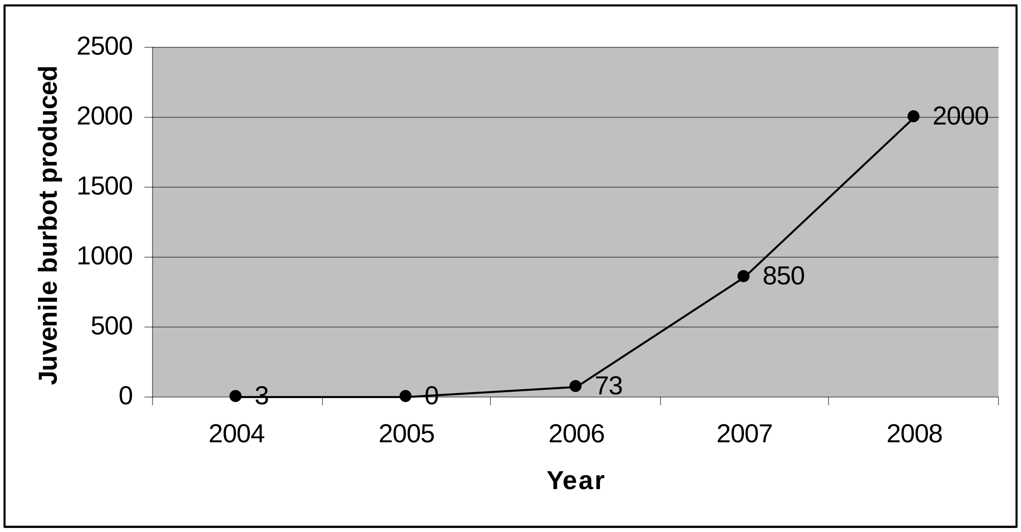


Figure 2. Juvenile burbot produced post commercial larval diet transition for research needs 2004-08.

Source: UI-ARI Unpublished data; http://www.kootenai.org/kvri_docs.html

Additionally, the 2004 progeny were raised to maturity in the laboratory and spawned in 2008 and 2009, which marks the first time cultured F1 burbot progeny have contributed gametes to a captive breeding program.

During 2009, research objectives included condition factor characterization while further developing culture methods, including evaluation of extensive (earthen pond style rearing) and semi-intensive (aerated outdoor fiberglass tanks) rearing alternatives, and studying how water temperature affects growth of pre- and post-metamorphosed young-of-the-year and commercial diet transitioned juvenile burbot. Over 40,000 burbot were used in experimental trials in 2009 (Table 6) and 247 were released (Table 4). These 2009 research endeavors will continue at least through 2010.

1.13) Date program started (years in operation), or is expected to start

The Twin Rivers hatchery is expected to be operational by 2012, building upon aquaculture techniques initiated by the Kootenai Tribe in 2001 with the collaboration of UI-ARI and other partners. Results from this work have confirmed the feasibility of culture (i.e., spawning, egg incubation, larval rearing, juvenile grow out, etc.) (Figure 2, Table 7). Establishing a conservation aquaculture program for burbot has been identified as a critical component for the restoration of this species within the Kootenai/Kootenay system of Idaho and British Columbia.

Table 6. Numbers of burbot produced by life stage for research during 2009 at UI-ARI.

Burbot Numbers	Feeding stage	Study	Study location
17,772	45 d on live feed	Extensive rearing feasibility	Fredrick's Pond, Bonners Ferry
360	45 d on live feed	Extensive cage rearing project year 2/IDFG project	Fredrick's Pond, Bonners Ferry
4,625	45 d on live feed	Extensive rearing feasibility	Cow Creek Pond, Bonners Ferry
11,025	45 d on live feed	Semi-intensive rearing experiment	UI-ARI, Moscow
3,000	30 d on live feed	Temperature related growth experiment 1	UI-ARI, Moscow
2,400	75 d on live feed	Temperature related growth experiment 2	UI-ARI, Moscow
600	Commercial diet transitioned	Temperature related growth experiment 3	UI-ARI, Moscow
1,200	164 d on live feeds, transitioned to commercial diet	Weaning experiment/test alternate commercial diets, characterize macronutrient status (proximal analysis)	UI-ARI, Moscow
40,982	Total burbot produced for research during 2009		

1.14) Expected duration of program

The expected duration of the program is until natural production is restored to levels that maintain a self-sustaining harvestable population.

1.15) Watersheds targeted by program

Watersheds within the Kootenai River Basin from Kootenay Lake, British Columbia upstream into Idaho are targeted by this program. The program area is contained within HUC 17010101.

Table 7. Current status of various aspects of burbot aquaculture at the UI-ARI.

Critical Burbot culture components	Burbot culture activities	Progress to date	Immediate experimental needs	Future experimental needs	Production feasibility status	Comments
Adults	Collection	Good	None	None	Requirements met	Adult stage activities do not currently limit production
	Holding	Good	None	None	Requirements met	
	Spawning	Good	None	None	Requirements met	
Egg stage	Incubation	Good	None	None	Requirements met	Egg stage activities do not currently limit production
Larval stage	Holding (pre-mouth development)	Good	None	None	Requirements met	System design has been improved
	Feeding (intensive – live prey)	Good	None	None	Requirements met	Intensive methods established and do not limit production
	Feeding (extensive/semi-intensive-outdoor ponds)	Good	None	Confirm production potential	Repeat study during 2010	Graduate student project underway
Juvenile stage	Grow-out	Good	None	Analyze feed trial experiments and continue to optimize feed transition	Requirements nearly met	Transition to artificial feed successful. Improved survival desired but not essential for production
Burbot health	Assessment of formalin and H_2O_2 for fungal control on eggs	Good	None	None	Requirements met	Results *in press: North American Journal of Aquaculture*
	Disease susceptibility	Good	None	None	Requirements met	Paper s submitted: *Diseases of Aquatic Organisms*
	Pathogen screening (Development of cell line as diagnostic tool)	Good	None	None	Requirements met	Paper submitted: *Journal of Fish Diseases* (cell line supplied to fish diagnostic labs)

1.16) Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed.

A range of alternatives for burbot conservation were considered by the Tribe, including maintaining current Libby Dam flow management measures, developing an artificial production facility or modifying an existing facility to accommodate production.

Alternative 1: Status Quo

Under this alternative, ongoing measures would continue. These include: 1) reducing discharge from Libby Dam to the extent possible during the winter months to stimulate reproductive migrations that could lead to natural production, and 2) providing more normative fall and winter thermographs in the Kootenai River to the extent possible through altered operations at Libby Dam.

If Alternative 1 were to be adopted, the expected outcome would be extinction of the population. Studies indicate that there has been inadequate burbot recruitment over the last decade (Pyper et al. 2004, KVRI 2005, Paragamian et al. 2008).

Alternative 2: Implement Conservation Aquaculture at a New Facility

Under this alternative, a new aquaculture facility would be constructed to propagate burbot. Stocks native to the Kootenai River subbasin would be spawned and reared in an effort to rebuild a burbot population in the lower Kootenai River. This facility would be co-located with the proposed Kootenai sturgeon aquaculture program at the Twin Rivers site, resulting in shared infrastructure components and components and significant cost and operation efficiencies.

Alternative 2 appears to have the highest likelihood of restoring burbot to this reach of the Kootenai River, particularly when combined with the habitat improvement measures proposed by the Kootenai Tribe under the Kootenai River Habitat Restoration Project.

Alternative 3: Implement Conservation Aquaculture at an Existing Facility

Artificial propagation of burbot would be accomplished at an existing hatchery in the Kootenai subbasin. Under this alternative, existing facilities would be modified or expanded to accommodate production of this species. Potential locations considered were 1) the Tribal Sturgeon Hatchery near Bonners Ferry and 2) the Fort Steele Hatchery in British Columbia. Facilities at the University of Idaho currently being used to experimentally propagate burbot are suitable for research programs but cannot be expanded into production facilities, nor can they be used in the long term.

Both the Tribal Sturgeon Hatchery and Fort Steele facilities currently operate at capacity and the option of adding burbot production would occur at the expense of ongoing production commitments. Reprogramming was not considered to be a feasible option. Expanding facilities at the Tribal Sturgeon Hatchery was determined to be infeasible primarily because the supply of high quality water and land needed for expansion are limited. Although the Fort Steele facilities provide an important fail-safe function for Kootenai sturgeon production, until the need for such a function is determined for the burbot program, the Tribe does not intend to pursue use of this site with its Canadian partners. Finally, no other suitable existing facilities were identified in either the Idaho or Montana portions of the subbasin that could accommodate a burbot program.

When considering out-of-basin fish rearing options, the Tribe weighed the following issues: disease introduction and pathogen transfer, transportation and acclimation, escapement, as well as fiscal, and policy challenges. These issues are briefly described below.

Disease introduction concerns and risks

- If disease is detected in fish reared out-of-basin, there is little chance that fish would be released due to concern over introduction of non-endemic pathogens or unique strains of a pathogen to new waters.
- Research at UI has provided baseline information regarding disease susceptibility and diagnostic tools have been developed (Polinski et al. 2009; Polinski et al., *in press*; Polinski et al., *accepted*). This is critical for full scale implication of a recovery program and provides fish health managers with valuable data useful for regulating movement and stocking of hatchery produced burbot (see Section 6.7).
- Disease inspections that follow USFWS Title 50 requirements are completed prior to release.
    - The risk of detecting a pathogen that is non-endemic to the Kootenai system cannot be discounted. Such detection would preclude fish from being transported and released and result in loss of at least one year class.
    - Due to the reliance on a closed or semi-closed recirculation system for current production of fish at UI-ARI, the detection of a non-endemic pathogen may require the eradication of all fish at the facility and complete disinfection. This is a significant risk that would be minimized by implementing design criteria and rearing fish within basin.

Transportation and acclimation issues

- Transporting fish to release sites introduces stress.
- The need for acclimation or imprinting for burbot is unknown but may prove to be important.

Escapement issues

- Implementing such safeguards at other potential out-of-basin facilities may be difficult and expensive.

Fiscal Implications

Combining use of facilities to rear several species at the Twin Rivers Hatchery represents fiscal responsibility and provides many cost efficiencies. The burbot facilities represent a relatively modest investment that would capitalize on many shared sturgeon operational components. Expanding existing facilities or constructing facilities outside of the basin (even if possible and recommended) would likely require greater expenditures over the long term.

Policy implications

Best aquaculture practices endorsed by the NPCC and others discourage transferring fish out-of-basin for both ecological and pathological reasons.

SECTION 2. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

2.1) Describe alignment of the hatchery program with other hatchery plans and policies. Explain any proposed deviations from the plan or policies.

This burbot conservation aquaculture program was developed as part of an adaptive multi-species, ecosystem and habitat restoration program by the Kootenai Tribe. It is consistent with the Kootenai Subbasin Plan, the Kootenai River Adaptive Management Plan, the Kootenai River white sturgeon and burbot 5-year RM&E Plans, the Kootenai River White Sturgeon Recovery Plan, and the Kootenai Valley Resource Initiative (KVRI) Burbot Subcommittee recommendations. This integrated approach aligns the burbot conservation aquaculture program and all other relevant hatchery plans, policies, and research and management objectives (Table 8).

Table 8. Relationship of Kootenai River burbot conservation measures to other actions in the Kootenai River subbasin.

Conservation Measure Description	*Time Frame**	*Lead Agency*	*Cooperating Agencies*
Fish Management			
Continue current restrictions on burbot harvest in the Kootenai River, and Kootenay Lake, and their tributaries.	*O-L*	*IDFG, MFWP, BC MoE*	*IDFG, MFWP, BC MoE*
Continue to monitor and limit incidental impacts and prohibit illegal harvest of burbot.	*S-L*	*IDFG, MFWP, BC MoE*	*IDFG, MFWP, BCMOE*
Integrate aspects of Conservation Strategy into the multi-agency Kootenai River Adaptive Management Program, using IKERT as an annual review and input forum	*O-L*	*All Agencies*	*All agencies*
Consider resumption of subsistence and recreational fisheries after Conservation Strategy targets are met.	*L*	*IDFG, MFWP, BC MoE*	*Kootenai Tribe*
Habitat Restoration			
Seek opportunities to reestablish lost natural river functions in the lower Kootenai River, including hydrograph cycles, habitat diversity, and floodplain connectivity and function.	*M-L*	*Kootenai Tribe, IDFG, MFWP, BC MoE, USFWS, KVRI*	*KVRI Burbot Committee, IDEQ, NRCS*

Conservation Measure Description	Time Frame*	Lead Agency	Cooperating Agencies
Continue to implement tributary habitat improvement projects that address instream, riparian, and upland conditions that affect stream discharge, water quality, and habitat diversity and complexity.	*M-L*	*Kootenai Tribe, IDFG, MFWP, BC MoE, USFS*	*KVRI Burbot Committee, IDEQ, IDL, USFS, NRCS*
System Productivity, Aquatic Communities			
Continue annual fertilization of Kootenay Lake (North Arm fertilization began in 1992, South Arm began during 2004) and expand the program to include the Kootenai River in Idaho, near the Idaho-Montana border (2005) to increase the forage base available to burbot.	*S*	*BC MoE, BC Hydro, Kootenai Tribe, IDFG*	*IKERT*
Continue efforts to restore and maintain other components of the native fish community including kokanee and Kootenai sturgeon through approved habitat and population enhancement measures.	*S-O*	*USFWS, Kootenai Tribe, IDFG, MFWP, BC MoE,USACE*	*IKERT, BEF*
Endorse potential benefits to the burbot population and food base of ongoing efforts in other forums to assess and remedy sources of environmental contaminants.	*S-L*	*USFWS, Kootenai Tribe, IDFG, MFWP, BC MoE*	*All agencies*
Conduct controlled and in-situ laboratory bioassays to determine the physiological effects of temperature, contaminants, predation, nutrients and other potential environmental stressors on different life stages of burbot.	*S-M*	*USFWS, Kootenai Tribe, IDFG, MFWP, BC MoE*	*UI-ARI, USGS, and other labs*
Hydro Operations			
Develop an experimental Kootenai River flow/water temperature operation to evaluate the effectiveness of restoring natural spawning, and recruitment by reducing winter temperatures and velocities. Implement experimental operations when conditions allow to evaluate burbot spawning requirements while preserving flexibility in needed hydropower production and flood control operations.	*S-M*	*USACE, BPA, BC Hydro*	*IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee*
Document specific temperature and flow requirements that provide for natural spawning, incubation, rearing, recruitment, and survival of Kootenai River burbot.	*S-L*	*IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS*	*USACE, BPA, BC Hydro, KVRI M&E and Hydro Operations Subcommittee*
Investigate existing hydrological models based on historic temperature, flow, and velocity data, and modify if necessary to evaluate effects of operational alternatives on conditions required for completing various burbot life stages.	*S-L*	*BPA, USACE, USGS, BC Hydro*	*IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee*

Conservation Measure Description	*Time Frame**	*Lead Agency*	*Cooperating Agencies*
Evaluate use of selective withdrawal during migratory pre-spawning periods to affect thermograph near Bonners Ferry and downstream to benefit burbot. Monitor water temperature at Porthill.	*S*	*USACE*	*IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee*
Develop a long-term process to recommend annual Libby Dam operations for burbot, while providing for other project uses consistent with Endangered Species Act and other statutory and regulatory responsibilities. The multi-year plan may explore opportunities for experimental operations to evaluate burbot response to the operations.	*L*	*BPA, USACE, USFWS, BC Hydro*	*IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee*
Culture, Supplementation & Reintroduction			
Develop effective methods to successfully hold, spawn, fertilize, and rear burbot in a hatchery. Develop these techniques using burbot from other regional populations to avoid impacts to remnant Kootenai River, Kootenay Lake, and Duncan Reservoir populations.	*S*	*Kootenai Tribe, BC MoE, UI-ARI*	*KVRI Burbot Culture Subcommittee*
Evaluate donor stock suitability using a multidisciplinary broodstock evaluation template that incorporates: genetic, evolutionary, biological, ecological, and management parameters for fish in receiving and donating waters. In the short term, complete burbot microsatellite analysis to identify stock structure and guide decisions regarding stock source for conservation aquaculture.	*S*	*Kootenai Tribe, UI-ARI IDFG, MFWP, BC MoE, CFS*	*KVRI Burbot Culture Subcommittee*
When effective burbot culture techniques have been identified, and if natural recruitment sufficient to meet recovery goals has not been restored, implement an experimental burbot stocking program to: 1) identify life cycle bottlenecks in burbot survival, 2) determine whether hatchery-produced burbot can effectively survive in the wild, and 3) contribute to demographic and genetic vigor of remnant or re-introduced populations.	*S-L*	*Kootenai Tribe, UI-ARI IDFG, MFWP, BC MoE*	*KVRI Burbot Culture Subcommittee, CFS*
Design, evaluate, and implement a fish culture strategy with strict genetic guidelines, fish health protocols, and rigorous M&E components to assess and balance benefits and risks of natural production, while recognizing the need for significant conservation measures.	*S-L*	*Kootenai Tribe, UI-ARI, IDFG, BC MoE*	*KVRI Culture Subcommittee, CFS*

Conservation Measure Description	*Time Frame**	*Lead Agency*	*Cooperating Agencies*
Identify subsequent hatchery roles in burbot conservation, based on monitoring and evaluation of post-release fish performance and responses of any natural recruitment to other recovery measures, and to the performance of experimental releases of hatchery fish.	*S-L*	*IDFG, MFWP, BC MoE, Kootenai Tribe*	*UI-ARI, WSU, IDFG*
Research, Monitoring, and Evaluation			
Periodically conduct standardized assessments of burbot status in the Kootenai River from Montana downstream into Kootenay Lake contingent on availability of appropriate sample numbers, and on donor source brood stock populations.	*S-L*	*IDFG, BC MoE, MFWP, Kootenai Tribe (w/ hatchery progeny)*	*KVRI Burbot Committee*
Periodically conduct standardized assessments of wild larval and juvenile abundance.	*S-L*	*IDFG, BC MoE, MFWP, Kootenai Tribe (w/ hatchery progeny)*	*KVRI Burbot Committee*
Identify essential habitats and conditions by monitoring burbot movement and habitat use.	*S-L*	*IDFG, BC MoE, MFWP*	*KVRI Burbot Committee*
Evaluate current use and suitability of the mainstem Kootenai River and its tributaries for burbot spawning.	*S-M*	*IDFG, Kootenai Tribe, MFWP, BC MoE*	*KVRI Burbot Committee*
Evaluate the contribution of entrainment from Libby Dam to the downstream Kootenai River burbot population.	*S-L*	*MFWP, IDFG, BC MoE*	*KVRI Burbot Committee*
Identify burbot behavior in Kootenay Lake to determine whether special habitat limitations or biological interactions affect effectiveness of the burbot Conservation Strategy.	*S-M*	*BC MoE*	*KVRI Burbot Committee*
Monitor burbot responses to specific conservation measures, and modify projects/operations to meet biological performance targets.	*S-L*	*IDFG, Kootenai Tribe, MFWP, BC MoE*	*Relevant KVRI Sub-Committees*
Design, implement and evaluate natural production experiments.	*S-L*	*IDFG, Kootenai Tribe, MFWP, BC MoE*	*Relevant KVRI Sub-Committees*
Information and Education			

Conservation Measure Description	Time Frame*	Lead Agency	Cooperating Agencies
Increase public awareness of the need for Kootenai River burbot conservation by developing and distributing informational and educational materials and by hosting periodic public meetings.	*S-L*	*KVRI I&E Committee*	*KVRI Burbot Committee*
Pursue opportunities to link Kootenai River burbot conservation activities with other ongoing fish management, fish and wildlife recovery activities, and habitat and ecosystem restoration efforts via the multi-agency Kootenai River Adaptive Management Plan.	*S-L*	*IDFG, Kootenai Tribe, BC MoE, USFWS, MFWP*	*All agencies*
Prepare and distribute annual monitoring, evaluation and research reports.	*S-L*	*IDFG, Kootenai Tribe, BC MoE, USFWS, MFWP*	*All Agencies*
Continue to involve a broad coalition of stakeholders in burbot conservation through the Kootenai Valley Resource Initiative Process.	*S-L*	*KVRI Burbot Committee*	*All Agencies*
Planning, Implementation, and Coordination			
Maintain a standing technical committee to coordinate and adapt implementation of this Conservation Strategy.	*S-L*	*KVRI Burbot Committee*	*All Agencies*
Review and update this Conservation Strategy annually; formally update it every five years or less as necessary.	*S-L*	*KVRI Burbot Committee*	*All Agencies*
Continue to build regional and international program coordination and participate in timely data sharing.	*S-L*	*KVRI Burbot Committee*	*All Agencies*

*L=long term (>10 years); S=short term (<5 years); M= medium term (5-10 years); O-L=ongoing to long term; S-L=short to long term; M-L=medium to long term; S-O=short term, ongoing; S-M=short to medium term

Source: KVRI Burbot Recovery Strategy (KVRI 2005)

An excerpt from the Kootenai River Subbasin Plan (KTOI and MFWP 2004) further describes the relationship of this burbot aquaculture program with research, monitoring, and evaluation objectives in the subbasin:

> "The Kootenai River Native Fish Conservation Aquaculture Program is a critical component in a suite of projects and actions that collectively will help achieve the Kootenai River Subbasin vision of: the establishment and maintenance of a healthy ecosystem characterized by healthy, harvestable fish and wildlife populations, normative and/or natural physical and biological conditions, and sustainable human communities."

The Kootenai sturgeon and burbot aquaculture programs address the following Urgent and High Priority Aquatic Objectives identified in the Kootenai Subbasin Plan (KTOI and MFWP 2004):

- **Restore Burbot – Conservation Aquaculture:** SBP Objectives BUR 3a and 3b and BUR 4. Achieve consistent natural recruitment in at least three different spawning areas. Achieve stable size and age distributions as determined by an upward trend in a 6-year moving average of population abundance. Achieve a minimum number of 2,500 adults per burbot population (KVRI Burbot Conservation Strategy Measure 9.5).
    - ***BUR3a, 3b and BUR 4 strategies***: Develop and implement a conservation aquaculture program for Kootenai River/Kootenay Lake burbot using the developed Burbot Conservation Strategy and SBP as a guide.
- **Coordination, Outreach and Information Exchange:** SBP Objectives AP2, AP3, AP4, and AP5. Develop and maintain adequate regional and international coordination. Pursue and support independent peer review and scientific counsel. Support locally recognized stakeholder group to improve coordination and implementation. Provide for and support distribution of information.
    - ***AP2-AP5 strategies:*** Develop and maintain international, regional and local coordination to successfully implement project objectives. Support and enhance existing coordination forums to efficiently and successfully implement the subbasin plan. Support and enhance outreach and information exchange. Involve community stakeholder groups. Use SBP strategies as a guide.
- **Kootenai Subbasin Plan Priorities:** The Kootenai River Native Fish Conservation Aquaculture Program meets all Tier 1 criteria and the following Tier II criteria (1, 3, 5, 6, 7, 8, and 9) found in Section 10.5 of the Kootenai Subbasin Plan. The Subbasin Plan also states, "after applying and meeting Tier I criteria, ongoing projects that address urgent objectives will be afforded the highest priority for funding". The Tribe's proposed Kootenai sturgeon and burbot programs fall in the aforementioned category.

2.2) List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates.

Indicate whether this HGMP is consistent with these plans and commitments, and explain any discrepancies.

This Kootenai River Burbot HGMP is consistent with all existing cooperative agreements, including the Subbasin Plan (KTOI and MFWP 2004), the MOA of the Kootenai Valley Resource Initiative and Lower Kootenai River Burbot Conservation Strategy (KVRI 2005), and the international, cooperative Kootenai River Burbot 5-year R, M&E Plan (Table 8).

No court orders direct burbot production programs because the species is not listed as threatened or endangered under the ESA. However, in 2005, the KVRI published its Kootenai River Burbot Conservation Strategy which initiated a collaborative project to develop methods to culture this species, which began in 2003 (UI-ARI 2004, 2007).

2.3) Relationship to harvest objectives

Explain whether artificial production and harvest management have been integrated to provide as many benefits and as few biological risks.

2.3.1) Describe fisheries benefiting from the program, and indicate harvest levels and rates for program-origin fish for the last 12 years if available. *Also provide estimated future harvest rates on fish propagated by the program, and on listed fish that may be taken while harvesting program fish.*

In both Idaho and Montana, burbot is listed as a Species of Special Concern, and the population in the Canadian portion of the subbasin has been Red Listed. Because of the remnant status of this population, harvest is not possible in Idaho.

Without natural production, no future burbot harvest is envisioned for at least 10-20 years (1-2 generations). Offsetting such predictions would require restoration of habitat and ecological functions. Because this project is new, no fish have been released that are large enough to provide any fishery benefits to date (the first release of several year-classes of hatchery-produced juveniles occurred during fall 2009). No legal harvest has occurred on this native population in the lower Kootenai River since the harvest fishery was closed in 1984.

2.4) Relationship to habitat protection and purposes of artificial production

Describe the major factors affecting natural production (if known). Describe any habitat protection efforts, and expected natural production benefits over the short- and long-term.

Ecosystem-based habitat restoration actions are the focus of a number of Tribal projects, including the Kootenai River habitat restoration project (BPA 200200200) to be implemented in 2011, Operational Loss Assessment (BPA 200201100), and the Ecosystem Improvement Project (BPA 9404900). The goal of the burbot program is to reintroduce burbot to reestablish a self-sustaining population. If habitat restoration actions succeed in providing a self-sustaining population with adequate natural production to sustain future harvest, then there will be no further need for the conservation hatchery program. Alternatively, if a self-sustaining, naturally produced burbot population that can support future harvest goals is not attainable following habitat restoration actions, then this program will be required to maintain a harvestable burbot population in the Kootenai River.

Finally, the presence of a burbot population in the Kootenai River that can sustain some level of harvest is consistent with goals and objectives of the NPCC Fish and Wildlife Program, BPA funded mitigation activities and the U.S. federal trust responsibility with the Kootenai Tribe.

2.5) Ecological interactions

Describe all species that could (1) negatively impact program; (2) be negatively impacted by program; (3) positively impact program; and (4) be positively impacted by program.

The Kootenai River ecosystem includes a variety of species including bull trout, interior redband trout, westslope cutthroat, rainbow trout, native kokanee, and burbot. Sturgeon generally occupy a benthic habitat niche and do not interact with most of these species in any significant fashion. Where interactions with burbot may occur, they are subtle and beyond our ability to measure or distinguish from interactions with other features of the system. Some species such as spawned-out kokanee represented a historical food source but are no longer present in significant numbers. Interactions with other sensitive species are expected to be minimal.

Inadequate numbers of burbot currently exist in the Kootenai River (Pyper et al 2004; Paragamian et al. 2008) to constitute a risk to a receiving population. Benefits and risks associated with the program are presented in Table 3 and described in Sections 1.10.1 and 1.10.2.

SECTION 3. WATER SOURCE

3.1) Provide a quantitative and narrative description of the water source (spring, well, surface), water quality profile, and natural limitations to production attributable to the water source.

For integrated programs, identify any differences between hatchery water and source, and "natal" water used by the naturally spawning population. Also, describe any methods applied in the hatchery that affect water temperature regimes or quality.

Withdrawals from the Kootenai River will supply most aquaculture operations at Twin Rivers Hatchery, supplemented by surface withdrawals from the Moyie River at certain times of the year. Small volumes of groundwater will provide a pathogen-free supply to incubate eggs and run early-life rearing experiments to refine burbot culture.

Surface Water

River water needs for the Kootenai sturgeon and burbot programs will gradually increase during the first year of operation and range seasonally from approximately 600 to 1,220 gpm thereafter. Intake structures are proposed on both the Kootenai and Moyie rivers. Water will flow by gravity through intake screens into the pump stations adjacent to the river intakes. From the Kootenai intake, water will be pumped into a sediment pond to remove settleable solids prior to further treatment and use. The Moyie River water supply is expected have a much lower sediment load than the Kootenai, enabling it to be pumped directly to mechanical filtration in the water treatment building. The preliminary location for the Kootenai River intake is approximately 150 feet upstream of the existing unimproved boat ramp. On the Moyie River, an intake will be installed at the far north end of the project site in slow deep water at the base of a rock outcrop.

Groundwater

Relatively small amounts of groundwater will be used in the hatchery to provide a pathogen-free supply for incubation, make-up water for the live feed program, and perhaps for temperature control of river water at certain times of the year. Groundwater demand will range seasonally from 15 to 150 gpm. Two new 150 gpm on-site wells will provide redundant sources of groundwater. An existing well will continue to be used to supply potable water.

Water Temperature Control

Tempered river water and groundwater flow requirements will range seasonally from 100 to 300 gpm, and 10 to 100 gpm respectively. Redundant boiler and chiller systems with automatic set-point controllers will be used to reliably provide appropriate water temperature at each facility. Primary heat exchangers will likely be used to recover energy from heated and chilled hatchery effluent in order to reduce equipment sizes and conserve energy.

Water Treatment

Water pumped from the Kootenai River will first be routed through sediment ponds to remove settleable solids. This step may be supplemented by ozone treatment for micro-flocculation. After initial settling, particulates in the river water will be removed through a drum screen followed by booster pumps and high-rate sand filtration. The filtered water will be disinfected with ultra-violet sterilization to destroy any remaining pathogens.

Disinfected water will be routed either directly to the hatchery headbox for use as ambient water or to heat exchangers to adjust the water temperature. All water supplies will be gas-stabilized at the head box prior to use in the hatchery. Groundwater testing is underway to determine if any treatment in addition to standard gas stabilization will be needed.

Water treatment systems will be located in a central room or building in order to simplify operations and maintenance. The sediment pond will be covered to prevent icing. Back-up generators with automated phone alarms will provide emergency power to critical treatment equipment.

A shared water supply system for the Kootenai sturgeon and burbot programs is proposed because it will reduce costs for land acquisition, design, permitting, construction, and long-term operations.

3.2) Indicate any appropriate risk aversion measures that will be applied to minimize the likelihood for the take of listed species as a result of hatchery water withdrawal, screening, or effluent discharge.

The hatchery water supply flow rates are low compared to the base flows in both the Kootenai and Moyie rivers. Hatchery intake screens will be sized to provide screen face velocities of less than 0.2 feet per second, with openings of less than 1.75 millimeters. The screens will be automatically, actively cleaned to avoid creating high velocity zones due to partial screen fouling and will conform with NMFS and USFWS screening guidelines to minimize the risk of impingement of listed species. The screens will be located in areas with good sweeping velocities to further reduce these risks.

Hatchery effluent will be treated in accordance to State of Idaho and Federal NPDES permit conditions. An off-line settling basin will be used to remove pollutants from the hatchery effluent prior to discharge. Water quality testing will be performed on a regular basis to monitor hatchery effluent properties and inform the operators if problems arise.

SECTION 4. FACILITIES

Only 5,725 square feet of the Twin Rivers Hatchery will be dedicated to the burbot program (Table 9). In addition, six exterior burbot ponds are proposed that will occupy 20,000 square feet.

Table 9. Proposed footprint of burbot rearing facilities.

Proposed Burbot Buildings	
Burbot Broodstock/Spawning	1,125 SF
Burbot Incubation	1,280 SF
Burbot Rearing (Indoors)	1,800 SF
Burbot Mechanical/Electrical	200 SF
Cyro/Freezer/Feed Prep/Lab	720 SF
Burbot Live Feed/Feed Preparation	600 SF
Burbot Subtotal	**5,725 SF**
Outdoor Facilities	
Burbot Ponds (6)	20,000 SF

4.1) Broodstock collection, holding, and spawning facilities

Broodstock collection facilities

Unlike broodstock collection facilities associated with salmon hatcheries, no broodstock collection facilities are involved with burbot culture. Gametes (and broodstock) are collected in the field and held in facilities described in the next section.

Broodstock holding facilities

Broodstock (25 male, 25 female; 2.5kg average body weight) will be held in up to four 6-foot-diameter, 3-foot-deep covered round tanks supplied with ambient river water. Experimental holding densities of one 2.5kg adult/100L of water appear adequate. Insulating the tanks may be necessary to meet the unique thermal needs during winter and the late-winter spawning season (2-4˚C). Holding tanks may also be used for spawning tanks, in which fine mesh screening (500 micron) is added over the tank outflow to prevent egg losses during volitional spawning.

Spawning facilities

Broodstock holding tanks described above may also be used for spawning. Additional spawning tanks will be needed if paired mating matrices are incorporated into the breeding program. In this scenario, broodstock would be divided over as many as 10 to 20 spawning tanks (4- to 6-foot diameter and 2- to 3-foot deep) with sex ratios of 1 female:2 males or 2 females:2 males. All spawning tanks will require 500 micron mesh screened outflows to prevent egg losses due to volitional spawning. In addition, external standpipes equipped with egg collection baskets may be warranted to collect volitionally spawned eggs.

4.2) Fish transportation equipment

Gamete and broodstock collections will be coordinated through multiple agencies using transportation equipment and holding facilities already in place. A boat is required when cod traps are used and may be needed for releases. When burbot are trapped, captures are brought aboard, temporarily held in 100 L plastic containers with water, given a unique tag, and then placed in a haul tank for transport. Although past broodstock collections have not included gender determination, future collections may incorporate such procedures if one gender is desired. Portable ultrasound, catheter or gentle stripping methods would be used depending on time of year (e.g., November through January, testes are distinguishable from ovaries).

Manual field gamete collection requires smaller hauling containers, typically an insulated 150 L cooler with a layer of ice under a layer of paper. Fertilized eggs are held in 50 L plastic bags filled with tempered water and oxygen atmosphere and must be transported to the hatchery incubation facility within 24 hours.

Haul tanks vary in size and function depending on the number of fish and relative biomass or quantity of gametes. Oxygen is diffused into the holding tank water to maintain a minimum 5 ppm dissolved oxygen concentration. Water is tempered based on the time of year, location, burbot life stage and the length of transport. Under normal circumstances (above freezing), water from the hatchery will be added to the haul tank prior to adding fish, or alternatively, water from the river may be used.

For release of juvenile burbot from Twin Rivers, standard fish transportation trucks with insulated, oxygenated 150 to 250 gallon tanks will be used. Fish are netted from the rearing tanks into the trucks and then netted out of the transportation tanks at the release site. At the release site, water temperature in the transportation tank is manipulated by adding water from the release site. After temperature acclimation, burbot are netted from the tank truck and released into the river. Some release sites require access by boat, in which case, burbot are loaded by net into a live well on the boat, thermally acclimated within the live well, netted out of the well at the release site, and released directly into the river.

4.3) Incubation facilities

Burbot incubation will occupy 1,280 square feet in a separate room in the burbot building. Burbot eggs will be incubated in Imhoff cones mounted over three-foot-diameter fiberglass round tanks or troughs that will collect the young as they hatch. Recent studies show that conical upwelling incubators produce higher hatch rates than McDonald type jars (Jensen et al. 2008a) so these will be incorporated into the Twin Rivers facility. Each 1.2 liter Imhoff incubation cones, has the potential to hold over 250,000 eggs at flows of 300 ml/ minute. Burbot eggs will be treated with a fungicide (formalin or hydrogen peroxide). Eggs will be maintained in water near 3˚C. Hatching typically begins 30 to 40 days after incubator stocking and burbot larvae have been observed to continue to hatch slowly from the egg mass for up to 40 additional days. Larvae hatch from incubators and flow directly into rearing tanks, which eliminates handling at this early developmental stage. The grated floor decking in the incubation area will cover below-grade trenches designed to accommodate different types of tanks, depending on fish culture needs.

4.4) Rearing facilities

Burbot rearing will occur year-round. Burbot spawning, which typically occurs from February-March, but can range from December-April, occurs in circular tanks equipped with fine mesh screened outflows at water temperatures 2-4˚C. Yolk sac fry will be reared from February to June at water temperatures of 6 to 10°C. All rearing beyond the yolk-sac larvae stage will occur in circular tanks (250 -1000 L volume), raceway troughs or square tanks with external standpipes, insulated when appropriate.

Rearing densities of <1,000 fry per liter are targeted for <0.1 gram fish, with low flows and fine mesh screened (400 micron) outflows required for fry containment. Subsequent rearing of exogenously feeding fry will occur April through September at water temperature ranging from 10 to 15°C at densities of 100 to 250 fish per liter (averaging 0.1 to 1.5 grams).

Fingerlings will be reared from January through December at 10 to 20°C at a target density of 100 fish per liter (averaging from 1.5 to 25 grams). Ongoing growth and survival experiments at the UI-ARI with age 0 burbot indicate that growth is maximized as temperatures approach 20°C, but survival increases when temperatures are closer to 10°C (pers. comm., J. Barron, UI-ARI). Thus, age 0, 1, and 2 juvenile rearing will occur

January through December and temperature will be controlled depending on production goals or release timing (10 to 20°C). Target rearing densities of 1 to 10 fish per liter, at 25 to 150 grams are recommended.

Live feed rearing will be required for burbot fry and broodstock. Rotifers (*B. plicitilis*) and *Artemia* (Great Salt Lake, UT strain) will be reared on a continuous or seasonal basis to feed burbot fry. Rotifers will be maintained year-round with a master culture in several 50-100 L containers and mass produced in during fry feeding phase (April through September) in a closed recycling system (350 L total volume). *Artemia* will be batch cultured in 19 or 80 L tanks depending on production season demands. Burbot broodstock will be fed live rainbow trout (*O. mykiss*; 10-50 g average body weight). Rainbow trout growout will occur in raceway style troughs (8- to 12-foot-long) and 4- or 5-foot circular tanks. Eyed rainbow trout eggs (3,000-5,000) will be purchased three times per year (March, July, October) and reared on commercial grade feed at same temperature as adult burbot at a target size of ≤50g/fish.

4.5) Acclimation/release facilities

No acclimation or release facilities are currently planned. Prior to fish release, water temperature acclimation within transport containers will occur and gametes will be tempered within transport bags prior to stocking into incubation facilities.

4.6) Describe operational difficulties or disasters that led to significant fish mortality

4.6.1) Indicate available back-up systems, and risk aversion measures that minimize the likelihood for the take of listed species that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

No available systems exist because the Twin Rivers hatchery has not yet been constructed.

4.6.2) Indicate needed back-up systems, and risk aversion measures that minimize the likelihood for the take of listed species that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

The hatchery will be staffed full-time and equipped with various temperature, water level and flow alarms to help prevent catastrophic fish loss resulting from water system failure. Redundant pumping, filtration, temperature control, disinfection, and back-up power systems will be incorporated to minimize the risk of mechanical failure. Comprehensive operations and maintenance manuals will be prepared in conjunction with training for hatchery staff to ensure that proper procedures are followed during all phases of aquaculture operations.

Hatchery facilities will be constructed well above flood elevations, with robust drain systems to prevent flooding damage.

Pathogen free groundwater will be used for incubation and early life stage fish development. River water supplies will be filtered and UV sterilized to inhibit pathogen growth. Aquaculture fish and egg handling protocols will be followed to limit the risk of disease outbreaks. The Kootenai Tribal hatchery staff have demonstrated successful operating experience at the Bonners Ferry Sturgeon Hatchery.

SECTION 5. BROODSTOCK ORIGIN AND IDENTITY

5.1) Source

The program uses Moyie Lake burbot as the source of gametes or broodstock. Adult burbot and/or gametes from the remnant Kootenai River may be incorporated if available.

5.2) Supporting information

5.2.1) History

Provide a brief narrative history of the broodstock sources. For listed natural populations, specify its status relative to critical and viable population thresholds (use section 10.2.2 if appropriate).

Moyie Lake stock is a natural population maintained by natural production without hatchery influence.

5.2.2) Annual size

Provide estimates of the proportion of the natural population that will be collected for broodstock. Specify number of each sex, or total number and sex ratio, if known. For broodstocks originating from natural populations, explain how their use will affect their population status relative to critical and viable thresholds.

A target captive broodstock of 25 adult male and 25 adult female burbot, with an average 2.5kg body weight burbot is recommended for the new facility. Facility design for the captive broodstock facilities is based on this number of fish.

5.2.3) Past and proposed level of natural fish in broodstock

If using an existing hatchery stock, include specific information on how many natural fish were incorporated into the broodstock annually.

This question is not applicable to this burbot program or any of its possible broodstock/gamete sources.

5.2.4) Genetic or ecological differences

Describe any known genotypic, phenotypic, or behavioral differences between current or proposed hatchery stocks and natural stocks in the target area.

This is not an issue for this program because too few local natural burbot remain to be negatively affected by program operations.

5.2.5) Reasons for choosing broodstock traits

The Moyie Lake burbot population was selected based on geographic location, connectivity to the Kootenai River in Idaho, management priorities and logistics. Empirical genetic evidence also suggests that the Moyie population is a closely related stock to the remnant lower Kootenai River population and is demographically capable of sustaining a gamete collections and intermittent take of limited numbers of adults.

No specific traits or characteristics were chosen other than naturally adaptive, within-basin native genotypes, phenotypes, behaviors and life history trait expressions.

5.2.6) ESA-Listing status

The burbot proposed for use in this program have no ESA-listed status.

5.3) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects that may occur as a result of using the broodstock source.

Similar questions throughout this HGMP inquire about proposed risk aversion measures taken to minimize risk from the program. These questions are found in sections: 3.2, 4.6.1, 5.3, 6.9, 7.4, and 8.28. To simplify and avoid redundant responses to these questions, we addressed these issues, including the following risk aversion facility design features and program operations.

This program will implement risk aversion measures to reduce the risk of low within-population diversity. This will be achieved by following strict breeding matrices that: 1) diversify gamete and broodstock collections within years and over a period of many years; 2) select and cross gametes and broodstock across the widest range of time and space possible; and 3) incorporate cryopreserved gametes to maximize cross diversification. Because burbot are currently functionally extinct in the Kootenai River, there is no genetic risk or adverse ecological effects to the functionally extinct existing population.

For logistical and broodstock accountability purposes, if annual spawner groups are captured and possibly transitioned into captivity (if a captive broodstock population is established and maintained), each will be given a PIT-tag for unique identification and gender will be determined using ultrasound. Individual identity will allow reuse of individual broodstock or their gametes in ways to avoid unintentional inbreeding of iteroparous fish.

The risk of disease amplification and introduction to natural waters will be controlled by incorporating standard operating procedures, best management practices, and fish health policies. Disease testing will follow required procedures for inspection under the USFWS Title 50 act. Samples will be submitted to the Idaho Fish Health Center (USFWS) for testing and inspection prior to annual releases (see Section 6.7).

Risk aversion is further practiced by:

- Maintaining optimal life-stage specific densities in the hatchery (Section

8.2.2., Table 12);

- Maintaining optimal life-stage specific water quality (Section 8.2.3, Table 13);
- Maintaining optimal fish health (Section 8.2.6)
- Feeding adults certified disease free food (rainbow trout) (Section 8.2.5, Table 14)
- Single pass water use, and providing (Section 3)
- Incoming water filtration and sterilization (Section 3).

SECTION 6. BROODSTOCK COLLECTION

6.1) Life-history stage to be collected (eggs, juveniles, adults)

Gamete and broodstock collection from Moyie Lake will occur annually, unless facility capacity is met and/or the future captive broodstock population meets or exceeds the proposed production and genetic diversity targets. Gametes (up to 10 million eggs) will be collected annually by capturing gravid females and flowing males during their natural spawning time (February to April). These gametes may be raised up to adulthood and used for the captive rearing program or be used for experimental releases. If broodstock collection occurs during a given year, these fish typically average 0.5 to 5.0 kg and will be collected prior to spawning (October to January).

6.2) Collection or sampling design

Include information on the location, time, and method of capture. Describe measures to reduce sources of bias that could lead to a non-representative sample of the desired broodstock source.

Sampling location

Gametes and broodstock will be collected from Moyie Lake, B.C. Recent annual reports detailing characteristics of the Moyie Lake burbot population and sampling efforts are available at the following links:

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=17097

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=16158

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=13484

Sampling and collection timing

Burbot gamete collection from Moyie Lake occurs during February and March. Adult broodstock collection, if it occurs, takes place during October and November.

Method of capture

Angling will be the sole means of burbot capture for gametes or broodstock. This technique minimizes known injury and mortality associated with burbot trapping and retrieval from depths (Neufeld and Spence 2008). Fish are captured, brought to the surface and then placed into holding tanks (large Tupperware™ containers) oxygenated with bottled oxygen and a diffusing stone. Because cold ambient air temperatures can cool the holding tanks, water in the tanks is insulated from the surface of the ice to prevent rapid cooling and is changed every hour to reduce temperature stress on burbot. Because air temperatures can be well below 0° C (morning temperatures are often −20°C) sampling may be postponed until late morning when temperatures increase. Under these conditions, fish sampling may occur in an ice tent that is warm enough to avoid fish damage associated with freezing tissue.

Most captured burbot captured will be measured (TL) and weighted, assessed for sex and maturity, tagged with a Floy tag and then released. A subset of suitable mature male and female burbot will provide gametes for hatchery rearing trials and other fish culture activities in Idaho. These fish were first anesthetized in a water bath containing 200 ppm clove oil. Once anesthetized, burbot are spawned and gametes placed into a bowl, mixed together, water activated, and then rinsed with fresh water. After spawning, burbot are allowed to recover in a fresh water bath and then released. To maximize post-fertilization survival, fertilized eggs are held in a plastic container in fresh water for a period of at least one hour to allow eggs to water harden before transport. Uninterrupted minimum travel time under best highway conditions from Moyie Lake to Twin Rivers is only about two hours.

6.3) Identity

Describe method for identifying (a) target population if more than one population may be present; and (b) hatchery origin fish from naturally spawned fish.

Only fish from Moyie Lake will be used, so there will be no additional need to identify populations.

6.4) Proposed number to be collected

6.4.1) Program goal (assuming 1:1 sex ratio for adults):

Less than 20 broodfish per year (sexes combined) if needed, would be collected to reach the captive broodstock target of 50 fish, twenty-five male and 25 female burbot.

Table 10. Broodstock collection levels for most recent years available.

Year	Adults			Eggs	Juveniles
	Females	Males	Undetermined		
2001	14	6	3	0	0
2002	10	10	0	0	0
2003	13	7	0	0	0
2004	21	5	0	1,337,000	0
2005	16	7	7	0	0
2006	12	9	8	0	0
2007	7	10	0	0	0
2008	0	0	0	0	0
2009	0	0	0	7,000,000	0

6.5) Disposition of hatchery-origin fish collected in surplus of broodstock needs

This burbot conservation aquaculture project will not involve hatchery-origin fish (adults); therefore this question is not applicable to the burbot program.

6.6) Fish transportation and holding methods

Burbot transportation and holding methods as part of this program are described in Section 4.2.

6.7) Describe fish health maintenance and sanitation procedures applied

Strict implementation of standard culture practices used for the white sturgeon fish health program at the Kootenai Sturgeon Hatchery is recommended for burbot. Standard operating procedures and best management practices will be employed to control potential in-hatchery disease outbreak and disease transmission risks (see Section 8.2.6). Furthermore, significant progress has occurred in the new field of burbot pathology (Polinski et al., 2010, 2009a, 2009b) and aquaculture techniques (Jensen et al. 2008a, 2008b, 2008c, 2010) that directly benefit this program.

Implementation of routine disease management strategies will reduce the risk of infection by pathogens and strict disease testing will be implemented in accord with Title 50 pathogen screening at the Idaho Fish Health Center (USFWS) prior to release of juvenile fish to ensure disease free status. In addition to establishing baseline information for the most concerning fish diseases, a new cell line was established from burbot embryo cells and provided to disease diagnostic laboratories (Polinski et al. 2009). This will provide a screening tool that will be valuable in detecting potential viral pathogens of burbot.

6.8) Disposition of carcasses

Because burbot are iteroparous fish (they do not die after they spawn like semelparous anadromous salmonids), there is no need to dispose of any carcasses as part of the program. Mortalities will be incinerated or disposed of in a landfill.

6.9) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed species resulting from the broodstock collection program.

This program will implement risk aversion measures to reduce the risk of low within-population diversity. This will be achieved by following strict breeding matrices that: 1) diversify gamete and broodstock collections within years and over a period of many years; 2) select and cross gametes and broodstock across the widest range of time and space possible; and 3) incorporate cryopreserved gametes to maximize cross diversification. Because burbot are currently functionally extinct in the Kootenai River, there is no potential for genetic risk or adverse ecological effects an existing population.

For logistical and broodstock accountability purposes, if annual spawner groups are captured and possibly transitioned into captivity (if a captive broodstock population is established and maintained), each will be given a PIT-tag for unique identification and gender determined using ultrasound. Individual identity will allow reuse of individual broodstock or their gametes to avoid unintentional inbreeding of iteroparous fish.

The risk of disease amplification and introduction to natural waters will be controlled by incorporating standard operating procedures, best management practices, and fish health policies. Disease testing will follow required procedures for inspection under the USFWS Title 50 Act. Samples will be submitted to the Idaho Fish Health Center (USFWS) for testing and inspection prior to annual releases.

SECTION 7. MATING

In this section, we describe mating protocols and associated performance indicators that are based on burbot research results, not just on numbers of fish produced.

7.1) Spawner selection method

To meet performance indicators, strict breeding matrices will be employed to maximize genetic variability and simulate gene flow patterns exhibited by naturally spawning burbot populations. Additional efforts to maximize genetic diversity and associated life history traits and behaviors will include gamete collection from the largest temporal and spatial range of spawning feasible. Gamete or broodstock sampling is initiated prior to expected collection of flowing males or ripe females to ensure that gametes from the earliest spawners are available to the program.

For the proposed Twin-Rivers facility, adult broodstock or field-collected and field-spawned eggs will be used. If fertilized eggs were to be chosen for developing a captive brood population, production will be delayed 3 to 5 years awaiting maturation. If wild adult spawners are collected, choice will depend on angling effort(s), trapping effort, the number of days or years of collection and in-hatchery acclimation and survival. In addition, spawning matrices will dictate when additional brood stocks are needed. Spawner stock location is restricted to the Kootenai(y) subbasin with initial efforts focusing on Moyie Lake, B.C.

7.2) Fertilization

Describe spawning protocols applied, including the fertilization scheme used (such as equal sex ratios and 1:1 individual matings; equal sex ratios and pooled gametes; or factorial matings). Explain any fish health and sanitation procedures used for disease prevention.

Spawning protocols will include manual gamete collections and natural in-tank spawning of pairs or groups. Manual gamete collections with subsequent controlled crosses based on pre-determined spawning matrices, including equal sex ratio 1:1 mating, unequal sex ratio mating (1 female: multiple males), field collected gametes, and cryopreserved semen will also be incorporated into the breeding program.

Burbot fertilization methods have been successfully developed using raw and cryopreserved semen (Jensen et al 2008a). Annual average burbot embryo survival rates 48 hours after fertilization ranged from 51 to 73% (from 2006 through 2009), with an overall average of 67% across years.

Fish health and facility sanitation procedures will follow manufacturers recommended concentrations and exposure times. Disinfection of fertilized eggs during water hardening will be accomplished using 25 to 50 parts per million buffered PVP iodine treatments to suppress and control pathogen transmission.

7.3) Cryopreserved gametes

If used, describe number of donors, year of collection, number of times donors were used in the past, and expected and observed viability.

Gametes from all Moyie Lake males (21) captured for experimental burbot aquaculture research during 2006 and 2007 are represented in the Kootenai Tribal cryostorage tank at the University of Idaho Biological Sciences Department. Any or all of the Moyie semen donors may be used in future spawning matrices based on methods developed at UI-ARI which verified the use of cryopreserved burbot semen as a viable tool (Jensen et al. 2008). Fertilization success rates up to 75% have been achieved on small batches of eggs (averaging 1,300 eggs: five-0.25ml straws containing semen and freezing extender).

7.4) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme.

Too few burbot remain in the river to be affected by future burbot hatchery operations. See Sections 5.3 and 6.9 for further details.

SECTION 8. INCUBATION AND REARING

8.1) Incubation

8.1.1) Number of eggs taken/received and survival rate at stages of egg development

Burbot eggs from various broodstock populations (Duncan Reservoir, Arrow Lakes, Moyie Lake, all in B.C.) were collected for experimental development of burbot aquaculture at the UI-ARI from 2004 through 2009. A total of 38.7 million burbot eggs were collected during these years; 4.3 million were collected in the field, 35.7 million were collected from captive broodfish during these years (Table 11).

Fertilization success for individual burbot crosses using live (non-cryopreserved) gametes has been as high as 100%, compared to up to 75% for crosses involving thawed cryopreserved milt. Annual average burbot embryo survival 48 hours after fertilization ranged from 51 to 73% (from 2006 through 2009), with an overall average of 67% across years (Table 11).

Future egg take will be determined by back calculating production needs, incorporating empirical survival rates to reach future age class structures and adult population abundance targets.

Table 11. Burbot egg collections and egg and embryo survival data for experimental scale operations 2001-2009.

Year	Eggs collected		Total	Survival % 48 hours post activation/ fertilization
	In captivity	From wild		
2001	ND	ND	-	-
2002	ND	ND	-	-
2003	ND	ND	-	-
2004	ND	1,337,000	ND	ND
2005	1,650,000	0	1,650,000	ND
2006	8,019,501	0	8,019,501	73
2007	5,867,461	0	5,867,461	61
2008	7,639,775	0	7,639,775	84
2009	12,557,998	2,990,615	15,548,613	51
Total	35,734,735	4,327,615	38,725,350	Mean: 67%

* ND=not determined or data not dependable

Note: data reported in this table were subject to experimental demands and limited incubation capacity.

8.1.2) Loading densities applied during incubation

Based on six years of burbot spawning and experimental aquaculture at the UI-ARI (2004 through 2009), incubator flow rates depend on embryo loading or densities (i.e., higher egg volumes require higher flow rates). Typical flows used in the existing experimental facility with experimental 1.2 L custom Imhoff cone incubators are < 2 L/min. Based on experimental observations to optimize hatching success during the past six years, it is recommended to limit egg loading to 300,000 per incubator when using 1.2 L Imhoff cone incubators (Jensen et al. 2008).

8.1.3) Incubation conditions

Describe monitoring methods, temperature regimes, minimum dissolved oxygen criteria (influent/effluent), and silt management procedures (if applicable), and any other parameters monitored.

Incubation system function monitoring will occur multiple times daily until hatching is completed. Water quality will be monitored weekly unless there is a reason to sample more frequently. Monitored water quality parameters include: alkalinity, total dissolved solids, total suspended solids, N, ammonia, NO3 + NO2, and ortho-phosphorous. Water temperature, Dissolved oxygen and saturation, and bacteria will also be monitored on a routine basis. Inorganic parameters that will be monitored include: calcium, copper, magnesium, manganese, and zinc. Quality control analysis will be included in the water quality reports.

The incubation system(s) will be set up in a flow through style. Water temperature will be maintained near 3° C and will not exceed 7° C. Effects of dissolved oxygen on burbot embryo incubation have not been documented; however, 100% saturation is recommended with a minimum of 5 or 6 parts per million dissolved oxygen considered acceptable. Cold water temperatures during much of the year, especially during spawning and early life stages greatly reduce concerns of dissolved oxygen limitation for most burbot life stages in the hatchery.

Solids in the water source will be removed because the low flows required during incubation typically involve needle valves which can become clogged easily. Other parameters that will be monitored include fungus manifestation and fungicide treatment systems.

All incubators will also be observed multiple times daily for channelization of the flow within egg masses. When channels are observed within egg masses, each will be stirred gently to promote a more uniform flow through the egg mass, facilitating oxygen dispersal to more embryos and more complete removal of incubation embryo metabolites.

8.1.4) Ponding

Ponding methods for burbot are currently being developed and optimized at the UI-ARI in a set of six semi-intensive (aerated and seeded with zooplankton) outdoor tanks and in two earthen ponds near Bonners Ferry, Idaho. Based on preliminary findings, it is recommended that larvae be fed 45 days on live feeds prior to being stocked into ponds with measurable zooplankton levels, at stocking densities not exceeding 500,000 larvae per hectare of pond surface area (Jensen et al. 2008a). Based on results of additional semi-intensive experiments rearing experiments during 2009 and 2010, optimal fish stocking timing, zooplankton and fish stocking densities, and general ponding methods will be established, refined and published.

8.1.5) Fish health maintenance and monitoring

During water hardening (30 minutes post fertilization, 30 minutes treatment time), PVP iodine is used at concentrations of 25 to 50 parts per million. During incubation (48 hours post fertilization), aquatic mold and fungus control methods include the use of formalin and/or hydrogen peroxide, at concentrations of 1,500 parts per million and 500 parts per million respectively, as approved for use by the AADAP. Incubation system fungicide treatments will occur on a daily basis through the onset of observed hatching. A recent study recommended a minimum of 1,667 mg/L formalin or 500 mg/L hydrogen peroxide to maximum egg survival and fungus control during egg incubation for burbot (Polinski et al., in press), and these recommendations will be followed in the future. Dead embryos will be removed daily or more frequently if needed using small strainers or siphons.

8.1.6) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to fish during incubation

Eggs will be activated and incubated using "first-use" or flow-through pathogen free filtered (UV and sediment) water (well water, treated river water, or some thermally optimal mixture). Water chillers and heaters will be sized appropriately sized to meet the thermal requirements as noted above in Section 8.1.3.

To prevent adverse genetic effects, parental crosses will be controlled, recorded, and each group of eggs or family will be held apart to prevent inbreeding depression of captive stocks where necessary. Breeding matrices will be applied when possible. However, eggs may also be collected after adults spawn naturally within rearing tanks on their own volition. Volitional spawning will be incorporated into the breeding program to allow natural spawning and subsequent egg collection and as this behavior is more closely studies may be used as a tool decrease handling stress of adults. In this scenario, rotating or interchanging adult breeding groups on an annual basis will increase genetic diversity and reduce the probability of inbreeding.

Ecological effects will be controlled by maintaining a flow-through style incubation system. In addition, egg incubation will occur in a room detached or separated from wild captive adults.

8.2) <u>Rearing</u>

8.2.1) Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to release) for the most recent twelve years or for years dependable data are available.

There is no survival data available from the proposed Twin Rivers Hatchery because it has not been built yet.

Due to the experimental nature of the existing feasibility-scale operation at UI-ARI, there is limited data about survival rates because routine culling takes place during each life stage. However, 2008 experimental production was characterized as an example of what the experimental facility annual production curve looks like (Figure 3).

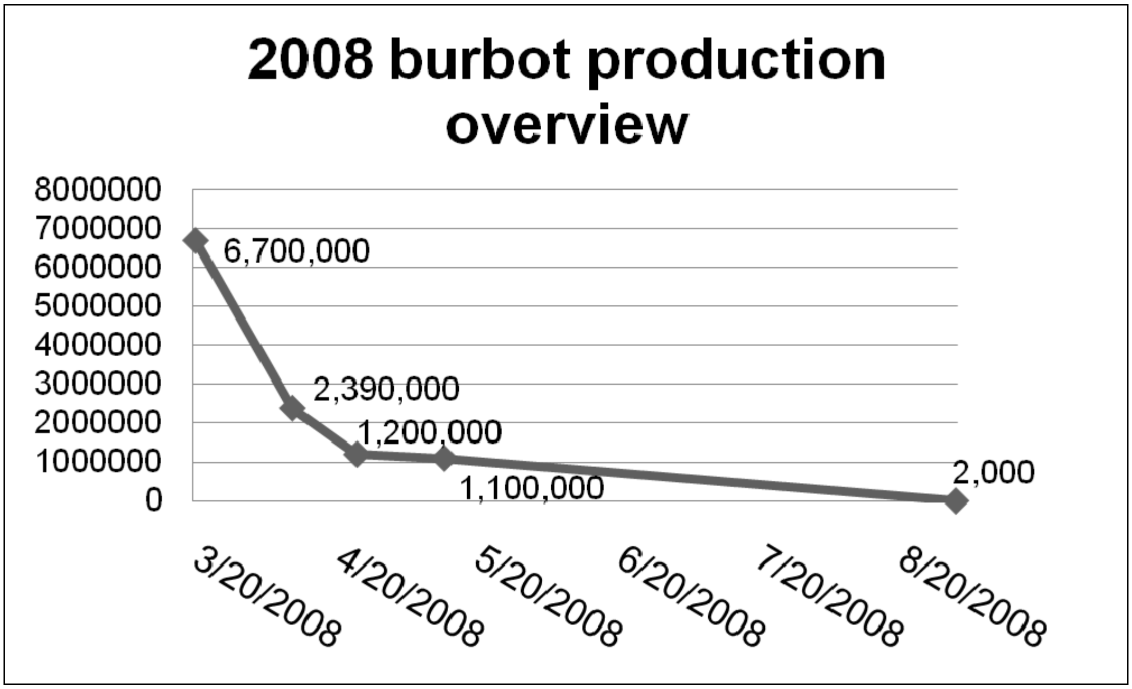


Figure 3. Experimental program burbot production in 2008 at UI-ARI.

Prior to 2004, burbot experimental culture efforts focused on spawning and early life rearing and no fry survived to the juvenile life stage due to UI-ARI facility (space and water) limitations (UI-ARI 2004, 2007). The level of production depicted in Figure 3 represents a conservative, constrained estimate of burbot production potential in a facility not designed for or capable of optimizing or maximizing production.

Production values for dry feed-transitioned juveniles from 2004 through 2008 are reported in Section 1.12. However, these values do not portray true survival rate or program performance potential because fundamental aquaculture method developments included terminal study designs where surviving progeny were euthanized or subjected to protocols that cause intentional disease and death (i.e., disease challenges). Rather, the experimental program performance to date as part of the experimental culture program at the UI-ARI was measured by the success and the value of research produced and its contribution to developing burbot aquaculture.

8.2.2) Density and loading criteria (goals and actual levels)

Include density targets (lbs fish/gpm, lbs fish/ft3 rearing volume, etc.).

Optimal density and loading criteria continue to be developed as part of the ongoing experimental breeding program. While optimal densities for each life stage (eggs, free embryos, first feeding larvae, larvae post metamorphosis, pond ready age 0 semi-intensive and extensive, dry feed transitioned young-of-year, age 1+, and adult rearing and spawning) are unknown, recommendations are made based on knowledge gained during experimental aquaculture trials at the UI-ARI. These recommended density estimates are provided in Table 12 and are briefly described below.

Table 12. Recommended burbot rearing density by life stage.

Life stage	Recommended incubation or rearing density
Incubating embryos	≤ 300,000/ 1.2L Imhoff Cone
Free embryos (yolk sac fry)	≤ 1,000/L
First feeding larvae	≤ 1,000/L
Pond-ready Age-0	≤ 500,000/ hectare of pond surface area
Post-metamorphosed larvae	≤ 250/L
Post dry feed transitioned larvae	≤ 100/L
Age 1+	1-10/L
Adults	≤ 1/L

Due to the minuscule size of the early life stages (free embryos are approximately 3 mm total length and 3 milligrams) and the need to monitor predator:prey ratios for maintaining zooplankton densities (10 per ml minimum), density targets involve per-fish volumetric standards rather than biomass per unit of rearing volume.

For eggs and fertilization, it is recommended that 1 to 2 ml of raw semen be used per 300,000 ova, and incubator loading densities should not exceed 300,000 per 1.2 L Imhoff cone incubator (Jensen et al. 2008). If cryopreserved semen is used, this 1 to 2 ml quantity should be increased to counter the dilution of semen in the freezing extender solution (see Section 7.2) (Jensen et al. 2008).

Free-embryos have been successfully maintained at densities as high as 2,000 per liter. However, this density represented an extreme case due to limited rearing space and the need to keep family groups separated, and likely caused mortality. Therefore, it is recommended that free-embryo densities do not exceed 1,000/L.

First feeding larvae require live feeds (brackish rotifers are currently used), and density likely plays a major role in feeding efficiency and survival. Furthermore, high densities (≥ 1,000/L) likely contribute to cannibalistic behavior, especially if live feeds are scarce. Therefore, a density of < 1,000 first feeding larvae/L is recommended.

Optimal stocking densities for pond-ready age-0 burbot are currently being investigated and experimental trials are expected to conclude in 2010 at the UI-ARI. Currently, it is recommended that stocking density does not exceed 500,000 per hectare of surface area, and only exogenously feeding larvae (45 days on live feeds) should be stocked to optimize survival (see ponding descriptions in Section 8.1.4 for more information).

Post-metamorphosed larvae (still on live feeds, although transitioned to *Artemia*) and dry feed transitioned young-of-year are highly cannibalistic and must be graded down to densities less than 250 per L and 100/L respectively. In addition, daily observations should be made seeking cannibals. If any are found, they should be immediately removed. Cannibals should be held at densities of less than 1/L with in-tank cover and concealment opportunities provided.

Age 1+ rearing densities of 1-10 burbot/L have been used with good results. Adult rearing and spawning densities of 1 adult (average body weight 2 kg) per 10 L have been used with good success.

8.2.3) Fish rearing conditions

Weekly water quality monitoring is described in Section 8.1.3. Inorganic parameters that will be monitored are identified in Table 13.

Water temperatures for rearing will range from 1 to 20˚C. Water quality monitoring will occur in the same fashion as ongoing monitoring protocol at the Tribal Sturgeon Hatchery where monthly water samples are collected at water source inlets (before filtration) and at the head tank (after filtration). Standard pond management procedures are currently being developed.

Table 13. Recommended "no effect" physical and chemical parameter values supporting cold water conservation aquaculture practices.

Water Quality Parameter	Parameter Value Ranges
Alkalinity	50-200 mg/l as $CaCO_3$
Ammonia (as NH_3)	<0.03 mg/l constant <0.05 mg/l intermittent
Calcium	> 50 mg/l
Carbon Dioxide (CO_2)	< 2.0 mg/l
Copper	< 0.006 mg/l in soft water <0.3 mg/l in hard water
Dissolved oxygen	6-8 mg/l
Dissolved solids	50-200 mg/l
Heavy metals (e.g. Hg, Zn, Cu, Cd)	< 0.1 mg/l
Iron	< 1.0 mg/l
Nitrite-N	< 0.55 mg/l
Nitrogen	< 100 % saturation
pH	6.7-8.5
Suspended solids	< 80 mg/l
Water temperatures	Species dependent
Zinc	< 0.04 mg/l @ pH 7.5

Source: Klontz 1991.

8.2.4) Indicate biweekly or monthly fish growth information (*average program performance*), including length, weight, and condition factor data collected during rearing, if available.

The following fish growth data collection and rationale apply to burbot culture at the Twin Rivers facility. Growth information will not be collected on a bi-weekly or monthly basis due to unacceptably high levels of stress associated with handling early life stages of burbot in culture settings. Instead, family or progeny groups of fish will be enumerated periodically during the rearing season to monitor the existing hatchery population(s) and to meet R, M &E needs, such as growth estimation at critical biological development stages, without negatively affecting fish condition, performance, or survival. This approach maximizes information gained wile minimizing fish loss due to handling stress.

Egg and larval abundance is estimated volumetrically. Eggs are enumerated with a 1 ml syringe. A settled volume is measured within the syringe barrel and then subsequently counted. This is repeated 3 or 4 times, averaged and multiplied by a total settled egg mass volume.

Larvae are enumerated using a small container with a known volume. Three samples are collected by inverting the container and plunging into the water column midway, thus trapping an air bubble of known volume, then the container is turned up and the sample containing larvae is manually counted.

Growth data will be available after the 2010 rearing season. Adult broodstock pre-spawn length and weight data will be collected annually to identify fish that spawn of their own volition, which is typical of burbot in captivity (at least to date in recirculation systems). If a single female in a group of spawners releases eggs, it can quickly be identified by a sudden weight loss.

8.2.5) Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (*average program performance*).

Food type used, daily application schedule, and feeding rate range are provided in Table 14. Feed conversion efficiencies have not been calculated for any experimentally cultured burbot but will be calculated during later project phases.

Table 14. Food type, daily application schedule, and feeding rate range for burbot culture.

Life stage	Feed type(s)	Daily application(s)	Feed Rate	Feed conversion
Wild Adult	Live rainbow trout (5-50 g)	Maintain 1:1 adult:trout	Apparent satiation	Not yet calculated
Cultured adult	Commercial trout food (soft moist)	By hand one time daily or automated feeder used for continuous feeding	1-3% BW depending on water temperature and relative tank biomass	Not yet calculated
Larval	Live zooplankton*	Continuous by hand and injected	Rotifers 10:1ml rearing volume, Artemia 5:1ml rearing volume	Not yet calculated
Juvenile	Commercial grade larval diets	By hand two times daily minimum or automated feeder used for continuous feeding	1g feed: 100 L rearing volume at start, then gradual increase to 1-3% BW depending on water temperature and relative tank biomass	Not yet calculated

*Rotifers (*Branchionus plicatilis* are mass produced in closed brackish systems, 10-15 ppt) and *Artemia* (Great Salt Lake strain ≥80% hatch rate, decapsulated are hatched in 5 ppt solution).

8.2.6) Fish health monitoring, disease treatment and sanitation procedures

A primary goal of any aquaculture program is to minimize introduction and transmission of pathogens in cultured and native populations. Available scientific information will be used to develop conservation and management strategies that minimize the transmission of disease from cultured fish to native populations and the potential severity of disease in the native population (LaPatra et al. 1999). Although asymptomatic infection may be widely distributed within and among wild populations, maintenance of optimal rearing conditions (e.g., optimal rearing densities, temperature regimes, water quality conditions) will reduce or prevent stress-mediated disease in the hatchery setting.

Recent studies characterized disease susceptibility in burbot (Polinski et al. 2010, 2009a, 2009b). Strict implementation of standard disease testing protocols developed for the white sturgeon program at the Kootenai Hatchery will be implemented for burbot to minimize potential in-hatchery disease outbreak and disease transmission risks to the remnant wild population.

Disease testing in burbot indicated that this species is susceptible to infectious hematopoietic necrosis virus (IHNV) when challenged by immersion and to *Aeromonas salmonicida* by intraperitoneal (i.p.) injection. IHNV persisted in fish for at least 28 days, whereas *Aeromonas salmonicida* was not re-isolated beyond 17 days post challenge. In contrast, burbot appeared refractory to *Flavobacterium psychrophilum* following intramuscular (i.m.) injection and to infectious pancreatic necrosis virus (IPNV) by immersion. However, IPNV was re-isolated from fish following i.p. injection for the duration of the 28 days challenge. *Renibacterium salmoninarum* appeared to induce an asymptomatic carrier state in burbot following i.p. injection, but overt manifestation of disease was not apparent. Viable bacteria persisted in fish for at least 41 days, and bacterial DNA isolated by diagnostic polymerase chain reaction was detected from burbot kidney tissue 90 days after initial exposure. This study provides valuable information that will aid in efforts to culture and manage this species (Polinski et al. 2009). Implementation of routine disease management strategies will reduce the risk of infection by these and other pathogens and strict disease testing at the Idaho Fish Health Center (USFWS) prior to release of juvenile fish will ensure disease free status. In addition to establishing baseline information for the most concerning fish diseases, a new cell line was established from burbot embryo cells and provided to disease diagnostic laboratories (Polinski et al. 2009). This will provide a screening tool that will be valuable in detecting potential viral pathogens of burbot.

8.2.7) Indicate the use of "natural" rearing methods as applied in the program

Natural habitat for burbot at different life stages is currently being studied. However, it is known that the unique life history and behavior of age 1+ and adult burbot requires different rearing strategies than for salmon or trout. Therefore, efforts are underway to combine results of current and future field, lab, and aquaculture research to best define life stage-specific habitat requirements and to use this information to inform facility designs and operations.

Current practice is to hold wild adult burbot in dark, covered circular tanks that provide low light intensity, water velocity, and water temperature conditions, similar to life stage specific habitat use in the wild. Adult burbot are winter spawners and water temperatures are maintained as low as 1˚C during the spawning season. Wild captive adult burbot will be fed a diet of live certified disease-free rainbow trout.

Larval burbot must be intensively reared at the onset of exogenous feeding. Semi-intensive and extensive, outdoor aerated tanks and earthen ponds respectively, are currently being studied to determine the feasibility of using these rearing options. Design of hatchery features and operations are underway to allow all life stages of burbot to have access to environmental conditions similar to those used in the wild.

8.2.8) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to fish under propagation.

Burbot are currently being reared for release at age 0-2. The need to mark all hatchery fish to distinguish from year classes precludes release at a very small sizes (<5 g BW). The only suitable tag or mark that can be expected to persist over the life span of these long-lived fish is a PIT-tag. However, we are currently researching alternative marking methods for smaller fish including Visible Implant Elastomer (VIE tags) in an effort to minimize the risk of domestication selection effects that may be imparted through rearing to age ≥2.

The risk of disease amplification and introduction to natural waters will be minimized by incorporating standard fish health policies. Disease testing will follow required procedures for inspection under USFWS Title 50 act. Samples will be submitted to the Idaho Fish Health Center (USFWS) for testing and inspection will be completed prior to annual releases. Due to redundancy in questions in this HGMP, responses to this question are also provided in Sections 2.5 regarding ecology, 3.2 regarding water, 6.7 regarding stock, 6.9 regarding fish health, 7.4 regarding breeding, 8.1.6 regarding eggs, and 8.2.6 regarding fish health.

SECTION 9. RELEASE

Describe fish release levels, and release practices applied through the hatchery program

Specify any management goals (e.g., number, size or age at release, population uniformity, residualization controls) that the hatchery is operating under for the hatchery stock in the appropriate sections below.

9.1) Proposed fish release levels

Table 15. Proposed fish release levels.

Life Stage	Release Location	Annual Release Level
Eyed Eggs	Kootenai River	Millions
Unfed Fry	Kootenai River	Millions
Fry	Kootenai River	Hundreds of Thousands
Fingerling	Kootenai River	Thousands
Yearling	Kootenai River	Hundreds - Thousands
Spawner	Kootenai River	Hundreds

9.2) Specific location(s) of proposed release(s).

Stream, river, or watercourse:

Release point: Kootenai River (rkm 170-276) and possible tributaries in Idaho

Kootenay River (rkm 120-170) and possible tributaries in B.C.

Major watershed: Kootenai River

Basin or Region: Columbia River Basin, Kootenai River Subbasin, Mountain Columbia Province

More specific future release sites will be determined as post-release habitat use, performance, and survival information becomes available.

9.3) Actual numbers and sizes of fish released by age class through the program.
To date, this program has been operated experimentally at UI-ARI. Data in Table 16 reflects this limited experience.

Table 16. Number and size of burbot released in 2009.

Release year	Eggs/ Unfed Fry	Avg size	Fry	Avg size	Fingerling	Avg size	Yearling	Avg size
2009	0	0	0	0	217	10g	30	450g
Average	0	0	0	0	217	10g	30	450g

9.4) Actual dates of release and description of release protocols.
Provide the recent five year release date ranges by life stage produced (mo/day/yr). Also indicate the rationale for choosing release dates, how fish are released (volitionally, forced, volitionally then forced).

The first experimental releases of burbot from this program occurred during fall of 2009 (Table 4). Four releases occurred during October and November 2009 in four different locations with three year classes of fish, all produced at the UI-ARI. Sections 4.2 and 4.5 describe transport and acclimation release protocols, respectively.

9.5) Fish transportation procedures, if applicable
Describe fish transportation procedures for off-station release. Include length of time in transit, fish loading densities, and temperature control and oxygenation methods.

These issues are addressed in Section 4.2. All burbot releases would likely be within one hour of the Twin Rivers facility.

9.6) Acclimation procedures (*methods applied and length of time*)

Acclimation procedures will include tempering fish prior to release. The proposed facility will use ambient river water and it is presumed that fish reared on ambient river water will require minimal thermal or chemical acclimation.

At the release site, water temperature within the transportation tank is manipulated by adding water from the release site to temper the haul tank water to the release site. After temperature acclimation, burbot are netted from the tank truck and released into the river. Some release sites require access by boat, in which case, burbot are loaded by net into a live well on the boat, thermally acclimated within the live well, netted out of the well at the release site, and released directly into the river.

9.7) Marks applied, and proportions of the total hatchery population marked, to identify hatchery component.

Prior to release, each fish will be weighed, measured, and marked. Marks applied and tags used will depend on fish size. Smaller age 0 fish (<25g) will be marked with Visible Implant Elastomer (VIE) and/or fin-clipped, larger fish (>25g) will be implanted with PIT and VIE tags, and fin clipped or freeze branded with liquid nitrogen. The proportions of the hatchery population and progeny groups marked, and which marks will be applied, will depend on the future release objectives and goals. All fish stocking will require unique marks to identify family, year class, and release site.

9.8) Disposition plans for fish identified at the time of release as surplus to programmed or approved levels

See Section 6.8, Disposition of carcasses

9.9) Fish health certification procedures applied pre-release

See Section 8.2.6

9.10) Emergency release procedures in response to flooding or water system failure

See 3.2 for risk aversion measures, water systems and release

9.11) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed species resulting from fish releases.

See Section 8.2.6 regarding fish health, 8.1.6 regarding eggs, 7.4 regarding breeding, 6.9 regarding fish health, 6.7 regarding stock, 3.2 regarding water, 2.5 regarding ecology.

SECTION 10. BURBOT PROGRAM EFFECTS ON ALL ESA-LISTED, PROPOSED, AND CANDIDATE SPECIES (FISH AND WILDLIFE)

Kootenai River white sturgeon (*Acipenser transmontanus*) are listed as endangered under the ESA and are sympatric with the burbot restoration area (Lower Kootenai River) Bull trout?

10.1) List all ESA permits or authorizations in hand for the hatchery program.

No burbot proposed for use in the proposed program have any ESA-listed status; therefore, no ESA permits or authorizations are required.

10.2) Provide descriptions, status, and projected take actions and levels for ESA-listed natural populations in the target area.

No burbot proposed for use in the proposed program have any ESA-listed status.

See appendix Table 1.

10.2.1) Description of ESA-listed, proposed, and candidate species affected by the program.

Include information describing: adult age class structure, sex ratio, size range migration timing, spawning range, and spawn timing; and juvenile life history strategy, including smolt emigration timing. Emphasize spatial and temporal distribution relative to hatchery fish release locations and weir sites.

- Identify the ESA-listed population(s) that will be directly affected by the program. *(Includes listed fish used in supplementation programs or other programs that involve integration of a listed natural population. Identify the natural population targeted for integration).*

No ESA-listed population(s) will be directly affected by this burbot aquaculture program.

- Identify the ESA-listed population(s) that may be incidentally affected by the program.

(Includes ESA-listed fish in target hatchery fish release, adult return, and broodstock collection areas).

No ESA-listed population(s) will be incidentally affected by this burbot aquaculture program.

10.2.2) Status of ESA-listed species affected by the program.

No response is required here because no ESA-listed species are affected by the burbot aquaculture program.

- **Describe the status of the listed natural population(s) relative to "critical" and "viable" population thresholds** (*see definitions in "Attachment 1").*

- Provide the most recent 12 year (e.g. 1988 - present) progeny-to-parent ratios, survival data by life-stage or other measures of productivity for the listed population. Indicate the source of these data.

- Provide the most recent 12 year (e.g. 1988 - 1999) annual spawning abundance estimates, or any other abundance information. Indicate the source of these data. *(Include estimates of juvenile habitat seeding relative to capacity or natural fish densities, if available).*

- Provide the most recent 12 year (e.g. 1988 - 1999) estimates of annual proportions of direct hatchery-origin and listed natural-origin fish on natural spawning grounds, if known.

10.2.3) Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of listed species in the target area, and provide estimated annual levels of take *(see "Attachment 1" for definition of "take")*. **Provide the rationale for deriving the estimate.**

No response is required here because no ESA-listed species are affected by the burbot aquaculture program.

- Describe hatchery activities that may lead to the take of listed species in the target area, including how, where, and when the takes may occur, the risk potential for their occurrence, and the likely effects of the take.

- **Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken and observed injury or mortality levels for listed fish**.

- Provide projected annual take levels for listed species by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).

Complete the appended "take table" (Table 1) for this purpose. Provide a range of potential take numbers to account for alternate or "worst case" scenarios.

- Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program.

SECTION 11. MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

This section describes how Performance Indicators listed in Section 1.10 will be monitored. Results of Performance Indicator monitoring will be evaluated annually and used to adaptively manage the hatchery program, as needed, to meet the Performance Standards.

11.1) Monitoring and evaluation of Performance Indicators presented in Section 1.10.

11.1.1) Describe the proposed plans and methods necessary to respond to the appropriate "Performance Indicators" that have been identified for the program.

A series of research, monitoring, and evaluation activities for burbot are included as part of this program. Measurable biological objectives and metrics associated with burbot aquaculture for pre-release and post-release periods are identified in Tables 17 and 18, including specific monitoring and evaluation activities during pre-spawning, spawning, incubation, and early rearing life stages in the hatchery.

11.1.2) Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program.

Funding, staffing, and other support logistics are available and committed to that will allow implementation of the monitoring and evaluation program.

11.2) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed species resulting from monitoring and evaluation activities.

Fish Health Monitoring

The burbot program will include protocols to monitor and minimize pathogen introduction and transmission in hatchery and natural populations. These protocols will be similar to those implemented for the sturgeon program. Research is ongoing to limit pathogen transmission during egg incubation, develop cell lines for improved diagnostics and assess burbot susceptibility to pathogens. These efforts, described below, are helping to define optimal treatments to control fungus during egg incubation, to address possible viral diseases through new cell line development, and to establish baseline data regarding burbot susceptibility to a number of fish pathogens.

As part of the proposed monitoring program, all broodstock and at least 30 progeny from each brood year will be tested for the presence of pathogens. Burbot will be subjected to the federal fish health Title 50 pathogen screen. Disease testing may include parasitology, bacteriology, virology and histology examinations. Burbot evaluation protocols will be developed by state, provincial, federal, and tribal management agencies and disease test results will be reviewed by all parties.

Table 17. Pre-release biological objectives, metrics and target values to be monitored and evaluated in the burbot conservation aquaculture program.

Program Aspect	Biological Objectives	Life Stage or Activity	Metrics	Target Metric Values for Burbot	Timeframe
Spawning	Provide adequate broodstock	Spawners	Gamete viability	Sperm motility > 80%	Up to 3 mo. annually, typically Feb-June
	Provide adequate breeding matrices for genetic diversity		Effective population size (*Ne*); No. of breeders (*Nb*); fertilization	20-30 female broodstock annually, spawned with > 1 male each	
Incubation/ Hatch	Provide adequate incubation and hatch rates	Embryos	Survival (hatch)	Hatching success 2%	Up to 4 mo. annually, typically May-Sept
Early rearing	Provide adequate fry and larval survival	Fry and larvae	Survival	> 2% for each life stage	Up to 5 mo. annually, typically May-Sept
	Provide adequate YOY survival	YOY rearing	Survival, fish health	Survival > 50 %; no visible signs of fish health problems; Negative Title 50 pathogen test results if post-release fish tested	Up to 4 mo. annually, Sept-Dec.
	Provide adequate juvenile survival	Juvenile rearing	Survival, condition, fish health	Survival > 50 %; Negative Title 50 pathogen test results	Up to 9 mo. annually, typically Jan-Sept, including fall of previous year for YOY
	Provide adequate fish marking	YOY and juveniles	Mark retention	PIT tag retention > 90%	

Table 18. Post-release biological objectives, metrics and target values to be monitored and evaluated in the burbot conservation aquaculture program.

Program Aspect	Biological Objectives	Life Stage or Activity	Metrics	Target Burbot Metric Values	Timeframe
Post-release monitoring	Ensure adequate post-release survival, growth, and biological condition to support future mature adults	Juvenile and adult sampling	Survival, annual growth, biological condition (*K*), relative weight	Target survival 30-50% first year post-release; consistent positive growth; condition factors and relative weights ; consistent, positive trends over years	Annually or periodically based on recapture data
	Create and maintain favorable age class distribution		Age class distribution; recruitment magnitude and frequency	Hatchery-produced year classes annually	Annually, year-round
	Maintain adequate individual and population health		Adequate fish health to support adult target goals	External health and behavior visually suitable; negative Title 50 pathogen test results	Annually, year-round
	Provide genetic diversity within and among progeny groups		Diversity, heterozygosity metrics, genetic distance and inbreeding coefficients	Genetic diversity targets from mating plan under development	Annually, year-round
All stages	Sustainable adult population target	All life stages	Population abundance (adults)	From 3 groups of 2,500 to approximately 10,000 adults	Annual sampling, periodically update abundance estimates & age class structure characteristics. May occur up to 30 years

Establishment of Burbot Cell Lines and Characterization of Viral Susceptibility

To screen and monitor burbot for the presence of viral pathogens, an early-larval cell line has been established (Polinski et al., unpublished results). This burbot cell line has been maintained in laboratory culture over 3 years and passed nearly 90 times. Although relatively slow growing compared to other established laboratory fish cell lines, increased growth rates have been observed as *in vitro* passage increases. Cryopreservation of this cell line has been achieved with up to 90% viability. If novel viruses affect this species, this burbot cell line will be an important tool in early diagnosis and possible virus isolation.

Susceptibility of this cell line to multiple viruses and strains has been determined. The line shows a cytopathic effect when exposed during incubation to IHNV. Tests to determine susceptibility to IPNV produced conflicting results and remain undetermined. Information from this ongoing research is expected to be available in the near term. In addition, submission of burbot samples to standard Title 50 pathogen testing will reveal suitability for future experimental release.

Susceptibility of Juvenile Burbot to Fish Pathogens

Because virtually no information was previously available about the susceptibility of burbot to disease, experiments in 2007 and 2008 at the University of Idaho challenged juvenile burbot with various pathogens. In challenge experiments on progeny from captive broodstock, juveniles were not susceptible to a virulent strain of *Flavobacterium psychrophilum*, the agent that causes bacterial coldwater disease. In addition, disease testing was conducted on mortalities in wild-caught broodstock; generally deaths were not due to disease but associated with factors such as swim bladder rupture linked to collection methods. Fish pathogens were tested on burbot in controlled, replicated pathogen challenges at the University of Idaho: IHNV, IPNV, *Flavobacterium psychrophilum, Renibacterium salmoninarum* (which causes BKD), and *Aeromonas salmonicida* (which causes furunculosis).

Pathology research to date indicates that burbot are: 1) susceptible to IHNV and may be potential carriers; 2) not susceptible to IPNV, although more research is needed; 3) not susceptible to *F. psychrophilum*; and 4) can be susceptible to *Aeromonas salmonicida.* These results, as well as ongoing pathogen investigations, will adaptively inform the burbot aquaculture program.

Burbot Genetics

Genetic analysis was used to inform broodstock choice for this project. A mitochondrial DNA study revealed that the Moyie Lake burbot stock in British Columbia is closely related to the functionally extinct Kootenai River burbot stock (Paragamian et al. 1999). This stock is found within the Kootenai subbasin and appears to be large enough to yield up to several dozen broodstock annually for experimental and production purposes.

In addition to stock identification and differentiation issues, genetic analysis also will be used to estimate diversity measures, genetic distance, and population genetic parameters such as effective population size for burbot broodstock and progeny groups as part of this project.

Burbot Gamete Cryopreservation

Cryopreservation is a successfully developing risk-aversion technique for burbot that conserves native genetic material in the form of frozen gametes (Jensen et al. 2008). Cryopreservation allows additional flexibility for including individual broodstock in spawning matrices than would exist using with fresh gametes only. Subsamples of milt, collected and cryopreserved from Moyie Lake and Duncan Reservoir stocks, have been used to establish a germ plasm repository in the Tribe's cryopreservation unit at the University of Idaho. Cryopreservation of semen from Kootenai burbot was investigated and optimal methanol concentrations determined for a conservation breeding program (Jensen et al. 2008b). The following results support the use of cryopreserved burbot semen to develop germ plasm repositories for imperiled fish stocks:

- Optimal methanol concentrations to provide a permeable cryoprotectant in the semen extender were determined.
- Post-freeze semen motility was evaluated and fertilization rates were determined
- The effect of methanol concentrations in the extender on motility and fertilization percentages was determined.
- Techniques derived from this research will be applied to broodstock monitoring and evaluation. The motility and fertility of all cryopreserved burbot semen will be screened for suitability for use as broodstock.

SECTION 12. RESEARCH

12.1) Objective or purpose

Research is needed to guide program development, inform adaptive management, and increase the probability of program success.

12.2) Cooperating and funding agencies

Cooperating agencies include the UI-ARI, IDFG, the British Columbia Ministry of Environment, the University of Idaho Life Sciences Department, U.S. Fish and Wildlife Service and others. See Section 1.3 and Table 8 for additional details. Most of this work is funded through the Kootenai Tribe of Idaho with support provided under Project 1988-06400 from the Bonneville Power Administration. The USFWS provides additional monetary support for development of burbot aquaculture.

12.3) Principle investigator or project supervisor and staff

Name (and title): Sue Ireland, Fish and Wildlife Program Director
Agency or Tribe: Kootenai Tribe of Idaho
Address: 242 Hatchery Rd., P.O. Box 1269, Bonners Ferry, ID 83805

Telephone: (208) 267-3620
Fax: (208) 267-1131
Email: ireland@kootenai.org

12.4) Status of population, particularly the group affected by project, if different than the population(s) described in Section 1.2.

Burbot (*Lota lota maculosa*), Lower Kootenai River, Idaho
Conservation status / Classification:
Rangewide: Secure (G5)
Statewide (Idaho): Critically imperiled (S1)
ESA: No current or pending status
USFS: Region 1: Sensitive; Region 4: No status
BLM: Regional/State imperiled (Type 3)
IDFG: Game fish; Endangered
(From: http://fishandgame.idaho.gov/cms/tech/CDC/cwcs_appf/Burbot.pdf)

12.5) Techniques: include capture methods, drugs, samples collected, tags applied

Broodstock capture methods include hook and line angling in shallow water near-shore habitats in Moyie Lake, B.C. This capture technique minimizes injury and delayed mortality that was associated with hoop netting efforts for burbot collection from deep water (Neufeld and Spence 2008). No drugs are used other than clove oil as a temporary sampling anesthetic to aid in live gamete collection on the ice during February, and hydrogen peroxide anti-fungal treatments of burbot eggs prior to transport. Samples include broodstock collected each February, and post-release juveniles capture throughout the year from the Kootenai River. Tags include Floy tags to wild broodstock, Elastomer (visual implant) tags to juveniles for release, PIT-tags to larger fish and potential captive broodstock, and a small subset of fish tagged with Vemco sonic or radio transmitters.

