U.S. Fish & Wildlife Service

Draft Revised Recovery Plan for the Kootenai River Distinct Population Segment of the White Sturgeon

(Acipenser transmontanus)

Photograph of juvenile Kootenai sturgeon used by permission of the Kootenai Tribe of Idaho.

Draft Revised Recovery Plan for the Kootenai River Distinct Population Segment of the White Sturgeon

(Original Approved: September 30, 1999)

December 2018

Prepared by:
U.S. Fish and Wildlife Service
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for

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: XXXXXXXXXXXXXXXXXXXXXXXXXX
Regional Director, Region 1
U.S. Fish and Wildlife Service

Date: XXXXXXXXXXXXXXXXXXXXXXXXXX

Disclaimer

Recovery plans delineate reasonable actions needed to recover and/or protect listed species. We, the U.S. Fish and Wildlife Service (Service), publish recovery plans, sometimes preparing them with the assistance of recovery teams, contractors, State agencies, and others. Objectives of the recovery plan are accomplished, and funds made available, subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities with the same funds.

Recovery plans do not necessarily represent the views or the official positions or approval of any individuals or agencies involved in the plan formulation, other than our own. They represent our official position only after signed by the Director or Regional Director. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and completion of recovery actions.

Recovery Planning Process

The Service recently revised its approach to recovery planning; we are now using a process termed Recovery Planning and Implementation (RPI) (see https://www.fws.gov/endangered/esa-library/pdf/RPI-Feb2017.pdf). The RPI approach is designed to reduce the time needed to develop and implement recovery plans, increase recovery plan relevancy over a longer timeframe, and add flexibility to recovery plans so they can be adjusted relatively quickly to address new information or circumstances. Under RPI, a recovery plan includes the statutorily-required elements under section 4(f) of the Act (objective and measurable recovery criteria, site-specific management actions, and estimates of time and costs), along with a concise introduction and our strategy for how we plan to achieve species recovery. The RPI recovery plan is supported by two supplementary documents: a Species Status Assessment, which describes the best available scientific information related to the biological needs of the species and assessment of threats; and the Recovery Implementation Strategy, which details the near-term activities needed to implement the recovery actions identified in the recovery plan. Under this approach new information on species biology or details of recovery implementation may be incorporated by updating these supplementary documents without concurrent revision of the entire recovery plan, unless changes to statutorily required elements are necessary.

We developed the Draft Revised Recovery Plan for the Kootenai River White Sturgeon using this RPI approach. The draft revised recovery plan is supported by the 2011 5-year status review and associated science review for Kootenai River White Sturgeon (USFWS 2011a, 2011b), which provide information on background, life history, and threat assessment and function as the Biological Report under the RPI process. We will also develop a separate working document as the Recovery Implementation Strategy, to be posted on our website (see https://www.fws.gov/idaho/#), which will step down from the more general description of actions described in the draft revised recovery plan to detail the near-term, specific activities needed to implement recovery.

Literature citation of this document should read as follows:
U.S. Fish and Wildlife Service. 2018. Draft Revised Recovery Plan for the Kootenai River White Sturgeon. U.S. Fish and Wildlife Service, Portland, Oregon. vi + 33 pp.

An electronic copy of this recovery plan is also available at:

<https://www.fws.gov/pacific/ecoservices/endangered/recovery/plans.html>

and

<http://www.fws.gov/endangered/species/recovery-plans.html>

Acknowledgments

This revised recovery plan was drafted by Jason Flory in the Idaho Fish and Wildlife Office—Spokane, with help from our Kootenai River White Sturgeon Recovery Team. We also thank Tara Nicolaysen of the Service's Branch of Conservation Integration for her guidance on developing this draft revised recovery plan using the RPI process.

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EXECUTIVE SUMMARY

Species Status: The Kootenai River[1] distinct population segment of the white sturgeon (*Acipenser transmontanus*) (hereafter, Kootenai sturgeon) was listed as endangered on September 6, 1994 (USFWS 1994; 59 FR 45989). A final recovery plan was signed in 1999 (USFWS 1999). Critical habitat for Kootenai sturgeon was designated on September 6, 2001 (USFWS 2001; 66 FR 46548). An interim rule designating additional critical habitat was published on February 8, 2006 (USFWS 2006; 71 FR 6383), and a final rule published on July 9, 2008 (USFWS 2008; 73 FR 39505). Five-year status reviews for Kootenai sturgeon were finalized and published in 2011 and 2018 (USFWS 2011a, USFWS 2018). In those reviews, the Service concluded that the Kootenai sturgeon should remain classified as endangered.

We are revising the 1999 recovery plan because we have information that improves our understanding of what is needed to conserve and recover the Kootenai sturgeon. This draft revised recovery plan, which when finalized will serve as the new recovery plan for the Kootenai sturgeon, provides revised recovery criteria, actions, and time and cost estimates for recovery.

Recovery Vision: The vision of recovery for the Kootenai sturgeon is a population that reproduces and recruits in the wild at levels sufficient to sustain the population. Full recovery will be achieved only when threats to the population are reduced to a level whereby it is no longer at risk of extinction nor likely to become endangered in the foreseeable future. Once this is achieved, the species can be removed from the list of threatened or endangered species.

Recovery Strategy: To address the threats of alteration of the Kootenai River hydrograph and thermograph, and concomitant low biological productivity in the Kootenai River, the strategy for recovering Kootenai sturgeon is to:

(1) continue a conservation aquaculture program to ensure adequate reproduction occurs until adequate natural levels of reproduction have been reestablished, thereby also ensuring genetic and phenotypic diversity is preserved in future populations of Kootenai sturgeon;
(2) manage flow and temperature from Libby Dam to ensure spawning and rearing conditions are appropriate;
(3) add nutrients to the system to support the food web and provide additional food resources for Kootenai sturgeon;
(4) conduct habitat restoration and enhancement in the Kootenai River basin to support all life stages;
(5) support the recovery effort with research and monitoring that will inform adaptive management; and
(6) conduct public outreach.

We note that new or emerging threats, such as climate change, or new understanding of Kootenai sturgeon behavior or habitat use, may arise over time. If any such issues are so significant as to result in a need to change the recovery strategy or the statutorily required elements of the recovery plan under section 4(f)(1) of the ESA, we will revise the plan again.

[1] The Kootenai River is spelled Kootenay in Canada.

Recovery Criteria: For downlisting, Kootenai sturgeon demonstrate consistent natural in-river production of juveniles, with production of wild age-3 juveniles occurring at an annual average of at least 700 individuals over 10 consecutive years. Production of 700 or more wild age-3 juveniles occurs in at least 3 of the 10 years, ensuring the annual average is not the result of an anomalous single-year event. For delisting, the number of Kootenai sturgeon wild recruits (offspring that survive to sexual maturity at 25 years) added to the adult (25 years or older) population annually averages at least 250 individuals per year over 10 years. In addition, the population includes at least 10,000 wild juveniles aged from 3 to 24 years.

Recovery Actions Needed (throughout the range of Kootenai sturgeon):

- Conservation Aquaculture
- Flow and Temperature Management
- Nutrient Addition
- Restore and Enhance Habitat
- Research and Monitoring
- Public Outreach and Education

Estimated Average Annual Cost of Recovery Actions (in Fiscal Year 2019 dollars):

Recovery Actions	Recovery Action #	Estimated Average Annual Costs
Conservation Aquaculture	1.0	$2,200,000
Flow and Temperature Management	2.0	$250,000
Nutrient Addition	3.0	$1,700,000
Restore and Enhance Habitat	4.0	$2,000,000 to 7,000,000
Population Research Monitoring and Evaluation	5.0	$450,000
Public Outreach and Education	6.0	$250,000
	TOTAL:	**$6,850,000 to $11,850,000**

Date of Recovery: Recovery criteria could be met by 2058, based on the conservative assumption that all recovery plan actions are required to be fully funded and implemented as currently outlined, including gaining full cooperation of all partners needed to achieve recovery.

TABLE OF CONTENTS

List of Figures

List of Tables

Acronyms and Abbreviations

BPA	Bonneville Power Administration
BCMFLNRORD	British Columbia Ministry of Forests, Lands and Natural Resource Operations and Rural Development
ESA	Endangered Species Act
IDFG	Idaho Department of Fish and Game
KTOI	Kootenai Tribe of Idaho
MFWP	Montana Fish, Wildlife and Parks
SARA	Canadian Species at Risk Act
SSA	Species Status Assessment
USACE	United States Army Corps of Engineers
USBOR	United States Bureau of Reclamation
USFWS, or Service	United States Fish and Wildlife Service

INTRODUCTION

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (ESA) protects species of wildlife and plants that are endangered or threatened with extinction. Recovery is defined as "the process by which listed species and their ecosystems are restored and their future is safeguarded to the point that protections under the ESA are no longer needed", according to the 2018 updated National Marine Fisheries Service's and the U.S. Fish and Wildlife Service's (Service) Interim Recovery Planning Guidelines, Version 1.4 (NMFS and USFWS 2018).

Recovery plans are guidance documents developed to provide recommendations to reduce or alleviate threats to the species and ensure self-sustaining populations in the wild. The ESA (section 4(f)(1) stipulates that recovery plans include: (1) a description of site-specific management actions necessary to conserve the species; (2) objective, measurable criteria that, when met, will allow the species or populations to be removed from the Federal List of Endangered and Threatened Wildlife; and (3) estimates of the time and cost required to achieve the plan's goals and intermediate steps.

In the United States, Kootenai sturgeon were listed as endangered on September 6, 1994 (59 FR 45989). Kootenai sturgeon were listed as endangered under the Canadian Species at Risk Act in 2006. At the time of ESA listing, threats to the species were decline in the adult population and the almost complete lack of natural recruitment; loss of suitable spawning and rearing habitat as a result of Libby Dam operations; reduced biological productivity in the basin; and contaminants leading to poor water quality. Critical habitat for the population was designated in 2001 (66 FR 46548). An interim rule designating additional critical habitat was published in 2006 (71 FR 6383) and a final rule published in 2008 (73 FR 39505).

To guide the conservation and recovery of the sturgeon, a recovery plan was finalized in 1999 (USFWS 1999). We knew little about the species and its needs at that time, and therefore developed downlisting criteria but not delisting criteria. The plan focused on ameliorating the threats of loss of spawning and rearing habitat due to Libby Dam operations, the declining population of wild adults, loss of biological productivity, contaminants in the Kootenai River, and gaining more knowledge of the behaviors and needs of Kootenai sturgeon.

