Priest Rapids Project – FERC P-2114

White Sturgeon Management Plan

License Article 401(a)(11)

Public Utility District No. 2 of Grant County
PO Box 878
Ephrata, WA 98823

April 2009

Executive Summary

The development of hydroelectric power generation facilities within the Columbia River Basin has had negative impacts on white sturgeon (*Acipenser transmontanus*). White sturgeon populations in the middle and upper Columbia River now reside in regulated and impounded reservoirs between dams. All of these populations experience complete or frequent recruitment failures that are likely related to river regulation, flooding of historical critical spawning and rearing habitats, increases in predators due to habitat alteration, introduction of exotic species, and pollution. At present, what limited natural recruitment does occur is likely insufficient to maintain existing population levels.

White sturgeon populations in Priest Rapids and Wanapum reservoirs (collectively referred to as the Priest Rapids Hydroelectric Project [Project]) on the middle Columbia River, were investigated from 1999 to 2002 as part of Grant PUD's Priest Rapids Project relicensing process. This investigation was the first comprehensive study conducted on white sturgeon in the Project area. Results of this study indicated that resident white sturgeon populations are present in both reservoirs. White sturgeon spawning was documented in the tailrace areas of Wanapum Dam (upper boundary of the Priest Rapids reservoir) and Rock Island Dam (upper boundary of Wanapum reservoir) in June and/or July of 2000, 2001, and 2002. Approximately 22% of the white sturgeon sampled in the Wanapum Reservoir were juveniles, suggesting that some level of natural reproduction has occurred, either within the Project area or in adjacent reservoirs.

The Washington Department of Ecology (Ecology) issued a Final Water Quality Certification on April 3, 2007, with modifications filed on March 17, 2008, for the operation of the Priest Rapids Project. Under the 401 Certification (6.2 (5)(b)), Grant PUD is required, in consultation with the Priest Rapids Fish Forum (PRFF), to develop and implement a White Sturgeon Management Plan (WSMP) within one year of issuance of the New License.

The Federal Energy Regulatory Commission (FERC) issued a license for the Project on April 17, 2008 (FERC 2008). Article 401 of the license order requires that Grant PUD file a White Sturgeon Management Plan within 1 year of license issuance. In addition, Article 401 requires the WSMP be submitted to the Commission for approval prior to plan implementation.

Specific Biological Objectives in the WSMP include the following;

1) Spawning and rearing in Project area: Natural reproduction potential reached via natural recruitment.
2) Spawning, rearing, and harvest in Project reservoirs: Increase the white sturgeon population in the Project reservoirs to a level commensurate with available habitat.
3) Adult and juvenile upstream and downstream migration: Provide safe, effective, and timely volitional passage, if reasonable and feasible passage means are developed.
4) Until reasonable and feasible means for reestablishing natural production and providing support for migration are available, and recognizing that those means appear unlikely in the foreseeable future, the Biological Objective is to sustain a population at a level commensurate with available habitat through implementation of a white sturgeon supplementation program in the Project reservoirs. The supplementation program will provide an initial foundation for the Monitoring and Evaluation (M&E) Program, which is designed to a) identify existing impediments to achieving the Biological Objectives, b)

sustain the populations until the existing impediments can be corrected, and c) mitigate for population losses due to Project impacts.

5) The goal of the WSMP is to: (1) identify and address Project effects on white sturgeon and, (2) develop and implement "Implementation Measures" designed to avoid and mitigate for Project effects of white sturgeon. Adaptive management shall be applied to resolve critical uncertainties. In addition, the following tasks consistent with achieving the Biological Objectives incorporated into the WSMP are:

   Task 1 Determine the effectiveness of the supplementation program in creating a sustainable white sturgeon population in the Project reservoirs based on natural production potential and adjust the supplementation program accordingly.

   Task 2 Determine the carrying capacity of available white sturgeon habitat in each reservoir.

   Task 3 Participate and cooperate in the development of any regional white sturgeon management effort initiated for the purpose of addressing flow fluctuation effects on the Hanford Reach white sturgeon population as a result of Project operations. If questions arise as to the appropriate level of participation and cooperation, Grant PUD shall request clarification from Ecology.

   Task 4 Determine juvenile downstream passage rates and survival.

By March 31, following issuance of the New License, and each year thereafter for the term of the New License, Grant PUD is required to provide an annual report summarizing activities undertaken to identify and address impacts of the Project to white sturgeon, including results of those activities. This report shall include a compilation of information on other white sturgeon supplementation programs in the Columbia River Basin in order to assess whether the supplementation program being implemented at the Project is: (i) consistent with other supplementation programs in the region; (ii) cost effective to implement at the Project; and (iii) whether improvements can be made which are appropriate to implement at the Project.

As outlined in Section 3, the WSMP identifies the following Protection, Mitigation, and Enhancement measures (PMEs) to be implemented by Grant PUD:

1) Prepare a brood stock collection and breeding plan within year one of the effective date of the New License and, if feasible, begin brood stock collection in year two of the New License.
2) Implement a white sturgeon supplementation program by releasing up to 5,000 yearling white sturgeon into the Wanapum reservoir each year and 1,500 yearling white sturgeon into the Priest Rapids reservoir annually for Years 3 through 7 of the program, with subsequent annual release levels to be determined by the PRFF, based on monitoring results.
3) Design and implement a long-term juvenile index monitoring program over the term of the New License to monitor age-class structure, survival rates, growth rates, distribution, and habitat selection of juvenile sturgeon.
4) As part of the supplementation program, conduct tracking surveys of juvenile white sturgeon released with active tags to determine emigration rates and passage survival from the Priest Rapids Project area.

5) Compile information on other white sturgeon supplementation programs in the region.
6) Use the information collected above to direct and modify the supplementation program strategy.

Table of Contents

List of Figures

List of Tables

List of Appendices

List of Abbreviations

BPA	Bonneville Power Administration
CRITFC	Columbia River Inter-Tribal Fish Commission
FERC	Federal Energy Regulatory Commission
Ecology	Washington Department of Ecology
FL	fork length
Grant PUD	Public Utility District No. 2 of Grant County
IDFG	Idaho Fish and Game
KSH	Kootnay Sturgeon Hatchery
KTH	Kootenai Trout Hatchery
KTOI	Kootenai Tribe of Idaho
KTOIH	Kootenai Tribe of Idaho Hatchery
LBV	Little Benthic Vehicle
M&E	Monitoring and Evaluation
PI	polarization index
PIT-tag	Passive Integrated Transponder Tag
PMEs	Protection, Mitigation and Enhancement measures
Project	Priest Rapids Project
PRPA	Priest Rapids Project Area
RM	river mile
SARA	Canadian Species At Risk
TL	total length
WDFW	Washington Department of Fish and Wildlife
WSMP	White Sturgeon Management Plan
WSTG	White Sturgeon Technical Group

UCWSRI	Upper Columbia White Sturgeon Recovery Initiative
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
YOY	young of the year

PART A: BACKGROUND AND PLAN DEVELOPMENT

1.0 Plan Development and Consultation

On February 4, 2009, Public Utility District No. 2 of Grant County (Grant PUD) submitted a draft White Sturgeon Management Plan (WSMP) to the U.S. Fish and Wildlife Service (USFWS), Washington Department of Fish and Wildlife (WDFW), Wanapum, Yakama Nation, Colville Confederated Tribes, Confederated Tribes of Umatilla, Columbia River Inter-Tribal Fisheries Commission (CRITFC), Bureau of Indian Affairs, and Washington Department of Ecology (Ecology) for 60-day comment/review. Comments on the plan from these entities were discussed prior to and during the April 1, 2009 Priest Rapids Fish Forum (PRFF) meeting (see meeting minutes, Appendix C). All PRFF voting members approved the WSMP on April 1, 2009, except USFWS which gave their approval via email on April 6, 2009.

A total of six comment letters and/or emails were received (Appendix B). Comments were received from the USFWS, WDFW, Yakama Nation, CRITFC, and the Wanapum. A summary of Grant PUD's responses are included in Appendix D.

2.0 Background

White sturgeon are the largest freshwater fish in North America. They occur throughout the U.S. portion of the Columbia River and in many of its larger tributaries. Historically, white sturgeon moved throughout the mainstem Columbia River from the estuary to the headwaters, although passage was probably limited at times by large rapids and falls (Brannon and Setter 1992).

Dam construction has created what biologists believe to be "isolated" populations of white sturgeon. Beginning in the 1930s, with construction of Rock Island, Grand Coulee, and Bonneville dams, migration was disrupted because white sturgeon generally do not pass upstream through fish ways built for salmon, although they do pass downstream through dams (Lepla et al. 2001). Current populations in the Columbia River Basin can be divided into three groups: fish below the Bonneville Dam with access to the ocean; fish isolated functionally, but not genetically, between dams; and fish in several large tributaries. However, the population dynamics and factors regulating production of white sturgeon within these isolated populations are poorly understood.

2.1 White Sturgeon Management Plans in the Columbia Basin

Management programs to protect white sturgeon in the Kootenai River and the upper Columbia River are on-going and provide a relevant framework for white sturgeon management programs in the Priest Rapids and Wanapum reservoirs. These recovery programs were initiated to protect and restore white sturgeon populations before they became extinct (i.e., Kootenai population) or were extirpated (i.e., Upper Columbia population). While detailed information about the white sturgeon population in the Project area exists, these other programs have provided important information that helped shape this WSMP. Relevant information on these programs is provided in the following sections.

Immediately upstream of the Priest Rapids Project, both Chelan County PUD and Douglas County PUD are also preparing to implement long-tem white sturgeon programs to mitigate for Project affects of the Rocky Reach and Wells hydroelectric projects, respectively. Immediately below the Priest Rapids Project significant enhancements to White sturgeon management and populations are now being developed as mitigation by Bonneville Power Administration for affects due to the operation of the Federal hydroelectric projects. Grant PUD recognizes the unique role of the Washington Department of Fish and Wildlife (WDFW) and the Confederated Tribes and Bands of the Yakama Nation as the co-managing fisheries agencies responsible for coordinating all of these various activities and is working closely with these agencies to ensure its White sturgeon mitigation program (both production and monitoring and evaluation) will be consistent and complementary with these other regional efforts.

2.1.1 Kootenai River White Sturgeon Recovery

Studies in the late 1970s and early 1980s confirmed that white sturgeon in the Kootenai River in Idaho (spelled Kootenay in Canada) had decreased in abundance compared to data collected in the previous two decades (Partridge 1983). Of greater concern, however, was the relative absence of younger age-classes. In the early 1980s, fisheries management staff in British Columbia began documenting an apparent reduction in adult white sturgeon abundance, as well as a reduction in the numbers of young fish. A detailed monitoring program was instituted in the early 1990s by Idaho Department of Fish and Game (IDFG) to provide further empirical information about the status of this species (Apperson and Anders 1991). With funding from IDFG, the BC Ministry of Environment also started a comparable monitoring program in 1989 in the Canadian portion of the Kootenay River, as well as in Kootenay Lake.

By the mid to late 1980s, it was obvious that the near total recruitment failure of what is termed the “Kootenai White Sturgeon” stock (which includes the British Columbia portion of the drainage, i.e., the lower Kootenay River above Kootenay Lake, Kootenay Lake and the Kootenay River downstream of Nelson to Bonnington Falls) required aggressive intervention to ensure this species did not disappear (USFWS 1999). A pilot hatchery was designed and constructed near Bonners Ferry, Idaho, in 1991 with funding provided by the Bonneville Power Administration (BPA). This mini-hatchery was run by the Kootenai Tribe of Idaho (KTOI), with technical direction provided by the IDFG.

In 1994, the U.S. Fish and Wildlife Service (USFWS) listed the Kootenai stock of white sturgeon as endangered, which introduced a higher level of management and control by various authorities in the drainage and region. A recovery team was established to provide technical direction regarding the numbers of fish produced at the hatchery, release numbers, and breeding (to address genetic introgression issues). A final “Kootenai White Sturgeon Recovery Plan,” which had undergone public and agency review in both the U.S. and Canada, was signed by the USFWS in 1999.

A major habitat restoration focus of the Kootenai White Sturgeon Recovery Plan has been to increase the extent and duration of spring freshet flows in the Kootenai River. Essentially, this is provided through releases from the U.S. Army Corps of Engineer’s Libby Dam in Montana. To date, the results of these increased flows have been inconclusive; i.e., there is as yet no indication that high flows during the spring translates into increased survival of white sturgeon eggs and/or fry. This assessment must be tempered, however, because of the difficulties of sampling young-of-the-year (YOY) white sturgeon fry. At present, white sturgeon must be a minimum of one to two years of age before they can be captured adequately by standard sampling gear. As a consequence, it is difficult to assess the relationship between flows and recruitment. Another habitat manipulation that has recently been attempted is the addition of suitable spawning substrate (boulders and cobbles) into the river near known spawning locations in an attempt to provide suitable spawning substrate. The results of this program are still being assessed. Other options being investigated include major river training works and/or increases in Kootenay Lake levels to increase the river thalweg depth through a shallow braided channel area to provide better upstream passage conditions that will allow spawners to access more suitable spawning habitats in upstream reaches of the river.

The Kootenai Tribe of Idaho Hatchery (KTOIH), which experienced significant challenges during the early years of its operation, now produces high-quality juvenile white sturgeon for a directed stocking program (KTOI 2007). In addition, there is a fail-safe hatchery for Kootenai sturgeon at the Kootenay Trout Hatchery (KTH) at Wardner, B.C. Every year, half of all the fertilized eggs produced at the KTOIH are transported to the KTH in case either facility should experience a major problem with egg and/or fry survival.

One of the ongoing issues regarding the Kootenai White Sturgeon Recovery Plan is potential genetic swamping of the “wild” sturgeon by those produced and stocked from the hatchery. A breeding plan was developed in the mid-1980s that focused on determining an appropriate method of breeding fish to maximize the genetic diversity of hatchery-produced fish (Kincaid 1993). This approach involved the production of full or half-sibling families and separate rearing of each family so that family contributions could be equalized. The approach was based on conservative estimates of survival, distribution, sexual maturity, and availability of breeding fish. Some of these assumptions have since been judged as either erroneous or overly conservative, based on recent genetic guidelines in the scientific literature that recommend the use of factorial, or partial factorial mating rather than simple paired mating in order to maximize effective spawning population size in conservation aquaculture programs (Fiumera et al. 2004; Dupont-Busack; Knudsen 2007). As a consequence, the breeding plan for the Kootenai White Sturgeon Recovery Plan was rewritten to incorporate the newest and best available data (KTOI 2004). The new plan has two main goals, which are 1) to preserve the locally adapted Kootenai River white sturgeon genotypes, phenotypes, and associated life history traits; and 2) to restore age-class structure to maximize future population viability and persistence. The plan incorporates an Adaptive Management approach (Walters 1997) and will be modified as necessary, following collection and analysis of the most recent and most complete empirical datasets.

Another major uncertainty in the Kootenai White Sturgeon Recovery Plan implementation centers on stocking rates and fish size at release. In the absence of empirical data or, at minimum acceptable bio-standards, these uncertainties are difficult to resolve since “historical” levels of white sturgeon abundance and recruitment in the river and the lake are unknown. Changes to the Kootenai River ecosystem from regulation by Libby Dam further complicate this problem. To date, the approach has been to annually revisit the stocking number and fish size issue based on the most up-to-date information on juvenile survival and growth rates. Recent examinations of stocking levels and size-at-release strongly suggest there is density and size dependant mortality effects on hatchery reared juvenile white sturgeon (Casey et al, in press). This has led to a recommendation to implement management actions that prioritize the release of fewer, larger size fish to improve first year survival rates and subsequent recruitment to the spawning-age population. This type of adaptive management approach also incorporates new information on natural spawning success collected during annual monitoring programs.

2.1.2 Upper Columbia River White Sturgeon Recovery Initiative

White sturgeon populations in the Canadian (upper) portion of the Columbia River between the U.S.-Canada Border and Hugh L. Keenleyside Dam were initially studied in the early 1980s. General fish inventory studies conducted in this area in the early 1990s demonstrated that the size-class distribution of white sturgeon had shifted significantly in the interim from a population dominated by younger white sturgeon (less than 1.0 m total length (TL)) in the 1980s to one dominated by adults (greater than 1.5m TL) in the 1990s (Hildebrand et al 1999). Based on this information, the white sturgeon population in the Columbia River in Canada was listed by the B.C. Conservation Data Centre as endangered in 1996, and the fishery for this species (recreational and guided) was closed. Subsequent studies of the white sturgeon population that resides in the Columbia River between Hugh L. Keenleyside Dam and Grand Coulee Dam (the Transboundary recovery area) have supported the initial assumption that recruitment to this trans-boundary population is extremely limited and the remaining population is aging and declining in abundance.