12.6) Dates or time period in which research activity occurs

Research of aquaculture and burbot life stages occurs during different times of the year.

12.7) Care and maintenance of live fish or eggs, holding duration, transport methods

The Twin Rivers Hatchery will include burbot holding, spawning and rearing tanks would be located in a separate building from Kootenai sturgeon and rainbow trout to minimize potential pathogen transmission. Components specific to burbot aquaculture include:

Adult Fish Holding/Spawning - Round tanks with adequate cover to hold adult burbot.

Incubation - Burbot eggs will be incubated in one liter Imhoff cones mounted over small circular start tanks.

Start Tanks - Post-hatch burbot volitionally move up through the water column out of the top of the incubators into the start tanks where they will be fed and closely monitored for disease as they grow to a size acceptable for transfer out of the start tank room. Burbot hatchlings require live feed (rotifers and *Artemia)* that will be raised in an adjacent live feed culture room.

Rearing Tanks - Four-foot-diameter indoor circular tanks will be used for burbot grow-out.

Burbot Ponds - Six 10-square-meter outdoor earthen ponds are planned for experimental larval and extended burbot rearing. Each pond will have a concrete harvest and water level control structure, supply, drain piping and predator barriers. Larger ponds for long-term holding of captive broodstock are also being considered.

12.8) Expected type and effects of take and potential for injury or mortality

No take of any ESA-listed fish is expected as part of the program (See Appendix Table 1 for more details)

12.9) Level of take of listed species: number or range of individuals handled, injured, or killed by sex, age, or size, if not already indicated in Section 2 and the attached "take table" (Appendix Table 1).

See Appendix Table 1 for more details.

12.10) Alternative methods to achieve project objectives

A range of alternatives for burbot conservation were considered by the Tribe. These are described in Section 1.16.

12.11) List species similar or related to the threatened species; provide number and causes of mortality related to this research project.

Not applicable.

12.12) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury, or mortality to listed species as a result of the proposed research activities.

Not applicable.

SECTION 13. ATTACHMENTS AND CITATIONS

References

Aquaculture Research Institute (ARI) 2007. Jensen, N.R, P. J. Anders, and K.D. Cain. Burbot (*Lota lota*) conservation aquaculture progress report. Report to the Kootenai Tribe of Idaho. 36 pp.

Dixon, C.J., and J.C. Vokoun. 2008. Burbot resource selection in small streams near the southern extent of the species range. Ecology of Freshwater Fish 18:234-246.

Ireland, S.C. and P.N. Perry. 2008. Burbot restoration in the Kootenai River basin: Using agency, tribal, and community collaboration to develop and implement a conservation strategy. American Fisheries Society Symposium 59:251-256.

Jensen, N. and K. Cain. 2009. Burbot: not just another cod. Hatchery International 10(3).

Jensen, N.R., M.D. Zuccarelli, S.J. Patton, S.R. Williams, S.C. Ireland and K.D. Cain. 2008b. Cryopreservation and Methanol Effects on Burbot Sperm Motility and Egg Fertilization. North American Journal of Aquaculture. 70: 38-42.

Jensen, N.R., P.J. Anders and K.D. Cain. 2008. Burbot Conservation Aquaculture Progress-2007. Annual progress report prepared for the Kootenai Tribe of Idaho.

Jensen, N.R., S.C. Ireland, J.T. Siple, S.R. Williams and K.D. Cain. 2008a. Evaluation of Egg Incubation Methods and Larval Feeding Regimes for North American Burbot. North American Journal of Aquaculture. 70: 162-170.

Jensen, N.R., S.R. Williams, S.C. Ireland, J.T. Siple, M.D. Neufeld and K.D. Cain. 2008. Preliminary Captive Burbot Spawning Observations. Pages155-165 *in* V.L. Paragamian and D.H. Bennett, editors. Burbot: Ecology, Management, and Culture. American Fisheries Society, Symposium 59, Bethesda, MD.

Klontz, G.W. 1991. Fish for the Future: Concepts and Methods of Intensive Aquaculture. Idaho Forest, Wildlife and Range Experiment Station, College of Forestry, Wildlife and Range Sciences. University of Idaho, Moscow, ID. 192 pp.

KTOI and Montana Fish Wildlife and Parks (MFWP). 2004. Kootenai Subbasin Plan. A report prepared for the Northwest Power and Conservation Council. Portland, OR. October 11, 2004.

KVRI Burbot Committee. 2005. Kootenai River/Kootenay Lake Burbot Conservation Strategy. Prepared by the Kootenai Tribe of Idaho. 77 pp. plus appendices.

Kootenai Tribe of Idaho. 2009. Kootenai River Native Fish Aquaculture Program Master Plan. Volume 1. August 2009. 238 pp. plus appendices,

LaPatra, S. E., S. C. Ireland, J. M. Groff, K. M. Clemens, and J. T. Siple. 1999. Adaptive disease management strategies for the endangered population of Kootenai River white sturgeon. Fisheries 24(5): 6-13.

Neufeld, M. 2008. Moyie Lake Burbot: Population Assessment 2007. BC Ministry of Environment, Nelson, BC.

Neufeld, M. D., and C. R. Spence. 2008. Evaluation of a simple decompression procedure to reduce trauma in trap-caught burbot. Pages 249-250, In: American Fisheries Society Symposium 59. AFS, Bethesda, MD.

Northwest Power and Conservation Council (NPCC). 2009. Columbia Basin Fish and Wildlife Program: Mainstem Amendments. (http://www.nwcouncil.org/library/2009/2009-09/).

Northwest Power and Conservation Council (NPCC). 1999. Artificial Production Review. NPPC Document 99-15. (http://www.nwcouncil.org/LIBRARY/1999/99-15.pdf) 245 pp. October 13, 2009.

Paragamian, V.L., M. Powell, and J. Faler. 1999. Mitochondrial DNA analysis of burbot *Lota lota* stocks in the Kootenai River Basin in British Columbia, Montana, and Idaho. Transactions of the American fisheries Society 128:868-874.

Paragamian, V., B. Pyper, M. Daigneault, R. Beamesderfer and S. Ireland. 2008. Population dynamics and extinction risk of burbot in the Kootenai River, Idaho, USA and British Columbia, Canada. American Fisheries Society Symposium 59:213-234.

Polinksi, M.P., N. R. Jensen, and K.D. Cain. 2010. Assessment of formalin and hydrogen peroxide use during egg incubation of North American burbot. North American Journal of Aquaculture 72:111–117.

Polinski, M.P, T. R. Fehringer, K.A. Johnson, K. R. Snekvik, S. E. LaPatra, B. R. LaFrentz, S. C. Ireland, and K D Cain. Characterization of susceptibility and carrier status of burbot, Lota lota (L.), to IHNV, IPNV, Flavobacterium psychrophilum, Aeromonas salmonicida and Renibacterium salmoninarum. Journal of Fish Diseases (*In Press*).

Polinski, M.P., J.D. Drennan, W.N. Batts, S.C. Ireland, and K.D. Cain. Establishment of a cell line from burbot (*Lota lota*) with characterization of susceptibility to IHNV, IPNV, and VHSN. Diseases of Aquatic Organisms (*In Press*).

Powell, M., V. Paragamian, and J. Dunnigan. 2008. Mitochondrial variation in Western North American burbot with special reference to the Kootenai River in Idaho and Montana, USA. Pages 3-28, *In:* American Fisheries Society Symposium 59. AFS Bethesda, MD.

Pyper, B.J., M.J. Daigneault, R.C.P. Beamesderfer, V.L. Paragamian, and S.C. Ireland. 2004. Status and population dynamics of burbot in the Kootenai River, Idaho and British Columbia, Canada. *In* V.L. Paragamian Kootenai River Fisheries Investigation: burbot stock status. Idaho Department of Fish and Game. Bonneville Power Administration. Annual Progress Report, Project 88-65. Boise, Idaho.

Van Houdt, J.K., B. Hellemans, and F.A.M. Volckaert. 2003. Phylogenetic relationships among Palearctic and Nearctic burbot (*Lota lota*): Pleistocene extinctions and recolonization. Molecular Phylogenetics and Evolution 29: 599-612.

Van Houdt, J.K., L. DeCleyn, A. Perretti, and F.A.M. Volckaert.2005. A mitogenic view on the evolutionary history of the Holoarctic ganoid, burbot (*Lota lota*). Molecular Ecology14:2445-2457.

Zuccarelli, M.D., N. Jensen and R.L. Ingermann. 2007. Inhibitory effect of osmotic concentration, potassium and pH on motility of the sperm of North American burbot (*Lota lota maculosa*). Journal of Fish Biology. 70:178-189.

SECTION 14. CERTIFICATION LANGUAGE AND SIGNATURE OF RESPONSIBLE PARTY

"I hereby certify that the foregoing information is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this HGMP is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or penalties provided under the Endangered Species Act of 1973."

Name, Title, and Signature of Applicant:

Certified by_____________________________ Date: _____________

Appendix Table 1. Estimated listed species take levels by hatchery activity.

Listed species affected: White sturgeon ESU/Population: Kootenai River population Activity:				
Location of hatchery activity:_______________________ Dates of activity:_____________________ Hatchery program operator:__________________				
Type of Take	Annual Take of Listed Fish By Life Stage (*Number of Fish*)			
	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass[a]	0	0	0	NA
Collect for transport[b]	0	0	0	NA
Capture, handle, and release[c]	0	0	0	NA
Capture, handle, tag/mark/tissue sample, and release[d]	0	0	0	NA
Removal (e.g. broodstock)[e]	0	0	0	NA
Intentional lethal take[f]	0	0	0	NA
Unintentional lethal take[g]	0	0	0	NA
Other Take (specify)[h]	0	0	0	NA

a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at weirs.
b. Take associated with weir or trapping operations where listed fish are captured and transported for release.
c. Take associated with weir or trapping operations where listed fish are captured, handled and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release, or through carcass recovery programs.
e. Listed fish removed from the wild and collected for use as broodstock.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to spawning or prior to release into the wild, or, for integrated programs, mortalities during incubation and rearing.
h. Other takes not identified above as a category.

Instructions:

1. *An entry for a fish to be taken should be in the take category that describes the greatest impact.*
2. *Each take to be entered in the table should be in one take category only (there should not be more than one entry for the same sampling event).*
3. *If an individual fish is to be taken more than once on separate occasions, each take must be entered in the take table*

Appendix D

Twin Rivers Water Quality Testing Data

Aquatic Research, Inc.
3927 Aurora Ave. N. , Seattle, WA 98103 | (206) 632-2715

TOTAL PCBs SAMPLE REPORT

Results of Analysis by EPA Method 8082A

Measurement of Total PCBs in Wastewater by GC/ECD

Case File Number:	KOO00536A1	**Matrix:**	Water
Sample ID No.:	P1	**Sample Vol. (ml)**	1050
Date Collected:	6/18/2008	**Dilution Factor:**	1
Date Received:	6/19/2008	**Prepped:**	TM
Date Prepped:	6/27/2008	**Analyst:**	JDS
Date Analyzed	7/1/2008	**Supervisor's Initials:**	
Date of Report:	7/2/2008		

Total PCBs

Aroclor	Result (ug/L)	RL (ug/L)
Total PCBs	< 0.1	0.1

Surrogate Compounds

Parameter	% Rec.	LCL	UCL
Decachlorobiphenyl (DCB)	101%	70%	130%

MCL: Maximum Contaminant Level

RL: Reporting Limit

LCL: Lower Control Limit

UCL: Upper Control Limit

Aquatic Research, Inc.
3927 Aurora Ave. N. , Seattle, WA 98103 | (206) 632-2715

TOTAL PCBs SAMPLE REPORT

Results of Analysis by EPA Method 8082A

Measurement of Total PCBs in Wastewater by GC/ECD

Case File Number:	KOO00536A2	**Matrix:**	Water
Sample ID No.:	P2	**Sample Vol. (ml)**	1030
Date Collected:	6/18/2008	**Dilution Factor:**	1
Date Received:	6/19/2008	**Prepped:**	TM
Date Prepped:	6/27/2008	**Analyst:**	JDS
Date Analyzed	7/1/2008	**Supervisor's Initials:**	
Date of Report:	7/2/2008		

Total PCBs

Aroclor	Result (ug/L)	RL (ug/L)
Total PCBs	< 0.1	0.1

Surrogate Compounds

Parameter	% Rec.	LCL	UCL
Decachlorobiphenyl (DCB)	106%	70%	130%

MCL: Maximum Contaminant Level

RL: Reporting Limit

LCL: Lower Control Limit

UCL: Upper Control Limit

Aquatic Research, Inc.
3927 Aurora Ave. N. , Seattle, WA 98103 | (206) 632-2715

TOTAL PCBs SAMPLE REPORT

Results of Analysis by EPA Method 8082A

Measurement of Total PCBs in Wastewater by GC/ECD

Case File Number:	KOO00536A3	**Matrix:**	Water
Sample ID No.:	P3	**Sample Vol. (ml)**	1050
Date Collected:	6/18/2008	**Dilution Factor:**	1
Date Received:	6/19/2008	**Prepped:**	TM
Date Prepped:	6/27/2008	**Analyst:**	JDS
Date Analyzed	7/1/2008	**Supervisor's Initials:**	
Date of Report:	7/2/2008		

Total PCBs

Aroclor	Result (ug/L)	RL (ug/L)
Total PCBs	< 0.1	0.1

Surrogate Compounds

Parameter	% Rec.	LCL	UCL
Decachlorobiphenyl (DCB)	86%	70%	130%

MCL: Maximum Contaminant Level

RL: Reporting Limit

LCL: Lower Control Limit

UCL: Upper Control Limit

Aquatic Research, Inc.
3927 Aurora Ave. N. , Seattle, WA 98103 | (206) 632-2715

TOTAL PCBs LABORATORY REAGENT BLANK REPORT

Results of Analysis by EPA Method 8082A

Measurement of Total PCBs in Wastewater by GC/ECD

Case File Number:	06/27/08 LRB	**Matrix:**	Water
Sample ID No.:	LRB	**Sample Vol. (ml):**	1000
Date Collected:	NA	**Dilution Factor:**	1
Date Received:	NA	**Prepped:**	TM
Date Prepped:	6/27/2008	**Analyst:**	JDS
Date Analyzed	7/1/2008	**Supervisor's Initials:**	
Date of Report:	7/2/2008		

Total PCBs

Aroclor	Result (ug/L)	UCL (ug/L)	RL (ug/L)
Total PCBs	< 0.1	< 0.1	0.1

Surrogate Compounds

Parameter	% Rec.	LCL	UCL
Decachlorobiphenyl (DCB)	114%	70%	130%

MCL: Maximum Contaminant Level
RL: Reporting Limit
LCL: Lower Control Limit
UCL: Upper Control Limit

Aquatic Research, Inc.
3927 Aurora Ave. N. , Seattle, WA 98103 | (206) 632-2715

TOTAL PCBs LABORATORY FORTIFIED BLANK REPORT

Results of Analysis by EPA Method 8082A

Measurement of Total PCBs in Wastewater by GC/ECD

Case File Number:	06/27/08 LFB	**Matrix:**	Water
Sample ID No.:	LFB	**Sample Vol. (ml)**	1000
Date Collected:	NA	**Dilution Factor:**	1
Date Received:	NA	**Prepped:**	TM
Date Prepped:	6/27/2008	**Analyst:**	JDS
Date Analyzed	7/1/2008	**Supervisor's Initials:**	
Date of Report:	7/2/2008		

Total PCBs

Arochlor	RECOVERY	LCL	UCL
Total PCBs	82%	70%	130%

Surrogate Compounds

Parameter	% Rec.	LCL	UCL
Decachlorobiphenyl (DCB)	122%	70%	130%

MCL: Maximum Contaminant Level

RL: Reporting Limit

LCL: Lower Control Limit

UCL: Upper Control Limit

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**KOO005-36**		**PAGE 1**	
REPORT DATE:	**07/22/08**			
DATE SAMPLED:	**06/18/08**	**DATE RECEIVED:**	**06/19/08**	

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM KOOTENAI TRIBE

CASE NARRATIVE

Fifteen samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent pages. Organic analytes will follow as separate reports.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/l)	TDP (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TOTAL-N (mg/l)	SULFIDE (mg/l)
N1	0.002	<0.002	<0.001	0.006	0.056	0.068	
N2	<0.002	<0.002	0.001	0.005	0.060	0.147	
N3	0.003	<0.002	<0.001	0.008	0.058	0.081	
S1							<0.005
S2							<0.005
S3							<0.005

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: KOO005-36 **PAGE 2**
REPORT DATE: 07/22/08
DATE SAMPLED: 06/18/08 **DATE RECEIVED:** 06/19/08
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM KOOTENAI TRIBE

SAMPLE DATA

	DISSOLVED METALS						
	ALUMINUM	ARSENIC	CADMIUM	CHROMIUM	COBALT	COPPER	IRON
SAMPLE ID	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
M1	0.0048	<0.0050	<0.00020	<0.0020	<0.010	0.0049	0.023
M2	0.0035	<0.0050	<0.00020	<0.0020	<0.010	0.0057	0.012
M3	0.0034	<0.0050	<0.00020	<0.0020	<0.010	0.0049	0.016

	DISSOLVED METALS						
	LEAD	MANGANESE	MERCURY	NICKEL	SELENIUM	ZINC	TSS
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
M1	<0.0010	<0.005	<0.00010	<0.010	<0.0030	0.057	
M2	<0.0010	<0.005	<0.00010	<0.010	<0.0030	0.050	
M3	<0.0010	<0.005	<0.00010	<0.010	<0.0030	0.066	
T1							<0.50
T2							<0.50
T3							<0.50

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: KOO005-36 **PAGE 3**
REPORT DATE: 07/22/08
DATE SAMPLED: 06/18/08 **DATE RECEIVED:** 06/19/08
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM KOOTENAI TRIBE

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TDP (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TOTAL-N (mg/l)	SULFIDE (mg/l)
METHOD	SM18 4500PF	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	SM204500NC	SM204500S2D
DATE ANALYZED	06/24/08	06/24/08	06/20/08	06/20/08	06/20/08	06/27/08	06/25/08
DETECTION LIMIT	0.002	0.002	0.001	0.005	0.010	0.050	0.005
DUPLICATE							
SAMPLE ID	N3	BATCH	BATCH	N3	N3	BATCH	S3
ORIGINAL	0.003	0.002	0.003	0.008	0.058	0.187	<0.005
DUPLICATE	0.002	0.002	0.003	0.007	0.058	0.212	<0.005
RPD	12.78%	2.73%	10.48%	16.86%	0.06%	12.31%	NC
SPIKE SAMPLE							
SAMPLE ID	N3	BATCH	BATCH	N3	N3	BATCH	
ORIGINAL	0.003	0.002	0.003	0.008	0.058	0.187	
SPIKED SAMPLE	0.052	0.053	0.023	0.207	0.266	1.25	
SPIKE ADDED	0.050	0.050	0.020	0.200	0.200	1.00	
% RECOVERY	98.34%	100.79%	100.90%	99.32%	104.31%	106.47%	NA
QC CHECK							
FOUND	0.092	0.092	0.033	0.318	0.417	0.434	
TRUE	0.090	0.090	0.033	0.324	0.408	0.435	
% RECOVERY	101.95%	101.95%	99.76%	98.03%	102.31%	99.72%	NA
BLANK	<0.002	<0.002	<0.001	<0.005	<0.010	<0.050	<0.005

RPD = RELATIVE PERCENT DIFFERENCE
NA = NOT APPLICABLE OR NOT AVAILABLE
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION

AQUATIC RESEARCH INCORPORATED
LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**KOO005-36**	**PAGE 4**	
REPORT DATE:	**07/22/08**		
DATE SAMPLED:	**06/18/08**	**DATE RECEIVED:**	**06/19/08**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM KOOTENAI TRIBE

QA/QC DATA - DISSOLVED METALS

QC PARAMETER	ALUMINUM (mg/l)	ARSENIC (mg/l)	CADMIUM (mg/l)	CHROMIUM (mg/l)	COBALT (mg/l)	COPPER (mg/l)	IRON (mg/l)
METHOD	EPA 200.8	EPA 200.8	EPA 200.8	EPA 200.8	EPA 200.7	EPA 200.8	EPA 200.7
DATE ANALYZED	07/16/08	07/16/08	07/18/08	07/16/08	07/10/08	07/16/08	07/10/08
DETECTION LIMIT	0.0030	0.0050	0.00020	0.0020	0.010	0.0010	0.010
DUPLICATE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.0081	<0.0050	<0.00020	<0.0020	<0.010	0.0013	<0.010
DUPLICATE	0.0075	<0.0050	<0.00020	<0.0020	<0.010	0.0012	<0.010
RPD	8.12%	NC	NC	NC	NC	3.62%	NC
SPIKE SAMPLE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.0081	<0.0050	<0.00020	<0.0020	<0.010	0.0013	<0.010
SPIKED SAMPLE	0.0578	0.0522	0.05201	0.0505	0.925	0.0482	0.934
SPIKE ADDED	0.0500	0.0500	0.05000	0.0500	1.00	0.0500	1.00
% RECOVERY	99.40%	104.36%	104.02%	101.08%	92.46%	93.77%	93.37%
QC CHECK (mg/l)							
FOUND	0.0501	0.0519	0.04758	0.0498	0.987	0.0508	0.977
TRUE	0.0500	0.0500	0.05000	0.0500	1.00	0.0500	1.00
% RECOVERY	100.12%	103.74%	95.16%	99.50%	98.74%	101.56%	97.66%
BLANK	<0.0030	<0.0050	<0.00020	<0.0020	<0.010	<0.0010	<0.010

RPD = RELATIVE PERCENT DIFFERENCE
NA = NOT APPLICABLE OR NOT AVAILABLE
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMI
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATIO

AQUATIC RESEARCH INCORPORATED
LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: KOO005-36 **PAGE 5**
REPORT DATE: 07/22/08
DATE SAMPLED: 06/18/08 **DATE RECEIVED:** 06/19/08
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM KOOTENAI TRIBE

QA/QC DATA - DISSOLVED METALS

QC PARAMETER	LEAD (mg/l)	MANGANESE (mg/l)	MERCURY (mg/l)	NICKEL (mg/l)	SELENIUM (mg/l)	ZINC (mg/l)	TSS (mg/l)
METHOD	EPA 200.8	EPA 200.7	EPA 245.1	EPA 200.7	EPA 200.8	EPA 200.7	SM202540D
DATE ANALYZED	07/16/08	07/10/08	06/25/08	07/10/08	07/16/08	07/10/08	06/25/08
DETECTION LIMIT	0.0010	0.005	0.00010	0.010	0.0030	0.005	0.50
DUPLICATE							
SAMPLE ID	BATCH	BATCH	M3	BATCH	BATCH	BATCH	T3
ORIGINAL	<0.0010	<0.005	<0.00010	<0.010	<0.0030	<0.005	<0.50
DUPLICATE	<0.0010	<0.005	<0.00010	<0.010	<0.0030	<0.005	<0.50
RPD	NC	NC	NC	NC	NC	NC	NC
SPIKE SAMPLE							
SAMPLE ID	BATCH	BATCH	M3	BATCH	BATCH	BATCH	
ORIGINAL	<0.0010	<0.005	<0.00010	<0.010	<0.0030	<0.005	
SPIKED SAMPLE	0.0468	0.956	0.00501	1.01	0.0539	0.929	
SPIKE ADDED	0.0500	1.00	0.00500	1.00	0.0500	1.00	
% RECOVERY	93.52%	95.62%	100.20%	100.78%	107.84%	92.93%	NA
QC CHECK (mg/l)							
FOUND	0.0491	1.01	0.00532	1.04	0.0534	0.995	9.4
TRUE	0.0500	1.00	0.00500	1.00	0.0500	1.00	10
% RECOVERY	98.28%	100.85%	106.40%	104.15%	106.86%	99.45%	94.00%
BLANK	<0.0010	<0.005	<0.00010	<0.010	<0.0030	<0.005	<0.50

RPD = RELATIVE PERCENT DIFFERENCE
NA = NOT APPLICABLE OR NOT AVAILABLE
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION

SUBMITTED BY:

Steven Lazoff
Laboratory Director

Appendix E

Supplementary Cost Tables

Appendix E-1: Estimated (Detailed) Construction Costs – Tribal Sturgeon Hatchery

DESCRIPTION	QTY	UNIT	UNIT COSTS MATL/EQU	UNIT COSTS INSTALL	MATL/EQU COST	INSTALL COST	TOTAL ESTIMATED COST
Critical Upgrades							
Adult Fish Transport Improvements	1	LS	$10,000	$10,000	$10,000	$10,000	$20,000
Adult Fish Spawning Area 20' x 32' Remodel	1	LS	$30,000	$30,000	$30,000	$30,000	$60,000
Drum Screen Heating System	1	LS	$10,000	$5,000	$10,000	$5,000	$15,000
Fire Alarm and Lighting Systems Upgrades	1	LS	$30,000	$30,000	$30,000	$30,000	$60,000
Improved Insulation	1	LS	$15,000	$15,000	$15,000	$15,000	$30,000
Sanitary Wall Panels in Wet areas - 8 feet high	6600	SF	$2	$2	$13,200	$13,200	$26,400
Feed Storage	200	SF	$40	$40	$8,000	$8,000	$16,000
Boat Storage	200	SF	$40	$40	$8,000	$8,000	$16,000
Interior Partition of Electrical/Controls in Treatment Building	2000	SF	$5	$5	$10,000	$10,000	$20,000
Ventilated Cabinet and Alarm for Ozone Generator	1	LS	$2,000	$2,000	$2,000	$2,000	$4,000
Allowance for Water System/Energy Recovery Upgrades	1	LS	$25,000	$25,000	$25,000	$25,000	$50,000
Allowance for Increased Chiller Demand	1	LS	$60,000	$15,000	$60,000	$15,000	$75,000
Allowance for Water Systems Controls Upgrades	1	LS	$5,000	$5,000	$5,000	$5,000	$10,000
Backwash Flow Meter & Throttling Valve	1	LS	$4,000	$3,000	$4,000	$3,000	$7,000
Concrete Pads at Rearing Shed Doorways	1	LS	$6,000	$6,000	$6,000	$6,000	$12,000
Rearing Shed #2 – Tank Replacement & Conc Floor	1	LS	$80,000	$40,000	$80,000	$40,000	$120,000
Extend 4-inch River Water Supply from Shed #1 to Shed #2	1	LS	$8,000	$8,000	$8,000	$8,000	$16,000
Add 10 hp Booster Pump	1	LS	$6,000	$6,000	$6,000	$6,000	$12,000
						Const Cost Subtotal	$569,400
						Inflation / Escalation to Mid-Point Construction	$82,563
						Mob/Demob, GC's	$85,410
						Subtotal	$737,373
						Contingency	$147,475
						Taxes	$17,697
						Total Estimated Cost	$903,000

Notes & Assumptions;

- Estimates are escalated from 2009 dollars at 4.5% annually to an assumed mid-point construction date of June 2012

Appendix E-2: Estimated (Detailed) Construction Costs – Twin Rivers

DESCRIPTION	QTY	UNIT	UNIT COSTS MATL/EQU	UNIT COSTS INSTALL	MATL/EQU COST	INSTALL COST	TOTAL ESTIMATED COST
River Water Supply Intakes							
Passive Screening System – 3 cfs.	2	EA	$10,000	$10,000	$20,000	$20,000	$40,000
Suction Piping	200	LF	$20	$50	$4,000	$10,000	$14,000
Raw Water Pump Stations	2	LS	$200,000	$200,000	$400,000	$400,000	$800,000
Sediment Pond	1	LS	$80,000	$80,000	$80,000	$80,000	$160,000
Drum Screen	1	LS	$60,000	$5,000	$60,000	$5,000	$65,000
Ozone Micro-Floc System	1	LS	$25,000	$10,000	$25,000	$10,000	$35,000
Treated Water Pump Station	1	LS	$75,000	$75,000	$75,000	$75,000	$150,000
Electrical/Controls	1	LS	$60,000	$120,000	$60,000	$120,000	$180,000
10-inch Transmission Piping	2200	LF	$30	$20	$66,000	$44,000	$110,000
						Subtotal	$1,554,000
Groundwater Supply							
Well Drilling	2	EA	$15,000	$50,000	$30,000	$100,000	$130,000
Well Pumps Pitless Adapters and Valves	2	EA	$10,000	$10,000	$20,000	$20,000	$40,000
4-inch Transmission Piping	500	LF	$10	$15	$5,000	$7,500	$12,500
Power and Controls	2	EA	$6,000	$10,000	$12,000	$20,000	$32,000
						Subtotal	$214,500
Water Treatment Building							
Building Shell and Floor	1200	SF	$45	$45	$54,000	$54,000	$108,000
HVAC	1200	SF	$6	$6	$7,200	$7,200	$14,400
Lighting and Electrical	1200	SF	$6	$3	$7,200	$3,600	$10,800
Plumbing	1200	SF	$2	$2	$2,400	$2,400	$4,800
Degassing Headboxes	3	EA	$30,000	$10,000	$90,000	$30,000	$120,000
Sand Filtration 1100 gpm ea.	2	EA	$50,000	$10,000	$100,000	$20,000	$120,000
UV Disinfection - 1100 gpm	2	EA	$40,000	$10,000	$80,000	$20,000	$100,000
Duplex Chiller Systems	3	EA	$80,000	$20,000	$240,000	$60,000	$300,000
Duplex Boiler System	4	EA	$30,000	$25,000	$120,000	$100,000	$220,000
Energy Recovery Sump, Pumps HX, & Controls	2	EA	$30,000	$20,000	$60,000	$40,000	$100,000
Piping and Valves	1	LS	$75,000	$75,000	$75,000	$75,000	$150,000
Power and Controls	1	LS	$20,000	$30,000	$20,000	$30,000	$50,000

DESCRIPTION	QTY	UNIT	UNIT COSTS MATL/EQU	UNIT COSTS INSTALL	MATL/EQU COST	INSTALL COST	TOTAL ESTIMATED COST
Emergency Generator	1	EA	$54,000	$3,900	$54,000	$3,900	$57,900
						Subtotal	$1,355,900
Site Work							
Field testing, allowance	1	LS		$50,000	$0	$50,000	$50,000
Temporary power, sani cans, water delivery	1	LS	$20,000		$20,000	$0	$20,000
Temporary site fencing, silt fence and dust control	1	LS	$20,000		$20,000	$0	$20,000
Topsoil stripping, 300hp dozer, 6-inches, and haul off	1000	CY		$15	$0	$15,000	$15,000
Rough Grading, for pavement and gravel areas	3000	SY		$1	$0	$3,000	$3,000
Cut and Fill	1000	CY		$10	$0	$10,000	$10,000
Aggregate Base for foundations and slabs	700	CY	$30	$15	$21,000	$10,500	$31,500
Pavement, 6" base & 4" top	2500	SY	$13		$32,500	$0	$32,500
Concrete Curb	200	LF	$7	$8	$1,400	$1,600	$3,000
Storm drainage system	1	LS	$30,000	$20,000	$30,000	$20,000	$50,000
Site lighting	1	LS	$21,600	$18,400	$21,600	$18,400	$40,000
Fencing, security, 6ft, 9ga aluminized steel	1800	LF	$6	$6	$10,800	$10,800	$21,600
Gates, double swing, 20' open	4	EA	$1,000	$1,000	$4,000	$4,000	$8,000
Main site power w/ stand-by generator	1	LS	$100,000	$100,000	$100,000	$100,000	$200,000
Site communications for instrumentation/alarms	1	LS	$50,000	$50,000	$50,000	$50,000	$100,000
Sewage process system, 5,000 gpd	1	LS	$20,000	$20,000	$20,000	$20,000	$40,000
Landscaping - Allowance	1	LS	$30,000	$20,000	$30,000	$20,000	$50,000
Cultural Resources Observation	1	LS		$20,000	$0	$20,000	$20,000
						Subtotal	$714,600
Process Water Distribution Piping from Headworks							
8-inch RW	900	LF	$25	$25	$22,500	$22,500	$45,000
4-inch RW/HW/CW	1800	LF	$10	$20	$18,000	$36,000	$54,000
4-inch GW	350	LF	$10	$30	$3,500	$10,500	$14,000
2-Inch	1000	LF	$5	$15	$5,000	$15,000	$20,000
Supply Valves	400	EA	$100	$100	$40,000	$40,000	$80,000
Overflow Drains	2000	LF	$25	$25	$50,000	$50,000	$100,000
Misc Valves and Fittings	1	LS	$30,000	$30,000	$30,000	$30,000	$60,000

DESCRIPTION	QTY	UNIT	UNIT COSTS MATL/EQU	UNIT COSTS INSTALL	MATL/EQU COST	INSTALL COST	TOTAL ESTIMATED COST
Live Feed Systems	1	LS	$15,000	$15,000	$15,000	$15,000	$30,000
Formallin System	1	LS	$5,000	$5,000	$5,000	$5,000	$10,000
Meters, Gages, Accessories	1	LS	$10,000	$10,000	$10,000	$10,000	$20,000
						Subtotal	$433,000
Sturgeon and Administration Building (~16,630 Square Feet)							
Site Prep/Erosion Control	1	LS	$10,000	$15,000	$10,000	$15,000	$25,000
Building Shell and Floor	16630	SF	$45	$45	$748,350	$748,350	$1,496,700
HVAC	16630	SF	$6	$6	$99,780	$99,780	$199,560
Lighting and Electrical	16630	SF	$12	$6	$199,560	$99,780	$299,340
Plumbing	16630	SF	$2	$2	$33,260	$33,260	$66,520
Finished Spaces Adder	2740	SF	$40	$40	$109,600	$109,600	$219,200
Diesel fuel storage	1	LS	$30,000	$10,000	$30,000	$10,000	$40,000
Incubation, full heath stacks, w/head trough and piping	2	EA	$4,000	$500	$8,000	$1,000	$9,000
10-foot Forage RBT Tanks	3	EA	$3,000	$1,000	$9,000	$3,000	$12,000
15-Foot RBT Broodstock	1	EA	$6,000	$1,000	$6,000	$1,000	$7,000
15-foot Sturgeon Broodstock	4	EA	$6,000	$1,000	$24,000	$4,000	$28,000
2 x 8-foot Sturgeon Hatch Troughs and Jars	30	EA	$1,300	$500	$39,000	$15,000	$54,000
6-foot Sturgeon Rearing Tanks	15	EA	$1,000	$500	$15,000	$7,500	$22,500
10-foot Sturgeon Rearing Tanks	20	EA	$3,000	$1,000	$60,000	$20,000	$80,000
						Subtotal	$2,558,820
Burbot Building (~5,570 Square Feet)							
Site Prep/Erosion Control	1	LS	$5,000	$8,000	$5,000	$8,000	$13,000
Building Shell and Floor	5570	SF	$45	$45	$250,650	$250,650	$501,300
HVAC	5570	SF	$6	$6	$33,420	$33,420	$66,840
Lighting and Electrical	5570	SF	$12	$6	$66,840	$33,420	$100,260
Plumbing	5570	SF	$2	$2	$11,140	$11,140	$22,280
Live Feed Water Treatment	1	LS	$15,000	$10,000	$15,000	$10,000	$25,000
6 to 10-foot Broodstock tanks	4	EA	$3,000	$500	$12,000	$2,000	$14,000
Dual Incubation Jars and 3-foot Hatch Tanks	20	EA	$750	$500	$15,000	$10,000	$25,000
4-foot Rearing Tanks	24	EA	$800	$500	$19,200	$12,000	$31,200
Monitoring and Alarms	1	LS	$20,000	$20,000	$20,000	$20,000	$40,000

DESCRIPTION	QTY	UNIT	UNIT COSTS MATL/EQU	UNIT COSTS INSTALL	MATL/EQU COST	INSTALL COST	TOTAL ESTIMATED COST
						Subtotal	$838,880
Effluent / Settling Structure – Dual Cell							
Slabs, 6"	44	CY	$60	$250	$2,667	$11,111	$13,778
Walls, 9"	43	CY	$75	$800	$3,250	$34,667	$37,917
Ramp, 8"	8	CY	$60	$400	$474	$3,160	$3,635
Flow Diffusers	2	EA	$2,000	$500	$4,000	$1,000	$5,000
Decanting Valves	2	EA	$1,000	$1,000	$2,000	$2,000	$4,000
						Subtotal	$64,329
Hatchery Housing – Add 2 residences							
Topsoil stripping, 300hp dozer, 6-inches, and spread onsite	100	SY	$0	$5	$0	$500	$500
Driveways - Gravel top course	30	CY	$25	$15	$750	$450	$1,200
2000 Square Foot House with 2- car Garage	2	EA	$120,000	$80,000	$120,000	$80,000	$400,000
On site Septic System - 3 Bedroom house	2	EA	$7,500	$5,000	$15,000	$10,000	$25,000
Water, Power, Telephone	2	EA	$5,000	$5,000	$10,000	$10,000	$20,000
						Subtotal	$446,700
Offsite Electrical (3 Phase Feeder)							
Offsite Electrical (3 phase Feeder)	1	LS					$80,000
						Subtotal	$80,000
						Construction Cost Subtotal	$8,260,729
						Inflation / Escalation to Mid-Point Construction	$1,197,806
						Mob/Demob, GC's	$1,239,109
						Subtotal	$10,697,644
						Contigency	$2,139,529
						Taxes	$256,743
						Total Estimated Cost	$13,094,000

Notes & Assumptions;

- Estimates are escalated from 2009 dollars at 4.5% annually to an assumed mid-point construction date of June 2012

Appendix E-3: Estimated (Detailed) Construction Costs – Twin Rivers Hatchery Separable Components

DESCRIPTION	QTY	UNIT	UNIT COSTS		MATL/EQU COST	INSTALL COST	TOTAL ESTIMATED COST
			MATL/EQU	INSTALL			
Burbot Ponds (6)							
Strip Topsoil	750	CY		$15	$0	$11,250	$11,250
Excavation and Backfill	500	CY		$15	$0	$7,500	$7,500
Clay Liner	1280	SY	$5	$5	$6,400	$6,400	$12,800
Harvest Kettles	6	EA	$8,000	$15,000	$48,000	$90,000	$138,000
Supply And Drain Piping and Valves	6	EA	$5,000	$5,000	$30,000	$30,000	$60,000
Structural Fill and Compaction	100	CY	$30	$15	$3,000	$1,500	$4,500
Gravel Berm Surfacing	150	CY	$30	$10	$4,500	$1,500	$6,000
Railings	100	LF	$25	$25	$2,500	$2,500	$5,000
Predator Netting	6	EA	$300	$600	$1,800	$3,600	$5,400
						Const Cost Subtotal	$250,450
						Inflation / Escalation to Mid-Point Construction	$36,315
						Mob/Demob, GC's	$37,568
						Subtotal	$324,333
						Contingency	$64,867
						Taxes	$7,784
						Total Estimated Cost	$397,000
Sturgeon Spawning Channels (2) 20' x 8' d							
Strip Topsoil	500	CY		$15	$0	$7,500	$7,500
Excavation and Backfill	500	CY		$15	$0	$7,500	$7,500
Concrete Slabs	90	CY	$100	$400	$9,000	$36,000	$45,000
Concrete Walls	110	CY	$100	$800	$11,000	$88,000	$99,000
Baffles	1	LS	$10,000	$5,000	$10,000	$5,000	$15,000
Bottom Gratings	2000	SF	$20	$20	$40,000	$40,000	$80,000
Propellers	12	EA	$1,000	$500	$12,000	$6,000	$18,000
Power / Controls	1	LS	$10,000	$10,000	$10,000	$10,000	$20,000
Supply And Drain Piping and Valves	2	EA	$3,000	$1,000	$6,000	$2,000	$8,000
Removable Media	2	EA	$5,000	$2,000	$10,000	$4,000	$14,000
Predator Netting	2000	SF	$5	$5	$10,000	$10,000	$20,000
						Const Cost Subtotal	$334,000

DESCRIPTION	QTY	UNIT	UNIT COSTS		MATL/EQU COST	INSTALL COST	TOTAL ESTIMATED COST
			MATL/EQU	INSTALL			
Inflation / Escalation to Mid-Point Construction							$48,430
Mob/Demob, GC's							$50,100
Subtotal							$432,530
Contingency							$86,506
Taxes							$10,381
Total Estimated Cost							$529,000
Sturgeon Remote Rearing Units – Two Locations							
Site Prep/ Access and Security Improvements	2	LS	$10,000	$10,000	$20,000	$20,000	$40,000
Intake Screen and Piping	2	LS	$5,000	$5,000	$10,000	$10,000	$20,000
Custom Trailer Unit	2	LS	$75,000	$5,000	$150,000	$10,000	$160,000
Effluent Piping	2	LS	$1,000	$1,000	$2,000	$2,000	$4,000
Const Cost Subtotal							$224,000
Inflation / Escalation to Mid-Point Construction							$32,480
Mob/Demob, GC's							$11,200
Subtotal							$267,680
Contingency							$53,536
Taxes							$6,424
Total Estimated Cost							$328,000

Notes & Assumptions;

- Estimates are escalated from 2009 dollars at 4.5% annually to an assumed mid-point construction date of June 2012

Appendix E-4: Estimated (Detailed) Construction Costs – Twin Rivers: Estimates of Burbot Program Facilities

Option 1 – Full Build-out of Burbot and Sturgeon Facilities (Embedded Value of Burbot Program Facilities)

DESCRIPTION	TOTAL SINGLE CONTRACT	COMPONENT OF COST FOR BURBOT FACILITIES % OF TOTAL	2012 BURBOT COST
River Water Supply Intakes	$1,554,000	20%	$310,800
Groundwater Supply	$214,500	20%	$42,900
Water Treatment Building	$1,355,900	20%	$271,180
Site Work	$714,600	24%	$171,504
Process Water Distribution Piping from Headworks	$433,000	30%	$129,900
Sturgeon and Administration Building (~16,630 Square Feet)	$2,558,820	0%	$0
Burbot Building (~5,570 Square Feet)	$838,880	100%	$838,880
Effluent / Settling Structure – Dual Cell	$64,329	0%	$0
Hatchery Housing – Add 2 residences	$446,700	0%	$0
Offsite Electrical (3 Phase Feeder)	$80,000	0%	$0
Construction Cost Subtotal	$8,260,729		$1,765,164
Inflation / Escalation to Mid-Point Construction	$1,197,806		$255,949
Mob/Demob, General Conditions	$1,239,109		$264,775
Subtotal	$10,697,644		$2,285,887
Contingency	$2,139,529		$4,57,177
Taxes	$256,743		$54,861
Total Estimated Cost	$13,094,000		$2,797,926

Notes & Assumptions;

- Fully build-out the burbot building (as originally proposed in this Master Plan), including all process piping, mechanical, electrical and plumbing.

Option 2 – Phased Development of Burbot Building and Site Work

DESCRIPTION	INITIAL CONTRACT TOTAL FOR STURGEON FACILITY and BURBOT UTILITIES	COST OF PHASED BURBOT BUILD-OUT	
		BUILDING ESTIMATE (STAND ALONE)	TOTAL PROJECT COST (INCLUDING STAND ALONE COST OF BUILDING DUE TO DELAY)
River Water Supply Intakes	$1,554,000		
Groundwater Supply	$214,500		
Water Treatment Building	$1,355,900		
Site Work	$543,096	$188,654	
Process Water Distribution Piping from Headworks	$303,100	$142,890	
Sturgeon and Administration Building (~16,630 Square Feet)	$2,558,820		
Burbot Building (~5,570 Square Feet)	$0	$922,768	
Effluent / Settling Structure – Dual Cell	$64,329		
Hatchery Housing – Add 2 residences	$446,700		
Offsite Electrical (3 Phase Feeder)	$80,000		
Construction Cost Subtotal	$7,120,445	$1,254,312	$8,374,757
Inflation / Escalation to Mid-Point Construction	$1,032,465	$313,578	$1,346,043
Mob/Demob, General Conditions	$1,068,067	$188,147	$1,256,214
Subtotal	$9,220,976	$1,756,037	$10,977,014
Contingency	$1,844,195	$439,009	$2,283,205
Taxes	$221,303	$43,901	$265,204
Total Estimated Cost	$11,286,475	$2,238,948	$13,525,423

Notes & Assumptions;

- Addition of 10% to costs for additional tie-ins
- Under this scenario, the 5,750 square foot burbot wing would be omitted from the initial project construction contract. It could be built two to three years later under a separate contract. River and groundwater supply systems and process water treatment room equipment would be over-sized for the sturgeon program so that it would accommodate future burbot program water requirements.

Option 3 – Construct Burbot Building Shell and Perform Site Work in Initial Contract

DESCRIPTION	INITIAL CONTRACT TOTAL	BURBOT BUILDING (MECHANICAL, ELECTRICAL, PLUMBING)	
	INITIAL CONTRACT TOTAL FOR STURGEON FACILITY AND BURBOT SHELL AND SITE WORK	ESTIMATE TO COMPLETE BURBOT BUILDING REQUIREMENTS (STAND ALONE)	TOTAL PROJECT COSTS (INCLUDING COMPLETION OF REMAINING BUILDING REQUIREMENTS)
River Water Supply Intakes	$1,554,000		
Groundwater Supply	$214,500		
Water Treatment Building	$1,355,900		
Site Work	$714,600		
Process Water Distribution Piping from Headworks	$433,000	$142,890	
Sturgeon and Administration Building (~16,630 Square Feet)	$2,558,820		
Burbot Building (~5,570 Square Feet)	$514,300	$357,038	
Effluent / Settling Structure – Dual Cell	$64,329		
Hatchery Housing – Add 2 residences	$446,700		
Offsite Electrical (3 Phase Feeder)	$80,000		
Construction Cost Subtotal	$7,936,146	$499,928	$8,436,077
Inflation / Escalation to Mid-Point Construction	$1,150,742	$124,982	$1,275,724
Mob/Demob, General Conditions	$1,190,422	$74,989	$1,265,412
Subtotal	$10,277,313	$699,899	$10,977,212
Contingency	$2,055,463	$174,975	$2,230,437
Taxes	$246,656	$17,497	$264,153
Total Estimated Cost	$12,579,431	$892,371	$13,471,803

Notes & Assumptions;

- Addition of 10% to costs for additional tie-ins
- The 5,750- square- foot burbot building shell and floor slab would be constructed as part of the initial construction contract. Rough-in mechanical, electrical, plumbing, and process water piping stub-outs would be included.

Appendix F

Excerpt from Libby Dam Biological Opinion

Appendix F

Excerpt from the USFWS Biological Opinion for Operation of Libby Dam by the US Army Corps of Engineers and the Bonneville Power Administration

The US Fish and Wildlife Service issued a Biological Opinion (BiOp) on February 18, 2006 addressing the effects of Libby Dam operations on endangered Kootenai River white sturgeon (*Acipenser transmontanus*) and threatened bull trout (*Salvelinus confluentus*). This document can be accessed at the Kootenai Tribe's website: http://www.kootenai.org/fish_resources.html.

In this BiOp, the USFWS identified a number of reasonable and prudent alternatives (RPA) formulated to reduce the effects of Libby Dam operations on these species. RPA Component 4 recommends continued support of a conservation aquaculture program for Kootenai sturgeon. The intent of this RPA is to counteract the low rates of successful embryo incubation through hatching, and low rates of successful free embryo incubation through yolk sac absorption attributed to the poor habitat conditions created by Libby Dam operations.

RPA Component 4: Conservation Aquaculture Program

The Kootenai sturgeon population estimates have declined, and the next generation of these fish will be produced primarily from the Conservation Aquaculture Program spawning wild adults. Population projections describe a significant bottleneck in spawner numbers as the wild population declines and the hatchery fish are not yet mature. Maintaining the Conservation Aquaculture Program and increasing numbers of juveniles produced per family in the hatchery will maintain the future of the Kootenai sturgeon population.

Action 4.1. The action agencies shall continue the conservation aquaculture program until advised otherwise by the Service.

Action 4.2. By February 2, 2007, the action agencies shall provide funding for the Kootenai sturgeon aquaculture program to expand adult holding and spawning capability.

Action 4.3. During years when full scale habitat restoration or creation actions are not being evaluated, the action agencies shall continue to provide funding for large scale fertilized egg releases.

Action 4.4. The action agencies shall maintain current levels of Kootenai sturgeon monitoring during the term of the action (20062015).

This page is intentionally blank.

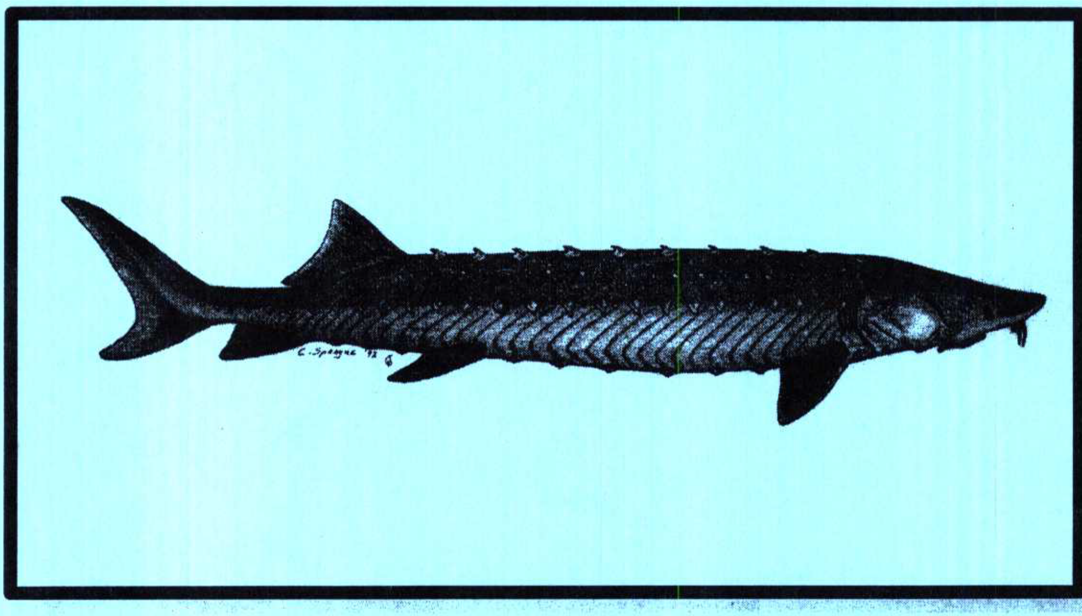
Appendix G

USFWS Kootenai River White Sturgeon Recovery Plan

U.S. Fish & Wildlife Service

Recovery Plan for the Kootenai River Population of the White Sturgeon

(Acipenser transmontanus)



Recovery Plan for the White Sturgeon (*Acipenser transmontanus*): Kootenai River Population

Published by
Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: Anne Badgley
Regional Director, Region 1, U.S. Fish and Wildlife Service

Date: 9/30/99

DISCLAIMER PAGE

Recovery plans delineate reasonable actions that are believed necessary to recover or protect the species. Plans are prepared by the U.S. Fish and Wildlife Service, sometimes with the assistance of recovery teams, contractors, State agencies, Tribal agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. Recovery plans represent the official position of the U.S. Fish and Wildlife Service *only* after they have been signed by the Director or Regional Director as *approved.* Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature Citation: U.S. Fish and Wildlife Service. 1999. Recovery Plan for the White Sturgeon (*Acipenser transmontanus*): Kootenai River Population. U.S. Fish and Wildlife Service, Portland, Oregon. 96 pp. plus appendices.

Additional copies may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814-2158
301-492-6403 or 1-800-582-3421
E-mail: fwrs@mail.fws.gov
http://fa.r9.fws.gov/r9fwrs/

The fee for the Plan varies depending on the number of pages of the Plan.

ACKNOWLEDGMENTS

Cover art for this plan was graciously provided by Calvin R. Sprague. The Recovery Plan was prepared by the Kootenai River White Sturgeon Recovery Team comprising the following individuals: [1]

Kootenai River White Sturgeon Recovery Team

Steve Duke
Team Leader
U.S. Fish and Wildlife Service
Snake River Basin Office
1387 S. Vinnell Way, Suite 368
Boise, Idaho 83709

Paul Anders
University of Idaho
Fish Genetics Lab
Aquaculture Research Institute
Moscow, Idaho 83844

Gordon Ennis
Canada Dept of Fisheries and Oceans
555 West Hastings Street
Vancouver, British Columbia
Canada V6B 5G3

Robert Hallock, PhD
U.S. Fish and Wildlife Service
Upper Columbia Basin Office
11103 East Montgomery Dr., #2
Spokane, Washington 99206

Jay Hammond
British Columbia Ministry of
Environment, Lands and Parks
401-333 Victoria Street
Nelson, British Columbia
Canada V1L 4K3

Sue Ireland
Kootenai Tribe of Idaho
P.O. Box 1269
Bonners Ferry, Idaho 83805

Jeff Laufle
U.S. Army Corps of Engineers
P.O. Box 3755
Seattle, Washington 98124

Larry Lockard
U.S. Fish and Wildlife Service
Ecological Services
780 Creston Hatchery Road
Kalispell, Montana 59901

Brian Marotz
Montana Fish, Wildlife & Parks
490 North Meridian Road
Kalispell, Montana 59901

Vaughn L. Paragamian
Idaho Department of Fish and Game
2750 W. Kathleen Ave.
Coeur d'Alene, Idaho 83814

Scott Bettin
Bonneville Power Administration
P.O. Box 3621-EWI
Portland, Oregon 97208

[1] Ray Lauzier, Canada DFO and Rick Westerhof, BPA, were members of the recovery team during development of the draft recovery plan.

EXECUTIVE SUMMARY

Recovery Plan for the White Sturgeon (*Acipenser transmontanus*): Kootenai River Population

<u>**Current Species Status**</u>: The Kootenai River population of white sturgeon was listed as endangered on September 6, 1994 (59 FR 45989). This white sturgeon population has been in general decline since the mid-1960's. In 1997 the population was estimated to be approximately 1,468 wild fish with few individuals less than 25 years of age. In 1997, the wild population was augmented with the release of 2,283 juvenile white sturgeon reared in the Kootenai Tribal hatchery in Bonners Ferry, Idaho.

<u>**Habitat Requirements and Limiting Factors**</u>: The Kootenai River population of white sturgeon became isolated from other white sturgeon in the Columbia River basin during the last glacial age (approximately 10,000 years ago). Once isolated, the population adapted to the predevelopment habitat conditions in the Kootenai River drainage. Historically, spring runoff peaked during the first half of June in the Kootenai River upstream of the existing Libby Dam in Montana. Runoff from lower elevations between Libby Dam and Bonners Ferry, Idaho was somewhat earlier, peaking in late May. Combined flows were often in excess of 1,700 cubic meters per second (m^3/s) (60,000 cubic feet per second (cfs)). During the remainder of the year, river flows declined to basal conditions of 113 to 226 cubic meters per second (4,000 to 8,000 cubic feet per second). Annual flushing events re-sorted river sediments providing a clean cobble substrate conducive to insect production and sturgeon egg incubation. Side channels and low-lying deltaic marsh lands were undiked at this time, providing productive, low velocity backwater areas. Nutrient delivery in the system was unimpeded by dams and occurred primarily during spring runoff. Flood plain ecosystems like the predevelopment Kootenai River are characterized by seasonal floods that promote the exchange of nutrients and organisms in a mosaic of habitats and thus enhance biological productivity (Bayley 1995; Junk et al. 1989; Sparks 1995).

Modification of the Kootenai River white sturgeon's habitat by human activities has changed the natural hydrograph of the Kootenai River, altering white sturgeon spawning, egg incubation, and rearing habitats; and reducing overall biological productivity. These factors have contributed to a general lack of recruitment in the white sturgeon population since the mid-1960's.

Recovery Objectives: **Downlisting and Delisting.** The short-term recovery objectives are to re-establish successful natural recruitment and prevent extinction through the use of conservation aquaculture. The long-term objective is to downlist and then delist the fish when the population becomes self-sustaining.

Recovery Criteria: Criteria required for reclassification or downlisting to threatened status include:

1. Natural production of white sturgeon occurs in at least 3 different years of a 10-year period; a naturally produced year class is demonstrated when at least 20 juveniles from a year class are sampled at more than 1 year of age.

2. The estimated white sturgeon population is stable or increasing and juveniles reared through a conservation aquaculture program are available to be added to the wild population each year for a 10-year period. Each of these year classes must be large enough to produce 24 to 120 sturgeon surviving to sexual maturity.

3. A long-term Kootenai River Flow Strategy is developed in coordination with interested State, Federal, and Canadian agencies and the Kootenai Tribe at the end of the 10-year period based on results of ongoing conservation efforts, sturgeon habitat research, and fish productivity studies. An important element of this strategy is demonstration of the repeatability of in-stream environmental conditions necessary to produce recruits (as described above) in future years.

Specific delisting recovery criteria have not been identified at this time, but will be developed as new population status, life history, biological productivity, and flow augmentation monitoring information is collected. However, recovery will not be complete until there is survival to maturity and natural reproduction of juvenile white sturgeon added to the wild population from the conservation aquaculture program. This may take upwards of 25 years since that is the approximate period for juvenile female white sturgeon to reach sexual maturity and reproduce to complete a new generation or spawning cycle.

Actions Needed:

- o Identify and restore white sturgeon habitats necessary to sustain white sturgeon reproduction (spawning and early age recruitment) and rearing while minimizing impacts on other uses of Kootenai River basin waters.

- Develop and implement a conservation aquaculture program to prevent the extinction of Kootenai River white sturgeon. The conservation aquaculture program will include protocols on broodstock collection, propagation, juvenile rearing, fish health, genetics, and stocking.

- Work within operational guidelines for Libby Dam based upon Kootenai Integrated Rule Curves (KIRC) developed by Montana Fish, Wildlife, and Parks to balance white sturgeon recovery with requirements for other aquatic species and recreational fisheries within the Kootenai River drainage, and VARQ (an enhanced flood control protocol), to ensure that more water is available for white sturgeon, salmon, and all species in lower water years.

- Continue research and monitoring programs (with achievable and measurable objectives) on life history, habitat requirements for all life stages, population status, and trends of the Kootenai River white sturgeon.

- Protect Kootenai River white sturgeon and their habitats using available regulatory mechanisms.

- Evaluate how changes in biological productivity in the Kootenai River basin affect white sturgeon and their habitats.

- Evaluate the effects of contaminants and possible additional biological threats, e.g. predation and species composition, on Kootenai River white sturgeon and their habitats.

- Increase public awareness of the need to protect and recover Kootenai River white sturgeon.

- Balance white sturgeon recovery measures with requirements for other aquatic species and recreational fisheries within the Kootenai River drainage.

- Secure funding for implementation of recovery tasks.

Estimated Cost of Recovery : Costs for some tasks are estimated to be $7,456,000 for the first 5 fiscal years. Total estimated recovery costs will likely increase as new information is received and as the ongoing biological studies are completed. Estimated costs do not include costs associated with native fish monitoring tasks. Future total costs may also decrease as some research tasks are completed.

Other Physical and Economic Impacts from Recovery: Implementing many of the conservation actions proposed in this recovery plan will create additional economic or environmental impacts, as well as associated benefits, not normally considered in estimating the "costs" of recovery. Economic or environmental impacts may include foregone power generation opportunities, reduced flood control, and possibly negative impacts to other regional resident fish.

Associated benefits include the partial restoration of a more natural Kootenai River hydrograph and flood plain function that benefits resident fish and wildlife. Periodic flushing flows would cleanse Kootenai River gravels and improve aquatic insect production. Improving aquatic ecosystem health leading to improved regional fisheries will provide secondary economic benefits to local communities. Such benefits go beyond the "benefits" typically considered in recovery actions. Conversely, failure to implement proposed recovery actions would have hidden costs that are typically not considered in cost/benefit analysis.

Date of Recovery: At a minimum, at least 25 years following implementation of an approved recovery plan are necessary before delisting of the white sturgeon population can be considered. This 25-year period would allow juveniles added to the population in the first 10 years to reach maturity and begin reproducing a new generation.

What is a recovery plan? A recovery plan is a template for the recovery of threatened or endangered species and their habitats. The recovery plan describes the process by which the decline of a listed species may be reversed and known threats to its long-term survival can be removed. Therefore, recovery is the restoration of a listed species to the point where they become secure, self-sustaining components of their ecosystem.

An approved recovery plan is not a decision document but is intended to provide information and guidance that the U.S. Fish and Wildlife Service believes will lead to recovery of a listed species, including its habitat. The recovery plan provides information necessary to describe the current status of the listed species as well as on-going or proposed actions designed to aid in the species ultimate recovery. Many of the recovery actions (or tasks) in this document will require further environmental analysis and public review, especially those actions taken by Federal agencies.

This final recovery plan serves as a guidance document listing various conservation actions for the recovery of the white sturgeon population within the Kootenai River basin and the ecosystem upon which it depends. It was developed by a recovery team composed of persons from State, Federal, Tribal, and Canadian agencies who have experience with this population of white sturgeon or the threats it faces. Because the white sturgeon population is only one component of its ecosystem, the recovery team took a holistic approach that will address other sensitive aquatic species that are dependent upon the Kootenai River drainage. Efforts proposed for Kootenai River white sturgeon recovery should benefit many other native aquatic species and possibly aid the restoration of declining species in Kootenai River drainage habitats before their status becomes critical. However, actions that will directly benefit the white sturgeon are given highest priority. Other lower priority actions, which could benefit nonlisted aquatic species and further contribute to overall ecosystem recovery, are also included in the recovery plan.

What is the Kootenai River ecosystem? An ecosystem is defined as an ecological community that together with its environment, functions as a unit. For the purposes of this recovery plan, the Kootenai River ecosystem is defined as the habitat and aquatic species complex within the Kootenai drainage basin including Koocanusa Reservoir upstream of Libby Dam, Kootenai River downstream including tributary streams, backwater sloughs, deltaic marshlands, and Kootenay Lake in British Columbia downstream to Corra Linn Dam at the outlet of the West Arm of Kootenay Lake. (Kootenai is spelled Kootenay in Canada.)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

Anecdotal Evidence	Information passed along by word of mouth but not documented scientifically.
Bedload	Streambed materials that are washed downstream and redeposited in a new location.
Biological Productivity	A measure of growth in living systems.
Biological Trophic Levels	Steps in the food chain from plants through plant eaters to meat eaters.
Biomass	The total weight of a living organism or a population of organisms.
Chlorinated Biphenyls	A contaminant that accumulates in the fatty tissues of organisms that can cause health problems.
Community Respiration	The amount of energy used by all of the organisms in a specified locality.
Conservation Aquaculture	A hatchery-based, captive culture program designed to 1) preserve the Kootenai River white sturgeon gene pool (genetic variation) and 2) rebuild the natural age class structure of white sturgeon in the wild through the release of hatchery-reared juvenile fish. The program is based on a breeding plan that includes protocols on adult broodstock collection, hatchery spawning and rearing, fish health, and genetics.

Delta (as in tributary)	Streambed materials that accumulate near the mouth of a stream.
Discharge	Water flow volume, usually used to describe a volume released from a dam.
Electrophoretic Analysis	A laboratory technique to examine genetic differences between similar species. Protein samples are placed in an electrical field producing bands on a gel plate. The bands are used like fingerprints to distinguish genetic traits.
Empirical Data	Information derived from measurements made in "real life" situations (e.g. field data).
Flow Ramping	The act of creating a gradual rather than abrupt change in flow. Typically used to define allowable fluctuations below a hydropower dam.
Gas supersaturation	Aquatic conditions that result from turbulence that allows water to absorb nitrogen or oxygen from air bubbles trapped several feet below the surface. As these waters rise back to the surface, they become supersaturated because pressure drops. Some of these gases may become trapped in a fish's blood vessels and cause injury or death.
Habitat Use Curve	A graph describing the distribution/occurrence of fish over a range of a specific environmental variable (e.g. velocity, temperature or depth).

Hydrograph	The recorded variations in stream discharge over time. Useful when comparing effects and changes in stream flow and depth between average natural conditions and altered stream flows (i.e. from dams and diversions).
In-stream Flow Incremental Methodology (IFIM)	A process that uses river channel measurements and hydraulic characteristics to estimate the amount of available fish habitat under various river discharges.
Koocanusa Reservoir	Also known as Libby Reservoir or Lake Koocanusa, located upstream of Libby Dam.
Kootenay Lake	A natural lake in British Columbia, which is regulated by Corra Linn Dam. The Kootenai River, downstream of Libby Dam enters Kootenay Lake from the south.
Limnological (limnology)	The science of the properties of fresh water including water chemistry, density, stratification and physical effects on living organisms.
Load Following	Short-term changes in hydropower operations to respond to subtle shifts in power demand. Flow fluctuations caused by load following are usually less dramatic than power peaking.
Microhabitat	Detailed description of where an animal lives.
Nutrient Dynamics	The way nutrients are used and reused, over time and distance, in a biological system.

Organochlorides	Complex toxic molecule containing carbon and chlorine that is soluble in fatty tissues and can cause health problems.
Photoperiod	A measurement of time exposed to light in a given day or series of days.
Power Peaking	Hydropower operations that occur for short time periods. Typically more power is generated during the day than at night, causing changes in stream flows.
Redox Potential	A measurable electric charge (volts) created when an oxidizing agent pulls electrons away from a reducing agent. This action is an important factor in nutrient cycling in water.
Recruitment	Survival of juveniles until they become a member of the spawning population.
Relative Abundance	A comparison of the number in one category to another (e.g. number of one species to another, male to female, young to old, etc.). Typically expressed as a percentage or proportion.
Reservoir Drawdown	Removing water from a reservoir and lowering the surface elevation.
Scutes	Hard ridges or bony structures along the back of sturgeons.
Tributary	A small stream or river, which enters and increases the volume of the receiving river, lake, or reservoir.
Vermiculite	A mineral mined from the earth having fire retardant and insulating properties.

Year class	All individuals of a fish population spawned and hatched in a given year.

LIST OF SYMBOLS AND ABBREVIATIONS

Act	Endangered Species Act of 1973 (as amended)
B.C.	British Columbia
B.A.	Biological Assessment
B.O.	Biological Opinion
BPA	Bonneville Power Administration
BR	Bureau of Reclamation
cfs	cubic feet per second
C.I.	confidence interval
cm	centimeter
DFO	Canada Department of Fisheries and Oceans
FCRPS	Federal Columbia River Power System
FWS	U.S. Fish and Wildlife Service
IDFG	Idaho Department of Fish and Game
in	inch
IRC	Integrated Rule Curves
kg	kilogram
KIRC	Kootenai Integrated Rule Curves
km	kilometer
KRBSC	Kootenai River Basin Steering Committee
KTOI	Kootenai Tribe of Idaho
lb	pound
MELP	British Columbia Ministry of Environment, Lands and Parks
mi	mile
MFWP	Montana Department of Fish, Wildlife, and Parks
m^3/s	cubic meters per second
NMFS	National Marine Fisheries Service
NPPC	Northwest Power Planning Council
PCB	polychlorinated biphenyl
ppm	parts per million
Program	Columbia River Basin Fish and Wildlife Program
PSMFC	Pacific States Marine Fisheries Commission
rkm	river-kilometer

rm	river-mile
Service	U.S. Fish and Wildlife Service
U.S.	United States
USACE	U.S. Army Corps of Engineers

PART 1 - INTRODUCTION

A. Overview

On September 6, 1994, the U.S. Fish and Wildlife Service listed the Kootenai River population of white sturgeon as an endangered species (59 FR 45989) under the authority of the Endangered Species Act of 1973, as amended.

The Kootenai River population is one of several land-locked populations of white sturgeon found in the Pacific Northwest. Although officially termed and listed as the "Kootenai River population of white sturgeon", this white sturgeon population inhabits and migrates freely in the Kootenai River from Kootenai Falls in Montana downstream into Kootenay Lake, British Columbia, Canada (Figure 1).

The Endangered Species Act specifies that recovery plans should, to the maximum extent practicable, give priority to those listed species most likely to benefit from recovery actions. The recovery priority for the Kootenai River population of white sturgeon is 3C indicating that: 1) taxonomically, it is a "distinct population segment" of a species; 2) it is subject to a high degree of threat; 3) the recovery potential is high; and 4) the degree of potential for conflict with construction or other development projects is high.

B. General Description

White sturgeon (*Acipenser transmontanus*) occur along the Pacific coast from the Aleutian Islands to central California. In unimpounded river systems, the species migrates between the sea and fresh water, and reproduces in at least three large river systems: the Sacramento-San Joaquin River in California, the Columbia River basin in the Pacific Northwest, and the Fraser River system in British Columbia. The Kootenai River population of white sturgeon is one of 18 land-locked populations of white sturgeon found in the Pacific Northwest. Their distribution extends from Kootenai Falls, Montana, located 50 river-kilometers [rkm] (31 river-miles [rm]) below Libby Dam, downstream through Kootenay Lake to Corra Linn Dam on the lower West Arm of Kootenay Lake, British Columbia.

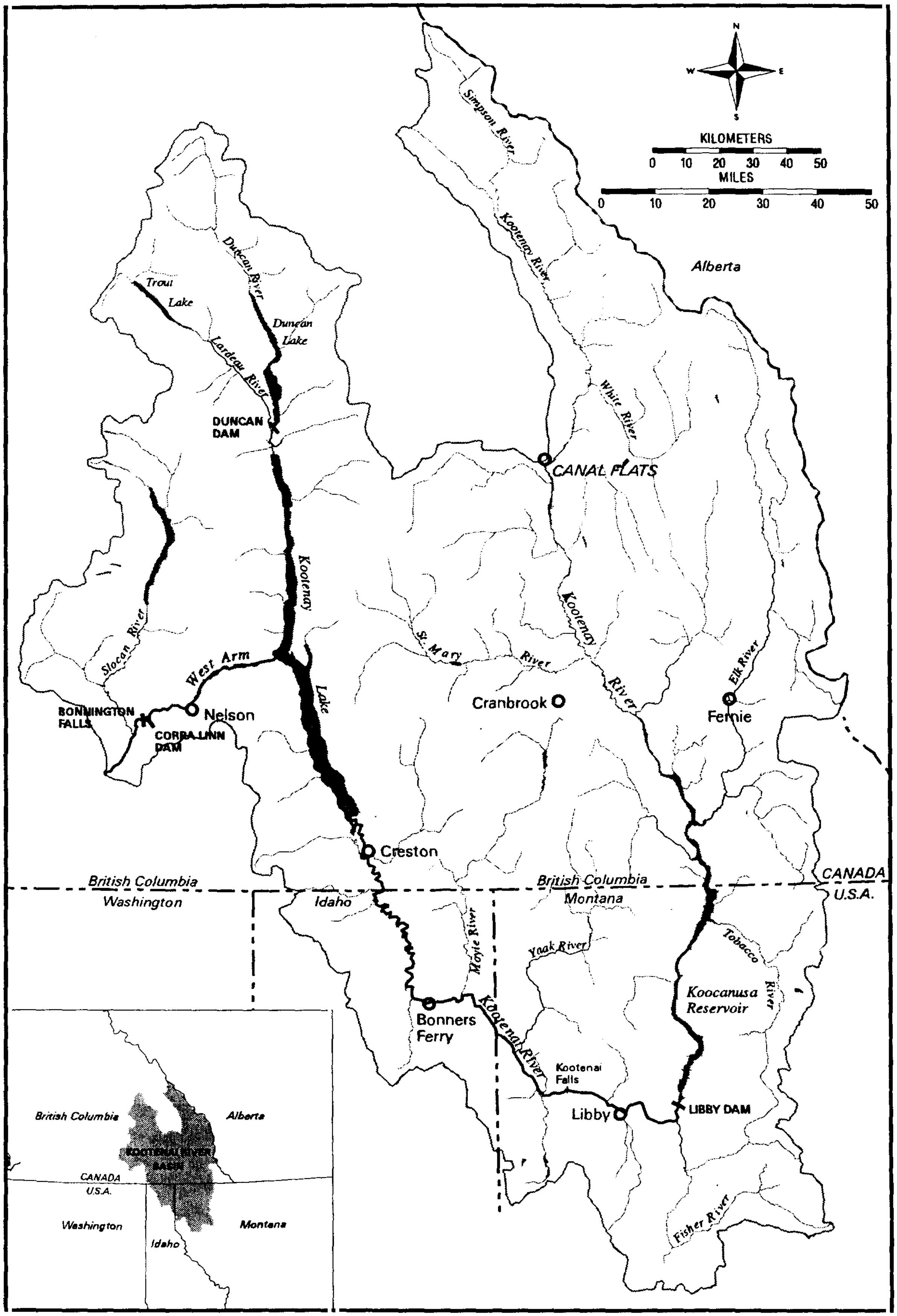


Figure 1. Map of the Kootenai River Basin.

Kootenai Falls may represent an impassible natural barrier to the upstream migration of white sturgeon although anecdotal evidence suggests the historic presence of white sturgeon upstream from Kootenai Falls in Montana and British Columbia. A natural barrier at Bonnington Falls downstream of Kootenay Lake has isolated the Kootenai River white sturgeon from other white sturgeon populations in the Columbia River basin since the last glacial age, approximately 10,000 years ago (Northcote 1973).

White sturgeon are included in the family Acipenseridae, which consists of 4 genera and 24 species of sturgeon. Eight species of sturgeon occur in North America with white sturgeon being one of five species in the genus *Acipenser*. White sturgeon were first described by Richardson in 1863 from a single specimen collected in the Columbia River near Fort Vancouver, Washington (Scott and Crossman 1973). White sturgeon are distinguished from other *Acipenser* by the specific arrangement and number of scutes (bony plates) along the body (Scott and Crossman 1973). The largest white sturgeon on record, weighing approximately 682 kilograms (1,500 pounds), was taken from the Snake River near Weiser, Idaho in 1898 (Simpson and Wallace 1982). Scott and Crossman (1973) describe a white sturgeon reported to weigh over 818 kilograms (1,800 pounds) from the Fraser River near Vancouver, British Columbia, date unknown. Individuals in landlocked populations tend to be smaller. The largest white sturgeon reported from the Kootenai River basin is a 159 kilograms (350 pounds) individual estimated at 85 to 90 years of age captured in Kootenay Lake during September 1995 (Lindsay 1995). White sturgeon are generally long-lived, with females living from 34 to 70 years (PSMFC 1992).

The size or age at first maturity for white sturgeon in the wild is quite variable (PSMFC 1992). In the Kootenai River system, females have been documented to mature as early as age 22 and males at age 16 (Paragamian et al. 1997). Only a portion of adult white sturgeon are reproductive or spawn each year, with the spawning frequency for females estimated at 2 to 11 years (PSMFC 1992). Spawning occurs when the physical environment permits egg development and cues ovulation. White sturgeon are broadcast spawners, releasing their eggs and sperm in fast water. Based upon recent studies, Kootenai River white sturgeon spawn during the period of historical peak flows from May through July

(Apperson and Anders 1991; Marcuson 1994). Spawning at peak flows with high water velocities disperses and prevents clumping of the adhesive eggs. Following fertilization, eggs adhere to the river substrate and hatch after a relatively brief incubation period of 8 to 15 days, depending on water temperature (Brannon et al. 1984). Recently hatched yolk-sac larvae swim or drift in the current for a period of several hours and then settle back into interstitial spaces in the substrate. Larval white sturgeon require an additional 20 to 30 days to metamorphose into juveniles with a full complement of fin rays and scutes.

Historically (pre-Libby Dam construction and operation), spawning areas for white sturgeon were not specifically known. White sturgeon monitoring programs conducted from 1990 through 1995 revealed that white sturgeon spawned within a 19 river-kilometer (12 river-mile) stretch of the Kootenai River, primarily from Bonners Ferry downstream to the lower end of Shorty's Island (Figure 2).

White sturgeon in the Kootenai River system and elsewhere are considered opportunistic feeders. Partridge (1983) found white sturgeon more than 70 centimeters (28 inches) in length feeding on a variety of prey items including clams, snails, aquatic insects, and fish. Andrusak (MELP, pers. comm., 1993) noted that kokanee (*Oncorhynchus nerka*) in Kootenay Lake, prior to a dramatic population crash beginning in the mid-1970's, were once considered an important prey item for adult white sturgeon.

Partridge (1983) noted that white sturgeon recruitment was intermittent and possibly decreasing from the mid-1960's to 1974 when Libby Dam started operations. This is demonstrated by the absence of white sturgeon year classes in samples collected in the early 1980's (i.e. 1965 to 1969, 1971, and 1975). Partridge speculated that the lack of recruitment in certain years was due in part to (1) the elimination of rearing areas for juveniles through diking of slough and marsh side-channel habitats; and (2) the increase in chemical pollutants, e.g. copper and zinc, released in the past from mineral processing facilities, which may have affected spawning or recruitment success.

Previous estimates of population size suggested that the Kootenai River white sturgeon population had declined from an estimated 1,194 fish in 1982 (Partridge

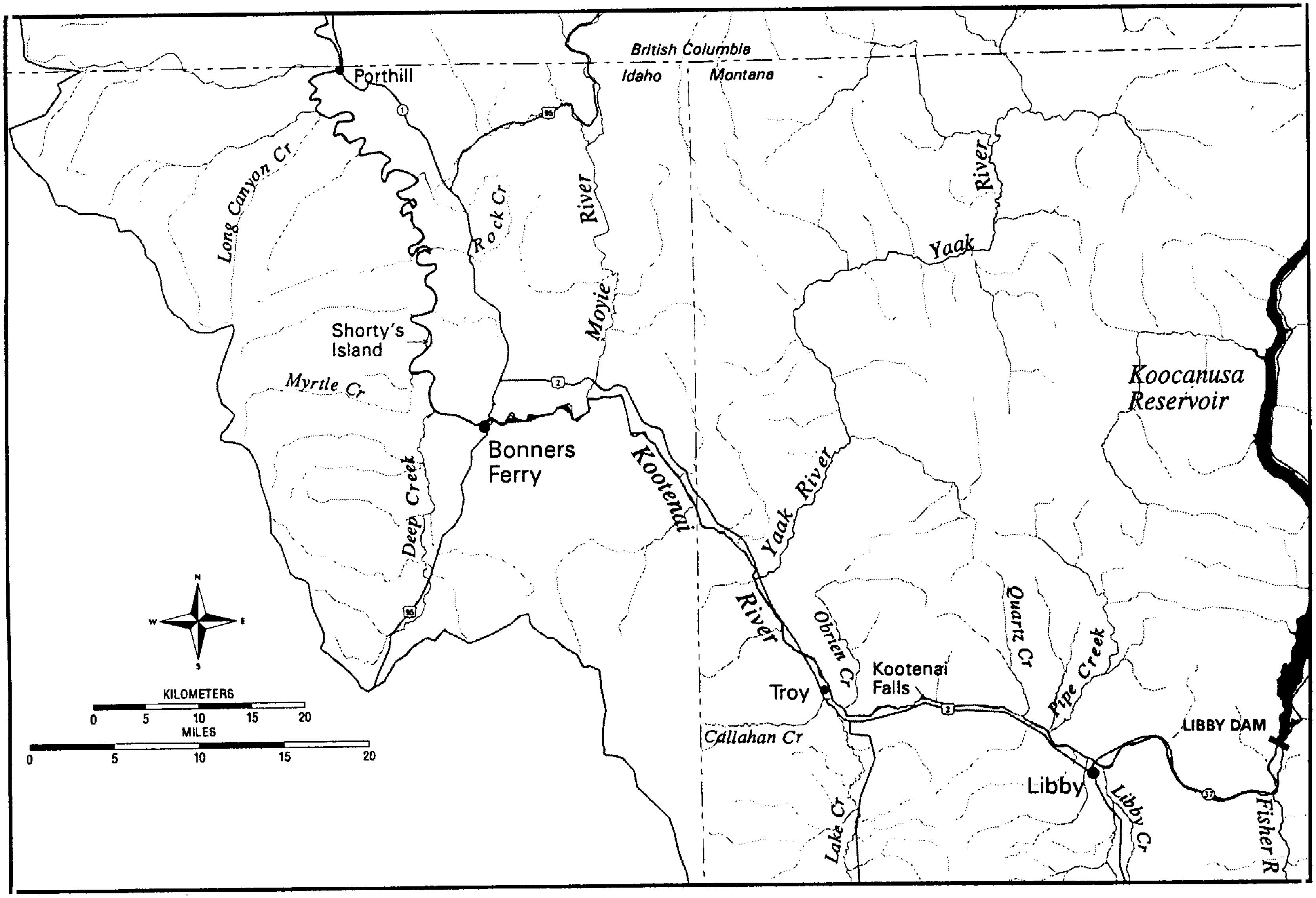


Figure 2. Map of the Kootenai River Basin in Idaho and Montana. Notable geographic features include Kootenai Falls, the suspected upstream migration barrier for white sturgeon, and the Kootenai River reach from Bonners Ferry downstream to Shorty's Island where white sturgeon spawning has been detected in recent years.

1983) to approximately 880 fish by 1990 (Apperson and Anders 1991). More recently, a refined white sturgeon population analysis using capture information collected from the Kootenai River and Kootenay Lake over a 4-year period estimated 1,468 adult fish (95 percent confidence interval: 740 to 2,197) and 87 wild juveniles. Although this revised estimated population is higher than the level when the white sturgeon was listed in 1994, the unbalanced population structure and primary factors affecting the listing decision persist.

The population is reproductively mature, with few of the remaining white sturgeon younger than 25 years old. The Idaho Department of Fish and Game (IDFG) estimated that 7 percent of female, and 30 percent of male white sturgeon in the Kootenai River were reproductively mature in any given year (Apperson 1992). Recent monitoring has documented an approximate 1.7:1 male to female ratio of adult fish (Paragamian et al. 1997).

The youngest white sturgeon collected in surveys since 1972 include representatives from 13 year classes (Paragamian et al. 1996, 1997). Captured fish include at least one fish hatched each year from 1972 through 1980; two fish hatched in1983 year; and at least nine, two, and one fish produced from the 1991, 1992, and 1995 year classes, respectively. Little is known about habitats used by juvenile white sturgeon in the Kootenai River basin.

Genetic analysis indicates that Kootenai River white sturgeon are a unique stock and constitute a distinct interbreeding population (Setter and Brannon 1990). The measure of genetic variation determined for the Kootenai River population is much lower compared to white sturgeon in the lower Columbia River (Setter and Brannon 1990). Based on these comparisons, Setter and Brannon (1990) concluded "...we find adequate evidence to distinguish these fish as a separate population...." This is consistent with the geographic isolation of the population since the last glacial age.

C. Aquatic Community

Fish community associates of the Kootenai River white sturgeon include the burbot (*Lota lota*) and several native salmonids: westslope cutthroat trout

(*Oncorhynchus clarki lewisi*), interior redband and rainbow trout (*Oncorhynchus mykiss gairdneri* and *O. m. irideus.*), bull trout (*Salvelinus confluentus*), kokanee, and mountain whitefish (*Prosopium williamsoni*) (Appendix A).

In general, fish populations have declined in the Kootenai River basin over the past several decades. Bull trout in the Kootenai River basin are part of the Columbia River population of bull trout listed as "threatened" in the United States under the Endangered Species Act on June 10, 1998 (63 FR 31647). Bull trout are now isolated into five subpopulations in the United States portion of the basin, with subpopulations generally with relatively low abundance. Kokanee populations have declined dramatically in the Kootenay Lake system since the 1970's. For example, kokanee runs into north Idaho tributaries of the Kootenai River numbering tens of thousands of fish as recently as the early 1980's (Partridge 1983) declined to only three fish in six of their historic spawning tributaries by 1997 (Sue Ireland, KTOI, pers. comm., 1998). Several factors are believed to have contributed to the kokanee collapse, primarily a decline in overall biological productivity due to Libby Dam construction and operations, and degraded spawning habitat. The introduction of mysid shrimp in Kootenay Lake, an efficient competitor with kokanee for food, has also contributed (Ashley and Thompson 1993). Additionally, catch rates of rainbow trout, and standing stock and growth rates of mountain whitefish in the Kootenai River have declined since the early 1980's (Paragamian 1994). The burbot population has also declined during recent decades, as indicated by an ongoing burbot population study in the Kootenai River and Kootenay Lake. The decline in burbot is not fully understood but is also thought to be partially due to the changing Kootenai River flow patterns during the winter burbot spawning period, and reduced biological productivity. Past overharvest of burbot in the Kootenai River and Kootenay Lake may also have reduced their population size (Paragamian and Whitman 1997).

D. Reasons for Decline

The significant change to the natural flows in the Kootenai River caused by flow regulation at Libby Dam is considered to be a primary reason for the Kootenai River white sturgeon's continuing lack of recruitment and declining numbers.

Beginning with the partial operation of Libby Dam in 1972 (though not fully operational until 1974), average spring peak flows in the Kootenai River have been reduced by more than 50 percent, and winter flows have increased by 300 percent compared to predam values (Figure 3). As a result of original Libby Dam operations until the initiation of experimental flows in 1992, the natural high spring flows thought to be required by white sturgeon for reproduction rarely occurred during the May to July spawning season when suitable temperature, water velocity, and photoperiod conditions would normally exist. In addition, cessation of periodic flushing flows has allowed fine sediments to build up in the Kootenai River bottom substrates. This sediment fills the spaces between riverbed cobbles, reducing fish egg survival, larval and juvenile fish security cover, and insect production.

Additionally, the elimination of side-channel slough habitats in the Kootenai River flood plain due to diking and bank stabilization to provide flood protection for agricultural land; development of Creston Valley Wildlife Management Area in British Columbia and Kootenai National Wildlife Refuge in Idaho; and lower Kootenay Lake spring maximum elevations are also a contributing factor to the white sturgeon decline. Much of the Kootenai River has been channelized and stabilized from Bonners Ferry downstream to Kootenay Lake resulting in reduced aquatic habitat diversity, altered flow conditions at potential spawning and nursery areas, and altered substrates in incubation and rearing habitats necessary for survival (Partridge 1983, Apperson and Anders, 1991).

As a consequence of altered flow patterns, average water temperatures in the Kootenai River are typically warmer (by 3 degrees Celsius; 37 degrees Fahrenheit) during the winter and colder (by 1 - 2 degrees Celsius; 34 - 36 degrees Fahrenheit) during the summer than prior to impoundment at Libby Dam (Partridge 1983). However, during large water releases and spills at Libby Dam in the spring, water temperatures in the Kootenai River may be colder than under normal nonspill spring flow conditions.

The overall biological productivity of the Kootenai River downstream of Libby Dam has been altered. Based on limnological studies of Kootenay Lake, Daley et al. (1981) concluded that the construction and operation of Libby Dam (and

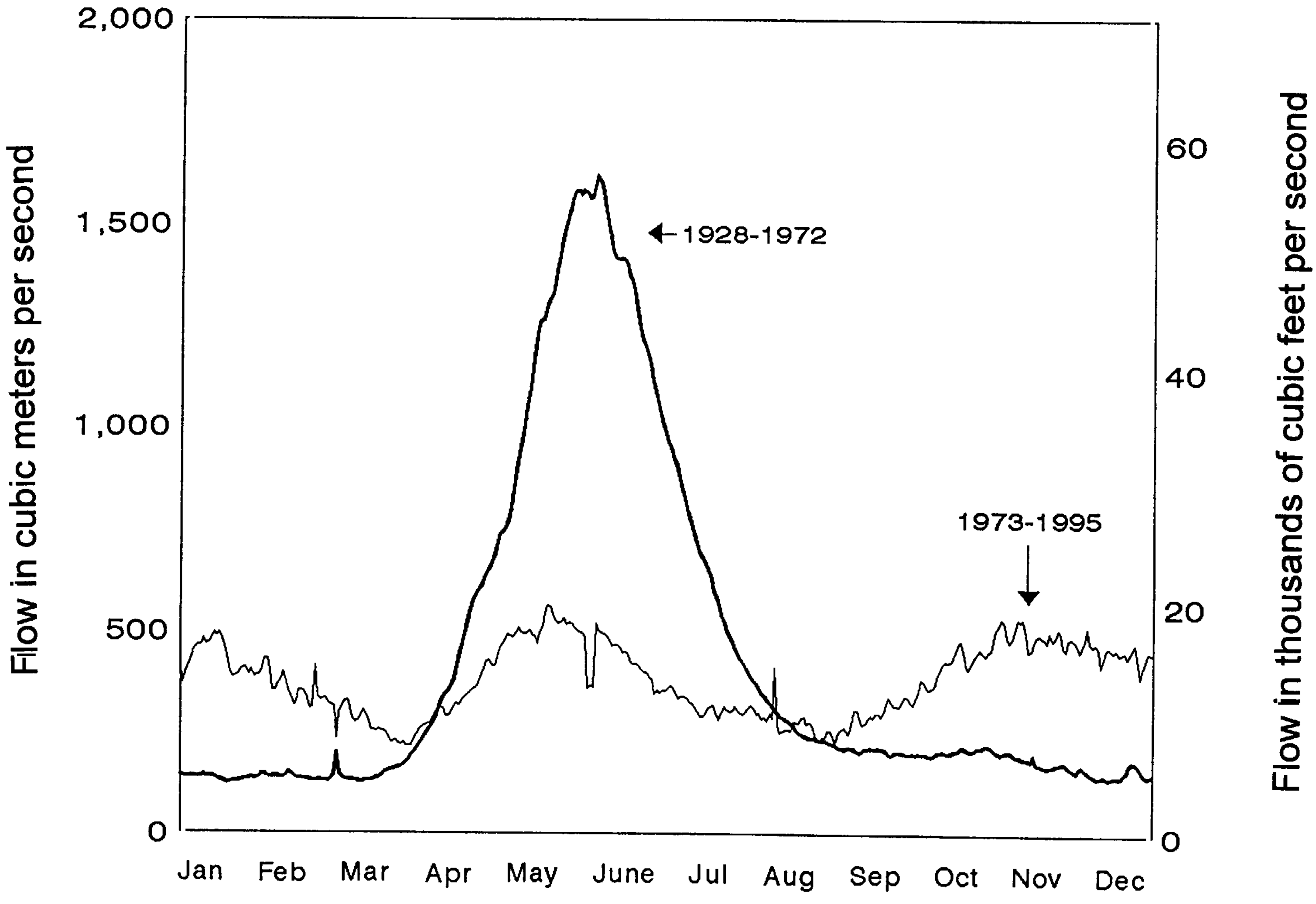


Figure 3. Mean monthly Kootenai River flows at Bonners Ferry for 1928-1972 (pre-Libby Dam) and 1973-1995 (post-Libby Dam) periods.