In the years since the 1999 recovery plan was published, we have accumulated new information that improves our understanding of the species and what it needs for recovery. Specifically, we have learned about Kootenai sturgeon early life stage behaviors, requirements, and preferences; the nature of the Kootenai River in the meander and braided reaches (e.g., morphology, flow characteristics, substrate composition); the potential for a second survival bottleneck in Kootenai sturgeon; the number of wild adults remaining in the population; the occurrence and amount of wild recruitment; the presence of spontaneous autopolyploidy[2] in the population; the effectiveness of certain flow management scenarios; the effectiveness of the conservation aquaculture program; and the efficacy of recovery actions, most notably the actions associated with the Kootenai River Habitat Restoration Program. We incorporated this new information in the Service's 5-year status review and accompanying science review document in 2011 (USFWS

[2] Spontaneous autopolyploidy refers to the anomalous duplication of one or more complete sets of chromosomes

2011a, 2011b). The 5-year status review provided updated information on the population status of Kootenai sturgeon and threats to the population. The science review summarized knowledge and information regarding the biology and ecology of Kootenai sturgeon, the status of recovery actions, and the factors affecting the species. Additional new information was assessed in 2018 in a subsequent 5-year status review (USFWS 2018). Therefore, the 5-year status review and science review documents serve as the scientific foundation for this recovery plan, functioning similarly to the species status assessment or biological reports used for other species under the Service's new RPI approach to recovery planning.

Throughout this draft revised recovery plan, reference is made to a variety of supporting documents where more detailed information on Kootenai sturgeon biology, life history, habitat, threats, current status, survey guidelines, need for long-term viability, and current and projected conditions of the population and conservation efforts can be found. Information within those documents may be updated at any time as new information becomes available. A summary of new information gained since the publication of the 5-year status review and science review (USFWS 2011a, 2011b) is provided in this draft revised recovery plan.

BACKGROUND

Basic Species Information

Kootenai sturgeon occur in the Kootenai River basin in Idaho, Montana, and British Columbia, Canada. The Kootenai River (spelled "Kootenay" in Canada) originates in Kootenay National Park in southeastern British Columbia, flows south into Montana, northwest into Idaho, then north back into British Columbia, where it flows through Kootenay Lake and joins the Columbia River at Castlegar, British Columbia (Figure 1).

The extent of the Kootenai sturgeon range is from Kootenai Falls, Montana, 31 river miles (RM) (49.9 river kilometers (RKM)) below Libby Dam, Montana, downstream throughout Kootenay Lake, north to Duncan Dam and west to Corra Linn Dam, located downstream of the outflow from Kootenay Lake in British Columbia. Approximately half of the population's range is located in British Columbia (Figure 1).

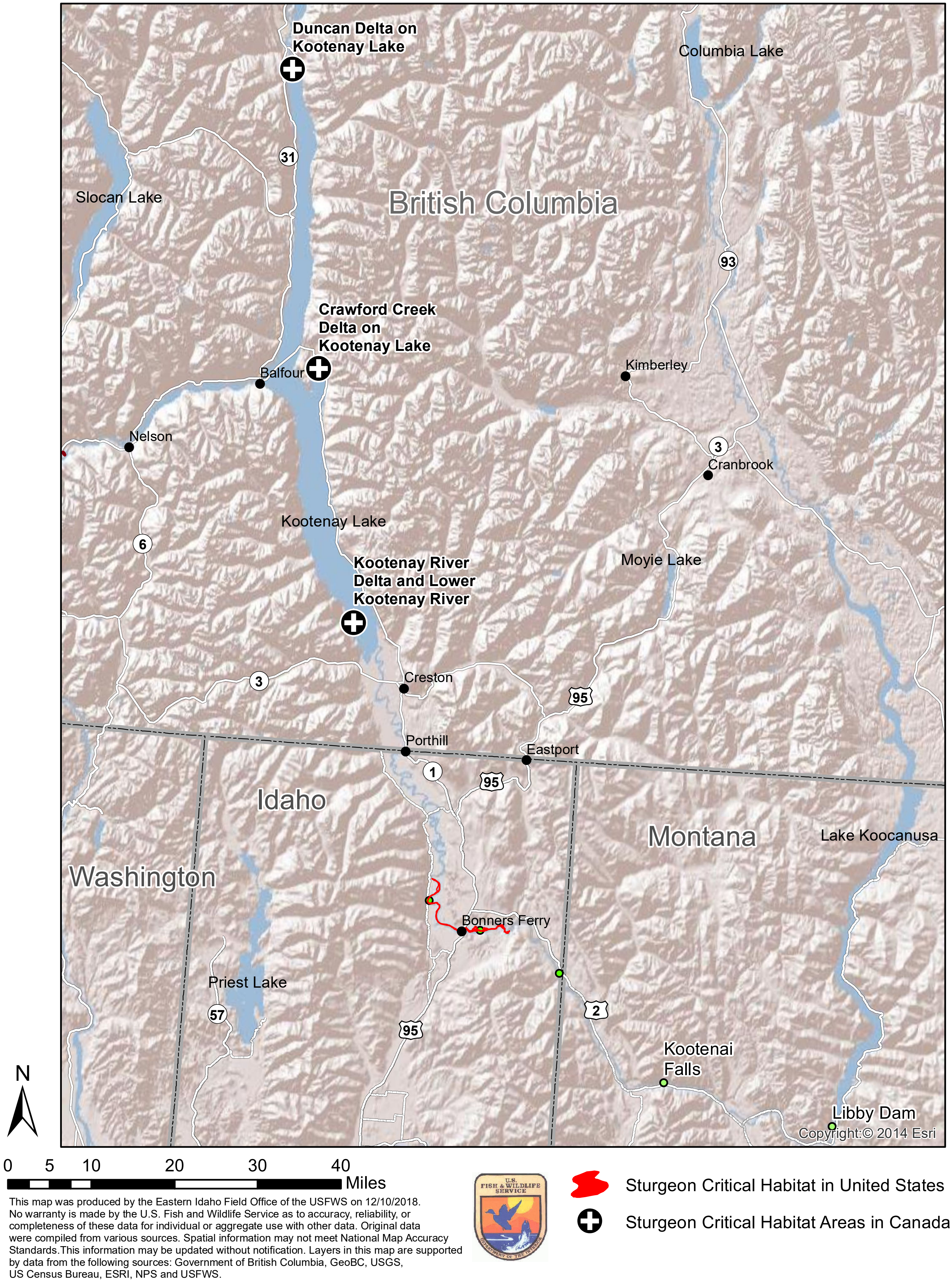

Figure 1. Map of Kootenai River Basin showing key features and Kootenai sturgeon critical habitat.

Kootenai sturgeon are considered opportunistic feeders. Partridge (1983) found Kootenai sturgeon more than 28 inches in length feeding on a variety of prey items including clams, snails, aquatic insects, and fish.

Annually from May through July, reproductively active Kootenai sturgeon respond to increasing river flows and temperatures by migrating upstream through the Kootenai River to their spawning sites. Spawning at near peak flows with high water velocities disperses and prevents clumping of the adhesive, demersal (sinking) eggs. Historically (prior to Libby Dam construction and operation), spawning areas for Kootenai sturgeon were reported to be in the roughly 1-mile (1.6-km) stretch of the Kootenai River below Kootenai Falls (U.S. Army Corps of Engineers [USACE] 1971; Montana Fish, Wildlife and Parks [MFWP] 1974). However, most spawning is currently occurring downstream of Bonners Ferry over sandy substrates, which are not conducive to egg and free-embryo survival.

Age at sexual maturity is variable, but has been estimated at age 30 for females and age 28 for males (Paragamian *et al*. 2005, USFWS 2011b). Only a portion of Kootenai sturgeon are reproductive or spawn each year, with the spawning frequency for females estimated at once every 4 to 6 years (Paragamian *et al*. 2005).

Following fertilization, eggs adhere to the rocky riverbed substrate and hatch after a relatively brief incubation period of 8 to 15 days (Brannon *et al*. 1985). Here they are afforded cover from predation by high near-substrate water velocities and ambient water turbidity, which preclude efficient foraging by potential predators.

Upon hatching, the embryos become "free-embryos" (the life stage after hatching through active foraging larvae, with continued dependence upon yolk materials for energy). Free-embryos initially undergo limited downstream redistribution(s) by swimming up into the water column where they are passively redistributed downstream by the current. This redistribution phase may last from one to six days depending on water velocity (Brannon *et al*. 1985; Kynard and Parker 2006). The inter-gravel spaces in the substrate provide shelter and cover during the free-embryo "hiding phase". Main channel complexity, large woody debris, riparian vegetation, and off-channel habitat may also provide shelter during the free-embryo hiding phase.

As the yolk sac is depleted, free-embryos begin to increase feeding, and ultimately become free-swimming larvae, entirely dependent upon forage for food and energy. At this point the larval Kootenai sturgeon are no longer highly dependent upon hiding places or high water velocity for survival (Brannon *et al*. 1985; Kynard and Parker 2006). With water temperatures typical of the Kootenai River, free-embryo Kootenai sturgeon may require more than 7 days post-hatching to develop a mouth and be able to ingest forage. At 11 or more days, Kootenai sturgeon free-embryos are expected to have consumed much of the energy from yolk materials, and to become increasingly dependent upon active foraging, at which point adequate sources of food for larval and juvenile fish (e.g., zooplankton and macroinvertebrates) become increasingly important. Juvenile and adult rearing occurs in the Kootenai River and in Kootenay Lake.

More detail on the life history of Kootenai sturgeon can be found in the 5-year status review and accompanying science review (USFWS 2011a, 2011b).

Threats to the Kootenai Sturgeon

The primary threats to Kootenai sturgeon stem from the presence and operations of Libby Dam, and fall into three main categories: (1) reductions in peak spring flows, (2) alterations to the annual thermal regime in the Kootenai River, and (3) reductions to/losses of nutrients and fundamental ecosystem processes (e.g., food web, floodplain interaction, riparian function).