Due to conservation concerns about upper Columbia white sturgeon, and in response to the provincial listing of the upper Columbia River white sturgeon population and the new Species at Risk Act (SARA) being drafted at that time by the Canadian federal government, a decision was made by Canadian organizations in 1996 to develop a recovery plan. The process was built upon a Canadian Columbia River white sturgeon stock stabilization report (Hildebrand and Birch 1996) that was based on the Kootenai River White Sturgeon Recovery Plan.

A common commitment to a recovery program was formalized by the Department of Fisheries and Oceans Canada, B.C. Environment, B.C. Fisheries, and BC Hydro in an August 17, 2000 Letter of Understanding. The letter outlined the approach for recovery planning and described agreements on funding for the development and delivery of a recovery strategy. The agreement also defined a process for engaging First Nations and stakeholders (interested parties) in recovery planning in order to build understanding and support for the plan and to explore possible sources of funding for full implementation of the plan. Since this trans-boundary stock was not listed (and presently remains unlisted) under the U.S. Endangered Species Act, the recovery of this population required the effective inter-jurisdictional coordination of Canadian and U.S. recovery efforts. This process led to active U.S. participation by the Spokane Tribe, Colville Confederated Tribes, USFWS, BPA, and the State of Washington.

In 2002, a bi-national technical Recovery Team, termed the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI), finalized the Upper Columbia White Sturgeon Recovery Plan (UCWSRI 2002). This plan was a cooperative effort that involved Canadian and U.S. governmental, aboriginal, industrial, and environmental organizations, as well as individual citizens. Plan development also involved an Action Planning Group, with representation by the Province, Department of Fisheries and Oceans Canada, regional governments, First Nations, members of the public, environmental and industrial stakeholders, and U.S. regulatory and tribal agencies. A recovery team consisting of technical representatives from federal, provincial, and state resource management agencies and from Canadian and U.S. tribes directs the recovery program. In August 2006, white sturgeon in the Canadian portion of the Columbia River were listed as endangered by the Canadian SARA.

Owing to the near total recruitment failure in the last two decades, a decision was made early in the recovery planning process to move immediately to development of a hatchery program to produce juvenile sturgeon for stocking into the Transboundary Reach of the Columbia River, which is the primary recovery area located between Hugh L. Keenleyside Dam and Grand Coulee Dam. Using the Kincaid (1993) breeding plan developed for the Kootenai sturgeon program as a model, a breeding plan was developed for upper Columbia sturgeon. Originally housed at the Hill Creek Hatchery at the upper end of the upper Arrow Lakes Reservoir, the rearing of all fish now occurs at the KTH (owing to operating efficiencies, staffing, and reliability of water supply).

A multi-component monitoring program is ongoing for the upper Columbia population (on both sides of the international border). A primary component is a juvenile index monitoring program to assess growth, survival, health, distribution, and relative abundance of released juveniles, as well as, document natural recruitment that may occur. The information collected by this program is essential to monitor the success of the hatchery stocking program. The information collected to date has provided valuable information on growth and survival rates of hatchery released juveniles, and this information was recently used as the basis to substantially reduce stocking rates in the Transboundary Recovery area (UCWSRI 2008). Annual Canadian trans-boundary release targets of yearlings were reduced from 12,000 to 4,000 while the annual U.S. trans-boundary releases of 4,000 yearlings were maintained. Trans-boundary releases of sub-yearlings after 2008 (2008 brood) was discontinued. To the extent practical, the size at release of sub-yearlings was increased by utilizing increased rearing flexibility provided by changes in release numbers and family rearing strategies. These release number targets will be adopted for the next 3-5 years (2008-2012 broods).

Additional information collected from other monitoring activities of the Columbia and Kootenai recovery programs have resulted in the following major changes to the Upper White Sturgeon Recovery Initiative's Recovery Plan:

1) Investigations on spawner movements and subsequent egg and larval sampling have led to the identification of two additional spawning areas in the Transboundary Reach, one in Canada and one in the United States.
2) Re-examination of the available population data has suggested 3000 adults as a reasonable population recovery target for combined natural and hatchery production of adults in the Transboundary Reach. This figure is based on the abundance of adults in 2003 at the time of initial COSEWIC listing as endangered.
3) Revision of the breeding plan. In 2009, the plan will call for the adoption of a partial factorial mating strategy where multiple half-sib families are created by crosses of multiple females and multiple males. In addition, mixed family rearing will be implemented to increase flexibility to bring all fish to comparable sizes for release and to reduce the potential for non-random hatchery selection.

Expansion of the recovery program to a second recovery area (Arrow Lakes Reach between Hugh L. Keenleyside Dam and Revelstoke Dam). In 2007 and 2008, 4000 and 6000 juvenile white sturgeon (age-8 months) respectively, were released into the upper end of the reach to assess the suitability of the area to support juveniles. In 2009, sturgeon larvae (immediately post-hatch) will be released into the area.

2.2 Status and Information Needs for the Priest Rapids and Wanapum Reservoirs

As part of the relicensing process, the Resident Fish Solution Group determined that Grant PUD should conduct intensive studies on white sturgeon populations in the two impoundments (Wanapum and Priest Rapids reservoirs) that comprise the Project.

2.3 Studies and Evaluation of Project Effects

Grant PUD contracted Golder Associates Ltd. (formerly R.L. & L. Environmental Services Ltd.) to conduct research to determine the abundance, distribution, population dynamics, and biophysical attributes of preferred habitat, seasonal movement patterns, and spawning characteristics of white sturgeon. This information has been used to assess the effects of the Project on white sturgeon populations in both Priest Rapids and Wanapum reservoirs.

2.4 Relicensing Studies

White sturgeon populations in Priest Rapids and Wanapum reservoirs, on the middle Columbia River, were investigated from 2000 to 2002 as part of Grant PUD's Priest Rapids Hydroelectric Project relicencing process. This investigation was the first comprehensive study that has been conducted on white sturgeon in the Project area to date.

A relatively small population of white sturgeon (lower estimated limit of 143 individuals), made up of older adults, was present in the Priest Rapids reservoir. Based on set line capture and sonic tag movement information, white sturgeon were distributed throughout the reservoir, with concentrations near Goose Island (river mile [RM] 398), Desert Aire (RM 401), Lake Geneva (RM 404), Lower Crab Creek (RM 409), and below Wanapum Dam (RM 415). Priest Rapids reservoir contained suitable habitats for white sturgeon feeding, spawning, and rearing (Batelle, unpublished data, 2001).

During set line capture programs conducted in 2000 and 2001 in the Priest Rapids reservoir, white sturgeon ranged from 161 to 299 cm in fork length (FL), and from 31 to 103 kg in weight. Length-frequency distributions of white sturgeon exhibited very minor differences between study years. Surgical examination of captured individuals indicate the population was dominated by females (approximately 2:1), mostly in pre- or late-vitellogenic maturation stages. Captured white sturgeon in the Priest Rapids reservoir ranged from age 16 to 42. One fish (unknown sex and maturity) was recaptured during the present study, and exhibited an increase in growth of approximately 2.5 cm per year.

In the Priest Rapids reservoir, 11 white sturgeon (one non-reproductive female, four pre-vitellogenic females, three late vitellogenic females, and three early reproductive males) were implanted with sonic transmitters during the fall of 2000 and 2001. Movement information collected by boat-based surveys and remote telemetry stations indicated that sonic-tagged white sturgeon were relatively inactive from October to early April, and usually remained in one of four overwinter areas identified during the present study. One early reproductive male was observed to move between two overwinter areas, most likely in response to changes in water temperature or food supply. Preliminary observations made on two mature females implanted with temperature and depth sensors indicate that diurnal movements may occur. However, these trends were not well developed (based on less than 10 days of information), and varied substantially between fish. During the spawning period, tagged mature white sturgeon moved upstream to the tailrace of Wanapum Dam between April and June, and most likely remained until August. The exact residence time for these fish was difficult to ascertain, since tag detection was sporadic due to high background noise levels produced by turbine and spill events during this period.

Spawning was detected in the Priest Rapids reservoir, below Wanapum Dam, during all three years of study. Newly spawned white sturgeon eggs were collected when water temperatures below Wanapum Dam were within suitable ranges for optimal development. Preliminary information indicated that larvae incubated *in situ* also hatched within the time required for normal embryo development. Spawning habitats below Wanapum Dam were similar to other white sturgeon habitats throughout the Columbia River. The estimated number of spawning events and the egg catch-rates were highest in 2002 (i.e., three events; 0.10 eggs/mat-day), followed by 2000 (i.e., two events; 0.05 eggs/mat-day), and 2001 (i.e., one event; 0.01 eggs/mat-day). The variability in the number of spawning events and egg catch-rates may be related to differences in discharge between years; 2001 was the second lowest discharge event recorded since the early 1960s.

The population of white sturgeon (estimated between 398 and 881 individuals) in the Wanapum reservoir contained both young and mature individuals. Approximately 20% of the total catch was composed of juvenile fish, an indication that this population either experiences natural recruitment or receives recruitment from upstream populations. Based on set-line capture and sonic-tag movement information, white sturgeon were distributed throughout the flowing portion of the reservoir upstream of Vantage Bridge (RM 421) to the Rock Island Dam tailrace (RM 452). Wanapum reservoir contained areas suitable for feeding, spawning, and rearing; these areas were similar to habitats observed in reservoirs throughout the Columbia River and on the Snake River. Spawning velocities were found to be slightly lower than those observed in the Priest Rapids reservoir below Wanapum Dam, but were within optimal spawning velocities established for white sturgeon during wet water years as calculated by a habitat model (Batelle, unpublished data, 2001).

During set-line capture programs conducted in 2000 and 2001 in the Wanapum reservoir, white sturgeon ranged from 50 to 231 cm FL, and 1 to 118 kg in weight. Juvenile/sub-adult fish were present in the sampled population. Length-frequency distributions of white sturgeon did not vary between study years. Surgical examination of captured individuals indicated that equal proportions of males and females were present in Wanapum reservoir. These fish were of varying sex and maturation stages. Captured white sturgeon in Wanapum reservoir ranged from age-4 to age-37, however intermediate aged fish were not well represented in the sampled population. The six fish were recaptured during the present study exhibited an average increase in growth of approximately 6.8 cm per year.

In the Wanapum reservoir, 31 white sturgeon (five non-reproductive females, three pre-vitellogenic females, four early vitellogenic females, six late vitellogenic females, one ripe female, three non-reproductive males, two maturing males, two early reproductive males, three late reproductive males, one juvenile/subadult, and one of unknown sex and maturation stage) were implanted with sonic transmitters during capture sessions conducted in the spring and fall of each year. Movement information collected by boat-based surveys and remote telemetry stations indicated that sonic-tagged white sturgeon were relatively inactive from September to May, and usually remained in one of four overwinter areas identified during the present study. Columbia Cliffs was identified as a very important overwinter area during the present study, based on the large proportion of sonic-tagged fish at-large that resided at this location during this period. Some fish moved between overwintering areas over the winter period. In October and November, a few white sturgeon moved from the main overwinter area at Columbia Cliffs to a feeding area located near Whiskey Dick Creek, likely to take advantage of the fall Chinook salmon that migrate during this time. One mature female that was implanted with a temperature and depth sensor (i.e., CHAT tag), moved into both deep and shallow habitats during the overwinter period, but these movements were not diurnal in nature. During the spawning period, mature white sturgeon moved upstream to the tailrace of Rock Island Dam in Wanapum reservoir in early June, and most remained in this general area until late July.

Short-term observations made on white sturgeon implanted with temperature and depth sensors indicated that one mature female moved into deep and shallow areas during the spawning period. These variations in depth were diurnal in nature and were more variable during the spawning season compared to the end of the overwinter period. Observations from another mature female also indicated that this fish was located in depths that were, on average, 10 m shallower during the early spawning season compared to the overwinter period.

Spawning was detected in the Wanapum reservoir, below Rock Island Dam, during all three years of study. Newly spawned white sturgeon eggs were collected when water temperatures below Rock Island Dam were within suitable ranges for optimal development. Preliminary information indicated that larvae incubated *in situ* also hatched within the time required for normal embryo development. Spawning habitats below Rock Island Dam were similar to other white sturgeon habitats throughout the Columbia River, with the exception of slightly lower water velocity during dry and normal water years as calculated by the habitat model (Batelle, unpublished data, 2001). The number of spawning events and egg catch-rates was highest in 2002 (i.e., seven events; 1.78 eggs/mat-day), followed by 2000 (i.e., five events; 0.06 eggs/mat-day), and 2001 (i.e., one event; 0.02 eggs/mat-day). The variability in the number of spawning events and egg catch-rates may be related to differences in discharge between years; 2001 was the second lowest discharge event recorded since the early 1960s.

2.4.1 Population Characteristics

Using the Schnabel population estimation method (Krebs 1989), the white sturgeon population in the Priest Rapids reservoir was estimated at approximately 134 fish, with a 95% confidence interval of 48 to 2680 fish. The confidence in this estimate is low due to the small number of fish marked and recaptured (n=1) in the Priest Rapids reservoir. The number of fish recaptured in the Priest Rapids reservoir was below the minimum number required to derive a population estimate using this technique.

The BayesPop™ program and the data were used to derive an alternate population estimate for the Priest Rapids reservoir. The lower bound was set to the number of newly marked individuals, the upper bound was set to the hypothesized maximum population (approximately 3000 for the

Priest Rapids reservoir), and the number of intervals was set to 901. Using this method, the estimated population of white sturgeon in the Priest Rapids reservoir was approximately 1161, with a 95% confidence interval of 143 to 4746 fish. The use of this method enabled an adequate minimum population estimate (i.e., lower 95% confidence interval) to be determined, however the estimated mean and upper bounds of the populations was not considered dependable because of the low number of recaptured fish observed during the study.

In the Wanapum reservoir, the white sturgeon population was estimated at approximately 551 fish, with a 95% confidence interval of 314 to 1460 fish. This estimate is considered preliminary since the sample size (*n*=9) is near the minimum required to derive a population estimate using the Schnabel technique. The estimated population, using the BayesPop™ (upper bound set to 5000 fish) was approximately 817, with a 95% confidence interval of 398 to 1711 fish.

2.4.2 Sex Ratio and Reproductive Potential

Sex ratio for white sturgeon captured in the Priest Rapids reservoir was 0.5:1 (6 males: 11 females) during the combined 2000 to 2001 study. Sex and maturation was not determined in 1999.

The maturation stages of the 21 white sturgeon captured in the Priest Rapids reservoir (2000 to 2001) were: seven pre-vitellogenic females; three late-vitellogenic females; five maturing males; and one late reproductive male. The sex and maturation stage of three adult fish could not be determined during surgical examination; one other fish escaped prior to being examined. Attritic oocytes were observed in the ovaries of two of the eight pre-vitellogenic white sturgeon; these two fish were captured in September 2001, which indicated that they would have been capable of spawning during the 2001 season.

The average age of pre-spawning female white sturgeon was 23 years (193.8 cm FL) and ranged from 19 to 29 years. Females not in pre-spawning condition were between age 22 and 26 (between 173.3 and 192.8 cm FL) and ranged from 18 to 28 years. The average age of females that were identified as post-spawners, by the presence of attritic oocytes, were age 24 (241.5 cm FL) and ranged from 23 to 25 years. The age of the one pre-spawning male white sturgeon was 23 years (216.0 cm FL). The average age of early reproductive males was 25 years (195.4 cm) and ranged from 16 to 42 years.

Sex ratio of white sturgeon in the Wanapum reservoir was approximately 1:1 (36 males: 35 females) during the combined 2000 to 2001 study. The maturation stages of the 95 white sturgeon captured in the Wanapum reservoir (including the fish released from the Abernathy Fish Culture Centre) during 2000 and 2001 were: 11 non-reproductive females; six pre-vitellogenic females; ten early vitellogenic females; seven late vitellogenic females; one ripe female; three females of unknown maturity (i.e., recaptured fish that were not re-examined); one non-reproductive male; 12 maturing males; 12 early reproductive males; 11 late reproductive males; and 19 juveniles. The sex and maturation of two adult fish could not be determined because excessive fluid in their body cavities obstructed the view of the gonads. Three juveniles (not included in the list above) were captured during the Grant PUD 1999 study. Attritic oocytes were observed in the ovaries of three of the six pre-vitellogenic white sturgeon; two fish were captured in early October 2000, and one fish was captured in early October 2001. The presence of attritic oocytes indicated these fish were capable of spawning during the 2000 and 2001 spawning periods, respectively.