Duncan Dam, British Columbia) "...has drastically altered the annual hydrograph and has resulted in modifications to the quality of water now entering the lake by removing nutrients, by permitting the stripping of nutrients from the water in the river downstream from Libby Dam, and altering the time at which the nutrients are supplied to the lake." Potential threats to Kootenai River white sturgeon from declining biological productivity include decreased prey abundance and food availability for some life stages of sturgeon downstream of Libby Dam, and possible reduction in the overall capacity for the Kootenai River and Kootenay Lake to sustain substantial populations of white sturgeon and other native fishes. For example, total zooplankton densities in the Kootenai River at Bonners Ferry (mean fewer than 0.1 organism/liter) are lower than in other rivers of the northwestern United States (Paragamian 1994).

Poor water quality and excessive nutrients in the upper Kootenai River were considered to be major problems for the white sturgeon and other native fishes prior to the construction and operation of Libby Dam. Graham (1981) believed that poor water quality conditions in the 1950's and 1960's, from industrial and mine development, most likely affected white sturgeon reproduction and recruitment prior to 1974. Significant improvements in Kootenai River water quality were noted by 1977, due in part to waste water control and effluent recycling measures initiated in the late 1960's. Although fertilizer processing, sewage, lead-zinc mine, and vermiculite discharges have been eliminated, many of these pollutants and contaminants persist, primarily bound in sediments.

Apperson (1992) noted detectable levels of aluminum, copper, lead, zinc, and strontium, along with polychlorinated biphenyls (PCB) and pesticides, in white sturgeon egg samples from the Kootenai River. However, other than copper, detectable levels of these compounds, e.g. polychlorinated biphenyls, organochlorides, and zinc, were lower than levels found in other Columbia River basin white sturgeon that successfully reproduce. Ultimately, the overall effects of these pollutants on sturgeon reproduction and survival are unknown. Kootenai River white sturgeon eggs have been hatched under experimental hatchery conditions using both Kootenai River water and domestic city water, however the chronic effects of heavy metals on egg hatching success and the dietary pathways of larvae and young-of-the-year white sturgeon have not been investigated.

Georgi (1993) noted that the chronic effects on wild sturgeon spawning in "chemically polluted" water and rearing over contaminated sediments, in combination with bioaccumulation of contaminants in the food chain, is possibly reducing the successful reproduction and early-age recruitment to the Kootenai River white sturgeon population.

E. Conservation Measures

At present, there are several State, Federal, Tribal, and Canadian programs and conservation efforts that may help achieve recovery objectives for the Kootenai River population of white sturgeon. These measures are described below.

1. Kootenai River management activities

The following is a brief summary of the 1991 through 1997 flow releases for Kootenai River white sturgeon. These flows, considered experimental from 1991 through 1997 and concurrent monitoring of white sturgeon, were intended to identify some factors limiting successful reproduction of Kootenai River white sturgeon and help achieve recovery.

1991: In the spring of 1991, the United States Army Corps of Engineers (USACE) and Bonneville Power Administration managed flows for white sturgeon at the request of the Idaho Department of Fish and Game. Approximately 566 cubic meters per second (m^3/s) (20,000 cubic feet per second [cfs]) were released at Libby Dam for a 2 week interval during the spawning period. The Army Corps of Engineers operations provided flows of above 991 cubic meters per second (35,000 cubic feet per second) at Bonners Ferry for 15 days with water temperatures at 14 degrees Celsius (57 degrees Fahrenheit). A peak flow of 1,521 cubic meters per second (53,700 cubic feet per second) was recorded on May 19 at Porthill, Idaho. This was accomplished without storing additional water in Koocanusa Reservoir because of above normal water conditions in the Kootenai River basin. The combination of local runoff below Libby Dam and water released to meet flood control requirements provided the range of flows (Figure 4). On July 3, 13 white sturgeon eggs were collected within 100 meters (300 feet) down river from the railroad bridge at Bonners Ferry

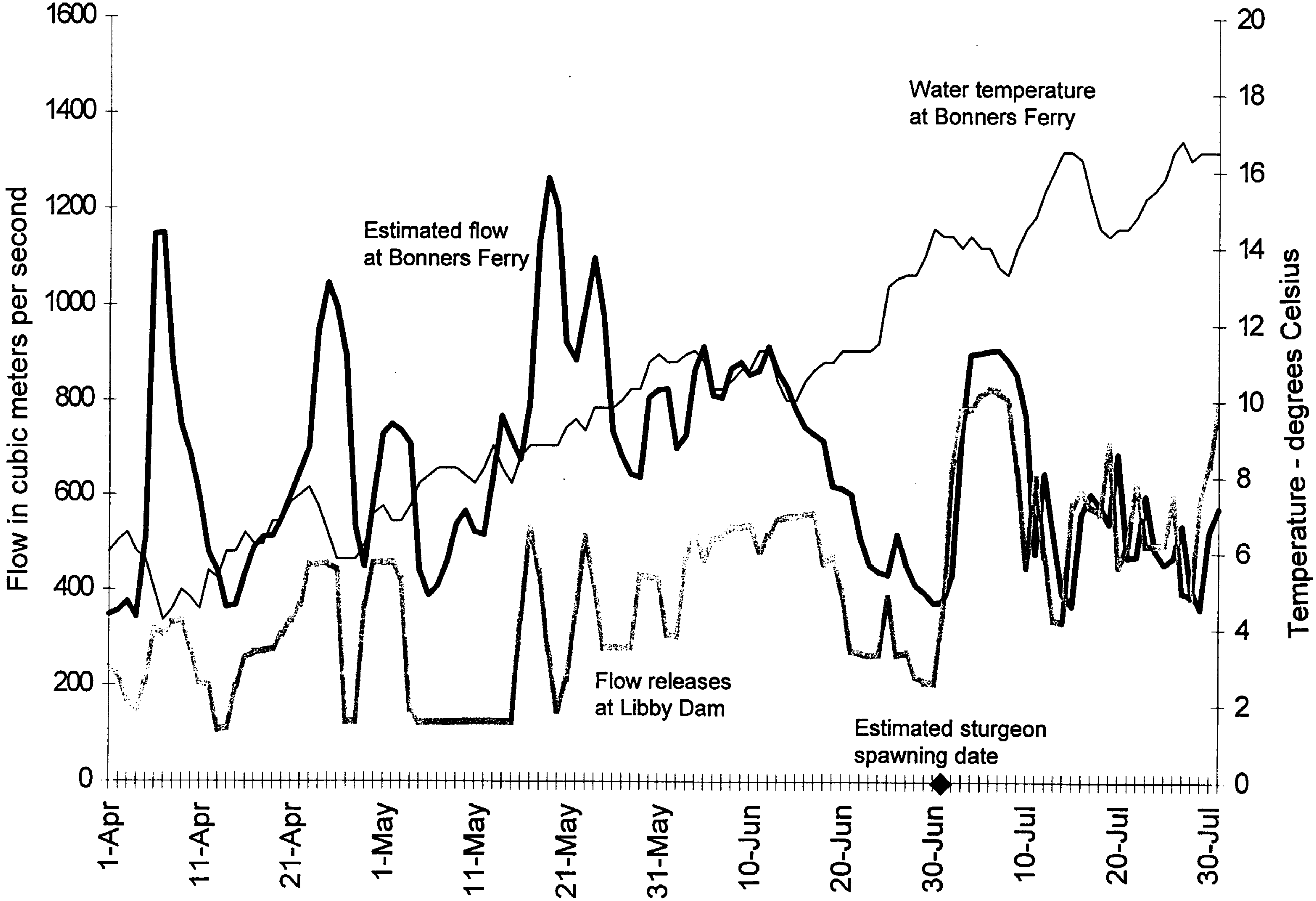


Figure 4. Kootenai River estimated flows and water temperature observed during April through July, 1991.

(river-kilometer 245, river-mile 153) (Apperson and Anders 1991). No larval white sturgeon were found in the Kootenai River in 1991. However, four juvenile white sturgeon aged to the 1991 year class have been found in subsequent sampling.

1992: The Bonneville Power Administration and the U.S. Army Corps of Engineers attempted to manage water releases similar to 1991 at the request of the Idaho Department of Fish and Game. However, because of the poor water year, water was not released for flood control during the white sturgeon spawning season (Figure 5). In June 1992, the Bonneville Power Administration was also requested by BC Hydro (supported by the Governor of Montana's concern for the health of the reservoir fishery) and the Army Corps of Engineers to store water in Koocanusa Reservoir for recreational purposes. As a result, flows dropped from nearly 566 to 113 cubic meters per second (20,000 to 4,000 cubic feet per second) in the Kootenai River during the critical white sturgeon spawning period. No white sturgeon eggs or larvae were found in the Kootenai River (Apperson and Wakkinen 1993).

1993: In an attempt to develop a regional prelisting recovery strategy for sturgeon that would form the basis of a conservation agreement between the U.S. Fish and Wildlife Service and various agencies, the Kootenai White Sturgeon Technical Committee (Technical Committee) was formed. The Committee comprised representatives from the U.S. Fish and Wildlife Service; Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; Kootenai Tribe of Idaho; Army Corps of Engineers; Bonneville Power Administration; and several other United States and Canadian agencies. Based upon recommendations by some Technical Committee members, the Fish and Wildlife Service requested flows of 991 cubic meters per second (35,000 cubic feet per second) for a 40-day period. The Army Corps of Engineers and Bonneville Power Administration were unable to implement the request because of operating constraints of the hydrosystem, but did store 493,413,000 cubic meters (400,000 acre-feet) of water in Koocanusa Reservoir for white sturgeon experimental flows. Water released provided 566 cubic meters per second (20,000 cubic feet per second) at Bonners Ferry from June 2 through June 16

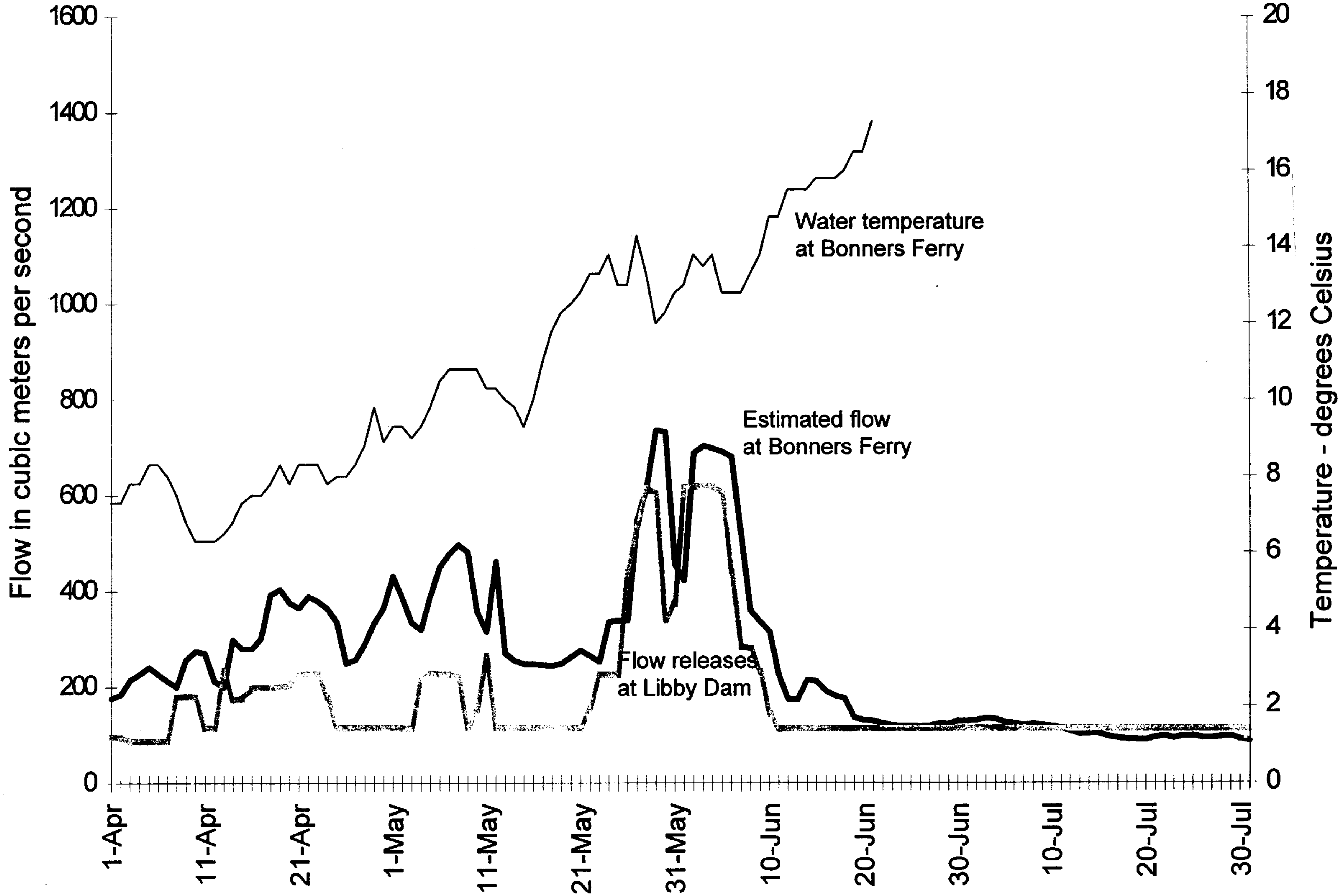


Figure 5. Kootenai River estimated flows and water temperature observed during April through July, [illegible]

(Figure 6). Three white sturgeon eggs (one fertilized, one dead, and one unfertilized) were collected in the Kootenai River near the US 95 Highway bridge at Bonners Ferry (river-kilometer 245, river-mile 153) when water temperatures were 12 degrees Celsius (48 degrees Fahrenheit). No larval white sturgeon were found (Marcuson 1994). To date, no 1993 year class juvenile white sturgeon have been found.

On July 7, 1993, the U.S. Fish and Wildlife Service proposed to list the Kootenai River population of white sturgeon as "endangered" under the Endangered Species Act.

1994: In July 1994, the Fish and Wildlife Service issued a formal Conference Opinion on the effects of the 1994-1998 Federal Columbia River Power System (FCRPS), concluding that the proposed operation was not likely to jeopardize the sturgeon. The action proposed by the Fish and Wildlife Service was in 3 out of 10 years to 1) maintain 425 cubic meters per second (15,000 cubic feet per second) at Bonners Ferry in May; 2) increase discharge from Libby Dam to provide 566 cubic meters per second (20,000 cubic feet per second) at Bonners Ferry for 35 days during the expected spawning season; 3) ramp down and maintain 312 cubic meters per second (11,000 cubic feet per second) for 28 days at Bonners Ferry; and 4) keep flow releases constant during May through July in years when flows were provided. This action could also benefit listed salmon species in the lower Columbia River drainage.

During the 1994 runoff period, the Bonneville Power Administration and the Army Corps of Engineers stored 1,480,000,000 cubic meters (1,200,000 acre-feet) of water behind Libby Dam as part of a flow augmentation program. This water was released to stimulate natural spawning of white sturgeon (Figure 7). Flow at Bonners Ferry was held above 425 cubic meters per second (15,000 cubic feet per second) during May and was increased to 566 cubic meters per second (20,000 cubic feet per second) on June 1 and maintained for 28 days. Flow was then decreased over 3 days to 340 cubic meters per second (12,000 cubic feet per second) by July 2, and held stable over the July 4 weekend at the request of the State of Montana to benefit recreation. Libby Dam discharge was then ramped down over 5 days to 113 cubic meters per second (4,000 cubic feet per second) by

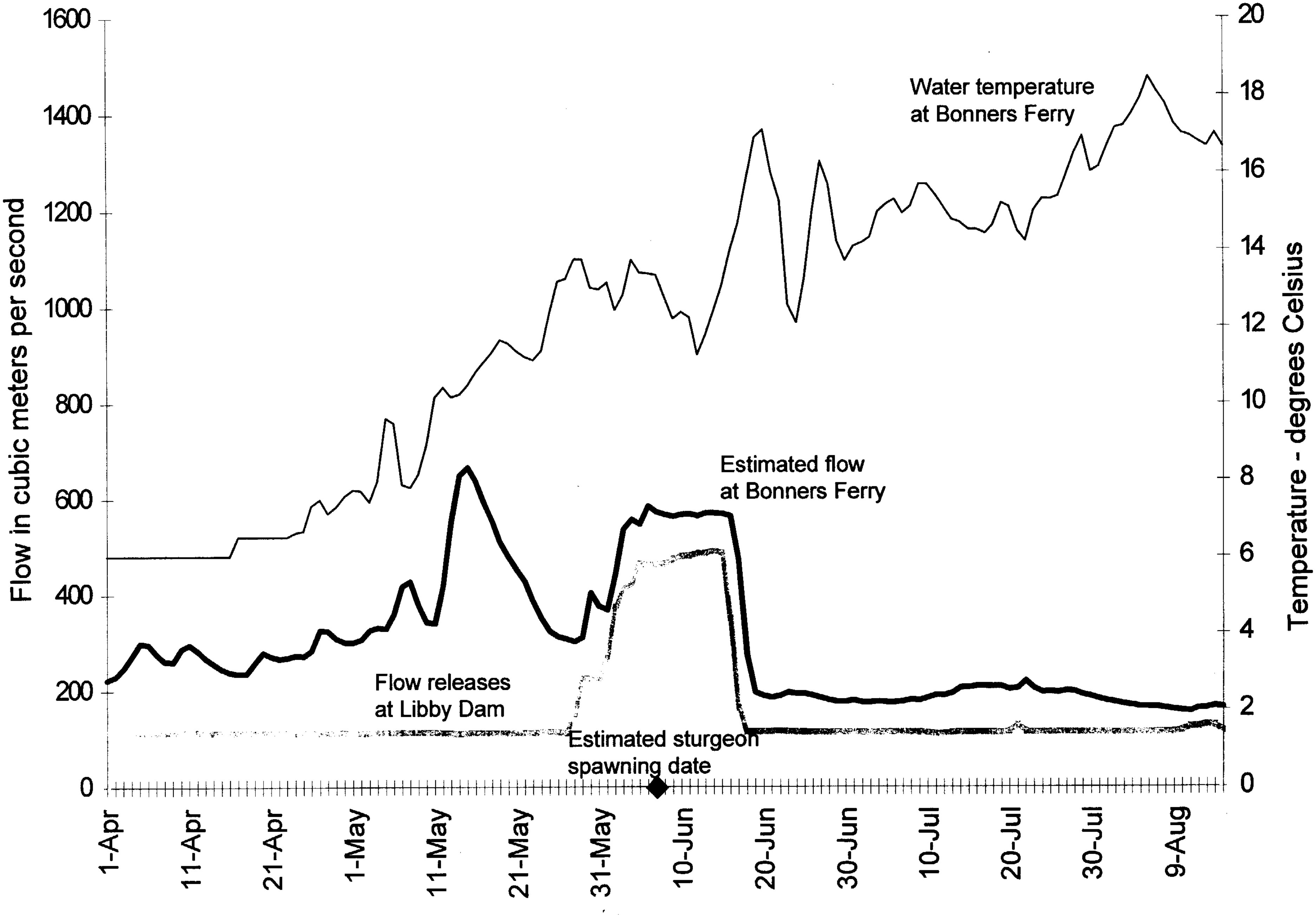


Figure 6. Kootenai River estimated flows and water temperature observed during April through July, 1993.

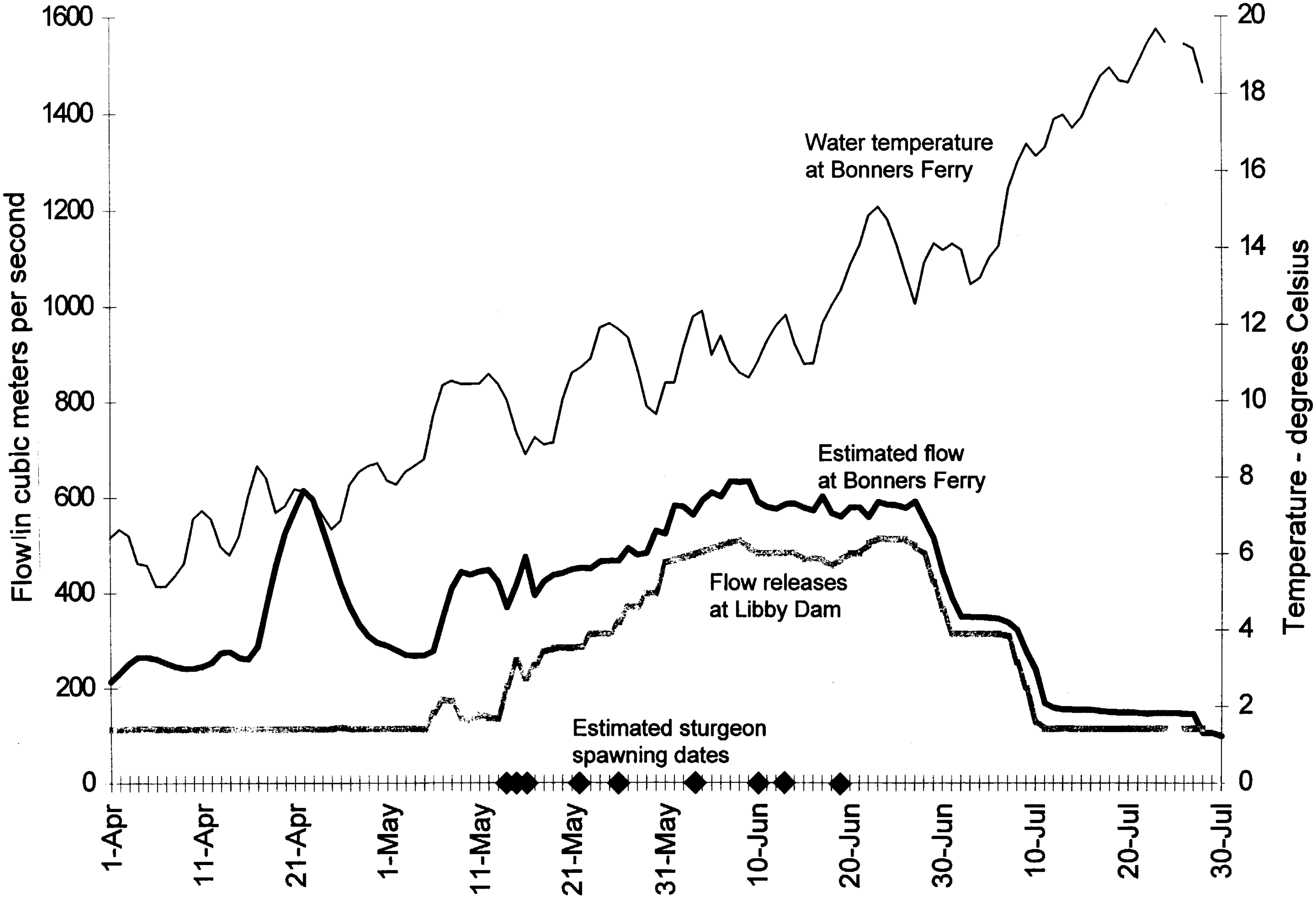


Figure 7. Kootenai River estimated flows and water temperature observed during April through July, 1994.

July 11, when the 1,480,000,000 cubic meters (1,200,000 acre-feet) of stored water was exhausted. A total of 213 white sturgeon eggs were collected over 19 days beginning May 15 through June 20 near Shorty's Island (river-kilometers 228.7 - 230.9; river-miles 143 - 144) and between Myrtle and Deep Creeks (river-kilometer 237.5; river-mile 147) (Kootenai Tribe et al. 1995). No live larval white sturgeon were found in the wild during 1994, however, one newly emerged larva was found in a largescale sucker stomach in early June.

The Kootenai River population of white sturgeon was listed as endangered under the Act on September 6, 1994. In the final rule the Fish and Wildlife Service stated "that there is no recent evidence of successful spawning and survival past the egg stage" and "...existing regulations and experimental flow programs have not been effective in arresting..." the decline of the species.

1995: On December 15, 1994, the Federal Columbia River Power System action agencies submitted a supplement to the 1994-1998 Biological Assessment (B.A.) to the Fish and Wildlife Service (see previous "1994" discussion). The supplement to the Biological Assessment addressed future operation of the Federal Columbia River Power System and potential impacts upon listed species. Beginning in mid-December, the Fish and Wildlife Service, National Marine Fisheries Service (NMFS), and the action agencies (the Bonneville Power Administration, Army Corps of Engineers, and the Bureau of Reclamation [BR]) formally consulted during a series of meetings and information exchanges. The Fish and Wildlife Service and the action agencies considered how the proposal to operate the Federal Columbia River Power System as described in the Supplemental Biological Opinion could avoid jeopardy to the Kootenai River white sturgeon. To consider all viewpoints, the Fish and Wildlife Service solicited comment on the January 25, 1995, draft Biological Opinion from affected State and Tribal management agencies. On March 1, 1995, the Fish and Wildlife Service issued a final Biological Opinion addressing the effects of Federal Columbia River Power System operations in 1995 and future years on the Kootenai River white sturgeon.

The final Biological Opinion described reasonable and prudent alternatives to regulate flows at Libby Dam for 1995 to 1998. Regulation of flows must be consistent with existing treaties and laws, e.g. the International Joint Commission and the Columbia River Treaty. Operations for 1995 were more limited than those described for 1996 to 1998 because only four of the five turbines in Libby Dam were functional.

The 1995 flow augmentation program (Figure 8) was implemented as follows: Approximately 2,467,000,000 cubic meters (2 million acre-feet) of water were stored in Koocanusa Reservoir to benefit white sturgeon. Increased flows began on April 29 to achieve 433 cubic meters per second (15,300 cubic feet per second) at Bonners Ferry on May 2. Flows ranged from 425 to 482 cubic meters per second (15,000 to 17,000 cubic feet) until May 15, when Libby Dam discharge increased to about 566 cubic meters per second (20,000 cubic feet per second) by May 16, allowing local inflow to vary Bonners Ferry flows while Libby outflow was held steady. Water temperatures remained below the optimal range for white sturgeon during most of the flow augmentation period. Bonners Ferry flows ranged from 765 to 1,076 cubic meters per second (27,000 to 38,000 cubic feet per second) during this period, which ended June 26. Flows were gradually decreased to minimum Libby Dam discharge of 113 cubic meters per second (4,000 cubic feet per second) by July 22; Bonners Ferry flow was 272 cubic meters per second (9,600 cubic feet per second). Flows were again increased on July 29, reaching about 437 cubic meters per second (16,000 cubic feet per second) by August 1, primarily to benefit salmon downstream in the Columbia River. On August 10, Kootenai River flows at Bonners Ferry reached 453 cubic meters per second (16,600 cubic feet), with very low local inflows. This second peak during the normally warm summer months departs from the natural hydrograph and can cause stranding of aquatic insects and fish eggs and larvae. Similar to 1994, 163 white sturgeon eggs were recovered only near Shorty's Island at approximately 12 river-kilometer (7.5 river-mile), downstream of Bonners Ferry, and were not recovered in the river near Bonners Ferry (Anders and Westerhof 1996). Most of the fertilized eggs were less than 60 hours old and no larvae or juvenile white sturgeon from the 1995 year class have been found through March 1996.

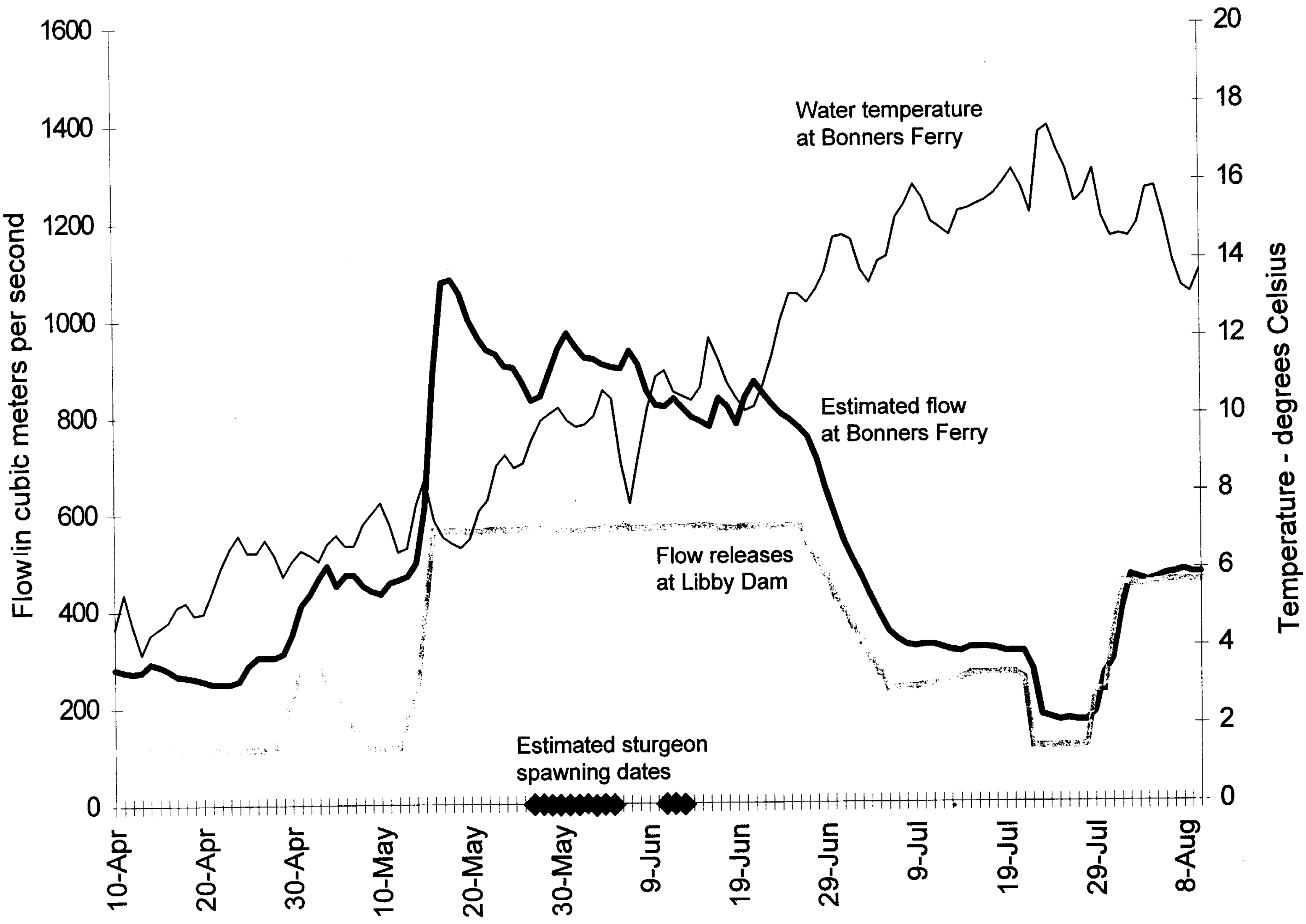


Figure 8. Kootenai River estimated flows and water temperature observed during April through July, 1995.

1996: Temperatures in the Kootenai River at Bonners Ferry reached an early though brief level of nearly 8 degrees Celsius (46 degrees Fahrenheit) in mid-April, and Libby Dam discharges were increased from base levels to about 650 cubic meters per second (23,000 cubic feet per second) by April 13. This level was held until about April 25, and lowland runoff complemented it, reaching peaks at Bonners Ferry of about 1,200 cubic meters per second (42,000 cubic feet per second) and 1,350 cubic meters per second (48,000 cubic feet per second) during that time (Figure 9). Lowland runoff tailed off while Libby discharge was dropped to a level of 263 cubic meters per second (9,300 cubic feet per second) by about May 1. In mid-May, lowland runoff again increased, and Libby discharges also increased in response to increasing inflows from higher elevations. A series of peaks as high as 1,400 cubic meters per second (49,500 cubic feet per second) occurred by early June at Bonners Ferry as water temperatures there exceeded 7 degrees Celsius (44 degrees Fahrenheit) and dam discharges were increased to stimulate sturgeon migration and spawning. Water temperatures reached 8 degrees Celsius (46 degrees Fahrenheit) by the end of May, and 9 degrees Celsius (48 degrees Fahrenheit) by early June. Local runoff declined starting in early June, and by the end of June was only about 300 cubic meters per second (10,600 cubic feet per second). By mid-July it was well under 100 cubic meters per second (3,500 cubic feet per second). Libby discharges were gradually dropped, but with peaks added above 700 cubic meters per second (24,700 cubic feet per second) in early and mid-July to further stimulate sturgeon reproductive activity, coinciding with temperatures of 12 degrees Celsius (54 degrees Fahrenheit), and 14 degrees Celsius (58 degrees Fahrenheit) respectively. In 1996, a total of 349 eggs were collected between June 8 and June 30. No white sturgeon larvae were collected in 1996.

1997: The Kootenai River at Bonners Ferry rose above 1,414 cubic meters per second (50,000 cubic feet per second) during 1997. Exceptionally heavy precipitation and 130 percent greater than average snow pack in the drainage raised flows at Bonners Ferry to over 1,526 cubic meters per second (54,000 cubic feet per second) during April and May (Figure 10). The peak flow for 1997 reached 1,547 cubic meters per second (54,600 cubic feet per second) on May 14. Most of the flow in April and May was local inflow. As a consequence, water management at Libby Dam was primarily for flood control at Bonners Ferry and

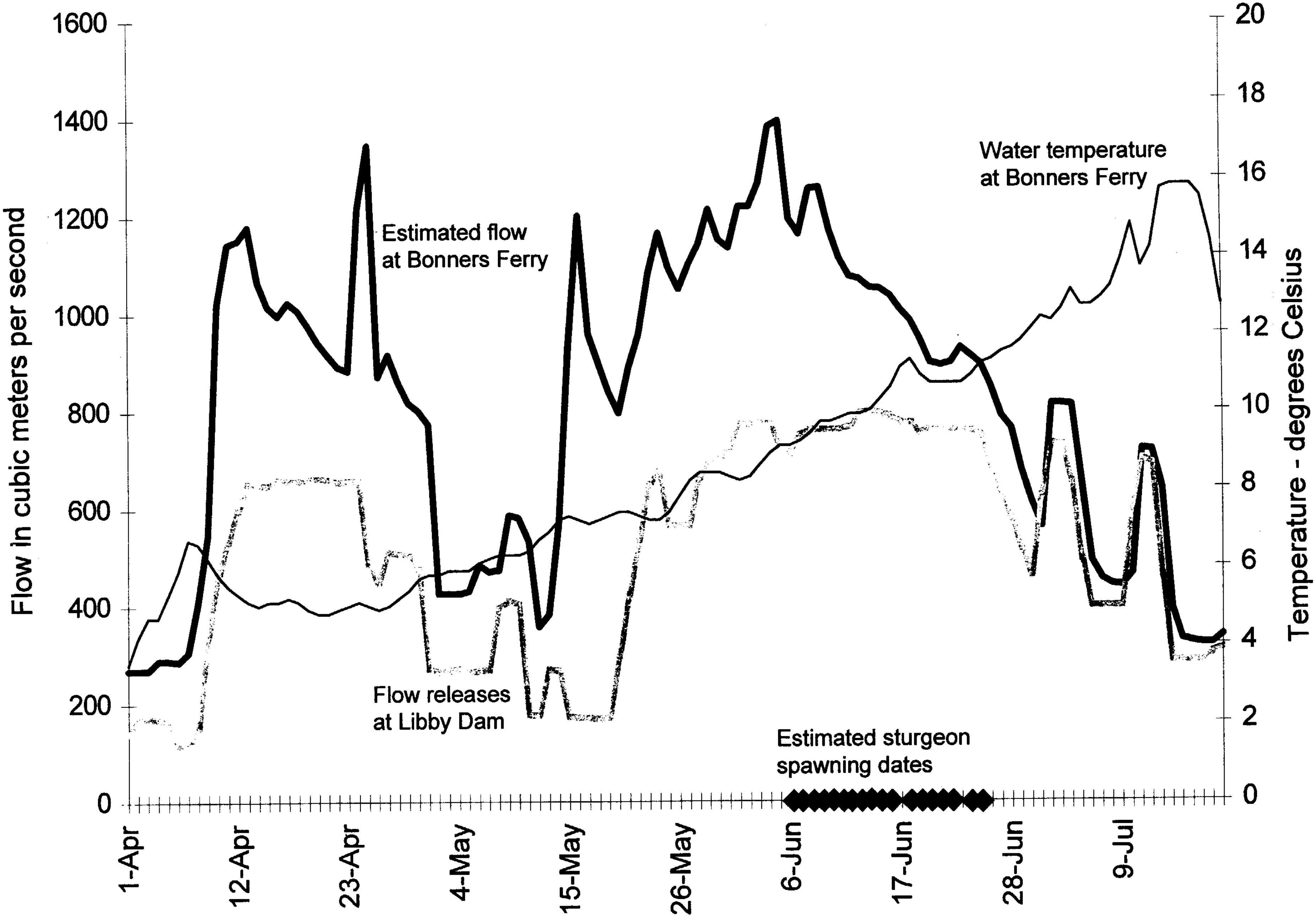


Figure 9. Kootenai River estimated flows and water temperature observed during April

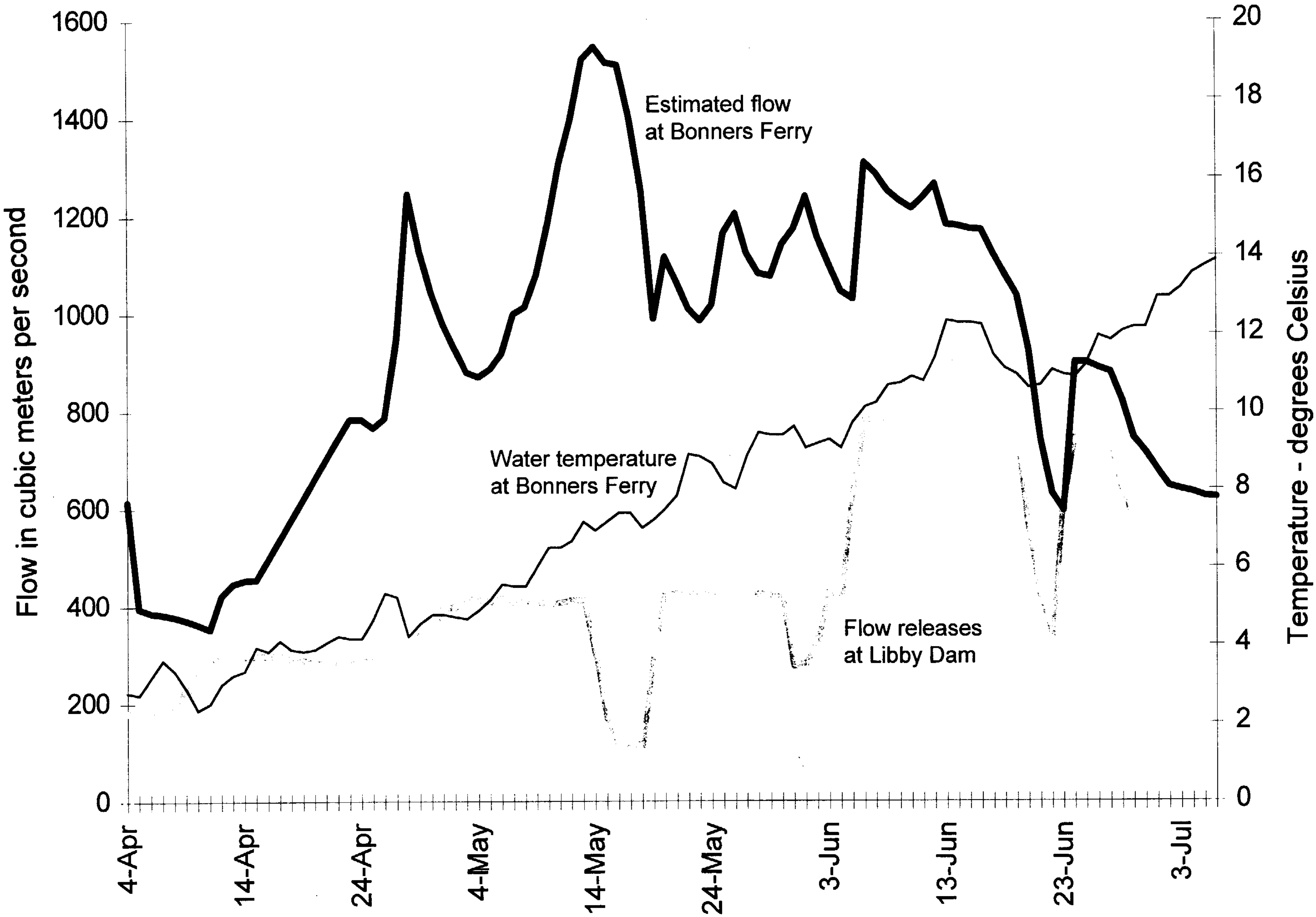


Figure 10. Kootenai River estimated flows and water temperature observed during April through July, 1997.

the Kootenai River valley. Discharge from Libby Dam was held to only 162 to 354 cubic meters per second (5,700 to 12,500 cubic feet per second) for the entire month of April. Despite these efforts, near flood conditions still prevailed in the lower portion of the drainage because of the volume of local inflow. Test flows were initiated on June 5; flows reached 1,320 cubic meters per second (46,600 cubic feet per second) on June 6. Temperature rose from about 9.1 degrees Celsius (48 degrees Fahrenheit) on June 4 to 10.1 degrees Celsius (50.2 degrees Fahrenheit) on June 6. The first test ended when flows at Bonners Ferry were reduced slightly to 1,220 cubic meters per second (43,000 cubic feet per second) by June 10 and then increased with augmented flows from Libby Dam to produce 1,270 cubic meters per second (44,700 cubic feet per second) by June 12 at Bonners Ferry, which was the beginning of the second test. Temperature during the second flow test increased from 10.1 degrees Celsius (50.2 degrees Fahrenheit) to 11.4 degrees Celsius (52.5 degrees Fahrenheit) on June 12. Following ramp down on June 13, the temperature increased to 12.3 degrees Celsius (54.1 degrees Fahrenheit) for 3 days. Flows were gradually ramped down after the second test and were as low as 357 cubic meters per second (12,6000 cubic feet per second) by the end of July. A total of 75 eggs were collected between June 5 and June 24. One larval white sturgeon was collected in the Kootenai River near Myrtle Creek at river-kilometer 236 (river-mile 145).

2. Columbia River Basin Fish and Wildlife Program

The Northwest Power Act of 1980 authorized the States of Idaho, Montana, Oregon, and Washington to create a policy-making and planning body for electrical power and the Columbia River basin's fish and wildlife resources (Northwest Power Planning Council 1987). The Northwest Power Planning Council (NPPC) was created in 1980 to develop the Columbia River Basin Fish and Wildlife Program (Program). The Program was intended to protect, mitigate, and enhance fish and wildlife resources affected by hydroelectric development in the Columbia River basin in the United States. In 1987 and 1994, the Program was amended to address several issues of concern in the Kootenai River drainage (NPPC 1987, 1994). The Bonneville Power Administration, the Army Corps of Engineers, the Bureau of Reclamation, and the Federal Energy Regulatory Commission are the Federal agencies responsible for implementing the Program.

The 1987 Program directed the Bonneville Power Administration to fund the following efforts related to the Kootenai River system:

1) Evaluate the effect of Libby Dam operations on reproduction and rearing of white sturgeon in the Kootenai River. Section 903(b)(1)C.

2) Develop operating procedures for Libby Dam to ensure that sufficient flows are provided to protect resident fish in the Kootenai River and Lake Koocanusa. Section 903(a)(5). Consult with the State of Montana if a conflict occurs between meeting minimum flows in Section 903(a)(5) and maintaining reservoir levels required by Section 903(b)(1).

3) Determine the impact of development and operation of the hydropower system on white sturgeon in the Columbia River basin. Section 903(e)(1).

4) Increase the number of rainbow trout, burbot (ling), and white sturgeon in the Kootenai River. Section 903(e)(7).

5) Design, construct, operate, and maintain a low-capital white sturgeon hatchery on the Kootenai Indian Reservation. Explore alternative ways to make effective use of the hatchery year-round. Section 903(g)(1)(H).

6) Survey the Kootenai River downstream of Bonners Ferry to the United States/Canada border to evaluate the effectiveness of the hatchery and assess the impacts of water fluctuations caused by Libby Dam on hatchery outplanting of white sturgeon in the Idaho portion of the Kootenai River. Section 903(G)(1)G.

The 1994 Program amendments called for the Bonneville Power Administration to continue to fund several of the 1987 measures for the Kootenai River drainage described above, and added several additional measures including:

1) Develop operating procedures for Libby Dam to ensure that sufficient flows are provided to protect resident fish. Section 10.3(B)(1).

2) Implement the Integrated Rule Curves (IRCs) for Koocanusa Reservoir; refine integrated rule curves to limit Koocanusa Reservoir drawdown to protect resident fish; and review State and Tribal recommendations on the biological effectiveness of the Integrated Rule Curves. Section's 10.3(B)(2,3,4).

3) Fund studies to evaluate the effect of Libby Dam operations on resident fish. Section 10.3(B)(5).

4) Design, construct, operate, and maintain mitigation projects in the Kootenai River system and Koocanusa Reservoir to supplement natural propagation of fish. Section 10.3(B)(11).

5) Operate and maintain a low-capital white sturgeon hatchery by the Kootenai Tribe of Idaho (KTOI). Section 10.4(B)(1).

6) Release water from Libby Dam to augment river discharge during the May through July sturgeon spawning period. Section 10.4(B)(3).

7) Restore white sturgeon and burbot populations in the Kootenai River. Section 10.6(C)(1).

3. Kootenai River white sturgeon research and monitoring

Research on white sturgeon in the Kootenai River basin by the Idaho Department of Fish and Game began in 1978 and continued through 1982. Study results indicated that white sturgeon recruitment began to decline in the mid 1960's, and that the general lack of recruitment was most pronounced after the construction of Libby Dam in 1972. White sturgeon research and monitoring in the Kootenai River basin resumed in 1988 based on the Northwest Power Planning Council's

1987 Fish and Wildlife Program (described in 2 above). These studies are funded by the Bonneville Power Administration in an effort to identify environmental factors limiting the white sturgeon population, and to recommend appropriate conservation and management actions to restore the wild white sturgeon population. The research and monitoring program has expanded in recent years with Bonneville Power Administration funding additional monitoring efforts by Montana Department of Fish, Wildlife, and Parks; Kootenai Tribe of Idaho; and British Columbia Ministry of Environment, Lands, and Parks, in addition to efforts by Idaho Department of Fish and Game. Much of the information generated from these studies was used by the Fish and Wildlife Service in the original listing determination and by the recovery team in developing this final recovery plan.

4. Kootenai Tribe of Idaho White Sturgeon Hatchery

The Kootenai Tribe of Idaho white sturgeon hatchery began as an experimental program in 1990 in response to questions concerning water quality, white sturgeon gamete viability, and feasibility of aquaculture as a component in recovery. Culture efforts first documented successful egg fertilization, incubation, egg viability, and juvenile white sturgeon survival (Apperson and Anders 1991). In 1991, 1992, 1993, and 1995, progeny from wild adult white sturgeon were successfully hatched and reared in the hatchery. The release of 305 hatchery reared age-1 and age-2 fish in 1992 and 1994 provided the first habitat use, movement, survival, and growth information for juvenile white sturgeon in the Kootenai River system. Subsequent monitoring results indicate that survival of these released fish is high and growth normal. In April and October 1997, 2,283 juvenile white sturgeon from the 1995 year class were released into the Kootenai River. Target release numbers for the conservation aquaculture program will be adjusted as more information on survival of hatchery reared juveniles becomes available.

5. Kootenai River Aquatic Investigations

Several studies authorized for the Kootenai River under the Program (as summarized in Conservation Measure #2) have been initiated or completed since

1983. These studies include:

Burbot and Rainbow Trout and Fisheries Inventory: Idaho Department of Fish and Game began the study in 1993 with the objectives to (1) identify factors that are limiting populations of burbot, rainbow trout, and other fish populations within the Kootenai River drainage in Idaho and British Columbia, and recommend management alternatives to restore the fishery to sustainable levels; and (2) determine if the burbot population is being limited by reproductive success, survival, and/or the recruitment of young burbot. Mitochondrial DNA analysis has indicated there may be two or more stocks of burbot in the Kootenai River basin (Paragamian et al. *in press*). Haplotypes from burbot collected from the Idaho and British Columbia reach of the Kootenai River were significantly different from burbot captured from two other locations within the Kootenai River drainage in Montana. A Kootenai River burbot recovery committee was formed during the spring of 1998 to devise methods and programs to restore this population.

Kootenai River Sediment and Water Quality Investigation: In 1995, the Kootenai Tribe of Idaho completed a 15-month investigation to determine if heavy metal pollutants from past mining, fertilizer production, and industrial and agricultural uses were present in the Kootenai River water column and river bed sediments. Eight sites were sampled monthly from Eureka, Montana downstream to Porthill, Idaho. Water and sediment samples were analyzed for arsenic, copper, lead, chromium, zinc, iron, mercury, selenium, and manganese. Analytical results from the water samples indicated the following pollutants violate Environmental Protection Agency aquatic criteria at several sites: mercury, lead, and selenium. Arsenic, copper, and lead were also found in river sediments. Preliminary study results concluded that at various sites, the river bottom is moderately polluted. The study has been funded for an additional 5 years to continue investigations of the biological, chemical, and limnological characteristics of the Kootenai River.

Kootenai River Ecosystem and Fishery Improvement Study: Beginning in 1995, the Kootenai Tribe of Idaho was contracted by Bonneville Power Administration to describe the existing biological community and nutrient availability in the Kootenai River. The study results will include an evaluation on the possible effects of Libby Dam operations on the biotic community and water quality, as well as remedies for any problems identified.

Ecosystem Metabolism and Nutrient Dynamics: In 1996, Idaho State University completed a comprehensive nutrient study funded by the Bonneville Power Administration for the Kootenai River in relation to flow enhancement. Study results revealed that Lake Koocanusa retained approximately 63 percent of its total phosphorus and 25 percent of its total nitrogen loading. Thus, the reservoir acts as a nutrient sink and the river downstream is nutrient deprived. Lake Koocanusa does not appear to chemically stratify. Thus, selective withdrawal from areas of nutrient concentrations is not currently possible. An energy budget developed for the river basin indicated that during most sampling periods, the river was dependent upon sources of energy other than that supplied directly by within-reach autotrophic productivity. Further analysis indicated that macroinvertebrates were not energy (food) limited.

Instream Flow Incremental Methodology study: A study to determine white sturgeon habitat availability in the Kootenai River downstream of Libby Dam under various flow regimes is being conducted by the Montana Department of Fish, Wildlife, and Parks. Microhabitat investigations will be completed during 1998. Model analyses have begun and results specific to white sturgeon and associated prey organisms will be available in 1999.

Kootenai Basin Trout Genetic Analysis: Recent genetic analysis of trout species inhabiting the Kootenai River drainage indicates that interior redband trout, westslope cutthroat, and bull trout were native species in portions of the Kootenai drainage prior to development (Huston 1995). Interior redband trout still exist in the drainage, and are genetically distinct from Gerrard rainbow trout native to Kootenay Lake. Prior to Huston's genetic assessment, it was believed that interior redband were native only in areas downstream of Kootenai Falls (Sage et al. 1992; Behnke 1992). Populations of genetically pure redband trout were located in the Yaak River drainage and upstream of Kootenai Falls. Additional sampling is presently underway to establish the range of interior redband trout in the Kootenai River drainage upstream of Kootenai Falls.

6. Kootenay Lake Fertilization Experiments

The British Columbia Ministry of Environment, Lands, and Parks and BC Hydro are currently fertilizing the North Arm of Kootenay Lake to increase biological productivity and restore native fish populations (Ashley and Thompson 1993). This program was initiated in 1992 in response to a long-term decline in the kokanee population, especially stocks from the North Arm of Kootenay Lake. These declines raised concerns for the future of the Kootenay Lake sport fishery, dominated by the Gerrard rainbow trout. Conversely, increasing overall biological productivity in Kootenay Lake should benefit white sturgeon by increasing a potential prey base.

The project involves releasing liquid fertilizer into a 16-kilometer (10-mile) zone of the North Arm of Kootenay Lake once per week from late April through early September. The fertilizer formulation is a blend of ammonium polyphosphate (10-34-0) and urea-ammonium nitrate (28-0-0). Approximately 317 tons of 10-34-0 and 581 tons of 28-0-0 are released each year during the application period, which is the equivalent of 70 percent of preimpoundment (1949) loading levels. As of early 1997, physical limnology parameters such as temperature, dissolved oxygen, pH, Redox potential, and water clarity have not changed significantly. However, total phosphorus concentrations have increased to preimpoundment levels, which is the target for the fertilizer loadings. Additionally, algal biomass levels in the fertilized area have increased similarly. Both mysid shrimp and kokanee abundance have increased. To date, the number of kokanee spawners in two tributaries of the North Arm (Meadow Creek and Lardeau River) have ranged from a low of 300,000 in 1991 to 1.5 million in 1997.

7. Harvest Regulations

There is no legal fishing for white sturgeon within the Kootenai River drainage in either the United States or Canada (Table 1).

Table 1. Summary of historical harvest regulations for white sturgeon within the Kootenai River drainage in the United States and Canada.

Year	Idaho	Montana	British Columbia
1944	two in possession; no yearly limit; no commercial harvest		
1948	one setline; one in possession		
1949	one setline; one in possession; 76 centimeters minimum size		
1952			setlines permitted; one per day; 92 centimeters minimum size
1955	one setline; one in possession; 102 centimeters minimum size		
1957	one setline; two per year; 102 centimeters minimum size	setlines permitted for burbot only	
1960	one setline; two per year; one in possession; 92 - 183 centimeters length restriction		
1968		setline permitted for sturgeon February 15 through June 30	

Year	Idaho	Montana	British Columbia
1973		six setlines with six hooks/ line, season Feb 15 to June 30; two per year; 102 - 183 centimeters in length	
1975		no setlines permitted; two per year; 102 - 183 centimeters length restriction	
1978			100 centimeters minimum size
1979	two per year; one in possession; 92 - 183 centimeters length restriction; permit required	all fishing prohibited	
1981			one per year; 100 centimeter minimum size
1982			sturgeon declared a sport fish
1983	setlines prohibited; July 1 to December 31; one per year; 92 - 183 centimeters length restriction		
1984	catch and release only; open all year		
1989			setlines prohibited
1990			catch and release only
1994	fishing prohibited		fishing prohibited

8. Libby Reservoir Modeling

A computer model was developed by the Montana Department of Fish, Wildlife, and Parks to assess the effects of Libby Dam operations on the biota in Koocanusa Reservoir (Marotz et al. 1996). The model design was based on empirical data (field collections) from 1982 to 1995. Model components representing the physical environment and biological trophic levels were calibrated separately to assure reliable output. Model studies were used to develop Integrated Rule Curves (IRC) for Libby Dam operation. The Integrated Rule Curves contain variable reservoir drawdown and refill targets dependent on monthly inflow forecasts. Reservoir elevations and dam discharges resulting from the Integrated Rule Curves are designed to balance the many demands on Kootenai River drainage waters (including sturgeon recovery measures) with fisheries in the headwaters and salmon recovery actions in the lower Columbia River system, power production, and flood control. One aspect of the Integrated Rule Curves concept contains "tiered" water releases to simulate a natural spring runoff event to aid white sturgeon spawning and rearing. The amount of flow augmentation is proportional to water availability (drought to flood) in a given year. Water stored for later release improves annual reservoir refill probability.

9. Kootenai River Model

In 1997, through a series of workshops, an Adaptive Environmental Assessment (AEA) model for the Kootenai River was developed as part of an adaptive management process to examine the potential benefits and impacts of alternate flow regimes from Libby Dam on white sturgeon recruitment and other resources in the system. The main objective for developing the model was to provide a tool that would aid in design of an experimental management program to define management measures that would benefit white sturgeon juvenile recruitment. The discussions and data synthesis required to develop the model, and the model simulations were used to eliminate unlikely hypotheses for sturgeon recruitment decline and to eliminate policies that provided unacceptable outcomes for other resources in the system. The model consists of three main components: 1) a hydrology submodel that uses historic inflows into Libby Reservoir and tributaries, and a reservoir operation simulation (for Libby, Duncan, and Corra

Linn dams) to allow users to develop realistic discharge scenarios; 2) an aquatic production submodel that simulates turbidity, nutrient dynamics, and macroinvertebrate production in the Kootenai River; and 3) a fisheries submodel that simulates the effects of various habitat impacts related to dam operations and other watershed changes (e.g. declining nutrient loading, flood plain development) on population dynamics of white sturgeon, kokanee, burbot, rainbow and redband trout, squawfish, and other species. The model simulations summarize the tradeoffs between power economics, flood protection, and fisheries benefits, as well as tradeoffs among species associated with different flow regimes.

F. Strategy for Recovery

Recovery of Kootenai River white sturgeon is contingent upon reestablishing natural recruitment, minimizing additional loss of genetic variability to the population, and successfully mitigating biological and physical habitat changes caused by human development within the Kootenai River basin and the construction and operation of Libby Dam. This recovery plan proposes conservation actions to benefit white sturgeon within the entire Kootenai River watershed in the United States and Canada. However, the Endangered Species Act does not impose any restrictions or commitments on Canada. This recovery plan describes a strategy for improving coordination and cooperation between the United States and Canada on the operation of Libby Dam with the operation of other hydroelectric facilities within the Kootenai River basin and elsewhere in the Canadian portion of the Columbia River basin. If required for recovery, a United States - Canada binational agreement could be entered into to aid Kootenai River white sturgeon recovery, as occurred for the endangered whooping crane.

Implementation or scheduling of tasks is also based on a priority system. Priority 1 tasks are those actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future. Priority 2 tasks are those actions that must be taken to prevent a significant decline in species population and habitat quality, or some other significant negative impact short of extinction. Priority 3 tasks are all other actions necessary to provide for full recovery of the species. Proposed actions for native fishes have not been assigned a priority number. However, information from these actions will be useful to evaluate how resident fish are affected by conservation actions proposed for Kootenai River white sturgeon.

Actions (or tasks) that will have the highest priority for implementation include:

Restore natural recruitment to the Kootenai River white sturgeon population (Priority 1).

Recovery will require that suitable Kootenai River ecosystem functions, including augmented seasonal Kootenai River flows, are restored to ensure habitat conditions necessary for successful white sturgeon reproduction and recruitment, i.e. survival of juveniles during their first year of life and beyond. The first stated purpose of the Endangered Species Act is, " . . . to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." The continued preservation of the sturgeon solely through artificial propagation would not be considered recovery.

Use conservation aquaculture to prevent the extinction of Kootenai River white sturgeon (Priority 1).

One recovery objective for the Kootenai River white sturgeon population is to prevent extinction by developing and implementing, for at least the next 10 years, a conservation aquaculture program, i.e. hatchery propagation. A conservation aquaculture program will include protocols on broodstock collection, gene pool preservation, broodstock mating criteria, juvenile rearing, fish health, and stocking.

Monitor the survival and recovery of the Kootenai River white sturgeon and its ecosystem (Priority 1, 2, and 3).

Concurrent with efforts to restore natural recruitment and prevent the extinction of the Kootenai River white sturgeon, further research and monitoring are necessary on life history and habitat requirements of white sturgeon and other aquatic species within the Kootenai River ecosystem.

This information is essential to understand the population dynamics of other fish species and allow resource managers to evaluate the effectiveness of conservation measures in meeting recovery goals.

Update and revise recovery plan criteria and objectives (Priority 2).

The Recovery Plan for the White Sturgeon: Kootenai River Population will be updated and revised as additional information becomes available, recovery tasks are accomplished, and as environmental conditions change.

PART II - RECOVERY

A. Recovery Objectives

The short-term recovery objectives of this recovery plan (Plan) are to a) reestablish natural recruitment to the Kootenai River population of white sturgeon and b) prevent extinction through conservation aquaculture. Proposed recovery actions include providing additional Kootenai River flows to reestablish natural recruitment and using conservation aquaculture, i.e. hatchery propagation, to prevent extinction. Due to uncertainties in egg-through-yearling survival for wild white sturgeon and the general lack of recruitment since the mid-1960's, conservation aquaculture should be used to rear juvenile white sturgeon for release into the Kootenai River, and possibly Kootenay Lake, in each of the next 10 years. The Kootenai River white sturgeon population could be considered for downlisting to threatened status in approximately 10 years if downlisting criteria described in section B. Recovery Criteria below are achieved.

The long-term objectives are to provide suitable habitat conditions and restore an appropriate age structure and effective population size to ensure a self-sustaining Kootenai River population of white sturgeon.

Recovery actions proposed in this final Plan are intended to balance white sturgeon recovery with requirements for other fish species and recreational fisheries (Executive Order 12962 of June 7, 1995) within the Kootenai River drainage. In all but the most extreme low water years, the Plan should complement conservation measures designed by the National Marine Fisheries Service to meet Snake River chinook and sockeye salmon recovery objectives downstream in the Columbia River.

B. Recovery Criteria

Criteria for reclassification or downlisting to threatened status for Kootenai River white sturgeon include:

1. Natural production of white sturgeon occurs in at least 3 different years of a 10-year period. A naturally produced year class is demonstrated through detection by standard recapture methods of at least 20 juveniles from that class reaching more than 1 year of age, and;

2. The estimated white sturgeon population is stable or increasing and juveniles reared through a conservation aquaculture program are available to be added to the wild population each year for a 10-year period. For this purpose, a year class will be represented by the equivalent of 1,000 one-year old fish from each of 6 to 12 families, i.e. 3 to 6 female parents. Each of these year classes must be large enough to produce 24 to 120 white sturgeon surviving to sexual maturity. Over the next 10 years, the number of hatchery reared juvenile fish released annually will be adjusted depending upon the mortality rate of previously released fish and the level of natural production detected. Additionally, if measures to restore natural recruitment are successful, the conservation aquaculture program may be modified. Conversely, the Fish and Wildlife Service may recommend that the conservation aquaculture program be extended beyond 10 years if adequate natural recruitment to support full protection of the existing Kootenai River white sturgeon gene pool is not clearly demonstrated, and;

3. A long-term Kootenai River Flow Strategy is developed in consultation of interested State, Federal, and Canadian agencies and the Kootenai Tribe at the end of the 10-year period based on results of ongoing conservation actions, habitat research, and fish productivity studies. This strategy should describe the environmental conditions that resulted in natural production, i.e. recruitment (as described in criterion No. 1), with emphasis on those conditions necessary to repeatedly produce recruits in future years.

Recovery or delisting will be based on providing suitable habitat conditions and restoring an effective population size and age structure capable of establishing a self-sustaining Kootenai River population of white sturgeon. Specific delisting recovery criteria will be developed as new population status, life history, biological productivity, and flow augmentation monitoring information is collected. However, it will be approximately 25 years following approval of this recovery plan before delisting of the white sturgeon population can be considered. Twenty-five years is the approximate period for female white sturgeon added to the population during the next 10 years to reach maturity and reproduce to complete a new generation or spawning cycle.

<u>Actions Needed to Initiate Recovery:</u>

- Identify and restore white sturgeon habitats necessary to sustain white sturgeon reproduction (spawning and early age recruitment) and rearing while minimizing impacts on other uses of Kootenai River basin waters, e.g. recreational facilities and the resident fishery in Koocanusa Reservoir, Kootenay Lake, and Kootenai River.

- Develop and implement a conservation aquaculture program to prevent the extinction of Kootenai River white sturgeon. The conservation aquaculture program will include protocols on broodstock collection, gene pool preservation, propagation, juvenile rearing, fish health, and preservation stocking.

- Work within operational guidelines for Libby Dam based upon Kootenai Integrated Rule Curves (KIRC) to balance white sturgeon recovery with requirements for other fish species and recreational fisheries within the Kootenai River drainage, and VARQ to ensure that more water is available for white sturgeon, salmon, and all species in lower water years.

- Continue research and monitoring programs on life history, habitat requirements for all life stages, population status, and trends of the Kootenai River white sturgeon.

- Protect Kootenai River white sturgeon and their habitats using available regulatory mechanisms, including section 7 and 10 of the Endangered Species Act, section 404 of the Clean Water Act, and the Canadian Fisheries Act.

- Evaluate how changes in biological productivity in the Kootenai River basin affect white sturgeon and their habitats.

- Evaluate the effects of contaminants and possible additional biological threats, i.e. predation, on Kootenai River white sturgeon and their habitats.

- Increase public awareness of the need to protect and recover the Kootenai River white sturgeon.

- Balance white sturgeon recovery measures with requirements for other aquatic species and recreational fisheries within the Kootenai River drainage.

- Secure funding for implementation of recovery tasks.

Recovery of the Kootenai River population of white sturgeon will require improved coordination between United States and Canadian governmental and nongovernmental organizations. In this Plan, the Fish and Wildlife Service acknowledges numerous programs underway through local, State, Tribal, Federal, and Canadian entities to address Kootenai River basin issues. Improved interagency coordination will ensure that these, and future programs, are compatible with recovery objectives proposed for the Kootenai River white sturgeon. Additionally, a United States - Canada binational agreement could be entered into to aid Kootenai River white sturgeon recovery efforts, as occurred for the endangered whooping crane.

The Fish and Wildlife Service will use the results of ongoing research and monitoring to update and revise the plan as needed.

C. Recovery Measures Narrative

Figure 11 outlines the proposed Kootenai River white sturgeon recovery measures. Recovery tasks 11, 21, 22, 23, 24, 25, 26, 32, 41, and 42, described as follows, are short-term recovery measures essential to prevent extinction of Kootenai River white sturgeon.

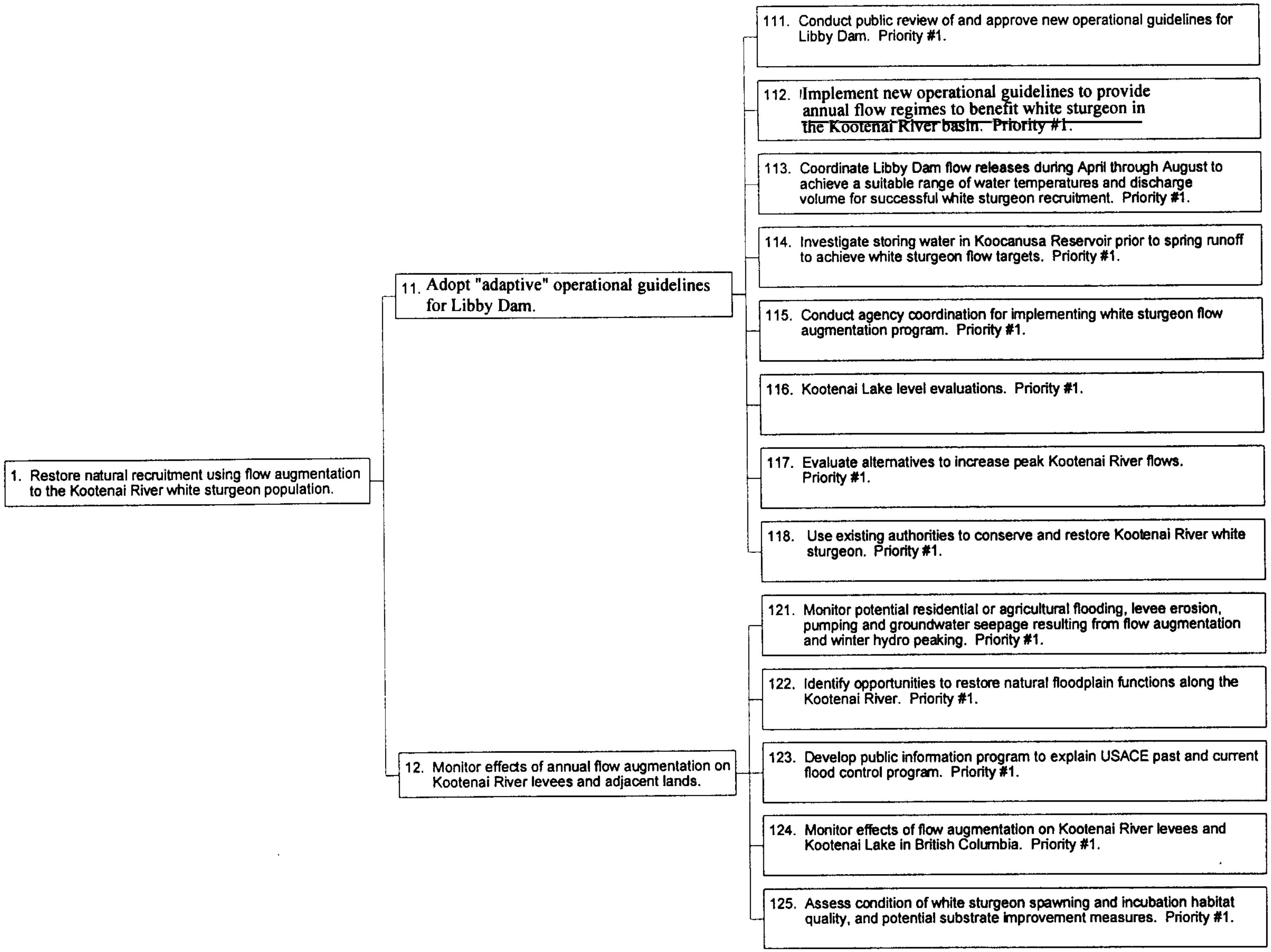


Figure 11. Flow chart summarizing Kootenai River white sturgeon recovery measures.

- 2. Refine, implement and evaluate a genetically sound white sturgeon conservation aquaculture program.
  - 21. The conservation aquaculture program will follow policies and procedures of the Northwest Power planning Council's Columbia Basin Fish and Wildlife program and the Service's artificial propagation policy.
    - 211. Obtain necessary local State, Tribe, Federal and canadian approval and permits for all conservation aquaculture activities. Priority #1.
  - 22. Develop performance standards for KTOI hatchery facilities.
    - 221. Determine water quality standards for KTOI hatchery. Priority #1.
    - 222. Upgrade KTOI hatchery to meet aquaculture objectives. Priority #1.
    - 223. Maintain Kootenai Trout Hatchery as secondry rearing facility. Priority #1.
    - 224. Implement the conservation aquaculture program. Priority #1.
  - 23. Implement genetic preservation guidelines for broodstock collection and mating desgin options.
    - 231. Use adopted white sturgeon broodstock protocol. Priority #1.
    - 232. Collect adequate numbers of male and female broodstock to maintain the genetic variability. Priority #1.
    - 233. Annually evaluate the conservation aquaculture program. Priority #1.
  - 24. Develop a release plan for Kootenai River white sturgeon.
    - 241. Evaluate appropriate production goals. Priority #1.
    - 242. Develop a fish health plan for hatcheries reared white sturgeon. Priority #1.
    - 243. Develop tagging protocol for hatchery reared white sturgeon. Priority #1.
    - 244. Develop a policy for hatchery white sturgeon in excess of beneficial uses identified in recovery. Priority #1.
    - 245. Evaluate feasibility of establishing an experimental white sturgeon population outside of its current occupied range. Priority #1.
  - 25. Release hatchery reared white sturgeon into the Kootenai River basin.
    - 251. Adjust white sturgeon releases, as necessary, to meet objectives of the Kincaid breeding plan. Priority #1.
  - 26. Monitor ecological interactions between hatchery reared and white sturgeon.
    - 261. Determine factors limiting production (natural or hatchery) and habitat use patterns for each life history stage Priority #1.

Figure 11. Continued

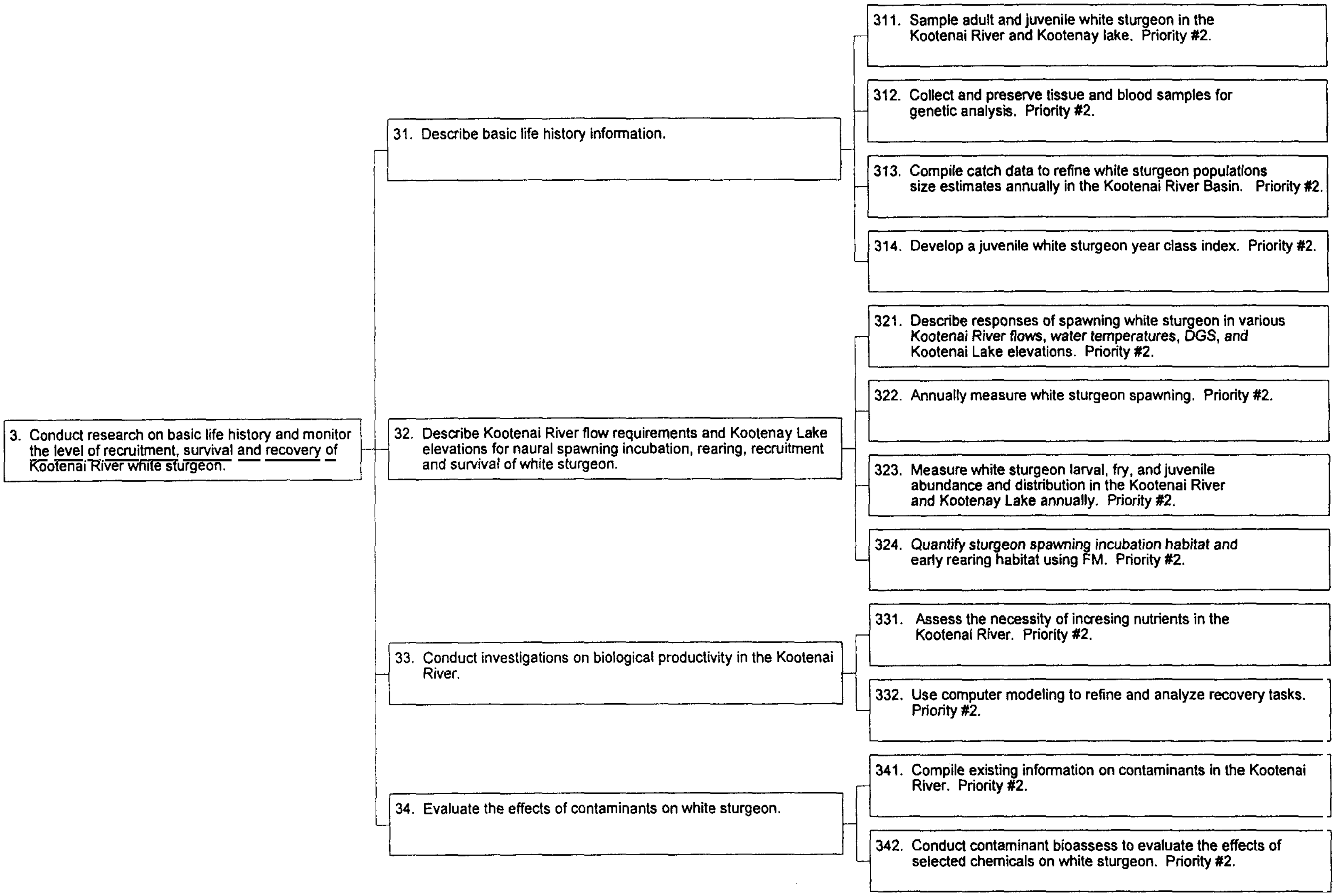


Figure 11. Continued

- 4. Implement conservation and recovery of Kootenai River white sturgeon.
  - 41. Develop a Participation Plan to support implementation of the Kootenai River white sturgeon recovery plan.
  - 42. Identify source's required funding to achieve Kootenai River white sturgeon recovery.
    - 421. Recommend research and management regarding ecosystem and fishery improvement measures for the Kootenai River Basin. Priority #2.
  - 43. Re-evaluate downlisting ad/or delisting criteria as needed.
  - 44. Determine the indirect recovery costs of foregone power generation.
  - 45. Increase public awareness of the need to protect Kootenai River white sturgeon.
- 5. Monitor the status of native fishes in the Kootenai River drainage.
  - 51. Conduct studies on kokanee below Libby Dam.
    - 511. Collect baseline abundance, distribution, and reproduction data for kokanee in the lower Kootenai River tributaries.
  - 52. Determine the status and distribution of burbot in the Kootenai River Basin.
    - 521. Determine distribution and life history of burbot.
    - 522. Determine secondary impacts from the flow augmentation program on burbot.
  - 53. Identify factors limiting rainbow trout survival and/or recruitment in the Kootenai River Basin.
    - 531. Determine the status, distribution and habitat use of rainbow trout in the Kootenai River from Libby Dam to Bonners Ferry.
  - 54 Develop information on bull trout in the Kootenai River Basin
    - 541. Determine distribution and status of bull trout in tributaries of the Kootenai River.
    - 542. Identify additional conservation measures to protect bull trout in the Kootenai River drainage in Montana, Idaho and B.C.
  - 55. Conduct research on whitefish in the Kootenai River from Libby Dam to Bonners Ferry.
    - 551. Determine the secondary effects of proposed white sturgeon flow augmentation on mountain whitefish.
  - 56. Evaluate impacts of flow augmentation on resident fish in Canada
    - 561. Effects of flow augmentation on DGS in the Kootenai River and Columbia River downstream of Kootenay Lake. Priority #3.
    - 562. Effects of flow augmentation on the Duncan and Arrow Reservoir/Lower systems. Priority #3.
    - 563. Evaluate effects of hydro peaking on native fish throughout the Kootenai River downstream of Libby Dam. Priority #3.
    - 564. Evaluate measures to reduce risk to native and resident sport fish below Libby Dam. Priority #3.
- 6. Assess the overall success of implementation of the recovery plan and revise accordingly.

Figure 11. Continued

1 **Restore Kootenai River white sturgeon natural recruitment using flow augmentation.**

Recovery of the Kootenai River white sturgeon will require providing suitable habitat conditions so that the remaining wild white sturgeon can successfully reproduce and recruit as juveniles (greater than age 1) to the population. Restoring natural recruitment to ensure a self-sustaining white sturgeon population will require implementing new operational guidelines for Libby Dam such as using tiered flows (Kootenai Integrated Rule Curves) to set aside water volumes for spring sturgeon flows and VARQ (an enhanced flood control protocol) to ensure that more water is available for white sturgeon, salmon, and all species in lower water years. The VARQ is an alternative flood control protocol developed by the U.S. Army Corps of Engineers for regulating flood control at Libby Dam, while the Kootenai Integrated Rule Curves (KIRCs) are designed to balance white sturgeon recovery with requirements for other species and recreational fisheries within the Kootenai River basin. The effects of operations at Libby extend well beyond the Kootenai basin, and flow management decisions must consider resources throughout the Columbia River basin. Factors other than flow possibly affecting white sturgeon recruitment, i.e. contaminants, predation, biological productivity, are addressed in recovery tasks # 311 through 342.

11 **Adopt "adaptive" operational guidelines for Libby Dam.**

Specific flow requirements for natural white sturgeon spawning and successful recruitment in the Kootenai River remain largely unknown. Until flows that contribute to successful recruitment are established, annual Kootenai River flow augmentation for white sturgeon should be based on water availability in the upper Kootenai River basin. This Plan proposes working within Libby Dam operational guidelines based upon increasing reservoir refill probability by adopting an operations model such as (KIRCs) that balances white sturgeon flow targets with Koocanusa Reservoir water levels and other aquatic resources in the Kootenai River basin, and using flood control operations like VARQ to ensure additional water is available for white sturgeon, salmon, and all species in lower water years. Under these "adaptive" operational guidelines, flow targets will vary annually by water temperature, water volume, duration, and shape. The effects of flow and water temperature on various life stages of white sturgeon will also be monitored. This operational strategy was designed to balance resident fish concerns with power production, flood control, and Koocanusa Reservoir refill under varying water availability ranging from drought to flood conditions (Appendix C).

111 Conduct public review and approve new operational guidelines for Libby Dam.

Implementation of new reservoir operational guidelines will require improved coordination with Canadian water management entities such as the British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries and Oceans; and hydro power producers such as BC Hydro. In addition, the adoption of new reservoir operational guidelines could be affected by the National Marine Fisheries Service's section 7 requirements relative to flows for listed Snake River salmon. In recognition of the need to meet the conservation requirements for sturgeon, salmon, and bull trout listed under the Endangered Species Act, the Fish and Wildlife Service and National Marine Fisheries Service will continue coordination on operations and flow augmentation programs with the goal of providing sufficient water for all listed species. Following final National Environmental Policy Act documentation and review, the North Pacific Division of the Army Corps of Engineers would issue a Record of Decision on adoption of new operational guidelines for Libby Dam.

112 Implement new operational guidelines to provide annual flow regimes to benefit white sturgeon in the Kootenai River basin.

Following completion of recovery task 111 and implementation by the Army Corps of Engineers of the new operational guidelines to manage Libby Dam operations, annual Kootenai River flow targets will be selected based on forecasted inflow volumes (i.e. reservoir inflow expected during April 1 through August 30 in million acre-feet). White sturgeon flow targets would represent minimum flows at Bonners Ferry (i.e. Libby Dam discharge plus unregulated runoff between Libby Dam and Bonners Ferry). There would be no specific Libby Dam flow augmentation for white sturgeon in an extended drought or low water years, e.g. critical water years (less than 4.8 million acre-feet), unless increased discharges are required for emergency flood control (see Appendix C for a more complete description).

Proposed water volume released for white sturgeon will be estimated using monthly volume runoff or inflow forecasts beginning in January. The final augmentation volume will be based on the May 1 forecast (Table 2). When the forecast underestimates the actual inflow volume, minimum white sturgeon flow targets may be exceeded as excess water is released to slow the rate of reservoir refill. Overestimation of seasonal runoff may impact Koocanusa Reservoir refill by releasing water to achieve the minimum white sturgeon flow target.

Actual water releases from Libby Dam by the Army Corps of Engineers and Bonneville Power Administration during April through August will be based upon section 7 consultation with the Fish and Wildlife Service (task 118) and fine tuned through in-season management based on known in-river conditions and recommendations by several coordinating entities as described in task 113.

Table 2. "Tiered" volumes of water for sturgeon flow enhancement to be provided at Bonners Ferry according to the April-August volume runoff forecast at Libby. Actual flow releases would be shaped according to seasonal requests from the Fish and Wildlife Service and in-season management of water actually available. Volumes are in addition to the Libby minimum release of 4,000 cfs. (maf = million acre feet)

Forecast runoff volume (maf) at Libby	Sturgeon flow volume (maf) at Bonners Ferry
0.00 ≤ forecast < 4.80	0.71
4.80 ≤ forecast < 6.00	1.42
6.00 ≤ forecast < 6.70	1.77
6.70 ≤ forecast < 8.10	2.56
8.10 ≤ forecast < 8.90	3.89
8.90 ≤ forecast	4.77

113 Coordinate Libby Dam flow releases during April through August to achieve a suitable range of water temperature and discharge volume for successful white sturgeon recruitment.

The adoption of new reservoir operational guidelines will provide flexibility to assure that the flow augmentation for successful white sturgeon recruitment corresponds with suitable water temperatures. At Libby Dam, operators are able to release or selectively withdraw reservoir water from appropriate depths to achieve a more natural temperature regime as measured at Bonners Ferry. As appropriate water temperatures (10 to 14 degrees Celsius [50 to 57 degrees Fahrenheit]) become available at the appropriate outlet depth, and in consideration of ambient weather conditions and tributary additions downstream, Libby Dam discharge can be regulated to achieve the optimal mix of Kootenai River flow and temperature.

Annual flow management plans to manage water releases from Libby Dam during April through August will be based on coordination between the Army Corps of Engineers, Bonneville Power Administration, National Marine Fisheries Service, Fish and Wildlife Service, and other coordinating entities (e.g., State of Montana; Kootenai - Salish Nation; British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries; and BC Hydro), and implemented through the Regional Forum's Technical Management Team or its successor. These entities will use a systematic approach to evaluate (task 321) how flow shaping, timing, water volume, water depth, water temperatures, prespawning flows, and substrate type may affect white sturgeon spawning behavior and recruitment. For example, the flow management plan would consider water availability in a given year and attempt to shape flows to mimic Kootenai River flows and water temperatures observed in years when some white sturgeon recruitment occurred, e.g. 1970, 1974, 1980, and 1991. White sturgeon should respond to these stimuli by forming prespawning aggregate groups below Bonners Ferry in anticipation of moving upstream to spawn where suitable incubation, water temperature, water depths, water velocities, and substrate type exist. Evaluating the success of an annual flow management plan will be part of task 321; with success partially defined as detecting white sturgeon eggs spawned into suitable habitats and documenting some level of natural recruitment.

At present, the Army Corps of Engineers and Montana Department of Fish, Wildlife, and Parks have an agreement to release water no closer than 16 meters (50 feet) beneath the Koocanusa Reservoir surface elevation to reduce the loss of fish (primarily kokanee) through the turbines (entrainment). Recent sampling of fish entrainment (Skaar et al. 1996) revealed that downstream losses of various fish species are severe in June, particularly when reservoir levels are low. However, to achieve temperature criteria for white sturgeon spawning in the Bonners Ferry reach, it has been necessary to withdraw surface water (upper 10 to 11 meters [30 to 35 feet]) from Koocanusa Reservoir during May and June. Methods of reducing entrainment should be pursued as part of the annual coordination to balance the effects of thermal control and flow augmentation on the reservoir fishery.

114 Investigate storing water in Koocanusa Reservoir prior to spring runoff to achieve white sturgeon flow targets.

The Montana Department of Fish, Wildlife, and Parks has shown that storing water behind Libby Dam during the winter period not only increases water availability for white sturgeon flow augmentation but also reduces impacts to the Koocanusa Reservoir fishery. By storing water for white sturgeon, reservoir elevations should remain more favorable for biological production and refill probability will be enhanced. Water releases for sturgeon then continue downstream to aid juvenile anadromous fish migration to the Pacific Ocean. Bull trout, west-slope cutthroat trout, rainbow trout, and possibly burbot, in the Kootenai River may respond favorably to this operating strategy because the timing of releases corresponds with their life cycle requirements.

The VARQ was a flood control strategy developed by the U.S. Army Corps of Engineers while the KIRCs incorporate a flood control strategy that is compatible with flood control rule curves for Libby Dam under evaluation by the Army Corps of Engineers. The rule curves of both of these operational guidelines facilitate storing additional water prior to the spring runoff. The Army Corps of Engineers, in coordination with appropriate United States and Canada fishery agencies, should complete their analysis as it may allow for the storage of additional water available for white sturgeon flow augmentation and the minimization of impacts to Koocanusa Reservoir through more frequent refill.

115 Conduct agency coordination for implementing white sturgeon flow augmentation program.

The Army Corps of Engineers, Bonneville Power Administration, Fish and Wildlife Service, National Marine Fisheries Service, First Nations, BC Hydro, appropriate States, and Canada will require specific information to plan and implement annual Kootenai River white sturgeon recruitment flow proposals. These entities should coordinate annually to ensure that regional flood control requirements will be met, adequate water volume is stored in Koocanusa Reservoir, and system power needs and regional aquatic resource issues are addressed in years when white sturgeon flow augmentation will occur.

Prior to implementing the operational changes in the way water is stored and released from Libby Dam, the operating agencies should also cooperate using Columbia River Treaty protocols. Protocol V of the Treaty describes responsibilities of the entities and requires cooperation on a continuous basis to coordinate the operation of

Libby Dam with the operation of hydroelectric plants on the Kootenai River and elsewhere in Canada in accordance with the provisions of Articles XII (5), XII (6), IV (2a), and IV (2k) of the Treaty.

116 Kootenay Lake level evaluations.

One potential reason Kootenay River white sturgeon spawn in areas of apparent suboptimal conditions may be the result of implementing the 1938 International Joint Commission (IJC) Order, controlling the level of Kootenay Lake. The International Joint Commission, formed to ensure property rights are not impacted by actions of the neighboring countries, responded to a proposal to construct a hydroelectric facility at the outlet of Kootenay Lake by issuing an order that effectively controlled the surface elevation of Kootenay Lake. However, with the regulation of inflows by Libby Dam, the interpretation of the International Joint Commission order has resulted in Kootenay Lake mean maximum levels being approximately 2 meters (6.6 feet) lower since the construction of Libby dam in 1972. The Fish and Wildlife Service believes the lower maximum lake elevation may contribute to the lack of successful white sturgeon reproduction by altering river stage, flow velocity, and substrate relationships in the vicinity of sturgeon spawning habitat near Bonners Ferry. Velocities are important to spawning behavior and locations. Altered river velocities resulting from these lake elevation changes could partially explain the recent observation of white sturgeon spawning in the Kootenai River farther downstream than expected and over a sand substrate where eggs may not survive. Further discussion between appropriate Canada and United States officials should occur to determine whether lake elevation should be determined based on regulated or natural inflows. Other issues of concern as part of this evaluation include effects of International Joint Commission actions on Koocanusa Reservoir refill, and seasonal flooding effects along the Kootenai River and Kootenay Lake.