Prior to the construction and operation of Libby Dam in the early 1970s, the natural hydrograph of the Kootenai River downstream of the dam consisted of a spring freshet (elevated river flows from rain or meltwater) with high peak flows, followed by a rapid drop in flows into August (Figure 2). Tetra Tech (2003) found that the primary changes in hydrology from Libby Dam operations included a decrease in annual peak discharges on the order of 50 percent, a decrease in the duration of high and low flows, an increase in the duration of moderate flows, and a redistribution of seasonal flow characteristics. Together, these changes have affected the stage, velocity, depth, temperature, and shear stress within the river, which in turn have altered sediment and nutrient transport conditions and have greatly reduced the physical forces needed to produce and maintain physical habitat diversity and complexity (Anders *et al*. 2002; Burke *et al*. 2009, KTOI 2009). Despite the dam's water temperature control structure, hydropower generation and necessary flood control operations preclude winter river temperatures from being as cold as they were prior to dam construction. Further, pre-dam fisheries investigations and inventories stated that prior to the construction of Libby Dam, Kootenai sturgeon spawned in the roughly 1-mile stretch of the Kootenai River downstream of Kootenai Falls (USACE 1971; MFWP 1974). The reductions in peak spring flows and associated altered river conditions during the Kootenai sturgeon spawning period are the likely reason behind Kootenai sturgeon spawning over sand and silt substrates downstream of Bonners Ferry, rather than over the rocky substrates that exist from Bonners Ferry upstream to Kootenai Falls. This change in Kootenai sturgeon spawning location was predicted by fisheries biologists prior to the construction of Libby Dam (USACE 1971, MFWP 1974).

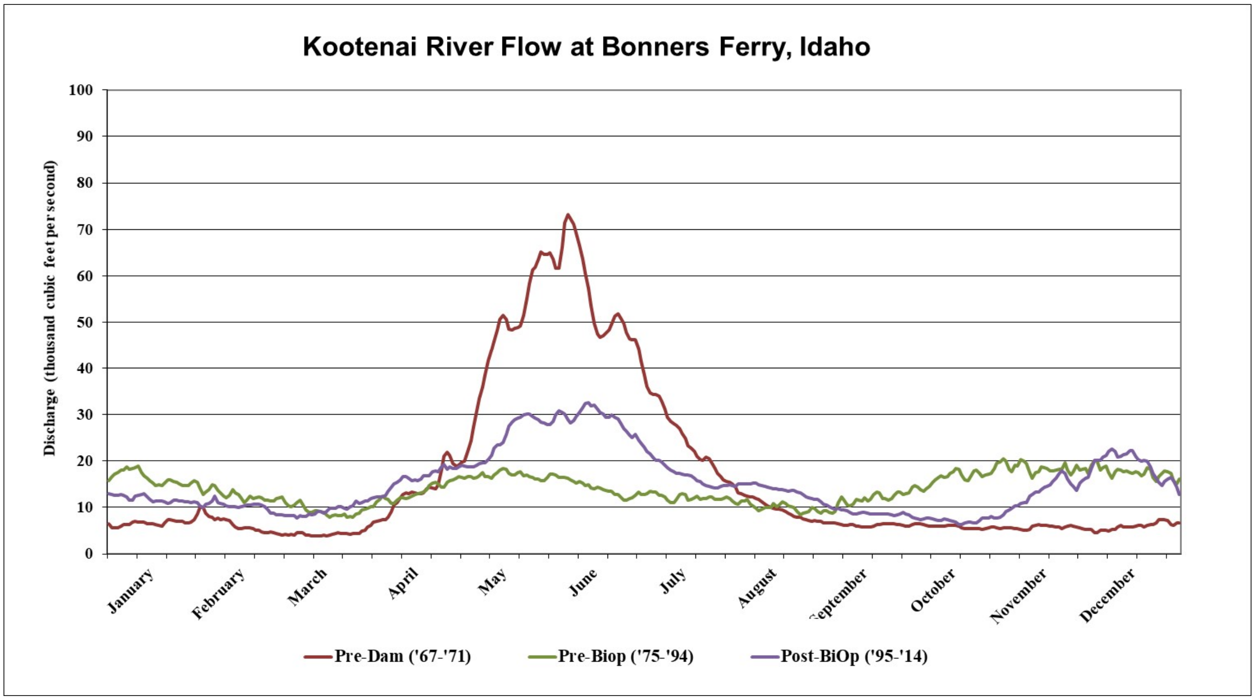

Figure 2. Average Kootenai River flow over the year at Bonners Ferry, Idaho.

The presence and operations of Libby Dam have also substantially influenced biological processes in the Kootenai River by affecting nutrient and carbon transport and altering thermal regimes; Koocanusa Reservoir has acted as a nutrient sink, decreasing the productivity and overall carrying capacity of the system downstream (Tetra Tech 2003; Burke *et al*. 2009). Additionally, winter power peaking (i.e., increasing hydropower generation during periods of high electrical demand) at Libby Dam alters winter flows and river temperatures, and increases downstream erosion and scour. Aquatic and terrestrial vegetation that would have normally provided secure riparian habitat along river margins are now lacking, and stabilized soils have not been able to fully reestablish each summer due to the post-dam varial zone (i.e., the area along the river that alternates between wet and dry due to dam operations). As a result, fine sediment materials are more easily eroded and swept back into the channel. The result of all these changes has been significant impacts to the food web, including periphyton, aquatic insects, and fish populations (Hoyle *et al*. 2014; Minshall *et al*. 2014). These changes negatively affect Kootenai sturgeon via reductions in prey items that are important for early life stages, and reduction in overall ecosystem productivity, which negatively affects all life stages.

Suspended sediment levels in the Kootenai River have also decreased substantially since the construction of Libby Dam (USACE 2005). Suspended sediment records for the Libby Dam era show that the only notable, multi-week suspended sediment transport event with streamflow that approached pre-Libby Dam conditions took place from April 24 to July 5, 1974, during the Kootenai sturgeon spawning season (Barton 2004, USACE 2005). Suspended sediment and turbidity may be a critical component of flow that allows for Kootenai sturgeon egg and larvae survival. Significant reductions in sediment loading following the construction of Libby Dam are also directly associated with significant reductions in downstream nutrient loading, which has significantly reduced biological production through reduced nutrient and food availability for Kootenai sturgeon (Hoyle *et al*. 2014; Minshall *et al*. 2014).

According to Jamieson and Braatne (2001), the lower Kootenai River floodplain downstream of the Moyie River in Idaho likely supported one of the largest and richest riparian-forest and wetland complexes in the Pacific Northwest. Since 1890, 22,000 acres (8,900 hectares (ha))of ephemeral and perennial wetlands have been lost in the U.S. portion of the basin (EPA 2004). These substantial wetland losses are attributed to a combination of factors that include the operations of Libby Dam, reductions in hydrologic connectivity (diking and land leveling), draining associated with agricultural development, and tributary channelization (Richards 1997; Anders *et al*. 2002; Burke *et al*. 2009). These changes have altered fundamental ecosystem processes in the basin and lowered the overall productivity of the Kootenai River, which have negatively affected Kootenai sturgeon. The reductions in ecosystem functions and productivity are the most likely reason behind a second survival bottleneck at the larval to age-2 life stages in Kootenai sturgeon, the initial survival bottleneck occurring when eggs and free-embryos become covered in sand and silt due to spawning taking place in the meander reach (USFWS 2011b).

Additionally, average water temperatures in the Kootenai River are typically warmer in the winter and colder in the summer than they were prior to the construction of Libby Dam (USACE 2005). Current average spring temperatures tend to be cooler than under pre-dam conditions (Figure 3), and the differences may be increased even more when flow from Libby Dam dominates the total river flow (USACE 2005). These temperature alterations may affect the population in multiple ways. For example, warmer winter river temperatures may cause juveniles to engage in foraging behavior at a time when food availability is low (Kynard *et al.* 2009). Additionally, cooler river temperatures in the spring may delay the onset of spawning in adults and/or slow rates of development in larvae and juveniles.

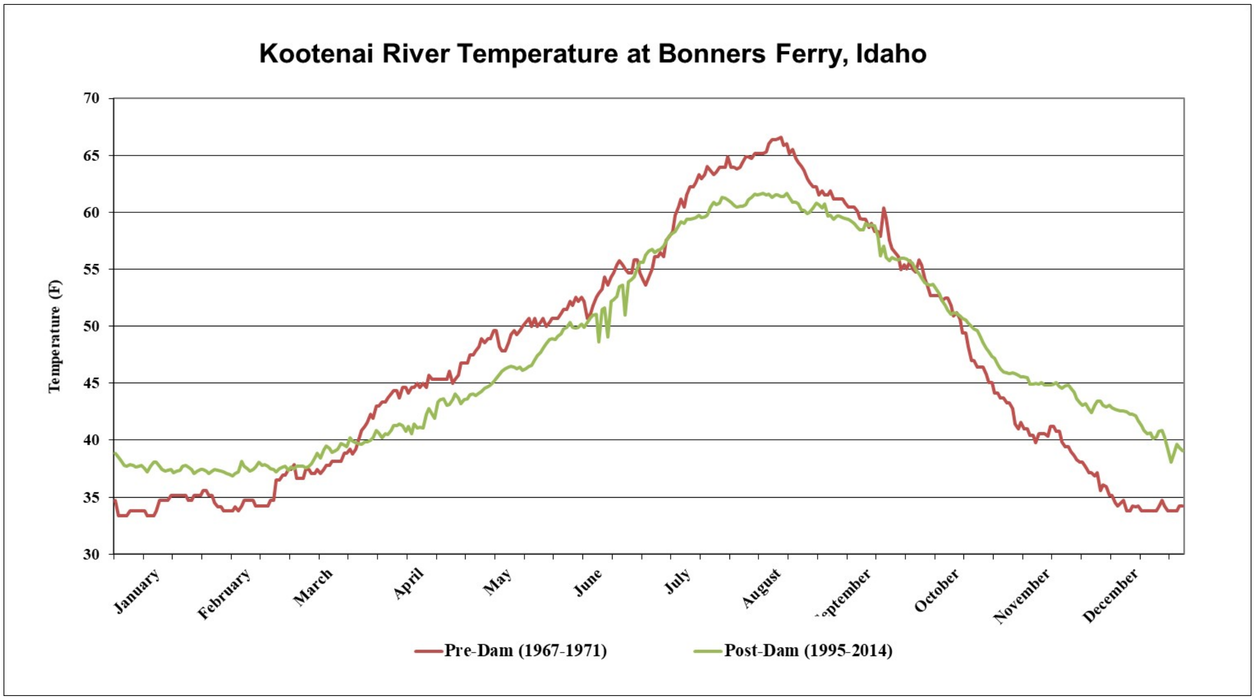

Figure 3. Mean Kootenai River water temperatures over the year at Bonners Ferry, Idaho

Other threats to Kootenai sturgeon include removal of side-channel and off-channel habitats, which are important rearing habitats for early-life stage sturgeon; and alterations to tributaries to the Kootenai River, which serve as additional sources of nutrients into the ecosystem.