The average age of pre-spawning female white sturgeon was 23 years (205.1 cm FL) and ranged from 18 to 28 years. Females that were not in pre-spawning condition were between age 17 and 25 (between 157.5 and 204.8 cm FL) and ranged from 4 to 37 years. The average age of females that were identified as post-spawners, by the presence of attritic oocytes, were age 24 (241.5 cm FL) and ranged from 19 to 34 years. The average age of pre-spawning male white sturgeon was 21 years (181.0 cm FL) and ranged from 15 to 26 years. Males that were not in pre-spawning condition were between age 19 and 22 (between 173.9 and 176.7 cm FL) and ranged from 7 to 37 years.

2.4.3 Spawning Investigations

In total, 2,347 white sturgeon eggs and five larvae were captured during 215 012.1 mat-hours of sampling in the Project area (2000 to 2002). The majority (*n*=2179) of white sturgeon eggs were caught below Rock Island Dam in the Wanapum reservoir, with the remainder (*n*=168) recorded from the Wanapum Dam tailrace in the Priest Rapids reservoir. The amount of sample effort expended was similar between reservoirs (Wanapum = 119 811 mat-hours; Priest Rapids = 95 201 mat-hours). Higher catch-rates of eggs/larvae were observed in Wanapum (0.44 eggs/mat-day) compared to Priest Rapids (0.04 eggs/mat-day) reservoirs over the duration of the spawning studies (2000 to 2002).

White sturgeon spawning activity was monitored below Wanapum Dam from May 27 to August 5, 2000, May 25 to August 10, 2001, and May 27 to August 1, 2002. In total, 30, 20, and 31 substrate mat sites were placed below Wanapum Dam in 2000, 2001, and 2002, respectively. Water temperatures, measured below Wanapum Dam by Grant PUD hydrolabs set at Beverley Bridge during the duration of the study, ranged from 12.1°C to 18.9°C in the 2000 spawn monitoring period, 12.6°C to 18.9°C in 2001, and 10.8°C to 18.5°C in 2002. Average daily discharge, measured below Wanapum Dam during the 2000, 2001, and 2002 spawning period (May 24 to August 10) was 3,787 m/s, 2,292 m/s, and 5,747 m/s, respectively.

In 2000, 54 white sturgeon eggs and two larvae were captured during 27 967.9 mat-hours of sampling for a catch-rate of 0.05 eggs/mat-day. In 2001, nine white sturgeon eggs were captured during 42 581.6 mat-hours of sampling for a catch-rate of 0.01 eggs/mat-day; white sturgeon larvae were not captured. In 2002, 105 white sturgeon eggs were captured during 24 651.4 mat-hours of sampling for a catch-rate of 0.1 eggs/mat-day; white sturgeon larvae were not captured.

White sturgeon spawning activity was monitored below Rock Island Dam from May 28 to August 4, 2000, May 23 to August 9, 2001, and May 27 to August 1, 2002. In total, 34, 28 and 21 substrate mat sites were placed below Rock Island Dam in 2000, 2001, and 2002, respectively. Water temperatures, measured below Rock Island Dam by Grant PUD thermisters over the duration of the spawn monitoring program, ranged from 11.9°C to 18.7°C in 2000, 11.8°C to 18.5°C in 2001, and 10.7°C to 17.9°C in 2002. Average daily discharge, measured below Rock Island Dam during the 2000, 2001, and 2002 spawn monitoring periods (May 24 to August 10) was 3609 m/s, 2005m/s, 5388 m/s, respectively.

In 2000, 127 white sturgeon eggs and two larvae were captured during 48 706 mat-hours of sampling for a catch-rate of 0.06 eggs/mat-day; note that for calculation purposes, larvae are converted as eggs. In 2001, 29 white sturgeon eggs were captured during 42 582 mat-hours of sampling for a catch-rate of 0.02 eggs/mat-day; white sturgeon larvae were not captured in 2001. In 2002, 2023 white sturgeon eggs and one larvae were captured during 27 301 mat-hours of sampling for a catch-rate of 1.78 eggs/mat-day.

2.4.4 Growth

Ages were determined for 29 white sturgeon from the Priest Rapids reservoir (1999 to 2002). These fish ranged from age-16 to age-42, which represented the 1958 to 1984 year-class range. The majority of white sturgeon captured in the Priest Rapids reservoir were between the 1972 and 1984 year-classes. Fork length was not significantly related to age in the Priest Rapids reservoir, likely because of the small sample size of fish aged (Regression; $r^2 = 0.11$; $p=0.08$)

One recaptured white sturgeon (unknown sex and maturation) from the Priest Rapids reservoir exhibited an incremental growth-rate of approximately 2.5 cm per year. This fish was initially captured in the 1999 Grant PUD fall session and was subsequently recaptured during the 2001 fall session.

Ages were determined from 104 white sturgeon from the Wanapum reservoir. For comparative purposes and to allow grouping of the samples aged in each year of the study, ages were standardized to year of birth (year-class). The 21 fish that were less than 100 cm FL were from the 1992 to 1997 year-classes. The ninety-five fish over 100 cm FL were from the 1964 to 1990 year-classes. The majority of white sturgeon captured in the Wanapum reservoir were from the 1975 to 1984 year-classes. Fork length was significantly related to age in the Wanapum reservoir (Regression; $r^2 = 0.89$; $p=0.00$).

The six recaptured white sturgeon from the Wanapum reservoir exhibited a mean incremental growth-rate of 6.8 cm per year. The actual annual growth of these six fish ranged between 4.0 and 11.5 cm per year.

2.4.5 Movements

In the Priest Rapids reservoir, fish were not tagged until late September, 2000. Therefore, boat-based tracking surveys to locate sonic-tagged white sturgeon were not conducted until January 19, 2001. Sonic-tagged white sturgeon in the Priest Rapids reservoir usually remained in one of four possible overwintering areas. In relative order of use, these were: Goose Island (RM 398), Wanapum Dam tailrace (RM 414), near Lake Geneva (RM 404), and below Lower Crab Creek (RM 409). From October to early April, white sturgeon movements between these overwintering areas were infrequent. Sonic-tagged white sturgeon moved upstream to Wanapum Dam tailrace (RM 414) in April or early May, likely in response to feeding and/or spawning activity; water temperatures at this time were generally between 6°C and 11°C. Sonic-tagged white sturgeon usually remained in the tailrace of Wanapum Dam until August (water temperatures between 18°C and 19°C), after which time they returned to downstream situated feeding and/or overwintering areas.

In 2001, three white sturgeon implanted with CHAT tags, and eight implanted with coded pinger tags were at-large in the Priest Rapids reservoir. Four fish (previously tagged in late September and November 2000: P#14, P#22, P#23, and P#27) were detected below Wanapum Dam between RM 413 and RM 415 from late March to mid-June 2001. In July, these four fish were detected in the Wanapum Dam tailrace (RM 416) and because they were not in pre-spawning condition, were likely present in the area for feeding activities. By mid-July, three of these fish [one female (P#14) and two males (P#22 and P#23)] had moved downstream. One female (P#14) moved to RM 414 and was detected in this area until late November, while one male (P#22) moved to this location until mid-August, and was always detected below Lower Crab Creek (RM 409) for the remainder of the year. One male (P#23) was located in the Priest Rapids Dam forebay (RM 397) from mid-August until early October, and later located downstream of Lake Geneva (RM 404) for the remainder of the year. Another male (P#27) was located in the Wanapum Dam tailrace from January to December 2001.

Movements of seven white sturgeon were monitored by boat and remote telemetry receiver stations after their initial capture in late September and early October 2001. One female (P#32) was located upstream of Lake Geneva (RM 405) in mid-October, and in the Priest Rapids Dam forebay (RM 397) in November and December. One female (P#36) was located in the Wanapum Dam tailrace (RM 414) in late September, and near Goose Island (RM 398) in November and December. Three females (P#40, P#44, and CHAT #159) were located in the Wanapum Dam tailrace (RM 415) from

From October to December, one female (CHAT #239) was located below Wanapum Dam (RM 414) in late October and then downstream of Lake Geneva (RM 403) in November, where she was last detected on November 21, 2001. One female (CHAT #271) was located near its initial capture area (RM 413) from early October to early November, and in December this fish was detected downstream of Lake Geneva (RM 401).

From January to March 2002, four sonic-tagged white sturgeon (P#14, P#40, P#44 and CHAT #159) were detected in the Wanapum Dam tailrace (RM 414 to 415), two fish (P#32 and P#36) were located near Goose Island (RM 398), and two fish (P#23 and CHAT #271) were located downstream of Lake Geneva (RM 401 to 403). One fish (P#14) was located at Goose Island in April and July. Another fish (P#23) was detected in the Wanapum Dam tailrace from April to July, and was subsequently detected near Goose Island in July and August. One fish (P#32) was detected in the Wanapum Dam tailrace in July; this fish and one other individual (P#36) were last located near Goose Island in August and March, respectively. One sturgeon (P#40) was last located in the Wanapum Dam tailrace on May 31, while another fish (CHAT #159) was last detected in the same area on March 21. CHAT #271 was last detected downstream of Lake Geneva (RM 404) on May 2, while CHAT #239 was not located after November 21, 2001. From January to August 2002 P#27 was detected in the Wanapum Dam tailrace. P#22) was located below Lower Crab Creek (RM 409).

A potential pre-spawning female (P#44), tagged in the Priest Rapids reservoir on October 31, 2001 was detected below Wanapum Dam (RM 415) on May 2, 2002. This fish was subsequently detected several times by a remote telemetry station at Columbia Cliffs (RM 442) in the Wanapum reservoir from May 14-27. This fish was also detected by a remote telemetry station at the Rock Island Dam tailrace (RM 452) from June 27 to July 30, 2002. While boat-based telemetry surveys did not verify the presence of this fish in the Wanapum reservoir, it was suspected that this fish moved upstream from the Priest Rapids reservoir into the Wanapum reservoir, since the tag was detected by two different receivers in the upper section of the Wanapum reservoir and the detection patterns picked up by remote telemetry stations did not resemble noise patterns usually observed by this technology. This movement indicated that some adult white sturgeon were capable of ascending the fish ladder at Wanapum Dam

Sonic-tagged white sturgeon tagged and released in the Wanapum reservoir usually remained in one of four possible overwintering areas from September to May. In relative order of use, these were the Columbia Cliffs, below Rock Island Dam (RM 453), Sunland Estates (RM 429), and near Vantage Bridge (RM 421)] Water temperatures during this period ranged from 2°C to 18°C. The Columbia Cliffs area appeared to be the primary overwintering location for sonic-tagged white sturgeon. Some white sturgeon moved between Columbia Cliffs and Sunland Estates during the 2000 and 2001 overwintering period; this pattern was not observed in 2002. Upstream movements from overwintering areas to the Rock Island Dam tailrace commenced in May at water temperatures from 8 to 13°C. Pre-spawning female white sturgeon were usually located in the Rock Island Dam tailrace (RM 453) by June or July when water temperatures ranged between 11°C and 18°C. Non-spawning females were located in this area from May to August (water temperatures ranged between 14°C and 19°C). Pre-spawning male white sturgeon were located below Rock Island Dam from June to July; one male remained there throughout the year. Other males (not in spawning condition) were usually located in the Rock Island Dam tailrace from June to July with some remaining in this area until late September.

From May to August 2000, 16 sonic-tagged white sturgeon at-large were located below Rock Island Dam from RM 450 to RM 453. By November 30, 19 of the 23 sonic-tagged white sturgeon at-large were located at Columbia Cliffs between RM 441 and RM 442. One white sturgeon was located downstream of Sunland Estates (RM 429), and one fish was detected below Rock Island Dam (RM 451) at this time.

A remote telemetry receiver station (set to detect coded pingers) was deployed at the Columbia Cliffs area (RM 442) on December 3, 2000. This monitor detected 18 of the 23 fish equipped with coded pingers at-large in the reservoir.

The fish with CHAT #15 was last detected on June 29, 2000 and was recaptured on October 2, 2000. The VR28T hydrophone system was unable to pick up a signal from the tag at this time, and the tag was removed so that temperature and depth data could be retrieved. The tag was returned to Vemco Ltd. and it was determined that a manufacturing defect had caused the tag to malfunction. A similar malfunction was suspected for fish implanted with CHAT #47 and CHAT #63.

From January to June 2001, 20 white sturgeon were detected in overwintering and/or feeding areas near Columbia Cliffs (RM 442), Sunland Estates (RM 429; CHAT #79; coded pinger #1), near Vantage Bridge (RM 421), between RM 424 and RM 428, and in Rock Island Dam tailrace (upstream of the Alcoa Launch) at RM 450. From early June to mid-August, 20 of 23 sonic-tagged white sturgeon at-large were detected in the Rock Island Dam tailrace area (RM 450 to RM 452); their presence in this area was likely related to feeding and/or spawning activity. Weekly tracking surveys, conducted from June to August, indicated that 13 of 23 sonic-tagged white sturgeon at-large moved between the tailrace and downstream situated feeding areas on several occasions during this period. One fish (CHAT #79) was last located below Rock Island Dam on June 27; it was assumed that the tag battery had expired.

From early September to early December 2001, 19 of 23 sonic-tagged white sturgeon at-large were detected in the overwintering and/or feeding area at Columbia Cliffs, Sunland Estates, near Vantage Bridge, and six between RM 424 and RM 428. One fish was detected in the Rock Island Dam tailrace area (RM 452) during this time.

One white sturgeon (P#34), tagged on September 29, 2001, was located below Rock Island Dam (RM 452) from October to November, and was always detected at Columbia Cliffs (RM 442) for the remainder of the year. One other fish, implanted with a CHAT #255 on September 29, 2001, was not detected since release.

In 2002, 16 of the 24 pinger-equipped white sturgeon at-large were detected at the Columbia Cliffs overwintering area from January to mid-May. From mid-May to early August, nine of these 16 fish had moved into the tailrace area below Rock Island Dam (RM 452); four were early to late reproductive males, four were early to late vitellogenic females, and one was of undetermined sex and maturity at the time of capture. The movements of the reproductively advanced fish were considered to be spawning related and movements by the other individuals were likely related to feeding. Of the remaining seven of these 16 fish that either were not located at the Columbia Cliffs overwintering area or were not located in the spawning area (RM 452) during this time:

- two were immature females (P#3 and P#6) that were detected in the narrows below Rock Island Dam (RM 449) in mid-June and were located in the spawning area (likely for feeding) from late June to early August;
- one was a late vitellogenic female (P#9) that was located downstream of Whiskey Dick Creek (RM 426) in late March and early May and was detected in the spawning area from early June to early August;
- one was a pre-vitellogenic female (P#24) detected downstream of Scammon's Landing (RM 427) in late March, located at Columbia Cliffs in June, and detected below Rock Island Dam from July to August;
- one was a early reproductive male (P#25) that was detected downstream of Quilomene Creek (RM 433) from early May to early August;
- one was a non-reproductive male (P#29) was detected near Quilomene Creek (RM 433) in late May and early June and then located in the spawning area from late June to early August;
- one was a non-reproductive female (P#34) detected near Quilomene Creek (RM 433) in late May and early June, located in the spawning area in late June, and from July to August was detected downstream of Whiskey Dick Creek (RM 426).

Three (P#2, P#13, P#16) of the 24 pinger-equipped fish at-large were detected downstream of Whiskey Dick Creek (RM 426) in February and March 2002; one early reproductive male (P#13) was detected there until August. One non-reproductive female (P#2) was located downstream of

Rock Island Dam (RM 452) from late June to early August. One maturing male (P#16) was detected at Columbia Cliffs (RM 442) on 12 June, in the narrows below Rock Island Dam (RM 449) on June 14, and in the Rock Island Dam tailrace (RM 451 to 453) from June 21 to July 30.

For the remaining five of the 24 pinger-equipped fish at-large:

- one late reproductive male (P#7) was detected in the spawning area below Rock Island Dam (RM 452) from early February to early-August;
- three fish (P#11, P#12, P#28) have not been detected since October 27, November 30, and May 11 2001, respectively; and
- one juvenile (P #21) was detected near Vantage (RM 421) from early January to early August.