117 **Evaluate alternatives to increase peak Kootenai River flows.**

Examine alternatives to reliably provide peak flows in the Kootenai River at Bonners Ferry, Idaho, in the 1,100 to 1,400 cubic meters per second (40,000 to 50,000 cubic feet per second) range during the sturgeon spawning period. With the existing Libby Dam configuration two alternatives exist. The Water Resources Development Act of 1996 authorized appropriation of $16 million to complete the installation of existing generating units 6 through 8 in Libby Dam. Since these generating units are also connected to the selective withdrawal system they could increase peak flows of temperature regulated waters by as much as 60 percent. However, flood control and public safety considerations are important to that discussion. Use of the spillway, if it were modified with fliplips to reduce dissolved gas in outflows, might be an alternative to additional generating units. However, in years of high runoff, the spillway might not be available because the reservoir surface would probably be below the spillway crest elevation of 2,450 feet, for flood control purposes. Furthermore, in such situations, reservoir temperature stratification is still essentially nonexistent in early June, making warmer water difficult to obtain. This may also provide benefits to resident fish including bull trout in the Kootenai River downstream of Libby Dam if less conservative flood rule curves are adopted (Kootenai Integrated Rule Curves) and spill frequency increases.

118 **Use existing authorities to conserve and restore Kootenai River white sturgeon.**

Section 7(a) of the Endangered Species Act requires Federal agencies to use their authorities to carry out programs to conserve endangered and threatened species. The Fish and Wildlife Service will continue to request that the Army Corps of Engineers annually evaluate the direct and indirect effects of Libby Dam operations on the Kootenai River white sturgeon under section 7(a).

12 Monitor effects of annual flow augmentation on Kootenai River levees and adjacent lands.

The monitoring program begun in 1995 to evaluate the physical impacts of flow augmentation on Kootenai River levees and adjacent lands downstream of Bonners Ferry should be continued by the Army Corps of Engineers and the British Columbia Ministry of Environment, Land, and Parks. The Army Corps of Engineers should identify areas where levee repairs may be necessary to protect developed areas and also identify areas where levees can be removed or left in their current state. The biological evaluation of potential impacts and benefits to resident fish and other aquatic resources will be conducted through implementing recovery tasks 32 through 562.

121 Monitor potential residential or agricultural flooding, levee erosion, pumping, and groundwater seepage resulting from flow augmentation and winter hydro peaking.

The Army Corps of Engineers' annual monitoring report for the 1995 flow augmentation program should include a description of seepage-caused inundation of agricultural lands flooded, levee erosion from peak spring flows and winter hydro peaking, and any flooding that may have resulted from white sturgeon augmentation flows. The results of this study will be useful in developing procedures and guidelines for implementing an annual levee monitoring program.

122 Identify opportunities to restore natural flood plain functions along the Kootenai River.

Based on the results of task 121, the action agencies should identify opportunities to restore natural flood plain and wetland functions along the Kootenai River downstream of Bonners Ferry in Idaho. For example, identify landowners in flood-prone areas that may be willing to sell, lease, or assign conservation easements on portions of their land suitable for restoring natural flood plain functions. Funding may be available to implement this task through Section 206 Aquatic Ecosystem Restoration of the Water Resources Development Act of 1996.

The British Columbia Ministry of Environment, Lands, and Parks should work with the Creston Valley Wildlife Management Authority to further investigate altered Kootenai River flooding patterns to improve white sturgeon habitat.

123 Develop a public information program to explain Army Corps of Engineers past and current flood control program.

The Army Corps of Engineers should develop and distribute information on flood control operations and potential risks as part of their annual public meetings, as well as in any National Environmental Policy Act documentation of Kootenai River flow augmentation proposals.

124 Monitor effects of flow augmentation on Kootenay River levees and Kootenay Lake in British Columbia.

Proposed flow augmentation measures are designed to benefit white sturgeon reproduction primarily in the United States portion of the Kootenai River. However, physical impacts may also occur in Canada along the Kootenay River and Kootenay Lake. The British Columbia Ministry of Environment, Lands, and Parks should develop and implement a monitoring program in Canada similar to recovery task 121.

125 Assess the condition of white sturgeon spawning and incubation habitat quality, and potential substrate improvement measures.

Researchers generally agree that white sturgeon egg deposition and spawning downstream from Bonners Ferry in low velocity, silt/sand deposition areas of the Kootenai River are not currently occurring in optimal habitat for successful egg incubation, hatching, and larval rearing. An evaluation on the future use of artificial spawning and rearing substrates should be conducted. Artificial substrates have been introduced for various sturgeon species in North America, Russia, and France with varying degrees of success. These habitat projects have involved placing rock and boulder substrates in known spawning reaches of the target species.

2 Refine, implement, and evaluate a genetically sound conservation aquaculture program.

To prevent extinction of the Kootenai River white sturgeon population, a conservation aquaculture program will be implemented and evaluated for a minimum of 10 years (1999 through 2008). This program will help preserve the 10 population's remaining wild genetic variability and will begin to rebuild the natural age class structure of the wild white sturgeon population over the next 10 years. If measures to restore natural white sturgeon recruitment (described in tasks 111 to 116) are successful, the conservation aquaculture program may be adjusted before 2009. Components of this conservation aquaculture program include the following tasks:

21 The conservation aquaculture program will follow the policies and procedures of the Northwest Power Planning Council's Columbia Basin Fish and Wildlife Program and the Fish and Wildlife Service's artificial propagation policy.

All white sturgeon produced and released in the Kootenai River will be consistent with management goals and policies. Fishery managers from the participating agencies will review existing policies and goals for consistency with the conservation aquaculture program. Additionally, they will ensure that the conservation aquaculture program is consistent with the Northwest Power Planning Council Fish and Wildlife Program and the Fish and Wildlife Service's artificial propagation policy.

211 Maintain necessary local, State, Tribal, Federal, and Canadian approval and permits for all conservation aquaculture activities.

Appropriate agencies will be properly informed of conservation aquaculture activities. Required permits for broodstock collection, transport, and release of white sturgeon in the Kootenai River system will be renewed through consultation with the Fish and Wildlife Service and appropriate State agencies. For example, a section 10 (a)(1)(A) permit authorized under the Endangered Species Act is required in order to collect, propagate, rear, and release white sturgeon.

22 Develop performance standards for the Kootenai Tribe of Idaho hatchery facilities.

Hatchery performance standards for white sturgeon are necessary to successfully spawn and rear healthy Kootenai River white sturgeon. For best results, the existing Kootenai Tribe of Idaho white sturgeon hatchery should be operated following well defined performance standards. The Kootenai Tribe of Idaho, in coordination with the Idaho Department of Fish and Game; Bonneville Power Administration; British Columbia Ministry of Environment, Lands, and Parks; Montana Department of Fish, Wildlife, and Parks; and the Fish and Wildlife Service, will develop a set of performance standards that include a description of suitable facilities, water quality standards, rearing capacities, and egg hatching/rearing protocols.

221 Maintain water quality standards for Kootenai Tribe of Idaho hatchery.

A reliable water supply with acceptable water quality is needed to ensure that healthy white sturgeon are reared in the Kootenai Tribe of Idaho hatchery. Water quality standards will be determined since the main hatchery water source is the Kootenai River. The physical characteristics of the water in the Kootenai River are variable throughout the year. Water quality factors monitored weekly by the Kootenai Tribe of Idaho include water temperature, dissolved gases, turbidity, alkalinity and hardness, nitrite, contaminants, and pathogens.

222 Upgrade Kootenai Tribe of Idaho hatchery to meet conservation aquaculture objectives.

To achieve the proposed conservation aquaculture objectives, the current Kootenai Tribe of Idaho hatchery near Bonners Ferry will require additional facility improvements and expansion. Some of the hatchery needs include additional rearing capabilities, a water sterilization system, a sediment removal system, and a supplemental oxygen system. Upgrades to the existing facility, begun in 1998, will enable the Kootenai Tribe of Idaho to remove sediment and bacteria from river water, improve water capacity, and moderately control water temperature.

223 Maintain Kootenay Trout Hatchery as secondary rearing facility.

At present, there is the risk of losing hatchery reared juvenile white sturgeon due to accidents or other unanticipated events, e.g. power outage or loss of water supply. To minimize the risk of losing one or more white sturgeon families held in the Kootenai Tribe of Idaho hatchery until fish are large enough to be marked and released, the Kootenai Tribe of Idaho will work with appropriate

Canadian officials to establish the Kootenay Trout Hatchery in Fort Steele, British Columbia as a secondary rearing or "fail-safe" facility within the Kootenai River basin.

224 Implement the conservation aquaculture program.

The Bonneville Power Administration has funded the design, development, construction, and operation of the Kootenai Tribe of Idaho hatchery since 1988 as directed by measure 10.4B.1 in the Northwest Power Planning Council Program. The hatchery successfully spawned, incubated, and reared white sturgeon in 1991, 1992, 1993, and 1995. This program is vital to the recovery of the white sturgeon population and the Bonneville Power Administration should continue to fund the Kootenai Tribe of Idaho hatchery from 1999 to 2008. The Kootenai Tribe of Idaho and Idaho Department of Fish and Game will implement the conservation aquaculture program to prevent the extinction of the Kootenai River population of white sturgeon.

23 Implement genetic preservation guidelines for broodstock collection and mating design options.

In 1993, the Bonneville Power Administration funded the development of a breeding plan for the Kootenai River white sturgeon (Kincaid 1993). The breeding plan provided a systematic approach to preserve the white sturgeon population's genetic variability while management agencies continued work to restore Kootenai River habitat conditions necessary to reestablish natural recruitment (Appendix D).

231 Use adopted white sturgeon broodstock collection protocol.

Broodstock collected will represent the genetic variability of the population by taking representative samples with respect to run timing, size, sex, age, and other important traits to maintain long-term fitness. A broodstock collection protocol developed by the

Kootenai Tribe of Idaho and the Idaho Department of Fish and Game is summarized in Appendix E. The protocol, partially adapted from Kincaid's (1993) breeding plan, is designed to maximize collection efficiency, reproductive success, and genetic variation of broodstock while minimizing negative effects of handling stress on the natural spawning white sturgeon in the Kootenai River.

232 Collect adequate numbers of male and female broodstock to maintain the genetic variability.

Annually collect and spawn three to six females and six to nine males for broodstock (Appendix E). These fish will be held in the Kootenai Tribe of Idaho hatchery for 1 to 2 months until they are ready to be spawned. This protocol is adapted from Kincaid's (1993) breeding plan and will allow the genetic variability of the wild population to be maintained over the next 10 years.

The breeding plan incorporates a spawning matrix to minimize white sturgeon inbreeding and genetic drift. This spawning matrix is designed to maximize the diversity of genetic material passed on from artificially spawned adult white sturgeon when the hatchery-reared fish are released back into the wild population. Maximizing genetic diversity is important for the long term fitness and survival of Kootenai River white sturgeon. See Appendix D (Kincaid 1993) for more information.

233 Annually evaluate the conservation aquaculture program.

The conservation aquaculture program should be evaluated annually to ensure that the genetic variability of the Kootenai River white sturgeon population is preserved. Tissue samples from all broodstock and representative numbers of progeny are currently being archived for future electrophoretic or DNA analysis to determine the genetic baseline for the white sturgeon population. The genetic baseline is necessary to determine if the broodstock collection protocol and spawning matrix are avoiding inbreeding and genetic drift.

24 Develop a release plan for Kootenai River white sturgeon.

A plan will be developed to govern the release of hatchery-reared fish so that conservation aquaculture objectives are met. Fish size, release time, and release locations are three factors that may affect survival of hatchery-reared sturgeon in the Kootenai River. The size of hatchery-reared sturgeon released into the Kootenai River should take into account predation and food availability to achieve maximum growth. The release plan will specify release sizes, release times, and release locations for hatchery-reared white sturgeon.

241 Evaluate appropriate production goals.

Annual production goals will range from 6,000 to 12,000 yearling white sturgeon depending on how many families are produced in any given year. This goal is designed to produce the 24 to 120 sexually mature sturgeon in each year class needed to rebuild a more natural age structure of Kootenai River white sturgeon. Based on 7 years of survey information, female and male Kootenai River white sturgeon reach sexual maturity as young as age 22 and 16 years, respectively (Vaughn L. Paragamian, IDFG, pers. comm.). White sturgeon releases should begin as soon as juvenile white sturgeon from the 1998 year class are large enough for marking, and continue for a minimum of 10 years. The production goal was developed using estimates of longevity, current survival estimates, and average age to maturity. Production goals may be altered based on the approval and future operation of a secondary backup rearing facility (see task 223).

242 **Develop a fish health plan for hatchery-reared white sturgeon.**

Fish health protocols will be developed to ensure that hatchery-reared white sturgeon available for release into the Kootenai River are generally healthy and disease free. Protocols will include a health inspection program for all white sturgeon life stages and prophylactic measures to prevent disease transfer in the hatchery. It is recommended that the health inspection program be administered by certified fish pathologists. These protocols will help minimize adverse impacts on the wild population and increase survival of hatchery-reared white sturgeon released into the Kootenai River basin.

243 **Develop tagging protocols for hatchery-reared white sturgeon.**

Permanent marking and tagging techniques are necessary to differentiate hatchery-produced white sturgeon from naturally produced white sturgeon in the Kootenai River. Protocols should use a combination of tagging methods (e.g. Passive Integrated Transponder Tags, scute removal patterns, and oxytetracycline). All fish must be permanently tagged to allow future identification by family and year class. Standardized tagging and collection methods will be developed to ensure that all appropriate information is recorded. The tagging protocol will be coordinated and approved by the Kootenai Tribe of Idaho; Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries and Oceans; and the U.S. Fish and Wildlife Service.

244 Develop a policy for hatchery-reared white sturgeon produced in excess of beneficial uses identified in the recovery plan.

The Kootenai Tribe of Idaho; Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries and Oceans; and the U.S. Fish and Wildlife Service will decide on the disposition of surplus juvenile white sturgeon. Once production goals have been met, beneficial use of surplus white sturgeon may include 1) establishment of a live gene bank or refugia population (task 245); 2) genetic analysis (mitochondrial DNA, nuclear DNA, or electrophoresis); 3) contaminant bioassays; 4) viral and bacterial research; 5) permanent marking techniques; 6) public displays and other educational purposes. Any fish remaining after all beneficial uses have been identified and addressed will be euthanized.

245 Evaluate feasibility of establishing an experimental white sturgeon population outside of the current occupied range.

When preserving any species, the probability of its persistence increases dramatically if that species exists in several populations. A nonessential experimental population of white sturgeon established somewhere in the Kootenai River basin would provide a long-term source of gene pool preservation, i.e. hatchery-reared fish, which would be available to augment the existing population if mortality rates are greater than expected or some natural catastrophe occurs. The Fish and Wildlife Service, in coordination with the affected State and Canadian entities, should evaluate the feasibility of establishing such a population, identify possible locations, e.g. Koocanusa Reservoir or Duncun Reservoir, and identify appropriate permits and disclosure documentation.

25 Release hatchery-reared white sturgeon into the Kootenai River basin.

Following completion of tasks 241 through 244, up to 1,000 juvenile white sturgeon per family will be released annually into the Kootenai River beginning in 1996. Based on the breeding plan developed by Kincaid (Appendix D and E), family releases will include the same number of juvenile sturgeon per year class to maintain the genetic variability of the Kootenai River white sturgeon population. Release times and locations will be developed to ensure optimal survival of hatchery-reared white sturgeon. Prior to release, white sturgeon will be tested for disease and visually inspected for physical deformities. Fish with obvious physical deformities will not be released and will be euthanized.

251 Adjust white sturgeon releases, as necessary, to meet objectives of the Kincaid breeding plan.

Based on implementing task 241 and using the monitoring results of recovery task 26, it may be necessary to adjust the numbers of hatchery-reared fish released in order to meet the goal of producing 4 to 10 spawning adult white sturgeon per family. Actual release numbers will be dependent upon the level of natural white sturgeon survival and recruitment detected for a given year. (Appendix D)

26 Monitor ecological interactions between hatchery-reared and wild sturgeon.

Interactions between hatchery-reared and wild white sturgeon will be monitored. A monitoring plan will be developed to ensure that hatchery white sturgeon are meeting the goals of the conservation aquaculture program. For example, survival and growth rates of released sturgeon are currently uncertain. Therefore, it is necessary to monitor released fish to determine survival and growth rates in the Kootenai River and Kootenay Lake in order to evaluate whether the Kincaid goal of producing 4 to 10 spawning adults per family spawned is being met.

261 Determine factors limiting production (natural and hatchery) and habitat use patterns for each life history stage.

A total of 2,588 hatchery-reared juvenile white sturgeon from 1991, 1992, 1993, and 1995 year classes have been released into the Kootenai River. Some of these fish will be captured at regular intervals to determine habitat preferences, movement, distribution, growth rate, food preferences, survival, and interactions with wild white sturgeon. This information will be used to determine habitat availability for juvenile white sturgeon, and identify additional areas to sample for wild white sturgeon spawning in the Kootenai River system.

3. Conduct research on basic life history and monitor the level of recruitment, survival, and recovery of Kootenai River white sturgeon.

Recovery of the Kootenai River white sturgeon can be achieved only by restoring the ecosystem upon which the fish depends. In addition to the interruption of natural spring runoff, other physical, chemical, and biological factors are believed to negatively affect the reproduction and survival of Kootenai River white sturgeon. These factors include habitat changes due to impounding water, diking, backwater habitat loss, changing levels of Kootenay Lake and the Kootenai River, altered bed-load transport rates, siltation, reduced productivity, nutrient loss, and water temperature modification. Potential biological factors include a declining effective population size, egg suffocation, lack of interstitial space, larval starvation, and predation on early life stages of white sturgeon. A better understanding of the white sturgeon life history and physical and biological factors affecting survival is necessary for developing specific recovery criteria and evaluating the success of proposed recovery measures.

31 Describe basic life history information.

Although much has been learned regarding the life history of Kootenai

River white sturgeon, further information regarding growth, longevity, age of maturation, migration patterns, specific spawning locations, egg, larvae and juvenile survival, and food selection is needed. This information will help document the ecological needs of the Kootenai River white sturgeon and also help to determine population viability.

311 Sample adult and juvenile white sturgeon in the Kootenai River and Kootenay Lake.

Collect biological information from captured fish including length, weight, girth, sex, pectoral fin samples for aging, and reproductive stage. This information will be useful to determine accurate age and growth rates of white sturgeon and determine environmental conditions necessary for natural reproduction and recruitment. As many as 120 sonic or radio transmitters previously attached to white sturgeon for monitoring purposes are still active or attached to free roaming fish. Most of these transmitters were attached with stainless steel wire that persists beyond the expected battery life. The Idaho Department of Fish and Game; Bonneville Power Administration; Montana Department of Fish, Wildlife, and Parks; and Kootenai Tribe of Idaho will evaluate the need to continue attaching transmitters to additional white sturgeon each year to fulfill research and monitoring needs. Only nonpermanent attachment methods should be used where feasible to ensure that transmitters remain attached only as long as necessary.

312 Collect and preserve tissue and blood samples for genetic analysis.

Tissue samples are being archived for future electrophoretic or DNA fingerprinting analysis to determine the genetic baseline for the population. This effort should be expanded basin wide to include tissue samples from white sturgeon collected in the West Arm, North Arm, and South Arms of Kootenay Lake; and Duncun Reservoir.

313 Compile catch data to annually refine white sturgeon population size estimates in the Kootenai River basin.

Information regarding the number of juveniles and adults in the Kootenai River system is necessary to develop and prioritize short and long term recovery objectives. Catch data should be compiled and analyzed annually to determine what the natural age class structure of the population is and the effective population size are relative to recovery criteria.

314 Develop a juvenile white sturgeon year class index.

The results from annual juvenile white sturgeon sampling studies will be useful to management agencies to develop an index of annual year class strength. This method will also be useful to document the effect of flow augmentation on white sturgeon natural recruitment in meeting recovery criteria, and also detect significant differences in year-class abundance.

32 Describe Kootenai River flow requirements and Kootenay Lake elevations for natural spawning, incubation, rearing, recruitment, and survival of white sturgeon.

Specific flow requirements for natural white sturgeon spawning that result in successful recruitment are not yet well defined. However, the best available information on the relationship between Kootenai River flows and recruitment comes from collecting naturally reared recruited year classes of 1970, 1974, 1980, and possibly 1991. In these years, peak flow events at Porthill coincident with water temperature of 11 to 13 degrees Celsius (51 to 55 Fahrenheit) ranged from 708 cubic meters per second (25,000 cubic feet per second) in 1980 to 1,841 cubic meters per second

(65,000 cubic feet per second) in 1970. However, the strongest recent year class, 1974 had flow peaks of 1,416 and 1,558 cubic meters per second (50,000 and 55,000 cubic feet per second) at Porthill.

With the regulation of inflows by Libby Dam the interpretation of the Integrated Rule Curves order has resulted in Kootenay Lake mean maximum levels being more than 2 meters (6.6 feet) lower since the construction and operation of Libby Dam in 1974. We believe that lower maximum lake elevation may have contributed to the lack of successful white sturgeon reproduction in the Kootenai River by altering river stage, flow velocity, and substrate relationships in the vicinity of sturgeon spawning habitat near Bonners Ferry. Essentially, with lower Kootenay Lake levels the backwater effect of the lake is not as pronounced and therefore the white sturgeon detects suitable velocities farther downstream in the area of the sand substrates. As evidence, in 1994, 1995, and 1996, as Kootenai River peak flow and lake stage increased progressively, white sturgeon egg collections occurred increasingly farther upstream near Bonners Ferry (Paragamian et al. 1996).

Another important component of this recovery plan is to evaluate whether implementing recovery tasks 112 and 113 results in successful white sturgeon recruitment. This would entail using a systematic approach to evaluate how flow shaping, timing, water volume, water temperatures, and substrate type affect white sturgeon spawning behavior and recruitment. Also, with young-of-the-year fish produced in the system, we may begin to evaluate other factors affecting early age survival in the Kootenai River ecosystem.

321 Describe the response of spawning white sturgeon to various Kootenai River flows, water temperatures, gas supersaturation, and Kootenay Lake elevation.

Potential spawning white sturgeon will be captured and tagged with ultrasonic and radio transmitters. Both females and males will be tracked daily using telemetry gear prior to and throughout the spawning season. Habitat used by tagged adults will be described including depth, substrate, water temperature, and mean column velocities.

Habitat use curves will be developed for white sturgeon spawning in the Kootenai River. Detailed maps of the movement and distribution of tagged sturgeon from April through September will also be developed. This information will be used to evaluate the success of proposed flow augmentation measures as described in task 11 in providing natural recruitment, and also useful in establishing habitat based recovery criteria as part of task 43.

Gas supersaturation (DGS) in the Kootenai River originating from Libby Dam may influence white sturgeon survival and riverine health. Although adult white sturgeon occupy deeper water and are less prone to gas bubble trauma, larvae and juveniles using shallow river margins and backwater sloughs may be influenced directly or indirectly (via impacts on the food supply) by elevated gas levels. Measurements of gas concentrations by the Montana Department of Fish, Wildlife, and Parks during Libby Dam spills in the 1970's revealed that saturation levels violated current Montana State water quality standards (greater than 110 percent total dissolved gas) in the Kootenai River. Supersaturated water persisted downstream beyond Kootenai Falls into the river reach inhabited by white sturgeon and their prey. This monitoring program should measure dissolved gas levels in the Kootenai River downstream of Libby Dam to assure that white sturgeon recovery is not compromised by elevated gas concentrations. Recent studies on white sturgeon larvae in the lower Columbia River revealed changes in swimming ability and increased vulnerability to predation due to gas supersaturation at sublethal exposure (Counihan et al. 1998).

This analysis will also relate the level of white sturgeon spawning and recruitment to Kootenay Lake levels. Since Libby Dam flow regulation began, Kootenay Lake maximum spring elevations have decreased compared to pre-Libby Dam conditions. Decreased lake elevations would reduce the backwater effect of Kootenay Lake and thereby alter velocity patterns upstream in the Kootenai River. Velocities are important to spawning behavior and locations. Altered river velocities resulting from these lake elevation changes could partially explain the recent observation of white sturgeon spawning in the Kootenai River farther downstream than expected and over a sand substrate where eggs may not survive.

322 <u>Annually measure white sturgeon spawning.</u>

Artificial substrate mats, D-ring plankton nets, and predator fish stomachs will be used to sample eggs in the Kootenai River. Physical habitat parameters at egg collection sites will be measured including water depth, river bottom type, and mean water column velocity. Predator fish stomachs should be removed and examined for the presence of white sturgeon eggs.

Spawning can be verified by collection of eggs during the flow augmentation period. A relative index of the number of spawning episodes that occurred will be developed. Fertilized white sturgeon eggs will be analyzed to determine developmental stage. Combined with water temperature during the incubation period, this information will be used to back-calculate time of spawning and associated physical habitat parameters.

323 <u>Measure white sturgeon larvae, fry, and juvenile abundance and distribution in the Kootenai River and Kootenay Lake annually.</u>

Year class abundance can be determined for most types of fish during the first year of life. As yet there are no reliable techniques for determining year-class abundance of young-of-the-year or age 1 white sturgeon in the Kootenai River basin. The monitoring program (described under task 3) will continue to use and evaluate a variety of traps, trawls, and nets to reliably sample white sturgeon larvae and fry in the Kootenai River system. Abundance estimates will be calculated annually for white sturgeon larvae and fry in the Kootenai River, along with potential larval and young-of-the-year rearing habitat. These data will provide further insight into locations of spawning and rearing habitat and fish movements.

Juvenile white sturgeon abundance and distribution will be monitored with small mesh gill nets in the Kootenai River and Kootenay Lake. Relative abundance estimates will be calculated for juvenile fish using a sampling design based on location, time of year, gill-net sampling effort, and total catch. Potential juvenile rearing habitat will also be identified. Habitat use curves will then be prepared and compared to available aquatic habitat through the use of In-stream Flow Incremental Methodology (IFIM) (task 324). Knowledge of critical life-cycle requirements will be used to evaluate and direct habitat enhancement efforts.

324 Quantify sturgeon spawning/incubation habitat and early rearing habitat using In-stream Flow Incremental Methodology.

Habitat use data developed in tasks 321 through 323 will be used in the In-stream Flow Incremental Methodology model to quantify and locate spawning habitat and early rearing habitat in the Kootenai River system at different river discharge levels. This information will be used to evaluate the response of white sturgeon to habitat available during various flow regimes.

33 Conduct investigations on biological productivity in the Kootenai River.

Koocanusa Reservoir currently acts as a nutrient sink and thus limits the primary and secondary productivity of the Kootenai River downstream of

Libby Dam. Changes in nutrient availability affect the food chain for the fish community, the prey base for many species including white sturgeon, growth rates, and possibly survival of larval fish.

331 Assess the necessity of increasing nutrients in the Kootenai River.

Similar to the Kootenay Lake fertilization project previously described in Part I - Conservation measure 5, artificial additions of phosphorus and nitrogen may be a potential means of restoring primary and secondary productivity in the Kootenai River. All existing information regarding stream fertilization should be compiled and evaluated. Following this evaluation, a program describing potential nutrient dynamics and possible benefits to Kootenai River white sturgeon recovery from stream fertilization should be developed in cooperation with appropriate Canada, Montana, Idaho, and Indian Tribes. Improved primary and secondary productivity in the Kootenai River basin will also benefit other fish species, e.g. bull trout, rainbow trout, kokanee, burbot, and mountain whitefish.

332 Use computer modeling to refine and analyze recovery tasks.

In 1997, through a series of workshops, an Adaptive Environmental Assessment (AEA) model for the Kootenai River was developed as part of an adaptive management process to examine the potential benefits and impacts of alternate Kootenai River flow regimes on white sturgeon recruitment and other resources in the system. The main objective was to provide a tool that would aid in design of an experimental management program to define a flow regime that would benefit white sturgeon juvenile recruitment. The model simulations summarize the tradeoffs between power economics, flood protection, and fisheries benefits, as well as tradeoffs among species, associated with different flow regimes. The model will be used to evaluate the effectiveness of recovery tasks presented in this plan.

34 **Evaluate the effects of contaminants on white sturgeon.**

The Bonneville Power Administration funded a water and sediment quality study of the Kootenai River in the United States from Eureka, Montana downstream to Porthill at the United States/Canada border. However, lethal and sublethal effects of water and sediment chemical constituents on early life stages of white sturgeon still need to be determined.

341 **Compile existing information on contaminants in the Kootenai River.**

Use available information found in recent studies completed by the Kootenai Tribe of Idaho and Idaho State University to determine the presence and concentrations of contaminants including metals, organics, and inorganics in the water, sediment, and biota in the Kootenai River.

342 **Conduct contaminant bioassays to evaluate the effects of selected chemicals on white sturgeon.**

Laboratory studies of effects of heavy metals and other contaminants on white sturgeon eggs, larvae, and juveniles should be initiated. Existing protocols should be used where applicable; where no protocols exist, they should be developed with the cooperation of the Environmental Protection Agency.

4 **Implement conservation and recovery of Kootenai River white sturgeon.**

Recovery of Kootenai River white sturgeon is dependent upon regional coordination and adequate funding to implement conservation measures proposed in this plan.

41 Develop a Participation Plan to support implementation of the Kootenai River white sturgeon recovery plan.

Implementation of this recovery plan for Kootenai River white sturgeon will be accomplished only through interagency cooperation and participation leading to the timely recovery of the species while minimizing regional social and economic impacts. To meet these objectives, the Fish and Wildlife Service on July 1, 1994 issued new policy to develop a public Participation Plan for implementing recovery actions. Participation Plans are intended to ensure that a feasible recovery strategy involves and addresses the concerns of affected interest groups while providing realistic and timely recovery of the species. In the case of the Kootenai River white sturgeon, a Participation Plan would be developed by most of the agencies represented on the recovery team, and could include summaries of annual work plans for Kootenai River monitoring, research, and hatchery projects and section 7 consultations.

42 Identify funding required to achieve Kootenai River white sturgeon recovery.

Existing budgets of participating and responsible parties are not capable of funding all recovery tasks identified in this final plan. The recovery team should be retained to identify various funding strategies, including congressional appropriations, water-use fees, Federal mitigation programs, and binational agreements that may be useful in implementing white sturgeon recovery efforts.

421 Recommend research and management regarding ecosystem and fishery improvement measures for the Kootenai River basin.

As new information is developed and recovery actions are implemented, the recovery team should meet to address "new" research and management needs concurrent with white sturgeon recovery activities. The Fish and Wildlife Service anticipates that new questions and data needs will arise as white sturgeon recovery implementation occurs. The recovery team would meet to develop specific proposals to address these data gaps and recommend possible funding sources.

43 **Reevaluate downlisting and/or delisting criteria as needed.**

As initial recovery measures (see tasks 1-342) are accomplished and/or additional information regarding the ecology of Kootenai River white sturgeon becomes available, specific delisting criteria will be established.

44 **Determine the indirect recovery costs of foregone power generation.**

Implementing the many conservation actions proposed in this recovery plan may create additional economic impacts that are not normally considered a true "cost" of recovery. These impacts include foregone power generation opportunities, flood control impacts, and resident fish impacts.

The Army Corps of Engineers, Bonneville Power Administration, and BC Hydro should conduct an economic analysis of proposed white sturgeon recovery actions in terms of foregone power generation and remedial flood control requirements. This analysis should determine if the current "base economic assumptions" regarding lost power revenues are valid. The analysis should also consider alternative regional power marketing strategies to reduce revenue impacts and identify innovative measures to reduce potential flood control costs.

45 **Increase public awareness of the need to protect Kootenai River white sturgeon.**

Increase public awareness of the need to protect Kootenai River white sturgeon and their habitat (or ecosystem). Specific tasks to accomplish this might include periodic news releases, brochures, interactive presentations, in-school presentations by recovery team members, and possibly television documentaries.

5. **Monitor the status of native fishes in the Kootenai River drainage.**

The Kootenai River basin once provided important recreational, consumptive, and native subsistence fisheries. In addition to white sturgeon, residents and nonresidents fished for kokanee, burbot, rainbow trout, westslope cutthroat trout, bull trout, and mountain whitefish. All of these fisheries have declined dramatically over the past several decades. For example, a recent creel survey by the Idaho Department of Fish and Game revealed that fishing effort in the Idaho portion of the Kootenai River is the lowest of all waters surveyed in northern Idaho (Vaughn L. Paragamian, IDFG, pers. comm., 1996). Conversely, the abundance of nongame fish (e.g. suckers, northern squawfish) is three times higher than prior to the construction and operation of Libby Dam. Restoration of recreational fisheries is important to anglers and the regional economy.

Studies on the status of native fish in the Kootenai River basin were first authorized by the Northwest Power Planning Council in 1983. Although many of these studies continue, additional information is still needed on the status and important habitats required by several of the native and recreationally important fish species, including bull trout, kokanee, rainbow trout, burbot, and mountain whitefish. This information will also be useful to evaluate how resident fish are affected by conservation actions for Kootenai River white sturgeon.

51 **Conduct studies on kokanee downstream from Libby Dam.**

The Montana Department of Fish, Wildlife, and Parks; Idaho Department of Fish and Game; Kootenai Tribe of Idaho; and British Columbia Ministry of Environment, Lands, and Parks should continue annual monitoring to determine if kokanee entrained through Libby Dam during white sturgeon and salmon flow augmentation survive and contribute to downstream regional fisheries. Annual population estimates of kokanee would also be useful in determining whether increasing kokanee populations observed in recent years are affected by nutrient availability in the Kootenai River and Kootenay Lake.

511 Collect abundance, distribution, and reproduction data for kokanee in the lower Kootenai River tributaries.

Annual kokanee spawning population estimates will be determined. Information will be used to provide recommendations for improving kokanee spawning habitat and reintroducing kokanee in the Kootenai River tributaries. Additionally, the Idaho Department of Fish and Game; British Columbia Ministry of Environment, Lands, and Parks; and Kootenai Tribe of Idaho should evaluate opportunities to enhance spawning habitats in the Yaak River and Lake Creek.

52 Determine the status and distribution of burbot in the Kootenai River downstream of Kootenai Falls and Kootenay Lake.

Burbot are currently classified as a State threatened species by the Idaho Department of Fish and Game. The commercial and sport harvest of burbot prior to 1974 was estimated as high as 25,000 kilograms (55,000 pounds) in some years. This was primarily a winter fishery with few burbot caught in the spring and fall. Since that time, the burbot fishery in the Kootenai River basin has collapsed. There has been scant evidence of reproduction, only one juvenile burbot and no larvae have been captured in recent years. Sonic telemetry studies and recaptures reveal that the Goat River is the only known spawning location in the lower Kootenai River drainage (Paragamian et al 1997).

521 Determine distribution and life history of burbot.

The study begun in 1993 to identify distribution, life history, and factors limiting populations of burbot within the Kootenai River drainage should continue to be funded by the Bonneville Power Administration. All burbot captured will be tagged, and population estimates will be conducted annually to monitor population trends.

522 Determine secondary impacts from the flow augmentation program on burbot.

Recent research efforts by the Idaho Department of Fish and Game suggests that high, fluctuating Kootenai River flows during the winter affect winter migrations of burbot and possibly impact reproduction. Information garnered from implementing task 11 and completing task 521 should be used to evaluate how the proposed flow augmentation program will impact burbot recruitment. Preliminary study results indicate that burbot migrations during the spawning season may be effected by Libby Dam outflows during the winter for power production and flood control. Flow tests should be conducted to determine the maximum tolerable discharge and duration to allow burbot migration. This information is important because burbot in Idaho and British Columbia are genetically distinct from burbot in the Montana reach of the Kootenai River. Some believe this stock may be at greater risk of extinction than sturgeon.

53 Identify factors limiting rainbow trout survival and/or recruitment in the Kootenai River basin.

Rainbow trout spawning activity should be monitored to evaluate egg desiccation and/or redd scouring impacts in the Kootenai River from the white sturgeon flow augmentation program.

531 Determine the status, distribution, and habitat use of rainbow trout in the Kootenai River from Libby Dam to Bonners Ferry.

The Idaho Department of Fish and Game and the Montana Department of Fish, Wildlife, and Parks should further investigate the status and distribution of rainbow trout, including native Gerrard and interior redband, in the Kootenai River downstream of Libby Dam. Habitat use will be determined for fry, juvenile, and adult rainbow trout using scuba and snorkeling in the Kootenai River. This information will be useful to evaluate the effects of white sturgeon flow augmentation on rainbow trout.

54 <u>Develop information on bull trout in the Kootenai River basin.</u>

On June 10, 1998, the Columbia River population of bull trout was listed as a "threatened" species (63 FR 31647) under the Endangered Species Act. Additional information is needed on life history requirements, distribution, and factors regulating bull trout subpopulations within the Kootenai River drainage.

541 <u>Determine distribution and status of bull trout in tributaries of the Kootenai River.</u>

Bull trout are known from the Kootenai River, Koocanusa Reservoir, Kootenay Lake, and several tributaries within the Kootenai River basin. Bull trout are currently isolated into five subpopulations in the Unites States portion of the basin, with subpopulations generally stable with relatively low abundance. Monitoring by Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries and Oceans; and the Kootenai Tribe of Idaho will better describe the distribution, abundance, and habitat availability for bull trout. For example, bull trout surveys, including redd counts, should be conducted for all Montana streams where bull trout have previously been found, including Quartz, O'Brien, Libby, and Pipe Creeks and the Fisher River.

542 <u>Identify additional conservation measures to protect bull trout in the Kootenai River drainage in Montana, Idaho, and British Columbia.</u>

The Idaho Department of Fish and Game; Montana Department of Fish, Wildlife, and Parks; British Columbia Ministry of Environment, Lands, and Parks; Canada Department of Fisheries and Oceans; and the Kootenai Tribe of Idaho, using information garnered from task 541, should identify additional conservation measures necessary to maintain bull trout within the Kootenai River basin. Additionally, these agencies should evaluate whether recovery measures proposed for white sturgeon impact bull trout.

55 **Conduct research on mountain whitefish in the Kootenai River from Libby Dam downstream to Bonners Ferry.**

Habitat use will be determined for fry, juvenile, and adult mountain whitefish using SCUBA and snorkeling. If possible, separate use data will be obtained for winter, summer, and spawning habitat. Microhabitat measurements (e.g. depth, velocity, substrate, and cover) will be taken at locations where fish are encountered.

551 **Determine the secondary effects of proposed white sturgeon flow augmentation on mountain whitefish.**

A secondary effect of the white sturgeon flow augmentation program would be less water available during the winter when mountain whitefish spawn. In order to meet normally high, daily power demands during the winter, Libby Dam discharge fluctuations could possibly dewater and kill incubating mountain whitefish eggs. The Montana Department of Fish, Wildlife, and Parks and the Idaho Department of Fish and Game should monitor these potential impacts.

56 **Evaluate impacts of flow augmentation on resident fish in Canada and the United States.**

Flow augmentation proposals to benefit white sturgeon and salmon will result in water spill at Canadian Kootenay River dams. Additional monitoring is needed to evaluate the potential fisheries impacts on the Duncan, Arrow, and Koocanusa systems due to proposed recovery measures.

561 **Effects of flow augmentation on total gas pressure in the Kootenay River and Columbia River downstream of Kootenay Lake.**

Flow augmentation proposals to benefit white sturgeon will result in water spill at Canadian Kootenay River dams. This will increase total gas pressure levels to possibly lethal levels for some fish downstream of Brilliant Dam. Columbia Power Corporation, the Canada Department of Fisheries and Oceans, The British Columbia Ministry of Environment, Lands, and Parks, and Environment Canada should monitor these impacts, and consideration should be given to increasing hydroelectric capacity or using other gas reduction technology at Brilliant Dam as a means to mitigate these resident fish impacts.

562 **Effects of flow augmentation on Kootenay Lake and on the Duncan and Arrow Reservoirs/Columbia River systems.**

Potential fisheries impacts on the Duncan and Arrow reservoir systems due to white sturgeon flow augmentation from Libby Dam include 1) fluctuating flow releases from Duncan Dam during bull trout spawning migrations. This may affect bull trout movement and general spawning behavior; 2) decreased flow releases from Keenleyside Dam during rainbow trout spawning and rearing periods. This may reduce available spawning habitat and changes in temperature regimes due to flow changes, which may result in changes in incubation times; 3) decreased flow releases from Keenleyside may negatively effect staging and spawning of Columbia River white sturgeon; and 4) August releases from Libby Dam passing through Kootenay Lake and/or Arrow reservoir may flush nutrients and forage organisms from upper strata waters affecting overall biological productivity.

563 Evaluate effects of hydro peaking on native fish throughout the Kootenai River downstream of Libby Dam.

Daily load following and power peaking at Libby Dam may increase flows by fivefold in a few hours. These types of flows have altered the Kootenai River in the reach downstream from Bonners Ferry to Kootenay Lake to the extent that the river rarely freezes during the winter. These practices may particularly be impacting bull trout in the vicinity of Libby Dam in Montana and burbot in Idaho. Evaluations as part of tasks 51, 52, 53, 54, and 55 should include the effects of load following and power peaking.

564 Evaluate measures to reduce risk to native and resident sport fish below Libby Dam.

Demand for refill at Libby Dam for salmon recovery efforts, white sturgeon recovery, and sport fishing interests may lead to less conservative flood rule curves at Libby Dam in the 85- to 100-year protection range proposed in the original project justification. This would result in increasing the risk of spill and injury to bull trout and other native or resident sport fish since the frequency of "unregulated" spill will increase. The Army Corps of Engineers; Bonneville Power Administration; Montana Department of Fish, Wildlife, and Parks; and the Fish and Wildlife Service should evaluate "flip lips" and other structures that could minimize fish injuries and gas supersaturation downstream of Libby Dam.

6 Assess the overall success of implementation of the recovery plan and revise accordingly.

This plan should be updated on a 5-year basis as recovery tasks are accomplished, or revised as environmental conditions change and/or monitoring results or additional information becomes available.

The recovery team should meet annually to review annual monitoring reports and summaries and make recommendations to the Fish and Wildlife Service to revise the Plan.

REFERENCES CITED

Anders, P.J. and R. Westerhof. 1996. Natural spawning of white sturgeon (*Acipenser transmontanus*) in the Kootenai River, Idaho, 1995. Preliminary Report of Research FY 95. Kootenai Tribe of Idaho and Bonneville Power Administration. 14 pp.

Apperson, K.A. 1992. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1991. Idaho Department of Fish and Game and the Bonneville Power Administration. Contract No. DE-AI79-88BP93497; Project No. 88-65. Portland, Oregon.

Apperson, K.A. and P.J. Anders. 1991. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1990. Idaho Department of Fish and Game and the Bonneville Power Administration. Contract No. DE-AI79-88BP93497; Project No. 88-65. Portland, Oregon. 67 pp.

Apperson, K.A. and V.D. Wakkinen. 1993. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1992. Idaho Department of Fish and Game and the Bonneville Power Administration. Contract No. DE-AI79-88BP93497; Project No. 88-65. Portland, Oregon. 37 pp.

Ashley, K. and L. Thompson. 1993. Kootenay Lake fertilization experiment - year 1 (1992/1993) report. Fisheries Branch, Ministry of Environment, Lands and Parks, University of British Columbia. Fisheries Project Report No. RD 32. 52 pp.

Bayley, P.B. 1995. Understanding large river floodplain ecosystems. Bioscience. Vol. 45, No. 3. Pp 153-158.

Behnke, R.J. 1992. Native trout of Western North America. American Fisheries Society. Monograph #6. 261 pp.

Brannon, E.L., C.L. Melby, and S.D. Brewer. 1984. Columbia River white sturgeon enhancement. Final Report to Bonneville Power Administration. Contract No. DEAI79-84BP18952; Project No. 83-316. Portland, Oregon. 43 pp.

Counihan, T.D., A. J. Miller, M.G. Mesa, and M. J. Parsley. 1998. The effects of dissolved supersaturation on white sturgeon larvae. Transactions of the American Fisheries Society. 127: 316-322.

Daley, R.J., E.C. Karmach, C.B.J. Gray, C.H. Pharo, S. Jasper, and R.C. Wiegand. 1981. The effects of upstream impoundments on the limnology of Kootenay Lake, B.C. Scientific Service No. 117. National Water Research Institute, Inland Waters Directorate. Vancouver, British Columbia, 1981. 96 pp.

Georgi, A. 1993. The status of Kootenai River white sturgeon. Report prepared for the Pacific Northwest Utilities Conference Committee. September 1993. 58 pp plus appendices.

Graham, P.J. 1981. Status of white sturgeon in the Kootenai River. Montana Department of Fish, Wildlife and Parks. Kalispell, Montana. 26 pp.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-floodplain systems. Canadian Special Publication, Fish Aquatic Sciences. 106: 110-127.

Huston, J.E. 1995. A report on Kootenai River drainage native species search,1994. A report to the U.S. Fish and Wildlife Service. Montana Fish, Wildlife & Parks. 21 pp., attached GIS map.

Kincaid, H.L. 1993. Breeding plan to preserve the genetic variability of the Kootenai River white sturgeon. Report prepared for the Bonneville Power Administration. Contract No. DE-AI79-93B002886. Portland, Oregon.

Lindsay, R.A. 1995. Kootenay Lake white sturgeon investigations. Progress Report prepared for the IDFG. September, 1995. 8 pp.

Marcuson, P. 1994. Kootenai River white sturgeon investigations. Annual Progress Report FY 1993. Idaho Department of Fish and Game and the Bonneville Power Administration. Contract No. DE-AI79-88BP93497; Project No. 88-65. Portland, Oregon. 67 pp.

Marotz, B. L., D. Gustafson, C. Althen, and B. Lonon. 1996. Model development to establish integrated operational rule curves for Hungry Horse and Libby Reservoirs, Montana. Report prepared for the Bonneville Power Administration. Portland, Oregon. 110 pp.

Northcote, T.C. 1973. Some impacts of man on Kootenay Lake and its salmonids. Great Lakes Fishery Commission, Technical Report, No. 2.

Northwest Power Planning Council. 1987. Columbia River basin fish and wildlife program.Portland, Oregon.

Northwest Power Planning Council. 1994. Columbia River basin fish and wildlife program.. Publication 94-55. Northwest Power Planning Council. Portland, Oregon.

Pacific States Marine Fisheries Commission. 1992. (Hanson, D.L., editor). White sturgeon management framework plan. 200 pp.

Paragamian, V.L. 1994. Kootenai River Fisheries Investigations: Stock status of burbot and rainbow trout and fisheries inventory. Annual Report 1993. Idaho Department of Fish and Game and Bonneville Power Administration. Contract No. DE-B179-88BP93497. 28 pp.

Paragamian, V.L. and V. Whitman. 1997. Kootenai River fisheries investigations: stock status of burbot. Annual Report 1997. Idaho Department of Fish and Game and Bonneville Power Administration. Contract No. DE-B179-88BP93497.

Paragamian, V.L., G. Kruse, and V. Wakkinen. 1996. Kootenai River Fisheries white sturgeon spawning and recruitment evaluation.. Annual Report 1996. Idaho Department of Fish and Game and Bonneville Power Administration. Contract No. DE-B179-88BP93497.

Paragamian, V.L., G. Kruse, and V. Wakkinen. 1997. Kootenai River Fisheries white sturgeon spawning and recruitment evaluation.. Annual Report 1997. Idaho Department of Fish and Game and Bonneville Power Administration. Contract No. DE-B179-88BP93497.

Paragamian, V. L., M. Powell, and J.C. Faler. In press. Mitochondrial DNA analysis of burbot Lota lota stocks in the Kootenai River basin of British Columbia, Montana and Idaho. Transactions of the American Fisheries Society.

Partridge, F. 1983. Kootenai River fisheries investigations in Idaho. Idaho Department of Fish and Game, Boise, Idaho.

Sage, G.K., R.F. Leary, and F.W. Allendorf. 1992. Genetic analysis of 45 trout populations in the Yaak River drainage, Montana. Wild Trout and Salmon Genetics Laboratory Report, 92/3, Division of Biological Sciences, University of Montana, Missoula, Montana.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada, Bulletin 184. Fisheries Research Board Canada. Ottawa, Canada.

Setter, A. and E. Brannon. 1990. Report on Kootenai River white sturgeon electrophoretic studies - 1989. Report for Idaho Department of Fish and Game. Aquaculture Extension, University of Idaho. Pp. 43-50 In: Apperson, K.A., editor. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1989. Idaho Department of Fish and Game and the Bonneville Power Administration. Contract No. DE-AI79-88BP93497; Project No. 88-65. Portland, Oregon.

Skaar, D., J. DeShazar, L. Garrow, T. Ostrowski, and B. Thornburg. 1996. Quantification of Libby Reservoir levels needed to maintain or enhance reservoir fisheries: investigations of fish entrainment through Libby Dam, 1990-1994. Annual Progress Report. Montana Fish, Wildlife and Parks and the Bonneville Power Administration. Contract No. DE-AI79-83-BP12660; Project No. 83-467. Portland, Oregon.

Simpson, J. and R. Wallace. 1982. Fishes of Idaho. Northwest Naturalist Book, Moscow, Idaho. 238 pp.

Sparks, R.E. 1995. Need for ecosystem management of large rivers and their floodplains. Bioscience. Vol. 45, No. 3: 168-182.

PART III - IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows describes recovery task priorities, task numbers, task descriptions, duration of tasks, potential or participating responsible parties, and lastly, estimated costs, if available. These tasks, when accomplished, will contribute to recovery of the Kootenai River population of white sturgeon as discussed in Part II of this Plan.

Parties with authority, responsibility, or expressed interest to implement a specific recovery task are identified in the Implementation Schedule. Listing a responsible party does not imply that prior approval has been given or require that party to participate or expend any funds. However, willing participants will benefit by demonstrating that their budget submission or funding request is for a recovery task identified in an approved recovery plan, and is therefore part of a coordinated recovery effort to recover the Kootenai River population of white sturgeon. In addition, section 7(a)(1) of the Endangered Species Act directs all Federal agencies to use their authorities to further the purposes of the Act by implementing programs for the conservation of threatened or endangered species.

Other physical and economic impacts from recovery

Implementing the many conservation actions proposed in this recovery plan will create additional economic or environmental impacts, and also associated benefits, not normally considered in estimating the "costs" of recovery. Economic and environmental impacts include foregone power generation opportunities, flood control impacts, and resident fish impacts.

- Flood control impacts can include agricultural and residential flooding, groundwater seepage, and pumping costs. For example, crop losses ranging from 30 to 100 percent of a total 650 acres on 12 farms in the United States portion of the Kootenai Valley were attributed to the 1995 white sturgeon/salmon recovery flows (Dave Wattenburger, Boundary County Extension, *in litt.* 1996). The value of crop losses has not been estimated to date. Some farmlands were inundated, others were yellowed through soil saturation, and other lands were inaccessible during the growing season for weed control activities. Irrigation drainage pumping costs for the period May 1 through July 15, 1995 were estimated at $19,325 in the same United States portion of the Kootenai Valley. This cost will be adjusted downward when baseline pumping costs for ongoing average pumping needs are provided.

- Nontargeted Fish impacts. Flow augmentation proposals to benefit white sturgeon and salmon will result in water spill at Kootenay River dams, in Canada. This will increase total gas pressure levels to possibly lethal levels for some fish downstream of Brilliant Dam. Impacts should be monitored and consideration should be given to increasing hydroelectric capacity or using other gas reduction technology at Brilliant Dam as a means to mitigate these impacts on resident fish.

  Potential fisheries impacts on the Duncan and Arrow Reservoirs and Columbia River systems due to white sturgeon flow augmentation from Libby Dam include 1) fluctuating water releases from Duncan Dam during bull trout spawning migrations, which may affect bull trout movement and general spawning behavior; 2) decreased water releases from Keenleyside Dam during rainbow trout spawning and rearing periods, which may reduce available spawning habitat and changes in temperature regimes due to flow changes may result in changes in incubation times; and 3) decreased water releases from Keenleyside, which would negatively effect staging and spawning of Columbia River white sturgeon.

Associated benefits include the partial restoration of a more natural Kootenai River hydrograph and flood plain function that benefit resident fish and wildlife. Periodic flushing flows would cleanse Kootenai River gravels and improve insect production. Improving the aquatic ecosystem health leading to improved regional fisheries will provide secondary economic benefits to local communities. Such benefits go beyond the "benefits" typically considered in recovery actions. Conversely, failure to implement proposed recovery actions would have hidden environmental costs that are typically not considered in cost/benefit analysis.

Following are definitions to column headings and keys to abbreviations and acronyms used in the Implementation Schedule:

Priority No.: All priority 1 tasks are listed first, followed by priority 2 and priority 3 tasks.

> Priority 1: Actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
>
> Priority 2: Actions that must be taken to prevent a significant decline in species population or habitat quality, or some other significant negative impact short of extinction.
>
> Priority 3: All other actions necessary to provide for full recovery (or reclassification) of the species.

Task Number and Task Description: Recovery tasks as numbered in the recovery outline. Refer to the Narrative for task descriptions.

Task Duration: Expected number of years to complete the corresponding task. Study designs can incorporate more than one task, which when combined, can reduce the time needed for task completion.

Responsible or Participating Party: Federal, State, Tribal, or Canadian government agencies, nongovernment organizations, or universities with responsibility or capability to fund, authorize, or carry out the corresponding recovery task.

RECOVERY PLAN IMPLEMENTATION SCHEDULE
WHITE STURGEON: KOOTENAI RIVER POPULATION

PRIORITY Number	TASK Number	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	COST ESTIMATES ($1,000) Total Cost	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	COMMENTS
1	111	Conduct public review of and approve new operational guidelines for Libby Dam.	1	USACE*, MFWP FWS, BPA, DFO, MELP	120	40	80				Begin in 1999
1	112	Implement new operational guidelines to provide annual flow regimes to benefit white sturgeon in the Kootenai River basin.	Continual	USACE*, BPA, MFWP, FWS	Unk						Costs include foregone power production; possible flood control costs, need to be determined.
1	113	Coordinate Libby Dam flow releases during April through August to achieve an optimum combination of water temperature and discharge volume.	Continual	USACE, BPA, BR, NMFS, FWS, MFWP, BC HYDRO	Unk						Instream management to fine-tune augmentation
1	114	Store water in Koocanusa Reservoir prior to spring runoff to achieve white sturgeon flow targets.	Ongoing	USACE*, BPA, MFWP	Unk						
1	115	Conduct agency coordination for implementing white sturgeon flow augmentation program.	Ongoing	USACE, BPA, BC HYDRO DFO, MELP, MFWP, IDFG	15	3	3	3	3	3	U.S./Canada coordination.
1	116	Kootenay Lake Evaluations.	Ongoing	USACE, MELP, FQ, BPA, USFW	Unk		Unk				
1	117	Evaluate alternatives increasing peak Kootenai River flows.	Continual	DFQ, BPA, USFWS	Unk			Unk			
1	118	Use existing authorities to conserve and restore Kootenai River white sturgeon.	Continual	USACE, FWS BPA, NMFS	Unk						Section 7 consultation on Libby Dam operations.
1	121	Monitor potential residential or agricultural flooding, levee erosion, and groundwater seepage resulting from flow augmentation.	Ongoing	USACE	Unk						Concurrent with Task 112.
1	122	Identify opportunities to restore natural floodplain functions along the Kootenai River.	Ongoing	USACE* NRCS, DFO MELP	Unk						
1	123	Develop public information program to explain USACE past and current flood control compensation program.	1-2	USACE	Unk	Unk	Unk				1 - 2 year public information program.
1	124	Monitor impacts of flow augmentation on Kootenai River levees and Kootenay Lake in British Columbia.	Continual	DFO, MELP	Unk						New monitoring program may be needed.
1	125	Assess consolidation of white sturgeo spawning and incubation, habitat quality, and potential substrate improvement measures.	1-2	FWS, IDFG, KTOI	***						Funded as part of Task 321

* - Lead Agency
*** - Costs associated as part of other recovery tasks.

unk - Cost estimates are unknown.
ongoing - Task is currently being implemented.
continual - Task will be implemented annually when approved and/or funded.

RECOVERY PLAN IMPLEMENTATION SCHEDULE
WHITE STURGEON: KOOTENAI RIVER POPULATION

PRIORITY Number	TASK Number	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	COST ESTIMATES ($1,000) Total Cost	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	COMMENTS
1	211	Obtain necessary local, State, Tribal, Federal, and Canadian approval and permits for all conservation aquaculture activities.	Continual	IDFG, KTOI, FWS, MFWP	Unk						Need to obtain permits annually e.g. Section 10.
1	221	Determine water quality standards for KTOI Hatchery.	1	BPA, KTOI* MFWP	***						1 year, as part of Task 224
1	222	Upgrade KTOI hatchery to meet conservation aquaculture objectives.	2 - 3	BPA, KTOI,	1711						Complete upgrade begun in 1998. Cost accrued beginning in 1998.
1	223	Maintain Kootenai Trout trout hatchery as a secondary rearing facility.	1	BPA, MFWP	310	61	62	63	62	62	Contract costs part of dollars allocated as part of task 222
1	224	Implement the conservation aquaculture program.	10	BPA, KTOI,	1300	240	290	260	270	280	Costs of operating existing KTOI hatchery, out year costs be higher if hatchery is expanded
1	231	Use adopted white sturgeon broodstock collection protocol.	10	BPA, KTOI,* IDFG	***						Funded as part of Task 224
1	232	Collect adequate numbers of male and female broodstock to maintain the genetic quality.	10	BPA, KTOI, IDFG	***						Funded as part of Task 224.
1	233	Annually evaluate the conservation aquaculture program.	10	BPA, KTOI IDFG, MFWP	***						Funded as part of Task 224 will be evaluated annually.
1	241	Evauate appropriate production goals	Continual	KTOI, BPA, FWS, MFWP, IDFG, DFO, MELP	***						Funded as part of Task 224
1	242	Develop a fish health plan for hatchery	Continual	KTOI*, ALL AGENCIES	***						Funded as part of Task 224
1	243	Develop tagging protocols for hatchery reared white sturgeon.	2	KTOI, IDFG*, DFO, MELP, MFWP	Unk	Unk	Unk				Funded as part of Task 224
1	245	Evaluate feasability of establishing an experimental white sturgeon population outside of the current occupied range.	2	ALL AGENCIES	***						Recovery team will consult with State and Canada agencies.

RECOVERY PLAN IMPLEMENTATION SCHEDULE
WHITE STURGEON: KOOTENAI RIVER POPULATION

PRIORITY Number	TASK Number	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	COST ESTIMATES ($1,000) Total Cost	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	COMMENTS
1	25	Release hatchery reared white sturgeon into the Kootenai River basin.	10	KTOI*, ALL AGENCIES	Unk						Funded as part of Task 224
1	251	Adjust white sturgeon releases as necessary, to meet objectives of the Kincaid breeding plan.	10	KTOI, FWS, MFWP, BPA	***						Funded as part of Task 224
1	261	Determine factors limiting production (natural and hatchery) and habitat use patterns for each life history stage.	Ongoing	BPA, KTOI, MFWP, IDFG	Unk						Funded as part of Task 321
1	321	Describe response of spawning white sturgeon to various Kootenai River flows, water temperatures, and Kootenay Lake elevations.	Continual	KTOI, MELP MFWP, IDFG, NMFS	4000	750	775	800	825	850	120 K of this total is for monitoring effects of augmentation in Kootenai Reservoir
1	322	Measure white sturgeon spawning annually.	Continual	IDFG, KTOI, MFWP	Unk						Funded as part of Task 321
1	323	Measure white sturgeon larval, fry, and juvenile abundance and distribution in the Kootenai River and Kootenay Lake annually.	Continual	BPA, IDFG, KTOI, MFWP	Unk						Funded as part of Task 321
1	41	Develop a Participation Plan to support implementation of the Kootenai River white sturgeon recovery plan.	1	ALL AGENCIES	Unk		Unk				Will be completed as part of final recovery plan.

RECOVERY PLAN IMPLEMENTATION SCHEDUAL
WHITE STURGEON: KOOTENAI RIVER POPULATION

PRIORITY Number	TASK Number	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	COST ESTIMATES ($1,000) Total Cost	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	COMMENTS
2	244	Develop a policy for hatchery white sturgeon produced in excess of beneficial uses identified in this plan.	1	BPA, FWS, KTOI, IDFG, MFWP, DFO, MELP	***	Unk					May require need for Section 10 permits. Funded as part of Task 223.
2	311	Sample adult and juvenile white sturgeon in the Kootenai River and Kootenay Lake.	Ongoing	BPA, KTOI, MFWP, IDFG BC, MELP	***						Funded as part of Task 321.
2	312	Collect and preserve tissue and blood samples for genetic analysis. system.	Ongoing	BC, MELP BPA, KTOI, MFWP, IDFG	***						Funded as part of Task 321.
2	313	Compile catch data to refine white sturgeon population size estimates annually in the Kootenai River basin.	Ongoing	BPA	***						Funded as part of Task 321.
2	314	Develop a juvenile white sturgeon year class index.	2	BPA, IDFG*	***	Unk	Unk				Funded as part of Task 321.
2	323	Measure white sturgeon larval, fry, and juvenile abundance and distribution in the Kootenai River and Kootenay Lake annually.	Ongoing	BPA	***						Funded as part of Task 321.
2	324	Quantify sturgeon spawning incubation habitat and early rearing habitat using IFIM.	2	BPA, IDFG, KTOI, MFWP	***		Unk	Unk			Begin in 1997, funded as part of Task 321.
2	331	Assess the necessity of increasing nutrients in the Kootenai River.	5	BPA, KTOI	***						Funded as part of task 321.
2	332	Use computer modeling to refine and analyze recovery tasks	1	USFWS, MELP, IDFG, KTOI	Unk	Unk					Either 1996 or 1997.
2	341	Compile existing information on contaminants in the Kootenai River.	2	BPA, KTOI* IDFG	Unk	Unk	Unk				Funded as part of Task 331.
2	342	Conduct contaminants bioassays to evaluate the effects of selected chemicals on white sturgeon.	5	BPA, KTOI*	Unk						Part of recovery Task 331
2	421	Recommend additional research and management regarding ecosystem and fishery improvement measures for the Kootenai River Basin.	Ongoing	Recovery Team	Unk						Ongoing as needed.

RECOVERY PLAN IMPLEMENTATION SCHEDULE
WHITE STURGEON: KOOTENAI RIVER POPULATION

PRIORITY Number	TASK Number	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY	COST ESTIMATES ($1,000) Total	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	COMMENTS
3	44	Determine the indirect recovery needs of foregone power generation	Ongoing	BPA, USACE, BCHYDRO	Unk						
n/a	511	Collect baseline abundance, distribution, and reproduction date for kokanee in Idaho Kootenai River tributaries.	5	IDFG, KTOI MFWP	809	147	155	162	169	176	Ongoing
n/a	521	Determine distribution and life history of burbot.	5	IDFG*, MFWP	735	133	140	147	154	161	Ongoing
n/a	522	Determine secondary impacts from proposed flow augmentation program on burbot reproduction.	2	IDFG*, MFWP	Unk	Unk					Costs part of Task 521.
n/a	531	Determine the status. distribution, and habitat use of rainbow trout in the Kootenai River from Libby Dam to Bonners Ferry.	5	IDFG, MFWP	900	170	175	180	185	190	Ongoing
n/a	541	Determine distribution and status of bull trout in in tributaries of the Kootenai River.	2	IDFG*, MFWP	300	54	57	60	63	66	Started in 1996, ongoing
n/a	542	Identify additional conservation measures to protect bull trout in the Kootenai River drainage in Montana, Idaho, and B.C.	1	BPA, MFWP IDFG	Unk			Unk			Using results from Task 541.
n/a	551	Determine the secondary effects of proposed white sturgeon flow augmentation on mountain whitefish.	4	BPA, MFWP	75	13	14	15	16	17	
3	561	Effects of flow augmentation on TGP in the Kootenay River and Columbia River downstream of Kootenay Lake.	?	DFO, MELP	Unk						Canada projects
3	562	Effects of flow augmentation on the Duncan and Arrow Reservoir/Lower systems	?	DFO, MELP	Unk						Canada projects.
3	6	Assess the overall success of implementation of the recovery plan and revise accordingly.	Ongoing	Recovery Team	Unk						

Kootenai Tribe of Idaho, Revised June 2010

Kootenai River Native Fish Conservation Aquaculture Program Master Plan

BONNEVILLE POWER ADMINISTRATION

Northwest Power and Conservation Council

Kootenai River Native Fish Conservation Aquaculture Program

Project Sponsor Responses to ISRP Comments 2009 - 40

Prepared by the Kootenai Tribe of Idaho

June 2010

Cover photos courtesy of Ernest Keeley and the Kootenai Tribe.

Kootenai River Native Fish Restoration and Conservation Aquaculture Program

Project Sponsor Responses to ISRP Comments 2009-40
June 2010

The Kootenai Tribe of Idaho (the Tribe or Kootenai Tribe) appreciates the opportunity to communicate with the ISRP and to address the comments and suggestions provided on October 13, 2009. The Tribe believes that considering and addressing the ISRP's recommendations has significantly improved the Kootenai River Native Fish Restoration and Conservation Aquaculture Program. Responses to individual ISRP comments are addressed sequentially below, with ISRP comments presented in italics and Tribal responses in plain text. A revised Master Plan for Kootenai River white sturgeon and burbot, that incorporates the information presented below and address additional ISRP comments, is also submitted.

ISRP Comment 1: *Provide a complete history of the sturgeon production and release program from adults collected and spawned, juveniles released, survival and current status of released individuals (for example, the repeat recapture history of individual brood fish). The purpose of this information and historical summary is to permit an adequate assessment of whether the captive propagation and release can work/is working toward recovery goals*

Project Sponsor Response 1:

This response addresses the goals and objectives of the Kootenai Tribe's program to recover Kootenai River white sturgeon. Production history is described in response to Comment No. 2.

Past and planned sturgeon culture activities address long-term recovery goals and interim objectives that chart a pathway to recovery. Recovery goals and hatchery objectives have evolved over the last ten to twenty years based on new information and experience. The proposed hatchery facilities identified in the Master Plan are an adaptive response to developments and new information collected since the Kootenai River White Sturgeon Recovery Plan was adopted in 1999 (USFWS 1999).

The 1999 Kootenai River White Sturgeon Recovery Plan identified objectives and criteria reflecting the best available information at that time. The plan described intial steps for preventing extinction and initiating recovery, focusing on the first 5-10 years of recovery efforts. At the time of listing, it was believed that flow regulation associated with Libby Dam operations (post 1974) was the primary factor responsible for natural recruitment failure at the spawning and early life history life stage.

Because restoring natural recruitment by modifying Libby Dam operations involves considerable uncertainty, the conservation aquaculture program was included as a second key element in the Recovery Plan. The Kootenai River White Sturgeon Conservation Aquaculture Program was initially designed as a temporary "bridge" to fill in a gap of missing year classes until effective flow measures could restore natural recruitment. The 1999 Recovery Plan also recognized substantial uncertainty about limiting factors and action effectiveness, and emphasized research, monitoring, and evaluation to address and reduce these critical uncertanties. Subsequent work and findings have demonstrated the wisdom of this precautionary, adaptive approach in preventing extinction of the endanged Kootenai sturgeon population.

Initial hopes for a relatively simple water management solution to the recruitment problem have not been realized. Although a variety of measures have been implemented since completion of the Recovery Plan, all efforts to date have failed to increase or restore natural natural recruitment or to identify an effective remedy for restoring natural recruitment (Paragamian and Beamesderfer 2004). We now know that recruitment failure results from much more pervasive changes in the Kootenai River ecosystem related to upstream hydro operations, watershed-scale land use impacts, Kootenai Valley floodplain development, river channel confinement, Kootenay Lake level management, and the additive, altered productivity and ecological effects of all these factors (Anders et al. 2002).

Refinements in aging methods indicated that recruitment failure pre-dates Libby Dam completion by 10-15 years (Paragamian and Beamesderfer 2003). Decades of post-release monitoring suggests that recruitment bottlenecks occur during incubation in the wild (Anders et al. 2002; Kock et al. 2006) and during the young-of-the-year life stage for hatchery released fish (Justice et al. 2009). Given that current regulated flows do not provide suitable conditions for effective reproduction, it is clear that other ecological limitations must also be addressed. It seems clear now that ongoing recruitment failure can not be expected to be resolved by slight increases of nutrient deficient water from Libby Dam that remain a fraction of average annual historic freshet volumes. This is why the Tribe has also developed, and will soon begin implementing, the complementary Kootenai River Habitat Restoration Master Plan (KTOI 2009).

Recent information suggests that recovery will be more difficult, take longer, and be more expensive than initially anticipated. Although the conservation aquaculture program was intially designed as a short-term, stop-gap measure, it now appears that the next generation of Kootenai white sturgeon will most likely come from the aquaculture program (Paragamian et al. 2005). Effective flow or habitat remedies have not yet been achieved, and population recovery by natural production is uncertain. At this point, even if some measure of restoration is achieved, natural production alone may not be adequate to produce enough fish or capture enough of the dwindling population to avoid future genetic founder effects and ensure the long-term population viability and persistence.

These realizations have led to a careful re-examination of recovery goals, recovery criteria, and aquaculture objectives in the context of current information and risks. A longer term perspective on the role of the conservation aquaculture program is now required, which in turn led to refinements in program objectives that are reflected in the Aquaculture Master Plan. The new facilities identified in the Master Plan are designed to meet the essential role and long-term requirements now identified for conservation aquaculture.

1999 Recovery Plan Goals & Criteria

The Recovery Plan adopted by the U. S. Fish and Wildlife Service in 1999 identified a long-term goal of downlisting and delisting Kootenai white sturgeon when the population becomes self-sustaining. Short-term objectives included reestablishing natural recruitment and preventing extinction through conservation aquaculture. The plan suggested that down-listing would be appropriate when short-term criteria are achieved. Three criteria for reclassification or downlisting were identified:

1. Natural production occuring in at least 3 different years of a 10-year period. A naturally-produced year class was defined as when at least 20 juveniles were sampled at more than 1 year of age.
2. Stable or increasing population. This includes juveniles released from the conservation aquaculture programeach year for a 10-year period in numbers large enough to produce 24 to 120 sturgeon surviving to sexual maturity.
3. A long-term flow strategy adequate to produce natural recruits.

The plan noted that recovery will not be complete until there is survival to sexual maturity, which may take upwards of 25 years for females and late teens for males. However, specific long-term goals or delisting criteria were not identified due to substantial uncertainties in population status, life history, biological productivity, and effects of flow augmentation.

Updated Recovery Goals and Criteria

A clear understanding of current recovery goals and criteria is critical to articulating and understanding the objectives of the conservation aquaculture program and Master Plan. The need to revise and update the 1999 Recovery Plan has been widely recognized (Paragamian et al. 2005). Plans for a revision are under discussion by the Kootenai River White Sturgeon Recovery Team but have not been implemented. In the interim, a series of working goals and criteria[1] have been identified from a review of essential elements common to other sturgeon and salmon recovery plans (Dryer et al. 1993; UCWSRI 2002; LCFRB 2004; NMFS 2007; CDFO 2009; NMFS 2009).

The long-term recovery goal for the Kootenai River white sturgeon population is unchanged – it is to restore the population to a level where sturgeon are no longer threatened with extinction. Downlisting and then delisting may occur when a species is naturally self-sustaining, where normal variation in abundance does not reduce numbers to a level from which recovery is unlikely or uncertain. Many recovery plans also include “broad sense” goals that recognize critical functions of a species within the ecosystem as well as social benefits related to opportunities for beneficial uses such as fishing.

The current working recovery goal for Kootenai white sturgeon is to ensure the persistence and viability of a naturally-reproducing population as an essential element of an adequately functional ecosystem and a resource supporting traditional beneficial uses. In many salmon recovery plans, viability/delisting levels are specifically defined as having a <1% risk of extinction within a 100 years (approximately 20 generations). Corresponding standards have not been established for sturgeon where criteria must

[1] Criteria identified in the 1999 Recovery Plan have not been formally revised to address current status and information. Working criteria are being used to guide hatchery planning and implementation but have not been formally adopted into the Recovery Plan.

consider the unique life history and address a much longer time frame consistent with sturgeon longevity and delayed onset of first maturity/reproduction.

Current recovery criteria related to long-term viability/delisting of Kootenai sturgeon are based on four population attributes: abundance, productivity, distribution/spatial structure, and diversity. The technical basis relating viability to these four attributes is adapted from salmon conservation, as reflected in the Viable Salmonid Population concept (McElhany et al. 2000). Population attribute criteria applicable to sturgeon are identified in Box 1. Explanations of the biological basis for these criteria are summarized in the following paragraphs.

Box 1. Working criteria established to guide the development of conservation aquaculture program objectives for Kootenai white sturgeon.

Abundance

- A minimum adult population size of 2,500 (for downlisting) and a target adult population size of 8,000-10,000 (for delisting).

Productivity

- Naturally-produced recruitment and juvenile population sizes sufficient to support the desired adult population size.
- Stable or increasing trends in adult and juvenile numbers.
- Representative and stable size and age structure.

Distribution

- Distribution and use of habitats throughout the majority of the historical range.
- Breadth of distribution such that population is not vulnerable to any single human-caused catastrophic event (chemical spill for instance).

Diversity

- Stable genetic diversity (including frequencies of common and rare alleles).
- Effective population sizes adequate to allow for normal genetic and evolutionary processes.

Use

- Numbers (consistent with above) adequate to support significant subsistence harvests and recreational fishery uses.

Abundance

Long-term abundance objectives for conservation are generally based on minimum viable population sizes that are naturally self-sustaining. A viable population is large enough to: 1) survive normal environmental variation, 2) allow compensatory processes to provide resilience to perturbation, 3) maintain genetic diversity, and 4) provide important ecological functions (McElhany et al. 2000). Critical low abundance levels occur due to: 1) the breakdown in normal population processes as low numbers (e.g depensation), 2) genetic effects of inbreeding depression or fixation of deleterious mutations, 3) demographic stochasticity, and 4) uncertainty in status evaluations (Lande and Barrowclough 1987; Nelson and Soulé 1987; Lynch 1990; Hilborn and Walters 1992; Lande 1993; Lawson 1993; Lynch 1996; Courchamp et al. 1999; McElhany et al. 2000; Lynch and O'Hely 2001).

A wide range of viable abundance values has been established for different species. The conservation science literature typically identifies a minimum viable genetic effective population size of at least 50 to 1,000 adults (Thompson 1991; NRTWS 2009). Because census numbers are typically several times greater than effective population size because of non-random mating, population abundance targets ranging from 1,000 to 20,000 have been recommended for various species (IUCN 2001, NRTWS 2009). Other white sturgeon recovery plans have identified abundance objectives ranging from 1,000 per population with multiple populations (NRTWS 2009) to a single population value of 2,500 (UCWSRI 2002). Historical numbers also provide a useful reference point for establishing goals, and are presumed to be consistent with historical levels of ecological function. For planning purposes, we used 2,500 (IUCN 2001; UCWSRI 2002) as a downlisting objective and estimates of historical population sizes of 8,000-10,000 (Paragamian et al. 2005) as a delisting objective.

Productivity

Productivity refers to a population's ability to replace itself and rebound from a low level to a viable equilibrium population level. Productivity of viable populations is such that: 1) abundance can be maintained above the viable level, 2) viability is independent of hatchery subsidy, 3) numbers are maintained even during extended sequences of poor environmental conditions, 4) declines in abundance are not sustained, 5) life history traits are not in flux, and 6) conclusions are independent of uncertainty in parameter estimates (McElhany et al. 2000).

Productivity objectives for sturgeon obviously include natural recruitment in numbers sufficient to support adult abundance objectives. Net recruitment is a function of annual spawner numbers or population fecundity, frequency of suitable conditions, and the magnitude of annual or individual recruitment success. No specific annual recruitment objective is identified for sturgeon because adult objectives can be achieved by a variety of combinations of these factors. However, diversity objectives discussed below will require significant recruitment contributions from multiple parents during multiple years to maintain inherent or desirable population characteristics. Stable or increasing trends in juvenile and adult numbers are clearly related to long-term population viability. For long-lived species such as sturgeon, size, age, and sex ratios are particularly powerful indicators of long-term productivity patterns. Viable sturgeon populations are characterized by a broad distribution of sizes and ages. Size and age distributions are stable over the long term in a population at equilibrium.

Distribution/Spatial Structure

Spatial structure refers to the amount of habitat available, the organization and connectivity of habitat patches, and the relatedness and exchange rates of adjacent populations. Large habitat patches or a connected series of smaller patches are generally associated with wider species distribution and increased population viability. In a highly viable species: 1) the number of habitat patches is stable or increasing; 2) exchange rates among metapopulations are stable; 3) marginally suitable habitat patches are preserved; 4) refuge source populations are preserved, and 5) uncertainty is taken into account (McElhany et al. 2000).

In Kootenai sturgeon, there is only one extant population and limited opportunity to establish an additional population within the historical range[2]. Spatial structure objectives for this population would be met by the broad distribution of sturgeon among river, delta, and lake habitats, the diversity of habitat types accessible within the historical range, and the relative stability and resilience of the Kootenay Lake habitat where a large portion of the adult population spends a majority of its time.

Diversity

Diversity refers to individual and population variability in genetic-based life history, behavioral, and physiological traits. Genetic diversity is related to population viability because it allows a species to use a wider array of environments, protects species against short-term spatial and temporal changes in the environment, and provides the raw material for surviving long-term environmental changes (McElhany et al. 2000). Loss of diversity is thought to reduce productivity by reducing physiological and life history variability that is adaptive in a diverse and variable environment (NRC 1996). Reduced diversity is typically first manifested by the loss of rare alleles. Low diversity can also result in inbreeding depression which is the loss in fitness due to breeding between closely related individuals (for instance, through increased expression of deleterious recessive traits).

Diversity objectives for Kootenai sturgeon are based on genetic criteria. These include maintaining adequate abundance to protect existing diversity and to allow for normal genetic and evolutionary processes. Genetic risks are related to effective population size (N_e), which is based on an idealized population where every individual has an equal chance of mating with every other. Small N_es increase the likelihood of genetic drift, founder effects from managed populations, and inbreeding depression. Numbers associated with genetic risk are largely theoretical and are generally derived from simple population genetics models and conservation biology literature. Genetic considerations are a primary driver for abundance objectives and conservation aquaculture objectives identified for Kootenai sturgeon.

Use

Specific use-related objectives are not identified for Kootenai sturgeon but working objectives recognize a long-term interest in considering the need and feasibility for broad sense use objectives when conservation objectives are met. Natural production rates sufficient to provide harvest or withstand other fishery impacts recognize a desire to restore historical fishing opportunities. Reproductive rates that provide a harvestable surplus within the limitations of current system capacity also provide an additional safety factor from long-term risks to population viability.

Conservation Aquaculture Objectives

Conservation aquaculture objectives were developed to support long-term recovery goals and critieria consistent with the essential role of the program in light of continuing natural recruitment failure. "Long-term" takes on a special meaning for species like sturgeon for which planning horizons must be expressed in decades or even centuries. Developing an effective conservation aquaculture strategy is, in effect, an optimization exercise in balancing a number of time-sensitive risks (Table 1).

[2] A guidance document for evaluating an experimental, non-essential (ESA 10(j)) Kootenai River white sturgeon population was provided to the USFWS (Anders 2007).

Table 1. Conservation risks for Kootenai white sturgeon: wild population risks that the aquaculture program is designed to address and hatchery-related risks that the aquaculture program is designed to avoid.

Risk	***Summary***
Demographic	
Depletion	Population declines in response to reduced annual reproduction or recruitment
Depensation	Collapse of normal population processes at low numbers resulting in a spiraling slide toward extinction (the "extinction vortex")
Functional extinction	Too few fish for effective reproduction or to provide hatchery broodstock
Genetic	
Loss of diversity	Founder effect in next generation that results from failure to include adequate numbers of fish in the spawning broodstock
Inbreeding depression	Unbalanced contribution of only a few fish to the next generation that accrues deleterious recessive traits and reduces fitness
Selection	Directional change in genetic composition due to domestication or inadvertent selection over time in the hatchery
Ecological	
Intraspecific competition or predation	Depression of wild recruit survival, growth, maturation, etc.
Disease magnification	Increased incidence of disease and associated effects resulting from transmission in the hatchery
Uncertainty	
Measurement	Many activities are scaled to uncertain estimates of survival, etc. Hatchery fish may also confound detection of natural recruitment
Process	Fundamental lack of understanding of limiting factors and population dynamics

Near- and long-term objectives are identified for the aquaculture program in order to address conservation-related risks over time (Box 2). It is helpful to organize objectives by sturgeon generation. Near-term objectives focus primarily on the current generation that includes the declining remnant wild population. Long-term objectives involve future generations, including fish produced primarily in the hatchery from the remnant wild generation, and any natural recruits in the interval until the last wild fish dies or becomes scenescent.

Box 2. Period-specific objectives of the conservation aquaculture program to protect and restore Kootenai white sturgeon (periods describe the interval during which related risks are manifested).

Near Term

1. Prevent demographic extinction by replacing failed natural recruitment.
2. Establish an increasing trend and broad distribution of ages and sizes in the wild population in order to ensure future sustainability.
3. Preserve native genetic and life history diversity by capturing and spawning significant numbers of representative broodstock.
4. Provide contingencies for uncertain future availability of wild broodstock and prospects for restoring natural recruitment.
5. Inform recovery strategies by using hatchery fish to identify limiting life stages and habitat capacity.

Long Term

6. Avoid annual spawning stock limitation where too few fish might be available to capitalize on favorable natural spawning conditions in any year (or to continue to provide hatchery broodstock).
7. Minimize, to the extent possible, the time interval between the functional extinction of remaining wild adults and maturation of the first hatchery generation.
8. Maintain an effective population size in the wild adequate to avoid genetic bottlenecks that risk loss of diversity or inbreeding depression in the next generation.
9. Avoid significant detrimental impacts of hatchery fish on natural production due to competition, predation, or disease magnification.
10. Avoid hatchery selection or domestication that might reduce future fitness or viability.

Questions regarding sturgeon conservation aquaculture objectives often focus on long-term outcomes – e.g., how many juveniles need to be released in order to meet adult abundance objectives (or to seed the available habitat to capacity). However, both near-term and long-term risks warrant careful consideration in the design of an effective conservation program. Short-term objectives help plot a course forward from a population's current demographic and genetic condition to future desired conditions. Long-term objectives provide a vision of the ultimate destination. Short-term objectives establish a sound foundation for meeting the long long-term objectives. Proposed changes to the ongoing aquaculture program, including new facilties, are designed to address these important near-term and long-term risks.

Forestalling demographic extinction is an essential near-term objective of the program. Simple demographic objectives are both a function of fish quantity and quality, as reflected by the amount of genetic diversity they represent. They are also met by producing fish in numbers adequate to reverse the declining population trend. Given ongoing, long-term natural recruitment failure, long-term commitment to propagation is necessary to sustain population growth in a long-lived species like sturgeon. Consistent regular production rebuilds the broad size and age structure that is typical of a healthy sturgeon population. Avoiding demographic extinction was a primary focus of the 1999 Recovery Plan and previous program activities when the immediate objective was replacement of a 20-year period of missing year classes (Kincaid 1993; Duke et al. 1999; USFWS 1999).

Since the Kootenai River White Sturgeon Recovery Plan was completed, aquaculture objectives have evolved from replacement of a few year classes to the replacement an entire sturgeon generation, which must now serve as the basis for all subsequent generations. This fundamental shift in project purpose requires preserving the native genetic and life history diversity of the current population and propagating this material for the next sturgeon generation. At best, the hatchery can only perpetuate the native genetic material represented in the broodstock. Failure to collect adequate and representative numbers of broodstock will reduce genetic diversity in the next generation even if no artificial selection or domestication occurs within the rearing facility. This objective generally requires maximizing the number of different wild adult spawners and the corresponding number of families produced, both within and among years by maximizing the distribution of collections across the spatial and temporal extents of annual spawning seasons.

Considerable uncertainty remains regarding the status of the remnant wild population and how long significant numbers of adults will remain available for hatchery broodstock or to take advantage of proposed habitat improvements. Recent analyses suggest that the population may be somewhat larger than previously estimated (Beamesderfer et al. 2009). However, the remaining population remains composed entirely of adults that continue to decline in numbers each year. Many adult-sized fish do not appear to be spawning as frequently as was previously estimated, and we have no way of knowing if or when reproductive senescence might occur. Hatchery objectives therefore require and include contingencies for future uncertainties such as front-loading current production while broodstock remain available.

At the same time, there is a lot we don’t know about current habitat capacity for sturgeon and related constraints on recovery in general, and in the Kootenai River specifically. Monitoring hatchery fish will continue to provide useful information regarding recovery prospects and alternatives (e.g., Ireland et al. 2002a; Beamesderfer et al. 2009; Justice et al. 2009). Hatchery releases provide an experimental basis for evaluating habitat capacity and potential limiting factors. Very few wild juveniles have been produced over the years (Anders et al. 2002),system productivity has declined and current habitat capacity for sturgeon is unknown[3]. Recent analysis of post-release hatchery fish survival suggests there may be size-related density-dependent limitations during the first year of age. Additional information on the habitat capacity for larger juvenile and subadult sturgeon will be provided by future monitoring and evaluation, including information that will be gained through implementation of the Tribe’s habitat restoration program and related monitoring and evaluation. Hatchery fish are also being used to evaluate habitat suitability for early life history in areas upstream from Bonners Ferry and to assess the feasibility of imprinting fish to upstream areas with more suitable spawning habitat. The Tribe recognizes that evaluation objectives require carefully-structured experimental designs, tests, and controls.

---

[3] The Tribe, along with the IDFG and BCMOE, is successfully implementing river and lake fertilization to mitigate denutrification.

Long-term recovery objectives address the viability of the next sturgeon generation in the wild. Long-term population abundance objectives are established in part to avoid genetic bottlenecks that risk loss of diversity or inbreeding depression in the next generation. Even if bottlenecks are avoided in the current generation, failure to release enough families or enough fish per family could simply postpone the problem until the hatchery-produced cohort matures and spawns. This objective requires propagation of a diverse population consisting of large numbers of unrelated individuals[4]. The ideal strategy is to produce many families with sufficent releases from each family to ensure that representative numbers survive to adulthood, without swamping the contributions from other families.

Of particular relevance to this program is that no mention is made regarding a large, naturally produced year class being naturally regulated by competition, predation, and finite resource and habitat availbility, even in the altered river environment. In other words, nobody worries about a naturally produced year class being too large because its size will be naturally regulated by these ecological mechanisms. However, unless one assumes that hatchery-produced fish are somehow inferior to wild-produced fish (which in this case don't exist), the same ecological regulating mechanisms must also be assumed to operate on hatchery-produced year-classes. Furthermore, unlike many large salmon hatchery programs with release numbers in the millions, individual sturgeon releases in this program do not dwarf the recipient population by orders of magnitude. This further diminishes the relevance of the demographic and genetic swamping argument as applied to this program. In addition, the sheer number of release groups within a sturgeon generation also greatly reduces the individual contribution of any particular family release group, further reducing concerns of demographic or genetic swamping.

Adequate numbers of mature males and females must be spawned each year to capitalize on future natural spawning conditions that may only periodically be favorable. If natural production continues to fail, numbers will need to be sufficiently large to ensure that adequate hatchery broodstock can continue to be collected in a cost effective manner. This risk is of particular concern during the time between the disappearance of the remnant wild cohort and the first maturation of hatchery fish from initial releases that began in the 1990s. Thus, another program objective is to minimize, to the extent possible, the time interval of potential spawning stock limitation. Future spawner availability is a function of release numbers, years of release, and time required for adequate numbers of released fish to reach sexual maturity and reproduce. Interestingly for sturgeon, larger annual releases can reduce the interval until hatchery fish begin to mature because individual variation in growth rate is large and greater release numbers produce more fast-growing individuals. However, tradeoffs also exist between release numbers and the potential for density-dependent reductions in growth rates (Justice et al. 2009).

Hatchery objectives include avoiding significant detrimental impacts of hatchery fish on natural production due to factors such as competition, predation, or disease magnification. Increased competition is of particular concern due to the potential for large numbers of hatchery fish to reduce growth or survival of natural-origin fish. This was a significant concern in the initial years of hatchery operation when it was hoped that restoration of natural recruitment was imminent. However, given the continued lack of natural recruitment, the choice at this time is clear: this program must produce

[4] In a remnant, post-glacially re-founded, isolated population (one that receives no incoming gene flow), outbreeding depression is not expected to be a concern).

enough fish to ensure that the next generation of endangered Kootenai sturgeon is demographically and genetically fit, because the program must provide all the genetic diversity required for the long-term viability of the population in all future generations.

Finally, hatchery objectives include avoiding selection or domestication that might reduce future individual and population level fitness or viability. Impacts of selection or domestication will likely not be manifested until the next (hatchery-produced) population begans to spawn in the wild. Failure to adopt non-selective spawning and rearing practices would likely have long-term irreversible consequences. This objective is generally met by maximizing family sizes, minimizing rearing density, minimizing rearing mortality and selective culling, and avoiding fish quality effects that might translate into differential post-release mortality.

ISRP Comment 2: *Justify the numerical biological objectives for genetic and abundance goals (the work performed by Kincaid (1993) and Paragamian et al. (2005) is a useful preliminary step, but may be superseded by information and changes to the state of the science since publication (e.g., Beamesderfer et al. 2009). A modeling exercise using a range of deterministic life-stage survival values and stochastic survival rates to establish the extinction risk and population abundance trajectory is needed.*

Project Sponsor Response 2:

Conservation Aquaculture Strategies & Production Targets

The conservation goals of the Kootenai sturgeon program require fundamentally different hatchery strategies than in many salmonid production or conservation programs. While the lessons learned from the uses and misuses of hatcheries for salmon provides useful cautionary instruction, sturgeon hatchery considerations can be hampered by the application of "salmo-centric" thinking due to the fundamental differences in life history and reproductive strategies between sturgeon and salmon.