As described above, the primary cause of recruitment failure is suffocation of fertilized eggs and free-embryos as a result of spawning taking place over sand and silt substrates. There are also indications of a second, productivity-related survival bottleneck. Therefore, recovery efforts for Kootenai sturgeon must address these factors and the other threats described in this plan, and minimize them to the point where they no longer threaten the continued existence of Kootenai sturgeon.

<u>Recent Information on Status, Threats and Conservation Efforts</u>
Libby Dam Flow and Temperature Management

When the 5-year species status review and science review documents were completed in 2011, sturgeon managers (and others) were in the process of preparing for the second of three years of spill tests at Libby Dam. The spill tests were intended to test whether additional outflows from Libby Dam and subsequent river conditions (i.e., higher river stages) would cause spawning Kootenai sturgeon to migrate to, and spawn over, rocky substrates that exist upstream of Bonners Ferry. The first spill test was conducted in 2010, but due to low water supply conditions, did not achieve the desired river conditions. In 2011, due to above-average water supply, it was not necessary to spill excess water from Libby Dam to achieve the desired river conditions (i.e., full powerhouse releases were sufficient). In fact, Libby Dam releases were curtailed in the midst of sturgeon operations due to flood risk concerns for the Kootenai River and Kootenay Lake. In 2012, a combination of higher than average water supply and an unusually wet spring resulted in the largest water year on record since Libby Dam was constructed. Spill for the 2012 test began on June 4, but became intermittent throughout the sturgeon operations due to flood risk concerns. Also, due to cold weather and delayed melt of the snow pack, temperatures in the Kootenai River were lower than expected. Nevertheless, the subsequent river conditions were sufficient to test the hypothesis that higher river stages (within current constraints) would cause a change in Kootenai sturgeon migration and spawning behavior. Overall however, telemetry data from spawning adult sturgeon in 2010-2012 did not show a significant change in their behavior.

In 2013, the Kootenai River White Sturgeon Recovery Team began discussing alternative approaches to managing outflows at Libby dam to improve sturgeon habitat (termed "sturgeon operations"). The team agreed to test a new approach with two main components: (1) a double peak shape to the spring freshet, and (2) an alternative approach to temperature management. The first peak was intended to provide Kootenai sturgeon with cues to begin upstream migration and pre-spawn staging, while the second was intended to provide Kootenai sturgeon cues to migrate further upstream from their staging areas and spawn towards the end of the second peak and/or on its descending limb. This alternative approach to temperature management also involved targeting 50° F (10° C) toward the end of the second peak to trigger spawning after Kootenai sturgeon have fully migrated upstream.

This approach was successfully implemented in 2013, 2014, and 2017, but low water supply prevented full implementation (i.e., one peak rather than two) in 2015 and 2016. Telemetry data from spawning Kootenai sturgeon indicates that in 2017 there was an increase (~20%) in the number of spawning sturgeon migrating upstream of Bonners Ferry, over the mean for 2012-2016 (K. McDonnell, pers. comm.). Subsequent analyses showed that the number of days with river flows above 30,000 cubic feet per second (cfs) (measured at Bonners Ferry) best predicted the likelihood of spawning Kootenai sturgeon migrating upstream of Bonners Ferry (McDonnell 2018). The threshold of 30,000 cfs was chosen to represent the hypothesis that the duration of high water events may influence spawning migration behavior. Based on these results, in 2018 the Flow Plan Implementation Protocol (FPIP) Technical Team recommended that Kootenai sturgeon operations at Libby Dam focus on maximizing the number of days above 30,000 cubic feet per second (measured at Bonners Ferry). This latest approach was successfully implemented in 2018, and data from that operation are being analyzed.

Adult Population Estimate

In 2014, a final report estimated that wild adult Kootenai sturgeon population abundance had declined from approximately 3,000 individuals in 1990 to 990 individuals (confidence interval 733-1,375) in 2011 (Beamesderfer *et al*. 2014a). Annual survival rates (estimated by the mark-recapture analysis) appeared to have declined from "around 97 percent" prior to 2008 to 85 percent from 2007 to 2010. These latest estimates are the most current information available and constitute the best available science on the abundance and survival of wild adult Kootenai sturgeon.

Habitat Restoration Actions

In 2009, the Kootenai Tribe of Idaho (Kootenai Tribe) completed the Kootenai River Habitat Restoration Program[3] Master Plan, which developed a framework for implementing a large-scale, ecosystem-based habitat restoration program in the Idaho portion of the Kootenai River (KTOI 2009). This habitat restoration program focuses on addressing threats to Kootenai sturgeon including changes to river morphology, and reductions in floodplain interaction, riparian habitat and nutrients. Between 2011 and 2016, the Kootenai Tribe completed construction of nine habitat restoration projects under this program, including eight projects in the braided reach of the Kootenai River and one project in the meander reach (Figure 4):

- 2011 – Phase 1A and Phase 1B projects
- 2012 – Upper Meander and North Side Channels projects
- 2013 – Middle Meander and Phase 1A Extension projects
- 2014 – Substrate Enhancement Pilot project
- 2015 – Bonners Ferry Islands project (part 1)
- 2016 – Bonners Ferry Islands (part 2) and Straight Reach projects

[3]Note: the Kootenai River Habitat Restoration Program was mistakenly referred to as the Kootenai Ecosystem Restoration Program in the 5-year status review. The Ecosystem Restoration Program is a nutrient addition program jointly managed by the Kootenai Tribe of Idaho and the Idaho Department of Fish and Game.

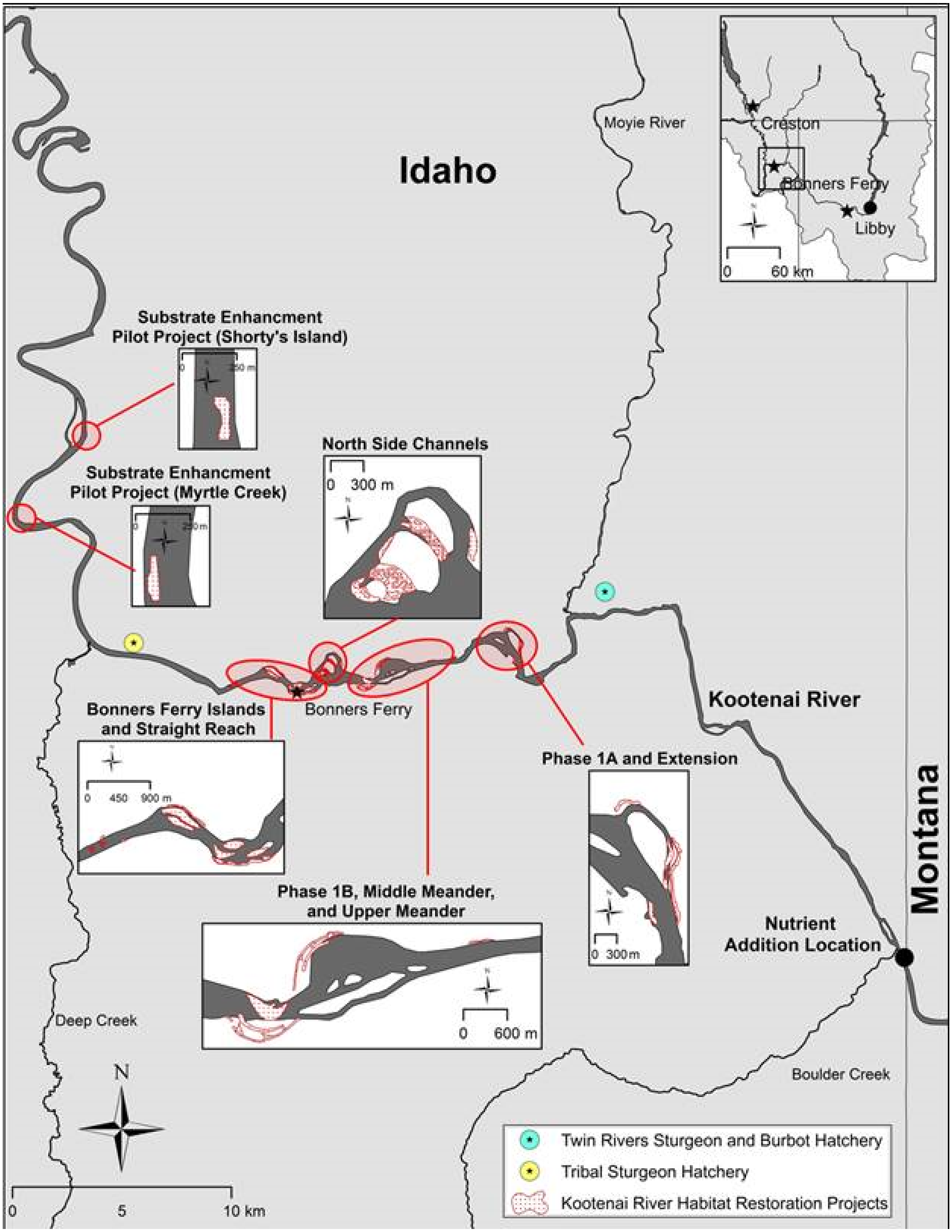

Figure 4. Kootenai River Habitat Restoration Program projects completed from 2011 through 2016 (with location of Kootenai Tribe hatcheries for reference).

Major treatments implemented under the Kootenai River Habitat Restoration Program between 2011 and 2016 include:

- Construction of large and small pool-forming and flow redirection structures designed to address limited aquatic habitat complexity to support all Kootenai sturgeon life stages, e.g., maintaining and/or scouring pools, creating alcove habitat, and enhancing hydraulic complexity (Upper Meander, Middle Meander, Bonners Ferry Islands, and Straight Reach projects).

- Construction and/or enhancement of a chain of pools through the braided reach to provide habitat for Kootenai sturgeon to stage for spawning, enhance the diversity of existing aquatic habitat, and to provide conditions (i.e., deep water habitat) that may encourage migration upstream to areas where suitable spawning habitat exists (Upper Meander, Middle Meander, and Bonners Ferry Islands projects).