2.5 Findings to Date

The four years of white sturgeon study conducted for relicensing in the Priest Rapids and the Wanapum reservoirs in 1999 (Grant PUD 1999) and 2000 to 2002 (Golder 2003) and review of existing information resulted in the following key findings.

A relatively small population of white sturgeon (lower estimated limit of 143 individuals), made up primarily of older adults, was present in the Priest Rapids reservoir. This population could be a fragment of a larger migratory or resident population that was present prior to the construction of mid-Columbia River dams. Based on information collected from 1999 to 2001, recruitment to this population has been sporadic and limited to a strong recruitment period in the mid to late 1950s and a lesser degree of recruitment between 1969 and 1984. However, due to known difficulties in accurately ageing sturgeon, historical trends based on assigned ages of white sturgeon should be interpreted with caution.

The apparent gap in recruitment during the 1960s may correspond to the initiation of Wanapum Dam construction in 1959, and the operational changes that occurred in the years following (e.g., the reservoir was filled in 1963, and the final generation unit was operational in 1964). From 1969 to 1984, recruitment to the population appeared low, but was relatively consistent, with the exception of three years (i.e., 1970, 1971, 1973) where no evidence of recruitment was obtained. Based on the captured population, recruitment ceased in 1984. A spill operations program was initiated throughout the Columbia River basin from 1980 to 1986, where spill occurred for 12 hours at night instead of during the day. Whether these spill changes impacted recruitment in the reservoir during the 1980s is unknown.

Other basin-wide environmental effects may have also influenced white sturgeon recruitment in the Priest Rapids reservoir. For example, a decline in the abundance of young white sturgeon upstream of Hells Canyon on the Snake River was observed to correspond with an unusually prolonged drought that lasted eight consecutive years (1987 to 1994; Lepla and Chandler 2001). The effects of this drought may have impacted white sturgeon populations throughout the Columbia River. Recruitment in the Wanapum reservoir was also observed to be inconsistent from 1984 to 1992, perhaps indicating that the effects of this drought were a basin-wide phenomenon.

Another plausible explanation for the presence of the small, older population in the Priest Rapids reservoir may be due to an outmigration of young fish to downstream reservoirs. White sturgeon post-hatch larvae are typically mobile and use river currents as a means of passive dispersal from spawning areas to downstream rearing habitats. For example, sturgeon larvae have been reported up to 194 km (121 miles) downstream of known egg incubation and probable spawning sites (Kohlhorst 1976; McCabe and Tracy 1989). The Priest Rapids reservoir may not provide a long enough settling area for white sturgeon larvae spawned below Wanapum Dam to settle out prior to being entrained through Priest Rapids Dam. Observations made during set lining for adults indicated that higher velocities were experienced from a section that extended 16 km (10 miles) from Wanapum Dam to upstream of Lake Geneva; set lining was more difficult in these areas because of faster currents. These currents may disperse larvae, spawned below Wanapum Dam, to potential rearing areas that may occur near Lake Geneva and Goose Island or below Priest Rapids Dam.

Another possible explanation for the absence of juveniles may a lack of critical habitats for very early life stages (post-hatch larvae and free embryos). Habitats required for these life stages in the mainstem Columbia River are still poorly understood. White sturgeon larvae typically undergo a hiding phase after hatch until the yolk sac is absorbed and exogenous feeding commences, Based on laboratory studies, an absence of suitable sized substrate with suitable hiding spaces in areas within or downstream of the spawning area has been suggested as a potential key factor affecting larval survival. This lack of suitable early stage rearing habitat hypothesis has received a great deal of attention by the UCWSRI and is the subject of continued lab and field investigations.

Several studies on the middle and lower Columbia River, and on the Snake River in Washington have indicated that suitable habitats for older juvenile white sturgeon (age-1+) consist of depths between five and 14 meters, water velocities less than 0.25 m/s, as well as bottom types consisting of sand, sand/silt, or small gravels (McCabe and Tracy 1989, Parsley and Beckman 1994, Lepla and Chandler 2001). In the Snake River, larger juvenile white sturgeon (less than 120 cm TL) were observed negotiating velocities up to 2.5 m/s, however, these upper velocities were seldom used (Lepla and Chandler 2001). Kappenman et al. (1999) reported that white sturgeon less than 68 cm TL were not found in areas where mean water column velocities exceeded 1.6 m/s. Suitable rearing habitats for juvenile life stages of white sturgeon were not identified in the Priest Rapids reservoir (due to the absence of juveniles in the catch), but based on the above criteria, may be present at Goose Island (RM 398) or downstream of Lake Geneva (RM 404).

The white sturgeon population in the Wanapum reservoir (estimated between 398 and 881 individuals) contained both young and mature individuals. Approximately 20% of the total catch was composed of juvenile fish, which suggested this population either experiences natural recruitment or that juveniles recruit to the population from populations in adjacent reservoirs. Based on capture and movement studies conducted during the present study, seven locations were identified as potential rearing areas for older juvenile sturgeon. These were Vantage Bridge (RM 421), downstream of Whiskey Dick Creek (RM 426), downstream of Scammon's Landing (RM 427), Sunland Estates (RM 429), downstream of Quilomene Creek (RM 434), downstream of Tekison Creek (RM 438), and at Columbia Cliffs (RM 442). The extent and use of these areas for rearing is not well known. Suitability of the Wanapum reservoir for rearing by juvenile white sturgeon may be greater than in the Priest Rapids reservoir. This supposition is based on 1) the capture of juveniles in the Wanapum reservoir during three fall sample periods, 2) the presence of one tagged juvenile over the duration of the movement study, 3) the greater number of potential rearing areas, and 4) the greater habitat diversity likely available in the larger reservoir, especially during variable flow years.

Based on assigned ages of fish collected from 1999 to 2001, recruitment to the Wanapum population has occurred between 1964 and 1997; year-class strength after this year could not be determined, since sample gear biases likely precluded the capture of smaller individuals. Since Rock Island Dam (built in 1933) is a run-of-the-river facility, water level fluctuations are dependent upon operations further upstream in the Columbia River. Limited recruitment may have occurred prior to 1964, since there was an increase in dam construction activity, and river regulation in upstream areas during this time. Recruitment in the late 1980s also may have been impacted by a prolonged drought that occurred from 1987 to 1994, which caused a decline in juvenile white sturgeon abundance on the Snake River (Lepla and Chandler 2001). The relatively high proportion of juveniles captured during the present study from the 1997 year-class may suggest that high-flow years increase the survival and recruitment of juvenile white sturgeon (i.e., high flows provide increased turbidity or water volume for predator avoidance). The 1997 flow year was the highest on record since the construction of Priest Rapids Dam in 1961. Several researchers have reported a positive relationship between white sturgeon year-class strength and river outflow (e.g., Kohlhorst et al. 1991, Miller and Beckman 1995). Since aging methods for younger sturgeon are more precise (Rien and Beamesderfer 1994), the identification of the strong 1997 year-class in the Wanapum reservoir has a relatively high certainty of being accurate.

3.0 Protection, Mitigation and Enhancement Measures

The goal of the WSMP is to promote growth of the white sturgeon population in the Priest Rapids Project area to a level that is commensurate with the available habitat. To meet this goal, Grant PUD is proposing a supplementation program to increase the population through use of hatchery-reared fish, fish that have been captured in the lower Columbia River for direct release into the reservoir, or other methods recommended by the PRFF. The Protection, Mitigation and Enhancement (PME) measures of the WSMP are designed to meet the following objectives:

Objective 1: Increase the white sturgeon population in the reservoirs through supplementation to a level commensurate with available habitat;

Objective 2: Determine the effectiveness of the supplementation program;

Objective 3: Determine the carrying capacity of available habitat in the reservoirs and;

Objective 4: Determine natural reproduction potential in the reservoirs, and then adjust the supplementation program accordingly.

This WSMP is an adaptive management approach where strategies for meeting the goals and objectives may be adjusted through a collaborative effort with the relicensing stakeholders participating in the PRFF, based on new information and ongoing monitoring results. The WSMP is also intended to be consistent with other white sturgeon management plans in the mid-Columbia region**.**

The White Surgeon Technical Group (WSTG) developed the objectives and activities described in this section. The effectiveness of each strategy will be determined through the monitoring and evaluation program. Once the results of the monitoring and evaluation program have been considered, Grant PUD will determine, in consultation with the PRFF, any reasonable and feasible next steps, which may include adjusting the supplementation level.

Due to the adaptive nature of this program, the schedule for implementation of specific measures can only be estimated at this time. Table 1 provides an estimated schedule for implementing each activity, which will be adjusted through consultation with the PRFF, as new information becomes available.

3.1 Objective 1: Increase the Spawning and Rearing of White Sturgeon in the Priest Rapids Project

As required under the 401 Certification (6.2 (5)(b)), Grant PUD has completed a draft plan for an adaptively managed, long-term, white sturgeon supplementation program in the Project area. Primary components of the draft supplementation program are the development and implementation of a broodstock collection and breeding plan, a juvenile white sturgeon stocking program in the reservoirs, and a monitoring and evaluation program. These components are briefly introduced below and described in greater detail in Part B of this document.

3.1.1 Brood Stock Collection and Breeding Plan

Due to the low population estimates in the Project area as indicated by the 2000 to 2002 white sturgeon baseline investigations, there is a low probability that sufficient brood stock from the reservoirs can be obtained for a long-term supplementation program; therefore, other sources of fish must be considered to increase the white sturgeon population. Grant PUD has prepared a draft brood stock collection and breeding plan, which considers such factors as genetics and questions of imprinting. Possible sources of fish that could be used in the hatchery supplementation program include:

- Brood stock collected from the Priest Rapids and the Wanapum reservoirs and nearby reservoirs (or above McNary);
- Brood stock collected from the lower Columbia River;
- Excess juveniles from the UCWSRI white sturgeon supplementation program in the Transboundary Reach;
- Juveniles purchased from a commercial and Tribal facilities for direct release into the reservoirs; and
- Juveniles from new or existing Grant PUD-funded hatchery facilities retrofitted to accommodate white sturgeon brood stock, egg incubation, and juvenile rearing.

The initial source of brood stock will be determined in consultation with the PRFF within one year of the effective date of the New License, and collection is presently scheduled to begin in year two of the New License, if fish are available and the PRFF determines that brood stock collection within such a timeframe is feasible (see Table 1, footnote 1). If collection is not feasible, by year two of the New License Grant PUD shall proceed on a schedule to be determined by the PRFF, using the adaptive management approach depicted in Table 1. The intent of brood stock collection is to use their progeny, if feasible, in the future for the white sturgeon stocking program.

3.1.2 Juvenile White Sturgeon Stocking

Beginning in year three of the New License, Grant PUD will release sufficient yearling white sturgeon into the Wanapum and Priest Rapids reservoirs annually in Years 3 to 7, to achieve an adult white sturgeon population appropriate for the size of these reservoirs. The initial objectives of the conceptual WSMP called for adult populations of approximately 4,000 and 2,000 individuals for Wanapum and Priest Rapids reservoirs, respectively. These targets may overestimate the carrying capacity of these reservoirs, considering that the adult population target (based on abundance of the existing population) for the Transboundary Reach (a 300 km section of river and reservoir combined) has been set at 3,000 adults. However, for the reasons provided in Part B, these targets are intended to be maintained for the present as a mechanism to rapidly rebuild the population. These targets can be adjusted at any point in the future if monitoring or other information verifies that these abundance levels will exceed carrying capacity. The initial 5-year release program is suggested to provide sufficient time to collect information via the indexing program on spawning success, growth of wild and stocked fish, and survival rates. Also during this period, information from other white sturgeon recovery programs will likely be available to help inform decisions on stocking rates and adult population targets.

The number of fish to be released in the first 5 years will be determined in consultation with the PRFF using the model outputs provided in Part B of this document and based on best available information. In consultation with the PRFF, yearling fish will be acquired through one or more of the following: 1) production from a Grant PUD hatchery or cooperative mid-Columbia hatchery, 2) excess yearling fish production from other compatible supplementation programs, 3) purchase from a commercial hatchery, or 4) other measures identified by the PRFF. Extenuating circumstances could result in a failure to meet the three-year initiation of the juvenile release deadline. Grant PUD will meet with the PRFF to discuss any circumstances where the deadline will not be met, and alternatives will be developed and implemented (see Table 1, footnote 2).

Grant PUD shall ensure that in the initial stages of the supplementation program, all hatchery-reared juvenile white sturgeon released into the Priest Rapids and the Wanapum reservoirs are marked with Passive Integrated Transponder (PIT) tags (tags that emit a signal when activated by a reader, which must be held in close proximity to the tag) and year-specific scute marks for monitoring purposes. In order to allow for remote tracking of juvenile white sturgeon emigration and to assist in the identification of early life stage rearing habitats, Grant PUD shall ensure that up to one percent (or a maximum of 65) of the juvenile white sturgeon released into the Priest Rapids and the Wanapum reservoirs are large enough to allow implantation of a sonic telemetry tag prior to release.

The number of yearlings released in subsequent years (after the initial five-year stocking period) will be determined from the results of the indexing program and/or the evaluation of spawning potential and will be adjusted based on this data and in consultation with the PRFF (also see Table 1, footnotes 2 and 3).

In addition, following the fifth year of supplementation (unless the PRFF determines more analysis is required), Grant PUD may elect to release juveniles at younger or older ages than one year in order to compare success of fish released at varying life stages. For example, based on consultation with the PRFF, Grant PUD may elect to have a proportion of the hatchery-reared juveniles released at differing size intervals (with the minimum size being that which permits PIT-tagging), in order to monitor potential differences in survival and growth during future indexing periods. On a schedule developed in consultation with the PRFF (see Table 1), Grant PUD shall implant active sonic tags in a percentage, to be recommended by the PRFF, of juvenile white sturgeon released as part of the supplementation program, in anticipation of future emigration rate and habitat-use tracking surveys.

Annual stocking levels of yearlings or possibly other age-classes will be adjusted based on monitoring results in any given year. Methods for determining production goals, stocking locations, and breeding plans are described in Part B.

In year six of the New License, Grant PUD, in consultation with the PRFF, will determine the number and size of juveniles that will be released annually in the Wanapum and Priest Rapids reservoirs through the end of the term of the New License (44 years) or as adjusted by the PRFF through the adaptive management process consistent with monitoring and evaluation results.

3.2 Objective 2: Determine the Effectiveness of the Supplementation Program (Monitoring and Evaluation)

A Monitoring and Evaluation Plan shall include both a sampling program and an emigration rate assessment to determine: supplementation program effectiveness, carrying capacity for each reservoir, and reproduction potential for each reservoir.

3.2.1 Sampling Program

A portion of the hatchery releases will be equipped with sonic tags to identify important rearing areas for juvenile sturgeon, information that is needed to develop and implement a sampling program for the evaluation of survival rates, growth rates, fish distribution, habitat selection, habitat use, habitat availability, and habitat suitability. The program will include the following:

- Monitor to determine program effectiveness in Years 4, 5, 6, 8, and then every 3rd year for the term of the New License.
- Monitor to determine each reservoir's carrying capacity in Year 3 through the end of the term of the New License.
- Monitor to determine each reservoir's reproduction potential in Years 8, 9, 10, 13, and 18, and then every 3rd year for the term of the New License.

3.2.2 Assessment of Emigration Rate

In Years 4, 5, 6, 14, 20, and any additional years as determined by the PRFF, active-tagged sturgeon shall be used to assess the emigration rate of white sturgeon out of the Priest Rapids Project. This will require one percent of each of the first three annual classes of juvenile sturgeon (up to a maximum of 65 fish each year) to be reared large enough to implant an active sonic and/or radio tag for tracking purposes. The purpose of tracking active-tagged fish is to determine juvenile white sturgeon emigration rates out of the reservoirs and habitat use within the reservoirs.

3.2.3 Supplementation Program Review

Grant PUD, in consultation with the PRFF, shall compile information annually on other white sturgeon supplementation programs in the Columbia River basin in order to assess whether: 1) Grant PUD's supplementation program is consistent (e.g., stocking rates, release age and size, brood stock source, and monitoring programs) with similar regional programs; 2) harvest is appropriate to achieve management goals; 3) improvements to the Grant PUD program for the Project can be made; and 4) monitoring objectives can be met more economically.

3.3 Objective 3: Determine Carrying Capacity of Available Habitat in the Priest Rapids and Wanapum Reservoirs

Grant PUD expects to gather sufficient information through the monitoring and evaluation activities described in Section 3.2 to determine, in consultation with the PRFF, the carrying capacity of the Priest Rapids and the Wanapum reservoirs for white sturgeon.