Because of their very long life span and late age of maturation, sturgeon strategies demand a very measured consideration of time. The successful sturgeon life history strategy is characterized by accrued, additive impacts of small incremental effects in patterns that are manifested over time. Kootenai River white sturgeon are going extinct in slow motion and recovery will occur in the same fashion. Current trends are the result of impacts that occurred 50 years ago. Actions we take now will fix the path for the next 50 years and beyond.

Therefore, hatchery production strategies must take both a near-term and long-term point of view. It is not simply a case of establishing annual production targets and protocols. It is not as easy as identifying the future population goals and then backcalculating annual release numbers required to produce that number of fish. Hatchery priorities, strategies, and production targets will change over time based on temporal risk patterns, actions needed to address immediate risks, and actions designed to anticipate future risks.

The definition of production targets is complicated by the need to balance competing risks and objectives over time. Strategies to address specific objectives often provide competing direction. For example, the risk of genetic bottlenecks or founder effects in the current generation is addressed by the strategy of maximizing the number of broodstock incorporated into the program. The need to reduce the coming interval of adult scarcity and risks of having too few broodstock to support production during that interval argues for a front-loaded production strategy of large releases as a contingency for future uncertainty. However, large numbers of broodstock produce large numbers of offspring that potentially exceed the habitat rearing capacity and increase risks of competition with any wild fish that are produced. Numbers might be reduced by culling to a smaller family release target, but any kind of reduction risks inadvertent selection or loss of some of the diversity we are trying to propagate. Consistent releases of small family sizes also increase the likelihood that too few progeny might survive to spawn in the next generation, which would fail to meet program objecties and simply delay the bottleneck issue.

To address program objectives and future desired population conditions for endangered Kootenai sturgeon, this program is organized into three sequential strategic phases based on program scope and period-specific objectives:

I. Developmental Phase. This phase spanned the first two decades of the program from inception in 1988 until about 2008. The program started as a very basic experimental facility designed to research critical uncertainties and limiting factors, to assess gamete viability, and to explore the feasibility of sturgeon aquaculture. Program objectives and facilites evolved following the initial success of sturgeon propagation and stocking, and the recognition of the need to artificially supplement ongoing natural recruitment failure.

II. Preservation Phase. This phase began in the last few years with the recognition that the next sturgeon generation will be produced primarily in the hatchery. The preservation phase will extend for the next 10-20 years during which the remnant wild population will gradually dwindle and disappear. Wild broodstock are expected to be available for at least the immediate future to support aquaculture; however, the duration of future broodstock availability is uncertain. In this period, the driving objectives are to capture a representative portion of the native genetic diversity and propagate it in such a manner that can effectively sustain the next generation of adults, whether they may spawn in the wild or in the hatchery. It is these objectives that determine the need for the new facilities identified in the master plan. The preservation phase will coincide with implementation of extensive habitat restoration actions in the Kootenai River during the next 10-15+ years.

III. Adaptive Management Phase. The future of the program beyond the next 10-20 years will be determined by events as they unfold and will be managed in an adaptive fashion. We know that by that time, most of the wild fish will have died, wild hatchery broodstock will become increasingly scarce, and the oldest hatchery fish will begin to reach maturity. We don't know how quickly any of these events will unfold or what other surprises we will encounter along the way. Precautionary actions during the preservation phase are key to providing a firm foundation for the adaptive management phase. The adaptive management phase will coincide adaptive management of Kootenai River habitat restoration actions.

Production targets identified in the Master Plan are designed to ensure that immediate preservation objectives are met while balancing considerations of longer term risks. Targets for total broodstock, family size, fish size at release, and total releases (Table 2) are derived from a series of quantitative analyses tailored to address specific risks. The basis for these targets is described in the following sections.

Table 2. Production targets of facilities described in the Master Plan.

	Target	Focus
Broodstock Number	>500 (minimum) >1000 (optimum)	Preserve existing diversity
Families produced	Up to 40/year	Near-term precaution for future uncertainty
Fish / family	1,000 - 1,500	Perpetuate diversity through the next generation
Size at release	30 grams (avg.)	Optimize survival/selection balance
Total releases / year	20,000 – 40,000	Balance demographic objectives & risks

Broodstock/Family Number

Broodstock and family number targets were established to address the near-term objective of preserving native genetic and life history diversity by capturing and spawning significant numbers of representative broodstock. The future program objective reflected in the Master Plan is to increase the production targets from the current level of 12-18 familes[5] per year to up to 40 familes per year to achieve an optimum effective population size (N_e) in the hatchery of at least 1,000 broodstock.

For hatchery planning purposes, broodstock targets from the current wild population were established at >500 (minimum) and >1,000 (optimum) (Table 2). At the typical 1 female:2 male spawning matrix, the target corresponds to approximately 1,000-2,000 half-sibling families. Minimum and optimum targets are identified because the scientific literature does not provide clear guidance on what effective population sizes are necessary to represent normal population diversity. As discussed in Response 1, numbers needed to meet long-term genetic conservation objectives are highly uncertain. Most literature values are based on relatively simple genetic population models with unclear transferability to natural populations. The minimum 500 fish target was based on recommendations by Thompson (1991) corresponding to an effective population size adequate to preserve genetic diversity including rare alleles. However, effective population size (N_e) is defined as a theoretical population where every individual has the opportunity to mate with every other. Therefore, significantly greater census population sizes are needed to provide the same level of protection in a natural population where mating is obviously non-random, especially in severely altered ecosystems like the Kootenai River where altered habitat conditions further limit natural production. The number of breeders in a population in a given year (N_b) is a subset of the total or census population (N), and the effective population is the successfully reproducing subset of N_b. Furthermore, additional loss of individuals occurs due to mortaility between spawning and survival to sexual maturity.

Therefore, this optimum fish target of >1,000 reflects the need for a census population size substantially greater than the theoretical N_e. For context, these targets are only 20-40% of the working recovery goal

[5] A family is defined as the offspring from one pair of parents. Families from one female and one male are referred to as full-sibling families. Families from the same female and different males are referred to as half-sibling families. The Kootenai program typically divides the eggs from individual females into separate lots which are fertilized with milt from different males in order to maximize fertilization, survival and genetic contribution.

of 2,500, about 5-10% of the historical population size, but only 50-100% of the current population estimate. It is not possible to capture and spawn every remaining wild fish in the hatchery. However, a precautionary approach will involve propagating as many of these wild fish as possible during the next decade or more.

The conservation strategy places a very high priority on preserving diversity over the near-term in order to preserve the long-term viability and adaptive potential or plasticity of the population.[6] For the aquaculture program, this involves both capturing representative diversity from the remaining population and ensuring that enough diversity is propagated to prevent a bottleneck in the next generation. In simplistic terms, the effective population size is rapidly reduced in successive generations when only a portion of the adult population is able to spawn effectively (Figure 1). Chances of a second generation founder effect would be substantially increased by low initial hatchery numbers, low future broodstock sample rates, or low natural spawning frequencies. The dynamics of actual population genetics are likely much more complicated than this simple example illustrates. On the one hand, many individuals in the population share common alleles. On the other hand, expression of individual variation through recombination and intergenerational, communal spawning provides the spectrum of traits that helps sustain population viability in the face of normal variation in habitat and environmental conditions. However, the magnitude, severity, and duration of anthropogenic disturbance in the Kootenai River continues to jeopardize population restoration by natural production.

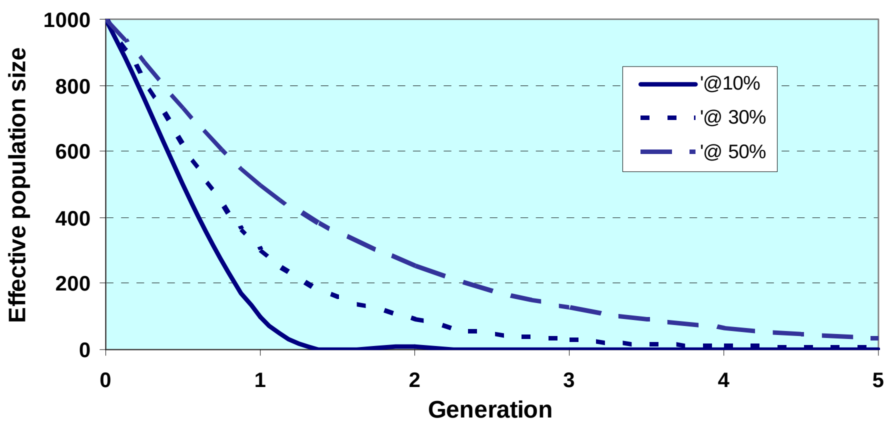


Figure 1. Theoretical reduction in effective population size over generations based on the proportion of the available adults that reproduce effectively.

Furthermore, because sturgeon genetic population dynamics are still not that well understood, the conservation aquaculture program has elected to take the precaution of targeting a relatively large number of broodstock. Any locally adapted genetic material not incorporated by wild broodstock would be permanently lost because all future populations will be founded by the current and subsequent

[6] *It is important to keep in mind that conservation aquaculture is only one component of the overall sturgeon recovery strategy. In light of the failure of flow-only mechanisms to restore natural recruitment, there is increased motivation to implement the Tribe's comprehensive ecosystem-based habitat restoration program, and to continue the efforts of ongoing Tribal programs. These include the Tribe's tributary restoration work and nutrient restoration program. It will take these collective efforts to restore the pervasive habitat degradation that has occurred over the last century in the Kootenai River ecosystem.*

generations. There will be no do-overs in this population if we fail to take advantage of opportunity afforded by incorporating the remaining wild spawners into the program.

Another way to look at the multi-generation aspects of the limitations imposed by the hatchery production capacity is to consider the effective population size in relation to sturgeon generation time and annual broodstock numbers. At a sturgeon generation time of 25 years, annual production of 20 adults will result in an effective broodstock population size of just 500 fish during that period (Figure 2). Forty spawners would be needed per year to meet a 1,000 fish target within a 25-year period.

Increasing demands of the aquaculture program due to the continuing natural recruitment failure explain the large increases in broodstock and family targets relative to those initially identified by Kincaid (1993). Kincaid developed initial program targets of 3 to 9 females spawned with an equal number of males to produce 4 to 12 families annually for 20 years, targeting an effective population size of 200 fish (10 per year), and an assumption that natural recruitment would be restored during those 20 years (1994-2013). These targets were designed to approximate a normal expanding natural population and to avoid exaggerated genetic contributions of a small fraction of the parent population from the hatchery to the natural population (Kincaid 1993). However, since the conservation aquaculture program was initiated the 1990s, natural recruitment has not increased and annual recruitment failure continues into its fifth decade.

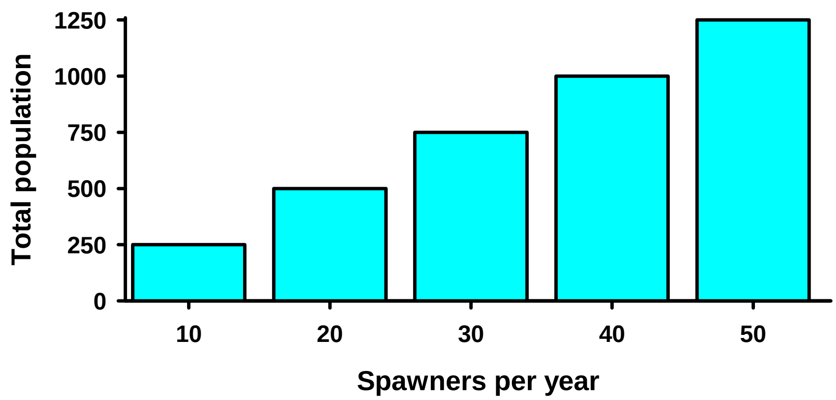


Figure 2. Estimated founder broodstock population size in a 25-year sturgeon generation in relation to annual numbers.

The need to increase broodstock and family numbers is driven by concerns regarding the limited and dwindling broodstock availability period, uncertainty in the effective reproduction lifespan of the very old fish that comprise the remaining population, and difficulties handling very large fish. The recovery strategy involves front-loading production over the next decade while significant numbers of wild broodstock are available. Front-loading broodstock is a strategy that recognizes the need to provide contingencies against future uncertainties. As the sturgeon population continues to decline, it is likely that it will be increasing difficult to collect broodstock. Broodstock availability will be further constrained because as more and more fish from the shrinking population are used for broodstock, previously-used broodstock will comprise an increasing proportion of the available catch in annual collection efforts. Current broodstock collection practices use only fish that have not been previously spawned[7]. New individuals are the preferred source for broodstock in order to maximize the number of remaining fish that have contributed via the hatchery to the next generation.

The 40 family/year goal will not be met every year because it depends on the success in capturing ripe fish for spawning. The average family number is expected to be less, particularly beginning 10-20 years hence. However, a front-loaded strategy requires maximum hatchery production rather than average production. This is one of reasons the proposed new hatchery facility is needed at Twin Rivers.

From 1990 through 2009, 249 wild broodstock have been spawned (171 males and 78 females), producing 156 full or half-sibling families (Table 3). Annual broodstock numbers averaged 6.5 per year from 1995-1998 following adoption of the Kincaid plan, 14.8 per year from 1999 to 2004 following the 1999 upgrade of the Tribal Strugeon Hatchery and the involvement of facilities in British Columbia, and 24.2 per year since 2005 when targets were increased to the capacity of the existing facilities in response to continuing recruitment failure. Current production capacity of the combined Tribal Sturgeon Hatchery and the Kootenay Sturgeon Hatchery in British Columbia is 12-18 familes per year, with up to 5 families currently produed annually at the B.C. facility. The Master Plan calls for a total production capacity of 40 families per year in the existing Tribal Sturgeon Hatchery and new Twin Rivers facility to maximize use of remnant locally adapted genetic material, including continued production of up to 5 families annually at the Kootenay Sturgeon Hatchery in B.C.

Actual genetic effective population sizes (N_e)[8] of broodstock used to date were estimated inTable 4. Annual effective population size ranged from 2 to 24.4 fish from 1990 through 2009 (shaded cells in Table 4). Annual N_e values increased as the program and facilties were refined, averaging 2.7 fish for 1990 through 1995, 8.9 fish from 1996 through 2000, and 18.5 fish from 2001 through 2009. The cumulative total of 208 fish was less than the actual broodstock contribution of 249 fish because of the production of half-sibling families.[9]

---

[7] *Only one female has been spawned twice in the history of the program. At the point where previously un-spawned ripe females are no longer available, females will be reused by spawning with new males. Ripe males are not typically in short supply.*

[8] *The effective breeding number (N_e) for a population is the number of individuals in a random breeding population with an equal sex ratio, which would yield the same rate of inbreeding or genetic drift as the population being studied (Falconer 1981; Kincaid 1993): N_e = 4 X (Nm~ x Nf/)/ (Nm +NF). This formula calculates the N_e (effective population size) for populations produced from random mating of Nm male parents and Nf female parents. Ideally, N_e is calculated from counts of the actual number of parents that contribute progeny to the next broodstock generation. Because the actual number of individuals contributing progeny to the next generation and the number of progeny each contributes is unknown in most populations, the number of individuals that spawn and produce progeny is used in the calculation, i.e., the total number of fish spawned of each sex. For animal species with multi-year generation intervals, N_e is calculated using the sum of all males (Nm) and females (Nf) spawning each year for the number of years in the generation interval adjusted by any difference in sex ratio and the number of individuals that spawn more than once per generation. The generation interval is defined as the average age of females at first maturity, or about 20 years for the Kootenai River white sturgeon. The Ne will be the total of all spawners (different fish spawned) over the 20-year generation interval.*

[9] *While production of half-sibling families marginally reduces the calculated effective population size, it also reduces the chances that the contribution from any given female will be lost due to low fertilization rates from a particular male.*

Table 3. Summary of broodstock, egg take, and spawning success.

	Males	Females		Families	Egg take (thousands)			Egg-larval Survival		Effective Population	
Year	Brood	Held	Brood	Produced	Total	Mean	Range	Mean	Range	Annual	Cumulative
1990	1	1	1	1	60 [a]	60	--	2%	--	2.0	2
1991	3[e]	2	1	1	69 [a]	69	--	20%	--	3.0	5
1992	3 [f]	2	1	3	142 [a]	142	--	16%	na	3.0	8
1993	2	2	1	2	86 [ab]	86	--	21%	na	2.7	10.7
1994	0[g]	0[g]	0[g]	0[g]	0	--	--	--	--	0.0	10.7
1995	4	2	2	4	143 [b]	71	71–72	28%	--	5.3	16
1996	2	2	1	2	62 [b]	62	--	<1% [h]	--	2.7	18.7
1997 [i]	5	4	3	6	201 [b]	67	40–97	30%	na	7.5	26.2
1998	6	3	3	6	217 [b]	72	60–92	28%	na	8.0	34.2
1999	8	5	4	8	277 [bcd]	69	38–105	63%	40–80%	10.7	44.9
2000	11	6	6	11	306 [bcd]	51	17–112	73%	25–92%	15.5	60.4
2001	10	8	5	10	294 [bcd]	59	51–69	70%	35–86%	13.3	73.7
2002	9	6	3	9	151 [bcd]	50	34–62	86%	50–97%	9.0	82.7
2003	13	8	4	13	246 [bcd]	61	56–74	93%	85–99%	12.2	94.9
2004	11	13	5 [j]	17	369 [bcd]	74	60–98	81%	15–95%	13.8	108.7
2005	14	13	6[k]	16	1,163 [bcd]	108	17–255	78%	15–97%	16.8	125.5
2006	15	11	7	11 [l]	790 [bcd]	113	54-164	88%	66-100%	19.1	144.6
2007	18	8	5	18	289	58	38-85	94%	72-98%	15.7	160.3
2008	19	12	11	17	1,070	97	53-162	89%	60-99%	24.4	184.7
2009	17	11	9	12	1,025	114	70-179	95%	60-99%	23.5	208.2
Total	171	119	78	156	6,960	**78**	**17-255**	**61%**	**15-100%**		

[a] *Eggs collected by c-section*

[b] *Eggs collected by hand stripping*

[c] *Portion of egg take incubated at Tribal Sturgeon Hatchery*

[d] Portion of egg take used for research purpose

[e] Sperm from 3 males pooled

[f] Eggs fertilized separately from each male

[g] *No fish handled due to ESA listing*

[h] *Low success due to low gamete quality*

[i] *No survivors to release due to facility failure*

[j] *3 females transported upriver, 5 females released unspawned*

[k] *5 of 11 females spawned successfully were used only for egg outplants. 5 additional families were produced for experimental river releases*

[l] *5 additional families were produced for experimental river releases*

Table 4. Effective population size (N_e) from annual spawning (1990-2009) of Kootenai sturgeon.

Ne		Number of Female Parents											
		1	2	3	4	5	6	7	8	9	10	11	12
Number of Male Parents	1	2.0 1990	2.7	3.0	3.2	3.3	3.4	3.5	3.6	3.6	3.6	3.7	3.7
	2	2.7 (93,96)	4.0	4.8	5.3	5.7	6.0	6.2	6.4	6.5	6.7	6.8	6.9
	3	3.0 (91 92)	4.8	6.0	6.9	7.5	8.0	8.4	8.7	9.0	9.2	9.4	9.6
	4	3.2	5.3 1995	6.9	8.0	8.9	9.6	10.2	10.7	11.1	11.4	11.7	12.0
	5	3.3	5.7	7.5 1997	8.9	10.0	10.9	11.7	12.3	12.9	13.3	13.8	14.1
	6	3.4	6.0	8 1998	9.6	10.9	12.0	12.9	13.7	14.4	15.0	15.5	16.0
	7	3.5	6.2	8.4	10.2	11.7	12.9	14.0	14.9	15.7	16.5	17.1	17.7
	8	3.6	6.4	8.7	10.7 1999	12.3	13.7	14.9	16.0	16.9	17.8	18.5	19.1
	9	3.6	6.5	9.0 2002	11.1	12.9	14.4	15.7	16.9	18.0	19.0	19.8	20.6
	10	3.6	6.7	9.2	11.4	13.3 2001	15.0	16.5	17.8	19.0	20.0	21.0	21.8
	11	3.7	6.8	9.4	11.7	13.8 2004	15.5 2000	17.1	18.5	19.8	20.6	22.0	23.0
	12	3.7	6.9	9.5	12.0	14.1	16.0	17.7	19.1 2006	20.6	21.8	23.0	24.0
	13	3.7	6.9	9.8	12.2 2003	14.4	16.4	18.2	19.8	21.3	22.6	23.8	25.0
	14	3.7	7.0	9.9	12.4	14.7	16.8 2005	18.7	20.4	21.9	23.3	24.6	25.8
	15	3.8	7.1	10.0	12.6	15.0	17.1	19.1	20.9	22.5	24.0	25.4	26.7
	16	3.8	7.1	10.1	12.8	15.2	17.5	19.5	21.3	23.0	24.6	26.1	27.4
	17	3.8	7.2	10.2	13.0	15.5	17.7	19.8	21.8	23.5 2009	25.2	26.7	28.1
	18	3.8	7.2	10.3	13.1	15.7 2007	18.0	20.2	22.2	24.0	25.7	27.3	28.8
	19	3.8	7.2	10.4	13.2	15.8	18.2	20.5	22.5	24.4 2008	26.2	27.9	29.4
	20	3.8	7.3	10.4	13.3	16.0	18.5	20.7	22.9	24.8	26.7	28.4	30.0

Note: Shaded areas represent the effective population size for each year.

Genetic analysis of wild Kootenai River white sturgeon broodstock and juveniles provides a population-level indicator of how well the program is incorporating wild population genetic attributes into the next generation. Genetic variability (frequency distribution of alleles) and genetic diversity (total number of alleles) is monitored annually (Figure 3). All broodstock spawned and all progeny groups produced in the hatchery are analyzed using microsatellite DNA methods that have become widely used for many conservation and management applications due to their high resolution and highly variable nature (McQuown et al. 2000; Rodzen and May 2002; Rodzen et al. 2004; Drauch and May 2007, 2008, 2009). Recent microsatellite analysis revealed that the wild Kootenai River sturgeon population has 52 allelles, which is approximately 25 to 50% less diverse than eight other North American white sturgeon populations (Rodzen et al. 2004).

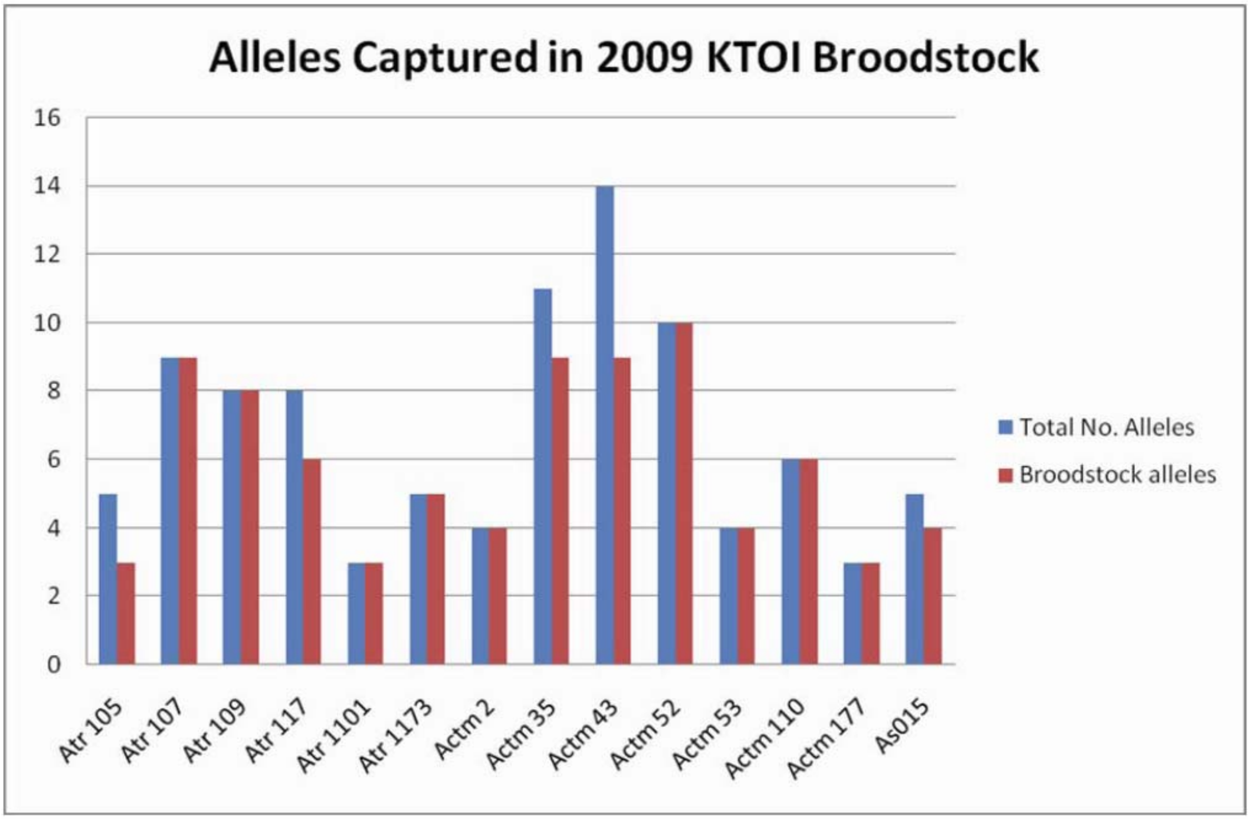


Figure 3. Example of the representation of population genetic diversity among Kootenai sturgeon broodstock (Drauch and May 2009).

This is not surprising given that the Kootenai population is a headwater population at the edge of the species' geographic range that has likely experienced a natural loss of rare alleles since post-Pleistocene refounding due to genetic drift. Further artificial loss of native diversity has occurred due to recent anthropogenic demographic and associated genetic bottlenecks. However, from 80 to 90% of all identified extant alleles have been incorporated into the hatchery broodstock groups annually from 2004 through 2009 (Drauch and May 2007, 2008, 2009), with over 95% of all wild population alleles incorporated into the broodstock during the 20 years of program operation (1991 through 2009) (pers. comm. Andrea Drauch, UC Davis Genomic Variation Lab).

Thus, long-term program success and the population's ability to be viable and persistent beyond the next generation depends on whether the remaining variability (i.e., that captured in the current program during the next 20 or so years) is adequate. These questions will ultimately be answered at that time. Meanwhile, incorporating as much of the extant remnant genetic variability as possible during the next 20 years, or until wild broodstock from the current generation are longer available, will maximize the likelihood of future population viability and persistence, and the success of the program.

In order to help illustrate the need for the enhanced hatchery capacity proposed through the Master Plan, we are providing a projection of the total wild broodstock numbers at the current hatchery capacity and with the expanded capacity (Figure 4). Projections with the current capacity assume that the recent average number of wild broodstock (24 per year) will continue to be available for the next 20 years and that previously-unspawned individuals would continue to be available during this interval. A total of 746 broodstock would be used by 2030 at the current facility capacity. This number exceeds the minimum target of 500 spawners but is substantially less than the optimal target of >1,000 spawners.

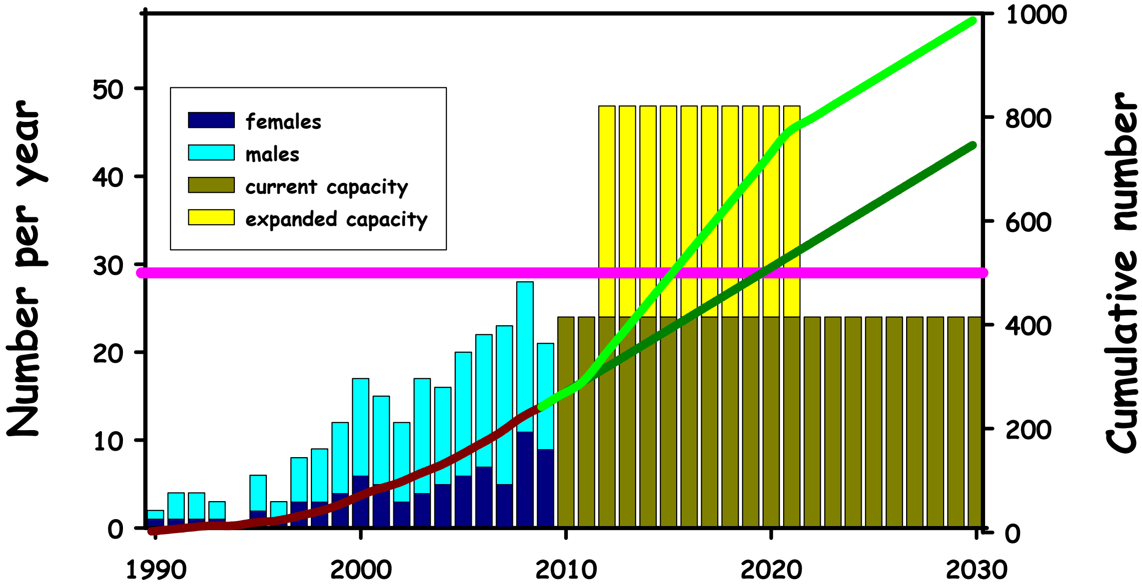


Figure 4. Broodstock numbers and projections with and without existing facilities.

Projections with the expanded capacity identified in the Master Plan assume that the number of wild broodstock will double for at least the next 10 years from 24 to 48 per year. Under these circumstances, we project that a total of 986 wild broodstock could be propagated into the next generation, very close to the optimal target of >1,000.

Note that genetic effective population sizes will continue to be less than the actual broodstock numbers because of the unbalanced male and female contributions that result from the difficulty of capturing and spawning ripe males and females, and the sex-specific difference in spawning periodicity (~2-3 years for males, and ~4-5 years for females).

For broodstock collected to date, the total program N_e was approximately 84% of the broodstock total (208 vs. 249). Using this empirical ratio, projected N_es in 2030 would be 626 at the current capacity and 828 with the proposed expanded production capacity. Estimates of the effective population size in the next generation assume that at least some offspring of all broodstock are effectively propagated and survive to adulthood. We already know that some families have fared poorly in the hatchery and that some groups of fish released at small sizes have fared poorly in the wild. Conversely, other families fare well in the hatchery; it is assumed that both genetics and hatchery conditions may be responsible for observed differences. Hence, estimates of effective population size based on broodstock numbers and mating matrices tend to overestimate the actual effective population of hatchery-origin adult spawners in the next generation.

Assessments of broodstock needs and numbers are based on a number of uncertain assumptions. These start with the effective population targets. We identified targets based on the available information, however, this area of science is simply not definitive for a species with complex genetic and reproductive characteristics like sturgeon.

Assumptions regarding the continuing availability of broodstock are also uncertain. Recent population assessments indicate the remnant wild population is larger than previously thought, but numbers continue to decline and the frequency of spawning by many of the fish estimated to be present in Kootenay Lake is less than that previously estimated from fish sampled in the river (Beamesderfer et al. 2009).

The lifespan and reproductive lifespan of individual fish are also unknown. By 2030, we project that the youngest of the remaining wild fish will be 70-80 years of age. There is little information in the sturgeon literature regarding the potential for reproductive senescence and no one has had experience using exclusive very old broodstock as will occur in this program. Old fish are also very difficult to handle as captive broodstock due to their large size. Nor do we know whether mortality rates of very old fish will begin to increase or whether the viability of their gametes or progeny will decrease. The program must contain functional contingencies for such possibilities.

At some point, broodstock availability will be acutely impacted by declining numbers, lack of fish that have not already been spawned, and/or senescence. The Kootenai sturgeon recovery program has elected to address these substantial uncertainties by increasing broodstock numbers now when fish are available, an objective constrained by the capacity limitation of the current aquaculture facility.

Family Size

Program targets for numbers per family at release are 1,000 to 1,500 fish at age 1 or older and weighing about 30 g or more. These targets are the same as those used by the program through 2003 but less than 2004-2008 levels. The original target was established by Kincaid (1993) for a very specific purpose: to avoid an exaggerated contribution of a small fraction of the parent population. In 2004, family size targets were increased to 3,000-4,000 because fish were released at a smaller size. Survival of the smaller fish was very poor relative to previous release groups. Justice et al. (2009) suggested that this could be related to size-specific density dependent effects. In 2009, targets were changed back to the original family size (1,000 -1,500 fish averaging 30 g) in an attempt to avoid an apparent population bottleneck at the young-of-the-year stage (Beamesderfer et al. 2009; Justice et al. 2009).

Family size targets are established to ensure survival of enough fish from each family to maintain a safe genetic effective population in the next generation, to avoid excessive contributions from any one family that might swamp the population genetics, and to limit total population size in order to reduce intra-species competition and density-dependent growth and survival limitations. For the purposes of this response, analyses using current data indicate that family size targets of 1,000 to 1,500 fish should be adequate to ensure that sufficient numbers of each family will be available to: 1) survive for 30-plus years to reach maturity and 2) produce succeeding generations in which the existing genetic diversity of each parent is represented in all recombinant permutations of offspring. We estimate per family recruitment of 42-62 fish on average to age 25 (Figure 5). These projections are extremely sensitive to even small differences in estimated annual survival. For instance, increases of 3% per year triples the projected number of recruits. Decreases of 3% per year reduce the estimate by two thirds. Variability in actual survival clearly limits the value of specific population projections of this nature due to additive effects of variability over decades.

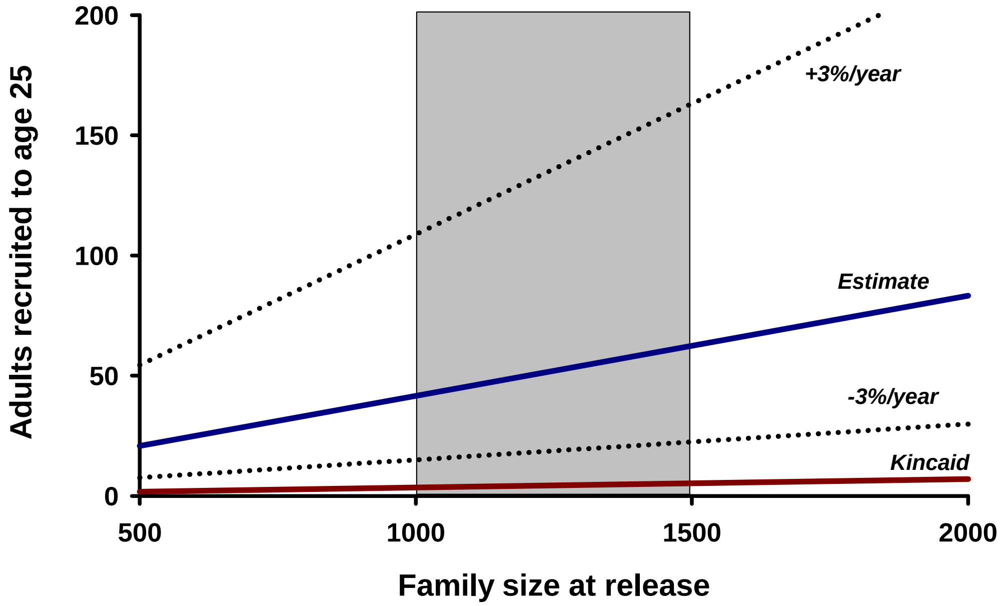


Figure 5. Effect of release group size on number of adult recruits from that cohort. Best current estimates are based on first year hatchery survival of 15% (recent average), 88% per year for age 1-3, and 96% thereafter. The shaded box represents planned family size production targets.

Current projections and targets for adult recruits per family are substantially greater than those originally developed by Kincaid (1993), even though family size targets are similar. Kincaid based the original calculation on an objective of 8 progeny per family at the assumed breeding age of 20. This estimate was based on the best available information at that time and a goal of supplementing natural production to create a "normal expansion" of the population. Since then, post-release survival rates of hatchery fish have been greater than Kincaid initially assumed (net survival of 3% vs. 0.8% to age 20) and age of maturity is older (25 vs. 20 years). Kincaid's original adult targets appear to be much too low to sustain the population in the absence of natural production. This was previously recognized and incorporated into the Tribe's 2004 Hatchery Genetic Management Plan (KTOI 2004).

Because of variation in spawning success and survival, family groups range in size from a few hundred to several thousand fish. Orders of magnitude differences among naturally produced families would also be expected, based on variability in genetic and environmental conditions affecting individual families. Jager (2005) found no long-term genetic risk of modest variation in family numbers and hence little benefit of family equalization. Very large differences in family size (e.g., 100,000 vs. 10,000) might be grounds for concern but differences on the order of a few hundred to a thousand are not a concern (e.g., less than an order of magnitude difference in release size may be acceptable). At this point, it is more important to release sufficient numbers from each family group to ensure a next generation than it is to try to equalize release numbers from each family in an attempt to balance the genetic contributions of hatchery fish to the generation after the next generation. This is especially true if such practices equalize release groups down to the size of the smallest family group.

Total Releases

The Kootenai Tribe's conservation aquaculture program has reared and released 170,870 Kootenai white sturgeon (age 1 or older) from 1992 through 2009 (Figure 6, Table 5). Significant releases began in 1997 after the hatchery was identified as a critical component of the recovery plan. Hatchery releases prior to 1997 were largely experimental. Full production was reached in 2003 after hatchery upgrades. Annual releases have ranged from about 3,000 to 37,000 fish per year from 2003-2009 (average 21,000). Past production has averaged about 16,000 yearlings or 33,000 subyearlings. The 2008 release of only 3,254 fish was a transition year from a subyearing to yearling release protocol (fish that would have been released in 2008 as yearlings had already been released in 2007 as subyearlings).

Release numbers consistent with family number and family release number targets designed to minimize genetic risks would be 30,000 to 40,000 sturgeon per year over 10 years[10]. These targets are similar to the maximum release in 2005 of 38,000 fish, but fish would be released as yearlings at a larger size (30 g) rather than as subyearlings in order to increase post-release survival. Annual and total release numbers are largely a function of broodstock number and family size guidelines adopted to balance near-term and long-term genetic and demographic risks.

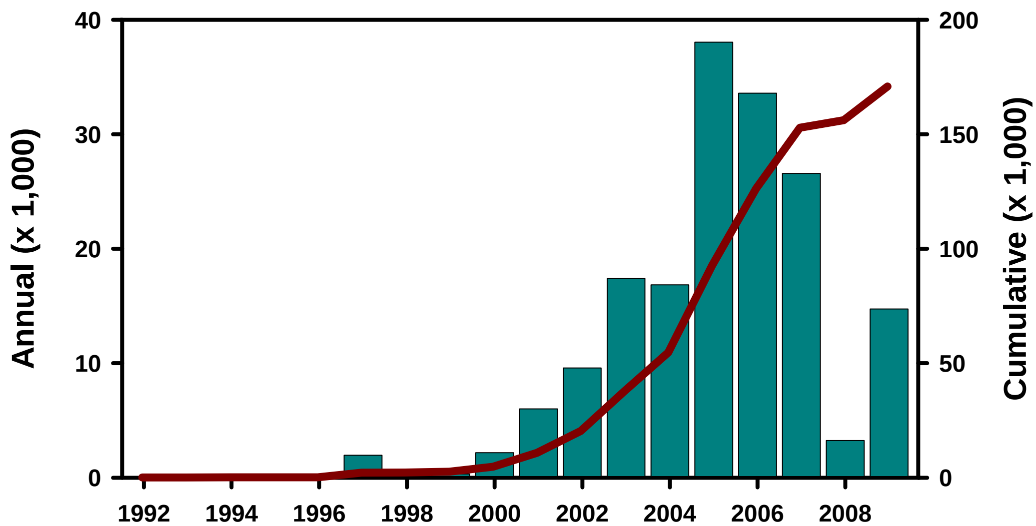


Figure 6. Annual (bars) and cumulative (line) numbers of juvenile white sturgeon released into the Kootenai River and Kootenay Lake.

[10] Family number targets are up to 40 per year but actual production likely will vary between 20 and 40 families per year over the next 20 depending on fish variability. Family size targets are 1,000-1,500 fish. We anticipate that smaller family sizes would be released in years with many families and that larger family sizes would be released in years with fewer families (e.g., 20 x 1500 = 30,000, 40 x 1000 = 40,000).

Table 5. Numbers of hatchery produced white sturgeon juveniles released into the Kootenai River and Kootenay Lake in Idaho and British Columbia, 1992-2008.

Year Class	Rearing Facility [a]	Release Number Tagged	Release Number Untagged	Mean Total Length (mm) (SD[b])	Mean Weight (g) (SD[b])	Release Season & Year
1990	KTOI	14	--	457 (53)	321 (112)	Summer 1992
1991	KTOI	104	--	255 (17)	66 (13)	Summer 1992
1992	KTOI	123	--	483 (113)	549 (483)	Fall 1994
1995	KTOI	1,075	--	228 (27)	47 (17)	Spring 1997
1995	KTOI	884	--	344 (44)	148 (64)	Fall 1997
1995	KTOI	97	--	411 (68)	288 (138)	Summer 1998
1995	KTOI	25	--	582 (40)	863 (198)	Summer 1999
1998	KTOI	309	--	260 (42)	79 (44)	Fall 1999
1999	KTOI	828	--	256 (22)	71 (18)	Fall 2000
1999	KH	1,358	--	248 (33)	67 (28)	Fall 2000
1999	KTOI	491	--	284 (54)	108 (60)	Spring 2001
1999	KH	1,583	--	306 (40)	56 (39)	Spring 2001
2000	KTOI	2,286	--	244 (39)	64 (31)	Fall 2001
2000	KH	1,654	--	240 (23)	58 (16)	Fall 2001
2000	KH	2,209	--	283 (29)	99 (30)	Spring 2002
2000	KH	30	--	365 (14)	195 (20)	Summer 2002
2000	KTOI	214	--	409 (54)	294 (110)	Fall 2002
2000	KTOI	907[c]	--	333 (36)	193 (63)	Jan. 2003
2000	KT	10[d]	--	558 (28)	88 (18)	Feb. 2004
2000	KT	3[e]	--	662 (61)	425 (66)	Summer 2006
2001	KT	2,672	--	200 (38)	33 (16)	Fall 2002
2001	KH	4,469	--	227 (24)	52 (17)	Fall 2002
2001	KH	1,715	--	257 (26)	72 (24)	April 2003
2001	KT	1[e]	--	570	750	Summer 2006
2001	KH	1[e]	--	560[j]	1152	Spring 2009
2002	KH	5,864	--	217 (25)	41 (14)	May 2003
2002	KT	856	--	214 (44)	42 (23)	Oct. 2003
2002	KT	~550[f]	--			Nov. 2003
2002	KT	3,852	--	215 (37)	43 (20)	Winter 2003
2002	KT	3,663	--	214 (55)	43 (27)	Winter 2003-2004
2002	KT	1[e]	--	550	740	Summer 2006
2003	KH	9,020	--	223 (26)	49 (24)	Spring 2004
2003	KH	19[g]	--	230 (27)	52 (19)	Sept. 2004
2003	KT	3,519	--	227(47)	55 (32)	Late winter 2004
2003	KT	3[e]	--	437 (27)	347 (49)	Summer 2006
2004	KT	--	3,000[h]			Fall 2004
2004	KT	--	1,275[h]			Winter 2004-2005
2004	KT	--	17, 723[h]			Spring 2005
2004	KH	1,238	800[i]	196 (28)[j]	57 (33)	Spring 2005
2004	KH	--	3,440[h]			Spring 2005
2004	KT	--	8,637[h]			Summer 2005
2004	KT	1	--	510	490	Winter 2007
2004	KH	5[e]	--	452(23)[j]	563(116.5)	Spring 2009
2005	KT	--	6,200[h]			Fall 2005
2005	KH	14[k]	--	299 (14)[j]	174 (28)	Spring 2006
2005	KH	1,765	--	198 (25)[j]	54 (22)	Spring 2006
2005	KH	--	13,665[h]			Spring 2006
2005	KT	--	3,947[h]			Spring 2006
2005	KT	510[l]	--	171(47)	27 (20)	Fall 2006
2005	KH	1[e]	--	330[j]	225	Spring 2009
2006	KH	--	6,900[h]			Fall 2006
2006	KH	--	600[i]	149 (11)[j]	23 (5)	Fall 2006
2006	KT	--	6,175[h]			Fall 2006
2006	KH	--	5,800[h]			Spring 2007
2006	KH	1,877	1,000[i]	182 (15)[j]	44 (12)	Spring 2007

Year Class	Rearing Facility [a]	Release Number		Mean Total Length (mm) (SD[b])	Mean Weight (g) (SD[b])	Release Season & Year
		Tagged	Untagged			
2006	KT	--	12,973[h]			Spring 2007
2006	KT	4,922	--	171 (30)	22 (11)	Winter 2007
2007	KH	2,167	--	241(24)[j]	92(27)	Spring 2008
2007	KT	884	203[i]	151(36)	20(10)	Fall 2008
2008	KH	9,982	--	198(35)[j]	56(19)	Spring 2009
2008	KT	3,875	882	194(52)	32(19)	Fall 2009
Total		**170,870**				

[a] *Kootenai Tribal Hatchery in Idaho (KT) or Kootenay Hatchery in British Columbia (KH)*
[b] *Standard deviation*
[c] *Ten fish from this group held over for later upriver release with transmitters*
[d] *These 10 fish were released upriver (rkm 306.5) with sonic and radio tags.*
[e] *These fish were held over for later release (2006-released with Vemco tags).*
[f] *No measurements available for these fish; exact number not known*
[g] *These fish were first taken to Kokanee Creek Provincial Park, then released in Sept.'04.*
[h] *These fish were not given a PIT-tag or measured.*
[i] *These fish did not have a PIT-tag added and were all given fish #999.*
[j] *Value given is for mean fork length (mm)*
[k] *These fish were released upriver (299.0 and 258.7), 6 of them with Vemco sonic tags.*
[l] *There were 200 fish held over at the Tribal Sturgeon Hatchery for Biopar study.*

Current habitat capacity for sturgeon is unknown and cannot be defensibly estimated from existing information. Even if capacity could be estimated, process uncertainty, natural variability and measurement errors in survival rates confound the accurate estimation of release numbers. Even very small differences in annual survival result in vastly different calculations of release numbers needed to establish any given population level. The Kootenai Tribe's restoration and conservation aquaculture program is addressing these limitations by designing for production levels that address the immediate problem of capturing and propagating existing genetic diversity. Habitat capacity is being experimentally estimated by intensive annual monitoring of post-release survival, condition, and growth in relation to juvenile abundance and size distribution. Future hatchery release numbers will be managed adaptively based on feedback from the monitoring program.[11]

Juvenile sturgeon are typically reared for up to 1 to 2 years in the hatchery before release. Fish are released from the Kootenai Trout Hatchery in British Columbia in the spring after reaching suitable tagging size (30 g). Fish are released from the Tribal Sturgeon Hatchery in the fall at age 1+ and include the faster growing individuals from a brood year cohort. Smaller fish from the same brood year are typically retained in the hatchery and released in the following spring as two-year-old fish.

Monitoring post-release survival of hatchery-reared fish has revealed excellent initial survival in the wild (Ireland et al. 2002b). Survival was estimated at 60% during the first year as hatchery fish adapt to the wild environment and 90% per year thereafter based on analysis of mark-recapture data. Growth and condition within the first 1-3 years after release were often poor (Ireland et al. 2002b). Many fish recaptured within a year or two of release weighed less than when released from the hatchery. However, after several years at large, most recaptured fish exhibited significant growth in length and/or weight. Fish that initially struggled may have adapted or died, leaving only the successful survivors. Size

[11] In the longer term, the Tribe is developing a comprehensive adaptive management plan that will incorporate monitoring information from the conservation aquaculture program, habitat restoration efforts, nutrient supplementation program and other efforts, in order to better understand the interrelated effects of these efforts and adaptively manage each program.

and condition in the wild were not related to size and condition at release. Thus, how well fish performed in the hatchery did not appear strongly related to how well they survived in the wild. This dynamic illustrates the importance of producing a diversity of individuals across the genetic spectrum on which natural selection can operate (Brannon 1993; Anders 1998). It also highlights the importance of avoiding selective rearing practices that favor fish that do well in the hatchery.

In 2004, concerns about ongoing natural recruitment failure led the Tribe to increase release numbers and family sizes within the constraints of the existing hatchery facilities as a precaution for the coming interval when too few wild fish will remain to provide broodstock. The Tribal Sturgeon Hatchery and the Kootenay Sturgeon Hatchery had the capacity to raise greater numbers of each family if fish were released at a smaller size. Numbers were increased by releasing fish at 10-15g as age 0+ in fall rather than 30 g at age 1+ or 2. This avoided the space limitation in the existing hatchery caused by simultaneously rearing multiple overlapping brood years. Minimizing time in the hatchery was also expected to minimize opportunities for hatchery selection effects and unforeseen rearing catastrophes (disease, equipment failure, etc.).

Previous production levels were constrained by the need to raise all fish to sizes suitable for PIT-tag placement and retention, and to rear families separately so that family sizes could be equalized within an order of magnitude upon release. Subsequent evaluations concluded that low population size in the next generation is a much more acute demographic and genetic risk than unequal family contributions in the following generation. Batch marking of fish with scute removal patterns allowed a smaller size at release while preserving a means of distinguishing hatchery-reared fish in the wild. Eliminating the PIT-tag requirement provided the flexibility to release fish at smaller sizes and ages which opened up space for more family groups in the hatchery. Upon release, smaller fish were expected to survive at similar annual rates as those observed in previous groups, although an extra year of natural mortality means that slightly fewer fish from any release group would be expected to survive to a given age. Increased release numbers allowed by this change in use of hatchery space was expected to more than offset this effect.

However, subsequent monitoring found that survival of the more recent release groups has declined substantially from the early estimates (Justice et al. 2009). Where very high recapture rates were observed for the initial release groups, recaptures of later releases occurred at a much lower rate (Table 6). The decline was most pronounced among the small hatchery fish (<25 cm) while survival of the larger hatchery fish was similar to previous estimates (Justice et al. 2009). This negative relationship between release numbers and survival suggested that density-related competition or predation may be influencing mortality of juvenile sturgeon during their first year at large. However, this effect appeared limited to the first year at large, as indicated by the relatively stable survival rates for fish recaptured after two or more years following release.

Although larger releases were intended to increase the number of hatchery juveniles in the wild, the release of fish at smaller sizes beginning in 2005 actually produced the opposite effect. The benefit of this adaptive experiment was identification of a second life history bottleneck during the first year of life that may affect both hatchery and wild fish. The effect of the Tribe's habitat restoration measures on this first year bottleneck will be one of the outcomes that are monitored. To date, large release numbers have not translated into a large juvenile population size. As a result, the program has now returned to releasing fewer, smaller, older fish (yearling and age 1) that continue to demonstrate high survival rates (Beamesderfer et al. 2009).

The actual population size of hatchery-reared juveniles in the wild is much smaller than the total hatchery release numbers due to significant mortality during the first year post-release adjustment period (Figure 7). Only 13% (~16,000) of the 153,000 hatchery sturgeon released into the system from 1992 through 2006 were estimated to have survived until 2007 (based on mark-recapture survival estimates). The 2007 population of hatchery-reared fish included an estimated 16,000 sturgeon that had survived at least one year in the wild. Juvenile sturgeon mortality is significant in the first year following release from the hatchery as individual success in adapting to natural conditions is variable. Similar patterns are observed in many other species, including salmon and steelhead. Growth and condition of many sturgeon has also been found to be poor in the first year following release. It is simply a difficult transition to go from the benign hatchery environment where food is readily available to a natural environment where food must be foraged and predators avoided. Some first-year mortality of small fish in release groups appears to be a function of sturgeon densities in the wild; however, survival of the large age 1 or older hatchery fish appears to be density-independent at this time. Early indications are that recent strategies that avoid the release of small hatchery sturgeon have been effective in avoiding the apparent density-dependent bottleneck of the smaller age 1 sturgeon. Different sizes of sturgeon are able to exploit different food resources and the larger fish may be able to take advantage of a broader diversity of food type.

This large difference between total numbers stocked and total numbers surviving is not viewed as a failure in the program, rather it reflects the reproductive strategy of sturgeons in the wild. Although individual female sturgeon have high fecundity (produce and spawn large numbers of eggs), very few survive to maturity given no parental care following broadcast communal spawning (i.e., sturgeons are “r-selected” vs. k-selected reproductive strategists [MacArthur and Wilson 1967]).

Table 6. Release and recapture number of tagged juvenile white sturgeon released by Kootenai hatchery programs, 1990-2006.[1]

Yr	Release					Rkm @ rel.		Number recaptured by year															Individuals[3]	
class	Year	Hat.	Seas.	No.	cm	lower	upper	93	94	95	96	97	98	99	00	01	02	03	04	05	06	Sum	#[2]	%
1990	1992	KT	Sum	14	39	204	243				3		1	1			1	1				7	4	1.6%
1991	1992	KT	Sum	104	22	204	243	1		14	23	9	8	16	8	3	7	6	7		2	104	59	24.3%
1992	1994	KT	Aut	10	61	304	310			4	4	1	2	1	2			1				15	8	2.6%
1992	1994	KT	Sum	113	40	204	246		1	8	12	11	7	8	11	10	10	1	4		5	88	49	19.9%
1995	1997	KT	Aut	884	30	241	245						104	52	64	70	40	12	27	7	9	385	279	113.9%
1995	1997	KT	Spr	1,075	20	243	245					33	62	53	70	61	51	22	31	28	10	421	317	129.4%
1995	1998	KT	Sum	96	36	241	259						1	7	15	12	7	3	1	2		48	37	14.3%
1995	1999	KT	Sum	25	51	241	241							2	3	2	3	1	1			12	8	3.3%
1998	1999	KT	Aut	309	22	230	258								8	15	6	6	2	4	1	42	36	14.0%
1999	2000	KT	Aut	1,358	21	170	200								4	103	46	41	50	33	28	305	259	129.5%
1999	2000	KT	Aut	828	22	200	259								1	37	14	22	14	24	11	123	108	41.7%
1999	2001	KT	Spr	1,583	26	170	200									124	90	43	70	46	61	434	379	189.5%
1999	2001	KT	Spr	491	18	240	245									5	6	7	7	2	3	30	28	11.4%
2000	2001	KT	Aut	1,419	20	170	200										19	29	24	12	12	96	89	44.5%
2000	2001	KT	Aut	2,286	21	170	245										24	18	17	8	9	76	73	29.8%
2000	2001	KT	Win	235	21	170	170										4	6	5	3	3	21	20	11.8%
2000	2002	KT	Aut	214	36	177	240											7	11	2	5	25	25	10.4%
2000	2002	KT	Spr	2,209	24	76	76										1		1		4	6	6	7.9%
2000	2002	KT	Sum	30	31	76	76															0		0.0%
2000	2002	KT	Win	907	29	170	170											19	28	11	12	70	67	39.4%
2000	2003	KT	Win	11	36	301	301															0		0.0%
2000	2006	KT	Sum	3	58	259	298															0		0.0%
2001	2002	KT	Aut	4,469	19	88	101														2	2	2	2.0%
2001	2002	KT	Aut	2,672	17	177	245											25	7	15	14	61	59	24.1%
2001	2003	KT	Spr	1,715	22	88	101														4	4	4	4.0%
2002	2003	KT	Aut	2,239	18	177	244														1	1	1	0.4%
2002	2003	KT	Spr	5,864	18	88	101												1	1	5	7	7	6.9%
2002	2003	KT	Win	6,132	19	170	258												5	1	1	7	7	2.7%
2003	2004	KT	Aut	19	19	75	75															0		0.0%
2003	2004	KT	Aut	324	21	307	307															0		0.0%
2003	2004	KT	Spr	8,501	19	144	151												168	56	77	301	297	196.7%
2003	2004	KT	Sum	519	22	144	144												16	7	3	26	25	17.4%
2003	2004	KT	Win	3,195	19	285	307													1	1	2	1	0.3%
2004	2005	KT	Spr	1,238	20	151	275													2	5	7	7	2.5%
2005	2006	KT	Aut	510	15	170	245															0		0.0%
2005	2006	KT	Spr	1,779	20	151	299														9	9	9	3.0%
2005	2006	KT	Sum	1	39	298	298															0		0.0%
2005	2006	KT	Win	200	15	170	170															0		0.0%
				53,581				1	1	26	42	54	185	140	186	442	329	270	497	265	297	2,735	2,270	4.2%

[1] Actual release groups may have been lumped or split to facilitate analysis. Only a portion of each annual release group is tagged.

[2] Average annual recapture rate based on release number and years where available for recapture.

[3] Number and percentage of individuals from a release group that are recaptured at least once.

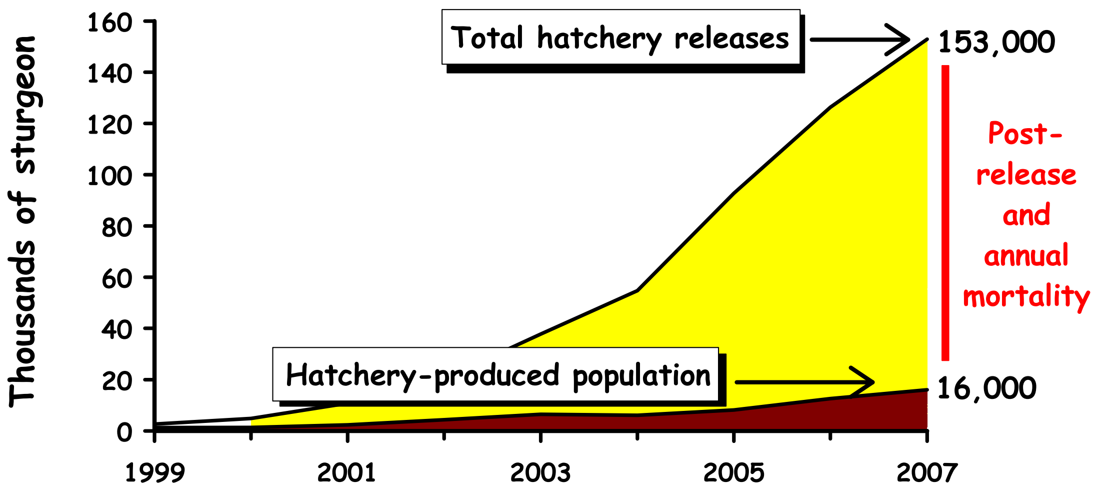


Figure 7. Estimated population of hatchery-reared sturgeon one year following release into the Kootenai River from 1999-2007.

Figure 8 illustrates the range of values that might be expected based on releases to date and future production targets. First year survival was relative high (60%) among initial hatchery releases but declined to an average of just 15% in recent years. Smaller average individual fish sizes in recent years are thought to account for at least some of the decline in survival. It remains to be seen if current plans to increase fish size at release will result in higher first year survival rates.

Figure 9 highlights the sensitivity of abundance projections to estimated survival rates due to the compounding effects over the long sturgeon lifespan. Just a ±1% change in annual survival amortized throughout the sturgeon life span can shift projected adult abundance by thousands of fish in either direction. These values are well within the range of error of current empirical estimates of stage-specific survival rates. The sensitivity of abundance to very small variation in survival rates results in low confidence in using release number target back-calculations to accurately predict (and meet) future abundance goals.

Density-dependent effects are possible from releasing large numbers of hatchery fish on natural or hatchery sturgeon populations in the wild. Results of the model sensitivity analysis (Figure 9) suggest that even small density effects could have significant implications for target release numbers. Detection of density-dependent effects is a key focus of the ongoing sturgeon monitoring program. Large, diverse, short-term hatchery releases provide the best prospects for the experimental detection of density dependent effects. Results will provide a quantitative, empirical basis for subsequent adaptive adjustments of future hatchery production targets.

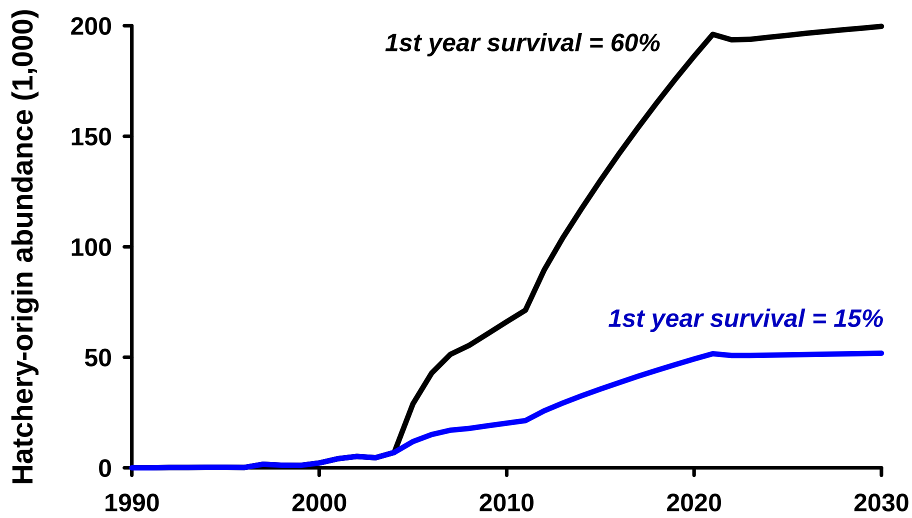


Figure 8. Projected numbers of hatchery-origin sturgeon in the wild based on early (60%) and recent (15%) first year survival rates.

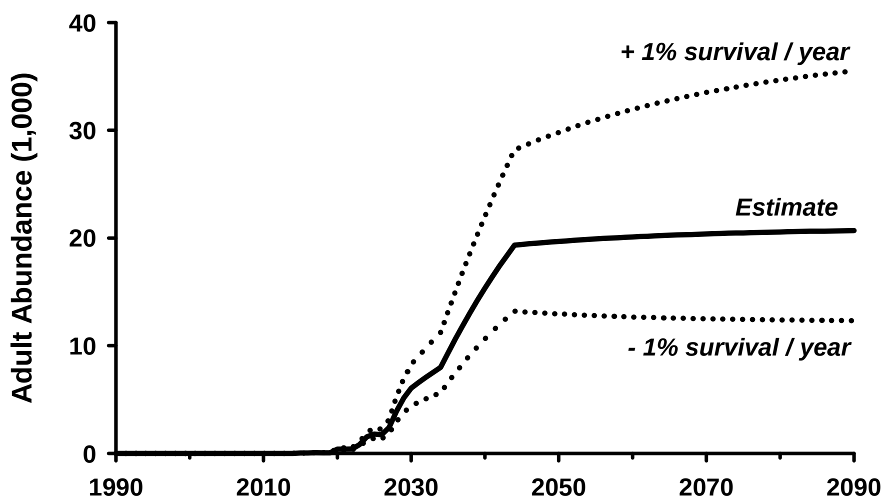


Figure 9. Sensitivity of projected adult abundance to small changes in annual survival rates (based on an actual releases and survival through 2007, annual releases of 40,000 per year from 2012-2021, starting with recent average survival estimates of 0.15 in the first year following release, 0.88 annually through age 3, and 0.96 thereafter).

ISRP Comment 3: *Design a production plan to achieve the biological objectives. Here, the ISRP looked for linkages between the numbers produced, the breeding design, and other biological outcomes with the facilities expansion and programmatic strategy. These were not sufficiently transparent in the current document*

Project Sponsor Response 3:

Facility and spatial requirements for conservation aquaculture programs are more extensive than for simple production programs. Conservation aquaculture is fundamentally about production quality rather than production numbers. Thus, facilities must be adequate to increase broodstock holding capacity, rear each family separately, avoid hatchery selection, and provide adequate fish health and facility infrastructure safety factors. Each of the biological objectives for the Tribe's Kootenai white sturgeon program is described below.

Increase Broodstock

To increase broodstock numbers, broodstock handling, holding, and spawning facilities will be expanded and temperature control systems added. The Tribal Sturgeon Hatchery near Bonners Ferry includes adult spawning and holding areas for broodstock purposes. Developing additional rearing capacity at Twin Rivers will allow conversion of some current rearing space and support systems in the Tribal Sturgeon Hatchery to satisfy the increased adult holding and spawning requirements. Heating and chilling controls will allow better management of maturation and spawning of wild sturgeon broodstock. Maturation cycles, gamete viability, and fertilization success has been hampered by unfavorable river temperatures or temperature fluctuations at the existing facility. Temperature regulation in the adult holding facility would also provide the opportunity to hold males at the hatchery and to bring them into spawning condition as females are ready.

Rear Families Separately

Separately rearing families requires many containers for each life stage (incubation jars, troughs, and circular tanks), which requires adequate hatchery floor space and systems to support each container. Separate family rearing is needed to ensure that offspring from each parent are adequately represented in short- and long-term arrays of release groups. If families are pooled, there currently is no way of knowing which fish comes from which parents. Different families often perform differently in the hatchery during spawning, incubation, and/or rearing stages. Survival and growth may vary substantially among different families, even when every effort is made to rear all families under similar or identical conditions. Growth, survival, and biological condition differences within and among families are likely due to inherent genetic and environmental variability. Separate rearing avoids inadvertent selection that can occur if the stronger-performing family is favored by rearing conditions or culling practices.

Avoid Hatchery Selection

To avoid hatchery-selective rearing, additional tank space and supporting systems are required. Because sturgeon are a benthically oriented species, the area of tank bottom available, not total water volume, dictates rearing space and tankage needs. Considerable variation in feeding and growth is apparent among hatchery sturgeon, even within a family group. While some individuals do better in a hatchery environment than others, these same traits did not categorically prove adapative when fish were released into the wild (Ireland et al. 2002b).

Thus, it is imperative that hatchery practices do not artificially select for fish that do well in the hatchery environment, for instance by grading fish to separate fast and slow growing individuals. Low rearing densities, selective size grading, and adequate containers are key program components to avoid size-related hatchery selection or survival. Experience has shown that individual variation is compounded by high rearing densities. The larger individuals in a cohort appear to outcompete or otherwise inhibit feeding of the smaller individuals, further exacerbating size dimorphism or polymorphism in ungraded rearing groups. When smaller individuals are moved to a separate rearing container containing similar-sized fish, they are able to catch up.

Fish Health Safety

Reducing rearing densities and using multiple facilities also reduces risks of catastrophic losses due to disease outbreaks or systems failures. Disease outbreaks are an ever-present risk in hatchery systems because fish densities and stress are elevated over natural conditions. Uncontrolled outbreaks can cause the loss of an entire brood year production or more likely selected families, both of which impairs our ability to effectively propagate the wild population's remaining genetic diversity. An increased incidence of disease among hatchery fish also poses a risk of pathogen transfer to fish in the river. Upgrades to the existing hatchery that improve handling of adult females brought into the hatchery will also reduce stress to those females.

Conservation Aquaculture Design

The proposed upgrades and newly developed hatchery facilities are designed to meet conservation aquaculture needs, as they are currently understood, and to provide adequate facilities to address future contingencies. The hallmark of the Kootenai sturgeon recovery effort has been its experimental adaptive approach to address substantial uncertainties. For instance, we do not know if and when natural recruitment will be restored, how long the aging wild population will remain reproductive, and whether hatchery-reared fish will ultimately be successful in the wild. We don't know if going back to a yearling release strategy will improve hatchery sturgeon survival from recent low rates, where future density-related limitations may reduce survival of older sturgeon, or to what extent future habitat productivity may be improved by a combination of nutrient enrichment and habitat restoration actions.

Therefore, current plans reflect our best attempt to implement an effective recovery strategy; however, experience has demonstrated that surprises and course adjustments will be inevitable. Research and monitoring efforts over the last 10-20 years have produced a number of surprises, each with significant implications for recovery. For instance, age validation studies showed that the wild fish are substantially older than previously thought, which led to reassessing the importance of non flow-related (pre-dam) habitat requirements and the nature, timing and causes of natural recruitment failure. Monitoring post-release survival of hatchery-reared fish identified a second critical life history bottleneck at the young-of-the-year stage that may constrain recovery efforts if habitat and carrying capacity issues are not addressed. More recently, expanded sampling efforts in Kootenay Lake demonstrated that the wild population is larger than previously estimated but that spawning frequency of many of these fish is relatively low.

The proposed upgraded and expanded hatchery facilities will provide the flexibility necessary to respond to new information and demands as they unfold. While it is difficult to translate the need for flexibility into a specific facility requirement, it is clear that improved facilities will provide an added margin of safety to mitigate future risks. The new facilities are also specifically designed to maximize operational flexibility. Without construction of the new Twin River facility, the flexibility of the Tribe's program is significantly constrained.

ISRP Comment 4: *Design production facilities to achieve the production plan.*

Project Sponsor Response 4:

The conservation production goal is to annually produce up to 40,000 age 1+ sturgeon for release (up to 1,000 fish per family for up to 40 families, including half-sibling families). Although production of 40 families is not expected to occur annually, facility designs intentionally provide adequate rearing capacity to meet this production target while providing optimal rearing densities.

A total of 70 tanks at both facilities will provide rearing capacity for up to 42,000 age 1+ sturgeon to meet annual production goals, based on a density of 750 fish per 10-foot-diameter tank (Table 7). Producing fewer than 40 families in a year, as dictated by broodstock limitation during a given year, will result in lower rearing densities. After 20 years of empirical sturgeon aquaculture, it is apparent that not only does annual variability in broodstock availability occur (and will occur more in the future until many hatchery-produced year-classes reach maturity), but considerable variability in family-specific survival of early life stages also occurs. This variability is thought to arise from a combination of genetic (heritable) and environmental conditions. Thus, the program's production capacity is designed to capitalize on the rare years in which large numbers of broodstock and high survival across all families occurs, while optimizing conditions during average production years (e.g., rearing density, reduced stress levels during rearing), which could involve considerably fewer fish.

Thus, proposed facility designs provide flexibility to safely meet production targets while maintaining adequately low densities that minimize stress-mediated complications and maximize growth, biological condition, and survival. Proposed designs at both facilities collectively meet conservation production plan goals, while providing an additional safety factor by reducing rearing densities from current operations. Reduced rearing densities reduce stress-mediated disease and competition. The proposed designs and operations will also provide the needed flexibility to grade and manage portions of families as needed to maximize growth, health, and condition.

Table 7. Production capacity for Age 1+ sturgeon at the upgraded Kootenai Hatchery and the proposed Twin Rivers Hatchery.

Tanks and Production		Annual Number of Fish	Annual Production Capacity by Facility	Total Annual Production Capacity
Twin Rivers				
15- 6 foot diameter	500 fish/tank x 15 tanks	7,500		
16- 10 foot diameter	750 fish/tank x 16 tanks	12,000		
Subtotal			19,500	
Tribal Sturgeon Hatchery[a]				
15-6 ft diameter	500 fish/tank x 15 tanks	7,500		
24-8 ft diameter	625 fish/tank x 24 tanks	15,000		
Subtotal			22,500	
Total Annual Production Capacity				42,000

[a] Production capacity includes the fail-safe program component at the Kootenay Sturgeon Hatchery in B.C.

ISRP Comment 5: *Has it been concluded that culture of age-1 sturgeon is the preferred future method of rebuilding the stock as opposed to release of age-0 fish in spite of the lower survival rate of the younger release? What are the plans, if any, for the age-0 releases? (Age-1 release plans are broadly and adequately outlined). Holding young for extended periods of time in the captive environment, while elevating short-term survival carries risks to future natural recruitment. The logic path for these risk/benefit trade-offs need a concise presentation.*

Project Sponsor Response 5:

Age 1 vs. Age 0 releases

Stocking age 1 and older fish is the preferred (and the only currently successful) method for rebuilding the population. This is based on extensive monitoring and evaluation of post-release survival of fish released at different ages and sizes during the past 20 years (Ireland et al. 2002b; KTOI 2004, 2008; Justice et al. 2009). Until 2004, fish were released primarily at age 1 or older in order to PIT-tag every hatchery fish so they could be distinguished from wild juveniles. Fish need to be about 30g for PIT-tagging. Beginning in 2005, fish were released at younger ages and smaller sizes in an attempt to increase production numbers while working within the current limitations of the Tribal hatchery facility. Survival of these smaller fish was much poorer than that of the larger, older fish (Justice et al. 2009).

There are obvious production trade-offs at the existing facility between releasing younger fish with reduced survival rates and releasing fewer larger fish that exhibit higher post-release survival rates. Net contributions to the natural population can still be greater with reduced survival as long as the larger release compensates for the decrease in survival. Unfortunately, that was not the case for the Kootenai sturgeon (Figure 10) and the program now has reverted to releasing larger fish. It remains to be seen whether the larger fish will survive at similar rates to the like-sized fish groups released before 2004, given increasing density of hatchery-reared juvenile sturgeon in the river. In addition, as the habitat restoration program is implemented, the magnitude of the habitat carrying capacity limitation may be reduced.

It might be argued that release of younger, smaller fish would reduce opportunities for selection in the hatchery or the development of domesticated behavior that is not adaptive in the wild. However, the Tribe's studies have concluded that the demographic risks of releasing fewer larger fish outweigh any presumed natural selectivity or behavioral benefits (Justice et al. 2009). We have observed that releases at a smaller average size actually compound hatchery selectivity risks by favoring survival of the larger fish in the release group. Instead, we are managing hatchery culling practices (currently required to limit total release numbers) irrespective of size.

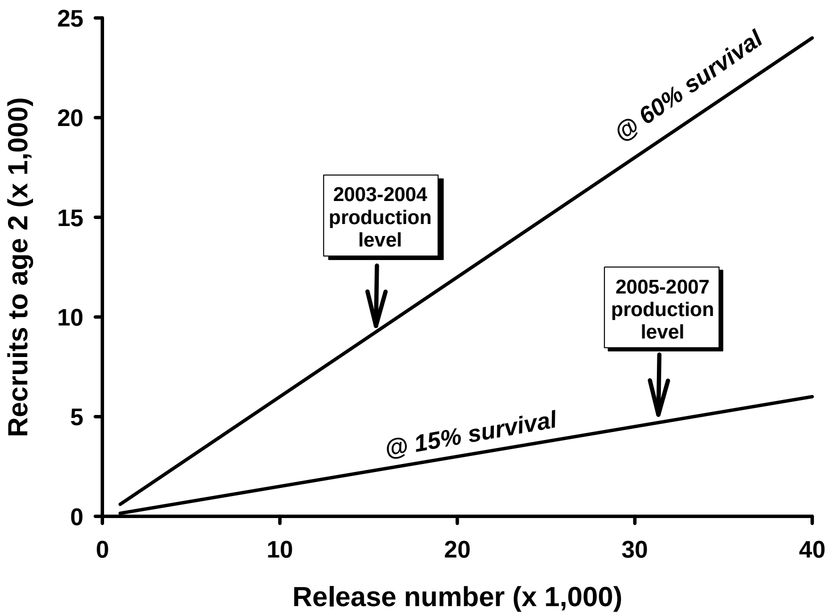


Figure 10. Tradeoff in recruitment between release number and survival.

Additional Age 0 release plans

We were also hopeful that release of embryos, free embryos, or larvae might prove to be an effective alternative to extended hatchery rearing because pallid sturgeon recovery efforts in the Missouri River system have documented some survival from larval releases. After monitoring post-release survival for several years, the survival rate of Kootenai sturgeon embryos, free embryos or larvae has been essentially zero (Rust et al. 2003; Rust and Wakkinen 2004). To date there is no evidence of survival from these free embryo releases, with the exception of a single 14-day post-hatch larva captured as part of a side-channel incubation and early rearing experiment [12] (pers. comm., Pete Rust, IDFG, December 2009).

Age 0 (free embryo) releases were recommended by the Recovery Team as a 5-year experiment (2008 through 2012) to assess: 1) post-release survival of free embryos produced at the Tribal Sturgeon Hatchery, and 2) suitability of receiving habitat for completion of age 0 life stages. These releases are identified as a Reasonable and Prudent Alternative (RPA) in the 2006 Biological Opinion and 2008 BiOp clarification for Libby Dam operations (USFWS 2006, 2008). Experimental in situ rearing has demonstrated the utility of this approach to evaluate habitat suitability. We have documented 14-day survival of free embryos over gravel/cobble, which supports the program objectives of encouraging upstream sturgeon migration to these habitats. Utility of age-0 releases for evaluating in-river habitat suitability is highlighted by the report at (http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=15882).

Risk/benefit trade-offs and logic

This ISRP comment reflects a common concern from salmonid hatchery programs that holding young fish for extended periods in the captive environment elevates short-term survival but carries some risk to future natural recruitment. Discussion of such risks in high-density conditions in salmon hatcheries often involves issues of domestication selection resulting in behavior modification that renders post-release juveniles more vulnerable to predation and less fit for survival (Ryman and Lairke. 1991). While some quantification of this concept has been published for salmon hatchery programs, investigation of this potential risk is not represented in the literature for sturgeons. Unlike broodstock populations in many salmon hatchery programs that have had decades of hatchery influence in their lineages, the Kootenai sturgeon release groups are the progeny of a wild broodstock population whose lineages have not yet been affected by any hatchery program operations.

We suggest that given the current status of Kootenai sturgeon, hatchery program benefits and risks should be weighed against the risks of not operating a hatchery program. With the Kootenai sturgeon population exhibiting consistent recruitment failure since the 1950s-1960s (Paragamian et al. 2005), repeated recruitment failure from age 0 and younger life stage releases, and the complete failure of modified Libby Dam operations to increase or restore natural recruitment during the past two decades, the paramount risk to the population is extinction. This extinction risk is real, not theoretical, and it lies at the core of the sturgeon hatchery program. When the putative risk to future natural recruitment from rearing juveniles in the hatchery to age 1 is balanced against the lack of meaningful natural production for over 40 years, despite nearly 20 years of altered dam operations, the choice is clear: reliably produce year classes to prevent extinction and retain as much native genetic material as possible to rebuild this native population.

---

[12] The Tribe's habitat restoration program includes measures to reconnect Kootenai River side channels and may create additional side channel habitat by redirecting flow into the primary channel.

ISRP Comment 6: *If both age-0 and age-1 releases are to be continued, how will those dual programs be managed and prioritized? That is, what is the proposed release schedule of age-1 versus age-0 fish? What are the ecological rationales for the proposed approach?*

Project Sponsor Response 6:

Age 1 and age 0 (free embryo) releases are concurrently managed for different but complementary purposes. Annual age 1 releases follow a decade of adaptively optimizing release scenarios to maximize survival and genetic diversity. Age 1 fish are released to build the population, whereas age 0 (embryo and free embryo) releases are small and experimental to evaluate incubation and early rearing habitat suitability as an RPA of the Libby Dam Biological Opinions.

Therefore, age 1 releases are expected to continue (at most annually) and are considered the highest priority until repeatable, adequate natural production is restored, whereas experimental age-0 (free embryo) releases are scheduled to end after 2012. To date, the age 0 releases have provided little value but remain a mandated part of recovery activities under the Libby Dam operations BiOp. More information is typically provided by controlled replicated studies of early life stage requirements, with results subsequently applied to the field conditions and in-river habitats (e.g., Kynard and Parker 2006a, 2006b; Kynard et al. 2007).

ISRP Comment 7: *How many age-1 sturgeon of a defined, post vulnerability size can be effectively reared in the existing hatchery facility (a) in its present form, (b) with proposed upgrades of the existing hatchery, and (c) with the new hatchery?*

Project Sponsor Response 7:

The Tribal Sturgeon Hatchery can effectively rear up to about 9-10,000 age 1+ fish under current family number and family size protocols, with additional production of up to 5 additional half-sibling families (1,500 fish per family) in the Kootenay Sturgeon Hatchery in B.C. With upgrades, about 22,500 age 1+ fish could be raised for release at the Tribal Sturgeon Hatchery. With proposed upgrades and construction of the new Twin Rivers Hatchery, up to 40,000 age 1+ fish could be released annually, including fish from up to 5 separately reared families at the Kootenay Sturgeon Hatchery in B.C.

ISRP Comment 8: *Assuming survival rates of 60% in year 1 and 90% thereafter, how does (a) the current stocking capability with hatchery in its present form, (b) the current hatchery with proposed upgrades, and (c) the new hatchery (which can result in up to 1,500 fish per family for up to 40 families annually) translate into future numbers of 5, 10, 15, 20, 25, 30, 34, and 40 year old sturgeon? What do the numbers of adult sturgeon become when survival rates are raised to 70% (year 1) and 95% (thereafter) and lowered to 50% and 80%? The evaluation of a 95% survival seems appropriate because of recent information by Beamesderfer et al (2009) that annual mortality rates of (admittedly larger) wild fish appear to be about 4%. This is lower than the 10% originally reported by Paragamian et al.*

(2005). The point is, the larger sturgeon seem to have very high survival rates. If hatchery fish do nearly as well, there would need to be fewer stocked than would have been projected prior to 2009.

Project Sponsor Response 8:

Population projections like those suggested by the ISRP are illustrated in Figure 9. These projections suggest that planned release levels will produce a large adult sturgeon population if current survival estimates are accurate and sustained, and if hatchery production levels can be sustained for an extended period. Population projections also indicate that current release levels will result in a sizable juvenile and subadult population, raising concerns for density-dependent reductions in survival or growth at some point in the future.

The current program acknowledges these concerns but is focused on the near-term need to capture remaining genetic diversity and propagate this diversity into the next generation. The abundance of adult hatchery-reared fish and population size in 5 to 40 years are long-term concerns that must be anticipated by the program. While the pursuit of short-term and long-term goals need not be mutually exclusive, the failure to meet short-term genetic and demographic goals will all but guarantee population failure in future generations.

Figure 9 also illustrates the effect of even very small differences in survival rates due to the compounding effects of these differences over time. Given the very high level of sensitivity in future projections to survival rate variation, we have concluded that while projections of this nature are illustrative and generally useful, they should not be the primary driver for current sturgeon program production. We expect that large process variation and uncertainty related to future broodstock availability, post-release survival trends, habitat capacity limitations, and the potential for density-dependent feedback will produce very substantial departures between projected and actual future trends.

With Kootenai sturgeon, we are presented with the rare opportunity to manage fish recovery in a truly adaptive fashion involving large scale implementation of actions to test the limits of the system and to monitor the response(s). This approach has already proven successful in identifying critical new information during the past 20 years of the program. Monitoring post-release survival of hatchery-reared fish has provided some evidence of density-related survival limitations of age 0 sturgeon. This limitation might be expected to affect naturally-produced juveniles even if no hatchery fish were present. Hence, the experimental adaptative approach has identified a critical second bottleneck (in addition to the spawning habitat limitations). It remains to be determined at what point density limitations will affect older, larger sturgeon, and to what degree growth and condition might be improved as a result of ongoing nutrient addition in the Kootenai River. Implementation of the habitat restoration program will also provide additional vital information about habitat capacity – as well as enhancing and increasing the availability of suitable habitat.

Meanwhile, the fish that have already been released provide a contingency against future uncertainties in natural production and broodstock availability. We can speculate on future broodstock availability and program sustainability but there are no guarantees. Fish in the water now are fish in the future sturgeon population bank.

ISRP Comment 9: *A few scenarios would better enable reviewers to evaluate the critical issue, namely, the importance and need of the proposed second hatchery.*

Project Sponsor Response 9:

The need for additional facilities in order to increase the number of wild broodstock propagated into the next generation is illustrated in Figure 4. This analysis shows that adding the proposed facilities would increase broodstock projections from 746 to 986, which is very close to the optimal target of >1,000 spawners.

The effects of additional facilities on future numbers of hatchery-origin juveniles and adults are shown in Figure 11. These projections assume that additional facilities would increase juvenile production from the current capacity of about 18,000 to about 40,000 age 1 sturgeon per year for a 10-year period before reverting back to an 18,000 fish-per-year production level. Example analyses assumed that broodstock would continue to be available for an indefinite period to support a base production level of 18,000 fish per year, that broodstock would begin to constrain production within 10-20 years, and that broodstock would become unavailable thereafter.

Example analyses also present a range of survival uncertainty, one scenario assuming a 60% first year post-release survival (as observed in early program years) and another scenario assuming a 15% survival rate (as seen in recent experimetnal releases of small fish) (Justice et al. 2009). Recent survival estimates were much less than rates observed during the early years of the program, but reductions were also associated with a smaller average size at release. Size at release has since been increased, but juvenile densities in the wild are substantially greater than during earlier years when larger fish were also released. Thus, it remains to be seen whether returning to a larger size at release will increase survival to 60% or if increased juvenile densities will begin to affect the larger fish as well.

Example analyses again highlight the sensitivity of future population projections to a variety of assumptions, including survival and broodstock availability. Future juvenile and adult abundance estimates were much greater under a 60% survival than a 15% survival. This assumes no other survival differences for other ages. Long-term trends obviously depend on broodstock availability. Adult peaks and declines are delayed, reflecting their older age, and are protracted, reflecting the broad age distribution of adults. Increased production associated with facility expansion substantially increases the number of juveniles and adults over an interim period. These analyses also highlight the consequences of near-term actions when considering long-lived species like sturgeon.

A significant limitation of these types of projections is that they assume average growth, survival and maturation for all individuals. We know that individual sturgeon exhibit tremendous variability, even among siblings. This variability is expected to substantially change population patterns relative to those illustrated by the simple examples presented in Figure 11. We are currently adapting an individual-based sturgeon population model to better represent these dynamics.

Future population projections do not consider the importance of other experimental uses of the proposed facilities. For instance, relocating incubation and rearing facilities nearer habitat that appears to be favorable for natural spawning and incubation is hoped to stimulate these fish to return to more suitable upstream habitat when they mature. Many sturgeon species around the world and in North America display specific homing fidelity to natal areas of native rivers. The significance of this effect for Kootenai white sturgeon is currently unknown. The Twin Rivers Hatchery will provide a means of experimentally testing this hypothesis over the long term.

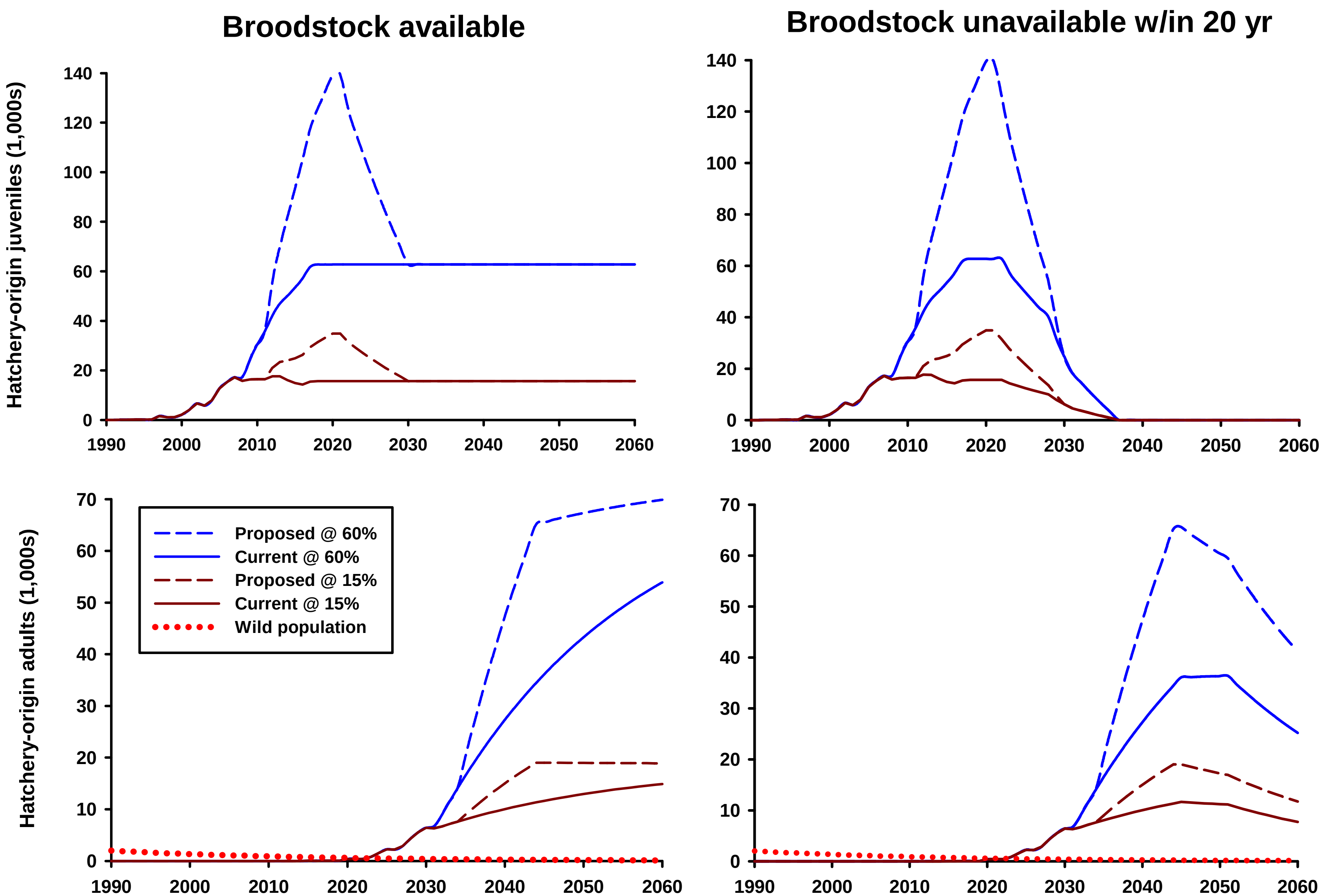


Figure 11. Projected numbers of hatchery-origin juveniles (ages 1-10) and adults (ages 25+) under various assumptions including post-release first year survival (15% or 60%) and the long-term availability of wild broodstock (indefinite or 20 years only).