- Construction of multiple islands on existing mid-channel bars in the braided reach to create additional vegetated floodplain surfaces, enhance hydraulic complexity, and enhance the food web, which will provide increased prey for larval and juvenile Kootenai sturgeon (Bonners Ferry Islands project).

- Construction and revegetation of 56 acres (23 ha) of floodplain to help enhance the food web (Phase 1A and Phase 1A Extension, Phase 1B, North Side Channels, Upper Meander, Middle Meander, and Bonners Ferry Islands projects).

- Placement of rocky substrates on the riverbed at two locations in the meander reach (2.0 acres (0.8 ha) total) and one location in the straight reach (0.75 acres (0.3 ha)). This treatment is designed to address factors limiting Kootenai sturgeon egg and larval survival (Substrate Enhancement Pilot and Straight Reach projects).

- Realignment and enhancement of approximately 2.3 acres (0.9 ha) of side channels to increase aquatic habitat complexity and enhance the food web (Phase 1A and North Side Channels projects).

- Restoration of approximately 24,000 linear feet (7,300 meters) of river bank, riparian planting, and 53 acres (21 ha) of reseeding to support the food web and prevent erosion (Phase 1A, Phase 1B, North Side Channels, Upper Meander, Phase 1A Extension, Middle Meander, Bonners Ferry Islands, and Straight Reach projects).

Additional Kootenai River Habitat Restoration Program projects in the braided and meander reaches are under development.

Recovery Vision and Strategy

A recovery vision is an explicit expression of recovery in terms of resiliency (the ability of a species to recover from periodic disturbance), redundancy (the number of populations of a species distributed across the landscape), and representation (the range of variation found within a species). It builds upon the description of viability for the species and defines what recovery looks like for the species. The recovery strategy provides a recommended approach for achieving the recovery vision, and, ultimately, the down- and delisting criteria.

Our recovery vision for Kootenai sturgeon is for the population to successfully reproduce and recruit in the wild at sufficient levels to sustain the population. Currently, the resiliency of wild Kootenai sturgeon is considered low due to the low level of natural recruitment occurring in the population. However, the conservation aquaculture program has successfully supplemented the population by releasing over 275,000 juvenile sturgeon into the population since 1991. As conditions in the Kootenai basin improve due to ongoing and future management activities, we expect levels of natural recruitment to increase.

Redundancy in Kootenai sturgeon is not applicable, as only a single, panmictic (all individuals in the population are potential mating partners) population of Kootenai sturgeon exists throughout its historical range, as has been the case since the end of the last ice age 10,000 years ago. Therefore, our recovery vision for Kootenai sturgeon does not incorporate an element of redundancy.

Our recovery vision for Kootenai sturgeon is to preserve the existing genetic diversity in the wild population and increase successful natural recruitment, which will expand genetic diversity. Representation in Kootenai sturgeon is considered low, because Kootenai sturgeon have lower genetic diversity than other white sturgeon populations in other river basins (USFWS 2011b). Geographic isolation, population founding effects, demographic bottlenecks, and past harvest may all be contributing factors to this phenomenon (Setter and Brannon 1990; Anders *et al.* 2002).

The recovery strategy for Kootenai sturgeon involves continuing the conservation aquaculture program; long-term continuation of management of flows and temperature from Libby Dam; adding nutrients, restoring and enhancing habitat in the Kootenai basin; conducting research, monitoring and evaluation; and conducting public outreach and education.

Much of the strategy for habitat restoration and enhancement is predicated on the relationship of Kootenai sturgeon to their physical, chemical, and ecological environments. Information on Kootenai sturgeon and their interaction with the ecosystem (e.g., evaluation of early life stage requirements, spawning cues site selection, population dynamics, and responses to threats) is required to support future science-based management decisions and conservation actions. Implementation of the draft revised recovery plan will require adaptive management strategies that use the most current information to inform the implementation of recovery actions.

Given that Kootenai sturgeon occur in both the U.S. and Canada (Figure 1) and are designated as endangered in both countries, the recovery of Kootenai sturgeon will require concerted international cooperation among Federal, State, Tribal, Provincial, local entities, private landowners, and other stakeholders. Therefore, the success of the recovery strategy, outlined above and elucidated below, will rely on the successful implementation of recovery activities conducted by our recovery partners.

We describe our recommendations for increasing the resiliency and representation of Kootenai sturgeon below, which are grouped by broad categories of actions.

Continue to Implement Conservation Aquaculture Program

Beamesderfer *et al*. (2014a) estimated natural recruitment to the wild population to be 13 new juveniles per year. However, the same analysis indicated that the number of naturally produced recruits are inadequate (i.e., too low) to accurately assess the number of wild juveniles produced annually. Applying sampling efficiencies of hatchery sturgeon to wild sturgeon, based on cumulative annual capture of wild juveniles between 3 and 24 years old, Ross *et al*. (2015) and Hardy *et al*. (2016) estimated that an average of approximately 85 new juvenile Kootenai sturgeon are naturally reproduced in the Kootenai River annually. Both estimates suggest that high levels of mortality are occurring in the population and the current level of natural recruitment is not sufficient to sustain the population.

In order to fill the demographic and genetic gap left by the absence of natural reproduction, hatchery origin Kootenai sturgeon have been released into the Kootenai River since 1990. Field surveys, analyses, and genetic studies show that post-release, hatchery-origin Kootenai sturgeon are surviving at levels sufficient to contribute to the future spawning adult population, and the aquaculture program is capturing and incorporating between 70-80 percent of wild alleles in the wild population (A. Schreier, pers. comm.). A more detailed description of this information can be found below in the Recovery Actions section.

These results, in addition to the continued lack of in-river recruitment among Kootenai sturgeon, make it clear that continuing the conservation aquaculture program, at a proper level, is vital to the recovery of Kootenai sturgeon.

Develop and Implement a Long-Term Strategy for Libby Dam Flow and Temperature Management to Benefit Kootenai sturgeon

Flow management from Libby Dam has an extensive history. In general, short-term flow management strategies have focused on providing additional water from Libby Dam during the spring freshet, shaping the freshet to a more "normative" (i.e., more closely resembling the shape of the pre-Libby Dam freshets) shape, and more recently, providing a more "normative" thermograph during the freshet. While these specific flows have shown multiple ecosystem benefits, to date, there is little evidence that these specific flow measures increased Kootenai sturgeon recruitment or changed their spawning and migration behavior. Given the widespread effects Libby Dam operations have on the Kootenai River ecosystem and the threats those effects pose to Kootenai sturgeon, it is imperative that sturgeon managers develop and implement a successful strategy over the long term for managing Libby Dam flows.

Continue to Implement Nutrient Addition Program(s)

To address threats related to reductions in nutrients, primary productivity, and fundamental ecosystem processes in the Kootenai River, one measure has been to add nutrients to the system. Since 2005, the Kootenai Tribe and Idaho Department of Fish and Game (IDFG) have implemented the Kootenai River Ecosystem Restoration Project, which involves direct injection of inorganic liquid phosphorus and nitrogen into the Kootenai River, just downstream from the Idaho-Montana border. The objective of this project is to restore nutrient concentrations and food availability to enhance biological production and restore the post-dam native fish community in the Kootenai River (note: the main nutrient enhancement effects extend only through the upper braided reach of the river).

Additionally, the British Columbia (BC) Ministry of Forests, Lands and Natural Resources Operations and Rural Development (BCMFLNRORD), BC Hydro, Bonneville Power Administration (BPA), and the Kootenai Tribe are currently fertilizing Kootenay Lake with controlled nitrogen and phosphorus releases into the north (begun in 1992) and south (begun in 2004) arms to increase biological productivity and restore native fish populations and their supporting food webs.

These ongoing nutrient addition programs continue to increase beneficial algal production, the abundance, biomass and diversity of invertebrate food items for fish, and overall biological productivity in the Kootenai system (Hoyle *et al*. 2014; Minshall *et al*. 2014). Continuing to implement these nutrient addition programs will benefit the ecosystem, which in turn will help alleviate the threats to Kootenai sturgeon that are related to reductions in nutrients and ecosystem processes, by increasing the availability and diversity of prey items for all life stages.

Additional means to add nutrients to the ecosystem include floodplain enhancement and riparian restoration (see habitat restoration strategy).

Restore and Enhance Kootenai Sturgeon Habitat

As noted earlier in this plan, Kootenai sturgeon are threatened by habitat modifications, primarily in the form of limited nutrient input, and significantly altered annual hydrographs and thermographs that stem directly from the construction and operation of Libby Dam. Addressing and correcting these habitat-related threats will require identification and restoration of Kootenai sturgeon habitats and ecological functions necessary to sustain reproduction (spawning and recruitment) and rearing while minimizing impacts on other uses of Kootenai River basin waters such as recreational facilities and the resident fishery in Koocanusa Reservoir, Kootenay Lake, and Kootenai River.

In 2009, the Kootenai Tribe completed the Kootenai River Habitat Restoration Program Master Plan (KTOI 2009). As described in the Master Plan, the goals of the Restoration Program are to:

- Restore and enhance Kootenai River habitat by addressing ecological limiting factors and constraints related to river morphology, riparian vegetation, aquatic habitat and river management. The desired result is a more resilient ecosystem, capable of sustaining diverse native plant and animal populations, and tolerant of natural disturbances and altered regimes.

- Restore and maintain Kootenai River habitat conditions that support all life stages (i.e., migration, occupancy, spawning, incubation, recruitment and rearing of early life stages (larvae and juveniles)) of endangered Kootenai sturgeon and other aquatic focal species; and

- Restore the Kootenai River landscape in a way that sustains Tribal and local culture and economy and contributes to the health of the Kootenai subbasin as both an ecological and socioeconomic region.

Implementation of the Kootenai River Habitat Restoration Program began in 2010 and is ongoing. Specific to Kootenai sturgeon, the Kootenai River Habitat Restoration Program is designed to address threats including reduced biological productivity, loss of floodplain and riparian function, and lack of suitable spawning substrates in current spawning areas. More information on the Habitat Restoration Project can be found in the Kootenai Tribe's Kootenai River Habitat Restoration Plan (KTOI 2009).