3.4 Objective 4: Determine Natural Reproduction Potential in the Priest Rapids and Wanapum Reservoirs

Until reasonable and feasible means for reestablishing natural production and providing support for migration are available, and recognizing that those means appear unlikely in the foreseeable future, the Biological Objective is to sustain a white sturgeon population at a level commensurate with available habitat through implementation of a supplementation program in the Project reservoirs. The supplementation program will provide an initial foundation for the Monitoring and Evaluation Program, which is designed to a) identify existing impediments to achieving the Biological Objectives, b) sustain the populations until the existing impediments can be corrected, and c) mitigate for population losses due to Project impacts. Suggested timelines proposed for implementation of supplementation program implementation measures are provided in Table 1.

3.5 Reporting

By March 31 following issuance of the New License, and each year thereafter for the term of the New License, Grant PUD will provide an annual report summarizing activities undertaken to identify and address impacts of the Project to white sturgeon, including results of those activities. This report shall include a compilation of information on other white sturgeon supplementation programs in the Columbia River Basin in order to assess whether the supplementation program being implemented at the Priest Rapids Project is: (i) consistent with other supplementation programs in the region; (ii) cost effective to implement at the Project; and (iii) whether improvements can be made which are appropriate to implement at the Project.

3.6 Adaptive Management

The WSMP also includes provisions to resolve critical uncertainties to further achievement of white sturgeon Biological Objectives. In the event that adverse Project effects on white sturgeon spawning, incubation, and rearing in the Hanford Reach are identified, the WSMP shall be amended to further investigate and quantify Project effects and to identify potential reasonable and feasible measures to mitigate such effects, taking into consideration the cumulative effects of the river system and using the adaptive management process. Draft plans for the investigation and evaluation shall be developed in consultation with PRFF, and proposed final plans submitted to Ecology for approval or modification. In the event that reasonable and feasible means for reestablishing natural production and providing support for migration become available, these measures shall be considered by the PRFF and the WSMP amended as appropriate for implementation.

Grant PUD shall consult with the PRFF during the term of the New License to ensure that the juvenile white sturgeon stocking program, indexing program and associated use of active tags (with limited lives) are coordinated to most effectively meet the overall monitoring goals and schedule. Table 1 demonstrates an estimated long-term schedule, subject to Adaptive

Management by Grant PUD, in consultation with the PRFF, to coordinate release, survey, tagging, and monitoring activities. Table 2 provides a summary of the actions, objectives, and measured parameters associated with the WSMP.

Table 1 Priest Rapids Project Area (PRPA) White Sturgeon Monitoring and Evaluation Program – Preliminary Schedule

New License Year	Update Baseline Data[1]	Collect Brood Stock[2]	Release Fish in Project area[3]	Juvenile Indexing[4]	Track Tagged Fish[5]	Assess Natural Production and Adult Population Status[6]
1	X					
2		X			X	X
3		X	X	X	X	
4		X	X	X	X	X
5		X	X	X	X	
6		X	X	X	X	
7		X	X	X	X	X
8		X	X		X	
9		X	X		X	
10		X	X	X	X	X
11		X	X			
12		X	X			
13		X	X	X	X	X
14		X	X			
15		X	X			
16		X	X	X	X	X
17		X	X			
18		X	X			
19		X	X	X	X	X
20		X	X			
21		X	X			
22		X	X	X	X	X
23		X	X			
24		X	X			
25[7]		X	X	X	X	X

1 Will involve spawn monitoring and summer distribution and abundance studies that will be conducted in a similar manner to studies conducted in 1999-2002. Will also involve assessing the feasibility of collecting broodstock from the Project area and identifying locations for future broodstock collection activities.

2 Collection of brood stock will focus on collections from the Project area but also may include capture of mature adults from the lower Columbia River or in the mid-Columbia or Snake River where reasonable and feasible. The initial source of brood stock will be determined in year one of the program and collection will begin in year two.

3 Assumes up to 5,000 yearlings will be released in the Wanapum Reservoir and 1,500 yearlings in the Priest Rapids Reservoir during each of the first five years. Total yearlings released in subsequent years will depend on results of indexing programs and information from other sturgeon recovery efforts. Yearlings will be produced from a Grant PUD hatchery. Breeding plans for all options will be developed in consultation with the PRFF.

4 Indexing will include monitoring of age, growth, habitat use, and survival of juvenile and adult sturgeon. Results will be used to determine future stocking rates, release locations, and timing. After Year 7, the frequency of indexing may be adjusted in consultation with the PRFF.

5 Active-tagged juvenile and adult sturgeon will be tracked to assess emigration, habitat use, and important habitats. Juveniles will be equipped with 1 to 3 year tags while adults will receive 10-year tags. The monitoring array will be deployed continuously for the initial Year 1-10 period. Subsequently, tracking of juveniles and adults will be conducted occasionally as required (determined in consultation with the PRFF) to monitor changes in habitat selection or emigration.

6 Conduct spawning surveys to identify natural production potential and natural recruitment in the reservoir and periodic adult assessments. The frequency of surveys will be determined in consultation with the PRFF.

7 Repeat until objectives of the program are met or modified. Modifications to the objectives will be determined in consultation with the PRFF.

Table 2 Priest Rapids Project Area (PRPA) White Sturgeon Monitoring and Evaluation Program – Actions and Objectives

Use/Action	Objective	Measured Parameter	Schedule	Actions if Objective Achieved	Alternative Management Actions
Adult white sturgeon	Re-establish baseline population status in PRPA; assess availability of broodstock PRPA	Population estimates; current spawning use; broodstock availability; past recruitment events	Year 2	Maintain Action. No additional action needed.	Adjust stocking level; investigate alternative brood stock sources.
Juvenile white sturgeon	Increase white sturgeon population in PRPA	Stock up to 6,500 yearlings in the PRPA	Years 3-7, each year	Maintain action. No additional action needed.	Adjust stocking level; alternative broodstock; excess production
Juvenile white sturgeon	Increase white sturgeon population in PRPA	Stock up to 6,500 yearlings in the PRPA	Years 8-44, each year	Maintain action. No additional action needed	Develop and implement collaborative plan to adjust stocking level
Juvenile and adult white sturgeon	Determine supplementation program effectiveness	Long-term indexing: survival rates; growth rates; tag and track fish; distribution; habitat selection, use, availability, and suitability	Years 3-7	Maintain action. No additional action needed	Develop and implement collaborative plan to address identified problem(s), if any.
Juvenile and adult white sturgeon	Determine supplementation program effectiveness	Emigration rate; track marked fish	Years 2-10, additional surveys TBD	Maintain action. No additional action needed	Develop and implement collaborative plan to address identified problem(s), if any.
Juvenile and adult white sturgeon	Supplementation program review	Compile additional information from other programs	Years 1-44 as required or warranted	Maintain action. No additional action needed	Develop and implement collaborative plan to address identified problem(s), if any.
Juvenile and adult white sturgeon	Determine reservoirs' carrying capacity	Long-term indexing results, emigration rate results	Years 7-44, at regular intervals as required	Maintain action. No additional action needed	Develop and implement collaborative plan to address identified problem(s), if any.
Adult white sturgeon	Natural reproduction potential	Tag adults and monitor through long-term indexing; egg mat placement	At 3 year intervals starting in Year 1	Maintain action. No additional action needed	Develop and implement collaborative plan to address identified problem(s), if any.

List of Literature

Apperson, K. and P. J. Anders. 1991. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1991. Bonneville Power Administration, Portland, Oregon. Contract DE-A179-88BP93497.

Brannon, E. and A. Setter. 1992. Movements of white sturgeon in Roosevelt Lake. Final Report (1988-1991) to Bonneville Power Administration, Portland Oregon. Project No. 89-45:35 p.

Busack, C., and C. M. Knudsen. 2007. Using factorial mating designs to increase the effective number of breeders in fish hatcheries. Aquaculture 273:24-32.

Casey, J., B.J. Pyper, R.C.P. Beamesderfer, V. L. Paragamian, P.J. Rust, M.D. Neufeld, and S.C. Ireland. In press. Evidence of density- and size-dependent mortality in hatchery-reared juvenile white sturgeon (*Acipenser transmontanus*) in the Kootenai River.

Fiumera, A. C., B. A. Porter, G. Looney, M. A. Asmussen, and J. C. Avise. 2004. Maximizing offspring production while maintaining genetic diversity in supplemental breeding programs of highly fecund managed species. Conservation Biology 18:94-101.

Golder Associates Ltd. 2003a. Rocky Reach white sturgeon investigations. 2002 study results. Report prepared for the Public Utility District No. 1 of Chelan County. Final report, May 30, 2003. 30 pp. plus Appendices.

Golder Associates Ltd. 2003b. Proposed methodology for white sturgeon enhancement on Rocky Reach reservoir. Report prepared for the Public Utility District No. 1 of Chelan County. Discussion Copy, June 24, 2003. 40pp.

Golder Associates Ltd. 2003c. White sturgeon investigations in Priest Rapids and the Wanapum reservoirs on the Middle Columbia River, Washington, U.S.A. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 002-8817F: 82p. + 5 app.

Hildebrand, L. and G. Birch. 1996. Canadian Columbia River white sturgeon: stock stabilization discussion document. Draft Discussion Document. Prepared for BC Ministry of Environment, Lands and Parks. 65 pp.

Hildebrand, L., C McLeod, and S, McKenzie. 1999. Status and management of white sturgeon in the Columbia River in British Columbia, Canada: an overview. Journal of Applied Ichthyology 15 (1999):164-172.

Kappenman, K., D. G. Gallion, P. E. Kofoot, and M. J. Parsley. 1999. White sturgeon mitigation and restoration in the Columbia and Snake rivers upstream from Bonneville Dam. Annual Progress Report by the U. S. Geological Survey, Western Fisheries Research Centre, and Columbia River Research Laboratory, Cook, Washington. 103 p.

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-A179-93B002886. Portland, Oregon.

Kohlhorst, D.W., L.E. Miller, and J.J. Orsi. 1980. Age and growth of white sturgeon collected in the Sacramento-San Joaquin estuary, California: 1965-1970 and 1973-1976. California Fish and Game 66:83-95.

Kohlhorst, D.W., L.W. Botsford, J.S. Brennen, and G.M. Cailliet. 1991. Aspects of the structure and dynamics of an exploited central California population of white sturgeon (*Acipenser transmontanus*). Pages 277-293 *In:* Williot, P.P [ed.]. *Acipenser* – Actes du premier collogue international sur l'esturgeon, Bordeaux 3-6 Octobre 1989, CEMAGREF Publ., France.

Krebs, C.J. 1989. Ecological methodology. Harper and Row, Publishers, New York, New York.

Lepla, K., J. A. Chandler, and P. Bates. 2001. Status of Snake River white sturgeon associated with the Hells Canyon complex. Idaho Power Company Technical Report, Appendix E.3.1-6 Chapter 1. 24 p.

McCabe, G., S.A. Hinton, and R.J. McConnel. 1989. Report D. Pages 167-207 *In:* A.A. Nigro (ed.). Status and habitat requirements of white sturgeon in the Columbia River downstream from McNary Dam. Annual Progress Report to Bonneville Power Administration, Portland, Or.

Miller, A. I., and L. G. Beckman. 1995. Predation on white sturgeon eggs by sympatric fish species in three Columbia River impoundments. 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. U.S. Department of Energy, Portland, OR.

Parsley, M.J., and L.G. Beckman. 1994. White sturgeon spawning and rearing habitat in the lower Columbia River. North American Journal of Fisheries Management 14: 812-827.

Partridge, F. 1983. Kootenai River fisheries investigations in Idaho. Idaho Department of Fish and Game, Boise, Idaho.

Rien, T.A. and Beamesderfer, R.C. 1994. Accuracy and precision of white sturgeon age estimates from pectoral fin rays. Transactions of the American Fisheries Society 123:255-265.

UCWSRI (Upper Columbia White Sturgeon Recovery Initiative). 2002. Upper Columbia White Sturgeon Recovery Plan.

UCWSRI (Upper Columbia White Sturgeon Recovery Initiative). 2008. Sturgeon hatchery release targets. Report prepared for the UCWSRI with the assistance of R. Beamesderfer and C. Justice, Cramer Fish Sciences. 34 p.

Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology [online]1(2):1. http://www.consecol.org/vol1/iss2/art1

PART B: WHITE STURGEON (*Acipenser transmontanus*) CONSERVATION AQUACULTURE PLAN, PRIEST RAPIDS PROJECT AREA, MID-COLUMBIA RIVER

1.0 Introduction

The development of hydroelectric power generation facilities within the Columbia River Basin has had negative impacts on white sturgeon (*Acipenser transmontanus*). White sturgeon in the middle and upper Columbia River are now segregated and isolated populations that reside in regulated impoundments between dams. All of these isolated populations experience complete or frequent recruitment failures that are likely related to river regulation, flooding of historical critical spawning and rearing habitats, increases in predators due to habitat alteration, introduction of exotic species, and pollution. At present, the limited natural recruitment that does occur is likely insufficient to maintain existing population levels. As such, these populations may continue to decline in abundance to the point where they either become extirpated from mid-Columbia River reservoirs or continue to exist only at low levels that are dependent upon occasional immigration from upper or lower Columbia River populations.

As part of the relicensing process, The Public Utility District No. 2 of Grant County (Grant PUD) commissioned intensive studies on white sturgeon populations in the two impoundments (Wanapum and Priest Rapids reservoirs) that collectively comprise the Priest Rapids Project. The results of these studies, undertaken from summer 1999 to early fall 2002, have indicated that resident white sturgeon populations are present in both reservoirs. White sturgeon spawning was documented in the tailrace areas of Wanapum Dam (upper boundary of the Priest Rapids Reservoir) and Rock Island Dam (upper boundary of the Wanapum Reservoir) in June and/or July of 2000, 2001, and 2002. Despite the apparent occurrence of annual spawning in each Reservoir, young sturgeon represented a very minor component of the population that is dominated by large mature fish. The information obtained for the white sturgeon population in the Priest Rapids Project area is very similar to that recorded for an upstream population that resides between Grand Coulee Dam in Washington and Hugh L. Keenleyside Dam in British Columbia (Hildebrand et al. 1999). This transboundary population is presently the target of an intensive international recovery effort that incorporates a conservation aquaculture component designed to supplement the native population until such time as adequate levels of natural recruitment can be restored.

This report outlines a plan for the development of a middle Columbia River white sturgeon conservation aquaculture facility and population supplementation plan in the Project area. For the purposes of this document, the proposed supplementation efforts (introduction of artificially raised fish into the reservoirs) will be limited to Priest Rapids and the Wanapum Reservoirs (Figure 1). Also, this report focuses primarily upon existing Grant PUD facilities and proposed facilities to be owned by Grant PUD. However Grant PUD recognizes that the Yakama Nation is currently spawning and rearing white sturgeon (Columbia River origin) with plans to significantly increase production capacity in the next 1-2 years. Grant PUD also recognizes that the Columbia River Inter-Tribal Fish Commission (CRITFC), in close coordination with the WDFW is planning to build a Columbia River Basin white sturgeon artificial production and species conservation facility in the near future. Grant PUD recognizes the unique role and responsibilities of the Yakama Nation, CRITFC and WDFW in the regional propagation and management of white sturgeon and will continue to evaluate potential opportunities through collaboration with these agencies. Specific items addressed in this conceptual plan include a:

- brief review of sturgeon life history;
- general overview of white sturgeon hatcheries with specific reference to conservation aquaculture hatcheries in the Columbia River basin;
- discussion of critical issues relevant to the use of a conservation aquaculture program in the mid-Columbia River;
- overview of sturgeon hatchery practices;
- logistical considerations regarding a mid-Columbia River conservation aquaculture facility;
- suggestions for preliminary production and release targets and strategies.

During the initial development of this plan, interviews and discussions were held with agency and tribal biologists, hatchery staff in the U.S. and Canada, as well as commercial sturgeon hatchery managers. Information obtained from these sources was provided on the understanding that its use would be restricted to the development of this plan.