ISRP Comment 10: *In addition to examining the effect of different deterministic scenarios as mentioned above, an investigation of the predictions of stochastic modeling on estimated future numbers when variability in yearly survival, mortality, wild spawning, hatchery spawning, and hatchery stocking are needed. Included should be an evaluation of the probability of extinction under various stochastic scenarios. The questions to be answered are: What is the likely range in the numbers in various age groups and what is the probability of extinction under the range of conditions likely to be encountered?*

Project Sponsor Response 10:

Stochastic analysis suggested by the ISRP is a commonly used approach in conservation biology to evaluate the chances that a population might "bottom out" due to combined effects of reduced productivity and normal environmental variation. These Population Viability Analyses, or PVAs, have been widely applied to salmon (Beamesderfer 2010) but are used less frequently for sturgeon. The Canadian Recovery Strategy for white sturgeon, listed under the Species at Risk Act (SARA), identified recovery targets based on a population viability framework that considered abundance, productivity, spatial structure and diversity (NRTWS 2009). Abundance targets were established based in part on results of PVAs reported in the conservation biology literature for other species; no PVAs specific to sturgeon were included because information was insufficient on Canadian white sturgeon populations. Jager (2001, 2005, 2006a, 2006b) used an individual-based stochastic population model to explore the effects of river fragmentation and individual variation on risks for sturgeon. Paragamian and Hansen (2008) also used a PVA approach to evaluate the effects of episodic natural recruitment on sturgeon demographics. However, this approach offers limited utility when applied to Kootenai River sturgeon, for which annual natural recruitment at the population level (to maturity) has been zero since the late 1950s to early 1960s (Paragamian et al. 2005).

We expect that a stochastic population analysis would highlight the point that it is not necessary to produce fish every year in order to forestall extinction if demographic extinction is the primary metric. The particulars of what risk level is associated with what level of production and variability would depend on parameterization of the simulation. Since we currently have no significant natural recruitment and variability is essentially zero, the purpose of this analysis would be largely to illustrate the concept rather than to provide any specific guidance.

Conventional PVAs of the effects of environmental variability on population cycles are not particularly informative for Kootenai sturgeon where the problem is not variable recruitment but no recruitment. Long-term trends in sturgeon populations with large overlap in the age structure of successive generations are essentially driven by long-term trends and averages in recruitment and mortality rather than annual patterns of variability. Where annual patterns cause large and risky fluctuations in abundance of impaired salmon populations, sturgeon populations are very well buffered from the effects of short-term variability. This is the cornerstone of the successful sturgeon life history strategy; however, the cost of this life history strategy is that populations that take a long time to go extinct also take a long time to recover.

Extinction probabilities in stochastic risk models are typically a function of variability (stochasticity) and generation times. High extinction probabilities are associated with high variability, shorter generation times, and low overlap in cohorts. Meaningful calculations of risk typically require simulations over multiple generations. In salmon for instance, many PVAs are currently based on 100-year simulations that include 20 or more salmon generations. A comparable time calculation for sturgeon would be 500 years at a 25-year generation time. However, simulations must also represent conditions throughout the period of interest and it would be difficult to argue that we can realistically parameterize conditions for the next five centuries, as this approach would suggest.

Rather than employing a stochastic PVA approach like that suggested by the ISRP, we identified production targets for this program based on a series of deterministic model projections focused on time-specific risks. Risks are compartmentalized into specific periods, which is an effective alternative to the problem of unstable population patterns addressed by the PVA. This approach includes sensitivity analyses of the effects of alternative assumptions that reflect the uncertainty in population parameter estimates.

We are in the process of adapting a stochastic individual-based model for Kootenai sturgeon; however, model analyses will be focused on the effects of individual variability on population dynamics and risk. In particular, we anticipate using this approach to evaluate effects of various hatchery production and mating alternatives on genetic and demographic population structure.

ISRP Comment 11: *How do the proposed stocking rates under the scenarios and their resulting adult fish compare to (a) historical estimated numbers of fish and (b) current carrying capacity of the river system for the fish? That is, given the lowered productivity of the Kootenai River and limited prospects for major improvement in this area, can the river support the high numbers of sturgeon proposed to be stocked?*

Project Sponsor Response 11:

As described previously, proposed stocking rates would initially appear to be greater than needed to produce historical numbers of fish. The value of such projections is compromised by uncertainty in future production and survival. The current carrying capacity is unknown and the only real means of determining capacity is to monitor density and post-release fish responses at the individual, cohort and population levels. The ultimate number of sturgeon that can be supported may vary over time and will be determined by the monitoring program. The risks of this approach appear to be substantially less in the near term than the risks of failure to propagate existing diversity into the next generation from which all others will be founded. Ultimately, sturgeon carrying capacity will vary by life stage and will vary over time, as the various aspects of the biological community (e.g., abundance, biomass, and density) respond to current and future habitat conditions, nutrient availability, and seasonal and inter-annual environmental variability. Effects of proposed future habitat restoration actions and ongoing nutrient addition may increase future carrying capacity.

ISRP Comment 12: *In addition, more thought should be provided on the desirability of "stocking and stacking" one-year class after another on top of each other in this comparatively unproductive environment. Justice et al. (2009) identifies the possibility that competition may be a factor affecting age-0 survival. It could also affect survival of older fish, but its main effects might be on growth and perhaps size and age at maturation. Studies on sturgeons in natural settings suggest that there may be wide differences in year class strength, and that for a variety of reasons, it may not be optimal to have every year class be "strong" and of the same approximate size. Has this been considered?*

Project Sponsor Response 12:

Over the 20-year history of the program, considerable thought has been devoted to the topic of stocking levels versus habitat capacity. Habitat capacity is a critical unknown. Justice et al. (2009) reported reduced post-release survival rates of younger life stages (age 0), and identified evidence for density dependent reductions in survival. However, no indication of density dependent growth or survival is yet apparent among older fish.

Current production levels are part of a purposeful strategy to experimentally identify habitat capacity based on monitoring the population response to increasing sturgeon numbers or densities. After extensive consideration of various alternatives for inferring capacity, we concluded that an experimental approach is the only effective approach. Consequently, the recovery program incorporates an intensive hatchery marking and annual monitoring program. Rather than speculating on where capacity lies and artificially limiting production based on assumptions, the experimental approach will provide a real answer with no significant downside risk (see Response 13). Post-release fish growth, condition, and survival are being monitored in the wild in relation to population size and density. Habitat capacity will be identified by a detectable response. Future juvenile, subadult, and adult population levels will be managed adaptively based on continuing monitoring and evaluation.

In weighing tradeoffs among risks and benefits, it is useful to consider the down-side risks if we are wrong.

- The greatest risks associated with large stocking rates probably revolve around density-related decreases in survival or growth. Survival feedback would be at least partially self-correcting, as is the case with naturally produced populations. Reduced survival would offset the large initial stocking rates; however, depressed survival could be a problem if it affects different brood years so as to reduce representation of family groups in the next generation[13]. Regardless, this risk will continue to be monitored.

- In the extreme case, reduced growth might also delay maturation of adults in the next generation and extend the interval between the demise of the wild fish and the maturation of the hatchery-reared generation. Because sturgeon growth varies widely among individuals, releasing many diverse individuals may offset this risk by increasing the number of fast-growing fish. Growth and maturation will also be monitored.

[13] Equal representation among families at maturity should not be assumed relative to genetic and environmental variability, even in wild populations.

- Another concern might be the limitation or swamping of natural production by large numbers of hatchery fish. Prospects for natural production remain uncertain following over 40 years of extreme limitation or failure. Small levels of sporadic natural recruitment seen in the data will not be adequate to sustain a population after nearly 50 years of recruitment failure. By marking hatchery fish and continuing the monitoring program, we will be able to detect significant natural recruitment if it occurs and the necessary accomodations can be made.

The central issue here is one of balancing the risks of losing genetic diversity versus risks of negative density-dependent responses in the population and the ecological community. We have concluded that the long-term downside risks of releasing too few fish signficantly outweigh those of releasing too many. Failure to conserve remnant locally adapted genetic material from this endangered population would be irreversible. Density-dependent circumstances are reversible and would eventually be self-regulating, albeit at some level of ecological cost. Furthermore, if it turns out that too many fish have been released, years of empirical recapture data confirm that some could be removed.

The ISRP also noted that studies on sturgeons in natural settings suggest that there may be big differences in year class strength, and that for a variety of reasons, it may not be optimal to have every year class be “strong” and of the same approximate size. In fact, the reproductive and life history strategies of sturgeons can provide for long-term population sustainability in the face of missing year classes or even periods of missing year classes. However, in a case of extreme protracted recruitment failure, as in the Kootenai River, more than 50 years of failed recruitment has created a very large hole in the current population structure. Failing to incorporate as much of the remaining genetic and life history diversity would be inconsistent with the stated goals and inherent approach of the Tribe’s program. The current production strategy is to support significant annual production to compensate for this unnatural, extended period of recruitment failure.

ISRP Comment 13: *How do projections of expected habitat restoration alter estimates of carrying capacity?*

Project Sponsor Response 13:

Current plans include a combination of flow, physical habitat restoration, and nutrient enrichment actions. These actions could have significant effects on habitat conditions and capacity for sturgeon, as well as the entire ecosystem. Actions are experimental and effects are uncertain. Improvements may or may not be signficant but will be monitored. Future recovery efforts, including the conservation aquaculture program, will be adapted accordingly.

Analysis is ongoing to assess effects of nutrient addition on condition, growth, and survival of post-release juvenile sturgeon before and after the onset nutrient addition. The Kootenai River has now undergone five years of experimental nutrient addition in a reach at the Idaho-Montana border. A significant response has been confirmed by analysis of pre- and post-fertilization nutrient availability, algae abundance, chlorophyll accrual rates, invertebrate biomass, diversity, and richness, and recruitment and size of juvenile mountain whitefish (Holderman et al 2009a, Holderman et al. 2009b; Ericksen et al. 2009; Holderman et al. in preparation; Hoyle et al., in preparation, Shafii et al. 2010).

Nutrient enhancement in Kootenay Lake has also stimulated a biological response that has been successfully managed since the early 1990s. Most noteably, kokanee abundance and escapement has increased from a low in the hundreds of thousands to recent escapment estimates of millions and abundance estimates in the tens of millions. Kokanee will be an important part of the food web for the sturgeon population and in addtion, will provide a general indicator of improving ecosystem health.

The Tribe's Kootenai River Habitat Restoration Project is moving forward, with implementation proposed in three phases generally working from upstream (braided reaches) to downstream (meander reaches). Implementation of the first phase is slated to begin in late 2011 or 2012. The restoration project is part of RPA Component 2 in the Libby Dam BiOp. Habitat restoration work will be implemented over the course of approximately 10 to 15 years:

- Phase 1 actions will take place in the upper portions of the braided reaches and will address significant bank erosion in that is contributing to sediment loading and degradation of habitat downstream. Improving bank structures will also provide benefits to the aquatic habitat by increasing or providing overhanging bank cover, shade and channel margin complexity. Phase 1 actions will also include a substrate enhancement project in the existing spawning area in the meander reaches intended to provide immediate benefits to the wild Kootenai River white sturgeon population (i.e., improve egg attachment and hiding/cover for early life stages) while the more extensive ecosystem restoration activities are being designed and implemented downstream during phase 2 of the project.

- Phase 2 actions will occur in the braided reaches and staight reach and will focus on creating more normative river conditions, including desirable depth and velocity attributes, by establishing channel dimensions that are sustainable given the morphological setting and governing flow and sediment regimes; gradually reducing sediment supply and transport competence in a downstream direction; promoting deposition of sediment on the floodplain; constructing a new floodplain that is connected to the channel during average annual peak flows; and revegetating the floodplain to foster a complex, multi-structured native plant community with a mosaic of age classes and hydrologic regimes.

- Phase 3 actions will occur in the meander reaches where the restoration strategy is based on improving interaction between the river and floodplain. Actions in the meander reaches will focus on areas inside the levees adjacent to the river and areas outside the levees that are known to be much lower in elevation and closer to the range of post-levee and post-dam river stage elevations. Working closely with landowners and diking districts, the Tribe will explore opportunities to restore wetlands and riparian plant communities in some of these low floodplain areas. Oher potential actions include possibly connecting some low lying areas to create off-channel habitat, removing fish passage barriers in tributaries, and restoring aquatic and riparian habitat along tributary streams. Due to the large percentage of private land ownership on the meander reach floodplain, site-specific rather than reach-scale opportunities to improve aquatic habitat will be implemented in cooperation with willing landowners as specific opportunities are identified and prioritized.

Biological responses to the collective measures associated with the Tribe's different habitat restoration and nutrient projects is a key component of the program-wide adaptive management approach currently under development. The extent to which sturgeon may benefit from these actions is unknown, but it is likely that improved ecosystem function, habitat complexity, and productivity could be beneficial.

ISRP Comment 14: *Please expand (from brief description in Chapter 6.5) on the alternatives for program termination if the production program is successful or fails.*

Project Sponsor Response 14:

Program termination or large substantive changes in program objectives and activities will be driven by monitoring and evaluation of the system responses. Termination can be triggered by either success or failure. Programs will be terminated when and if:

- Productive naturally self-sustaining populations of white sturgeon and burbot are restored in the Kootenai system (e.g., recovery criteria identified in Box 1 for sturgeon are met).
- Conservation aquaculture activities significantly interfere with or otherwise preclude restoration of productive naturally self-sustaining populations of white sturgeon and burbot in the Kootenai system.
- Conservation and restoration objectives (as in Box 2 for sturgeon) cannot be substantively achieved and programs cannot be reasonably adapted to achieve objectives.
- Benefits prove to be marginal and adaptations prove cost-prohibitive relative to program objectives.

Currently (2010), it is difficult to foresee which specific factors, conditions or metrics might trigger a fundamental reconsideration of the conservation aquaculture programs for sturgeon or burbot. It is expected that program objectives and activities will continue to be refined throughout their duration based on evolving conditions and new information.

Key decision points for the sturgeon program might be triggered by the restoration, frequency, and magnitude of natural recruitment, changes in spawning distribution following habitat restoration activities, identification of effective alternatives such as larval releases, unavailable or senile broodstock, strong density-dependent habitat limitations, or delayed maturation of hatchery-origin fish. Key decision points for the burbot program might be triggered by the success of production-scale rearing in the facility, significant survival of propagated juveniles upon release, and subsequent maturation and spawning success in the wild.

The Kootenai sturgeon conservation aquaculture program will include checkpoints and evaluations at periodic, scheduled intervals as part of the adaptive management and implementation plans that are overseen by the Kootenai Tribe, as well as the Kootenai White Sturgeon Recovery Team led by the

USFWS. The burbot conservation program will also include similar review and evaluation processed by the Kootenai Valley Restoration Initiative (KVRI) Burbot Committee.

ISRP Comment 15: *A recent re-evaluation of the population status of the wild sturgeon (Beamesderfer et al. 2009) indicates that the adult population size is larger than previously thought, and that mortality rates after age-1 are lower than previously thought. A key reason for the discrepancy was the selective mark and recapture of fish in the river compared to the lake. Mark-recapture assumptions were violated, resulting in an underestimate of stock size. The implications of this re-evaluation, as indicated in the paper, are that the wild component stock will persist a few decades longer into the future than previously assumed. Although this paper is referenced in the Literature Cited section of the Master Plan, Volume 1, its results do not seem to enter into the rationale. For example, under the population status section (Page 3-10 et. seq), no mention is made of this report or of its potential implications for sturgeon recovery and any changes in the rebuilding timeframe that may be called for. It also did not appear in the presentation at Astoria: the figure used was the older data of Paragamian et al. (2005), which suggested that the situation for wild fish was considerably more dire than projected in Beamesderfer et al. (2009). Do the results of Beamesderfer et al. (2009) affect the urgency of a rapid rebuilding effort? Does this revised population status make it less critical for an immediate second hatchery than if the demise of the wild component was more imminent? Can current stocking be spread out over more years to achieve the desired rebuilding status while seeking ways to improve wild reproduction? Under the situation outlined in Beamesderfer et al. (2009), would spreading out the stocking make more sense?*

Project Sponsor Response 15:

We apologize for any confusion resulting from the fact that the data published in Beamesderfer et. al (2009) was not fully incorporated into the draft Master Plan. That data became available to us in draft form in late June 2009, after we had completed our detailed internal reviews of the draft Master Plan. Rather than revising large sections of the document, we added the 2009 data only to the most relevant sections. The 2010 Revised Master Plan submitted with these responses incorporates the more current data throughout.

Although recent status assessments indicated that current population numbers are greater than previously estimated, the endangered population condition remains essentially unchanged: meaningful natural recruitment has not occurred for 40-50 years. Remnant numbers of wild adults continue to decline every year. The remaining fish are very old and we do not know how long they will remain reproductive. At some point, too few wild fish will be available to sustain the hatchery program or to take advantage of improved natural conditions if they occur. Without an effective conservation aquaculture program, the population will go extinct.

The good news is that there are more fish than previously estimated and the rate of decline is less than previously estimated (Beamesderfer et al. 2009). This could explain why the Tribe's aquaculture program has not yet encountered difficulty in collecting broodstock. The finding also suggests that prospects for broodstock availability are good for the foreseeable future. If hatchery-reared fish from past releases mature in a timely fashion, we might avoid an extended gap in adult numbers between the demise of the wild fish and the availability of hatchery-origin adults.

One explanation is that observations suggest a significant population segment in Kootenay Lake appear to enter the river spawning population at a lower frequency than fish that occupy the river upstream. These fish appear to be of reproductive sizes and ages but we don't know if they represent late maturing fish that will be available in future years, fish with greater spawning periodicity (more years between successive spawning events), or a post-reproductive component of the aging population. Although new population abundance estimates are a more accurate assessment of total population size, they might overestimate the actual spawning population (e.g., N_e vs. N).

We do not believe that the updated information reduces the urgency of the population rebuilding effort, that it suggests releases should be more spread out, or that the need for additional hatchery capacity is any less critical. Concern over current stocking densities remains largely hypothetical. We have indications of limitations in the yearling life stage but none among older fish. When habitat capacity limitations are experimentally identified, adjustments to stocking rates will be made. Meanwhile, we are faced with the critical need to capture and propagate existing genetic material. That is the primary risk driving current production levels. In order to propagate significant numbers of families, we need to make relatively large releases. Reducing family sizes to reduce population densities has its own set of problems due to increased risk of inadvertant hatchery selection due to family size culling. Given the aforementioned risks and benfits, it is recommended to release larger family sizes and allow natural selection to regulate subsequent survival than to attempt to make artificially random selections in the hatchery, even if natural selection is driven by density-related survival factors.

Our hatchery strategy is based on the calculated balance of current opportunity versus potential future risks given the backdrop of uncertainty about the future. Dwindling numbers of remnant broodstock are available now. Increasing broodstock numbers makes good sense from a genetic perspective. Current capability to capture broodstock is facility limited. We have not yet reached the capacity of the habitat. The precautionary biological arguments support taking advantage of the current situation rather than predicating actions based on future assumptions that may not be proven.

Proposed hatchery facilties ultimately represent an investment in reducing risk. Given the irrreversible consequences of failure, the Tribe concludes that the benefits of precautionary investments warrant the costs. Having operated the Tribal Sturgeon Hatchery for years on very modest budgets, we recognize that costs versus benefits must always be considered. Expanding hatchery capacity clearly involves a significant cost. In 30 years, we could very well look back and conclude that this precautionary measure was ultimately not necessary. At the same time, we would hate to look back in 30 years and conclude that the our failure to take aggressive action when we had the opportunity had detrimental long-term consequences. It would be particularly difficult to rationalize failure if the decision was based solely on cost rather than biological considerations.

ISRP Comment 16: *A significant influence on whether this program will work depends on the actions and approaches occurring/proposed in British Columbia. Much of the watershed, headwater, and compounding impacts are located north of the border. While the Master Plan outlines a number of cooperative actions north of the border (i.e., redundant rearing), a more thorough discussion of out-of-subbasin actions on program success would improve the plan.*

Project Sponsor Response 16:

Kootenai River white sturgeon are listed as endangered in Canada under the federal Species at Risk Act. White sturgeon migrate frequently across the border into the Kootenay River and Kootenay Lake, where critical habitats also occur. The Tribe is leading the development of fish culture and habitat restoration projects and it contracts with the BC Ministry of Environment to provide white sturgeon capture and stock assessment services on Kootenay Lake and associated waters in Canada to assist in the restoration process. This relationship has been successfully ongoing for over 15 years. Data and databases are successfully shared, and personnel from the Ministry, Kootenai Tribe, and IDFG freely communicate and work together in the field to ensure total coverage and cooperation concerning all aspects of Kootenai sturgeon research, monitoring, and evaluation.

Under contract with the Tribe, the Ministry is responsible for monitoring movements, habitat use, growth and survival of the Tribal hatchery progeny and wild progeny and adults in Canada. Additional cooperative components include telemetry projects to monitor adults and juveniles, tagging subjects in Canada for telemetry projects completed in Idaho, larval sampling, and other monitoring related to white sturgeon conservation aquaculture and recovery.

The ISRP comment about out-of-subbasin influences appears to misunderstand subbasin geography and the distribution of the Kootenai sturgeon population. The Kootenai River white sturgeon population is completely contained within the geographically isolated Kootenai Subbasin. Because of this physical isolation, no out-of-subbasin cooperative actions affect the success of any aspect of the Tribe's aquaculture program for sturgeon and burbot. Cooperative flow management practices within the subbasin do however, affect water levels downstream in the Columbia River. For example, flood control agreements and required releases to supplement Columbia River fishery flows periodically influence conditions in the Kootenai/y River.

ISRP Comment 17: *The Monitoring and Evaluation component of the Master Plan needs to reflect the changes recommended above. For example, measuring post-release survival with marked fish has different design criteria than determining whether these releases ultimately led to or will lead to natural recruitment.*

Project Sponsor Response 17:

Kootenai sturgeon recovery efforts are subject to a comprehensive monitoring program designed to evaluate population status in the wild and the effectiveness of recovery actions including aquaculture, flow and habitat measures. Field monitoring components of this program are cooperatively implemented by the Kootenai Tribe, IDFG, and the British Columbia Ministry of the Environment. The Master Plan describes monitoring and evaluation elements specific to implementation of the conservation aquaculture program. Monitoring and evaluation of the broader program context is addressed by elements described in the USFWS Recovery Plan, the current recovery implementation plan and schedule (KTOI 2005), and other project-specific plans including the Habitat Master Plan (KTOI 2009). The Tribe's white sturgeon recovery implementation plan (KTOI 2005) describes the general sturgeon population and habitat monitoring strategies, measures, and tasks (see Box 3).

Box 3. Sturgeon recovery and ecosystem monitoring strategy, measures and tasks (KTOI 2005).

3A. Natural Spawning Assessments

Measure 3A.1. Conduct annual assessments of sturgeon spawning activities to index spawning activity, identify spawning periods, and cue sturgeon flow requests.

Task 3A.1.1. Implement standardized substrate mat sampling at index sites in known spawning areas.

Task 3A.1.2. Implement standardized D-ring net larval sampling at index sites downstream from known spawning areas.

3B. Wild Adult Assessments

Measure 3B.1. Conduct annual adult sturgeon assessments to estimate population status and obtain spawners for the hatchery program.

Task 3B.1.1. Capture adults during spring and early summer in areas of concentration downstream from Bonners Ferry using setlines, gillnets, and angling.

Task 3B.1.2. Biological and mark-recapture sampling to estimate abundance, survival, and other population characteristics.

Task 3B.1.3. Use ripe spawners for hatchery broodstock or other applications as appropriate.

Task 3B.1.4. Tag adults with radio or acoustic and release for monitoring of spawning behaviour and movement patterns.

Task 3B.1.5. Annual wild population and brood stock genetics sampling.

3C. Juvenile Assessments

Measure 3C.1. Conduct periodic juvenile sturgeon assessments to estimate population status, index natural recruitment, and monitor hatchery program performance.

Task 3C.1.1. Capture juveniles during summer at standardized, spatially-stratified index sites throughout the U.S. and Canadian portions of the river using gillnets.

Task 3C.1.2. Biological and mark-recapture sampling to estimate abundance and survival.

Task 3C.1.3. Index natural recruitment based on marked-unmarked ratios.

Task 3C.1.4. Evaluate dispersal from release sites, subsequent movements, habitat use, growth and survival of hatchery reared juveniles.

Task 3C.1.5. Incorporate pectoral fin ray sampling from recaptures of large hatchery fish for aging method validation assessment.

3D. Telemetry

Measure 3D.1. Monitor distribution and movements of a representative sample of acoustic-tagged juveniles and adults to assess juvenile and adult habitat use and movements and monitor biological response of adult sturgeon to spawning habitat enhancement projects.

Task 3D.1.1. Maintenance and operation of Vemco receiver arrays.

Task 3D.1.2. Juvenile telemetry to define dispersal from hatchery release sites and subsequent juvenile habitat use, movements, and migration.

Task 3D.1.3. Adult telemetry to define adult movements and habitat use in current spawning sites and the area of interest for habitat creation above Ambush Rock in Idaho.

Task 3D.1.4. Installation and maintenance of a 3-D telemetry tracking array (acoustic positioning system) to monitor wild adult behavior near enhancement project structures.

Task 3D.1.5. Focused program to monitor the 3D movements of these fish in the small piece of river comprising the Substrate Enhancement Pilot Project.

3E. Habitat Assessment & Monitoring

Measure 3E.1. Measure and monitor physical conditions in critical habitat and potential spawning areas.

Task 3E.1.1. Map depth, velocity, and substrate in critical and potential spawning reaches to document baseline conditions.

Task 3E.1.2. Develop detailed computer hydraulic models of current and potential spawning reaches and calibrate to Kootenai River habitat conditions.

Task 3E.1.3. Periodically monitor changes in critical habitat parameters over time.

3F. Data Management & Reporting

Measure 3F.1. Maintain a central repository for data collected by various organizations to facilitate systematic applications.

Task 3F.1.1. Annual data storage and management for adult and juvenile index monitoring and tagging programs.

Task 3F.1.2. Periodic updates and reporting of estimates of adult population size and available breeders, population and hatchery genetics, and numbers and survival of hatchery and natural juveniles.

ISRP Comment 18: *Supplemental information (including a memo and some pertinent sturgeon and burbot papers) was received from the proponents after receipt of the Master Plan. While this information was helpful in addressing some of the questions above, it is still incomplete. For example, it did not reconcile the "healthy age structure" and abundance targets, or reconcile the abundance targets and release of 40 families of 1500 progeny. The table that showed the mortality schedule was for a single cohort, but there would be several cohorts recruiting to reproduction and substantially more than 8,000 to 10,000 adults. Some of this is identified in the updated recruitment analysis (Beamesderfer et al. 2009). Much of this material should be included in an updated Master Plan or Appendix.*

Project Sponsor Response 18:

The Tribe concurs. This topic is addressed in previous responses and will be incorporated into the Master Plan.

ISRP Comment 19: *One area in which the proposal could be improved is in explaining the importance of the food web in the Kootenai River ecosystem. The proponents state on page 9-3 concerning the white sturgeon "This apex predator species plays a key role in the food web of the Kootenai River ecosystem." This statement is provided as support for Principle 3. However, the proposal would be improved by adding more information on this point – the document does not provide any insight into white sturgeon feeding habits at present (when presumably important forage species are in low abundance). There is also a lack of information on feeding of the hatchery-reared white sturgeon once released. Are they going to be able to switch to natural food quickly, or is there a period of acclimation needed? Are food supplies sufficient to support them? Perhaps a trophic model such as ECOSIM or another model would help in this regard.*

Project Sponsor Response 19:

The Master Plan needs to provide more information on feeding and feeding habitats of the hatchery-reared white sturgeon once released.

Sturgeon are opportunistic, omnivorous predators that as adults, occupy an upper trophic niche that likely plays an important regulatory role in shaping prey taxa assemblages, affecting food web dynamics. The magnitude of this effect is expected to increase with population size.

The diet of white sturgeon varies with size of the fish. Juveniles typically rely on benthic invertebrates. Sub-adults consume a variety of benthic organisms. Larger white sturgeon are increasingly piscivorous. Because of very large differences in size over their lifespan, different size classes of sturgeon exploit, affect, and are limited by very different components of the aquatic community. We expect that carrying capacity will be specific to different size classes of sturgeon over the course of their lifespan. So while juveniles might be limited for a time by the productivity and availability of benthic invertebrates, these limitations might be relaxed as fish grow to larger sizes where they may take advantage of more diverse food sources.

One of the benefits of hatchery-origin fish is that they have been released in sufficient numbers to conduct food habitat studies that are not feasible with a listed population consisting predominately of adults. Stomach contents were collected from 41 juvenile Kootenai River white sturgeon in Idaho and BC (2 of 7 in BC from the delta) during 2002. Chironomid spp. were the most common diet item by weight and number (Rust et al. 2003). During 2003, 15 additional juveniles were found to contain primarily Chironomid larvae (Rust et al. 2004). Diets of juvenile white sturgeon from other areas of the Columbia Basin also included significant numbers of Chironomids along with large numbers of other benthic organisms such as mollusks and amphipods (Sprague et al. 1993; Duke et al. 1993). Nutrient additions to the Kootenai River have significantly increased abundance, biomass and species richness in the benthic invertebrate communities of treated reaches (Holderman et. al 2009; Hoyle et al. 2010), which may translate to better foraging opportunities and consumption rates for juvenile sturgeon in these reaches.

Are they going to be able to switch to natural food quickly, or is there a period of acclimation needed? Are food supplies sufficient to support them? Trophic model explanation.

Survival data indicate that there is a period of acclimation following release that might be related to success in transitioning to a natural diet (Ireland et al. 2002b; KTOI 2008). The current carrying capacity of the system for sturgeon is unknown. Previous responses discuss the uncertainty in system capacity and the question of density dependent effects. As previously detailed, we will evaluate capacity limitations based on an experimental approach whereby individual and population characteristics will be monitored in relation to increasing fish numbers and density. The experimental approach to capacity determination will be much more effective than inferences drawn from bioenergetics or trophic models that would rely on untested and probably untestable assumptions regarding system productivity and community interactions. Trophic models might provide some sense of the prey biomass that might be required to support a given sturgeon or burbot population level. However, these estimates would be academic without accurate information on seasonal food habitats and daily rations, prey abundance and productivity, and the community response to variable exploitation of specific components by sturgeon.

We also expect that trophic relationships and capacity limitations will change in the future in response to nutrient enhancement, habitat restoration, and restoration of key ecosystem elements such as the South Kootenay Lake Arm kokanee population. Nutrient enhancement in the Kootenai River and in Kootenay Lake has resulted in a significant production response at multiple trophic levels. Large-scale habitat restoration efforts are expected to restore greater ecosystem function (e.g., complexity, floodplain connection, development of more riparian habitat, side channels, etc.) with corresponding changes in the available food web and food supply. Kokanee restoration efforts have significantly increased annual returns to the Kootenai River and tributaries. Kokanee are believed to be a very significant food resource for the historical sturgeon population. The net effects of all these changes on system trophic dynamics and habitat capacity are extremely difficult to predict. These limitations are why an empirical monitoring and evaluation approach to identifying sturgeon capacity is being implemented using releases of hatchery-reared sturgeon.

ISRP Comment 20: *The ultimate biological objectives for the sturgeon program are two of the five elements of the Post-release Kootenai sturgeon conservation aquaculture program biological objectives on pages 4-9 and 4-10: "Ensure genetic diversity with and among progeny groups" (The target is an* *effective population size of greater than 20 spawners and over 200 fish per generation); and, Achieve a sustainable adult population target" (The abundance target is 8,000 to 10,000 adults)".*

The Master Plan needs to justify the 20 spawners and over 200 fish per generation. And also explain it. It is not clear what these targets refer to and how they will be measured. The Master Plan needs to justify the abundance target of 8,000 to 10,000 adults. Elsewhere in the Plan reference is made to establishing a healthy age class structure. It is not clear how the 8,000 to 10,000 adults fit with the 20 spawners and 200 fish per generation. This needs to be reconciled and explained.

Additionally, on page 4-8 production targets of 1,500 age 1 sturgeon from 40 families is identified, and on page 4-9 a bullet point has a target of spawning up to 18 females.

One objective of the sturgeon program is appropriately conservation of the remaining genetic variation in the extant declining adult population. A genetic breeding design based on the number of remaining fish and the goals of retaining variation (what percent over what timeframe) needs to be developed and incorporated into the Master Plan. This will establish one component of the needed size for the propagation plan. Monitoring should probably include molecular analysis of current and ongoing effective population size.

Project Sponsor Response 20:
We apologize for any numerical inconsistencies in the Master Plan and for any resulting confusion. To clarify, the N_e of 200 fish per generation was an expansion from the previous targets set by the Kincaid Plan in 1993 (10 fish spawned per year for 10 years). It is crucial to understand that the Kincaid Plan was written at a time (1993) when natural production was expected to be restored within the immediate future by effective flow measures, and as such was designed only to replace one lost generation of fish in a facility with limited broodstock holding and spawning capacity. Also at that time, generation time was thought to be much shorter than we now know it is. Since then, natural recruitment has not been restored, fewer broodstock remain, and the hatchery program is responsible for providing essentially all the genetic material for future generations, whether they result from future hatchery or natural production, or some combination.

The 8,000-10,000 adult fish range currently identified as a working target for delisting was defined by a hind-casting population demographic model, for what was thought to be a relatively viable population size before 1980 (Paragamian et al. 2005). Working criteria upon which the hatchery program is based also identify a 2,500 adult target as a potential down-listing goal. The current program production goal is to release adequate numbers of progeny from as many different progeny groups as possible to provide some future spawning representation until the remnant wild population of spawners dies off during the next 20 years or so. (Elsewhere in this response document we discuss at length the difficulty in predicting high-resolution production targets and release numbers due to additive variation from longevity, a point that is also relevant here).

We agree with the ISPR recommendation to include genetic monitoring and guidance. The Tribe has been working with the Genomic Variation Lab at UC Davis for more than a decade to characterize and ensure that diversity targets are being met. During the past 20 and the next 20 years, the goal is to spawn as many remnant wild adults in un-remated groups as possible to maximize the amount of unique genetic material available for future generations. UC Davis has also developed new microsatellite primers from the production of a Kootenai River white sturgeon gene library, an effort funded by this project to provide higher resolution markers (needed for a less diverse population), and continues to test assignment and paternity procedures to characterize hatchery and any natural production.

ISRP Comment 21: *The proposal would also be improved by more discussion/consideration of the major initiatives regarding upper Columbia sturgeon hatchery releases on the Canadian side and in Washington. For example, the Upper Columbia White Sturgeon Recovery Initiative has been underway since 2000 (see webpage for UCWSRI) but this work is not mentioned in the Plan. For burbot, the plan indicates responses to the Kootenai River Subbasin Plan and the Kootenai Valley River Initiative conservation strategies.*

Project Sponsor Response 21:

Study of white sturgeon populations in the Canadian portion of the Columbia River began in the 1980s. In the 1990s, general fish inventories conducted in this area showed that the population size-class had shifted from a population dominated by younger white sturgeon in the 1980s to one dominated by adults in the 1990s (Hildebrand and English 1999). The BC Conservation Data Centre added sturgeon to the provincial Red List of critically imperiled species in 1996 and at that time, the recreational and guided fishery was closed.

The Canadian Species at Risk Act (SARA) was proclaimed in 2003 and in November 2003, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determined that white sturgeon populations in Canada should be considered endangered. In 2006, COSEWIC listed Kootenay sturgeon under SARA (along with three other white sturgeon populations in BC). A draft national recovery plan for white sturgeon has been completed under SARA and has undergone extensive public review; the final recovery plan is expected in early 2010.

The Upper Columbia White Sturgeon Recovery Initiative (UCWSRI) was formed in 2000 in order to coordinate and help plan actions dedicated to the recovery of white sturgeon populations in the Upper Columbia River Basin upstream of the Grand Coulee Dam (UCWSRI 2008). The UCWSRI consists of a Technical Working Group (TWG) and a Community Working Group (CWG). The TWG's role is to provide technical content and advice, and specifically to identify focused research needs and to develop and help implement a recovery plan that encourages white sturgeon population growth in the upper Columbia River (UCWSRI website). The TWG includes Canadian and U.S. groups representing federal, state and provincial governments, industry, First Nations, and public stakeholders. The CWG's role is to develop a common vision and public support for sturgeon recovery, provide information and feedback on recovery operations, inform the public, and seek funding for recovery projects.

In 2002, the UCWSRI completed the Upper Columbia White Sturgeon Recovery Plan. The recovery plan was designed to address the recovery needs in the Canadian portion of the river as well as to serve as a master plan for sturgeon restoration efforts in the U.S. portion of the river upstream from Grand Coulee

Dam consistent with implementation of the Columbia Basin Fish and Wildlife Program under the 1980 Northwest Power Act (UCWSRI 2002). The recovery plan states that due to the almost complete failure of natural recruitment, severe population bottlenecks would occur within the next 10 years, and the population would become functionally extinct by 2044 (UCWSRI 2002). Development of this UCWSRI recovery plan was guided in part by the Kootenai River White Sturgeon Recovery Plan and other efforts being conducted on behalf of Kootenai River white sturgeon.

The UCWSRI 2002 recovery plan includes short-, medium- and long-term objectives. The short-term objective was to assess population status and act to prevent further reductions in white sturgeon distribution, numbers, and genetic diversity within the current geographic range. The medium-term objective (ongoing) is to determine survival limitations (bottlenecks) for remaining supportable populations and establish feasible response measures. The long-term objective is to re-establish natural population age structure, target abundance levels, and beneficial uses through self-sustaining recruitment in two or more recovery areas.

Recovery targets identified in the plan include: 1) minimum adult population sizes of 2,500 adults per area in two recovery areas (5,000 adults total); 2) naturally-produced recruitment and juvenile population sizes sufficient to support desired adult population sizes; 3) stable or increasing trends in adult and juvenile numbers; 4) stable size and age distribution; and 5) genetic diversity similar to current levels (UCWSRI 2002).

The UCWSRI implements a suite of research, monitoring and evaluation and production activities, which include (UCWSRI 2006):

- Sturgeon fish culture operations at British Columbia and Washington facilities
- Broodstock collection and tagging activities
- Transboundary reach juvenile monitoring
- Communications, public outreach and education efforts
- Contaminants and fin deformity investigations
- Adult sturgeon monitoring in Lake Roosevelt and Lake Waneta
- Stock assessment and telemetry studies in the transboundary reach
- Geomorphologic and population sub-structure analyses
- Temperature effects on incubation success and survival
- Technical and community working groups advisory and administrative support
- Annual public reporting through a public workshop

Early on, the UCWSRI determined that fish culture was a key element in the conservation and restoration of upper Columbia white sturgeon. The Freshwater Fisheries Society of British Columbia was enlisted to operate the fish culture facilities since they already had experience through their work with the Kootenai Tribe of Idaho (culturing Kootenai River white sturgeon stock in BC as part of the Tribe's fail-safe program).

A pilot hatchery program for upper Columbia white sturgeon was initiated with the modification of a provincial trout hatchery (Hill-Mackenzie Creek Hatchery) located at Galena Bay (UCWSRI 2008). Broodstock collection and spawning began in 2001 and juveniles were first released in 2002 (UCWSRI 2008). In 2003, the program was transferred to the larger Kootenay Sturgeon Conservation Hatchery near Cranbrook, BC. A pilot U.S. hatchery program was also begun at Moses Lake, Washington in

February 2004 with Canadian 2003 brood juveniles for release in 2004. The U.S. program began collecting its own broodstock in 2006 (UCWSRI 2008).

Through 2007, 92,818 hatchery-raised juvenile white sturgeon representing 44 families were released between Keenleyside and Lake Roosevelt (UCWSRI 2008). Since 2005, Canadian releases have included both fall (sub-yearling) and spring (yearling) release groups. Releases in the U.S. portion of the transboundary reach have occurred each year since 2004. Releases at Revelstoke were first made in 2007 (UCWSRI 2008). Production in the U.S. began in 2006.

Initial UCWSRI hatchery production targets were based on population targets and assumptions identified in the 2002 Recovery Plan (UCWSRI 2002). Monitoring of initial release groups has recently provided empirical estimates of hatchery survival and condition following release (UCWSRI 2008). Recent evaluations conducted as part of the Canadian listing under SARA also included a Recovery Potential Assessment, which modeled recovery trajectories based on assumed survival rates (UCWSRI 2008).

In 2008, the UCWSRI initiated a comprehensive review of the upper Columbia white sturgeon recruitment failure hypothesis (Gregory and Graham 2008). Ultimately, this review resulted in the prioritization of research, monitoring and evaluation, hatchery, and mitigation actions associated with specific prioritized recruitment failure hypotheses. The UCWSRI is currently working on merging the results of the 2008 recruitment failure hypotheses with revisions to their current five-year work plan. In addition, the recently completed national draft White Sturgeon Recovery Strategy, once finalized, is likely to provide additional guidance that the TWG will have to consider in their mitigation programs, monitoring and evaluation program and hatchery release targets.

The Kootenai Tribe maintains close dialog with participants in the UCWSRI including individuals who provide significant technical advice, monitoring and evaluation data, and analysis to the UCWSRI's TWG.

ISRP Comment 22: *For the white sturgeon material the Master Plan appears to address basinwide artificial production standards and strategies adequately, although no risk assessment to white sturgeon populations out of subbasin was done.*

Project Sponsor Response 22:

No risk assessment for white sturgeon populations outside the Kootenai subbasin was performed because all effects of the Tribe's program are contained entirely within the subbasin. No other white sturgeon populations are present within the subbasin.

ISRP Comment 23: *Burbot have largely disappeared from the lower Kootenai River but are not listed because other independent populations within the distinct population segment are sufficiently abundant and productive.*

Project Sponsor Response 23:

Burbot populations in the South Arm of Kootenay Lake, in the Kootenai River, and in the West Arm of Kootenay Lake have become functionally extinct and extirpated, respectively, by a combination of altered habitat, ecological and overfishing effects (Ahrens and Korman 2002; Paragamian et al. 2004).

In 2002, a petition was filed with the USFWS to list burbot in the Idaho portion of the Kootenai Subbasin as threatened under the U.S. Endangered Species Act (http://www.wildlands.org/w_burbot_pet.html). However, the USFWS 12-month finding for the petition reported that: "After reviewing the best available scientific and commercial information, we find that the petitioned action [listing] is not warranted, because the petitioned entity is not a distinct population segment (DPS) and, therefore, is not a listable entity" (USFWS 2003).

At the time of the ESA petition, no DPSs had been defined for any burbot populations, in part due to the lack of high-resolution nuclear genetic analysis. Information remains limited to mitochondrial DNA (mtDNA) which classified all populations south of Great Slave Lake, Canada in a common lineage consisting of Pacific, Mississippi, and Missouri clades (Van Houdt et al. 2003, 2005). Powell et al. (2008) observed clinal variation in mtDNA analyses of populations within the Pacific clade that includes the lower Kootenai burbot population.

While there is insufficient genetic data to determine if Kootenai burbot represent a distinct population segment, they are ecologically, socially and culturally significant. This population has been assigned a very high priority for restoration by the people of the region as part of a comprehensive ecosystem recovery program. Burbot are also identified as a focal species in the Kootenai River Subbasin Plan developed for the Northwest Power and Conservation Council's Fish and Wildlife Program (KTOI and MDFWP 2004).

Burbot are the subject of great interest to the Kootenai Tribe and the local community, where they historically supported subsistence and popular recreational fisheries (KVRI 2005). Their significance to the community is highlighted by the development of a burbot conservation strategy by the Kootenai Valley Restoration Initiative (KVRI), a local stakeholder group (KVRI 2005; Ireland and Perry 2008). The KVRI was formed in October 2001 under a Joint Powers Agreement (JPA) between the Kootenai Tribe, the City of Bonners Ferry, and Boundary County to foster community involvement and to restore and enhance the resources of the Kootenai Valley. The mission of KVRI is to act as a locally based effort to improve coordination, integration, and implementation of existing local, state, and federal programs that can effectively maintain, enhance, and restore the social, cultural, and natural resource bases in the community. The KVRI membership and its partners include the Kootenai Tribe, federal, state, and provincial fisheries and water regulatory agencies, regional city and county governments, private citizens, landowners, environmental advocacy groups, and regional representatives of business and industry. A KVRI Burbot Culture Subcommittee was formed to pursue coordinated burbot conservation and management. Congressional appropriations in 2003 and 2005 helped fund the coordination and development of the Burbot Conservation Strategy. The KVRI also provides a forum for local input and stakeholder involvement for subbasin plan implementation in the lower Kootenai Subbasin.

ISRP Comment 24: *The ostensible goal of the burbot program is to reintroduce burbot and attempt to re-establish a self-sustaining population (presumably independent of artificial propagation and supplementation). It is not clear that the environmental conditions required for sustainable burbot production will be re-established – a precursor to the goal of self-sustainability.*

Project Sponsor Response 24:

The most effective and expeditious method for identifying the suitability or limitations of current environmental conditions for burbot will be through research, monitoring, and evaluations following reintroduction. Too few naturally produced burbot are currently available to identify limiting factors or remedies for restoring suitable conditions or for restoring a population through natural production. Hatchery fish will tell us where the limitations occur based on an empirical adaptive project implementation design. Understanding burbot population bottlenecks, a prerequisite for long-term restoration success, will only be possible by having fish in the river. Currently this can occur only through experimental stocking and monitoring of cultured fish due to the additive magnitude and severity of habitat loss and alteration.

We know from long-term monitoring efforts that current habitat conditions in the Kootenai River and Kootenay Lake are suitable for subadult and adult life stages. Current conditions support migration and spawning. Population failure appears to occur somewhere in the incubation to early rearing stages. Releases of burbot at various sizes and ages will allow us to more narrowly identify the limiting life stage and focus restoration efforts on environmental factors that affect that life stage. Carefully monitored releases of hatchery fish are required to evaluate stage-specific habitat requirements. Experimental evaluations of this type require releases of adequate numbers of burbot to provide the statistical sampling power to estimate size-related differences in survival. These numbers exceed the capacity of existing experimental sturgeon hatchery facilities and require the development of additional space.

It is also unclear to what extent depensatory processes related to low numbers may have contributed to the decline of the burbot population or precluded their response to improving conditions. Depensatory processes are thought to cause populations to trend toward extinction when critical low thresholds are reached. Depensatory factors can occur in the spawning stage due to behavioral or genetic Allee effects or in the rearing stage due to predation or competition of juvenile burbot with other species that have expanded into the habitat following the burbot decline. The best way to test whether depensatory processes have contributed to the extirpation of the burbot population is to experimentally increase burbot numbers beyond current critical low thresholds from which they are unable to recover by themselves. Hatchery production is the only effective means of doing so.

At the same time, ongoing habitat and ecosystem restoration actions may have already improved conditions and will continue to do so in the foreseeable future. Burbot are also an important consideration in the development and design of the Tribe's eco-system based habitat restoration project. Using the hatchery to jumpstart the population by rearing fish past an apparent recruitment bottleneck will ensure that there are burbot in the river to take advantage of improved conditions when they occur. Once burbot numbers increase in the river, we will continue to work with cooperators on habitat rehabilitation issues. Further actions will be guided by increased knowledge of burbot behaviors and habitat requirements within the Kootenai River.

A naturally self-sustaining population will require the restoration of suitable habitat and environmental conditions. At that point, there will be no need for a continued conservation hatchery program. Alternatively, if a future self-sustaining naturally produced burbot population is not ultimately attainable following habitat restoration actions, then this program will be required to maintain a burbot population in the Kootenai River. The presence of a burbot population in the Kootenai River that can sustain some level of harvest is consistent with goals and objectives of the NPCC Fish and Wildlife Program, BPA funded mitigation activities, and the U.S. Federal Trust responsibility to the Kootenai Tribe.

ISRP Comment 25: *The program has yet to release fish on a study basis to determine the fate and likelihood of survival-to-maturity and participation in natural reproduction, let alone recruitment of any progeny into a wild population. No evidence of recruitment to reproduction or fisheries for other burbot culture programs is provided. This would provide a basic level of justification.*

Project Sponsor Response 25:

Burbot culture programs have not been widely implemented or evaluated due to a limited need and the lack of effective hatchery methods. Experimental burbot culture programs have recently been initiated in Europe (e.g., Belgium, Poland) where larval or juvenile burbot were released into natural waters to aid in population recovery. Dillen et al. (2008) reported preliminary results of cultured burbot introductions in three Belgian rivers. No fish from a release of 2 million burbot yolk sac larvae were subsequently recaptured; however, subsequent recaptures demonstrated significant post-release survival and growth from 4,400 burbot released as young-of-the-year.

North American burbot culture efforts appear to have been limited to an exploratory USFWS program at Garrison National Fish Hatchery in North Dakota and the developmental research effort at the University of Idaho – Aquaculture Research Institute (UI-ARI). The USFWS program reported some success in producing limited numbers of juvenile burbot in ponds. Burbot were reared from eggs to 1.25 inches in length in the spring of 2008 and 18,000 burbot were stocked in the headwaters of Lake Oahe in South Dakota. There have been no efforts to determine stocking success and the program is no longer operating (personal communication, Rob Holm, USFWS, Program Manager Garrison Dam Fish Hatchery Complex, January 4, 2010).

The primary problem with initial considerations of burbot culture was the lack of effective methods to spawn, incubate, and rear fish to sizes suitable for release. The UI-ARI has now successfully developed burbot incubation and rearing techniques and has demonstrated the feasibility of large-scale culture of this previously uncultured species. This work provides the essential foundation for implementing an experimental burbot aquaculture program.

The next questions about aquaculture effectiveness concern post-release survival rates, effective release sizes and times, cost-effective rearing practices, long -term survival, growth, maturation, and contributions to future wild production. These questions cannot effectively be addressed with the production limitations of existing facilities.

ISRP Comment 26: *At this time the ISRP feels that resources need to be allocated to gain an in-depth understanding of factors affecting burbot survival after stocking before development of a production-scale hatchery to rear and release burbot is initiated. Specifically, a deliberate step-wise approach proceeding from feasibility investigations to pilot studies is warranted prior to planning full implementation. In addition, a more thorough discussion of burbot culture by others is needed, that includes a summary or evaluation of the success of these programs toward re-establishing natural productivity. Ultimately, the ISRP recommends the burbot program should proceed on a feasibility scale primarily using existing facilities until sufficient proof exists to transition to pilot scale efforts.*

Project Sponsor Response 26:

The Kootenai Tribe has, in fact, developed and proposed an adaptive step-wise experimental program, not a production hatchery. The program includes four phases (Table 8), in which success in each phase is required to move the program forward to a subsequent phase.

Phase 1 (Developmental Aquaculture Feasibility Analysis) was initiated in 2001 and has been completed. Reliable, successful aquaculture apparatus and techniques were developed based on pioneering research. The progression of this burbot aquaculture program resembles the early years of the successful Kootenai Tribe white sturgeon program, which began in 1989 and has operated successfully for 20 years. 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. Burbot disease susceptibility has been well characterized in an effort to circumvent any such issues that may manifest under intensive conditions. This work demonstrated the feasibility of burbot culture at a significant scale and laid the groundwork for the next phase.

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 phase was initiated with the first experimental release of 247 burbot in October and November of 2009. Thirty of the fish were two years old and implanted with ultrasonic transmitters. This research will provide basic information on the biology and limiting factors for burbot under current habitat and environmental conditions. Part of the problem in designing an effective burbot restoration program has been the lack of basic information due to the lack of fish to serve as study subjects. These pilot study release groups will also provide preliminary information on the potential suitability of hatchery-origin fish for larger-scale population rebuilding

During the 5-year pilot study phase, the UI-ARI facility will serve a dual purpose. One purpose will be to rear small numbers of burbot for release and subsequent pilot study monitoring (approximately 5,000 age 0 burbot per year). Fish will be released at 5 to 10 grams, which is the minimum size that can be permanently tagged to provide reasonable potential for post-release survival. The second purpose of the UI-ARI facility will be to continue to develop and refine burbot culture methods and systems.

Continued research on propagation methods is expected to pay future dividends in increased effectiveness and reduced cost of burbot aquaculture. In addition to limited facility capacity, the research priority at the UI-ARI facility limits the total production that will be available to produce fish for pilot study releases. Up to 10,000 age 0 burbot might be produced annually if the UI-ARI facility were dedicated to production, but this would come at the cost of the critical research and developmental functions it provides.

Phase 3 (Adaptive Experimental Evaluation) steps up hatchery production and monitoring efforts to determine how well hatchery-produced burbot survive, grow and mature in sufficient numbers to reestablish a significant population in the Kootenai system. This phase involves a population-scale monitoring effort 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 to provide qualitative assessments of behavior and biology of hatchery-reared fish. Phase 3 involves a larger-scale, extensive quantitative monitoring effort designed to provide statistically testable numbers of burbot to experimentally evaluate post-release survival, growth, biological condition and maturation. The Twin Rivers facility is needed in Phase 3 to produce sufficient fish for a statistically robust evaluation. The Tribal Sturgeon Hatchery lacks the capacity to evaluate life stage limiting factors, habitat requirements, ecological interactions, density effects, and hydro and habitat action effectiveness in a system the size of the lower Kootenai[14].

A key objective of Phase 3 is to estimate post-release survival rates of hatchery-reared burbot with enough precision to guide future production efforts and to reach established population and use objectives. Population levels are extremely sensitive to moderate differences in annual survival. For instance, increases in annual survival from 40% to 70% result in a 30-fold difference in projected adult numbers from any given hatchery release level (Table 9). Data on annual survival rates of burbot in the Kootenai system is available for adults but not for juveniles. Pyper et al. (2004) estimated an annual natural survival rate of the remnant Kootenai River population at 37%. Ahrens and Korman (2002) estimated an annual natural survival rate of adults in the failed[15] Kootenay Lake burbot population at 71%. These estimates bracket the range of alternatives identified in Table 9. Experience with other species suggests that survival rates of hatchery-reared fish will be lower during the first year at large as released fish adapt to natural conditions. For planning purposes, we simply assumed a first year survival rate of half the annual average.

---

[14] The new facility at Twin Rivers is not proposed solely as a burbot facility. It is deemed essential by the Tribe for effective continuation and necessary expansion of the sturgeon program. Therefore, the inclusion of the burbot component is a cost-effective approach and the experimental nature of the program is lower in risk.

[15] Population failure was attributed to over fishing.

Table 8. Proposed operational phases of the Lower Kootenai River burbot population restoration project.

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 monitoring 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 2013-2017
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.	2017 and beyond

Table 9. Sensitivity of burbot population size to production numbers and survival rates.

Age	40% Annual Survival				55% Annual Survival				70% Annual Survival			
Rel no.	2000	5000	10000	20000	2000	5000	10000	20000	2000	5000	10000	20000
1	400	1000	2000	4000	550	1375	2750	5500	700	1750	3500	7000
2	160	400	800	1600	303	756	1513	3025	490	1225	2450	4900
3	64	160	320	640	166	416	832	1664	343	858	1715	3430
4	26	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	294	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	69	138
13	0	0	0	0	0	1	2	4	10	24	48	97
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

Phase 3 annual production targets of 10,000-20,000 age 0 burbot are consistent with the results of 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%) associated with a reasonable sampling effort. The power analysis also demonstrated that current production capacity of 5,000 fish per year is not adequate to provide reasonable levels of sampling precision, except at very high survival and sampling rates. Statistical power curves (Figure 12) 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. 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.

Larger release group sizes significantly enhance the monitoring effectiveness while smaller release numbers come at a cost of requiring increased sampling effort to provide the same precision. Sampling rate (the percentage of the population that is captured per year) is a function of sampling effort and catchability of burbot. Previous sampling efforts for Kootenai River burbot were reported by Paragamian et al. (2008) to result in an annual sample rate of approximately 20%. The effectiveness of sampling juvenile burbot in the Kootenai system is unknown at this time, but a rate of 5-10% likely represents a reasonable initial assumption. The proposed pilot study in Phase 2 is designed to provide initial estimates of the level of sampling required to produce a given sampling rate of the population. Based on Phase 2 results, Phase 3 release number targets will be set to provide enough fish to develop initial estimates of survival. Release numbers and sampling effort will be adjusted adaptively to provide the desired precision to evaluate this program.

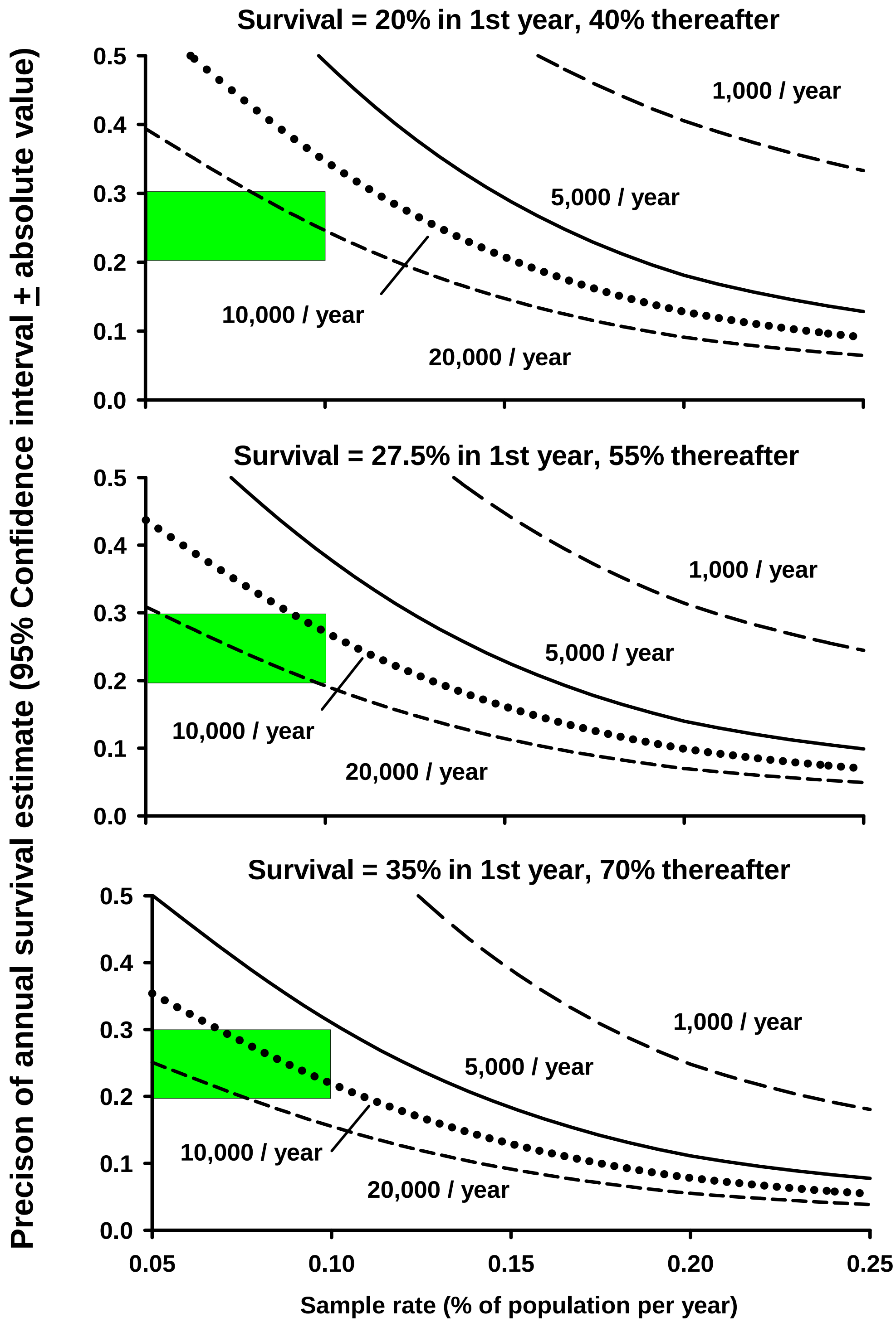


Figure 12. Power analysis of the effects of annual release number and sampling rate on 95% confidence intervals for survival under three different survival assumptions estimated using a simple Cormack-Jolly-Seber mark-recapture model (6-year sampling interval). Confidence intervals are approximated based on two times the standard error of the estimate. The shaded box shows target precision and sampling rates.

Phase 4 (Population and Rebuilding) involves implementation of a full-scale restoration program designed to meet population and use objectives based on the findings of Phase 3 evaluations. Table 9 illustrates that planned production levels identified for Phase 3 are likely to be adequate to meet minimum conservation abundance objectives (2,500) under only the most optimistic of assumptions. This does not mean that conservation objectives will not be met; rather, it underscores the need for implementation of possible expansions to the conservation aquaculture program in Phase 4. Although the historical size of the South Arm and Kootenai River burbot population is unknown, we believe that the minimum conservation abundance objectives and planned Phase 3 release levels are substantially less than the historical habitat capacity. Thus the proposed approach protects from indiscriminate, large-scale hatchery production and allows the program to grow adaptively as necessary.

The only suitable reference point available is from historical harvests of West Arm Kootenay Lake recreational fisheries. Peak harvest levels can be assumed to represent a minimum bound on a population estimate[16]. Peak harvests of 25,930 adult burbot in the West Arm fishery occurred in 1969 (Ahrens and Korman 2002; KVRI 2005). At an average size of approximately 70 cm and an average weight of 1.83 kg, this catch translates into a total biomass of 47,400 kg of burbot. Projected adult biomass of the proposed Kootenai releases of 10,000 to 20,000 per year range from 100 to 9,000 kg at annual survival rates of 40-70% (Figure 13). Numbers and biomass of the proposed South Arm/Kootenai River burbot population produced by Phase 3 of the proposed conservation aquaculture program are clearly much less than the historical 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 and the hatchery program comes nowhere close to that level of production. This example also has implications for potential ecological effects discussed further in responses to other ISRP questions.

Program expansion may be required if natural production remains limiting and survival rates are relatively low. The proposed Twin Rivers facility is being designed to provide the flexibility needed to implement a phased, adaptive burbot restoration program. Hatchery systems are being designed to optimize flexibility and to allow cost-effective modifications as necessary as the program unfolds. Flexibility will be enhanced by concurrent development of a joint sturgeon and burbot facility. For instance, the sturgeon restoration strategy involves front-loading production for the near term while wild adult broodstock continue to be available, but future production levels might be reduced to a level consistent with the long-term capacity of the habitat to support sturgeon. At the same time, future burbot restoration needs may require additional production capacity that might be obtained by rededicating a portion of the sturgeon system. At this time it is difficult to anticipate the future production demands required by the experimental adaptive approach to both sturgeon and burbot restoration. That is why the current design allows for optimum flexibility in future operations.

[16] Of course, total abundance is greater than harvest in proportion to the reciprocal of the harvest rate. Ahrens and Korman (2002) estimated a peak West Arm burbot population size of approximately 200,000 including juveniles and adults. However, we just used the peak catch as a minimum abundance for example purposes because it required no assumptions regarding annual harvest or recruitment rates.

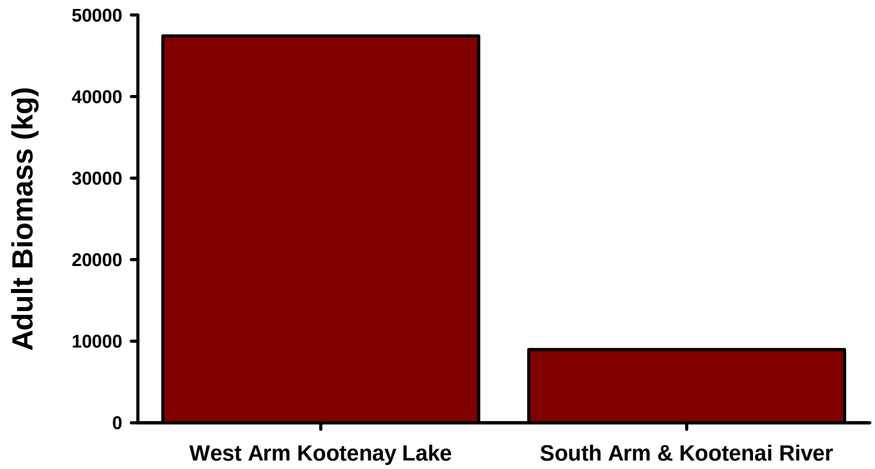


Figure 13. Comparison of minimum estimates of population biomass in the West Arm Kootenay Lake burbot population with maximum estimates of population biomass of the hatchery-produced burbot population in the South Arm and Kootenai River burbot population.

The burbot conservation strategy identifies the need for an aggressive, adaptive implementation strategy for burbot restoration (KVRI 2005). In the long run, this approach is likely to produce the most effective, timely, and cost-efficient method of burbot restoration in the lower Kootenai River. The sturgeon restoration program has very effectively demonstrated the success of an experimental approach involving releases of sufficient numbers of fish to support a robust monitoring, evaluation, and adaptive management design. The same general approach is proposed for burbot.

There is no significant downside to this aggressive experimental approach. At worst, this strategy will clearly establish the feasibility and requirements of burbot restoration within a reasonable period. The up-front costs of developing suitable facilities needed for an effective experimental evaluation will be more than compensated by the timeliness of the answers that will be obtained (and the new hatchery facility is needed for sturgeon program expansion regardless). Even if burbot facilities ultimately are not needed beyond some future point because aquaculture did not prove to be cost effective or because a naturally self-sustaining population was reestablished, facility development costs will be offset by the savings from avoiding a protracted and slower-paced research and monitoring strategy. Nor are there significant biological issues that argue for a slower, more cautious pace. The native population of burbot is essentially gone and any chance of capturing remnant genetic material is right now. No significant ecological risks to other species are apparent.

The burbot component of the proposed Twin Rivers facilities represents a relatively modest and fiscally responsible investment that capitalizes on many shared sturgeon operational components. Concurrent development of the sturgeon and burbot facilities results in significant cost savings for the burbot program relative to independently constructing new facilities at a later date. Independent construction costs would include separate water supply and treatment facilities, separate effluent treatment and distinct operational infrastructure. Expanding existing facilities or constructing facilities outside of the basin (even if possible and recommended) also would require greater expenditures over the long term.

ISRP Comment 27: *However, the required elements in several of the burbot sections of the Master Plan are incomplete/inadequate (e.g., missing HGMP, subbasin-wide risk assessment, and harvest plan). (BUR5)*

Project Sponsor Response 27:

Each of the sections identified in Comment 27 is addressed below.

Burbot HGMP - An HGMP for the proposed burbot program has now been developed and is provided in Appendix 2. This program involves a conservation aquaculture, reintroduction, and population rebuilding program, not a put-and-take supplementation hatchery as is commonly associated with anadromous salmon programs.

Subbasin Risk Assessment - Because burbot are functionally extirpated from the Lower Kootenai River, and because the expected range of stocked fish from this program is not expected to overlap with any extant burbot populations in the Kootenai River Subbasin, we foresee little or no risk to any other burbot populations in the subbasin from this program.

Furthermore, burbot gametes from within-subbasin broodstock in Moyie Lake are being collected non-invasively in the field instead of removing broodfish from the population, further reducing risk to any subbasin burbot population(s). In the event that gamete collection is not successful during any given year on Moyie Lake, Moyie Lake broodstock are available from initial collection efforts and the program will consider the occasional collection of additional broodfish. Moyie Lake supports a harvestable population of burbot and is monitored extensively by the BC Ministry of the Environment to assess donor stock resilience. Recent annual reports detailing characteristics of the Moyie Lake burbot population are available at the following links:

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=17097

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=16158

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=13484

Harvest Plan – Burbot harvest has been prohibited in the Kootenai River in Idaho since 1984 in response to long-term declining population abundance trends. The response of the population created by this burbot reintroduction program and simultaneous habitat improvements will be monitored to determine changes in species abundance, distribution, and life history trait expression. Tribal treaty rights for ceremonial and subsistence harvests may be exercised when population abundance is adequately restored by hatchery production, natural production, or some combination of both. Potential recreational harvest of burbot may resume at some level in the future when the demographic status is upgraded. Appropriate timing and magnitude of harvest will be determined by events and population statistics as they unfold.

ISRP Comment 28: *The proponents also state (as support for Principle 3) that burbot played a "key regulatory role" in the river ecosystem, but no information is provided as to what that role was.*

Project Sponsor Response 28:

Like adult sturgeon, adult burbot are opportunistic, piscivores that prey on a wide variety of aquatic organisms, including insects, macroinvertebrates, lamprey, suckers, minnows, perch and even other burbot (Bailey 1972; Scott and Crossman 1973; McPhail and Paragamian 2000). Diet varies with season, apparently based on prey availability. Being nocturnal and crepuscular feeders, burbot hide among available refugia, such as rocks and fallen logs in epibenthic habitats, and use ambush tactics to capture prey (Kahilainen and Lehtonen 2003). During times of low activity, they congregate in deep holes (Scott and Crossman 1973; Morrow 1980; Riede 2004). Burbot are also quite plastic in their behavior, diet, and habitat use in relation to the available resources.

Because burbot occupy upper trophic level positions or niches within the aquatic food web, they are theoretically able to exert top-down regulation on prey item or assemblage abundance and composition. They may play an important regulatory role in shaping or regulating community attributes of prey taxa or assemblages as well as affecting food web dynamics. It is also possible that burbot feeding habits could be regulated by prey availability, rather than controlling, the population dynamics of prey species.

The native burbot populations in Kootenai River and Kootenay Lake likely exploited a wide range of resources including mysids, kokanee, and a variety of native fish species. The availability of many of these resources has changed over time in response to habitat and environmental changes and perhaps changes in the abundance of other species such as burbot and sturgeon. For instance, large kokanee runs into South Arm streams may have been a critical food source for the native burbot populations, but these runs were largely extirpated and have only recently begun to rebound as a result of habitat restoration and related actions undertaken by the Tribe (Ericksen et al. 2009). Ahrens and Korman (2002) identified a shift in the demersal fish community of Kootenay Lake from burbot during the 1960s and 1970s to other species including northern pikeminnow and largescale sucker following the collapse of the burbot population in the lake. An environmentally driven community shift was one hypothesis for the burbot collapse (Ahrens and Korman 2002); however, it is unknown whether the community shift was a cause or effect of the burbot decline, or simply correlated with common factors. In the end, fish community interactions can be very complicated and consist of a variety of positive and negative effects. Without an experimental evaluation using reintroduced burbot, we can only speculate how burbot will affect, limit or be limited by the altered Kootenai ecosystem. As noted in previous responses, burbot restoration is but one element of a comprehensive ecosystem restoration effort in the Kootenai system. The driving hypothesis is that if enough of the historical components of the system can be restored, then some measure of the historical ecosystem function will be achieved as well, which theoretically can improve success of burbot and other native fish restoration programs (e.g., sturgeon and kokanee).

ISRP Comment 29: *The objectives are defined for white sturgeon and burbot in Chapters 4 and 6. However, additional development of the biological objectives is needed. The final biological objective(s) should be used to design the fish production program, and the fish production program should be used to design the scope and scale of production facilities.*

Project Sponsor Response 29:

Biological objectives for white sturgeon recovery and for sturgeon aquaculture are detailed in previous answers (please see Project Sponsor Responses 2, 3, 5, 6, 8, 12 and 20).

Biological objectives for burbot are detailed in the 2005 Kootenai River/Kootenay Lake burbot conservation strategy developed by the Kootenai Valley Resource Initiative (see Box 4).

Box 4. Biological objectives for Kootenai River and Kootenay Lake burbot.

Abundance

- A minimum adult population size of 2,500 adults in the Kootenai River and South Arm of Kootenay Lake.

Productivity

- Consistent natural recruitment in at least 3 different spawning areas with net recruitment and juvenile population size sufficient to support the desired adult abundance.

Distribution

- Stable size and age distributions.

Use

- Sufficient numbers of burbot to provide a harvest opportunity.

The KVRI conservation strategy explicitly identifies the use of aquaculture as a key short-term component for burbot protection and restoration:

> "Conservation aquaculture may be employed as a short-term tool to achieve natural recruitment and production objectives described in this Conservation Strategy. When consistent natural recruitment on at least three different spawning areas is achieved, conservation aquaculture will no longer be needed or included in this Conservation Strategy."

The burbot conservation aquaculture program described in the Master Plan is based on the stepwise objectives identified in Table 8. Phase 2 production levels from the UI-ARI facility of up to 5,000 age 0 burbot per year were established for the 2009-2013 Developmental Post-release Pilot Study phase in order to support initial evaluations of research on distribution, movements, habitat use, food habitats, and effective sampling methods by life stage. This level was determined by the very limited capacity of the UI-ARI facility for dual objectives, including fish for pilot study releases and continuing research to develop and refine effective propagation methods.

Phase 3 annual production targets increase to 10,000-20,000 age 0 burbot in the Adaptive Experimental Evaluation phase (2013-2017). This production level is based on statistical power analyses of the number of fish needed at various survival rates to determine whether hatchery-produced burbot survive, grow and mature in sufficient numbers to reestablish a significant population in the Kootenai system. This production level requires construction of the additional Twin River facility identified in the Master Plan.

Phase 4 production targets will depend on the outcome of Phase 3 evaluations. Production levels for burbot in the Kootenai River will be refined as this program progresses and will require substantial monitoring of experimentally released fish. Future annual Phase 4 production might range anywhere from zero to substantially greater than 10,000-20,000 burbot depending on findings. The conservation aquaculture program will be terminated if natural production objectives are met or if survival of hatchery fish is so low as to not be cost effective. The conservation program might also be replaced with a harvest-oriented program if restoration of natural production is ultimately determined to be infeasible. Habitat and environmental productivity and capacity will dictate long-term effective population sizes, production, and stocking requirements. Little biological information is available for burbot in this system, especially for juveniles; therefore, it will be essential to implement adaptive management to make decisions and adjust the scale and scope of a production program accordingly. The Twin Rivers facility will allow restocking efforts to be fully implemented in a manner that allows for this adaptive, experimental reintroduction and restoration program to meet its objectives.

ISRP Comment 30: [*A series of comments that appear on Page 8 of the ISRP Preliminary Review document are similar to comments expressed previously and each has been addressed above.*]

Project Sponsor Response 30:

This group of comments is addressed in previous responses.

ISRP Comment 31: *For Burbot, three alternatives are listed: status quo (do nothing), a new facility, and use of an existing facility. Evidently, because of concerns for the stock concept and escape of fish, the alternatives included only rearing fish within the Kootenai subbasin. Few alternatives thus exist. However, ongoing research at the University of Idaho identified in the plan suggests that there are no clear rules as to where (i.e., in which basin) the fish may be reared, at least for experimental purposes. Stronger scientifically based rationale needs to be articulated as to why the listed alternatives are limited to within the subbasin. Restricting considerations for rearing burbot to within the subbasin clearly limits options. Such within subbasin considerations may be ecologically sound and favor a new hatchery. However, because of the cost of a new hatchery, it should be clearly discussed why rearing of all types must remain in the subbasin and other production facilities could not be used. It would also be worthwhile to contact regional agencies with hatcheries to assess their restrictions and limitations. The proposed approach may indeed be the most appropriate one, but better justification for the limited range of alternatives considered would improve the plan.*

Project Sponsor Response 31:

In addition to the alternatives described in the Master Plan, other options for culturing burbot were considered but eliminated for regulatory and suboptimum fish culture reasons.

The UI-ARI facility is not adequate to meet Phase 3 program requirements for a number of reasons. The primary goals of the UI-ARI program are to develop and refine aquaculture techniques for burbot and to produce juvenile burbot to address a range of experimental questions. The facilities available at the UI-ARI are well suited for the majority of work that can be successfully performed at a small scale, but are inadequate in scale to fully address the needs of an experimental release and/or population restoration program. The use of the ARI facility in these initial phases of the program is well justified and has advanced our knowledge of this species substantially. Fish produced in the UI-ARI facility can continue to be used in the future for experimental releases; however, the scale at which this can be done is limited. The ability for the UI-ARI facility to be expanded is limited by water availability, dechlorination capabilities for the existing water supply, and available physical space. The UI-ARI could become a small-scale failsafe for the Twin Rivers facility assuming the continued program needs fit with the research mission of the UI-ARI. Fish produced at ARI currently meet the out-of-basin requirements for experimental release to the Kootenai River, but few other operations would be capable of this.

Furthermore, best aquaculture practices endorsed by NPCC and others discourage transferring fish out-of-basin for ecological and pathological reasons. Out-of-basin propagation alternatives suffer from a variety of problems that limit their suitability for the burbot aquaculture program. From this standpoint, the out-of-basin UI-ARI facility is not well suited for large-scale production of burbot destined for the Kootenai system.

Pathology concerns are particularly significant in out-of-basin facilities. Inter-basin transfers of fish and water risk introduction and spread of non-endemic pathogens. This risk greatly complicates the aquaculture program implementation. All states, provinces and collaborating agencies and tribes have serious concerns regarding the risks of inter-basin transfers and regulate fish movements. If disease is detected in fish reared out-of-basin, there is little chance that fish would be released due to concerns of introducing non-endemic pathogens or unique strains of a pathogen to new waters. Although extensive measures have been taken to monitor and avoid introduction of non-endemic pathogens, a significant outbreak would preclude fish from being transported and released in the Kootenai and would result in the loss of at least one year class. Due to the reliance on a closed or semi-closed recirculation system for current production of fish at UI-ARI, detection of a non-endemic pathogen may require the eradication of all fish at the facility and complete disinfection. Disease inspections following USFWS Title 50 requirements are completed prior to release to certify UI-ARI disease free status. Despite these measures, the risk of detecting a pathogen that is non-endemic to the Kootenai system cannot be discounted. This is a significant risk that would be minimized by implementing design criteria and rearing fish within basin, as is proposed at the Twin Rivers site.

Additional problems with out-of-basin rearing include transportation stress, acclimation requirements, and escapement risks. Long-distance transport increases the potential for stress-related direct and delayed post-stocking mortality. The combined stresses of transport and release into the unfamiliar natural environment could significantly reduce post-release survival. We just do not know how well burbot will respond to significant handling and it seems prudent to minimize potentially risky practices whenever possible. The significance of acclimation or imprinting for burbot is unknown but may be found to be important in the future. Rearing of burbot in close proximity to historical spawning areas will provide the best long-term prospects for successful migration and spawning if imprinting is important for burbot. Finally, local rearing also avoids risks associated with the potential escapement of non-endemic stocks. Current UI-ARI facilities are unique in that any effluent drains directly to the Moscow wastewater treatment plant and is fully disinfected. This prevents escapement of burbot (especially larvae) to natural waters where they are not native. Implementing such safeguards at other potential out-of-basin facilities may be difficult, expensive, and therefore infeasible.

The burbot component of the proposed Twin Rivers facilities represents a relatively modest and fiscally responsible investment that capitalizes on many shared sturgeon operational components. Concurrent development of the sturgeon and burbot facilities results in significant cost savings for the burbot relative to the independent construction of new facilities at a later date. These would include separate water supply and treatment facilities, separate effluent treatment and distinct operational infrastructure. Expanding existing facilities or constructing facilities outside of the basin (even if possible and recommended) would require greater expenditures over the long term[17].

Finally, developing the Twin Rivers facility satisfies a prerogative for local involvement in the Kootenai ecosystem recovery effort and requirements to address Treaty Trust obligations. Local involvement is a mandate of the KVRI burbot subcommittee, operating under a MOU signed by representatives of state, federal, tribal and provincial fishery and river management interests and local governments. Tribal Treaty and Trust obligations are furthered through development of the Twin Rivers Hatchery for a multitude of reasons. First, this aquaculture program has the potential to restore a culturally important Kootenai Tribal fishery and the ability of the Tribe to exercise its Treaty-reserved fishing rights. The U.S. government's government-to-government relationship with and trust responsibility to the Kootenai Tribe are also furthered through the partnerships developed under this Tribe-led program.

ISRP Comment 32: *As part of this justification, the burbot genetics, as far as are known, need to be clearly described, including ranges and locations of the fish of the different clades (Columbia, Missouri, Mississippi; Powell et al. 2008). Is it not so that both Mississippi and Columbia clades are found in the Kootenai basin? How well are different clades and stocks delineated? How different are they in life histories? Does the evidence suggest strong selection has occurred for stock-specific traits, as in salmon? Because so few burbot remain in the lower Kootenai (less than 50), a remnant neighboring stock is proposed. Are there clearly enough fish from this neighboring stock for the proponents to be sure that they will be a viable egg source?*

---

[17] Managers of the Fort Steele Hatchery in British Columbia were contacted about the potential to include burbot production at this existing facility (B. Ludwig, BCFFS, pers. comm. with S. Ireland, KTOI, May 18, 2010). Fort Steele Hatchery currently operates at capacity. Producing burbot would occur at the expense of ongoing production commitments.

Although the rudiments of burbot genetics and culture are being discovered, relatively little is known about the ecology of burbot and factors needed for their survival once released. This is supported by comments at the bottom of page 9-1. At this time the ISRP believes it is premature to initiate development of a production scale hatchery to rear burbot. Resources need to be committed to developing a better understanding of factors affecting their survival after stocking before full-scale hatchery is initiated.

Project Sponsor Response 32:

As part of this justification, the burbot genetics, as far as are known, need to be clearly described, including ranges and locations of the fish of the different clades (Columbia, Missouri, Mississippi; Powell et al. 2008).

Burbot's widespread distribution and persistence was the subject of two recent phylogeographic studies comparing Palearctic and Nearctic post-glacial dispersal (Van Houdt et al. 2003; 2005). Based exclusively on mitochondrial DNA (mtDNA), these authors reported two phylogenetically distinct burbot lineages in North America: L. lota maculosa (Hubbs and Shultz 1941) south of the Great Slave Lake, Canada and L. lota lota (Hubbs and Shultz 1941) in the remainder of the Nearctic region and all of Eurasia. They reported that L. lota maculosa consisted of three mitochondrial clades ostensibly arising from allopatric separation in different Wisconsonian glacial refugia (Van Houdt et al. 2003; 2005). Two of these North American clades were observed east of the Continental Divide (Mississippi and Missouri clades).

In the Kootenai River of Idaho, Montana and British Columbia, Paragamian et al. (1999) described statistically significant clinal variation using restriction fragment length polymorphism (RFLP) analysis with mtDNA. A significant difference in burbot mtDNA haplotype frequency distributions was reported between samples collected above and below Kootenai Falls, Montana. Subsequently, Powell et al. (2008) examined 372 burbot collected from 28 sample locations across its range in the Pacific Northwest. A 572 bp portion of the mitochondrial Cytochrome b-gene was used to estimate diversity and divergence among populations and further characterize matrilineal lines. Three distinct haplogroups of burbot were observed which correspond to past allopatric distributions within Pleistocene refugia, namely the Pacific, Mississippi, and Missouri clades. Within the Columbia/Kootenai River basins west of the Continental Divide, admixtures of Pacific and Mississippi matrilines were indicative of both post-glacial expansion and sorting, and clinal variation resulting from vicariant events as seen in the Kootenai River population downstream from Kootenai Falls.

As noted by the ISRP, Powell et al. (2008) reported that burbot in the Kootenai River of Idaho and British Columbia represented a mixture of Pacific and Mississippi River clades. Moyie Lake burbot were exclusively composed of Pacific clade fish. However, the actual sample sizes from each sampling location in this study were not published, so it is unclear to what extent these results may have been affected by small sample bias. Although these clades were clearly delineated, the mtDNA provides only comparative information on matrilinial phylogenies, and does not involve adequate resolution available from the nuclear (bi-parentally inherited) genome to distinguish recent fine-scale divergence among populations or stocks. This kind of information is needed to guide decisions about small scale and recent divergence issues associated with Kootenai program broodstock selection. The mtDNA analyses reported above should be supplemented with more informative, higher resolution nuclear microsatellite analyses that will be more appropriate for evaluating future decisions involving local burbot stock or population comparisons. Such analysis has not yet occurred. The Tribe will coordinate with IDFG to determine if they have appropriate samples for this analysis and whether such an analysis is planned.

Although the rudiments of burbot genetics and culture are being discovered, relatively little is known about the ecology of burbot and factors needed for their survival once released. This is supported by comments at the bottom of page 9-1.

Until recently, burbot have received relatively little management or research attention for a species with their wide distribution; however, this species has been the focus of growing interest in recent years. For instance, three international symposia recently focused on burbot. Two peer-reviewed proceedings have been published, including 38 papers on the biology, management, ecology, genetics and culture of burbot. A third proceeding will likely be available in 2010.

Kootenai burbot conservation and research efforts have made significant contributions to the scientific burbot literature. Since 2006, numerous scientific articles have been produced by the project collaborators (Ireland and Perry 2008; Jensen et al. 2008a, 2008b, 2008c; Jensen and Cain 2009; Polinski et al. 2009a, 2009b, 2009c; Paragamian et al. 2008; Zuccarelli et al. 2007). Appendix 1 provides a brief summary of burbot program development and success leading up to and including initial experimental releases that occurred in the fall of 2009. In summary, spawning and semen cryopreservation methods were developed, followed by incubation methods, and larval and juvenile feeding strategies involving intensive, semi-intensive (fertilized and zooplankton enhanced ponds) and extensive (unaided pond culture) methods. In addition, research to characterize burbot disease susceptibility and to establish burbot cell lines for diagnostic purposes was recently completed.

With these fundamental methods in place, and with the new knowledge gained through disease susceptibility studies, the experimental program was able to move forward with the first experimental release of cultured burbot in British Columbia and Idaho. During October and November 2009, 247 burbot cultured at the UI-ARI were released into the Kootenai River system in four different locations. These releases represent a milestone for the program, the species and the subbasin, as the first time burbot have been artificially propagated and released jointly into U.S. and Canadian waters for conservation purposes. The success of this experimental project paves the way for ongoing burbot conservation aquaculture development and facilitates research necessary to address in-river critical uncertainty and limiting factors.

Ongoing burbot aquaculture research is focused on developing extensive and semi-intensive culture methods and temperature related growth studies. The experimental release component of this project provides the foundation for studying post-release survival, growth, and condition of hatchery produced burbot. In addition, 30 of the 247 burbot released were two years old and were large enough to be implanted with ultrasonic transmitters. These sonic tagged hatchery reared fish are expected to provide valuable information about habitat preferences, seasonal movement patterns, spawning habitat selection, and reproductive behavior.

This work is supported by the Kootenai Tribe's fisheries program, the BC Ministry of Environment, the USFWS, the IDFG and the UI-ARI. University of Idaho burbot aquaculture and reproductive biology researchers are also in communication with burbot researchers who are investigating burbot recovery in Belgium, the United Kingdom, Germany and Finland, and contributing to success of the UI-ARI program, and to burbot conservation and restoration on both continents.

At this time, the ISRP believes it is premature to initiate development of a production scale hatchery to rear burbot. Resources need to be committed to developing a better understanding of factors affecting their survival after stocking before full-scale hatchery is initiated.

The Kootenai Tribe of Idaho is dedicated to the conservation and restoration of a healthy ecosystem that fully supports traditional Tribal and other important societal uses. A comprehensive ecosystem restoration program has been undertaken by the Kootenai Tribe in cooperation with multiple government and non-governmental parties, consistent with shared values and goals as well as tribal trust responsibilities. Burbot were a keystone species in the native ecosystem and are a high priority of the restoration effort. An expanded burbot culture facility is an essential element to achieve restoration objectives developed under the NPCC's Fish and Wildlife Program and the local Kootenai Valley Resource Initiative.

Kootenai burbot have been subject to almost two decades of research and monitoring which has documented the population collapse but failed to prevent extirpation (Paragamian et al. 2000; 2008). Too few wild burbot now remain to support an effective research and monitoring program to identify factors limiting survival and impediments to restoration. Too few wild burbot exist to take advantage of the benefits of other ecosystem measures including tributary habitat improvements, kokanee rebuilding, lake and river fertilization, and mainstem habitat improvements. However, while the disappearance of the native burbot population has eliminated any opportunity for conservation and rebuilding of this unique stock, it has also eliminated many of the hatchery-related risks to the wild fish that have driven concerns for other hatchery programs throughout the Pacific Northwest.

A conservation aquaculture program now provides the best prospects for timely diagnosis of the root causes of the burbot population failure, identification of effective remedies, and evaluations of restoration feasibility. Burbot culture plans and facilities are based on a stepwise, experimental, incremental, and adaptive approach to restoration. As previously discussed, phase I of the burbot program determined that aquaculture was feasible. This work was primarily research oriented and was conducted in laboratory facilities at the University of Idaho.[18] Phase II is a pilot study based on post-release monitoring of burbot produced at the UI facility. These fish will serve as research subjects to evaluate distribution, movements, habitat use, food habitats, and effective sampling methods by life stage. Phase III involves the production and release of sufficient numbers of burbot to support population-level research and monitoring based on survival, growth, and maturation. Experimental

[18] This work has effectively addressed concerns about uncertain prospects for the successful culture of this previously uncultured species. During the past several years, a team headed by the Kootenai Tribe of Idaho and the University of Idaho, has published nearly a dozen peer-reviewed papers on various aspects of burbot reproductive biology, aquaculture, and pathology. These pioneering efforts have now firmly established the feasibility of burbot culture.

releases of significant numbers of fish of various sizes will identify life stage limitations and provide a focus for habitat restoration efforts. Estimates of survival, growth, and maturation will provide a quantitative basis to estimate the scale of production that might be required to meet to long-term restoration objectives.

Phase III objectives drive the need for additional burbot production facilities. Potential survival schedules and statistical power analyses demonstrate that current production levels are unlikely to provide the precision necessary to assess burbot survival with any degree of confidence. In the long term, more limited releases may result in too few fish surviving to adulthood to determine if hatchery-reared fish might ultimately contribute to natural production. By scaling up to make a proper experimental evaluation, we have put ourselves in the best possible position to get definitive answers in a reasonable amount of time. The NPCC Fish and Wildlife Program has consistently identified the value of an adaptive experimental approach to conservation and restoration according to the original Kai Lee definition. The burbot restoration strategy is designed to do exactly that.