Continue Research, Monitoring and Evaluation

All of the aforementioned actions contain specifically targeted research, monitoring, and evaluation in order to determine the success and effectiveness of individual efforts in contributing to recovery objectives. Additional research, monitoring, and evaluation related to life history, habitat requirements for all life stages, population status, and trends of Kootenai sturgeon have continued to evolve since the 1994 listing. In particular, additional information about early life-stage behaviors and requirements (i.e., food/prey requirements for each life stage, habitat preferences for each life stage, juvenile use of and distribution in Kootenay Lake) will be vital to future recovery efforts. Field crews and researchers from multiple agencies and entities have conducted, and continue to implement, targeted research, monitoring, and evaluation (Table 1).

Table 1. Examples of Kootenai sturgeon-related research, monitoring, and evaluation activities by various agencies and entities

Agency/Entity	Research, monitoring, and evaluation
IDFG, BCMFLNRORD	Annual telemetry, adult and juvenile surveys
IDFG, Statistical Consulting Services, Cramer Fish Sciences	Abundance estimates, evaluation of aquaculture strategies, responses to nutrient addition
Kootenai Tribe	Adult and juvenile tagging, monitoring of hatchery releases, habitat evaluations
MFWP	Surveys of Kootenai sturgeon in Montana
IDFG, BCMFLNRORD, Kootenai Tribe, S.O. Conte Anadromous Fish Research Laboratory/BK-Riverfish LLC	Research into early life stage behavior and feeding.
USACE	Temperature and flow monitoring and evaluation in the Kootenai River downstream of Libby Dam.
U.S. Geological Survey	Monitoring and modeling hydrological and morphological characteristics of the Kootenai River, comparisons between Kootenai sturgeon spawning reaches in the Kootenai and Columbia basins

Ongoing monitoring for wild juvenile Kootenai sturgeon is critical as recovery actions continue to be implemented. Should an action prove "successful," i.e., result in a detectable increase in recruitment, it will be crucial to be able to identify the mechanisms and actions associated with success as quickly as possible and link them with a specific action. New monitoring results and other information will aid in making management decisions on an adaptive basis.

In addition to the examples of past and ongoing research, monitoring, and evaluation activities listed in Table 1, it will also be important to identify, research, monitor, and evaluate new threats to the population as they arise.

Continue Public Outreach and Education

Garnering public and political support is vital to funding and implementing the recovery strategy outlined in this plan. Publishing research results in agency presentations, reports, and peer-reviewed journals is another key aspect of public outreach and education that has helped this program to disseminate important science-based information about this species.

Staff from the Service, Kootenai Tribe, U.S. Army Corps of Engineers (USACE), IDFG, MFWP, U.S. Geological Survey, Cramer Fish Sciences, BPA, BCMFLNRORD, and other entities have been consistently engaging in outreach efforts since the 1994 listing.

Examples of effective outreach and education include the Kootenai Tribe's efforts for the Kootenai River Habitat Restoration Program, the Kootenai Valley Resource Initiative (a community-based, collaborative effort created to improve coordination of local, state, federal and Tribal programs to restore and maintain social, cultural, economic and natural resources), the

International Kootenai/ay Ecosystem Recovery Team, Kootenai Tribe of Idaho conservation aquaculture program open house tours, and annual public meetings (in both the U.S. and Canada) about sturgeon operations at Libby Dam. In addition, the Montana Chapter of the American Fisheries Society has posted an online review and summary of Kootenai sturgeon status and limiting factors to help inform the public and other stakeholder groups (Montana AFS 2013). In 2015, Gale Force Films produced the documentary "The Fish Between the Falls," featuring the history of collaborative Kootenai sturgeon research, management, and recovery activities. This film has been shown widely throughout the inland northwest, including airings on public broadcasting channels. National Geographic Television also broadcast an episode of their "Megafishes Project" production highlighting the status of Kootenai sturgeon and related recovery efforts. In 2017, Kyle & Rob Productions completed a film titled, "A Natural Balance: Partners in Restoration," that highlights the Kootenai Tribe's Kootenai River Habitat Restoration Program and the partnerships associated with that program.

RECOVERY CRITERIA

The Kootenai River distinct population of the white sturgeon should be considered for downlisting and delisting when the following objective and criteria have been met. Downlisting and delisting criteria are subject to change as additional information becomes available about species biology and threats.

Objective 1 – Restore Natural In-River Recruitment

> **Downlisting Criterion –** Kootenai sturgeon demonstrate consistent natural in-river production of juveniles, with production of wild age-3 juveniles occurring at an annual average of at least 700 individuals over 10 consecutive years. Production of 700 or more wild age-3 juveniles occurs in at least 3 of the 10 years, ensuring the annual average is not the result of an anomalous single-year event.
>
> **Delisting Criterion –** The number of Kootenai sturgeon wild recruits (offspring that survive to sexual maturity at 25 years) added to the adult (25 years or older) population annually averages at least 250 individuals per year over 10 years. In addition, the population includes at least 10,000 wild juveniles aged from 3 to 24 years.

Our objective to restore natural, in-river recruitment would be achieved for downlisting when Kootenai sturgeon naturally produce a minimum annual average of 700 wild age-3 juveniles over 10 years. In order to guard against downlisting being based on an anomalous single-year event, the downlisting criterion also requires production of a minimum of 700 wild age-3 juveniles in at least three of those years. This level of natural production would indicate that conditions in the Kootenai basin had improved to the point where Kootenai sturgeon are on the path to being able to sustain themselves via natural, in-river reproduction. The criterion utilizes age-3 juveniles because younger Kootenai sturgeon are not large enough to be captured by current sampling gear.

Our objective to restore natural, in-river recruitment would be achieved for delisting when Kootenai sturgeon naturally add a minimum annual average of 250 recruits (offspring that survive to sexual maturity at 25 years) over 10 years and the population includes a minimum of 10,000 wild juveniles (from 3 to 24 years of age). At this level of recruitment, we would expect the population to be increasing such that if recruitment began immediately, it would take approximately 50 years for the population to consist of 8,000 wild adults (assuming current mortality rates are sustained). Adding an annual average of 250 recruits over 10 years and the population including a minimum of 10,000 wild juveniles would indicate that the population has become resilient (i.e., the population is sustaining itself over time) and representative (i.e., is preserving its genetic diversity), and is no longer threatened with extinction.

Our emphasis on recruitment is particularly relevant to recovery, given the inability for additional populations to contribute to recovery (i.e., redundancy). Therefore, it is extremely important that the single population of Kootenai sturgeon have robust reproduction and survival to ensure it is self-sustaining (e.g., there is no opportunity for demographic rescue or genetic interchange with members of another population). Our criteria are designed to ensure that the existing threats to Kootenai sturgeon have been alleviated to a degree that consistent, robust reproduction and survival is taking place, while further ensuring that the Kootenai sturgeon population will be resilient to ongoing stressors and changing environmental conditions in the limited geographic range in which it occurs.

As described in the “Threats to the Kootenai Sturgeon” section of this plan, the primary threats to Kootenai sturgeon are the suite of negative impacts to their habitat that stem from the presence and operations of Libby Dam. The modifications to their habitat are the likely reason Kootenai sturgeon are spawning over sand and silt substrates, which has caused almost complete recruitment failure in the species. Therefore, Kootenai sturgeon producing wild juveniles and recruits at the levels required in the recovery criteria will be the most relevant indicator that the habitat-related threats to the population have been eliminated or minimized. Additional manmade threats to the species stem from reductions in hydrologic connectivity (diking and land leveling), draining associated with agricultural development, and tributary channelization. Together, these threats have led to the reduction of the wild population of Kootenai sturgeon to fewer than 900 wild adults in 2018. Specific to the five factors under Section 4(a) of the ESA, meeting the recovery criteria would indicate that threats related to the present or threatened destruction, modification, or curtailment of its habitat (Factor A) have been eliminated or minimized. Additionally, meeting the demographic targets in the recovery criteria would indicate that threats related to other natural or manmade factors (Factor E), including small population size and associated vulnerability to stochastic events and loss of genetic diversity, have been eliminated or minimized. Factors B (overutilization for commercial, recreational, scientific, or educational purposes), C (disease or predation), and D (inadequacy of existing regulatory mechanisms) do not apply to Kootenai sturgeon at this time.

It will take several decades to reach recovery. There are two reasons for this. First, Kootenai sturgeon are long-lived fish that can take as long as 30 years to reach sexual maturity. We have initial indications that the first hatchery-origin Kootenai sturgeon have been recruited into the population (i.e., have reached sexual maturity), and expect that each year additional hatchery-origin recruits will be added. Second, effecting change to ameliorate the habitat modifications that have occurred from Libby Dam is complex, expensive, and time consuming, and as such will likely take years to realize.

Although we do not have extensive historical data upon which to base our understanding of viability in this population, recent estimates suggest that the wild adult population of Kootenai sturgeon was approximately 8,000 in the late 1970s (Beamesderfer *et al*. 2014a; IDFG in preparation). Further, aging data from unmarked juveniles captured between 1977 and 2015 indicate that the three largest year classes of Kootenai sturgeon were produced in 1961, 1962, and 1974, all prior to the construction of Libby Dam (Anders *et al*. 2016). Therefore, the best available information indicates that prior to the construction of Libby Dam, Kootenai sturgeon persisted at levels of at least 8,000 individuals with no known genetic issues or demographic instability. Based on this information, we consider 8,000 adults to be a reasonable representation of a self-sustaining population of Kootenai sturgeon, and as such, have utilized that abundance estimate in our modeling. However, it should be noted that 8,000 wild adults is not a recovery target or criterion, and the criteria by which recovery will be evaluated are the number of naturally-produced juveniles and adults, and sustainment of that production as described in the downlisting and delisting criteria above.

To develop the downlisting and delisting criteria, a stochastic population model was used to simulate recruitment rate and time to recovery. To populate this model, the abundance estimate of 8,000 adults (described above) was used. The model also used the most recent estimate of 1,000 wild adults coupled with an annual survival rate of 96%, the mean survival of adults from 1990-2009 (Note: The 85% survival rate in Beamesderfer (2014a) likely reflects the mortality rate of a population that consists of very old individuals. Under a recovery scenario, the newly-recruited adults would be expected to survive at the 96% rate, which is more in line with a population of younger adults). For the purposes of the model, a recruit was defined as a sturgeon that survives and recruits to the spawning age of 25 (estimated age at sexual maturity of an adult female). Only ages 3-24 were defined as juveniles because fish younger than age three had not grown large enough to be captured by current sampling gear.