1.1 Species Account

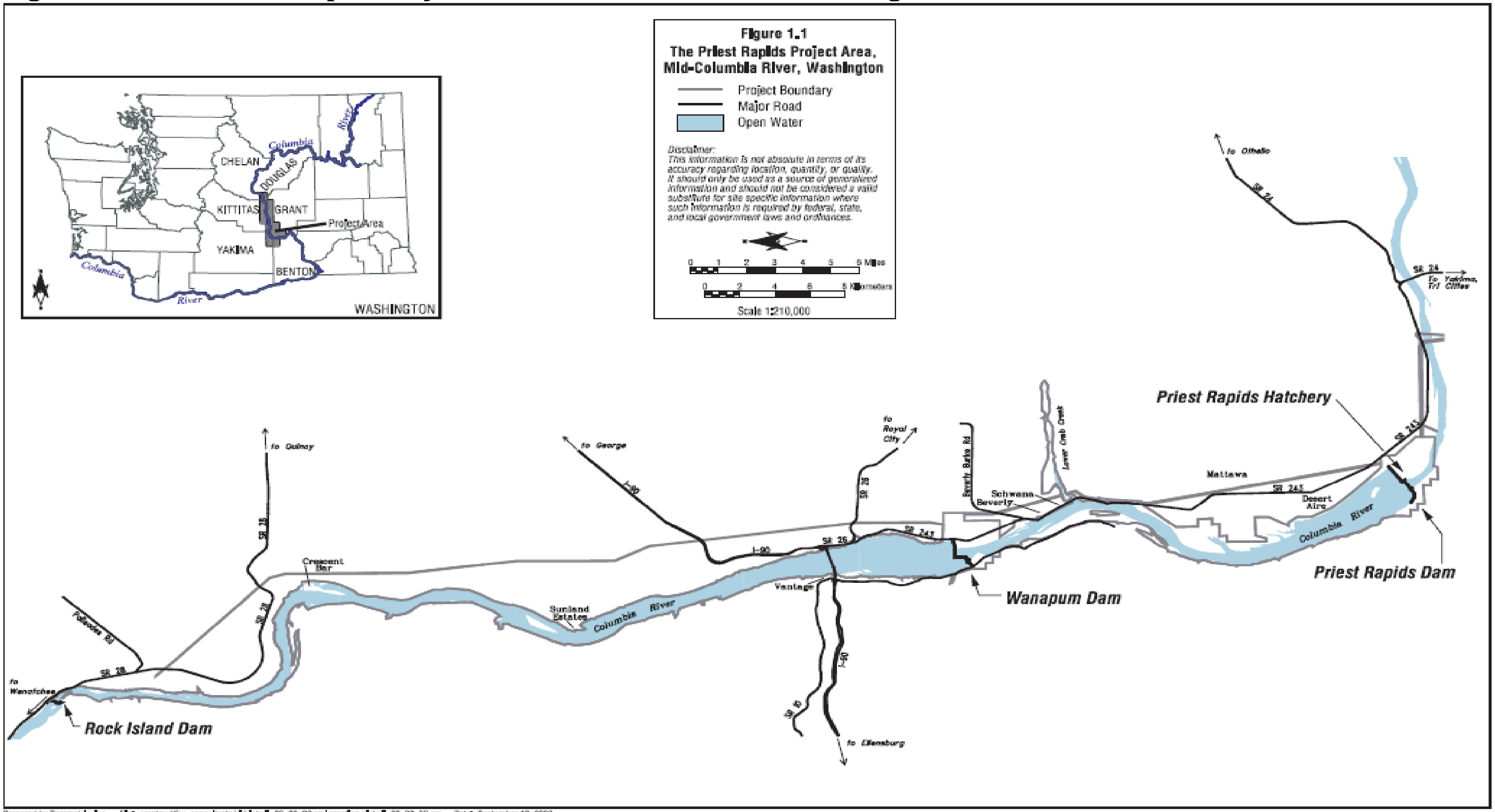
Sturgeons are a primitive group of teleost fish that evolved approximately 250 million years ago. They are distinguished from modern teleost by a skeleton that is mostly cartilage, a notochord that persists into adulthood, primitive fin and jaw structures, a spiral valve intestine, and a heterocercal tail. They belong to the Order Acipenseriformes/Family Acipenseridae, representatives of which are known for their longevity and large size (the largest confirmed record in the Fraser River, British Columbia was 629 kg; Scott and Crossman 1973). Sturgeon have five rows of large dermal bony plates called scutes as well as some ganoid scales. Their protrusible mouths draw in fish and benthic organisms that are detected by sensitive barbels beneath their snouts (Conte et al. 1988).

The white sturgeon inhabits drainage systems of the Pacific Coast of North America from the Aleutian Islands of Alaska south to Ensenada, Mexico. Tagged individuals have been known to move up the Pacific Coast 1,000 km (Chadwick 1959). One fish tagged below Bonneville Dam in 1983 was later recovered in 1986 nearly 3,200 km away in Bristol Bay, Alaska (Anderson 1988). The white sturgeon is usually uniformly gray on the dorsal surface with lighter coloration ventrally and is identified by the arrangement of its four barbels in a transverse row beneath a short, broad snout, with barbels closer to the tip of the snout than to the mouth, and by its 38 to 48 lateral scutes. Like other sturgeon, white sturgeon feed on an array of benthic invertebrates although larger individuals are piscivorous.

White sturgeon populations can be anadromous, semi-anadromous, and landlocked but according to Conte et al. (1988), are best defined as semi-anadromous. Conte et al. (1988) report that only a relatively small number of sturgeon species such as the green sturgeon (*Acipenser medirostris*) and Atlantic sturgeon (*Acipenser oxyrhynchus*) are truly anadromous living almost exclusively in a marine environment and returning to fresh water only to spawn. White sturgeon live primarily in estuaries of large rivers, are euryhaline, and often form landlocked (resident) populations in lakes and reservoirs. White sturgeon spawn several times during their life, with females spawning at intervals ranging from 2 to 8 years (possibly longer in some populations). Males mature from ages 9 to 22, females from ages 11 to 34, and at the time of spawning they are at least 110 cm in length. Because of their longevity, white sturgeon require more time to mature and produce viable sperm and eggs compared to other teleost fish.

Mature adults participate in a seasonal migration to spawning areas, and reproductively active fish usually spawn in areas of swift current over rocky bottoms, deep gravel riffles, or deep holes. In fall and winter, anadromous adults leave the ocean and estuaries and move upriver to spawn. Downstream migration occurs in late spring and summer. Spawning in the Columbia River typically occurs from May through July at water temperatures of 9 to 17°C. Fecundity rates of mature females range from 100,000 to 4,700,000 eggs. White sturgeon are broadcast spawners and the eggs are spawned into fast, moving water where they are dispersed over a large area. The relatively large black eggs are demersal and adhesive. Hatching occurs in 7 to 8 days at water temperatures of 14 to 16°C. After hatching, larval sturgeon exhibit hiding/dispersal behaviour. Two types of hiding/dispersal behaviors have been suggested for white sturgeon larvae. In the Sacramento River system, post-hatch sturgeon larvae initially disperse with river currents to downstream feeding areas where they then initiate a hiding phase in the substrate until the onset of exogenous feeding (Kynard and Parker 2005). The hiding/dispersal patterns for Columbia River sturgeon are still poorly understood, but initial lab and field data suggest post-hatch larvae may initiate hiding immediately after hatch and remain in the substrate until the onset of exogenous feeding, when they enter the drift and disperse to downstream feeding areas and begin foraging on natural benthic food sources (S. McAdam, BC Ministry of Environment, Vancouver, BC, pers. comm., 2008; Howell and McLellan 2007).

Figure 1 The Priest Rapids Project Area, mid-Columbia River, Washington



Prepared by Parametrix, Inc. Date: September 18, 2002

1.2 History of Sturgeon Hatcheries

Virtually all sturgeon stocks worldwide have experienced declines over in the last one-hundred years, not only because of the impact of human activities on sturgeon habitat but also because the high value of their flesh and caviar has resulted in over-fishing. These pressures, in concert with the effects of dam construction and watershed development, are the major factors behind the threatened and endangered status of sturgeon globally.

Historically, sturgeon products have been highly valued in Europe, Asia, and North America. Before 1900 the U.S. sturgeon landings were estimated at 6,800 metric tonnes (MT) on the East Coast and 4,500 MT on the West Coast. Today the U.S. commercial fishery is very limited and is focused primarily on white sturgeon. The international demand for sturgeon flesh and caviar has historically placed significant pressure on the world's sturgeon stocks. Declines in abundance of numerous sturgeon species were recognized in Russia and the U.S. as early as the second half of the nineteenth century. The first recorded attempts at artificial propagation of sturgeon were made by Ovsyandikov in Russia in 1870 and Green in the U.S. in 1875. Significant efforts to artificially propagate sturgeon continued in North America between 1875 and 1912, however, by 1920 practically all these efforts were abandoned (Conte et al. 1988).

Sturgeon hatchery research continued in the Soviet Union however, and was accelerated during the 1950s as part of mitigation programs to compensate for habitat alterations. Technical obstacles to artificial propagation were overcome, and by the 1980s the Soviets operated approximately 20 hatcheries producing 70 to 100 million fingerlings annually. These programs reportedly restored fisheries on three sturgeon species to historical levels and contributed 75 percent to the world's sturgeon catch. The annual international sturgeon fishery landings today are between 20,000 and 40,000 MT and are primarily located in the former Soviet Union and in Iran. The success of the sturgeon mitigation programs in the Soviet Union rekindled interest in sturgeon research in the U.S. The work of Detlaf, Gerbilisky, Ginzburg, Kozin, and their associates laid the groundwork for the advancement of sturgeon programs throughout North America (Conte et al. 1988).

In 1979, a grant from the U.S. Fish and Wildlife Service to researchers at the University of California led to a resurgence of sturgeon research. The development of hatchery technologies for white sturgeon has allowed the advancement of a growing commercial sturgeon aquaculture industry on the West Coast. A hatchery manual for white sturgeon (Conte et al. 1988) was developed by University of California (Davis) researchers and has been used to provide much of the information included in this conceptual plan.

Within the native range of white sturgeon in North America, particular attention has been placed on the advancement of a specific type of sturgeon hatchery involved in what is termed “conservation aquaculture”. Essentially these facilities are used as tools for the recovery of endangered sturgeon species/stocks. Given the issues associated with legislation regarding endangered species in North America (the Endangered Species Act in the U.S. and the Species at Risk Act in Canada), it is deemed unacceptable to stock large numbers of generic-stock white sturgeon as a method to recover endangered populations. Instead, a conservation aquaculture program was developed that factors in issues/concerns such as genetic make-up, genetic swamping, interaction with adjacent populations, breeding plans, family numbers, etc., as compared to a typical hatchery where production numbers and fish health are the dominant concerns. At present, the three white sturgeon conservation aquaculture facilities presently operating in the Pacific Northwest are:

- Kootenai Sturgeon Hatchery constructed in 1991 on the Kootenai River near Bonners Ferry, Idaho and run by the Kootenai Tribe of Idaho. This facility is the main culture facility for the Kootenai white sturgeon recovery program.
- Kootenay Trout and Sturgeon Hatchery at the upper end of Lake Koocanusa near Wardner, B.C and run by the British Columbia Ministry of Environment (BCMOE). This facility was originally a trout hatchery and was expanded in 1998 as a fail-safe facility to raise sturgeon for the Kootenai sturgeon recovery program and in 2001 commenced production for the Upper Columbia White Sturgeon Recovery program.
- In recent years, the Washington Department of Fish and Wildlife have conducted a small scale brood stock collection and spawning at the Sherman Creek Hatchery located near Colville, WA. The progeny from these fish are raised at the Columbia Basin Hatchery at Moses Lake before being released into the Washington section of the Transboundary Reach.

These facilities were either constructed specifically or were modified to produce fish for the Kootenai and upper Columbia white sturgeon recovery programs. Both of these populations are considered endangered, and are the focus of specific recovery plans. A Recovery Team directs the operational production at these facilities in terms of the families, numbers, and size of fish produced. The ultimate goal of each conservation aquaculture program is to ensure the continued existence of these two populations while attempting to maximize genetic diversity and keep hatchery-produced fish as “wild” as possible. This approach is fundamentally different from a traditional fish production facility.

It is useful to note that at this time, the Yakama Nation and the CRITFC are each in preliminary stages for developing white sturgeon conservation production facilities within the Columbia River Basin. Both programs are associated with mitigation obligations of BPA and are intended to supplement white sturgeon throughout the Snake and lower Columbia rivers (below Snake River confluence). The Yakama Nation and CRITFC are currently engaged in technical and policy level discussions which are leading to development of Master Plans for facility development and a Columbia River Basin conservation and supplementation strategy. This strategy could include supporting conservation efforts in the Priest Rapids Project Area, as well as other non-Federal hydroelectric projects in the Mid-Columbia River.

The Yakama Nation Fisheries Resources Program has been practicing sturgeon culture by rearing small numbers of white sturgeon in tribal hatchery facilities since the 1990s. Fish were obtained from various sources including the private Pelfy sturgeon hatchery operating downstream from Bonneville Dam and mid-Columbia hatchery research by CRITFC and the USFWS. The Yakama Nation has available 97 adult white sturgeon in captivity and the hatchery program has successfully spawned captive broodstock in 2007 and 2008 and is currently rearing age 0+ and 1+ sturgeon. In cooperation with the CRITFC, Yakama Tribal field staff has been assisting in sturgeon status assessments during ongoing sturgeon research, monitoring, and evaluation activities that have been underway in the mid-Columbia since 1986 as part of BPA project 86-50.

2.0 Supplementation Recovery Program Goals and Objectives

As outlined in Part A of this document, the goal of the White Sturgeon Management Plan is to promote growth of the white sturgeon population in the Priest Rapids Project area to a level that is commensurate with the available habitat by the year 2038. To meet this goal, Grant PUD is proposing a supplementation program to increase the population through use of hatchery-reared fish. The Protection, Mitigation, and Enhancement Measures (PMEs) of the WSMP are designed to meet the following objectives:

> Objective 1: Increase the white sturgeon population in the reservoirs through supplementation to a level commensurate with available habitat;
>
> Objective 2: Determine the effectiveness of the supplementation program;
>
> Objective 3: Determine the carrying capacity of available habitat in the reservoirs and;
>
> Objective 4: Determine natural reproduction potential in the reservoirs, and then adjust the supplementation program accordingly.

To meet Objective 1, Grant PUD has proposed the need for a conservation aquaculture facility whose purpose is to supplement existing sturgeon populations in the Wanapum and Priest Rapids Reservoirs. The desired end point is restoration and maintenance of the sturgeon populations through intensive hatchery intervention for the foreseeable future in order to provide a stable future population that could have the potential to support some level of a future harvest fishery. The source of the fish (i.e., their genetic origin/status) is equally as important as out-planting large numbers of healthy fish.

This document lays out the major issues involved in establishing the location for the sturgeon hatchery and with building the facility. The following assumptions were made in the preparation of this plan:

- natural reproduction is presently and will continue to be insufficient in the foreseeable future to maintain the existing populations of sturgeon in the Project area;
- the carrying capacity of the Project area is substantially greater than existing white sturgeon population levels;
- recruitment to the existing white sturgeon populations at levels necessary to sustain or increase the populations will only be achieved through a supplementation program;
- the existing potential for downstream passage will require that sturgeon stocked in these reservoirs should be genetically similar to the existing fish to minimize the risk of deleterious effects on distinct genetic populations downstream of the Priest Rapids Project ;

the supplementation program would entail i) the collection of broodstock (preferably from reservoirs within or adjacent to the project – see Part B, Section 2.6), ii) the construction or adaptation of facilities for holding and spawning adult fish and rearing sufficient numbers of juveniles to meet the supplementation targets, and iii) the subsequent release of juveniles into the project area and monitoring the success of these releases over time.

2.1 Population Assessments in the Priest Rapids Project

2.1.1 Current Population Status in Priest Rapids and Wanapum Reservoirs

Mark-recapture data were used to generate preliminary population estimates for white sturgeon in Priest Rapids and the Wanapum Reservoirs (Golder 2003). The white sturgeon populations in Priest Rapids and the Wanapum Reservoirs were estimated at approximately 134 (95% CI = 48 to 2680) and 551 (95% CI = 314 to 1460) fish, respectively. These population estimates are considered preliminary since the number of recaptures is near the minimum required to derive a population estimate using this technique. The confidence in this estimate is further reduced by the small number of fish recaptured in the three years of study (this includes the 1999 mark-period sampled by Grant PUD). What can be stated with a fair degree of confidence, however, is that the white sturgeon population in each of these reservoirs is small and comprised of mostly larger, older fish. With the exception of what appears to be significant recruitment by the 1997 year-class, there has been sporadic, limited annual recruitment to the Wanapum population since the early 1990s but virtually no recruitment in the 1970s and 1980s (Golder 2003). The absence of young fish in catches from the Priest Rapids pool suggests either that this population experiences frequent annual recruitment failures or that suitable habitats for juvenile sturgeon are not available in the reservoir.