The Master Planning exercise included careful consideration of other alternatives before developing the current proposal. The UI facility is not adequate to rear sufficient numbers to conduct Phase III evaluations. There is no room for expansion of the experimental program in the existing Tribal Sturgeon Hatchery or Canadian sturgeon facilities to accommodate burbot. Modification of other area facilities would require significant expenditures and involve potentially undesirable tradeoffs regarding staffing, priorities, transport, etc.

Burbot plans are informed by the 20-years of lessons from the sturgeon aquaculture program. The sturgeon program demonstrated that failure to develop effective programs and facilities at the outset could be much more costly and less efficient in the long run. Up-front investments in an aggressive adaptive experimental approach are likely to produce significant long-term cost savings relative to implementation of a more measured and mechanistic research program. The Columbia Basin Fish and Wildlife program has a history of very costly research that produced significant scientific findings that have not translated into direct fish benefits. Research can be beneficial in identifying and avoiding obviously ineffective actions. However, the only way to effectively evaluate many actions will be through carefully controlled experimental implementation, which is the Tribe’s proposed approach.

The Kootenai Tribe has a successful record of cost-effective, well-staged experimental research and conservation production of sturgeon. Based on a 20-year history of successes developing native primitive fish aquaculture programs in the face uncertainties, we are confident that the proposed approach provides the best balance between the precautionary approach, efficiencies, and success. The proposed approach intentionally provides phases, safeguards, flexibility, and an adaptive management approach to maximize the chances of program success and identify problems and failures early on and improve the program.

ISRP Comment 33: *Additional information needs to be provided regarding the historical importance of the burbot fishery. Were they a significant part of the fish community in terms of number and biomass?*

Project Sponsor Response 33:

The following historic burbot harvest information was excerpted from various documents including the Kootenai River Subbasin Plan (KTOI and MFWP 2004), Hammond and Anders (2003), Anders et al. (2002), Paragamian et al. (2002) and the KVRI Burbot Conservation Strategy (2005).

Historically, Kootenai subbasin burbot supported numerous and varied fisheries between Bonnington Falls and Kootenai Falls. Native Americans traditionally targeted burbot during the winter spawning period as a source of fresh meat when other food resources were limited. Recreational burbot fisheries subsequently developed throughout the subbasin, primarily focused on local spawning aggregations. Numerous credible, independent, written accounts of significant burbot harvest suggest that Dustbowl immigrants to the Idaho portion of the Subbasin were responsible for significant and unregulated burbot harvest during the 1930s (KVRI 2005).

A significant winter burbot fishery persisted into the 1950s and 1960s in the Idaho portion of the Subbasin. Partridge (1983) reported that local residents harvested and canned burbot during the winter months to supply their personal needs or for sale in local stores. Burbot were still reported to be abundant during the 1950s, with one angler selling 380 kg (838 lbs) in 1951, and a Bonners Ferry market handling 1,800 kg (3,940 lbs) of burbot during 1957. Three additional fishermen harvested over 2,000 kg (4,409 lbs) of burbot from the Kootenai River during 1958 (IDFG unpublished data). Anglers reported catching as many as 40 burbot per night during winter setline fishing trips in the Kootenai River, where past annual burbot harvest was estimated at approximately 22,700 kg (50,053 lbs) (Paragamian and Whitman 1996; Paragamian et al. 2000). This annual harvest weight represents just over 10,000 five-pound fish, or 16,684 three-pound fish, which does not appear to be sustainable.

A very popular recreational burbot fishery also occurred in the West Arm of Kootenay Lake during late spring and early summer in the 1960s and 1970s. Catches peaked at over 20,000 burbot per year around 1970 that substantially exceeded optimum sustained yield levels estimated for the population (Martin 1976). Catches declined rapidly after 1975 and the fishery disappeared by 1986 (Redfish Consulting Ltd. 1998).

ISRP Comment 34: *…adequate for white sturgeon Step 1, but lacking adequate detail for burbot. Once the biological objectives are clarified, Step 2 and Step 3 need to provide specifics on the monitoring to establish that both the production and post-release phase monitoring is reasonable and feasible. The ISRP is concerned that post-release survival monitoring, which obviously is very important to the KTOI aquaculture plan goals, depends on the cooperation of agencies outside the KTOI. The links are supposed to be made with other agencies, but the proposal would be improved by providing more explicit information. For example, are agreements in place or firmly proposed?*

Project Sponsor Response 34:

Burbot monitoring and restoration efforts over the last decade have been the subject of a cooperative program involving the Kootenai Tribe, BC Ministry of Environment, IDFG and a variety of other agencies that are signatories to the KVRI Burbot Conservation Strategy (KVRI 2005). The Tribe has ongoing contracts with BC MoE to provide burbot capture and stock assessment services on Kootenay Lake and associated waters in Canada as a component of the burbot restoration process. BC MoE is responsible for these species in Canadian waters and conducts monitoring activities required in that geographic area. The BC MoE also coordinates and oversees annual burbot broodstock and gamete collection at Moyie Lake.

These ongoing contracts with BC MoE include provisions for annual indexing programs for burbot and sturgeon in British Columbia, developing planning documents (5-Year Plan, Stocking Strategy, etc.) as well as maintaining a comprehensive telemetry array to evaluate white sturgeon and the most recent burbot releases from Tribe's hatchery program. These contracts also include projects that provide burbot broodstock for hatchery production from lakes in British Columbia, evaluate the impact of broodstock collection on these native populations, and monitor and evaluate additional mortality factors (angling and other sources) in these locations in order to safeguard broodstock sources for future hatchery program production.

The Tribe and its agency partners are in the process of updating their coordinated monitoring program for Kootenai burbot. Burbot sampling activities, currently involving only wild fish, are also coordinated among regional agencies under the KVRI Burbot Subcommittee and the MOU. Burbot sampling activities are implemented by coordinated efforts of the Tribe, IDFG, and BC MoE, as provided in the 5-Year Burbot Implementation Plan (2006-2010). Post-release monitoring of hatchery burbot is a core program element of the current plan. IDFG and BC MoE monitor remnant burbot in the Kootenai River and the annual releases of hatchery-produced burbot from the program that began during 2009. Adult population assessment methods are well established and currently undertaken on an annual basis. Burbot recruit to adult sampling gear at about 3 to 4 years of age and 400 mm in length. The presence of hatchery progeny in the river will provide the opportunity to develop effective sampling and assessment methods for juveniles as well. Long-term monitoring plans, to be initiated in 2011, are under development by the program cooperators. Detailed monitoring and evaluation plans will be provided as part of Step 2 materials supporting this proposal.

The burbot monitoring strategy builds upon the success of the Kootenai Tribe and its partners with white sturgeon. Sampling white sturgeon life stages in the Kootenai River (wild eggs, embryos, juveniles, and adults), and recapturing hatchery-produced juveniles has been successfully implemented for decades with the IDFG and the BC MoE. All sturgeon sampling activities are coordinated through the USFWS Recovery Team and through local coordination summarized in the 5-year Sturgeon Implementation Plan provided by the Tribe and cooperating agencies (this plan is currently being updated for 2011-2014).

ISRP Comment 35: *The Master Plan also cites a manuscript "Don't save sturgeon with salmon hatcheries" to indicate they have recognized the special features of sturgeon and burbot life histories that make the requirements for programs different from salmon programs. However, they have not actually summarized these points. It would be good to include more in depth discussion of how the* *breeding, culture, and release programs have been guided by the life-history attributes of the species. (BUR17)*

Project Sponsor Response 35:

The paper referred to in the ISRP comment (*Don't save sturgeon with salmon hatcheries: Life history matters*; Anders 2004) does not specifically mention burbot life history characteristics. However, the justifications provided below in response to this comment apply to any species in a conservation aquaculture program.

Two important points need to be made in this response. First, the distinction between conservation aquaculture and more familiar salmon supplementation hatchery programs is crucial and will be briefly explained. Secondly, the need to incorporate species-specific life history trait expressions and behaviors into a conservation aquaculture program's facilities and operations will be briefly explained.

Conservation Aquaculture vs. Supplementation Programs: The objective of *c*onservation aquaculture is to conserve and recover imperiled fish populations, without harvest or production quotas driving hatchery operations. Conservation hatcheries are focused on producing sustainable age class structures in populations with limited or no natural recruitment, while maximizing remaining native genetic diversity. Conservation aquaculture involves incorporating local gene pools and allowing sufficient migration of genes into hatchery broodstock and progeny groups to allow adequate allelic representation for population viability and persistence. It requires careful selective breeding programs to provide sufficient diversity within a fish population of interest. It necessitates eliminating as much artificial conditioning as possible. When successful, it provides the increased population base on which natural selection can operate. Because of its design, conservation aquaculture can reduce the commonly considered risks associated with high-density salmonid supplementation hatchery production, such as competitive feeding behaviors, reduced growth rates, domestication selection, and increased incidence of disease.

Conservation aquaculture by no means presents the same risks associated with letting nature take its course when nature is no longer able to sustain a wild, native fish population, as typically occurs in severely altered watersheds. In the case of both the Kootenai Tribe's burbot and sturgeon hatchery programs, aquaculture is proposed and currently used as an interim measure to protect or rebuild populations when the timeframes of habitat restoration greatly exceed estimated population persistence. In other words, without conservation hatchery programs these populations would go extinct before habitat restoration required to reestablish natural production could be implemented and tested. Finally, the success of restoring natural production, to the degree required to restore these populations, is not guaranteed. For example, in the Kootenai River, experimental hydro operations at Libby Dam affecting downstream hydrographs and thermographs since the early 1990s failed to improve or restore natural recruitment of sturgeon and burbot. Supplementation hatcheries often produce fish destined for release in other areas, compared to the within-basin focus of conservation programs, consistent with co-evolved plasticity, life history expression, and pathogen resistance attributes.

The conservation aquaculture approach proposed for burbot and ongoing with white sturgeon differs from more traditional hatchery supplementation programs that measure success largely by the total number of fish released. A comparison between the Tribe's proposed conservation aquaculture programs for burbot and sturgeon, and a salmon supplementation program is presented in Table 10 to enhance this discussion requested by the ISRP.

Table 10. Comparison of conservation aquaculture and supplementation programs.

Program Component	Conservation Aquaculture	Supplementation Programs
Goal	Conservation, recovery of threatened, endangered, or imperiled populations.	Harvestable excess, enhance population size
Production	Relatively few fish	Large number of fish
Rearing density	Lower	Higher
Disease risk	Reduced	Increased
Domestication risk	Lower	Higher
Post-stocking survival	Higher	Lower
Genetic criteria	High priority	Lower Priority

In this context, the Tribe's conservation aquaculture program is one complementary component of a multifaceted fish restoration program that includes habitat improvement efforts detailed in the Habitat Restoration Master Plan (KTOI 2009). Some supplementation programs treat the symptom of declining fish populations in lieu of addressing serious issues of degraded and lost fish habitat, or other causal factors. In contrast, the coordinated Kootenai Tribe's conservation aquaculture program is designed to be simultaneously implemented with habitat improvement and ecosystem restoration activities throughout the Kootenai Subbasin as described in the Subbasin Plan and the Tribe's Kootenai River Habitat Restoration Master Plan.

Incorporation of Species–Specific Life History Traits into Conservation Aquaculture: The failure to account for the natural range of species-specific life history trait expressions and behaviors in the hatchery can jeopardize the success of any hatchery program (Brannon 1993). Brannon (1993) further suggested that if hatchery programs neglect the requirements of natural populations, and therefore the traits they possess that allow them to synchronize their life history with specific environmental constraints, failure is all but certain.

Thus, well designed conservation aquaculture programs should focus on hatchery protocols and facility designs and operations that best mimic and complement natural reproductive and life history attributes of the target species (Table 11) and the adaptive and evolutionary benefits of those attributes (Table 12).

For example, because sturgeon (and burbot) are iteroparous, females should be allowed to serve as broodstock in the hatchery upon subsequent availability, as long as they are mated with numerous different males, as would occur during natural spawning of larger populations in the wild due to sex-specific differences in spawning periodicity. As another example, communal broadcast spawning naturally contributes to complex gene flow patterns in sturgeons. Burbot express similar reproductive traits (iteroparity and communal spawning), thus, this trait should also be reflected in the design of their breeding matrices. This feature can be addressed to some degree in the hatchery by fertilizing each female with gametes from multiple, different males, either directly or by volitional (in-tank) spawning by a unique array of male and female spawners in each tank.

Table 11. Comparison of white sturgeon and Pacific salmon reproductive and life history strategies.

Reproductive and Life History Attributes	**White Sturgeon *(Acipenser transmontanus*)**	**Burbot (*Lota lota*)**	**Pacific Salmonids (*Oncorhynchus spp*.)**
Spawning type	Iteroparity Communal spawners Broadcast spawning	Iteroparous, inter-mittent, communal spawning	Semelparity Paired spawners Redd-building
Individual fecundity (number of eggs per female)	100,000 ->1 million eggs	< ~ 3 million eggs 300,000-400,000 eggs per 20 kg Moyie Lake Fish UI-ARI	1,500 – 12,000 eggs
Generation length	20-30 years	~ 5 years	3-6 years
Longevity	≥ 100 years	Into their 20s	< 10 years
Age at first maturity	15-25 years	2-3years (males) 4-5 years (females)	2-7 years
Number of year-classes spawning together	Several - dozens	Several	1-3

Source: Modified from Anders 2004 to include burbot

Table 12. Beneficial aspects of white sturgeon reproductive and life history attributes to incorporate into conservation aquaculture programs.

Reproductive and Life History Attributes	Benefits
Iteroparity	Multiple opportunities to pass gametes on to subsequent generations within a single lifespan; increases among
Overlapping generations	Increases between and among generation gene flow
Differential sex-specific age at first maturity	Reduces reproductive synchrony of male female siblings and half
Differential sex-specific spawning periodicity, communal, broadcast spawning	Reduces reproductive synchrony of male and female siblings and half

Source: Anders 2004

Natural reproduction in viable sturgeon populations is also characterized by interbreeding individuals from many cohorts, year-classes, generations, and families. Spawning matrix design can partially incorporate this natural reproductive strategy by ensuring that fish of considerably different ages (sizes) are interbred. Although it is not assumed that every ripe male and female spawn successfully within a cohort, intentionally mating fish of considerably different sizes (ages) from larger populations increases inter-generational gene flow, based on assumptions of the natural sturgeon reproductive model, while acknowledging that the number of different family lineages decreases non-linearly with reduced population abundance or remnant population status.

Finally, whether in the wild or in the hatchery, reproductive and life history traits retained by natural selection and evolution as evolutionarily stable strategies affect cohort performance and survival before and after release from the hatchery. Therefore, it is critical that fisheries managers, hatchery managers, and fish culturists to work together to collectively understand the natural reproductive and life history strategies of fishes they manage and culture because these natural models provide successful, time-tested examples to guide design and operation of species-specific conservation aquaculture facilities and programs.

ISRP Comment 36: *For burbot, the plan does not present enough detail on the current naturally existing population of burbot to provide a model to guide artificially reared fish production to the point of release. There is scientific literature available to draw on, that could/should be incorporated into the plan. A risk assessment of potential impacts from artificially produced burbot to other burbot populations in the subbasin is needed.*

Project Sponsor Response 36:

The meaning or intent of the ISRP's statement that "the plan does not present enough detail on the current naturally existing population of burbot to provide a model to guide artificially reared fish production to the point of release" is unclear. If the ISRP is suggesting that we lack a natural population template for Kootenai River burbot – that is true. For practical purposes, the population has been extirpated, as has the formerly robust Kootenay Lake West Arm population (Ahrens and Korman 2002; Pyper et al. 2004; KVRI 2005; Paragamian et al. 2008). The restoration effort must thus rely on a combination of anecdotal historical information and experimentation to guide actions. For instance, initial experimental releases included 30 burbot fitted with ultrasonic transmitters that were released into the Goat River, a known historical spawning tributary of the lower Kootenai River.

We assume that the ISRP is not suggesting that we attempt to recreate natural incubation and rearing conditions in the hatchery prior to release. The hatchery program is designed to avoid potentially selective practices that reduce genetic diversity and favor traits or behaviors that may not prove adaptive in the wild. However, in order to provide adequate numbers of fish for the release experiments, incubation and rearing conditions and practices have to be tailored to practical realities. In the end, the success of reintroduced burbot must necessarily depend on the expression of innate behaviors and habitat use patterns otherwise unknown from field studies.

Risk to other subbasin populations of burbot have been determined to be very low. Populations in the Lower Kootenai River and the West Arm of Kootenay Lake have functionally ceased to exist. The burbot population in the Duncan system entering the North Arm of Kootenay Lake is isolated by Duncan Dam. Broodstock originate from the upper Moyie River system, so that population is subject to no genetic risks from program-produced fish because those fish remain downstream in the Kootenai River and Kootenay Lake. Furthermore, because there is an impassible dam on the lower Moyie River in Idaho (at Moyie Springs), none of these fish could migrate back upstream to Moyie Lake. Burbot are plentiful in the upper Kootenai system, including Lake Koocanusa where they are segregated from the lower Kootenay population by Kootenai Falls and Libby Dam.

ISRP Comment 37: *HGMP for white sturgeon is included in Appendix A, but it is dated 2000. It is the only source for some of the history of fish production of sturgeon by the program. While the HGMP doesn't require updating if it is not required for permitting under the ESA, additional presentation and summary of the production, release, and evaluation program is needed early in the Master Plan. No HGMP is provided for burbot.*

Project Sponsor Response 37:

Answers to the ISRP comments have included much additional background information on the history of the sturgeon conservation aquaculture program. A Kootenai Burbot HGMP has been prepared and is attached as Appendix 2.

ISRP Comment 38: *No, there is no separate section in the plan as the comprehensive environmental assessment. Do subsections 3.1, 3.2, and 3.3 serve this function? Seems like this information was taken directly from the Kootenai River Subbasin Plan?*

Project Sponsor Response 38:

The ISRP comments that the Master Plan does not contain a comprehensive environmental assessment and correctly observes that much of the information contained in Section 7.1 was taken from the Kootenai River Subbasin Plan.

In the NPCC's November 2006 guidance document for the Three-Step Review Process (NPCC document 2006-21), Part II generally describes what is to be included in the submittals for each step. A footnote to this section states that Step 2 documentation includes "preliminary design and cost estimation, and environmental (NEPA and ESA) review". Based on this guidance, the Step 1 Master Plan developed for the Native Fish Conservation Aquaculture Program defers the detailed environmental analysis until Step 2. We attempted to address further guidance from the NPCC to "describe the status of the comprehensive environmental assessment (Step 1 and 2)" by identifying the Tribe's plan for conducting this assessment.

While we appreciate that more detailed environmental information would contribute to a thorough evaluation of the Tribe's proposal, we believe that the current sequence is appropriate for several reasons. Preparing an environmental assessment or environmental impact statement is a very significant undertaking and must be based on the development scenario most likely to be pursued. To conduct such an assessment of a project still in the conceptual design phase would entail significant cost and risk that major design changes could occur during more detailed Step 2 preliminary design, necessitating a supplemental environmental evaluation. In order to balance this risk with the need for a general sense of the environmental soundness of a project, existing information was used to characterize the resources, habitat and uses that could be affected by the Tribe's proposed aquaculture program.

Location of Responses in the 2010 Revised Master Plan

The Tribe incorporated many of these responses into the revised Aquaculture Master Plan that was submitted to the NPCC in June 2010. The following table identifies the location in the revised Master Plan of these responses.

ISRP Comment	Location of Response in Revised Master Plan
1. History of sturgeon program	Sections 2.2, 2.2.1, 2.2.2, 2.2.2.1, 2.2.2.2, 2.2.2.3, 2.2.2.4, 2.2.2.5 and 2.2.3
2. Justify biological objectives for sturgeon	Section 4.1.2
3. Sturgeon production plan	Sections 4.1.3.2, 4.1.3.4 and 4.1.3.5
4. Facilities meet production plan	Section 4.3.1.2

ISRP Comment	Location of Response in Revised Master Plan
5. Release age for sturgeon	Section 4.1.2.4.
6. Release schedule for sturgeon	Section 4.1.3.7
7. Production numbers	Broodstock and family numbers are discussed in Section 4.1.2.1
8. Sturgeon survival rates	Sections 4.1.2.3 and 4.1.2.4 address this topic.
9. Need for Twin Rivers Hatchery	Section 4.1.1.2
10. Probability of extinction	Concepts addressed in Section 4.1.2.4
11. Habitat capability to support released sturgeon	Section 4.12
12. Year class sizes	Most of response added to Section 4.4.4.1
13. Habitat carrying capacity	Section 4.4.2.1
14. Sturgeon program termination	Section 4.5.2.2
15. Implications of revised sturgeon population estimates	Section 3.1.9.1
16. Cooperative sturgeon investigations	Sections 3.1 and 3.4.1.3
17. Monitoring and evaluation	Section 4.4
18. Sturgeon and burbot production numbers	Topic covered in other responses
19. Role of sturgeon in food web	Sections 3.3.1 and 4.4.4.1
20. Clarify production numbers and genetic breeding design	This topic was clarified and discussed in a number of places. Additionally, the Burbot HGMP was prepared and is presented in Appendix C.
21. Upper Columbia sturgeon initiatives	Section 3.1.4.3
22. Program risk to other sturgeon populations	No response required
23. Burbot in DPS are sufficiently abundant	Portions already addressed in Section 3.4.1.1. Other portion added to 3.1.9.2.
24. Habitat suitability for burbot	Section 5.4 and mentioned in Section 2.3.5
25. Evidence of burbot recruitment	Portion of response added to Section 5.1.2.1
26. Burbot program is premature	Section 5.1.2.2
27. Provide burbot HGMP, subbasin risk assessment and burbot harvest plan	Appendix C; Sections 5.1.2 and 5.11.3
28. Role of burbot in trophic assemblage	Section 5.7.3
29. Biological objects for burbot and sturgeon	Portions added to Section 5.1.2.3, portion added to Section 2.3.5, and remainder added into Section 5.1.2.2
30. Duplicate comments	No response provided.

ISRP Comment	Location of Response in Revised Master Plan
31. Burbot program alternatives	Sections 5.2.3, 5.2.4, 5.2.4.1 through 5.2.4.3
32. Burbot genetics and scale of hatchery program	Clades are addressed in Section 3.1.9.2; Scale of hatchery is addressed in Sections 2.3.2 and 2.3.3
33. Historic importance of burbot fishery	Section 3.1.9.2
34. Burbot monitoring	Sections 5.4.4. and 4.4
35. Conservation vs. supplementation aquaculture	No response required in Master Plan.
36. Hatchery burbot impacts on wild population	Information already included in Section 3.1.9.2.
37. Burbot HGMP	Section 5.1.4
38. Comprehensive environmental assessment needed	No response required in Master Plan.

REFERENCES

Aherns. R. and J. Korman. 2002. What happened to the West Arm burbot stock in Kootenay Lake? Use of an age-structured population model to determine the possible causes of recruitment failure. Report prepared for BC Ministry of Water, Land and Air Protection, Habitat Conservation Trust Fund and BPA.

Anders, P. 2007. A decision guidance document regarding establishment of an experimental population of Kootenai River white sturgeon under Section 10(j) of the Endangered Species Act. Report provided to the Kootenai Tribe of Idaho and the Kootenai River White Sturgeon Recovery Team. 8 pp.

Anders, P. J. 2004. Don't save sturgeon with salmon hatcheries: Life history matters. *In*: Proceedings of 55th Annual Northwest Fish Culture Conference. December 7-9, Victoria, British Columbia.

Anders, P.J. 1998. Conservation aquaculture and endangered species: Can objective science prevail over risk anxiety? Fisheries Vol. 23(11): 28-31.

Anders, P. J., D. L. Richards, and M. S. Powell. 2002. The First Endangered White Sturgeon Population (*Acipenser transmontanus*): Repercussions in an Altered Large River-floodplain Ecosystem. Pages 67-82 *In*: W. Van Winkle, P. Anders, D. Dixon, and D. Secor, eds. Biology, Management and Protection of North American Sturgeons. American Fisheries Society Symposium 28.

Bailey, M.M. 1972. Age, growth, reproduction, and food of the burbot, Lota lota (Linnaeus), in southwestern Lake Superior. Transactions of the American Fisheries Society 101:667-674.

Beamesderfer, R. 2010. Estimation of salmon recovery targets using population viability analysis. Lower Columbia River Salmon recovery and fish and wildlife subbasin plan. Washington Lower Columbia River Fish Recovery Board.

Beamesderfer, R., C. Justice, B.J. Pyper, V.L. Paragamian, P.J. Rust, M.D. Neufeld, and S.C. Ireland. 2009. Evidence of density- and size-dependent mortality in hatchery-reared juvenile white sturgeon (Acipenser transmontanus) in the Kootenai River.

Beamesderfer, R. and C. Justice. 2008. Upper Columbia White Sturgeon Recovery Initiative. Sturgeon hatchery release targets: Report to the Upper Columbia White Sturgeon Recovery Initiative Technical Working Group. Prepared by Cramer Fish Sciences.

Brannon, E. L. 1993. The perpetual oversight of hatchery programs. Fishery Research 18:19-27.

Canadian Department of Fisheries and Oceans (CDFO). 2009. Draft recovery strategy for white sturgeon. Species at risk act recovery strategy series.

Courchamp, F.T. Clutton-Brock, and B. Grenfell. 1999. Inverse density-dependence and the Alee effect. Trends Ecol. Evolution 14:405-410.

Dillen , A., I. Vught, D. DeCharleroy, D. Monnier, and J. Coeck. 2008. A preliminary evaluation of reintroductions of burbot in Flanders, Belgium. Pages 179-183 *In*: American Fisheries Society Symposium 59, Burbot: Ecology, Management, and Culture.V. Paragamian and D. Bennett eds.

Drauch, A. and B. May. 2007. Genetic monitoring of the Kootenai Tribe of Idaho White Sturgeon Conservation Aquaculture Program. Report prepared for the Kootenai Tribe by the Genomic Variation Laboratory, University of California-Davis. Davis, CA.

Drauch, A. and B. May. 2008. Genetic Monitoring of the Kootenai Tribe of Idaho White Sturgeon Conservation Aquaculture Program. Davis, CA. University of California at Davis, Department of Animal Science, Genomic Variation Laboratory. November 2008.

Drauch, A. and B. May. 2009. Continued Genetic Monitoring of the Kootenai Tribe of Idaho White Sturgeon Conservation Aquaculture Program. Davis, CA. University of California at Davis, Department of Animal Science, Genomic Variation Laboratory. November 2009.

Dryer, M. P., and A. J. Sandoval. 1993. Pallid sturgeon recovery plan. USWFS Region 6, Denver CO.

Duke, S., P. Anders, G. Ennis, R. Hallock, J. Laufle, R. Lauzier, L. Lockard, B. Marotz, V. Paragamian, and R. Westerhof. 1999. Recovery Plan for Kootenai River White Sturgeon (*Acipenser transmontanus*). Journal of Applied Ichthyology, Vol. 15:157-163.

Duke et al. 1993. Columbia River juvenile white sturgeon diet analysis report(s) under BPA 86-50.

Ericksen, R., P. Anders, J. Siple, and C. Lewandowski. 2009. Status of Kokanee Populations in the Kootenai River in Idaho, Montana, and South Arm Kootenay Lake, British Columbia. Report prepared for the Kootenai Tribe of Idaho and the Bonneville Power Administration. 30 pp.

Falconer, D. 5. 1981. Introduction to Quantitative Genetics, 2nd Edition. Longman Inc., London. 352 pp.

Gregory, R. and L. Graham. 2008. Summary and Key Findings of Upper Columbia River White Sturgeon Recruitment Failure Hypothesis Review Upper Columbia River White Sturgeon Recovery Initiative, Jan 2007 – July 2008.

Hammond, R.J. and P. J. Anders. 2003. Population biology and population genetics reviews of Kootenai Basin burbot upstream from Bonnington Falls, BC. Report prepared for the Bonneville Power Administration. Portland, OR. Contract No. 00012146.

Hilborn, R., and C. J. Walters. 1992. Quantitative fisheries stock assessment. Chapman and Hall, New York.

Hildebrand, L. and K. English. 1991. Lower Columbia River fisheries inventory, 1990 studies. Volume I. Main Report.

Holderman, C., P. Anders, B. Shafii and G. Lester. 2009a. Characterization of the Kootenai River aquatic macroinvertebrate community before and after experimental nutrient addition, 2003-2006. Report to Kootenai Tribe of Idaho and Bonneville Power Administration. 94 pp.

Holderman, C., P. Anders and B. Shafii. 2009b. Characterization of the Kootenai River algae and periphyton community before and after experimental nutrient addition, 2003-2006. Report to Kootenai Tribe of Idaho and Bonneville Power Administration. 76 pp.

Holderman, C., P. Anders, B. Shafii, and G. Hoyle. Characterization of Water Quality in the Kootenai River before and after Experimental Nutrient Addition, 2003-2008. Report prepared for the Kootenai Tribe of Idaho. 72 pp. *In Preparation.*

Hoyle, G., P. Anders, B. Shafii, and C. Holderman. 2010. Characterization of water chemistry, chlorophyll accrual and periphyton taxonomy in the Kootenai River during experimental nutrient addition. Report prepared for the Kootenai Tribe of Idaho. 69 pp

Hubbs, C.L., and L.P. Schultz. 1941. Contributions to the ichthyology of Alaska with descriptions of two new fishes. University of Michigan Museum of Zoology, Occasional Papers 431, Ann Arbor.

Ireland, S. C., P. J. Anders, and J. T. Siple. 2002a. Conservation aquaculture: an adaptive approach to prevent extinction of an endangered white sturgeon population. Pages 211-222. in W. Van Winkle, P. Anders, D. H. Secor, and D. Dixon, editors. Biology, Management, and Protection of North American Sturgeon. American Fisheries Society Symposium 28. Bethesda.

Ireland, S. C., R. C. P. Beamesderfer, V. L. Paragamian, V. D. Wakkinen and J. T. Siple. 2002b. Success of hatchery-reared juvenile white sturgeon (Acipenser transmontanus) following release in the Kootenai River, Idaho, USA. Journal of Applied Ichthyology 18: 642-650.

Ireland, S. C. and P. N. Perry. 2008. Burbot restoration in the Kootenai River basin: Using agency, tribal, and community collaboration to develop and implement a conservation strategy. American Fisheries Society Symposium 59:251-256.

IUCN (International Union for Conservation of Nature). 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. http://intranet.iucn.org/webfiles/doc/SSC/RedList/redlistcatsenglish.pdf

Jager, H. I. 2006a. Chutes and ladders and other games we play with rivers. I. Simulated effects of upstream passage on white sturgeon. Can. J. Fish. Aquat. Sci. 63: 165–175.

Jager, H. I. 2006b. Chutes and ladders and other games we play with rivers. II. Simulated effects of translocation on white sturgeon Can. J. Fish. Aquat. Sci. 63: 176–185.

Jager, H. I. 2005. Genetic and demographic implications of aquaculture in white sturgeon (*Acipenser transmontanus*) conservation. Can. J. Fish. Aquat. Sci. 62: 1733–1745.

Jager, H.I. 2001. Individual variation in life history characteristics can influence population extinction risk. Ecol. Model. 144: 61–76.

Jensen, N. and K. Cain. 2009. Burbot: not just another cod. Hatchery International 10(3).

Jensen, N.R., S.R. Williams, S.C. Ireland, J.T. Siple, M.D. Neufeld and K.D. Cain. 2008a. Preliminary Captive Burbot Spawning Observations. Pages 155-165 in V.L. Paragamian and D.H. Bennett, editors. Burbot: Ecology, Management, and Culture. American Fisheries Society, Symposium 59, Bethesda, MD.

Jensen, N. R., S. C. Ireland, J. T. Siple, S. R. Williams and K. D. Cain. 2008b. Evaluation of Egg Incubation Methods and Larval Feeding Regimes for North American Burbot. North American Journal of Aquaculture. 70: 162-170.

Jensen, N. R., S. C. Ireland, J. T. Siple, S. R. Williams and K. D. Cain. 2008c. Evaluation of Egg Incubation Methods and Larval Feeding Regimes for North American Burbot. North American Journal of Aquaculture. 70: 162-170.

Justice, C., B. J. Pyper, R. C. P. Beamesderfer, V. L. Paragamian, P. J. Rust, M. D. Neufeld, and S. C. Ireland. 2009. Evidence of density- and size-dependent mortality in hatchery-reared juvenile white sturgeon (*Acipenser transmontanus*) in the Kootenai River. Canadian Journal of Fisheries and Aquatic Sciences 66:802-815.

Kahilainen, K., and Lehtonen, H. 2003. Piscivory and prey selection of four predator species in a whitefish dominated subarctic lake. J. Fish Biol. **63**: 659–672.

KRBCC (Kootenai River Burbot Culture Committee). 2002. Draft Lower Kootenai River Burbot Conservation Strategy.

Kincaid, H. 1993. Breeding plan to preserve the genetic variability of the Kootenai River white sturgeon. Report of the U. S. Fish and Wildlife Service to Bonneville Power Administration, Portland, Oregon.

Kock, T. J., J. Congleton, and P. J. Anders. 2006. Effects of Sediment Cover on Survival and Development of White Sturgeon Embryos. North American Journal of Fisheries Management 26:134–141.

KTOI (Kooetnai Tribe of Idaho). 2009. Kootenai River Habitat Restoration Project Master Plan: A Conceptual Feasibility Analysis and Design Framework. Bonners Ferry, ID. 386 pp.

KTOI. 2008. Kootenai River White Sturgeon Conservation Aquaculture Program, 1990-2007 (Version 2). Bonners Ferry, Idaho. Report edited by R. Beamesderfer and P. Anders, Cramer Fish Sciences. 74 pp.

KTOI. 2005. Anders, P., R. Beamesderfer, M. Neufeld, and S. Ireland (eds). Kootenai River White Sturgeon Recovery Implementation Plan and Schedule (2005-2010). Prepared by S. P. Cramer and Associates for the Kootenai Tribe of Idaho, with assistance from the Kootenai River White Sturgeon Recovery Team.

KTOI. 2004. Anders, P. and R. Beamesderfer, (editors). An Adaptive Multidisciplinary Conservation Aquaculture Program for the Endangered Kootenai River White Sturgeon Population. Draft Hatchery Management Plan prepared for the Kootenai Tribe of Idaho. S. P. Cramer and Associates, Moscow, ID. 56 pp.

KTOI and MDFWP. 2004. Kootenai Subbasin Plan. Northwest Power and Conservation Council. Portland, OR.

KVRI (Kootenai Valley Resource Initiative) Burbot Committee. 2005. Kootenai River/Kootenay Lake burbot conservation strategy. Prepared by the Kootenai Tribe of Idaho.

Kynard, B., E. Parker, and B. Kynard. 2006a. Behavior and Habitat of Young Kootenai River White Sturgeon. Report prepared by B.K. Riverfish Inc, Amherst MA. for the Kootenai Tribe of Idaho. 24 pp.

Kynard, B., and E. Parker. 2006b. Ontogenetic Behavior and Dispersal of Kootenai River White Sturgeon Early Life Intervals: A laboratory Study. Report prepared by B.K. Riverfish Inc, Amherst MA. for the Idaho Department of Fish and Game. 35 pp.

Lande, R. 1993. Risks of population extinction from demographic and environmental stochasticity and random catastrophes. American Naturalist 142: 911-927.

Lande, R., and G.F. Barrowclough. 1987. Effective population size, genetic variation, and their use in population management in M.E. Soule, eds. Viable Populations for Conservation. Cambridge University, New York.

Lawson, P.W. 1993. Cycles in ocean productivity, trends in habitat quality, and the restoration of salmon runs in Oregon. Fisheries 18(8):6-10.

Lower Columbia River Fish Recovery Board (LCFRB). 2004. Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan.

Lynch, M. 1996. A quantitative-genetic perspective on conservation issues. In Avise, J.C. and J.L. Hamrick, eds. Conservation Genetics. Case Histories from Nature. Chapman and Hall, New York.

Lynch, M. 1990. Mutation load and the survival of small populations. Evolution 44:1725-1737.

Lynch, M., and M. O'Hely. 2001. Captive breeding and the genetic fitness of natural populations. Conservation Genetics 2:363-378.

MacArthur, R. and Wilson, E.O. (1967). *The Theory of Island Biogeography*, Princeton University Press (2001 reprint), ISBN 0-691-08836-5M.

McElhany, P., M.H. Rucklelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. NOAA Technical Memorandum NMFS-NWFSC-42.

McPhail, J. D. & V. L. Paragamian. 2000. Burbot Biology and Life History. American Fisheries Society: Burbot Biology, Ecology and Management 1: 11-23. In: V.L. Paragamian and D. Wills, editors. Burbot: biology, ecology, and management. American Fisheries Society, Fish Management Section, Bethesda, Maryland.1.

McQuown, E., G. A. E. Gall, and B. May. 2000. Characterization and inheritance of six microsatellite loci in Lake Sturgeon. Transactions of the American Fisheries Society (131):299-307

Martin, A.D. 1976. Kootenay Lake burbot fishery. Unpublished report. British Columbia Fish and Wildlife. Nelson, B.C.

Morrow, J. 1980. The Freshwater Fishes of Alaska. University of British Columbia Resource Ecology Library: University of British Columbia.

Nelson, K. and M. Soule. 1987. Genetical conservation of exploited fishes. Pages 345-368 in N. Ryman and F. Utter, eds. Population Genetics and Fishery Management. University of Washington Press, Seattle.

Neufeld, M. 2008. Kootenay Fisheries Field Report- Moyie Lake Burbot Survey. BC Ministry of Environment. February 2008. (http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=13484)

Neufeld, M. and C. Spence. 2009. Moyie Lake burbot program 2008-2009: Sport Fishery, Juvenile Sampling and Conservation Aquaculture/Spawning Survey. BC Ministry of Environment. October 2009. (http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=17097)

NMFS (National Marine Fisheries Service). 2009. Middle Columbia River Steelhead Distinct population Segment ESA Recovery Plan.

NMFS. 2007. Puget Sound Salmon Recovery Plan.

NRC (National Research Council). 1996. Upstream: Salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C.

NRTWS (National Recovery Team for White Sturgeon). 2009. Recovery strategy for white sturgeon (*Acipenser transmontanus*) in Canada. In Species at Risk Act Recovery Strategy Series. Ottawa: Fisheries and Oceans Canada.

Paragamian, V. L. and R. C. P. Beamesderfer. 2004. Dilemma on the Kootenai River - The risk of extinction or when does the hatchery become the best option? American Fisheries Society Symposium.

Paragamian, V. L., and R. C. P. Beamesderfer. 2003. Growth estimates from tagged white sturgeon suggest that ages from fin rays underestimate true age in the Kootenai River, USA and Canada. Transactions of the American Fisheries Society 132:895-903.

Paragamian, V. L., and M. J. Hansen. 2008. Evaluation of recovery goals for white sturgeon in the Kootenai River, Idaho, USA. North American Journal of Fisheries Management 28(1): 463–470.

Paragamian, V. L., R. C. P. Beamesderfer, and S. C. Ireland. 2005. Status, population dynamics, and future prospects of the endangered Kootenai River white sturgeon population with and without hatchery intervention. Transactions of the American Fisheries Society 134:518-532.

Paragamian, V.L., V.D. Wakkinnen and G. Crews. 2002. Spawning locations and movements of Kootenai River white sturgeon. Journal of Applied Ichthyology. 18 Vol. 9 p.

Paragamian, V.L., V. Whitman, J. Hammond and H Andrusak. 2000. Collapse of burbot fisheries in the Kootenai River, Idaho and Kootenay Lake, BC. Pages 155-164 *in* V.L. Paragamian and D. Willis, editors, Burbot Biology, Ecology and Management. Publication No. 1, Fisheries Management Section of the American Fisheries Society, Spokane, WA.

Paragamian, V. L., and V. Whitman. 1996. Kootenai River fisheries investigations. Idaho Department of Fish and Game. Annual Progress Report prepared for Bonneville Power Administration, Project 88-65, Portland, OR.

Paragamian, V. L., R. C. P. Beamesderfer, and S. C. Ireland. 2005. Status, population dynamics, and future prospects of the endangered Kootenai River white sturgeon population with and without hatchery intervention. Transactions of the American Fisheries Society 134:518-532.

Paragamian, V., B. Pyper, M. Daigneault, R. Beamesderfer and S. Ireland. 2008. Population dynamics and extinction risk of burbot in the Kootenai River, Idaho, USA and British Columbia, Canada. American Fisheries Society Symposium 59:213-234.

Partridge, F. 1983. Subproject IV: River and stream investigations- Study IV: Kootenai River Fisheries Investigations. Period covered: March 1, 1979 to February 28, 1983.

Polinski, M.P., Drennan, J.D., Batts, W.N., Ireland, S.C. and K.D. Cain. 2009a. Establishment of a cell line from burbot Lota lota with characterization of susceptibility to IHNV, IPNV and VHSV. Diseases of Aquatic Organisms (accepted).

Polinski, M.P., Fehringer, T.R., Johnson, K.A., Snekvik, K.R., LaPatra, S.E., LaFrentz, B.R., Ireland, S.C. and K.D. Cain. 2009b. Characterization of susceptibility and carrier status of burbot to IHNV, IPNV, *Flavobacterium psychrophilum, Aeromonas salmonicida,* and *Renibacterium salmoninarum*. Journal of Fish diseases (Accepted).

Polinski, M.P., N.R. Jensen, K.D. Cain, K.A. Johnson and S.C. Ireland. 2009c. Assessment of formalin and hydrogen peroxide use during egg incubation of North American burbot. North American Journal of Aquaculture 72: 111-117.

Powell, M. V.L. Paragamian, and J. Dunnigan. 2008. Mitochondrial variation in Western North American burbot with special reference to the Kootenai River in Idaho and Montana. Pages 3-28, In: American Fisheries Society Symposium 59.

Prince, A. and R. S. Cope. 2008. North Moyie Lake Burbot Creel Survey. Westslope Fisheries, Inc. March 2008. (http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=16158)

Pyper, B.J., M.J. Daigneault, V.L. Paragamian, and S.C. Ireland. 2004. Population dynamics and extinction risk of a burbot (*Lota lota*) stock in decline. S. P Cramer and Associates, Gresham, OR. Draft report prepared for the Kootenai Tribe of Idaho. 46pp.

Redfish Consulting, Ltd. 1998. Investigation of burbot in Kootenay Lake, 1997. Prepared for B.C. Fisheries, Nelson, British Columbia.

Riede, K. 2004. Global register of migratory species - from global to regional scales. Final report of the R&D Project 808 05 081. Bonn, Germany: Federal Agency for Nature Conservation.

Rodzen, J. B. May, P. Anders and S. Ireland. 2004. Initial microsatellite analysis of wild Kootenai River white sturgeon and subset brood stock groups used in a conservation aquaculture program. Report prepared for the Kootenai Tribe of Idaho and the U.S. Department of Energy, Bonneville Power Administration, Portland, OR. Contract No. 88-64. 36 pp.

Rodzen, J.A. and B. May. 2002. Inheritance of microsatellite loci in the white sturgeon (Acipenser transmontanus). Genome 45:1064-1076.

Rust, P. J., and V. Wakkinen. 2004. Kootenai River white sturgeon spawning and recruitment evaluation. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. IDFG Report Number 04-03, Boise, Idaho.

Rust, P. J., V. L. Paragamian, and V. Wakkinen. 2003. Kootenai River white sturgeon spawning and recruitment evaluation. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. IDFG Report Number 03-55, Boise, Idaho.

Ryman, N., and L. Lairke. 1991. Effects of supportive breeding on the genetically effective population size. Conservation Biology (5):325-329.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

Shafii, B., W. J. Price, C. Holderman, C. Gidley, and P, Anders. 2010. Modeling fish length distribution using a mixture model technique.

Sprague et al. 1993. Columbia River juvenile white sturgeon diet analysis report(s) under BPA 86-50

Thompson, G. G. 1991. Determining Minimum Viable Populations under the Endangered Species Act. NOAA Technical Memorandum NMFS F/NMC-198, NMFS, Seattle, Washington.

Upper Columbia White Sturgeon Recovery Initiative. 2006. Upper Columbia White Sturgeon Recovery Initiative 2004-2005- UCWSRI Annual Report.

Upper Columbia River White Sturgeon Recovery Initiative (UCWSRI). 2002. Upper Columbia River white sturgeon recovery plan.

UCSRB. 2007. Upper Columbia Spring Chinoook Salmon and Steelhead Recovery Plan.

USFWS (US Fish and Wildlife Service). 2006. Fish and Wildlife Service Biological Opinion regarding the Effects of Libby Dam Operations on Kootenai River White Sturgeon, Bull Trout and Kootenai Sturgeon Critical Habitat.

USFWS. 2003. (http://a257.g.akamaitech.net/7/257/2422/14mar20010800/edocket.access.gpo.gov/2003/pdf/03-5737.pdf)

USFWS. 2000. Fish and Wildlife Service Biological Opinion regarding the Operation of the Federal Columbia River Hydropower System.

USFWS. 1999. Duke, S., P. Anders, G. Ennis, R. Hallock, J. Laufle, R. Lauzier, L. Lockard, B. Marotz, V. Paragamian, and R. Westerhof (eds.). White Sturgeon: Kootenai River Population. Recovery Plan. Prepared by Region 1, U.S. Fish and Wildlife Service, Portland OR. USA.

Van Houdt, J. K., B. Hellmans, and F.A.M. Volkaert. 2003. Phylogenetic relationships among Palearctic and Nearctic burbot *lota lota*): Pleistocene extinctions and recolonization. Molecular Ecology 14: 2445-2457.

Van Houdt, J. K., J. L. De Cleyn, A. Perretti, and F.A.M. Volkaert. 2005. A mitogenic view on the evolutionary history of the Holoiarctic freshwater gadoid, burbot (*lota lota*). Molecular Phylogenetuics and Evolution 29:599-612.

Zuccarelli, M.D., N. Jensen and R.L. Ingermann. 2007. Inhibitory effect of osmotic concentration, potassium and pH on motility of the sperm of North American burbot. Journal of Fish Biology, 70(1): 178-189.

Appendix 1

Hatchery Reared Burbot Released for the First Time in British Columbia and Idaho

Nathan Jensen[1], Susan Ireland[2], Matt Neufeld[3], Paul Anders[4], Ray Jones[5], Vaughn Paragamian[6] and Kenneth Cain[1]

1. *University of Idaho, Department of Fish and Wildlife Resources and Aquaculture Research Institute, Moscow, ID. 83844-1136, USA.*
2. *Kootenai Tribe of Idaho, P.O. Box 1269, Bonners Ferry, ID. 83805, USA.*
3. *British Columbia Ministry of Environment, 401-333 Victoria Street, Nelson, BC, 1L4K3, Canada.*
4. *Cramer Fish Sciences, 121 Sweet Ave, Moscow, ID. 83843, USA.*
5. *U.S. Fish and Wildlife Service, Dworshak Fisheries Complex, P.O. Box 18, Ahsahka, ID 83520, USA.*
6. *Idaho Department of Fish and Game, 2885 Kathleen Ave. Coeur d' Alene, Idaho 83815, USA.*

Burbot (*Lota lota maculosa*) are freshwater cod native to the Kootenai River in Idaho, Montana, and British Columbia. Burbot are culturally significant to the Kootenai Tribe of Idaho (KTOI) and Idaho's Kootenai River burbot population once supported tribal sustenance harvests and popular sport and commercial fisheries. Drastic population declines have occurred over the last half-century, primarily due to habitat alteration and loss, now this population is considered functionally extinct within Idaho borders. According to Idaho Department of Fish and Game (IDFG), most recent abundance estimates for Kootenai River burbot were approximately 50 fish. To re-establish a burbot population in the Kootenai River, the Kootenai Valley Resource Initiative (KVRI) convened a burbot sub-committee to help develop a coordinated burbot conservation strategy. Development of burbot culture was one component of a larger multifaceted, international conservation approach that includes habitat restoration. Beginning in 2003, the KTOI, the University of Idaho's Aquaculture Research Institute (UI-ARI) and the British Columbia Ministry of Environment (BCMoE) initiated a research program to assess the feasibility of conservation aquaculture as an interim burbot restoration measure.

Spawning and semen cryopreservation methods were developed first, followed by incubation methods and larval and juvenile rearing strategies involving intensive, semi-intensive, and extensive culture methods. Additional research to characterize burbot disease susceptibility and to establish burbot cell lines for diagnostic purposes was recently completed. With these fundamental methods in place, aided by the knowledge gained through recent disease susceptibility studies conducted at the UI-ARI, the experimental program enabled the first experimental release of cultured burbot in British Columbia and Idaho.

During October and November of 2009, 247 burbot cultured at the UI-ARI were released into the Kootenai River system in four different locations in BC and Idaho. Thirty of the 247 released fish were two years old and implanted with ultrasonic transmitters. These fish are expected to provide valuable information concerning habitat use, movement and migration patterns, spawning habitat selection, and reproductive behavior.

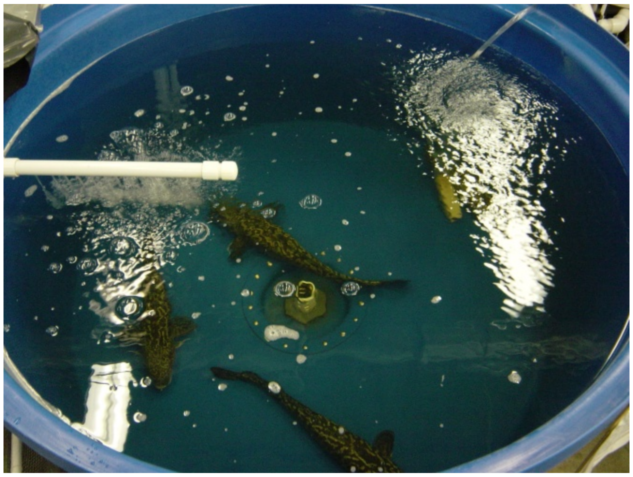
These releases represent a historical milestone for the program, the species, and the Subbasin, as this is the first time burbot have been artificially propagated and subsequently released jointly into U.S. and Canadian waters for conservation purposes. The success of this experimental project paves the way for ongoing burbot conservation aquaculture research and development, and facilitates needed in-river studies to begin.

Ongoing burbot aquaculture research is focused on optimizing techniques for intensive rearing, semi-intensive and extensive culture methods, and determining temperature related growth performance. The experimental release component of this project provides the foundation for studying post-release survival, growth, and condition of hatchery produced burbot.

As part of this collaborative international project, numerous reports and peer-reviewed papers have been published on various aspects of burbot aquaculture, pathology, and management since 2006. This body of literature has contributed substantially to this developing field and would not have been possible without the support and cooperation of the KVRI, the KTOI fisheries program, the BCMoE, the U.S. Fish and Wildlife Service, the IDFG, Cramer Fish Sciences, and the UI-ARI. University of Idaho researchers continue to communicate with European burbot researchers and culturists, further contributing to the success of the Idaho program, and to burbot conservation and restoration in Europe and North America.

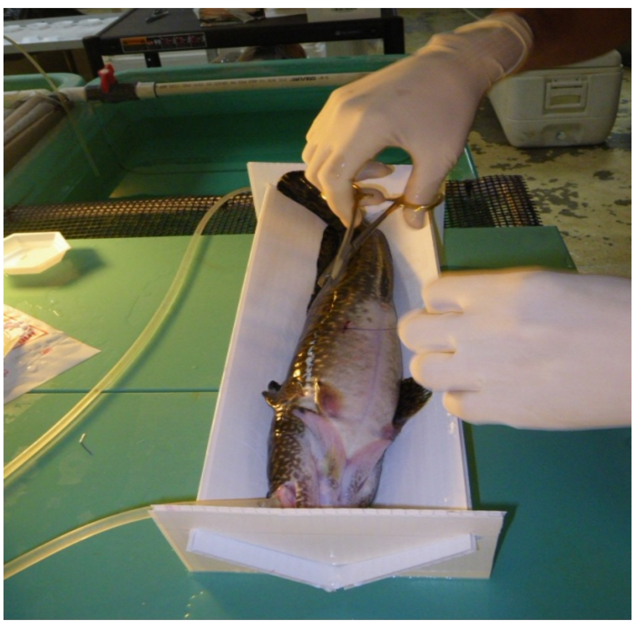
Funding for this burbot conservation aquaculture project is provided by the KTOI and the Bonneville Power Administration (Project No. 198806400).

Nathan Jensen and UI-ARI hatchery manager Scott Williams spawning the first captive burbot in the winter of 2004.



Adult burbot broodstock in a rearing tank at the UI-ARI
aquaculture laboratory.

Burbot cultured at the UI-ARI ready for release.



Burbot surgically implanted with an ultrasonic transmitter and PIT-tag prior to release.

KTOI Hatchery Manager Jack Siple releasing ultrasonic tagged burbot into the lower portion of Goat River, a tributary of the Kootenai River in BC.

Hatchery reared ultrasonic tagged burbot seeking natural cover following release.

Appendix 2 Hatchery and Genetics Management Plan for Burbot

KOOTENAI TRIBE OF IDAHO

HATCHERY AND GENETIC MANAGEMENT PLAN RESIDENT FISH VERSION (HGMP-RF)

Hatchery Program: Kootenai Tribe of Idaho Native Fishes Conservation Aquaculture Program

Species or Hatchery Population/Strain: Burbot (*Lota lota maculosa*)

Agency/Operator: Kootenai Tribe of Idaho

Watershed and Region: Kootenai River Subbain, Idaho

Date Submitted: June 2010

Date Last Updated: June 2010

SECTION 1. GENERAL PROGRAM DESCRIPTION

1.1) Name of hatchery or program

Twin Rivers Hatchery, Kootenai River Native Fish Restoration and Conservation Aquaculture Program (BPA Project No. 198806400)

1.2) Species and population (or strain) under propagation, ESA/population status.

Burbot (*Lota lota maculosa*), Lower Kootenai River, Idaho

Conservation status / Classification:
Rangewide: Secure (G5)
Statewide (Idaho): Critically imperiled (S1)
ESA: No current or pending status
USFS: Region 1: Sensitive; Region 4: No status
BLM: Regional/State imperiled (Type 3)
IDFG: Game fish; Endangered
(From: http://fishandgame.idaho.gov/cms/tech/CDC/cwcs_appf/Burbot.pdf)

1.3) Responsible organization and individuals

Name (and title): Sue Ireland, Fish and Wildlife Program Director

Agency or Tribe: Kootenai Tribe of Idaho
Address: 242 Hatchery Rd., P.O. Box 1269, Bonners Ferry, ID 83805
Telephone: (208) 267-3620
Fax: (208) 267-1131
Email: ireland@kootenai.org

Other agencies, Tribes, cooperators, or organizations involved, including contractors, and extent of involvement in the program

The Kootenai Tribe of Idaho (KTOI) administers the burbot experimental aquaculture program and the Idaho Department of Fish and Game (IDFG) and the British Columbia Ministry of Environment (BCMoE) conduct burbot monitoring and evaluation studies. The KTOI subcontracts to the University of Idaho's Aquaculture Research Institute (UI-ARI) for burbot aquaculture development and pathology investigations, the University of Idaho department of Life Sciences for development of burbot cryopreservation, Cramer Fish Sciences for project development, reporting and coordination, and the BC MoE for technical services and burbot field investigations.

The Burbot Aquaculture Program is part of a cooperative, multi-agency, international conservation strategy produced as a part of the Kootenai Valley Resource Initiative (KVRI 2005). The KVRI is a community-based, collaborative forum that facilitates communication to restore and enhance the resources of the Kootenai Valley. The KVRI coordinates the Burbot Culture Subcommittee, working to reestablish a burbot population in the Kootenai River. KVRI's conservation strategies delineate reasonable actions that are believed necessary to protect, rehabilitate, and maintain species and populations that have been recognized as imperiled, but not federally listed as threatened or endangered under the US Endangered Species Act. This strategy resulted from cooperative efforts of U.S. and Canadian federal, provincial, and state agencies, Native American Tribes, First Nations, local Elected Officials, Congressional and Governor's staff, and other resource stakeholders.

1.4) Funding source, staffing level, and annual hatchery program operational costs.

The Bonneville Power Administration, under the resident fish portion of the Northwest Power Planning Council's Fish and Wildlife Program, funds hatchery construction, operations, administration, research, and monitoring. Cost sharing is provided in the form of cash or in-kind facilities and services by the Idaho Department of Fish and Game, U.S. Fish and Wildlife Service, British Columbia Ministry of Environment, and the University of Idaho's Aquaculture Research Institute and Department of Life Sciences.

Staff and other resources will be shared between the sturgeon program and the burbot program at both the Tribal Sturgeon Hatchery near Bonner's Ferry and the proposed Twin Rivers Hatchery. Staffing and operational costs provided are based on the assumption of these proposed shared resources. For detailed presentation of potential operational and monitoring and evaluation costs refer to Chapter 8 in the Kootenai River Native Fish Conservation Aquaculture Program Master Plan.

Staffing Levels

It is estimated that inclusion of the burbot program at the proposed Twin River's facility will result in the need for about 4 FTE's. These FTEs are assumed to be Tribal staff and would be utilized for operational activities for both the sturgeon and burbot programs. Specific estimates by staff title are provided in Table 1.

Table 1. Estimated full time equivalent staff for the proposed burbot program

Staff Title	Estimated Annual FTEs for Sturgeon and Burbot Program	Estimate of FTEs for Burbot Program Only
Program Administrator/ Director	0.7	0.3
Program Biologist	0.7	0.3
Hatchery Manager	1.5	0.4
Fish Culture Technicians	7.0	2.0
Maintenance Manager	1.5	0.4
Administrative Assistant	0.5	0.3
Administrative Coordinator	0.5	0.3
Total FTE	**12.4**	**4.0**

Notes and Assumptions:
- Staffing levels are general estimates based on shared staffing with the current and future sturgeon programs at the existing Tribal Hatchery at Bonner's Ferry and proposed program at Twin Rivers
- Does not include labor estimates for subcontracted services
- Monitoring and evaluation costs for the burbot program are not included

Operational Costs

Estimated annual operating costs including labor could range from $180,000 to over $280,000 for the burbot program. Though expenses are interrelated, this doesn't include costs for annual monitoring and evaluation. Detailed costs by area are provided as Table 2.

Table 2: Estimated Annual Operating Expenses, Proposed Burbot Program, Twin River's Hatchery

Expense Area	Estimated Annual Operating Expenses with Existing Tribal Hatchery (2012 dollars)	Estimated Annual Operating Expenses Burbot / Low Estimate (2012 Dollars)	Estimated Annual Operating Expenses Burbot / High Estimate (2012 Dollars)
Payroll / Fringe	$401,950	$80,390	$120,585
Indirect	$237,150	$35,573	$59,288
Travel Costs (Mileage, Lodging, Per Diem)	$9,835	$1,475	$2,459
Professional Services (Data Base, Information System)	$4,371	$656	$1,093
Vehicles, Boats, Equipment, Transportation (Fuel, Oil, Maintenance, Mileage)	$24,005	$3,601	$6,001
Program Supplies (Office)	$3,278	$492	$820
Program Supplies (Fish Food, Aquaculture & Facility Chemicals, Hatchery Supplies)	$21,308	$3,196	$5,327
Equipment & Building Maintenance	$43,709	$6,556	$10,927
Utilities (Electrical, Telephone, Natural Gas, Water), Insurance	$48,080	$7,212	$12,020
Subcontracted Services	$185,960	$44,631	$65,086
TOTAL	$979,647	$183,781	$283,605

1.5) Location(s) of hatchery and associated facilities

Include name of stream, river kilometer, location, basin name, and state. Also include watershed code (e.g. WRIA number), or sufficient information for GIS entry.

The KTOI Twin Rivers Hatchery will be located at the Kootenai and Moyie River confluence (rkm 258.6), about 12 km upstream from Bonners Ferry, Idaho, at GPS coordinates: 559999.38 x 5396591.63 (UTM NAD83, Zone 11) (Figure 1). The Twin Rivers Hatchery site is located in the Kootenai River Basin (HUC 17010101).

1.6) Type of program(s)

Define as either: Integrated Recovery; Integrated Harvest; Isolated Recovery; or Isolated Harvest (see Attachment 1 - Definitions" section for guidance).

The Twin Rivers Hatchery will be an Integrated Recovery Program primarily designed to aid in the recovery, conservation or reintroduction of a natural population. Fish produced are intended to spawn in the wild or be genetically integrated with the natural population.

This recovery objective for burbot in the Kootenai River presupposes that natural spawning conditions for the wild population will be restored by proposed habitat measures.

1.7) Purpose (Goal) of program(s)

The goal of this program is to restore a burbot population in the lower Kootenai River using broodstock and gametes from within-basin native populations.

1.8) Justification for the program

Indicate why the hatchery program is needed and how it will enhance or benefit the survival of the listed population (integrated or isolated recovery programs), or how the program will be operated to provide fish for harvest while minimizing adverse effects on listed fish (integrated or isolated harvest programs).

The Twin Rivers Hatchery Program is needed to reestablish a burbot population in the lower Kootenai River. Decades of sampling the lower Kootenai River have confirmed that native burbot population abundance has declined to about 50 fish (25-100, 95% CI), a level considered to be functionally extinct (Pyper et al. 2004; KTOI and MFWP 2004; KVRI 2005; Paragamian et al. 2008). The program would restore an important biodiversity component of the ecosystem and its food web, which would likely benefit other native species within this system. Burbot are a culturally important species to the Kootenai Tribe, and establishing a sufficiently sized and diverse population capable of future ceremonial, subsistence, and sport harvest is the ultimate long-term goal of this program.

This aquaculture program is needed because there is no current or near-term alternative available for restoring a burbot population in the lower Kootenai River.

1.9) List of program "Performance Standards"

In their Artificial Production Review, the Production Review Committee of the Northwest Power and Conservation Council (NPCC defined "Performance Standards" as a set of specific criteria by which progress in achieving the program goal/purpose can be measured).

The goal of this program is to restore a burbot population in the lower Kootenai River using broodstock and gametes from within-basin native populations. The accompanying performance standards corresponding to this goal as defined in the Artificial Production Review Report (NPCC 1999), are to:

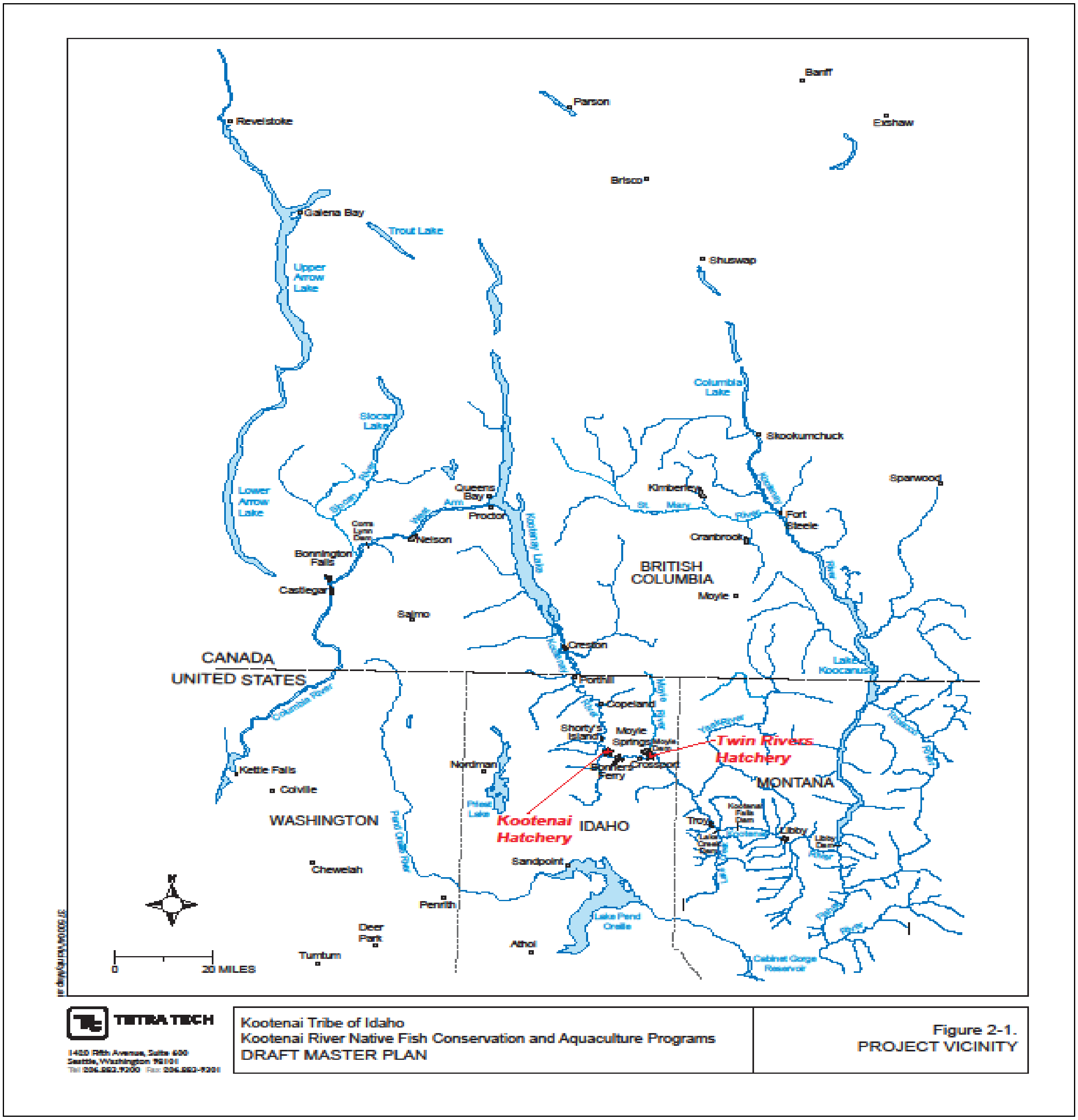


Figure 1. Map of the Kootenai River Basin indicating locations of existing (Kootenai) and proposed (Twin Rivers) hatchery locations.

1. Maintain, augment, and restore a viable naturally spawning population using artificial production strategies.
2. Incorporate genetic and life history trait diversity into a hatchery-produced burbot population for release into the Kootenai River, and life stage-specific habitat use and availability in the Kootenai River and in lab experiments.
3. Use hatchery-reared fish and facilities to conduct research on factors limiting natural production.
4. Conduct research to improve the performance and cost effectiveness of artificial propagation efforts and to minimize risks.
5. Avoid mortality risks to wild broodstock at capture and spawning and other earlier life stages in the hatchery.
6. Minimize the detrimental genetic or behavioral impacts of artificial propagation by stocking fish at the earliest point consistent with satisfactory growth and survival.
7. Avoid pathogen introduction and transfer, and reduce disease incidence in the hatchery produced population in the hatchery and in the river.
8. Avoid risk to the natural population by monitoring parameters that estimate biological condition and related population dynamics as a surrogate for estimating carrying capacity of the natural habitat.

1.10) List of program "Performance Indicators", designated by benefits and risks

"Performance Indicators" determine the degree that program standards have been achieved, and indicate the specific parameters to be monitored and evaluated. The list of "Performance Indicators" should be separated into two categories: "benefits" that the hatchery program will provide to the listed resident fish species, or in meeting harvest objectives while protecting listed resident fish species; and "risks" to listed resident fish species that may be posed by the hatchery program, including indicators that respond to uncertainties regarding program effects associated with a lack of data.

Performance indicators are specific operational measures of fish and hatchery attributes that address each performance standard. They determine the degree to which program standards have been achieved, indicate the specific parameters to be monitored and evaluated, and are used to detect and evaluate the success of the hatchery program and any risks to or impairment of recovery of affected, listed fish populations. Performance indicators must be measurable, realistic, feasible, understandable, affordable, and time-specific. Table 3 lists specific burbot performance standards, indicators, and activities associated with the program.

The first experimental release of cultured burbot from this program occurred during October and November of 2009 and will be repeated in 2010. Subsequent years of experimental, larger scale releases are required to further quantify benefits and risks to listed resident species, and to evaluate benefits and risks of program implementation.

1.10.1) "Performance Indicators" addressing benefits

Benefits of the proposed burbot hatchery program include: 1) creating and maintaining a burbot population with a sustainable age class structure, one dominated by immature juvenile fish that grow to reproductive adulthood; 2) incorporating adequate genetic diversity and life history trait diversity into the hatchery-produced population for viability and persistence; and 3) determining and counteracting natural production limitations to the extent feasible (Table 3).

The adaptive experimental approach being designed for this project involves a broad spectrum of expertise from tribal, governmental, university, and private sector participants. Performance standards will be addressed by a comprehensive monitoring and evaluation program of fish in the hatchery and in the wild following release (see Section 11). Numbers and mortality of eggs, larvae, and juveniles are tracked throughout the spawning and rearing process. An annual field sampling program will be implemented cooperatively with KTOI, IDFG, and BC MoE to recapture and evaluate hatchery-reared fish and any wild produced fish. Data on numbers, lengths, weights, and marks are used to estimate survival and growth rates.

Growth and condition factors will also provide an index of post-release burbot performance. A genetic testing program will be developed to identify gene frequencies in hatchery broodstock and progeny groups for comparison to target desirable population genetic metric values.

Excess eggs and hatchery-reared fish will also provide burbot for contaminant assessments, animal health research, *in–situ* hatching experiments, and other aquatic, biological, and ecological research to provide insight into factors limiting natural production of burbot.

A burbot population in the Kootenai River will be considered healthy when: 1) natural production (or if necessary a combination of natural and hatchery production) has restored a length and age frequency distribution in which all size and ages are represented in a fashion suggesting sustainability; 2) numbers of juveniles and adult spawners are sufficient to produce recruitment that maintains desirable population size and age distribution; 3) habitat improvements are sufficient to allow natural spawning to maintain the population in the absence of hatchery supplementation; and 4) population size is sufficient to maintain adequate genetic diversity and life history trait expression for burbot life cycle completion after release.

Table 3. Performance standards and indicators for the burbot conservation program. Italics indicate program actions or activities associated with performance indicators.

Performance Standard	*Type*	*Performance Indicator*
1. Maintain, augment, and restore a viable naturally spawning population using artificial production strategies	**Benefit**	Increase population size and enhance age composition as a result of hatchery propagation, release, and future recruitment of hatchery-produced fish: *Proportion of the size/age cohort contributed by hatchery* *Number of hatchery-reared fish by life stage including maturity* *Individual growth rates & condition factors*

Table 3. Performance standards and indicators for the burbot conservation program. Italics indicate program actions or activities associated with performance indicators.		
		Size & age specific survival rates
2. Incorporate genetic & life history diversity	**Benefit**	Retain life history characteristics and genetics by the hatchery reared population *Genetic population characteristics of hatchery broodstock and progeny* *Separate rearing of family groups* *Cryopreservation of male gametes* *Individual and population attributes as in #1 above.*
3. Use hatchery-reared fish for research on natural production limitations	**Benefit**	Understanding of the life history characteristics and factors limiting natural recruitment *Sampling to determine habitat use* *Research to assess habitat quality and quantity for all burbot life stages*
4. Conduct research to increase effectiveness & minimize costs	**Benefit**	Adaptive approach to achieve results while reducing process, administrative overhead, & operation costs *Complete planning and review processes and move to multi-year funding schedule with check points* *Adapt size and time of release to maximize benefits and minimize risks* *Marking methods to allow release as subyearlings* *Larval release experiments if appropriate* *Cryopreservation techniques*
5. Avoid mortality risks	**Risk**	Minimize mortality rate of broodstock in hatchery & after release *Modify collection and marking techniques (e.g. No FLOY tags; no sampling at great depths) to reduce mortality*
6. Minimize detrimental effects of artificial propagation	**Risk**	Release fish at youngest age/earliest life stage consistent with satisfactory growth and survival
7. Minimize pathogen transfer and disease risk	**Risk**	Minimal incidence of disease in the facility *Maintain appropriate spawning & rearing practices & densities, rigorous disease testing protocols, and rear disease-free trout for bait and broodstock feeding*
8. Avoid risks to natural population	**Risk**	Monitor parameters that estimate biological condition and related population dynamics as a surrogate for estimating carrying capacity of the natural habitat; modify program appropriately to minimize risks

1.10.2) "Performance Indicators" addressing risks

Performance indicators assessing risks associated with the burbot culture program include: 1) avoiding broodstock and early life stage mortality; 2) minimizing pathology transfer and disease risk; and 3) minimizing negative and behavioral and genetic impacts from breeding matrices and rearing techniques.

These risks are addressed by many of the same monitoring and evaluation indicators used to address program benefits. Burbot numbers and condition will be monitored in the hatchery and in the river following release. Burbot broodstock capture, gamete collection, cryopreservation, spawning, incubation, early rearing and feeding methods have been developed and are being refined to minimize stress and improve success of burbot aquaculture.

Genetic and animal health monitoring programs are being developed and refined, by project-funded efforts at the UI-ARI. Adjustments will be made throughout the development of this program and will continue to be made based on monitoring and evaluation results consistent with the adaptive management principles recommended by the Artificial Production Review Committee of the ISRP.

1.11) Expected size of program

In responding to the two elements below, take into account the potential for increased fish production that may result from increased fish survival rates affected by improvements in hatchery rearing methods, or in the productivity of fish habitat.

1.11.1) Proposed annual broodstock need (maximum number of fish)

The burbot biocriteria developed for this program recommend that a minimum of 25 female and 25 male broodstock (averaging 2 kg body weight) or their gametes will be needed to initiate the breeding program. Subsequent annual needs will depend on adult acclimation to captivity, post-spawn survival, and the final desired breeding matrix complexity to ensure adequate genetic variation in the small breeding population.

1.11.2) Proposed annual fish release levels (maximum number) by life stage and location

Annual release numbers will depend on in-river survival rates. Until these numbers are defined, interim release numbers will be based on population modeling efforts and data obtained from early experimental releases. The first experimental burbot release occurred during 2009 (Table 4). Details of this release, which used experimental, limited facilities, do not reflect attempts to maximize burbot production.

Table 4. Data from first experimental burbot releases in fall 2009.

Life Stage	2009 Release Location	2009 Release Level
Fingerling release 1	Bonners Ferry, Idaho, Ambush Rock Kootenai River (rkm 244.5)	21
Fingerling release 2	Between Bonners Ferry and Naples, Idaho, Deep Creek	177
Fingerling release 3	Snow Creek,	19
Age 2+	British Columbia, Canada. Goat River (UTM's 533131 5437543; rkm 152.5)	30
Total experimental release in 2009		247

In 2009, burbot fry were also stocked in two ponds to evaluate extensive culture. Stocking levels were:

- 4,500 fry in Cow Creek Pond
- 17,000 fry in Fredrick's Pond
- 360 fry in 5 cages in Fredrick's Pond

Proposed release numbers are derived from survival and demographic model simulation procedures using a series of possible post-release survival rate scenarios to establish future production and release numbers. These numbers will be refined based on program operations which will be adaptively managed as the program is implemented and monitoring and evaluation results are analyzed.

Future release locations and levels will depend on efforts to identify suitable habitat, river flow manipulations and future habitat modifications. The impetus for the 2009 experimental release (Table 4) in the Goat River, British Columbia, was to track the movement of juvenile burbot (age 2+) and subsequently identify seasonal habitat use over the next several years and beyond. Annual releases of ultrasonic tagged fish are planned and should provide valuable information on habitat use and potential spawning sites for adult burbot.

An adaptive release and monitoring program for burbot produced at Twin Rivers is being designed based on developing trends from collection and analysis of empirical post-release burbot data. This approach has been successfully implemented as part of the Tribe's white sturgeon conservation aquaculture program over the past two decades.

A series of burbot releases based on projected post-release survival scenarios will generate early survival data that will be used to refine subsequent release numbers. If favorable post-release survival rates and biological condition are observed from juvenile burbot releases (ages 0-2, the youngest age likely to exhibit favorable post-release survival), then a series of trials involving the release of younger or earlier life stage fish will be implemented. Annual release numbers would increase dramatically if younger life stages could be released.

Because empirical post-release survival rates for burbot are not yet available, the information presented in Table 5 is a preliminary order of magnitude estimate of future release strategies.

Table 5. Initial order of magnitude release numbers for burbot by life stage.

Life Stage	Release Location	Annual Release Level
Eyed Eggs	TBD	Millions
Unfed Fry	TBD	Millions
Fry	TBD	Hundreds of Thousands
Fingerling	TBD	Thousands
Yearling	TBD	Hundreds - Thousands
Spawner	TBD	Hundreds

1.12) Current program performance, including estimated survival rates, adult production

levels, and escapement levels. Indicate the source of these data.
Provide data (e.g., CPUE, condition factors) available for the most recent twelve years), or for the number of years of available and dependable information. Indicate program goals for these parameters.

Current program performance is relevant to the specific research objectives and questions identified by the KVRI burbot culture subcommittee as they relate to experimental scale development of fundamental aquaculture methods (e.g., spawning, egg incubation, larval feeding and rearing options). An experimental program is operated with limited labor, space, water resources at the University of Idaho Aquaculture Research Institute (UI-ARI).

This program began in 2003 to assess the feasibility of conservation aquaculture as a burbot population restoration tool. The initial objectives were to: 1) design, construct, and evaluate rearing systems to meet critical thermal parameters, and 2) develop handling and enumeration methods for adults, eggs, and young-of-year in the hatchery.

The first 20 burbot were spawned in 2004 at the UI-ARI; all 20 captive broodstock were successfully spawned. Several million eggs were collected, fertilized, and water hardened. Egg enumeration and incubation methods were developed, as were larval and juvenile feeding strategies. A precipitous decline in survival was observed post-hatch as a result of the delicate nature of burbot larvae (3-4 mm total length at hatch and no mouth or functional alimentary tract). Within 15-30 days post-hatch, >50% of embryos died or escaped through 500 micron mesh screening used to contain them. Following physiological development to a functionally feeding larval form, live feeds were required. Aside from developing methods to propagate burbot, live feed (Algae, Rotifers and *Artemia*) propagation techniques were successfully developed. By the juvenile life stage (post metamorphosis), 19 fingerlings remained and were transitioned to commercial dry feeds. This was the first time cultured burbot were successfully transitioned to a commercial dry diet and the first time burbot had been successfully propagated in the US from egg to juvenile stages.

By 2005, 50% of the original adults remained. Adult mortality was attributed to distended swim bladders during capture and handling when spawning. During 2005 (January and October), additional wild broodstock were collected. All January adult captures perished from infections caused by external Floy tagging and ruptured or distended swim bladders. Subsequently, capture, transportation and handling methods were refined to reduce trauma and these sources of mortality are now avoided.

During 2006, 73 juvenile burbot were produced past the larval diet transition stage in a limited trial. Juvenile survival and full transition to larval diets has improved each year, representing the project's exponential production success curve (Figure 2).

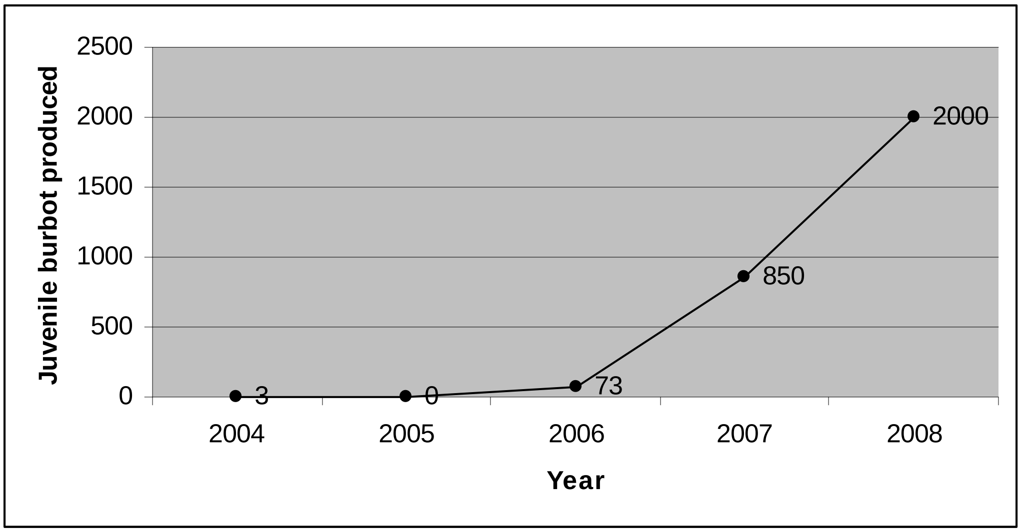


Figure 2. Juvenile burbot produced post commercial larval diet transition for research needs 2004-08.

Source: UI-ARI Unpublished data; http://www.kootenai.org/kvri_docs.html

Additionally, the 2004 progeny were raised to maturity in the laboratory and spawned in 2008 and 2009, which marks the first time cultured F1 burbot progeny have contributed gametes to a captive breeding program.

During 2009, research objectives included condition factor characterization while further developing culture methods, including evaluation of extensive (earthen pond style rearing) and semi-intensive (aerated outdoor fiberglass tanks) rearing alternatives, and studying how water temperature affects growth of pre- and post-metamorphosed young-of-the-year and commercial diet transitioned juvenile burbot. Over 40,000 burbot were used in experimental trials in 2009 (Table 6) and 247 were released (Table 4). These 2009 research endeavors will continue at least through 2010.

1.13) Date program started (years in operation), or is expected to start

The Twin Rivers hatchery is expected to be operational by 2012, building upon aquaculture techniques initiated by the Kootenai Tribe in 2001 with the collaboration of UI-ARI and other partners. Results from this work have confirmed the feasibility of culture (i.e., spawning, egg incubation, larval rearing, juvenile grow out, etc.) (Figure 2, Table 7). Establishing a conservation aquaculture program for burbot has been identified as a critical component for the restoration of this species within the Kootenai/Kootenay system of Idaho and British Columbia.

Table 6. Numbers of burbot produced by life stage for research during 2009 at UI-ARI.

Burbot Numbers	Feeding stage	Study	Study location
17,772	45 d on live feed	Extensive rearing feasibility	Fredrick's Pond, Bonners Ferry
360	45 d on live feed	Extensive cage rearing project year 2/IDFG project	Fredrick's Pond, Bonners Ferry
4,625	45 d on live feed	Extensive rearing feasibility	Cow Creek Pond, Bonners Ferry
11,025	45 d on live feed	Semi-intensive rearing experiment	UI-ARI, Moscow
3,000	30 d on live feed	Temperature related growth experiment 1	UI-ARI, Moscow
2,400	75 d on live feed	Temperature related growth experiment 2	UI-ARI, Moscow
600	Commercial diet transitioned	Temperature related growth experiment 3	UI-ARI, Moscow
1,200	164 d on live feeds, transitioned to commercial diet	Weaning experiment/test alternate commercial diets, characterize macronutrient status (proximal analysis)	UI-ARI, Moscow
40,982	Total burbot produced for research during 2009		

1.14) Expected duration of program

The expected duration of the program is until natural production is restored to levels that maintain a self-sustaining harvestable population.

1.15) Watersheds targeted by program

Watersheds within the Kootenai River Basin from Kootenay Lake, British Columbia upstream into Idaho are targeted by this program. The program area is contained within HUC 17010101.

Table 7. Current status of various aspects of burbot aquaculture at the UI-ARI.

Critical Burbot culture components	Burbot culture activities	Progress to date	Immediate experimental needs	Future experimental needs	Production feasibility status	Comments
Adults	Collection	Good	None	None	Requirements met	Adult stage activities do not currently limit production
	Holding	Good	None	None	Requirements met	
	Spawning	Good	None	None	Requirements met	
Egg stage	Incubation	Good	None	None	Requirements met	Egg stage activities do not currently limit production
Larval stage	Holding (pre-mouth development)	Good	None	None	Requirements met	System design has been improved
	Feeding (intensive – live prey)	Good	None	None	Requirements met	Intensive methods established and do not limit production
	Feeding (extensive/semi-intensive-outdoor ponds)	Good	None	Confirm production potential	Repeat study during 2010	Graduate student project underway
Juvenile stage	Grow-out	Good	None	Analyze feed trial experiments and continue to optimize feed transition	Requirements nearly met	Transition to artificial feed successful. Improved survival desired but not essential for production
Burbot health	Assessment of formalin and H_2O_2 for fungal control on eggs	Good	None	None	Requirements met	Results *in press: North American Journal of Aquaculture*
	Disease susceptibility	Good	None	None	Requirements met	Paper s submitted: *Diseases of Aquatic Organisms*
	Pathogen screening (Development of cell line as diagnostic tool)	Good	None	None	Requirements met	Paper submitted: *Journal of Fish Diseases* (cell line supplied to fish diagnostic labs)

1.16) Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed.

A range of alternatives for burbot conservation were considered by the Tribe, including maintaining current Libby Dam flow management measures, developing an artificial production facility or modifying an existing facility to accommodate production.

Alternative 1: Status Quo

Under this alternative, ongoing measures would continue. These include: 1) reducing discharge from Libby Dam to the extent possible during the winter months to stimulate reproductive migrations that could lead to natural production, and 2) providing more normative fall and winter thermographs in the Kootenai River to the extent possible through altered operations at Libby Dam.

If Alternative 1 were to be adopted, the expected outcome would be extinction of the population. Studies indicate that there has been inadequate burbot recruitment over the last decade (Pyper et al. 2004, KVRI 2005, Paragamian et al. 2008).

Alternative 2: Implement Conservation Aquaculture at a New Facility

Under this alternative, a new aquaculture facility would be constructed to propagate burbot. Stocks native to the Kootenai River subbasin would be spawned and reared in an effort to rebuild a burbot population in the lower Kootenai River. This facility would be co-located with the proposed Kootenai sturgeon aquaculture program at the Twin Rivers site, resulting in shared infrastructure components and components and significant cost and operation efficiencies.

Alternative 2 appears to have the highest likelihood of restoring burbot to this reach of the Kootenai River, particularly when combined with the habitat improvement measures proposed by the Kootenai Tribe under the Kootenai River Habitat Restoration Project.

Alternative 3: Implement Conservation Aquaculture at an Existing Facility

Artificial propagation of burbot would be accomplished at an existing hatchery in the Kootenai subbasin. Under this alternative, existing facilities would be modified or expanded to accommodate production of this species. Potential locations considered were 1) the Tribal Sturgeon Hatchery near Bonners Ferry and 2) the Fort Steele Hatchery in British Columbia. Facilities at the University of Idaho currently being used to experimentally propagate burbot are suitable for research programs but cannot be expanded into production facilities, nor can they be used in the long term.

Both the Tribal Sturgeon Hatchery and Fort Steele facilities currently operate at capacity and the option of adding burbot production would occur at the expense of ongoing production commitments. Reprogramming was not considered to be a feasible option. Expanding facilities at the Tribal Sturgeon Hatchery was determined to be infeasible primarily because the supply of high quality water and land needed for expansion are limited. Although the Fort Steele facilities provide an important fail-safe function for Kootenai sturgeon production, until the need for such a function is determined for the burbot program, the Tribe does not intend to pursue use of this site with its Canadian partners. Finally, no other suitable existing facilities were identified in either the Idaho or Montana portions of the subbasin that could accommodate a burbot program.

When considering out-of-basin fish rearing options, the Tribe weighed the following issues: disease introduction and pathogen transfer, transportation and acclimation, escapement, as well as fiscal, and policy challenges. These issues are briefly described below.

Disease introduction concerns and risks

- If disease is detected in fish reared out-of-basin, there is little chance that fish would be released due to concern over introduction of non-endemic pathogens or unique strains of a pathogen to new waters.
- Research at UI has provided baseline information regarding disease susceptibility and diagnostic tools have been developed (Polinski et al. 2009; Polinski et al., *in press*; Polinski et al., *accepted*). This is critical for full scale implication of a recovery program and provides fish health managers with valuable data useful for regulating movement and stocking of hatchery produced burbot (see Section 6.7).
- Disease inspections that follow USFWS Title 50 requirements are completed prior to release.
    - The risk of detecting a pathogen that is non-endemic to the Kootenai system cannot be discounted. Such detection would preclude fish from being transported and released and result in loss of at least one year class.
    - Due to the reliance on a closed or semi-closed recirculation system for current production of fish at UI-ARI, the detection of a non-endemic pathogen may require the eradication of all fish at the facility and complete disinfection. This is a significant risk that would be minimized by implementing design criteria and rearing fish within basin.

Transportation and acclimation issues

- Transporting fish to release sites introduces stress.
- The need for acclimation or imprinting for burbot is unknown but may prove to be important.

Escapement issues

- Implementing such safeguards at other potential out-of-basin facilities may be difficult and expensive.

Fiscal Implications

Combining use of facilities to rear several species at the Twin Rivers Hatchery represents fiscal responsibility and provides many cost efficiencies. The burbot facilities represent a relatively modest investment that would capitalize on many shared sturgeon operational components. Expanding existing facilities or constructing facilities outside of the basin (even if possible and recommended) would likely require greater expenditures over the long term.

Policy implications

Best aquaculture practices endorsed by the NPCC and others discourage transferring fish out-of-basin for both ecological and pathological reasons.

SECTION 2. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

2.1) Describe alignment of the hatchery program with other hatchery plans and policies. Explain any proposed deviations from the plan or policies.

This burbot conservation aquaculture program was developed as part of an adaptive multi-species, ecosystem and habitat restoration program by the Kootenai Tribe. It is consistent with the Kootenai Subbasin Plan, the Kootenai River Adaptive Management Plan, the Kootenai River white sturgeon and burbot 5-year RM&E Plans, the Kootenai River White Sturgeon Recovery Plan, and the Kootenai Valley Resource Initiative (KVRI) Burbot Subcommittee recommendations. This integrated approach aligns the burbot conservation aquaculture program and all other relevant hatchery plans, policies, and research and management objectives (Table 8).