It is important to note that because Kootenai sturgeon can take 25 to 30 years to become a recruit (i.e., reach sexual maturity), if natural, in-river production of juveniles were to increase immediately, it would be 25 to 30 years before we would be able to evaluate the status of that production relative to the recruitment target in the delisting criterion. In other words, at whatever level of natural, in-river production of juveniles occurs in a given year, we will need to allow 30 years for all of those juveniles to become recruits, so that we can then determine the number of new wild recruits added annually to the adult population in the delisting criterion.

It is also important to note that, because the goal is to restore natural, in-river recruitment, only naturally-produced (i.e., spawned and reared in the Kootenai River) Kootenai sturgeon will "count" towards meeting the recovery criteria. As hatchery-origin sturgeon (which are marked and tagged prior to release) mature and begin spawning in the wild, the offspring they produce will "count" towards the recovery criteria, because those offspring will have been naturally spawned and reared in the Kootenai River.

For the downlisting criterion, assuming that naturally-produced juveniles will survive at rates similar to their hatchery-origin counterparts, we can estimate the minimum number of juveniles that must be naturally produced in order to result in recruits at the rate required in the delisting criterion (Figure 5).

Model simulations showed that it would take approximately 50 years for the population to reach an abundance of 8,000 adults. Given an average of 25 years for Kootenai sturgeon to reach sexual maturity, the model also estimated the amount of juvenile production that would be needed to indicate that the population is on the path to meeting the recruitment target. The model showed that over a 10-year period, the population would need to produce an annual average of 700 age-3 juveniles in order to meet this abundance target in 50 years (Figure 5). Therefore, an annual average of 700 wild age-3 juveniles over 10 years would indicate that the population is on the path to being self-sustaining and resilient. Naturally-produced juveniles reaching sexual maturity and adding a minimum annual average of 250 recruits to the population over 10 years, while also including a minimum of 10,000 wild juveniles would then indicate that the population has become self-sustaining and resilient.

Standardized annual monitoring will provide the needed information on population trends to evaluate progress toward recovery and identify opportunities for adaptive management as new information is discovered. The resulting data will also be used to periodically reevaluate trends of recruitment to determine the rate of change in Kootenai sturgeon population metrics such as survival, abundance, capture efficiency, and carrying capacity.

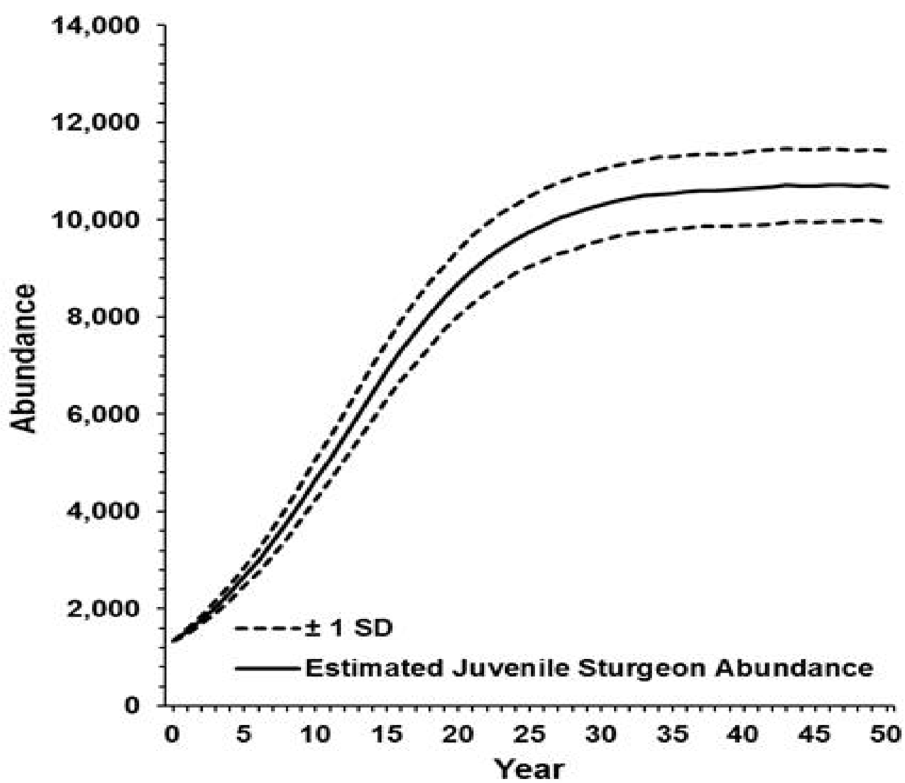

Figure 5. Estimated abundance of juvenile sturgeon over time to reach the abundance target of 8,000 adults in 50 years (year zero corresponds to commencement of recruitment).

RECOVERY ACTIONS

This draft revised recovery plan identifies broad actions needed to implement the recovery strategy and attain the recovery criteria. Implementation of an action will depend on its priority and logistical constraints of its complexity. A broad action may have multiple components developed as needed to best coordinate recovery implementation. In the future, these broad actions will be further refined into activities (collectively referred to as the Recovery Implementation Strategy) in coordination with the recovery partners interested and willing to work on implementing the activities. Activities are intended to be adaptable and guide recovery partners to coordinate recovery implementation and further describe those responsible for each action described in the plan. Because these activities will be described in working documents, they can be modified as needed without requiring future revision of the recovery plan, so long as they are consistent with the recovery plan.

As discussed in the Introduction, implementation of this draft revised recovery plan is voluntary and depends on the cooperation and commitment of numerous partners in this conservation effort. It is also important to note that all Federal agencies have obligations under Section 7(a)(1) of the ESA to implement conservation and recovery actions.

The actions needed to alleviate threats to the species and achieve recovery criteria are organized below into five categories: 1) conservation aquaculture; 2) flow and temperature management; 3) nutrient addition; 4) restore and enhance habitat; 5) research, monitoring, and evaluation; and 6) public outreach

1.0 Conservation Aquaculture

1.1 <u>Continue conservation aquaculture program</u>

As discussed in the Recovery Vision and Strategy section above, current natural recruitment levels cannot sustain the population to pre-dam population estimates of 8,000 adults, further suggesting that high levels of mortality are occurring during early life stages. As such, recruitment failure continues to be a major threat to population persistence and recovery (Anders *et al*. 2014, 2016).

In order to address recovery and fill the demographic and genetic gaps left by limited natural reproduction, hatchery-origin Kootenai Sturgeon have been spawned from wild broodstock and released into the Kootenai River (throughout the range of Kootenai sturgeon) annually beginning in 1992. Since 1992, the Kootenai Tribe's Kootenai Sturgeon aquaculture program has released over 284,000 hatchery-origin juvenile Kootenai sturgeon into the Kootenai River basin. During 1995–2014, 2,000– 40,000 juveniles ranging from age-0 to age-4 (mainly age-1) were released annually. Year classes were genetically represented by as many as 18 families ("family" = 1 female crossed with 1 male) until 2015 when the addition of the Twin Rivers Hatchery allowed for an increase to 30 families per year class.

Releases from 1992 to 1994 were largely experimental and constituted small year classes of variable ages and size. From 1999-2003, the addition of a second hatchery facility allowed annual releases to increase approximately 10,000 age-1 and age-2 juveniles. From 2004 to 2006, sturgeon managers focused on releasing a high number of smaller, age-0 and age-1 juveniles in order to maximize genetic diversity. Average annual releases increased to approximately 34,000 juveniles with a mean weight of only 0.35 ounces. Then beginning in 2007, the focus returned to the strategy similar to 1999-2003 (average annual releases of approximately 12,500 age-1 juveniles).

There have been multiple estimates of post-release survival rates of hatchery-origin Kootenai sturgeon. Ireland *et al*. (2002) estimated that hatchery juvenile Kootenai sturgeon survived at high rates after release, with 60 percent survival the first year after release and 90 percent the following years. Later analyses showed that hatchery origin Kootenai sturgeon released at smaller sizes survived at significantly lower rates than those released at larger sizes (Justice *et al*. 2009; Beamesderfer *et al*. 2014a; Dinsmore *et al*. 2015). In response, sturgeon managers recommended that hatchery origin Kootenai sturgeon released at age-1 be released when they are greater than approximately 10 inches fork length. Dinsmore *et al*. (2015) concluded that estimates of age-1 post-release survival have "declined dramatically since the early 1990s" (from 88 percent to less than 13 percent), but annual post-release survival at age-2 and older has been higher (64-95 percent for previously released age-2 fish, and over 92 percent for age-3+) and shows no evidence of decline. Additionally, Dinsmore *et al*. (2015) found that survival rates of fish released during the spring were 40 percent greater than those released in summer.

Recent genetic survey data indicate that differential post-release survival between family groups has affected the representation of wild alleles in the hatchery-origin population (Schreier *et al*. 2015). As discussed above, aquaculture strategies have varied over the history of the program, resulting in differential post-release survival among families. Nevertheless, the data indicate that in 2002-2009 brood years, approximately 70-80 percent of wild alleles were represented in surviving hatchery-origin juveniles (A. Schreier, pers. comm.).

These results, in addition to the continued low level of natural in-river recruitment among Kootenai sturgeon, make it clear that continuing the conservation aquaculture program is vital to the recovery of the species.

1.2 Continue to adaptively manage conservation aquaculture program

Continue to utilize monitoring data (from Action 5.1 below) to guide and refine implementation of the conservation aquaculture program in an adaptive management framework. The current program uses a rearing strategy based upon 25 years of monitoring, research, and evaluation; and will continue to adapt as necessary depending on future results.

The Kootenai Tribe's Sturgeon Conservation Program Annual Program Review provides an ongoing venue to determine the use and the specific biological targets of the conservation aquaculture program. Decisions are based upon the most up to date science, hatchery functions/capabilities, and input from co-managing agencies.

2.0 Flow and Temperature Management: Continue to manage flow and temperature from Libby Dam to benefit Kootenai sturgeon

It is important to note that it is not possible to achieve historical flow and temperature regimes in the Kootenai River due to flood risk management operations at Libby Dam.

To manage flood risk downstream from Libby Dam the USACE manages the dam's outflow so that river stage does not exceed 1,764 feet (mean sea level) at Bonners Ferry, Idaho. Elevation constraints for Kootenay Lake also prevent water managers from allowing flows in the Kootenai River below Libby Dam to approach historic spring flood levels. Thus, it is important to note that it is not possible to fully evaluate the hypothesis that regulated (reduced) peak spring flows and stages at Bonners Ferry are responsible for Kootenai sturgeon reproductive failure.