2.2 Incorporation of Recent Data

Since the development of the conceptual WSMP plan in 2003, there has been a considerable amount of research conducted on white sturgeon in the Columbia and Kootenai River systems. The results of this research have led to substantial changes to the upper Columbia and Kootenai sturgeon supplementation and recovery programs. Some key findings that have formed the basis for revisions to these recovery programs are summarized below.

- Updated information on juvenile and adult survival rates from nearby populations in the upper Columbia River (Golder 2007).
- Establishment of target adult population numbers in the Transboundary recovery area.
- Poor growth and missing year classes of stocked juveniles in the Kootenai River that suggest density-dependent growth and survival effects.
- A revised broodstock mating plan that uses a full factorial mating design, when possible, to maximize genetic diversity and preserve the existing genetic make-up of the population.

The information that led to the alteration of these recovery programs is also relevant to the present WSMP and has been incorporated into the Priest Rapids Project WSMP provided below. In some instances, incorporation of these data has resulted in substantial changes to the conceptual program that was provided in the 2003 document (Golder 2003).

2.2.1 Juvenile Survival Rates

Information from the upper Columbia program indicates survival rates by age-class are 0.280 (95% CI = [0.115, 0.538]) in the first six months after release and on average, 0.880 (95% CI = [0.346, 0.990]) in all subsequent years (Golder 2007). For population modeling purposes, it was assumed that 0.280 represented the survival rate for juvenile white sturgeon after their first year at large (age-1+) and 0.880 represented the survival rate for juveniles ages 2 to 10. Sub-adult and adult white sturgeon (ages ≥ 11) were assigned an annual survival rate of 0.973 based on mark-recapture estimates for wild white sturgeon in the Columbia River between HLK and the U.S.–Canada border (Irvine et al. 2007).

These survival estimates are very different from the values used in the original 2003 Priest Rapids Project WSMP, which assumed a survival of 0.7 for the first year after release, 0.88 (0.90 after adjustment for ageing error bias) for age-2 to age-10 juveniles and 0.92 for fish ≥ age-11. Assuming a stocking rate of 6,500 sub-yearlings per year for 20 years (the assumptions in the original model) and then using the three updated values in place of the original values for the Wanapum Reservoir model, the maximum projected adult population size increased from 4,000 to 7,000. Since the Wanapum Reservoir is likely incapable of supporting this population density, the logical means to reduce the ultimate population size achieved is through reduced stocking rates combined with the possible implementation of a targeted harvest fishery at some point in the future. The population model scenarios presented in Part B, Section 2.4 use the new data on survival estimates to determine the stocking rates necessary to achieve the adult population targets for each reservoir.

2.2.2 Adult Carrying Capacity Estimation

Long-term population objectives for conservation are generally based on minimum viable population sizes defined as the smallest possible number that can exist without facing extinction from natural disasters or demographic, environmental, or genetic variability (UCWSRI 2008). Minimum numbers are typically inferred from genetic risk analysis due to a lack of empirical information on abundance-related extinction risks. Population Viability Analyses (PVA) is also sometimes used in concert with genetic thresholds to help identify minimum populations. Unfortunately, the available data do not allow calculation of a formal PVA for any Columbia River sturgeon population. However, sturgeon are long-lived and populations consist of overlapping generations, factors that may substantially reduce short term extinction risks for sturgeon.

Numbers associated with genetic risk are generally derived from simple population genetics models and are expressed as "effective population size" or N_e. These numbers are largely theoretical and have been the subject of considerable debate. The ideal effective population size is a population where every individual has an equal chance of mating with every other individual. Minimum viable effective population sizes of 50 to 1,000 adults per generation have been widely applied to other species (NRTWS 2006 cited in UCWSRI 2008). However, because of non-random mating, adult numbers are typically several times greater than the effective population size and consequently, adult numbers ranging from 1,000 to 20,000 have been recommended for various species (NRTWS 2006).

Spatial population structure and productivity can also have a significant effect on minimum viable abundance levels. More productive populations are generally sustainable at a smaller abundance than less productive populations. Conversely, more-widely distributed or spatially complex populations are generally associated with larger minimum viable population numbers. These are often cited as good reasons to strive for more robust recovery targets that will provide an additional level of safety to offset unforeseen threats.

In the Canadian-U.S. Transboundary reach, the recovery target for the adult cohort (combined natural and hatchery production) was based on a "current" population estimate of 3,000 adults calculated in 2003, the year the population was listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; UCWSRI 2008). Current abundance provides a biological reference point for a recovery objective that is consistent with historical natural recruitment levels and the existing habitat carrying capacity for adults.

For the UCWSRI, separate goals were identified for recovery (natural and hatchery combined) and hatchery only contributions to balance the need for hatchery production to ensure conservation of a minimum viable population while also limiting hatchery effects on potential natural production. To this end, 1,000 adults in each of the Canadian and U.S. portions of the Transboundary reach (2,000 in total) was the target for the hatchery-reared component of the population. These values for the Canadian portion of the Transboundary recovery area were based on minimum numbers identified in the Canadian National Recovery Strategy for white sturgeon (DFO 2007). There was a recognition that any long-term population objective used in initial planning would be subject to adaptive refinements based on observed population dynamics as recovery actions unfold.

For the present WSMP, the initial adult production targets were based on the initial stocking targets that were derived from the UCWSRI program and at the time, appeared to be a reasonable starting point for recovery efforts in the Project area. However, following refinement of several key model assumptions as described in Part B, Section 2.2.1, revised model projections indicate that the original stocking targets will result in the production of much higher adult numbers than originally projected. Considering that the established adult population target in the Transboundary reach of the Columbia River, a 300 km section of combined river and reservoir habitat, is 3,000 adults, a simplistic assumption of equal distribution through the study area results in an average density of 10 adults/km. This information would suggest that a target of 4,000 adult in Wanapum Reservoir (approximately 97 km in length for a density of 41 adults/km) and 2,000 adults in Priest Rapids Reservoir (approximately 29 km in length for a density of 69 adults/km) will likely exceed the carrying capacities of these water bodies. Using the UCWSRI adult density value of 10 adults/km suggest that more reasonable adult targets for Wanapum and Priest Rapids Reservoirs may be in the neighborhood of 1000 and 300 adults, respectively. However, for the purposes of rapidly building up the population in the reservoirs to achieve the desired goal of the WSMP (to promote growth of the white sturgeon population in the Priest Rapids Project area to a level that is commensurate with the available habitat by year 30 of the New License), adult target numbers of 3,000 and 1,000 for Wanapum and Priest Rapids respectively, have been used for the baseline estimates provided below.

2.3 Production Goals

The annual production goals established in 2003 for the Project area were based on an average production target of 10,000 sub-yearlings for the two Reservoirs combined. This value was derived from the Upper Columbia River and the Kootenai River White Sturgeon Recovery Plans. The use of production goals for the Project area that approximated those of the two other supplementation/recovery programs currently underway in the Columbia River Basin was considered a reasonable target for use in the initial conceptual planning stage. In addition, the original stocking targets were based on information from WDFW and BCMOE stating that the annual natural mortality rate for white sturgeon in the wild is 10%. Additional assumptions included a conservative estimate of 30 years for female maturation and a 1:1 male-to-female ratio in surviving hatchery-reared juveniles.

The following model scenario outputs are based on the best information available on the white sturgeon life history metrics that are the required inputs to the model. The main management input (initial stocking number) is likely higher than needed to achieve adult population levels commensurate with reservoir carrying capacity. However, other recovery programs have recognized the need to "jump-start" populations in order to rapidly replace or supplement natural recruitment and build a future population of adults as soon as possible. These programs have therefore, been heavily front loaded in terms of juvenile releases with the understanding that, if subsequent monitoring indicates density-dependent effects on growth or survival, that stocking levels can be reduced and, if needed, a directed harvest fishery can be implemented to reduce population levels.

Juvenile release targets can be achieved by using a single pair mating (one male and one female spawning pair). The fecundity, fertility and survival of a single spawning event far exceed the juvenile stocking requirements. However simplistic this immediate answer may seem, it underscores the problematic structure of sturgeon recovery programs. The WSMP calls for the release of 1,500 and 5,000 juvenile sturgeon per year for five years into the Priest Rapids and Wanapum reservoirs, respectively. The broodstock management plan is based on the premise that to maintain an acceptable effective breeding population to achieve these release targets, six male and six female spawning sturgeon will have to contribute to the construction of six maternal families that are derived from a partial factorial mating design. To achieve the objective of six successfully spawning fish of each sex, eight male and female fish in spawning condition will need be caught and retained in the hatchery per year for the first five years.

Previous work by Golder (2003) has determined and reported that the estimated breeding population of the Priest Rapids area to be 150 adults of approximately equal male/female ratio. Of the 75 fish of each sex, the spawning periodicity is predicted to be once in five years or 13 male and 13 female spawners each year. The capture of 25% of this available population is possible and thus, capture and transport of three males and three females in spawning condition will be attempted. Only two female and two male spawning fish are required to meet targets, but experience in other programs has indicated that an additional spawning pair should be taken as a contingency against unforeseen circumstances. Similarly, the Wanapum Reservoir is estimated to contain 550 fish of which 80% are thought to be adult; with a spawning periodicity of five years, this would yield 44 male and 44 female spawning sturgeon per year. Therefore, to fulfill the requirement of stocking 5,000 juvenile per year, four male and female would be required to be successfully spawned and the offspring raised for release. Likewise for contingency purposes, five male and five female mature sturgeon would be caught and transported to the hatchery for spawning. In total, eight male and eight female mature sturgeon will be captured in the project area and transported to the hatchery where the combined spawning events will produce a total of 6,500 juvenile sturgeon for release.

Fish from the PRPA are considered to be one genetic stock. Therefore, in the breeding design, incubation and rearing stages of the hatchery program, offspring from both project areas will be out-crossed and combined. In addition, if more fish are required in any given year, the option to capture these fish from the Columbia River below Priest Rapids Dam is also an option. This practice will further assure greater genetic diversity among the progeny. At release there will be no distinction of which maternal family is released into either waterway; both reservoirs will receive an equal proportion of all maternal families.

The numbers of spawners required for broodstock represent 15% of the Priest Rapids Reservoir spawner population and 9% of the Wanapum Reservoir spawner population. The capture of a maximum of 15% available spawners does not impact the potential for natural recruitment while at the same time maximizes the genetic potential of the population by using a partial factorial mating design. By capturing only 16 (10%) of a predicted total of 163 mature fish from the two areas and considering a <10% mortality of the adult population of 150 for the Priest Rapids and 440 for the Wanapum reservoirs, the breeding population potential of the project area will be unaffected by the temporary removal of 16 spawning fish per year. Furthermore, it is unlikely that repeat use of spawning pairs will be done owing to the low percentage of the spawning year class (10%), the time period for which eight fish will be removed (10 years; management plan) and records (tagging) of spawning fish. In all, it is highly probable that as intended, the genetic and biological integrity of the project area's breeding population of sturgeon will be bolstered by this program.

2.4 Population Model Scenarios

Population trajectories were modeled for the white sturgeon populations in Priest Rapids and Wanapum Reservoirs with a simple age-structure demographic model using: i) hypothetical hatchery and wild sturgeon recruitment rates; ii) current data on abundance, growth, maturation, and juvenile and adult survival; iii) the assumptions outlined above in Part B, Section 2.3; and iv) assumptions inherent in the most recent version of the model developed by the UCRWSRI in 2008. The following scenarios represent expected population responses to supplementation measures (i.e., releasing hatchery-raised juveniles into Priest Rapids and the Wanapum Reservoirs). Through several model scenarios, it was determined that approximately 30 years was the minimum amount of time required to increase the white sturgeon population to a level that may be appropriate for the size of these reservoirs (i.e., adult populations of approximately 3,000 and 1,000 individuals for Wanapum and Priest Rapids Reservoirs, respectively). Because of the approximate 25 to 30 year age until full maturation (assumed to be age-25 for the baseline model), the existing adult population is projected to decline to very low numbers over the next 30 years even with the immediate release of hatchery-reared juveniles. After this period, adult numbers build as hatchery sturgeon mature and continue to supplement the adult population. A key parameter that determines the subsequent status of the population is the number of natural recruits produced by the hatchery-origin adults. This annual recruitment value is unknown at this time, so this input was arbitrarily adjusted to the number required to maintain a stable adult population at the specified target level.

Population trajectories modeled for Priest Rapids and the Wanapum Reservoirs are illustrated below only for the baseline scenarios. The results of other model runs to determine effects on changes to model assumptions of sub-adult harvest and age-at-maturity are discussed.

2.4.1 Priest Rapids Reservoir – Baseline Population

A baseline scenario was modeled based on the survival assumptions stated in Part B, Section 2.4 and the following assumptions: an initial population of 150 fish, 0 natural recruits per year, an initial stocking rate of 1,500 juveniles per year for the first 5 years (commencing in 2010) followed by a reduction to 450 juveniles annually for the next 30 years, and females maturing at age-25. This produced an initial population of approximately 670 adults by 2040, with a subsequent rise in population to a maximum of approximately 1,000 adults in 2060 (Figure 2). Assuming a 1:1 sex ratio of fish surviving to adulthood, approximately half of the adults would be mature females of which about 60 would spawn in any given year (assuming a 5-year spawning interval for females) by 2040 and 90 by 2060 (Figure 3). Restoration of a stable sturgeon age distribution for this scenario can be expected in approximately 50 years based on a natural recruitment rate after 30 years of 450 age-1 fish annually (Figure 4).

Implementation of this type of stepped population development structure may be more advisable than attempting to attain the 1,000 adult target level for Priest Rapids Reservoir in the same time frame as is achieved under this scenario for the production of 500 adults. This approach would allow the collection of data needed to assess growth and survival of fish from the initial supplementation and adjust future stocking rates as needed to achieve the overall management goal.

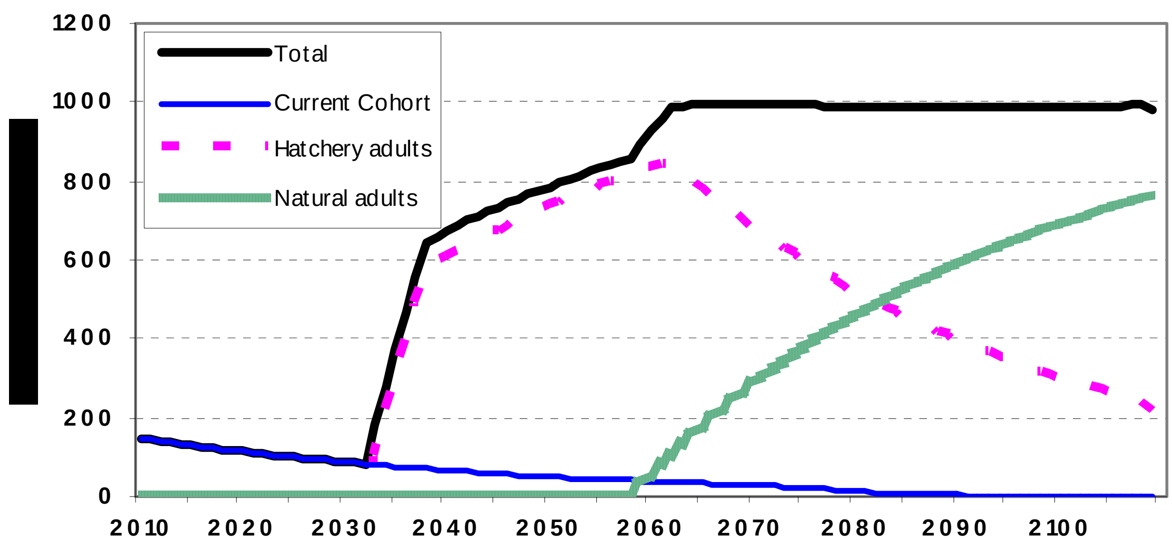


Figure 2 Projected future wild and hatchery adult white sturgeon population size following implementation of a baseline supplementation scenario at Priest Rapids Reservoir