Table 8. Relationship of Kootenai River burbot conservation measures to other actions in the Kootenai River subbasin.

Conservation Measure Description	*Time Frame**	*Lead Agency*	*Cooperating Agencies*
Fish Management			
Continue current restrictions on burbot harvest in the Kootenai River, and Kootenay Lake, and their tributaries.	*O-L*	*IDFG, MFWP, BC MoE*	*IDFG, MFWP, BC MoE*
Continue to monitor and limit incidental impacts and prohibit illegal harvest of burbot.	*S-L*	*IDFG, MFWP, BC MoE*	*IDFG, MFWP, BCMOE*
Integrate aspects of Conservation Strategy into the multi-agency Kootenai River Adaptive Management Program, using IKERT as an annual review and input forum	*O-L*	*All Agencies*	*All agencies*
Consider resumption of subsistence and recreational fisheries after Conservation Strategy targets are met.	*L*	*IDFG, MFWP, BC MoE*	*Kootenai Tribe*
Habitat Restoration			
Seek opportunities to reestablish lost natural river functions in the lower Kootenai River, including hydrograph cycles, habitat diversity, and floodplain connectivity and function.	*M-L*	*Kootenai Tribe, IDFG, MFWP, BC MoE, USFWS, KVRI*	*KVRI Burbot Committee, IDEQ, NRCS*

Conservation Measure Description	*Time Frame**	*Lead Agency*	*Cooperating Agencies*
Continue to implement tributary habitat improvement projects that address instream, riparian, and upland conditions that affect stream discharge, water quality, and habitat diversity and complexity.	*M-L*	*Kootenai Tribe, IDFG, MFWP, BC MoE, USFS*	*KVRI Burbot Committee, IDEQ, IDL, USFS, NRCS*
System Productivity, Aquatic Communities			
Continue annual fertilization of Kootenay Lake (North Arm fertilization began in 1992, South Arm began during 2004) and expand the program to include the Kootenai River in Idaho, near the Idaho-Montana border (2005) to increase the forage base available to burbot.	*S*	*BC MoE, BC Hydro, Kootenai Tribe, IDFG*	*IKERT*
Continue efforts to restore and maintain other components of the native fish community including kokanee and Kootenai sturgeon through approved habitat and population enhancement measures.	*S-O*	*USFWS, Kootenai Tribe, IDFG, MFWP, BC MoE,USACE*	*IKERT, BEF*
Endorse potential benefits to the burbot population and food base of ongoing efforts in other forums to assess and remedy sources of environmental contaminants.	*S-L*	*USFWS, Kootenai Tribe, IDFG, MFWP, BC MoE*	*All agencies*
Conduct controlled and in-situ laboratory bioassays to determine the physiological effects of temperature, contaminants, predation, nutrients and other potential environmental stressors on different life stages of burbot.	*S-M*	*USFWS, Kootenai Tribe, IDFG, MFWP, BC MoE*	*UI-ARI, USGS, and other labs*
Hydro Operations			
Develop an experimental Kootenai River flow/water temperature operation to evaluate the effectiveness of restoring natural spawning, and recruitment by reducing winter temperatures and velocities. Implement experimental operations when conditions allow to evaluate burbot spawning requirements while preserving flexibility in needed hydropower production and flood control operations.	*S-M*	*USACE, BPA, BC Hydro*	*IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee*
Document specific temperature and flow requirements that provide for natural spawning, incubation, rearing, recruitment, and survival of Kootenai River burbot.	*S-L*	*IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS*	*USACE, BPA, BC Hydro, KVRI M&E and Hydro Operations Subcommittee*
Investigate existing hydrological models based on historic temperature, flow, and velocity data, and modify if necessary to evaluate effects of operational alternatives on conditions required for completing various burbot life stages.	*S-L*	*BPA, USACE, USGS, BC Hydro*	*IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee*

Conservation Measure Description	*Time Frame**	*Lead Agency*	*Cooperating Agencies*
Evaluate use of selective withdrawal during migratory pre-spawning periods to affect thermograph near Bonners Ferry and downstream to benefit burbot. Monitor water temperature at Porthill.	*S*	*USACE*	*IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee*
Develop a long-term process to recommend annual Libby Dam operations for burbot, while providing for other project uses consistent with Endangered Species Act and other statutory and regulatory responsibilities. The multi-year plan may explore opportunities for experimental operations to evaluate burbot response to the operations.	*L*	*BPA, USACE, USFWS, BC Hydro*	*IDFG, Kootenai Tribe, BC MoE, MFWP, USFWS, KVRI M&E and Hydro Operations Subcommittee*
Culture, Supplementation & Reintroduction			
Develop effective methods to successfully hold, spawn, fertilize, and rear burbot in a hatchery. Develop these techniques using burbot from other regional populations to avoid impacts to remnant Kootenai River, Kootenay Lake, and Duncan Reservoir populations.	*S*	*Kootenai Tribe, BC MoE, UI-ARI*	*KVRI Burbot Culture Subcommittee*
Evaluate donor stock suitability using a multidisciplinary broodstock evaluation template that incorporates: genetic, evolutionary, biological, ecological, and management parameters for fish in receiving and donating waters. In the short term, complete burbot microsatellite analysis to identify stock structure and guide decisions regarding stock source for conservation aquaculture.	*S*	*Kootenai Tribe, UI-ARI IDFG, MFWP, BC MoE, CFS*	*KVRI Burbot Culture Subcommittee*
When effective burbot culture techniques have been identified, and if natural recruitment sufficient to meet recovery goals has not been restored, implement an experimental burbot stocking program to: 1) identify life cycle bottlenecks in burbot survival, 2) determine whether hatchery-produced burbot can effectively survive in the wild, and 3) contribute to demographic and genetic vigor of remnant or re-introduced populations.	*S-L*	*Kootenai Tribe, UI-ARI IDFG, MFWP, BC MoE*	*KVRI Burbot Culture Subcommittee, CFS*
Design, evaluate, and implement a fish culture strategy with strict genetic guidelines, fish health protocols, and rigorous M&E components to assess and balance benefits and risks of natural production, while recognizing the need for significant conservation measures.	*S-L*	*Kootenai Tribe, UI-ARI, IDFG, BC MoE*	*KVRI Culture Subcommittee, CFS*

Conservation Measure Description	*Time Frame**	*Lead Agency*	*Cooperating Agencies*
Identify subsequent hatchery roles in burbot conservation, based on monitoring and evaluation of post-release fish performance and responses of any natural recruitment to other recovery measures, and to the performance of experimental releases of hatchery fish.	*S-L*	*IDFG, MFWP, BC MoE, Kootenai Tribe*	*UI-ARI, WSU, IDFG*
Research, Monitoring, and Evaluation			
Periodically conduct standardized assessments of burbot status in the Kootenai River from Montana downstream into Kootenay Lake contingent on availability of appropriate sample numbers, and on donor source brood stock populations.	*S-L*	*IDFG, BC MoE, MFWP, Kootenai Tribe (w/ hatchery progeny)*	*KVRI Burbot Committee*
Periodically conduct standardized assessments of wild larval and juvenile abundance.	*S-L*	*IDFG, BC MoE, MFWP, Kootenai Tribe (w/ hatchery progeny)*	*KVRI Burbot Committee*
Identify essential habitats and conditions by monitoring burbot movement and habitat use.	*S-L*	*IDFG, BC MoE, MFWP*	*KVRI Burbot Committee*
Evaluate current use and suitability of the mainstem Kootenai River and its tributaries for burbot spawning.	*S-M*	*IDFG, Kootenai Tribe, MFWP, BC MoE*	*KVRI Burbot Committee*
Evaluate the contribution of entrainment from Libby Dam to the downstream Kootenai River burbot population.	*S-L*	*MFWP, IDFG, BC MoE*	*KVRI Burbot Committee*
Identify burbot behavior in Kootenay Lake to determine whether special habitat limitations or biological interactions affect effectiveness of the burbot Conservation Strategy.	*S-M*	*BC MoE*	*KVRI Burbot Committee*
Monitor burbot responses to specific conservation measures, and modify projects/operations to meet biological performance targets.	*S-L*	*IDFG, Kootenai Tribe, MFWP, BC MoE*	*Relevant KVRI Sub-Committees*
Design, implement and evaluate natural production experiments.	*S-L*	*IDFG, Kootenai Tribe, MFWP, BC MoE*	*Relevant KVRI Sub-Committees*
Information and Education			

Conservation Measure Description	*Time Frame**	*Lead Agency*	*Cooperating Agencies*
Increase public awareness of the need for Kootenai River burbot conservation by developing and distributing informational and educational materials and by hosting periodic public meetings.	*S-L*	*KVRI I&E Committee*	*KVRI Burbot Committee*
Pursue opportunities to link Kootenai River burbot conservation activities with other ongoing fish management, fish and wildlife recovery activities, and habitat and ecosystem restoration efforts via the multi-agency Kootenai River Adaptive Management Plan.	*S-L*	*IDFG, Kootenai Tribe, BC MoE, USFWS, MFWP*	*All agencies*
Prepare and distribute annual monitoring, evaluation and research reports.	*S-L*	*IDFG, Kootenai Tribe, BC MoE, USFWS, MFWP*	*All Agencies*
Continue to involve a broad coalition of stakeholders in burbot conservation through the Kootenai Valley Resource Initiative Process.	*S-L*	*KVRI Burbot Committee*	*All Agencies*
Planning, Implementation, and Coordination			
Maintain a standing technical committee to coordinate and adapt implementation of this Conservation Strategy.	*S-L*	*KVRI Burbot Committee*	*All Agencies*
Review and update this Conservation Strategy annually; formally update it every five years or less as necessary.	*S-L*	*KVRI Burbot Committee*	*All Agencies*
Continue to build regional and international program coordination and participate in timely data sharing.	*S-L*	*KVRI Burbot Committee*	*All Agencies*

*L=long term (>10 years); S=short term (<5 years); M= medium term (5-10 years); O-L=ongoing to long term; S-L=short to long term; M-L=medium to long term; S-O=short term, ongoing; S-M=short to medium term

Source: KVRI Burbot Recovery Strategy (KVRI 2005)

An excerpt from the Kootenai River Subbasin Plan (KTOI and MFWP 2004) further describes the relationship of this burbot aquaculture program with research, monitoring, and evaluation objectives in the subbasin:

> "The Kootenai River Native Fish Conservation Aquaculture Program is a critical component in a suite of projects and actions that collectively will help achieve the Kootenai River Subbasin vision of: the establishment and maintenance of a healthy ecosystem characterized by healthy, harvestable fish and wildlife populations, normative and/or natural physical and biological conditions, and sustainable human communities."

The Kootenai sturgeon and burbot aquaculture programs address the following Urgent and High Priority Aquatic Objectives identified in the Kootenai Subbasin Plan (KTOI and MFWP 2004):

- **Restore Burbot – Conservation Aquaculture:** SBP Objectives BUR 3a and 3b and BUR 4. Achieve consistent natural recruitment in at least three different spawning areas. Achieve stable size and age distributions as determined by an upward trend in a 6-year moving average of population abundance. Achieve a minimum number of 2,500 adults per burbot population (KVRI Burbot Conservation Strategy Measure 9.5).
    - ***BUR3a, 3b and BUR 4 strategies***: Develop and implement a conservation aquaculture program for Kootenai River/Kootenay Lake burbot using the developed Burbot Conservation Strategy and SBP as a guide.
- **Coordination, Outreach and Information Exchange:** SBP Objectives AP2, AP3, AP4, and AP5. Develop and maintain adequate regional and international coordination. Pursue and support independent peer review and scientific counsel. Support locally recognized stakeholder group to improve coordination and implementation. Provide for and support distribution of information.
    - ***AP2-AP5 strategies:*** Develop and maintain international, regional and local coordination to successfully implement project objectives. Support and enhance existing coordination forums to efficiently and successfully implement the subbasin plan. Support and enhance outreach and information exchange. Involve community stakeholder groups. Use SBP strategies as a guide.
- **Kootenai Subbasin Plan Priorities:** The Kootenai River Native Fish Conservation Aquaculture Program meets all Tier 1 criteria and the following Tier II criteria (1, 3, 5, 6, 7, 8, and 9) found in Section 10.5 of the Kootenai Subbasin Plan. The Subbasin Plan also states, "after applying and meeting Tier I criteria, ongoing projects that address urgent objectives will be afforded the highest priority for funding". The Tribe's proposed Kootenai sturgeon and burbot programs fall in the aforementioned category.

2.2) List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates.

Indicate whether this HGMP is consistent with these plans and commitments, and explain any discrepancies.

This Kootenai River Burbot HGMP is consistent with all existing cooperative agreements, including the Subbasin Plan (KTOI and MFWP 2004), the MOA of the Kootenai Valley Resource Initiative and Lower Kootenai River Burbot Conservation Strategy (KVRI 2005), and the international, cooperative Kootenai River Burbot 5-year R, M&E Plan (Table 8).

No court orders direct burbot production programs because the species is not listed as threatened or endangered under the ESA. However, in 2005, the KVRI published its Kootenai River Burbot Conservation Strategy which initiated a collaborative project to develop methods to culture this species, which began in 2003 (UI-ARI 2004, 2007).

2.3) Relationship to harvest objectives

Explain whether artificial production and harvest management have been integrated to provide as many benefits and as few biological risks.

2.3.1) Describe fisheries benefiting from the program, and indicate harvest levels and rates for program-origin fish for the last 12 years if available. *Also provide estimated future harvest rates on fish propagated by the program, and on listed fish that may be taken while harvesting program fish.*

In both Idaho and Montana, burbot is listed as a Species of Special Concern, and the population in the Canadian portion of the subbasin has been Red Listed. Because of the remnant status of this population, harvest is not possible in Idaho.

Without natural production, no future burbot harvest is envisioned for at least 10-20 years (1-2 generations). Offsetting such predictions would require restoration of habitat and ecological functions. Because this project is new, no fish have been released that are large enough to provide any fishery benefits to date (the first release of several year-classes of hatchery-produced juveniles occurred during fall 2009). No legal harvest has occurred on this native population in the lower Kootenai River since the harvest fishery was closed in 1984.

2.4) Relationship to habitat protection and purposes of artificial production

Describe the major factors affecting natural production (if known). Describe any habitat protection efforts, and expected natural production benefits over the short- and long-term.

Ecosystem-based habitat restoration actions are the focus of a number of Tribal projects, including the Kootenai River habitat restoration project (BPA 200200200) to be implemented in 2011, Operational Loss Assessment (BPA 200201100), and the Ecosystem Improvement Project (BPA 9404900). The goal of the burbot program is to reintroduce burbot to reestablish a self-sustaining population. If habitat restoration actions succeed in providing a self-sustaining population with adequate natural production to sustain future harvest, then there will be no further need for the conservation hatchery program. Alternatively, if a self-sustaining, naturally produced burbot population that can support future harvest goals is not attainable following habitat restoration actions, then this program will be required to maintain a harvestable burbot population in the Kootenai River.

Finally, the presence of a burbot population in the Kootenai River that can sustain some level of harvest is consistent with goals and objectives of the NPCC Fish and Wildlife Program, BPA funded mitigation activities and the U.S. federal trust responsibility with the Kootenai Tribe.

2.5) Ecological interactions

Describe all species that could (1) negatively impact program; (2) be negatively impacted by program; (3) positively impact program; and (4) be positively impacted by program.

The Kootenai River ecosystem includes a variety of species including bull trout, interior redband trout, westslope cutthroat, rainbow trout, native kokanee, and burbot. Sturgeon generally occupy a benthic habitat niche and do not interact with most of these species in any significant fashion. Where interactions with burbot may occur, they are subtle and beyond our ability to measure or distinguish from interactions with other features of the system. Some species such as spawned-out kokanee represented a historical food source but are no longer present in significant numbers. Interactions with other sensitive species are expected to be minimal.

Inadequate numbers of burbot currently exist in the Kootenai River (Pyper et al 2004; Paragamian et al. 2008) to constitute a risk to a receiving population. Benefits and risks associated with the program are presented in Table 3 and described in Sections 1.10.1 and 1.10.2.

SECTION 3. WATER SOURCE

3.1) Provide a quantitative and narrative description of the water source (spring, well, surface), water quality profile, and natural limitations to production attributable to the water source.

For integrated programs, identify any differences between hatchery water and source, and "natal" water used by the naturally spawning population. Also, describe any methods applied in the hatchery that affect water temperature regimes or quality.

Withdrawals from the Kootenai River will supply most aquaculture operations at Twin Rivers Hatchery, supplemented by surface withdrawals from the Moyie River at certain times of the year. Small volumes of groundwater will provide a pathogen-free supply to incubate eggs and run early-life rearing experiments to refine burbot culture.

Surface Water

River water needs for the Kootenai sturgeon and burbot programs will gradually increase during the first year of operation and range seasonally from approximately 600 to 1,220 gpm thereafter. Intake structures are proposed on both the Kootenai and Moyie rivers. Water will flow by gravity through intake screens into the pump stations adjacent to the river intakes. From the Kootenai intake, water will be pumped into a sediment pond to remove settleable solids prior to further treatment and use. The Moyie River water supply is expected have a much lower sediment load than the Kootenai, enabling it to be pumped directly to mechanical filtration in the water treatment building. The preliminary location for the Kootenai River intake is approximately 150 feet upstream of the existing unimproved boat ramp. On the Moyie River, an intake will be installed at the far north end of the project site in slow deep water at the base of a rock outcrop.

Groundwater

Relatively small amounts of groundwater will be used in the hatchery to provide a pathogen-free supply for incubation, make-up water for the live feed program, and perhaps for temperature control of river water at certain times of the year. Groundwater demand will range seasonally from 15 to 150 gpm. Two new 150 gpm on-site wells will provide redundant sources of groundwater. An existing well will continue to be used to supply potable water.

Water Temperature Control

Tempered river water and groundwater flow requirements will range seasonally from 100 to 300 gpm, and 10 to 100 gpm respectively. Redundant boiler and chiller systems with automatic set-point controllers will be used to reliably provide appropriate water temperature at each facility. Primary heat exchangers will likely be used to recover energy from heated and chilled hatchery effluent in order to reduce equipment sizes and conserve energy.

Water Treatment

Water pumped from the Kootenai River will first be routed through sediment ponds to remove settleable solids. This step may be supplemented by ozone treatment for micro-flocculation. After initial settling, particulates in the river water will be removed through a drum screen followed by booster pumps and high-rate sand filtration. The filtered water will be disinfected with ultra-violet sterilization to destroy any remaining pathogens.

Disinfected water will be routed either directly to the hatchery headbox for use as ambient water or to heat exchangers to adjust the water temperature. All water supplies will be gas-stabilized at the head box prior to use in the hatchery. Groundwater testing is underway to determine if any treatment in addition to standard gas stabilization will be needed.

Water treatment systems will be located in a central room or building in order to simplify operations and maintenance. The sediment pond will be covered to prevent icing. Back-up generators with automated phone alarms will provide emergency power to critical treatment equipment.

A shared water supply system for the Kootenai sturgeon and burbot programs is proposed because it will reduce costs for land acquisition, design, permitting, construction, and long-term operations.

3.2) Indicate any appropriate risk aversion measures that will be applied to minimize the likelihood for the take of listed species as a result of hatchery water withdrawal, screening, or effluent discharge.

The hatchery water supply flow rates are low compared to the base flows in both the Kootenai and Moyie rivers. Hatchery intake screens will be sized to provide screen face velocities of less than 0.2 feet per second, with openings of less than 1.75 millimeters. The screens will be automatically, actively cleaned to avoid creating high velocity zones due to partial screen fouling and will conform with NMFS and USFWS screening guidelines to minimize the risk of impingement of listed species. The screens will be located in areas with good sweeping velocities to further reduce these risks.

Hatchery effluent will be treated in accordance to State of Idaho and Federal NPDES permit conditions. An off-line settling basin will be used to remove pollutants from the hatchery effluent prior to discharge. Water quality testing will be performed on a regular basis to monitor hatchery effluent properties and inform the operators if problems arise.

SECTION 4. FACILITIES

Only 5,725 square feet of the Twin Rivers Hatchery will be dedicated to the burbot program (Table 9). In addition, six exterior burbot ponds are proposed that will occupy 20,000 square feet.

Table 9. Proposed footprint of burbot rearing facilities.

Proposed Burbot Buildings	
Burbot Broodstock/Spawning	1,125 SF
Burbot Incubation	1,280 SF
Burbot Rearing (Indoors)	1,800 SF
Burbot Mechanical/Electrical	200 SF
Cyro/Freezer/Feed Prep/Lab	720 SF
Burbot Live Feed/Feed Preparation	600 SF
Burbot Subtotal	**5,725 SF**
Outdoor Facilities	
Burbot Ponds (6)	20,000 SF

4.1) Broodstock collection, holding, and spawning facilities

Broodstock collection facilities

Unlike broodstock collection facilities associated with salmon hatcheries, no broodstock collection facilities are involved with burbot culture. Gametes (and broodstock) are collected in the field and held in facilities described in the next section.

Broodstock holding facilities

Broodstock (25 male, 25 female; 2.5kg average body weight) will be held in up to four 6-foot-diameter, 3-foot-deep covered round tanks supplied with ambient river water. Experimental holding densities of one 2.5kg adult/100L of water appear adequate. Insulating the tanks may be necessary to meet the unique thermal needs during winter and the late-winter spawning season (2-4˚C). Holding tanks may also be used for spawning tanks, in which fine mesh screening (500 micron) is added over the tank outflow to prevent egg losses during volitional spawning.

Spawning facilities

Broodstock holding tanks described above may also be used for spawning. Additional spawning tanks will be needed if paired mating matrices are incorporated into the breeding program. In this scenario, broodstock would be divided over as many as 10 to 20 spawning tanks (4- to 6-foot diameter and 2- to 3-foot deep) with sex ratios of 1 female:2 males or 2 females:2 males. All spawning tanks will require 500 micron mesh screened outflows to prevent egg losses due to volitional spawning. In addition, external standpipes equipped with egg collection baskets may be warranted to collect volitionally spawned eggs.

4.2) Fish transportation equipment

Gamete and broodstock collections will be coordinated through multiple agencies using transportation equipment and holding facilities already in place. A boat is required when cod traps are used and may be needed for releases. When burbot are trapped, captures are brought aboard, temporarily held in 100 L plastic containers with water, given a unique tag, and then placed in a haul tank for transport. Although past broodstock collections have not included gender determination, future collections may incorporate such procedures if one gender is desired. Portable ultrasound, catheter or gentle stripping methods would be used depending on time of year (e.g., November through January, testes are distinguishable from ovaries).

Manual field gamete collection requires smaller hauling containers, typically an insulated 150 L cooler with a layer of ice under a layer of paper. Fertilized eggs are held in 50 L plastic bags filled with tempered water and oxygen atmosphere and must be transported to the hatchery incubation facility within 24 hours.

Haul tanks vary in size and function depending on the number of fish and relative biomass or quantity of gametes. Oxygen is diffused into the holding tank water to maintain a minimum 5 ppm dissolved oxygen concentration. Water is tempered based on the time of year, location, burbot life stage and the length of transport. Under normal circumstances (above freezing), water from the hatchery will be added to the haul tank prior to adding fish, or alternatively, water from the river may be used.

For release of juvenile burbot from Twin Rivers, standard fish transportation trucks with insulated, oxygenated 150 to 250 gallon tanks will be used. Fish are netted from the rearing tanks into the trucks and then netted out of the transportation tanks at the release site. At the release site, water temperature in the transportation tank is manipulated by adding water from the release site. After temperature acclimation, burbot are netted from the tank truck and released into the river. Some release sites require access by boat, in which case, burbot are loaded by net into a live well on the boat, thermally acclimated within the live well, netted out of the well at the release site, and released directly into the river.

4.3) Incubation facilities

Burbot incubation will occupy 1,280 square feet in a separate room in the burbot building. Burbot eggs will be incubated in Imhoff cones mounted over three-foot-diameter fiberglass round tanks or troughs that will collect the young as they hatch. Recent studies show that conical upwelling incubators produce higher hatch rates than McDonald type jars (Jensen et al. 2008a) so these will be incorporated into the Twin Rivers facility. Each 1.2 liter Imhoff incubation cones, has the potential to hold over 250,000 eggs at flows of 300 ml/ minute. Burbot eggs will be treated with a fungicide (formalin or hydrogen peroxide). Eggs will be maintained in water near 3˚C. Hatching typically begins 30 to 40 days after incubator stocking and burbot larvae have been observed to continue to hatch slowly from the egg mass for up to 40 additional days. Larvae hatch from incubators and flow directly into rearing tanks, which eliminates handling at this early developmental stage. The grated floor decking in the incubation area will cover below-grade trenches designed to accommodate different types of tanks, depending on fish culture needs.

4.4) Rearing facilities

Burbot rearing will occur year-round. Burbot spawning, which typically occurs from February-March, but can range from December-April, occurs in circular tanks equipped with fine mesh screened outflows at water temperatures 2-4˚C. Yolk sac fry will be reared from February to June at water temperatures of 6 to 10°C. All rearing beyond the yolk-sac larvae stage will occur in circular tanks (250 -1000 L volume), raceway troughs or square tanks with external standpipes, insulated when appropriate.

Rearing densities of <1,000 fry per liter are targeted for <0.1 gram fish, with low flows and fine mesh screened (400 micron) outflows required for fry containment. Subsequent rearing of exogenously feeding fry will occur April through September at water temperature ranging from 10 to 15°C at densities of 100 to 250 fish per liter (averaging 0.1 to 1.5 grams).

Fingerlings will be reared from January through December at 10 to 20°C at a target density of 100 fish per liter (averaging from 1.5 to 25 grams). Ongoing growth and survival experiments at the UI-ARI with age 0 burbot indicate that growth is maximized as temperatures approach 20°C, but survival increases when temperatures are closer to 10°C (pers. comm., J. Barron, UI-ARI). Thus, age 0, 1, and 2 juvenile rearing will occur

January through December and temperature will be controlled depending on production goals or release timing (10 to 20°C). Target rearing densities of 1 to 10 fish per liter, at 25 to 150 grams are recommended.

Live feed rearing will be required for burbot fry and broodstock. Rotifers (*B. plicitilis*) and *Artemia* (Great Salt Lake, UT strain) will be reared on a continuous or seasonal basis to feed burbot fry. Rotifers will be maintained year-round with a master culture in several 50-100 L containers and mass produced in during fry feeding phase (April through September) in a closed recycling system (350 L total volume). *Artemia* will be batch cultured in 19 or 80 L tanks depending on production season demands. Burbot broodstock will be fed live rainbow trout (*O. mykiss*; 10-50 g average body weight). Rainbow trout growout will occur in raceway style troughs (8- to 12-foot-long) and 4- or 5-foot circular tanks. Eyed rainbow trout eggs (3,000-5,000) will be purchased three times per year (March, July, October) and reared on commercial grade feed at same temperature as adult burbot at a target size of ≤50g/fish.

4.5) Acclimation/release facilities

No acclimation or release facilities are currently planned. Prior to fish release, water temperature acclimation within transport containers will occur and gametes will be tempered within transport bags prior to stocking into incubation facilities.

4.6) Describe operational difficulties or disasters that led to significant fish mortality

4.6.1) Indicate available back-up systems, and risk aversion measures that minimize the likelihood for the take of listed species that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

No available systems exist because the Twin Rivers hatchery has not yet been constructed.

4.6.2) Indicate needed back-up systems, and risk aversion measures that minimize the likelihood for the take of listed species that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

The hatchery will be staffed full-time and equipped with various temperature, water level and flow alarms to help prevent catastrophic fish loss resulting from water system failure. Redundant pumping, filtration, temperature control, disinfection, and back-up power systems will be incorporated to minimize the risk of mechanical failure. Comprehensive operations and maintenance manuals will be prepared in conjunction with training for hatchery staff to ensure that proper procedures are followed during all phases of aquaculture operations.

Hatchery facilities will be constructed well above flood elevations, with robust drain systems to prevent flooding damage.

Pathogen free groundwater will be used for incubation and early life stage fish development. River water supplies will be filtered and UV sterilized to inhibit pathogen growth. Aquaculture fish and egg handling protocols will be followed to limit the risk of disease outbreaks. The Kootenai Tribal hatchery staff have demonstrated successful operating experience at the Bonners Ferry Sturgeon Hatchery.

SECTION 5. BROODSTOCK ORIGIN AND IDENTITY

5.1) Source

The program uses Moyie Lake burbot as the source of gametes or broodstock. Adult burbot and/or gametes from the remnant Kootenai River may be incorporated if available.

5.2) Supporting information

5.2.1) History

Provide a brief narrative history of the broodstock sources. For listed natural populations, specify its status relative to critical and viable population thresholds (use section 10.2.2 if appropriate).

Moyie Lake stock is a natural population maintained by natural production without hatchery influence.

5.2.2) Annual size

Provide estimates of the proportion of the natural population that will be collected for broodstock. Specify number of each sex, or total number and sex ratio, if known. For broodstocks originating from natural populations, explain how their use will affect their population status relative to critical and viable thresholds.

A target captive broodstock of 25 adult male and 25 adult female burbot, with an average 2.5kg body weight burbot is recommended for the new facility. Facility design for the captive broodstock facilities is based on this number of fish.

5.2.3) Past and proposed level of natural fish in broodstock

If using an existing hatchery stock, include specific information on how many natural fish were incorporated into the broodstock annually.

This question is not applicable to this burbot program or any of its possible broodstock/gamete sources.

5.2.4) Genetic or ecological differences

Describe any known genotypic, phenotypic, or behavioral differences between current or proposed hatchery stocks and natural stocks in the target area.

This is not an issue for this program because too few local natural burbot remain to be negatively affected by program operations.

5.2.5) Reasons for choosing broodstock traits

The Moyie Lake burbot population was selected based on geographic location, connectivity to the Kootenai River in Idaho, management priorities and logistics. Empirical genetic evidence also suggests that the Moyie population is a closely related stock to the remnant lower Kootenai River population and is demographically capable of sustaining a gamete collections and intermittent take of limited numbers of adults.

No specific traits or characteristics were chosen other than naturally adaptive, within-basin native genotypes, phenotypes, behaviors and life history trait expressions.

5.2.6) ESA-Listing status

The burbot proposed for use in this program have no ESA-listed status.

5.3) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects that may occur as a result of using the broodstock source.

Similar questions throughout this HGMP inquire about proposed risk aversion measures taken to minimize risk from the program. These questions are found in sections: 3.2, 4.6.1, 5.3, 6.9, 7.4, and 8.28. To simplify and avoid redundant responses to these questions, we addressed these issues, including the following risk aversion facility design features and program operations.

This program will implement risk aversion measures to reduce the risk of low within-population diversity. This will be achieved by following strict breeding matrices that: 1) diversify gamete and broodstock collections within years and over a period of many years; 2) select and cross gametes and broodstock across the widest range of time and space possible; and 3) incorporate cryopreserved gametes to maximize cross diversification. Because burbot are currently functionally extinct in the Kootenai River, there is no genetic risk or adverse ecological effects to the functionally extinct existing population.

For logistical and broodstock accountability purposes, if annual spawner groups are captured and possibly transitioned into captivity (if a captive broodstock population is established and maintained), each will be given a PIT-tag for unique identification and gender will be determined using ultrasound. Individual identity will allow reuse of individual broodstock or their gametes in ways to avoid unintentional inbreeding of iteroparous fish.

The risk of disease amplification and introduction to natural waters will be controlled by incorporating standard operating procedures, best management practices, and fish health policies. Disease testing will follow required procedures for inspection under the USFWS Title 50 act. Samples will be submitted to the Idaho Fish Health Center (USFWS) for testing and inspection prior to annual releases (see Section 6.7).

Risk aversion is further practiced by:

- Maintaining optimal life-stage specific densities in the hatchery (Section

8.2.2., Table 12);

- Maintaining optimal life-stage specific water quality (Section 8.2.3, Table 13);
- Maintaining optimal fish health (Section 8.2.6)
- Feeding adults certified disease free food (rainbow trout) (Section 8.2.5, Table 14)
- Single pass water use, and providing (Section 3)
- Incoming water filtration and sterilization (Section 3).

SECTION 6. BROODSTOCK COLLECTION

6.1) Life-history stage to be collected (eggs, juveniles, adults)

Gamete and broodstock collection from Moyie Lake will occur annually, unless facility capacity is met and/or the future captive broodstock population meets or exceeds the proposed production and genetic diversity targets. Gametes (up to 10 million eggs) will be collected annually by capturing gravid females and flowing males during their natural spawning time (February to April). These gametes may be raised up to adulthood and used for the captive rearing program or be used for experimental releases. If broodstock collection occurs during a given year, these fish typically average 0.5 to 5.0 kg and will be collected prior to spawning (October to January).

6.2) Collection or sampling design

Include information on the location, time, and method of capture. Describe measures to reduce sources of bias that could lead to a non-representative sample of the desired broodstock source.

Sampling location

Gametes and broodstock will be collected from Moyie Lake, B.C. Recent annual reports detailing characteristics of the Moyie Lake burbot population and sampling efforts are available at the following links:

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=17097

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=16158

http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=13484

Sampling and collection timing

Burbot gamete collection from Moyie Lake occurs during February and March. Adult broodstock collection, if it occurs, takes place during October and November.

Method of capture

Angling will be the sole means of burbot capture for gametes or broodstock. This technique minimizes known injury and mortality associated with burbot trapping and retrieval from depths (Neufeld and Spence 2008). Fish are captured, brought to the surface and then placed into holding tanks (large Tupperware™ containers) oxygenated with bottled oxygen and a diffusing stone. Because cold ambient air temperatures can cool the holding tanks, water in the tanks is insulated from the surface of the ice to prevent rapid cooling and is changed every hour to reduce temperature stress on burbot. Because air temperatures can be well below 0° C (morning temperatures are often −20°C) sampling may be postponed until late morning when temperatures increase. Under these conditions, fish sampling may occur in an ice tent that is warm enough to avoid fish damage associated with freezing tissue.

Most captured burbot captured will be measured (TL) and weighted, assessed for sex and maturity, tagged with a Floy tag and then released. A subset of suitable mature male and female burbot will provide gametes for hatchery rearing trials and other fish culture activities in Idaho. These fish were first anesthetized in a water bath containing 200 ppm clove oil. Once anesthetized, burbot are spawned and gametes placed into a bowl, mixed together, water activated, and then rinsed with fresh water. After spawning, burbot are allowed to recover in a fresh water bath and then released. To maximize post-fertilization survival, fertilized eggs are held in a plastic container in fresh water for a period of at least one hour to allow eggs to water harden before transport. Uninterrupted minimum travel time under best highway conditions from Moyie Lake to Twin Rivers is only about two hours.

6.3) Identity

Describe method for identifying (a) target population if more than one population may be present; and (b) hatchery origin fish from naturally spawned fish.

Only fish from Moyie Lake will be used, so there will be no additional need to identify populations.

6.4) Proposed number to be collected

6.4.1) Program goal (assuming 1:1 sex ratio for adults):

Less than 20 broodfish per year (sexes combined) if needed, would be collected to reach the captive broodstock target of 50 fish, twenty-five male and 25 female burbot.

Table 10. Broodstock collection levels for most recent years available.

Year	Adults Females	Males	Undetermined	Eggs	Juveniles
2001	14	6	3	0	0
2002	10	10	0	0	0
2003	13	7	0	0	0
2004	21	5	0	1,337,000	0
2005	16	7	7	0	0
2006	12	9	8	0	0
2007	7	10	0	0	0
2008	0	0	0	0	0
2009	0	0	0	7,000,000	0

6.5) Disposition of hatchery-origin fish collected in surplus of broodstock needs

This burbot conservation aquaculture project will not involve hatchery-origin fish (adults); therefore this question is not applicable to the burbot program.

6.6) Fish transportation and holding methods

Burbot transportation and holding methods as part of this program are described in Section 4.2.

6.7) Describe fish health maintenance and sanitation procedures applied

Strict implementation of standard culture practices used for the white sturgeon fish health program at the Kootenai Sturgeon Hatchery is recommended for burbot. Standard operating procedures and best management practices will be employed to control potential in-hatchery disease outbreak and disease transmission risks (see Section 8.2.6). Furthermore, significant progress has occurred in the new field of burbot pathology (Polinski et al., 2010, 2009a, 2009b) and aquaculture techniques (Jensen et al. 2008a, 2008b, 2008c, 2010) that directly benefit this program.

Implementation of routine disease management strategies will reduce the risk of infection by pathogens and strict disease testing will be implemented in accord with Title 50 pathogen screening at the Idaho Fish Health Center (USFWS) prior to release of juvenile fish to ensure disease free status. In addition to establishing baseline information for the most concerning fish diseases, a new cell line was established from burbot embryo cells and provided to disease diagnostic laboratories (Polinski et al. 2009). This will provide a screening tool that will be valuable in detecting potential viral pathogens of burbot.

6.8) Disposition of carcasses

Because burbot are iteroparous fish (they do not die after they spawn like semelparous anadromous salmonids), there is no need to dispose of any carcasses as part of the program. Mortalities will be incinerated or disposed of in a landfill.

6.9) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed species resulting from the broodstock collection program.

This program will implement risk aversion measures to reduce the risk of low within-population diversity. This will be achieved by following strict breeding matrices that: 1) diversify gamete and broodstock collections within years and over a period of many years; 2) select and cross gametes and broodstock across the widest range of time and space possible; and 3) incorporate cryopreserved gametes to maximize cross diversification. Because burbot are currently functionally extinct in the Kootenai River, there is no potential for genetic risk or adverse ecological effects an existing population.

For logistical and broodstock accountability purposes, if annual spawner groups are captured and possibly transitioned into captivity (if a captive broodstock population is established and maintained), each will be given a PIT-tag for unique identification and gender determined using ultrasound. Individual identity will allow reuse of individual broodstock or their gametes to avoid unintentional inbreeding of iteroparous fish.

The risk of disease amplification and introduction to natural waters will be controlled by incorporating standard operating procedures, best management practices, and fish health policies. Disease testing will follow required procedures for inspection under the USFWS Title 50 Act. Samples will be submitted to the Idaho Fish Health Center (USFWS) for testing and inspection prior to annual releases.

SECTION 7. MATING

In this section, we describe mating protocols and associated performance indicators that are based on burbot research results, not just on numbers of fish produced.

7.1) Spawner selection method

To meet performance indicators, strict breeding matrices will be employed to maximize genetic variability and simulate gene flow patterns exhibited by naturally spawning burbot populations. Additional efforts to maximize genetic diversity and associated life history traits and behaviors will include gamete collection from the largest temporal and spatial range of spawning feasible. Gamete or broodstock sampling is initiated prior to expected collection of flowing males or ripe females to ensure that gametes from the earliest spawners are available to the program.

For the proposed Twin-Rivers facility, adult broodstock or field-collected and field-spawned eggs will be used. If fertilized eggs were to be chosen for developing a captive brood population, production will be delayed 3 to 5 years awaiting maturation. If wild adult spawners are collected, choice will depend on angling effort(s), trapping effort, the number of days or years of collection and in-hatchery acclimation and survival. In addition, spawning matrices will dictate when additional brood stocks are needed. Spawner stock location is restricted to the Kootenai(y) subbasin with initial efforts focusing on Moyie Lake, B.C.

7.2) Fertilization

Describe spawning protocols applied, including the fertilization scheme used (such as equal sex ratios and 1:1 individual matings; equal sex ratios and pooled gametes; or factorial matings). Explain any fish health and sanitation procedures used for disease prevention.

Spawning protocols will include manual gamete collections and natural in-tank spawning of pairs or groups. Manual gamete collections with subsequent controlled crosses based on pre-determined spawning matrices, including equal sex ratio 1:1 mating, unequal sex ratio mating (1 female: multiple males), field collected gametes, and cryopreserved semen will also be incorporated into the breeding program.

Burbot fertilization methods have been successfully developed using raw and cryopreserved semen (Jensen et al 2008a). Annual average burbot embryo survival rates 48 hours after fertilization ranged from 51 to 73% (from 2006 through 2009), with an overall average of 67% across years.

Fish health and facility sanitation procedures will follow manufacturers recommended concentrations and exposure times. Disinfection of fertilized eggs during water hardening will be accomplished using 25 to 50 parts per million buffered PVP iodine treatments to suppress and control pathogen transmission.

7.3) Cryopreserved gametes

If used, describe number of donors, year of collection, number of times donors were used in the past, and expected and observed viability.

Gametes from all Moyie Lake males (21) captured for experimental burbot aquaculture research during 2006 and 2007 are represented in the Kootenai Tribal cryostorage tank at the University of Idaho Biological Sciences Department. Any or all of the Moyie semen donors may be used in future spawning matrices based on methods developed at UI-ARI which verified the use of cryopreserved burbot semen as a viable tool (Jensen et al. 2008). Fertilization success rates up to 75% have been achieved on small batches of eggs (averaging 1,300 eggs: five-0.25ml straws containing semen and freezing extender).

7.4) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme.

Too few burbot remain in the river to be affected by future burbot hatchery operations. See Sections 5.3 and 6.9 for further details.

SECTION 8. INCUBATION AND REARING

8.1) Incubation

8.1.1) Number of eggs taken/received and survival rate at stages of egg development

Burbot eggs from various broodstock populations (Duncan Reservoir, Arrow Lakes, Moyie Lake, all in B.C.) were collected for experimental development of burbot aquaculture at the UI-ARI from 2004 through 2009. A total of 38.7 million burbot eggs were collected during these years; 4.3 million were collected in the field, 35.7 million were collected from captive broodfish during these years (Table 11).

Fertilization success for individual burbot crosses using live (non-cryopreserved) gametes has been as high as 100%, compared to up to 75% for crosses involving thawed cryopreserved milt. Annual average burbot embryo survival 48 hours after fertilization ranged from 51 to 73% (from 2006 through 2009), with an overall average of 67% across years (Table 11).

Future egg take will be determined by back calculating production needs, incorporating empirical survival rates to reach future age class structures and adult population abundance targets.

Table 11. Burbot egg collections and egg and embryo survival data for experimental scale operations 2001-2009.

Year	Eggs collected		Total	Survival % 48 hours post activation/ fertilization
	In captivity	From wild		
2001	ND	ND	-	-
2002	ND	ND	-	-
2003	ND	ND	-	-
2004	ND	1,337,000	ND	ND
2005	1,650,000	0	1,650,000	ND
2006	8,019,501	0	8,019,501	73
2007	5,867,461	0	5,867,461	61
2008	7,639,775	0	7,639,775	84
2009	12,557,998	2,990,615	15,548,613	51
Total	35,734,735	4,327,615	38,725,350	Mean: 67%

* ND=not determined or data not dependable

Note: data reported in this table were subject to experimental demands and limited incubation capacity.

8.1.2) Loading densities applied during incubation

Based on six years of burbot spawning and experimental aquaculture at the UI-ARI (2004 through 2009), incubator flow rates depend on embryo loading or densities (i.e., higher egg volumes require higher flow rates). Typical flows used in the existing experimental facility with experimental 1.2 L custom Imhoff cone incubators are < 2 L/min. Based on experimental observations to optimize hatching success during the past six years, it is recommended to limit egg loading to 300,000 per incubator when using 1.2 L Imhoff cone incubators (Jensen et al. 2008).

8.1.3) Incubation conditions

Describe monitoring methods, temperature regimes, minimum dissolved oxygen criteria (influent/effluent), and silt management procedures (if applicable), and any other parameters monitored.

Incubation system function monitoring will occur multiple times daily until hatching is completed. Water quality will be monitored weekly unless there is a reason to sample more frequently. Monitored water quality parameters include: alkalinity, total dissolved solids, total suspended solids, N, ammonia, NO3 + NO2, and ortho-phosphorous. Water temperature, Dissolved oxygen and saturation, and bacteria will also be monitored on a routine basis. Inorganic parameters that will be monitored include: calcium, copper, magnesium, manganese, and zinc. Quality control analysis will be included in the water quality reports.

The incubation system(s) will be set up in a flow through style. Water temperature will be maintained near 3° C and will not exceed 7° C. Effects of dissolved oxygen on burbot embryo incubation have not been documented; however, 100% saturation is recommended with a minimum of 5 or 6 parts per million dissolved oxygen considered acceptable. Cold water temperatures during much of the year, especially during spawning and early life stages greatly reduce concerns of dissolved oxygen limitation for most burbot life stages in the hatchery.

Solids in the water source will be removed because the low flows required during incubation typically involve needle valves which can become clogged easily. Other parameters that will be monitored include fungus manifestation and fungicide treatment systems.

All incubators will also be observed multiple times daily for channelization of the flow within egg masses. When channels are observed within egg masses, each will be stirred gently to promote a more uniform flow through the egg mass, facilitating oxygen dispersal to more embryos and more complete removal of incubation embryo metabolites.

8.1.4) Ponding

Ponding methods for burbot are currently being developed and optimized at the UI-ARI in a set of six semi-intensive (aerated and seeded with zooplankton) outdoor tanks and in two earthen ponds near Bonners Ferry, Idaho. Based on preliminary findings, it is recommended that larvae be fed 45 days on live feeds prior to being stocked into ponds with measurable zooplankton levels, at stocking densities not exceeding 500,000 larvae per hectare of pond surface area (Jensen et al. 2008a). Based on results of additional semi-intensive experiments rearing experiments during 2009 and 2010, optimal fish stocking timing, zooplankton and fish stocking densities, and general ponding methods will be established, refined and published.

8.1.5) Fish health maintenance and monitoring

During water hardening (30 minutes post fertilization, 30 minutes treatment time), PVP iodine is used at concentrations of 25 to 50 parts per million. During incubation (48 hours post fertilization), aquatic mold and fungus control methods include the use of formalin and/or hydrogen peroxide, at concentrations of 1,500 parts per million and 500 parts per million respectively, as approved for use by the AADAP. Incubation system fungicide treatments will occur on a daily basis through the onset of observed hatching. A recent study recommended a minimum of 1,667 mg/L formalin or 500 mg/L hydrogen peroxide to maximum egg survival and fungus control during egg incubation for burbot (Polinski et al., in press), and these recommendations will be followed in the future. Dead embryos will be removed daily or more frequently if needed using small strainers or siphons.

8.1.6) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to fish during incubation

Eggs will be activated and incubated using "first-use" or flow-through pathogen free filtered (UV and sediment) water (well water, treated river water, or some thermally optimal mixture). Water chillers and heaters will be sized appropriately sized to meet the thermal requirements as noted above in Section 8.1.3.

To prevent adverse genetic effects, parental crosses will be controlled, recorded, and each group of eggs or family will be held apart to prevent inbreeding depression of captive stocks where necessary. Breeding matrices will be applied when possible. However, eggs may also be collected after adults spawn naturally within rearing tanks on their own volition. Volitional spawning will be incorporated into the breeding program to allow natural spawning and subsequent egg collection and as this behavior is more closely studies may be used as a tool decrease handling stress of adults. In this scenario, rotating or interchanging adult breeding groups on an annual basis will increase genetic diversity and reduce the probability of inbreeding.

Ecological effects will be controlled by maintaining a flow-through style incubation system. In addition, egg incubation will occur in a room detached or separated from wild captive adults.

8.2) Rearing

8.2.1) Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to release) for the most recent twelve years or for years dependable data are available.

There is no survival data available from the proposed Twin Rivers Hatchery because it has not been built yet.

Due to the experimental nature of the existing feasibility-scale operation at UI-ARI, there is limited data about survival rates because routine culling takes place during each life stage. However, 2008 experimental production was characterized as an example of what the experimental facility annual production curve looks like (Figure 3).

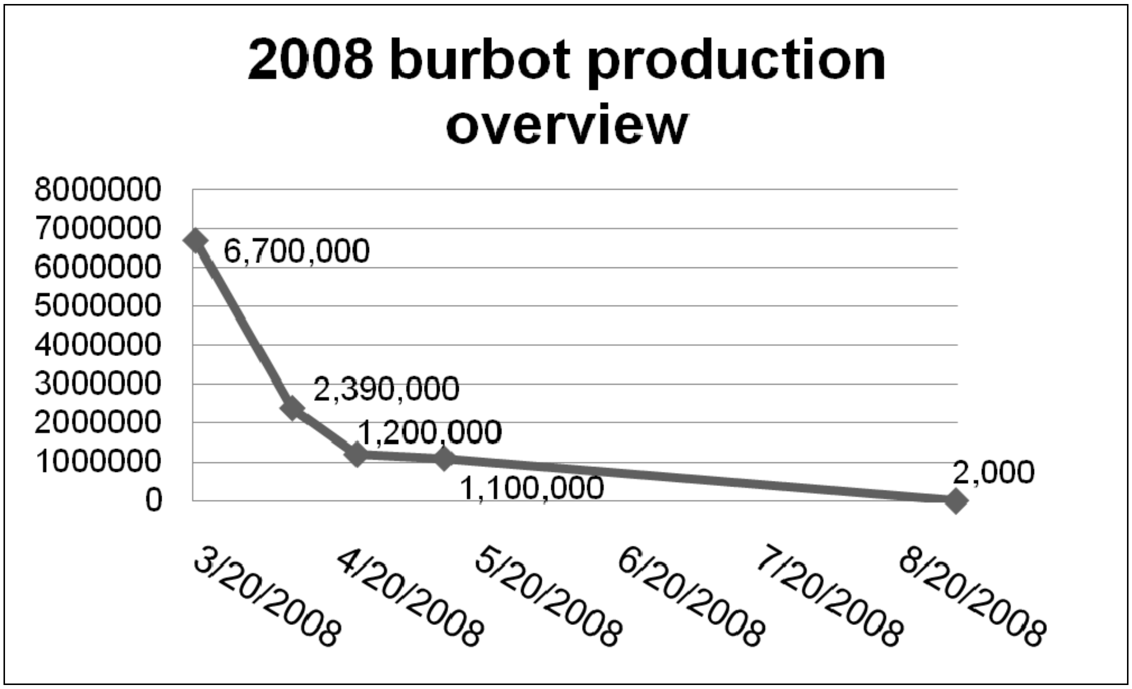


Figure 3. Experimental program burbot production in 2008 at UI-ARI.

Prior to 2004, burbot experimental culture efforts focused on spawning and early life rearing and no fry survived to the juvenile life stage due to UI-ARI facility (space and water) limitations (UI-ARI 2004, 2007). The level of production depicted in Figure 3 represents a conservative, constrained estimate of burbot production potential in a facility not designed for or capable of optimizing or maximizing production.

Production values for dry feed-transitioned juveniles from 2004 through 2008 are reported in Section 1.12. However, these values do not portray true survival rate or program performance potential because fundamental aquaculture method developments included terminal study designs where surviving progeny were euthanized or subjected to protocols that cause intentional disease and death (i.e., disease challenges). Rather, the experimental program performance to date as part of the experimental culture program at the UI-ARI was measured by the success and the value of research produced and its contribution to developing burbot aquaculture.

8.2.2) Density and loading criteria (goals and actual levels)

Include density targets (lbs fish/gpm, lbs fish/ft3 rearing volume, etc.).

Optimal density and loading criteria continue to be developed as part of the ongoing experimental breeding program. While optimal densities for each life stage (eggs, free embryos, first feeding larvae, larvae post metamorphosis, pond ready age 0 semi-intensive and extensive, dry feed transitioned young-of-year, age 1+, and adult rearing and spawning) are unknown, recommendations are made based on knowledge gained during experimental aquaculture trials at the UI-ARI. These recommended density estimates are provided in Table 12 and are briefly described below.

Table 12. Recommended burbot rearing density by life stage.

Life stage	Recommended incubation or rearing density
Incubating embryos	≤ 300,000/ 1.2L Imhoff Cone
Free embryos (yolk sac fry)	≤ 1,000/L
First feeding larvae	≤ 1,000/L
Pond-ready Age-0	≤ 500,000/ hectare of pond surface area
Post-metamorphosed larvae	≤ 250/L
Post dry feed transitioned larvae	≤ 100/L
Age 1+	1-10/L
Adults	≤ 1/L

Due to the minuscule size of the early life stages (free embryos are approximately 3 mm total length and 3 milligrams) and the need to monitor predator:prey ratios for maintaining zooplankton densities (10 per ml minimum), density targets involve per-fish volumetric standards rather than biomass per unit of rearing volume.

For eggs and fertilization, it is recommended that 1 to 2 ml of raw semen be used per 300,000 ova, and incubator loading densities should not exceed 300,000 per 1.2 L Imhoff cone incubator (Jensen et al. 2008). If cryopreserved semen is used, this 1 to 2 ml quantity should be increased to counter the dilution of semen in the freezing extender solution (see Section 7.2) (Jensen et al. 2008).

Free-embryos have been successfully maintained at densities as high as 2,000 per liter. However, this density represented an extreme case due to limited rearing space and the need to keep family groups separated, and likely caused mortality. Therefore, it is recommended that free-embryo densities do not exceed 1,000/L.

First feeding larvae require live feeds (brackish rotifers are currently used), and density likely plays a major role in feeding efficiency and survival. Furthermore, high densities (≥ 1,000/L) likely contribute to cannibalistic behavior, especially if live feeds are scarce. Therefore, a density of < 1,000 first feeding larvae/L is recommended.

Optimal stocking densities for pond-ready age-0 burbot are currently being investigated and experimental trials are expected to conclude in 2010 at the UI-ARI. Currently, it is recommended that stocking density does not exceed 500,000 per hectare of surface area, and only exogenously feeding larvae (45 days on live feeds) should be stocked to optimize survival (see ponding descriptions in Section 8.1.4 for more information).

Post-metamorphosed larvae (still on live feeds, although transitioned to *Artemia*) and dry feed transitioned young-of-year are highly cannibalistic and must be graded down to densities less than 250 per L and 100/L respectively. In addition, daily observations should be made seeking cannibals. If any are found, they should be immediately removed. Cannibals should be held at densities of less than 1/L with in-tank cover and concealment opportunities provided.

Age 1+ rearing densities of 1-10 burbot/L have been used with good results. Adult rearing and spawning densities of 1 adult (average body weight 2 kg) per 10 L have been used with good success.

8.2.3) Fish rearing conditions

Weekly water quality monitoring is described in Section 8.1.3. Inorganic parameters that will be monitored are identified in Table 13.

Water temperatures for rearing will range from 1 to 20˚C. Water quality monitoring will occur in the same fashion as ongoing monitoring protocol at the Tribal Sturgeon Hatchery where monthly water samples are collected at water source inlets (before filtration) and at the head tank (after filtration). Standard pond management procedures are currently being developed.

Table 13. Recommended "no effect" physical and chemical parameter values supporting cold water conservation aquaculture practices.

Water Quality Parameter	Parameter Value Ranges
Alkalinity	50-200 mg/l as $CaCO_3$
Ammonia (as NH_3)	<0.03 mg/l constant <0.05 mg/l intermittent
Calcium	> 50 mg/l
Carbon Dioxide (CO_2)	< 2.0 mg/l
Copper	< 0.006 mg/l in soft water <0.3 mg/l in hard water
Dissolved oxygen	6-8 mg/l
Dissolved solids	50-200 mg/l
Heavy metals (e.g. Hg, Zn, Cu, Cd)	< 0.1 mg/l
Iron	< 1.0 mg/l
Nitrite-N	< 0.55 mg/l
Nitrogen	< 100 % saturation
pH	6.7-8.5
Suspended solids	< 80 mg/l
Water temperatures	Species dependent
Zinc	< 0.04 mg/l @ pH 7.5

Source: Klontz 1991.

8.2.4) Indicate biweekly or monthly fish growth information (*average program performance*), including length, weight, and condition factor data collected during rearing, if available.

The following fish growth data collection and rationale apply to burbot culture at the Twin Rivers facility. Growth information will not be collected on a bi-weekly or monthly basis due to unacceptably high levels of stress associated with handling early life stages of burbot in culture settings. Instead, family or progeny groups of fish will be enumerated periodically during the rearing season to monitor the existing hatchery population(s) and to meet R, M &E needs, such as growth estimation at critical biological development stages, without negatively affecting fish condition, performance, or survival. This approach maximizes information gained wile minimizing fish loss due to handling stress.

Egg and larval abundance is estimated volumetrically. Eggs are enumerated with a 1 ml syringe. A settled volume is measured within the syringe barrel and then subsequently counted. This is repeated 3 or 4 times, averaged and multiplied by a total settled egg mass volume.

Larvae are enumerated using a small container with a known volume. Three samples are collected by inverting the container and plunging into the water column midway, thus trapping an air bubble of known volume, then the container is turned up and the sample containing larvae is manually counted.

Growth data will be available after the 2010 rearing season. Adult broodstock pre-spawn length and weight data will be collected annually to identify fish that spawn of their own volition, which is typical of burbot in captivity (at least to date in recirculation systems). If a single female in a group of spawners releases eggs, it can quickly be identified by a sudden weight loss.

8.2.5) Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (*average program performance*).

Food type used, daily application schedule, and feeding rate range are provided in Table 14. Feed conversion efficiencies have not been calculated for any experimentally cultured burbot but will be calculated during later project phases.

Table 14. Food type, daily application schedule, and feeding rate range for burbot culture.

Life stage	Feed type(s)	Daily application(s)	Feed Rate	Feed conversion
Wild Adult	Live rainbow trout (5-50 g)	Maintain 1:1 adult:trout	Apparent satiation	Not yet calculated
Cultured adult	Commercial trout food (soft moist)	By hand one time daily or automated feeder used for continuous feeding	1-3% BW depending on water temperature and relative tank biomass	Not yet calculated
Larval	Live zooplankton*	Continuous by hand and injected	Rotifers 10:1ml rearing volume, Artemia 5:1ml rearing volume	Not yet calculated
Juvenile	Commercial grade larval diets	By hand two times daily minimum or automated feeder used for continuous feeding	1g feed: 100 L rearing volume at start, then gradual increase to 1-3% BW depending on water temperature and relative tank biomass	Not yet calculated

*Rotifers (*Branchionus plicatilis* are mass produced in closed brackish systems, 10-15 ppt) and *Artemia* (Great Salt Lake strain ≥80% hatch rate, decapsulated are hatched in 5 ppt solution).

8.2.6) Fish health monitoring, disease treatment and sanitation procedures

A primary goal of any aquaculture program is to minimize introduction and transmission of pathogens in cultured and native populations. Available scientific information will be used to develop conservation and management strategies that minimize the transmission of disease from cultured fish to native populations and the potential severity of disease in the native population (LaPatra et al. 1999). Although asymptomatic infection may be widely distributed within and among wild populations, maintenance of optimal rearing conditions (e.g., optimal rearing densities, temperature regimes, water quality conditions) will reduce or prevent stress-mediated disease in the hatchery setting.

Recent studies characterized disease susceptibility in burbot (Polinski et al. 2010, 2009a, 2009b). Strict implementation of standard disease testing protocols developed for the white sturgeon program at the Kootenai Hatchery will be implemented for burbot to minimize potential in-hatchery disease outbreak and disease transmission risks to the remnant wild population.

Disease testing in burbot indicated that this species is susceptible to infectious hematopoietic necrosis virus (IHNV) when challenged by immersion and to *Aeromonas salmonicida* by intraperitoneal (i.p.) injection. IHNV persisted in fish for at least 28 days, whereas *Aeromonas salmonicida* was not re-isolated beyond 17 days post challenge. In contrast, burbot appeared refractory to *Flavobacterium psychrophilum* following intramuscular (i.m.) injection and to infectious pancreatic necrosis virus (IPNV) by immersion. However, IPNV was re-isolated from fish following i.p. injection for the duration of the 28 days challenge. *Renibacterium salmoninarum* appeared to induce an asymptomatic carrier state in burbot following i.p. injection, but overt manifestation of disease was not apparent. Viable bacteria persisted in fish for at least 41 days, and bacterial DNA isolated by diagnostic polymerase chain reaction was detected from burbot kidney tissue 90 days after initial exposure. This study provides valuable information that will aid in efforts to culture and manage this species (Polinski et al. 2009). Implementation of routine disease management strategies will reduce the risk of infection by these and other pathogens and strict disease testing at the Idaho Fish Health Center (USFWS) prior to release of juvenile fish will ensure disease free status. In addition to establishing baseline information for the most concerning fish diseases, a new cell line was established from burbot embryo cells and provided to disease diagnostic laboratories (Polinski et al. 2009). This will provide a screening tool that will be valuable in detecting potential viral pathogens of burbot.

8.2.7) Indicate the use of "natural" rearing methods as applied in the program

Natural habitat for burbot at different life stages is currently being studied. However, it is known that the unique life history and behavior of age 1+ and adult burbot requires different rearing strategies than for salmon or trout. Therefore, efforts are underway to combine results of current and future field, lab, and aquaculture research to best define life stage-specific habitat requirements and to use this information to inform facility designs and operations.

Current practice is to hold wild adult burbot in dark, covered circular tanks that provide low light intensity, water velocity, and water temperature conditions, similar to life stage specific habitat use in the wild. Adult burbot are winter spawners and water temperatures are maintained as low as 1˚C during the spawning season. Wild captive adult burbot will be fed a diet of live certified disease-free rainbow trout.

Larval burbot must be intensively reared at the onset of exogenous feeding. Semi-intensive and extensive, outdoor aerated tanks and earthen ponds respectively, are currently being studied to determine the feasibility of using these rearing options. Design of hatchery features and operations are underway to allow all life stages of burbot to have access to environmental conditions similar to those used in the wild.

8.2.8) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to fish under propagation.

Burbot are currently being reared for release at age 0-2. The need to mark all hatchery fish to distinguish from year classes precludes release at a very small sizes (<5 g BW). The only suitable tag or mark that can be expected to persist over the life span of these long-lived fish is a PIT-tag. However, we are currently researching alternative marking methods for smaller fish including Visible Implant Elastomer (VIE tags) in an effort to minimize the risk of domestication selection effects that may be imparted through rearing to age ≥2.

The risk of disease amplification and introduction to natural waters will be minimized by incorporating standard fish health policies. Disease testing will follow required procedures for inspection under USFWS Title 50 act. Samples will be submitted to the Idaho Fish Health Center (USFWS) for testing and inspection will be completed prior to annual releases. Due to redundancy in questions in this HGMP, responses to this question are also provided in Sections 2.5 regarding ecology, 3.2 regarding water, 6.7 regarding stock, 6.9 regarding fish health, 7.4 regarding breeding, 8.1.6 regarding eggs, and 8.2.6 regarding fish health.

SECTION 9. RELEASE

Describe fish release levels, and release practices applied through the hatchery program

Specify any management goals (e.g., number, size or age at release, population uniformity, residualization controls) that the hatchery is operating under for the hatchery stock in the appropriate sections below.

9.1) Proposed fish release levels

Table 15. Proposed fish release levels.

Life Stage	Release Location	Annual Release Level
Eyed Eggs	Kootenai River	Millions
Unfed Fry	Kootenai River	Millions
Fry	Kootenai River	Hundreds of Thousands
Fingerling	Kootenai River	Thousands
Yearling	Kootenai River	Hundreds - Thousands
Spawner	Kootenai River	Hundreds

9.2) Specific location(s) of proposed release(s).

Stream, river, or watercourse:

Release point: Kootenai River (rkm 170-276) and possible tributaries in Idaho

Kootenay River (rkm 120-170) and possible tributaries in B.C.

Major watershed: Kootenai River

Basin or Region: Columbia River Basin, Kootenai River Subbasin, Mountain Columbia Province

More specific future release sites will be determined as post-release habitat use, performance, and survival information becomes available.

9.3) Actual numbers and sizes of fish released by age class through the program.

To date, this program has been operated experimentally at UI-ARI. Data in Table 16 reflects this limited experience.

Table 16. Number and size of burbot released in 2009.

Release year	Eggs/ Unfed Fry	Avg size	Fry	Avg size	Fingerling	Avg size	Yearling	Avg size
2009	0	0	0	0	217	10g	30	450g
Average	0	0	0	0	217	10g	30	450g

9.4) Actual dates of release and description of release protocols.

Provide the recent five year release date ranges by life stage produced (mo/day/yr). Also indicate the rationale for choosing release dates, how fish are released (volitionally, forced, volitionally then forced).

The first experimental releases of burbot from this program occurred during fall of 2009 (Table 4). Four releases occurred during October and November 2009 in four different locations with three year classes of fish, all produced at the UI-ARI. Sections 4.2 and 4.5 describe transport and acclimation release protocols, respectively.

9.5) Fish transportation procedures, if applicable

Describe fish transportation procedures for off-station release. Include length of time in transit, fish loading densities, and temperature control and oxygenation methods.

These issues are addressed in Section 4.2. All burbot releases would likely be within one hour of the Twin Rivers facility.

9.6) Acclimation procedures (*methods applied and length of time***)**

Acclimation procedures will include tempering fish prior to release. The proposed facility will use ambient river water and it is presumed that fish reared on ambient river water will require minimal thermal or chemical acclimation.

At the release site, water temperature within the transportation tank is manipulated by adding water from the release site to temper the haul tank water to the release site. After temperature acclimation, burbot are netted from the tank truck and released into the river. Some release sites require access by boat, in which case, burbot are loaded by net into a live well on the boat, thermally acclimated within the live well, netted out of the well at the release site, and released directly into the river.

9.7) Marks applied, and proportions of the total hatchery population marked, to identify hatchery component.

Prior to release, each fish will be weighed, measured, and marked. Marks applied and tags used will depend on fish size. Smaller age 0 fish (<25g) will be marked with Visible Implant Elastomer (VIE) and/or fin-clipped, larger fish (>25g) will be implanted with PIT and VIE tags, and fin clipped or freeze branded with liquid nitrogen. The proportions of the hatchery population and progeny groups marked, and which marks will be applied, will depend on the future release objectives and goals. All fish stocking will require unique marks to identify family, year class, and release site.

9.8) Disposition plans for fish identified at the time of release as surplus to programmed or approved levels

See Section 6.8, Disposition of carcasses

9.9) Fish health certification procedures applied pre-release

See Section 8.2.6

9.10) Emergency release procedures in response to flooding or water system failure

See 3.2 for risk aversion measures, water systems and release

9.11) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed species resulting from fish releases.

See Section 8.2.6 regarding fish health, 8.1.6 regarding eggs, 7.4 regarding breeding, 6.9 regarding fish health, 6.7 regarding stock, 3.2 regarding water, 2.5 regarding ecology.

SECTION 10. BURBOT PROGRAM EFFECTS ON ALL ESA-LISTED, PROPOSED, AND CANDIDATE SPECIES (FISH AND WILDLIFE)

Kootenai River white sturgeon (*Acipenser transmontanus*) are listed as endangered under the ESA and are sympatric with the burbot restoration area (Lower Kootenai River) Bull trout?

10.1) List all ESA permits or authorizations in hand for the hatchery program.

No burbot proposed for use in the proposed program have any ESA-listed status; therefore, no ESA permits or authorizations are required.

10.2) Provide descriptions, status, and projected take actions and levels for ESA-listed natural populations in the target area.

No burbot proposed for use in the proposed program have any ESA-listed status.

See appendix Table 1.

10.2.1) Description of ESA-listed, proposed, and candidate species affected by the program.

Include information describing: adult age class structure, sex ratio, size range migration timing, spawning range, and spawn timing; and juvenile life history strategy, including smolt emigration timing. Emphasize spatial and temporal distribution relative to hatchery fish release locations and weir sites.

- Identify the ESA-listed population(s) that will be <u>directly</u> affected by the program. *(Includes listed fish used in supplementation programs or other programs that involve integration of a listed natural population. Identify the natural population targeted for integration).*

No ESA-listed population(s) will be directly affected by this burbot aquaculture program.

- Identify the ESA-listed population(s) that may be <u>incidentally</u> affected by the program.

(Includes ESA-listed fish in target hatchery fish release, adult return, and broodstock collection areas).

No ESA-listed population(s) will be incidentally affected by this burbot aquaculture program.

10.2.2) Status of ESA-listed species affected by the program.

No response is required here because no ESA-listed species are affected by the burbot aquaculture program.

- **Describe the status of the listed natural population(s) relative to "critical" and "viable" population thresholds** (*see definitions in "Attachment 1").*

- Provide the most recent 12 year (e.g. 1988 - present) progeny-to-parent ratios, survival data by life-stage or other measures of productivity for the listed population. Indicate the source of these data.

- Provide the most recent 12 year (e.g. 1988 - 1999) annual spawning abundance estimates, or any other abundance information. Indicate the source of these data. *(Include estimates of juvenile habitat seeding relative to capacity or natural fish densities, if available).*

- Provide the most recent 12 year (e.g. 1988 - 1999) estimates of annual proportions of direct hatchery-origin and listed natural-origin fish on natural spawning grounds, if known.

10.2.3) Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of listed species in the target area, and provide estimated annual levels of take *(see "Attachment 1" for definition of "take")*. **Provide the rationale for deriving the estimate.**

No response is required here because no ESA-listed species are affected by the burbot aquaculture program.

- Describe hatchery activities that may lead to the take of listed species in the target area, including how, where, and when the takes may occur, the risk potential for their occurrence, and the likely effects of the take.

- **Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken and observed injury or mortality levels for listed fish**.

- Provide projected annual take levels for listed species by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).

Complete the appended "take table" (Table 1) for this purpose. Provide a range of potential take numbers to account for alternate or "worst case" scenarios.

- Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program.

SECTION 11. MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

This section describes how Performance Indicators listed in Section 1.10 will be monitored. Results of Performance Indicator monitoring will be evaluated annually and used to adaptively manage the hatchery program, as needed, to meet the Performance Standards.

11.1) Monitoring and evaluation of Performance Indicators presented in Section 1.10.

11.1.1) Describe the proposed plans and methods necessary to respond to the appropriate "Performance Indicators" that have been identified for the program.

A series of research, monitoring, and evaluation activities for burbot are included as part of this program. Measurable biological objectives and metrics associated with burbot aquaculture for pre-release and post-release periods are identified in Tables 17 and 18, including specific monitoring and evaluation activities during pre-spawning, spawning, incubation, and early rearing life stages in the hatchery.

11.1.2) Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program.

Funding, staffing, and other support logistics are available and committed to that will allow implementation of the monitoring and evaluation program.

11.2) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed species resulting from monitoring and evaluation activities.

Fish Health Monitoring

The burbot program will include protocols to monitor and minimize pathogen introduction and transmission in hatchery and natural populations. These protocols will be similar to those implemented for the sturgeon program. Research is ongoing to limit pathogen transmission during egg incubation, develop cell lines for improved diagnostics and assess burbot susceptibility to pathogens. These efforts, described below, are helping to define optimal treatments to control fungus during egg incubation, to address possible viral diseases through new cell line development, and to establish baseline data regarding burbot susceptibility to a number of fish pathogens.

As part of the proposed monitoring program, all broodstock and at least 30 progeny from each brood year will be tested for the presence of pathogens. Burbot will be subjected to the federal fish health Title 50 pathogen screen. Disease testing may include parasitology, bacteriology, virology and histology examinations. Burbot evaluation protocols will be developed by state, provincial, federal, and tribal management agencies and disease test results will be reviewed by all parties.

Table 17. Pre-release biological objectives, metrics and target values to be monitored and evaluated in the burbot conservation aquaculture program.

Program Aspect	Biological Objectives	Life Stage or Activity	Metrics	Target Metric Values for Burbot	Timeframe
Spawning	Provide adequate broodstock	Spawners	Gamete viability	Sperm motility > 80%	Up to 3 mo. annually, typically Feb-June
	Provide adequate breeding matrices for genetic diversity		Effective population size (*Ne*); No. of breeders (*Nb*); fertilization	20-30 female broodstock annually, spawned with > 1 male each	
Incubation/ Hatch	Provide adequate incubation and hatch rates	Embryos	Survival (hatch)	Hatching success 2%	Up to 4 mo. annually, typically May-Sept
Early rearing	Provide adequate fry and larval survival	Fry and larvae	Survival	> 2% for each life stage	Up to 5 mo. annually, typically May-Sept
	Provide adequate YOY survival	YOY rearing	Survival, fish health	Survival > 50 %; no visible signs of fish health problems; Negative Title 50 pathogen test results if post-release fish tested	Up to 4 mo. annually, Sept-Dec.
	Provide adequate juvenile survival	Juvenile rearing	Survival, condition, fish health	Survival > 50 %; Negative Title 50 pathogen test results	Up to 9 mo. annually, typically Jan-Sept, including fall of previous year for YOY
	Provide adequate fish marking	YOY and juveniles	Mark retention	PIT tag retention > 90%	

Table 18. Post-release biological objectives, metrics and target values to be monitored and evaluated in the burbot conservation aquaculture program.

Program Aspect	Biological Objectives	Life Stage or Activity	Metrics	Target Burbot Metric Values	Timeframe
Post-release monitoring	Ensure adequate post-release survival, growth, and biological condition to support future mature adults	Juvenile and adult sampling	Survival, annual growth, biological condition (*K*), relative weight	Target survival 30-50% first year post-release; consistent positive growth; condition factors and relative weights ; consistent, positive trends over years	Annually or periodically based on recapture data
	Create and maintain favorable age class distribution		Age class distribution; recruitment magnitude and frequency	Hatchery-produced year classes annually	Annually, year-round
	Maintain adequate individual and population health		Adequate fish health to support adult target goals	External health and behavior visually suitable; negative Title 50 pathogen test results	Annually, year-round
	Provide genetic diversity within and among progeny groups		Diversity, heterozygosity metrics, genetic distance and inbreeding coefficients	Genetic diversity targets from mating plan under development	Annually, year-round
All stages	Sustainable adult population target	All life stages	Population abundance (adults)	From 3 groups of 2,500 to approximately 10,000 adults	Annual sampling, periodically update abundance estimates & age class structure characteristics. May occur up to 30 years

Establishment of Burbot Cell Lines and Characterization of Viral Susceptibility

To screen and monitor burbot for the presence of viral pathogens, an early-larval cell line has been established (Polinski et al., unpublished results). This burbot cell line has been maintained in laboratory culture over 3 years and passed nearly 90 times. Although relatively slow growing compared to other established laboratory fish cell lines, increased growth rates have been observed as *in vitro* passage increases. Cryopreservation of this cell line has been achieved with up to 90% viability. If novel viruses affect this species, this burbot cell line will be an important tool in early diagnosis and possible virus isolation.

Susceptibility of this cell line to multiple viruses and strains has been determined. The line shows a cytopathic effect when exposed during incubation to IHNV. Tests to determine susceptibility to IPNV produced conflicting results and remain undetermined. Information from this ongoing research is expected to be available in the near term. In addition, submission of burbot samples to standard Title 50 pathogen testing will reveal suitability for future experimental release.

Susceptibility of Juvenile Burbot to Fish Pathogens

Because virtually no information was previously available about the susceptibility of burbot to disease, experiments in 2007 and 2008 at the University of Idaho challenged juvenile burbot with various pathogens. In challenge experiments on progeny from captive broodstock, juveniles were not susceptible to a virulent strain of *Flavobacterium psychrophilum*, the agent that causes bacterial coldwater disease. In addition, disease testing was conducted on mortalities in wild-caught broodstock; generally deaths were not due to disease but associated with factors such as swim bladder rupture linked to collection methods. Fish pathogens were tested on burbot in controlled, replicated pathogen challenges at the University of Idaho: IHNV, IPNV, *Flavobacterium psychrophilum, Renibacterium salmoninarum* (which causes BKD), and *Aeromonas salmonicida* (which causes furunculosis).

Pathology research to date indicates that burbot are: 1) susceptible to IHNV and may be potential carriers; 2) not susceptible to IPNV, although more research is needed; 3) not susceptible to *F. psychrophilum*; and 4) can be susceptible to *Aeromonas salmonicida.* These results, as well as ongoing pathogen investigations, will adaptively inform the burbot aquaculture program.

Burbot Genetics

Genetic analysis was used to inform broodstock choice for this project. A mitochondrial DNA study revealed that the Moyie Lake burbot stock in British Columbia is closely related to the functionally extinct Kootenai River burbot stock (Paragamian et al. 1999). This stock is found within the Kootenai subbasin and appears to be large enough to yield up to several dozen broodstock annually for experimental and production purposes.

In addition to stock identification and differentiation issues, genetic analysis also will be used to estimate diversity measures, genetic distance, and population genetic parameters such as effective population size for burbot broodstock and progeny groups as part of this project.

Burbot Gamete Cryopreservation

Cryopreservation is a successfully developing risk-aversion technique for burbot that conserves native genetic material in the form of frozen gametes (Jensen et al. 2008). Cryopreservation allows additional flexibility for including individual broodstock in spawning matrices than would exist using with fresh gametes only. Subsamples of milt, collected and cryopreserved from Moyie Lake and Duncan Reservoir stocks, have been used to establish a germ plasm repository in the Tribe's cryopreservation unit at the University of Idaho. Cryopreservation of semen from Kootenai burbot was investigated and optimal methanol concentrations determined for a conservation breeding program (Jensen et al. 2008b). The following results support the use of cryopreserved burbot semen to develop germ plasm repositories for imperiled fish stocks:

- Optimal methanol concentrations to provide a permeable cryoprotectant in the semen extender were determined.
- Post-freeze semen motility was evaluated and fertilization rates were determined
- The effect of methanol concentrations in the extender on motility and fertilization percentages was determined.
- Techniques derived from this research will be applied to broodstock monitoring and evaluation. The motility and fertility of all cryopreserved burbot semen will be screened for suitability for use as broodstock.

SECTION 12. RESEARCH

12.1) Objective or purpose

Research is needed to guide program development, inform adaptive management, and increase the probability of program success.

12.2) Cooperating and funding agencies

Cooperating agencies include the UI-ARI, IDFG, the British Columbia Ministry of Environment, the University of Idaho Life Sciences Department, U.S. Fish and Wildlife Service and others. See Section 1.3 and Table 8 for additional details. Most of this work is funded through the Kootenai Tribe of Idaho with support provided under Project 1988-06400 from the Bonneville Power Administration. The USFWS provides additional monetary support for development of burbot aquaculture.

12.3) Principle investigator or project supervisor and staff

Name (and title): Sue Ireland, Fish and Wildlife Program Director
Agency or Tribe: Kootenai Tribe of Idaho
Address: 242 Hatchery Rd., P.O. Box 1269, Bonners Ferry, ID 83805

Telephone: (208) 267-3620
Fax: (208) 267-1131
Email: ireland@kootenai.org

12.4) Status of population, particularly the group affected by project, if different than the population(s) described in Section 1.2.

Burbot (*Lota lota maculosa*), Lower Kootenai River, Idaho
Conservation status / Classification:
Rangewide: Secure (G5)
Statewide (Idaho): Critically imperiled (S1)
ESA: No current or pending status
USFS: Region 1: Sensitive; Region 4: No status
BLM: Regional/State imperiled (Type 3)
IDFG: Game fish; Endangered
(From: http://fishandgame.idaho.gov/cms/tech/CDC/cwcs_appf/Burbot.pdf)

12.5) Techniques: include capture methods, drugs, samples collected, tags applied

Broodstock capture methods include hook and line angling in shallow water near-shore habitats in Moyie Lake, B.C. This capture technique minimizes injury and delayed mortality that was associated with hoop netting efforts for burbot collection from deep water (Neufeld and Spence 2008). No drugs are used other than clove oil as a temporary sampling anesthetic to aid in live gamete collection on the ice during February, and hydrogen peroxide anti-fungal treatments of burbot eggs prior to transport. Samples include broodstock collected each February, and post-release juveniles capture throughout the year from the Kootenai River. Tags include Floy tags to wild broodstock, Elastomer (visual implant) tags to juveniles for release, PIT-tags to larger fish and potential captive broodstock, and a small subset of fish tagged with Vemco sonic or radio transmitters.

12.6) Dates or time period in which research activity occurs

Research of aquaculture and burbot life stages occurs during different times of the year.

12.7) Care and maintenance of live fish or eggs, holding duration, transport methods

The Twin Rivers Hatchery will include burbot holding, spawning and rearing tanks would be located in a separate building from Kootenai sturgeon and rainbow trout to minimize potential pathogen transmission. Components specific to burbot aquaculture include:

Adult Fish Holding/Spawning - Round tanks with adequate cover to hold adult burbot.

Incubation - Burbot eggs will be incubated in one liter Imhoff cones mounted over small circular start tanks.

Start Tanks - Post-hatch burbot volitionally move up through the water column out of the top of the incubators into the start tanks where they will be fed and closely monitored for disease as they grow to a size acceptable for transfer out of the start tank room. Burbot hatchlings require live feed (rotifers and *Artemia)* that will be raised in an adjacent live feed culture room.

Rearing Tanks - Four-foot-diameter indoor circular tanks will be used for burbot grow-out.

Burbot Ponds - Six 10-square-meter outdoor earthen ponds are planned for experimental larval and extended burbot rearing. Each pond will have a concrete harvest and water level control structure, supply, drain piping and predator barriers. Larger ponds for long-term holding of captive broodstock are also being considered.

12.8) Expected type and effects of take and potential for injury or mortality

No take of any ESA-listed fish is expected as part of the program (See Appendix Table 1 for more details)

12.9) Level of take of listed species: number or range of individuals handled, injured, or killed by sex, age, or size, if not already indicated in Section 2 and the attached "take table" (Appendix Table 1).

See Appendix Table 1 for more details.

12.10) Alternative methods to achieve project objectives

A range of alternatives for burbot conservation were considered by the Tribe. These are described in Section 1.16.

12.11) List species similar or related to the threatened species; provide number and causes of mortality related to this research project.

Not applicable.

12.12) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury, or mortality to listed species as a result of the proposed research activities.

Not applicable.

SECTION 13. ATTACHMENTS AND CITATIONS

References

Aquaculture Research Institute (ARI) 2007. Jensen, N.R, P. J. Anders, and K.D. Cain. Burbot (*Lota lota*) conservation aquaculture progress report. Report to the Kootenai Tribe of Idaho. 36 pp.

Dixon, C.J., and J.C. Vokoun. 2008. Burbot resource selection in small streams near the southern extent of the species range. Ecology of Freshwater Fish 18:234-246.

Ireland, S.C. and P.N. Perry. 2008. Burbot restoration in the Kootenai River basin: Using agency, tribal, and community collaboration to develop and implement a conservation strategy. American Fisheries Society Symposium 59:251-256.

Jensen, N. and K. Cain. 2009. Burbot: not just another cod. Hatchery International 10(3).

Jensen, N.R., M.D. Zuccarelli, S.J. Patton, S.R. Williams, S.C. Ireland and K.D. Cain. 2008b. Cryopreservation and Methanol Effects on Burbot Sperm Motility and Egg Fertilization. North American Journal of Aquaculture. 70: 38-42.

Jensen, N.R., P.J. Anders and K.D. Cain. 2008. Burbot Conservation Aquaculture Progress-2007. Annual progress report prepared for the Kootenai Tribe of Idaho.

Jensen, N.R., S.C. Ireland, J.T. Siple, S.R. Williams and K.D. Cain. 2008a. Evaluation of Egg Incubation Methods and Larval Feeding Regimes for North American Burbot. North American Journal of Aquaculture. 70: 162-170.

Jensen, N.R., S.R. Williams, S.C. Ireland, J.T. Siple, M.D. Neufeld and K.D. Cain. 2008. Preliminary Captive Burbot Spawning Observations. Pages155-165 *in* V.L. Paragamian and D.H. Bennett, editors. Burbot: Ecology, Management, and Culture. American Fisheries Society, Symposium 59, Bethesda, MD.

Klontz, G.W. 1991. Fish for the Future: Concepts and Methods of Intensive Aquaculture. Idaho Forest, Wildlife and Range Experiment Station, College of Forestry, Wildlife and Range Sciences. University of Idaho, Moscow, ID. 192 pp.

KTOI and Montana Fish Wildlife and Parks (MFWP). 2004. Kootenai Subbasin Plan. A report prepared for the Northwest Power and Conservation Council. Portland, OR. October 11, 2004.

KVRI Burbot Committee. 2005. Kootenai River/Kootenay Lake Burbot Conservation Strategy. Prepared by the Kootenai Tribe of Idaho. 77 pp. plus appendices.

Kootenai Tribe of Idaho. 2009. Kootenai River Native Fish Aquaculture Program Master Plan. Volume 1. August 2009. 238 pp. plus appendices,

LaPatra, S. E., S. C. Ireland, J. M. Groff, K. M. Clemens, and J. T. Siple. 1999. Adaptive disease management strategies for the endangered population of Kootenai River white sturgeon. Fisheries 24(5): 6-13.

Neufeld, M. 2008. Moyie Lake Burbot: Population Assessment 2007. BC Ministry of Environment, Nelson, BC.

Neufeld, M. D., and C. R. Spence. 2008. Evaluation of a simple decompression procedure to reduce trauma in trap-caught burbot. Pages 249-250, In: American Fisheries Society Symposium 59. AFS, Bethesda, MD.

Northwest Power and Conservation Council (NPCC). 2009. Columbia Basin Fish and Wildlife Program: Mainstem Amendments. (http://www.nwcouncil.org/library/2009/2009-09/).

Northwest Power and Conservation Council (NPCC). 1999. Artificial Production Review. NPPC Document 99-15. (http://www.nwcouncil.org/LIBRARY/1999/99-15.pdf) 245 pp. October 13, 2009.

Paragamian, V.L., M. Powell, and J. Faler. 1999. Mitochondrial DNA analysis of burbot *Lota lota* stocks in the Kootenai River Basin in British Columbia, Montana, and Idaho. Transactions of the American fisheries Society 128:868-874.

Paragamian, V., B. Pyper, M. Daigneault, R. Beamesderfer and S. Ireland. 2008. Population dynamics and extinction risk of burbot in the Kootenai River, Idaho, USA and British Columbia, Canada. American Fisheries Society Symposium 59:213-234.

Polinksi, M.P., N. R. Jensen, and K.D. Cain. 2010. Assessment of formalin and hydrogen peroxide use during egg incubation of North American burbot. North American Journal of Aquaculture 72:111–117.

Polinski, M.P, T. R. Fehringer, K.A. Johnson, K. R. Snekvik, S. E. LaPatra, B. R. LaFrentz, S. C. Ireland, and K D Cain. Characterization of susceptibility and carrier status of burbot, Lota lota (L.), to IHNV, IPNV, Flavobacterium psychrophilum, Aeromonas salmonicida and Renibacterium salmoninarum. Journal of Fish Diseases (*In Press*).

Polinski, M.P., J.D. Drennan, W.N. Batts, S.C. Ireland, and K.D. Cain. Establishment of a cell line from burbot (*Lota lota*) with characterization of susceptibility to IHNV, IPNV, and VHSN. Diseases of Aquatic Organisms (*In Press*).

Powell, M., V. Paragamian, and J. Dunnigan. 2008. Mitochondrial variation in Western North American burbot with special reference to the Kootenai River in Idaho and Montana, USA. Pages 3-28, *In:* American Fisheries Society Symposium 59. AFS Bethesda, MD.

Pyper, B.J., M.J. Daigneault, R.C.P. Beamesderfer, V.L. Paragamian, and S.C. Ireland. 2004. Status and population dynamics of burbot in the Kootenai River, Idaho and British Columbia, Canada. *In* V.L. Paragamian Kootenai River Fisheries Investigation: burbot stock status. Idaho Department of Fish and Game. Bonneville Power Administration. Annual Progress Report, Project 88-65. Boise, Idaho.

Van Houdt, J.K., B. Hellemans, and F.A.M. Volckaert. 2003. Phylogenetic relationships among Palearctic and Nearctic burbot (*Lota lota*): Pleistocene extinctions and recolonization. Molecular Phylogenetics and Evolution 29: 599-612.

Van Houdt, J.K., L. DeCleyn, A. Perretti, and F.A.M. Volckaert.2005. A mitogenic view on the evolutionary history of the Holoarctic ganoid, burbot (*Lota lota*). Molecular Ecology14:2445-2457.

Zuccarelli, M.D., N. Jensen and R.L. Ingermann. 2007. Inhibitory effect of osmotic concentration, potassium and pH on motility of the sperm of North American burbot (*Lota lota maculosa*). Journal of Fish Biology. 70:178-189.

SECTION 14. CERTIFICATION LANGUAGE AND SIGNATURE OF RESPONSIBLE PARTY

"I hereby certify that the foregoing information is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this HGMP is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or penalties provided under the Endangered Species Act of 1973."

Name, Title, and Signature of Applicant:

Certified by_____________________________ Date: _____________

Appendix Table 1. Estimated listed species take levels by hatchery activity.

Listed species affected: White sturgeon ESU/Population: Kootenai River population Activity:				
Location of hatchery activity:______________________ Dates of activity:____________________ Hatchery program operator:_________________				
Type of Take	Annual Take of Listed Fish By Life Stage (*Number of Fish*)			
	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass[a]	0	0	0	NA
Collect for transport[b]	0	0	0	NA
Capture, handle, and release[c]	0	0	0	NA
Capture, handle, tag/mark/tissue sample, and release[d]	0	0	0	NA
Removal (e.g. broodstock)[e]	0	0	0	NA
Intentional lethal take[f]	0	0	0	NA
Unintentional lethal take[g]	0	0	0	NA
Other Take (specify)[h]	0	0	0	NA

a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at weirs.
b. Take associated with weir or trapping operations where listed fish are captured and transported for release.
c. Take associated with weir or trapping operations where listed fish are captured, handled and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release, or through carcass recovery programs.
e. Listed fish removed from the wild and collected for use as broodstock.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to spawning or prior to release into the wild, or, for integrated programs, mortalities during incubation and rearing.
h. Other takes not identified above as a category.

Instructions:

1. *An entry for a fish to be taken should be in the take category that describes the greatest impact.*
2. *Each take to be entered in the table should be in one take category only (there should not be more than one entry for the same sampling event).*
3. *If an individual fish is to be taken more than once on separate occasions, each take must be entered in the take table*

Kootenai Tribe of Idaho, June 2010

Kootenai River Native Fish Conservation Aquaculture Program
Project Sponsor Responses to ISRP Comments 2009 - 40

BONNEVILLE
POWER ADMINISTRATION

Northwest Power and Conservation Council