Sturgeon managers will continue to coordinate annually via the Kootenai River Ecosystem Function Restoration Flow Plan Implementation Protocol (FPIP). The FPIP includes an Technical Team that develops an annual recommendation on the shape, timing, and duration of expenditure of the tiered sturgeon volume, generally during late May into early June. The FPIP team is composed of regional biologists and water managers, and is independent of the Recovery Team, though representation is very similar.

Annual planning for Kootenai sturgeon flow augmentation operations commences with preparation of a draft sturgeon flow recommendation and associated monitoring plan by the Action Agencies (USACE and BPA) and the Service during early spring. The draft flow recommendation and monitoring plans are reviewed by the entire FPIP Technical Team, and then submitted to the FPIP Policy Team for review. Upon Policy Team approval, the plans are submitted to the Service, which prepares a Systems Operation Request (SOR) for Kootenai sturgeon flow augmentation based on the FPIP flow recommendation, and submits it to the USACE via the Technical Management Team (TMT). The SOR is discussed and approved at TMT prior to commencement of flow augmentation. The FPIP Technical Team holds coordination calls regularly prior to, and throughout, the augmentation period.

Managers may also need to consider the effects of climate change on sturgeon operations. As climate change alters hydrologic regimes, reservoir operations (e.g., refill schedules, flood risk management rule curves, and flood operating criteria) may need to be adjusted in order to maintain reliable water deliveries, power generation, support for environmental needs, and flood risk management (UACE *et al*. 2017). Multiple climate model simulations project that annual average surface temperatures will increase approximately 2.2° F by the 2020s and 3.5° F by the mid-21st century, compared to the average for 1970 to 1999 (Mote and Salathé 2010), with the greatest increases occurring in the summer. Predictions regarding precipitation are less certain, but the general expectation is for decreased summer precipitation and increased winter precipitation.

Specific to the Northern Rockies area, predictions are for warmer springs, earlier snowmelt, and hotter, drier summers with longer fire seasons (USACE *et al*. 2017). Together, these scenarios would alter inflow patterns and reservoir/river water temperatures in the region.

Reservoir systems in the Columbia River Basin were designed under the assumption that snowpack would act as an additional reservoir, holding water (in the form of snow) during the cool season and gradually releasing it in the summer months (USACE *et al*. 2017). Similarly, ecosystems in the Columbia River Basin have evolved to exist within specific hydrologic regimes. Climate change impacts to water supplies, runoff patterns, and water demands are likely to stress these systems, which will in turn affect management of the system (USBOR 2016). However, there is uncertainty regarding predictions relative to the precise extent and timing of changes that may occur in the Kootenai basin and the subsequent adjustments and actions that will need to be taken.

3.0 Nutrient Addition: Continue, and possibly expand, nutrient addition projects

Due to the loss of historical floodplains and the trapping of nutrients behind Libby Dam, an experimental river fertilization project implemented by Kootenai Tribe and IDFG began in the Kootenai River just downstream from the Idaho-Montana border in 2005. Additionally, the BCMFLNRORD, BC Hydro, BPA, and the Kootenai Tribe have ongoing programs to fertilize the north and south arms of Kootenay Lake to increase biological productivity and restore native fish populations and nutrient routing through their supporting food webs.

Continuing these nutrient programs will continue to increase overall biological productivity in the Kootenai system (Hoyle *et al*. 2014; Minshall *et al*. 2014), and thereby alleviate the threats to Kootenai sturgeon associated with loss of nutrients and primary productivity.

4.0 Restore and Enhance Habitat

4.1 <u>Increase in-river habitat complexity</u>

Restore and enhance in-river habitat complexity in reaches of the Kootenai River occupied by Kootenai sturgeon, by constructing, creating, or enhancing additional or existing pools, riffles, eddies, islands, side channels, and other in-river features that add to the overall habitat complexity of the river. These actions will provide the necessary diverse habitats that are needed to support all life stages (i.e., migration, occupancy, spawning, incubation, recruitment and early rearing) of Kootenai sturgeon.

4.2 <u>Enhance spawning habitat</u>

Provide adequate rock substrates and increased hydraulic complexity (e.g., velocity, turbulence) in appropriate areas of the straight, braided, and meander reaches of the Kootenai River. Adding these features will facilitate egg attachment and improve the success of embryo incubation, as well as free-embryo and larval rearing.

4.3 Increase pool habitat

Provide additional pool habitat in suitable areas of the river occupied by Kootenai sturgeon via construction of pool-forming structures, pool excavation, construction of islands, and other methods. Increasing pool habitat in these areas supports staging for spawning, holding, and resting, and will facilitate spawning migration to the braided and canyon reaches where rocky substrates, which appear conducive to successful spawning and recruitment, are present.

4.4 Restore and enhance riparian function

Restore riparian vegetation on river banks and islands, both along the Kootenai River in Montana and Idaho, and along tributaries to the Kootenai River. Riparian vegetation provides important components of aquatic habitat such as overhanging bank cover and large woody debris within the river and floodplain, and provides food web support, among other important functions. Riparian vegetation includes cottonwood and conifer forests, shrub complexes and other wetland and upland habitats. Restoration strategies include management actions such as weed control and development of riparian buffers, in addition to active restoration actions such as bioengineering, direct planting and construction of surface features.

4.5 Restore and enhance floodplain, side channel, and tributary connectivity and interaction

Restore and enhance floodplain surfaces that are hydrologically-connected to the main channel, to store sediment and facilitate riparian plant establishment in the Kootenai River. Re-establishment of historical off-channel (floodplain) habitats and side-channel habitat will also provide additional nutrient production and cycling, food production, and nursery habitat areas for various native fish species in the Kootenai River. Construction and reconnection of floodplain surfaces and reconnection of side channels will create diverse habitats adjacent to the river that can be accessed by average peak flows. Long-term, floodplain revegetation will increase roughness, adding a sediment filtering function that will promote sediment storage as part of natural floodplain building processes, as well as increase biological productivity in the Kootenai River system. Restoration or enhancement of tributary connectivity to the mainstem Kootenai River will also provide additional habitat complexity including potential spawning habitat in alluvial fans of tributaries, and contribute to the food web.

5.0 Research, Monitoring Evaluation: Continue research and monitoring of Kootenai sturgeon.

Although each of these identified actions inherently has research, monitoring, and evaluation needs to determine effectiveness, additional research, monitoring, and evaluation of the Kootenai River basin and Kootenai sturgeon has revealed new information vital to recovery efforts. More remains to be discovered about causes of recruitment failure and early life stage behaviors and requirements of Kootenai sturgeon. It is likely that the information gathered will also be vital to future recovery efforts. Further, continued monitoring for wild juvenile Kootenai sturgeon is important as recovery actions continue to be implemented. Should an action prove "successful" and result in a detectable increase in recruitment, it will be crucial to be able to identify the success as quickly as possible in order to link it to a specific recovery action. Research and monitoring will determine if the recovery criteria are being met.

Additionally, due to the reduced abundance of wild adult Kootenai sturgeon, it is imperative that research, monitoring, and evaluation activities minimize harm to the population through sampling, handling, collecting biological samples, and other research, monitoring, and evaluation activities. This is currently addressed via the Service's Section 10 permitting, which ensures that researchers and field crews have proper training and follow established protocols.

6.0 Public Outreach and Education: Continue, and expand where possible, current public outreach efforts

Continuing to expand public and political support for Kootenai sturgeon recovery efforts will be vital to implementing the actions listed in this recovery plan. Without such support, acquiring funding and authorization for implementation of actions will be difficult. Therefore, it is vital to inform the public, elected officials, and others about the status of Kootenai sturgeon and what needs to be accomplished in order to recover the population. Another key aspect of this process is the publishing of research results in peer-reviewed journals, which has helped to disseminate important science-based information.

TIME AND COST ESTIMATES

Presented below is a table of site-specific recovery actions and their estimated time and costs of implementation (Table 2). The time and cost table contains the estimated annual costs for each action. Estimated costs include only project specific contract, staff, or operations costs in excess of base budgets. They do not include budgeted amounts that support ongoing agency staff responsibilities. This draft revised recovery plan does not commit the Service or any partners to carry out a particular recovery action or expend the estimated funds.

Average annual costs described in Table 2 incorporate planning, design, implementation, and research, monitoring, and evaluation associated with specific actions. Adaptive management actions evaluate the implementation of those actions to ensure that management/conservation tools are appropriately and effectively addressing impacts to the species and meeting the objective of this draft revised recovery plan. If the tools are not effective, changes in management should be made and additional planning and scientific research may be necessary.

Table 2. Time, priority, cost, threat(s) addressed, and locations of recovery actions

Recovery Actions	Recovery Action #	Priority[a]	Estimated Average Annual Costs[b]	Threat(s) Addressed	Location
Conservation Aquaculture[c]	1.0	1	$2,200,000	Declining population, demographic structure, loss of genetic variation	Throughout range of Kootenai sturgeon
Flow and Temperature Management	2.0	1	$250,000	Altered hydrograph and thermograph	Libby Dam
Nutrient Addition[d]	3.0	1	$1,700,000	Loss of nutrients, reduction in primary productivity	Kootenay Lake and Kootenai River (Idaho/Montana border)
Restore and Enhance Habitat[e]	4.0	1	$2,000,000 to 7,000,000	Destruction and modification of habitat	Throughout range of Kootenai sturgeon
Population Research, Monitoring, and Evaluation[f]	5.0	2	$450,000	All	Throughout range of Kootenai sturgeon[g]
Public Outreach and Education	6.0	3	$250,000	All	Throughout range of Kootenai sturgeon
TOTAL COST ESTIMATE: $6,850,000 to $11,850,000					

Date of Recovery: Given the longevity and number of years to sexual maturity (15-30) of Kootenai sturgeon, it is difficult to estimate a year by which the population will achieve recovery. Nevertheless, if all actions are fully funded and implemented as outlined, including full cooperation of all partners needed to achieve recovery, then we estimate the earliest that the delisting criterion could be met would be 2058. This date is based on the following: if Kootenai sturgeon began producing an annual average of 700 wild age-3 juveniles in 2018, we would then need to allow 30 years for all of those juveniles to become recruits (i.e., new adults added to the population), and the population would need to sustain that recruitment rate for 10 years.

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December 2018