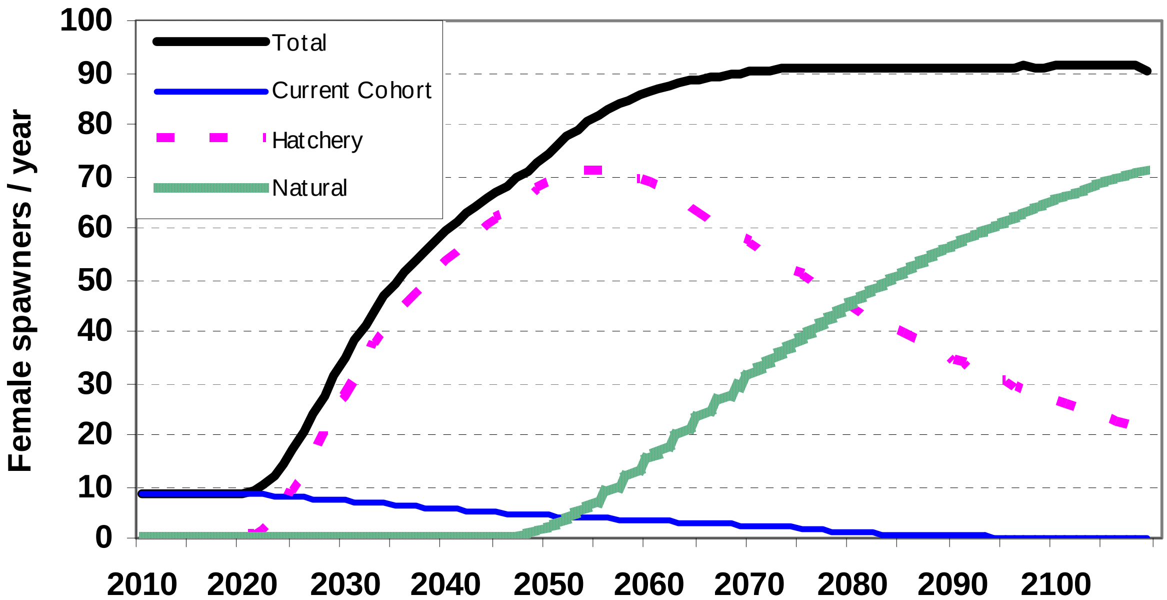


Figure 3 **Projected future reproductive potential of white sturgeon following implementation of a baseline supplementation scenario in Priest Rapids Reservoir**

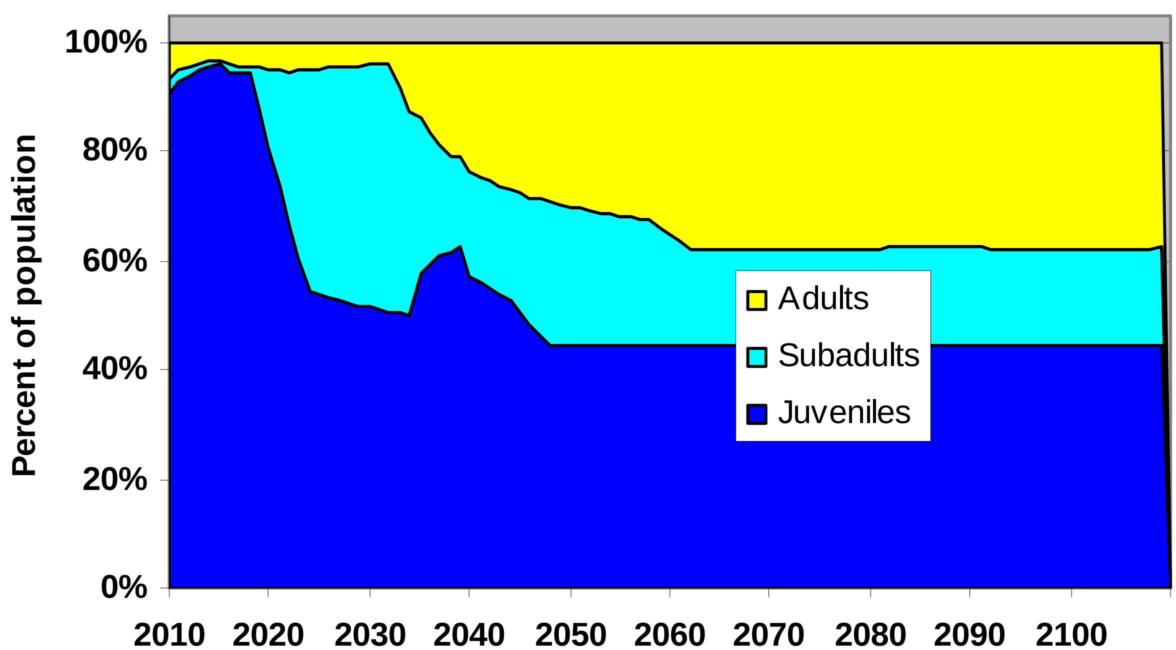


Figure 4 **Projected changes in sturgeon age composition following implementation of a baseline supplementation scenario in Priest Rapids Reservoir**

2.4.1.1 Sub-adult Harvest

Implementing a 5% annual harvest commencing 10 years after the initial stocking and targeting the 100 – 150 cm FL size-class (pre-spawners), would result in a maximum population size of 900 adults. If this harvest were increased to 10% for this size class, total maximum population would be approximately 800 adults. Both these estimates assume constant rates of stocking until year 35 and constant levels of natural recruitment after this point. This example illustrates how controlled harvest for sub-adults can be used to adjust future population targets of adult white sturgeon.

2.4.2 Wanapum Reservoir

2.4.2.1 Baseline Population

A baseline scenario was modeled based on the survival assumptions stated in Part B, Section 2.4 and the following assumptions: an initial population of 550 fish, 25 natural recruits per year, an initial stocking rate of 5,000 juveniles per year for the first 5 years (commencing in 2010) followed by a reduction to 1,300 juveniles annually for the next 30 years, and females maturing at age-25. This produced an initial population of approximately 2,000 adults by 2040, with a subsequent rise in population to a maximum of approximately 3,000 adults in 2060 (Figure 5). Assuming a 1:1 sex ratio of fish surviving to adulthood, approximately half of the adults would be mature females of which about 175 would spawn in any given year (assuming a 5-year spawning interval for females) by 2040 and a maximum of 260 spawning females by 2070 (Figure 6). Restoration of a stable sturgeon age distribution for this scenario can be expected in approximately 50 years based on a natural recruitment rate after 30 years of 1,300 fish annually (Figure 7).

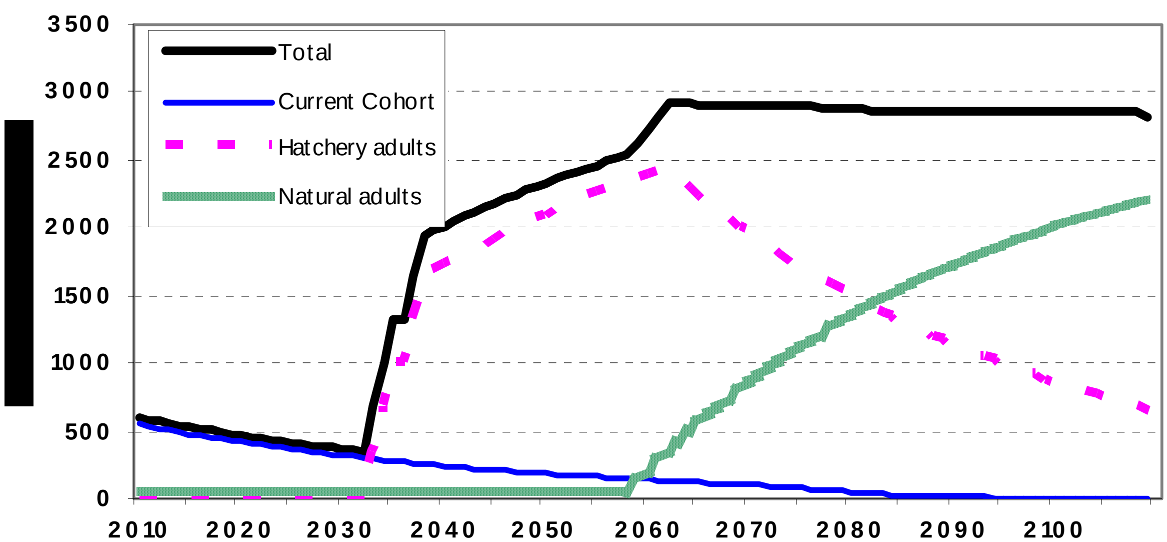


Figure 5 Projected future wild and hatchery adult white sturgeon population size following implementation of a baseline supplementation scenario in Wanapum Reservoir

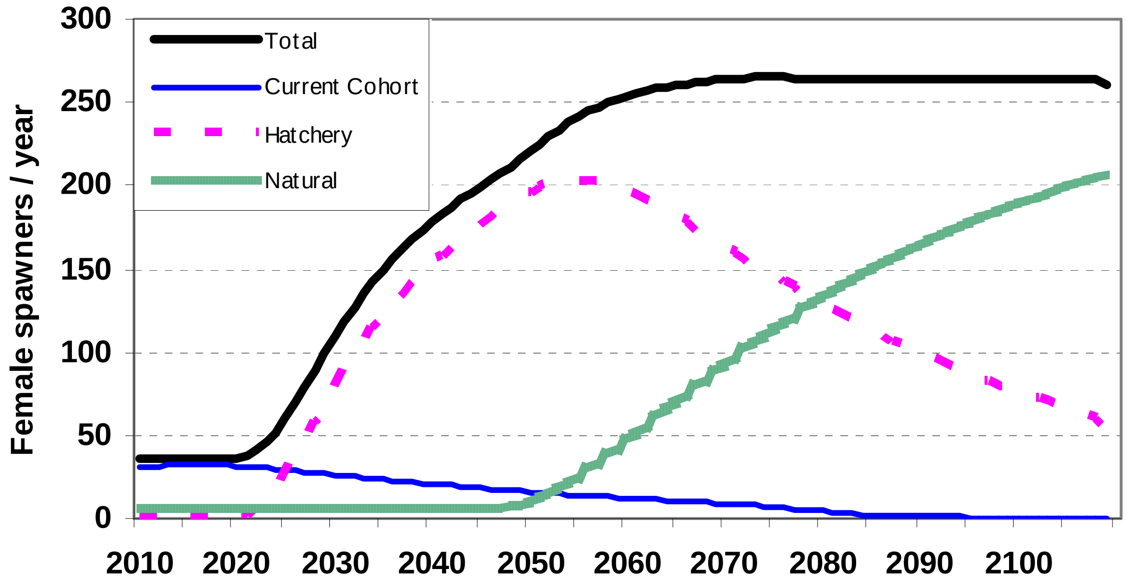


Figure 6 **Projected future reproductive potential of white sturgeon following implementation of a baseline supplementation scenario in Wanapum Reservoir**

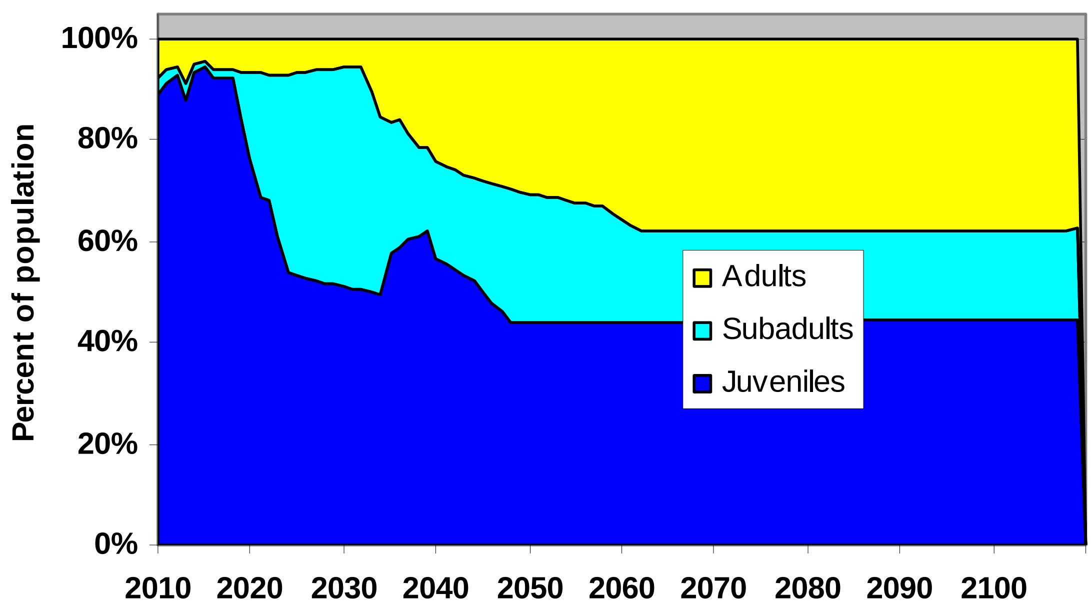


Figure 7 **Projected changes in sturgeon age composition following implementation of a baseline supplementation scenario in Wanapum Reservoir.**

Implementation of this type of stepped population development structure may be more advisable that attempting to attain the 3,000 adult target for Wanapum Reservoir in the same time frame as is achieved under this scenario for the production of 2000 adults. This approach will allow the collection of data needed to assess growth and survival of fish from the initial supplementation and adjust future stocking rates as needed to achieve the management goal.

2.4.2.2 Sub-adult Harvest

Implementing a 5% annual harvest commencing 10 years after the initial stocking and targeting the 100 – 150 cm FL size-class (pre-spawners), would result in a maximum population size of 2,500 adults. If this harvest were increased to 10% for this size class, total maximum population would be approximately 2,100 adults. Both these estimates assume constant rates of stocking until year 35 and constant levels of natural recruitment after this point. This illustrates how controlled harvest for sub-adults can be used to adjust future population targets of adult white sturgeon.

2.5 Age and Size at Release

The size at which to release juvenile sturgeon back into the wild is still the subject of study. U.S. Geological Survey (USGS) research indicates that juvenile sturgeon susceptibility to predation declines after they reach a length of approximately 15 cm (Mike Parsley, USGS, pers. comm., 2003). Rearing fish to a minimum of 15 cm requires from between 6 and 12 months depending upon water temperature. Preliminary studies on the Kootenai River indicate that size and condition of recaptured hatchery-reared fish was independent of differences in size or condition at release (Ireland et al. 2003). However, not enough information was available to determine minimum size requirements for release of hatchery-reared juveniles. Specific benefits of extended hatchery-based rearing have been suggested by Casey et al. (in review) who examined stocking levels and size-at-release of juveniles in the Kootenai River. These studies strongly suggested density and size dependent mortality effects on hatchery reared juvenile white sturgeon, which led to a recommendation to implement management actions that prioritize the release of fewer, larger size fish to improve first year survival rates and subsequent recruitment to the spawning-age population. Additional information on size-at-release effects will likely be obtained through experiments presently being conducted or proposed by the Kootenai and Upper Columbia recovery programs. For the purpose of this WSMP, it was assumed juveniles would be held for up to one full year at the hatchery prior to release, consistent with hatchery programs on the Kootenai and upper Columbia rivers. This assumption means that juveniles would be held concurrent with adult broodstock and therefore, separate holding facilities/structures would be required for each.

3.0 Genetic Considerations

The genetic integrity of wild sturgeon populations is an important consideration in any recovery program involving hatchery supplementation. Compared to salmon enhancement, white sturgeon aquaculture in the Columbia Basin is relatively new and as a result, policies regarding genetic issues and collection of broodstock are still being developed. At present, existing hatcheries use locally obtained broodstock, which is considered the most desirable practice from a regulatory perspective (Brad James, WDFW, pers. comm. 2002). Similarly for the WSMP, the preferred option is to collected broodstock from the Priest Rapids and the Wanapum Reservoirs. In the past, WDFW collected sturgeon broodstock from the McNary Reservoir as part of a cooperative aquaculture program with CRITFC in order to provide fish for planned experimental out-plants into the Rock Island Reservoir (Brad Cady and Brad James, WDFW, and Blaine Parker, CRITFC, pers. comm., 2003). Based upon this precedent, if target numbers of fish in spawning condition cannot be captured in the Priest Rapids and the Wanapum Reservoirs, a second option in the WSMP may be to collect broodstock from McNary Reservoir where adult white sturgeon are more abundant. This may serve to reduce the sample effort (and associated costs) expended to obtain the required numbers of broodstock from the smaller population within the project area. Furthermore, the sturgeon population in the middle Columbia River downstream from Rock Island Dam and the lower Columbia River below Bonneville Dam may be part of one large meta-population (Anders and Powell 2001). If so, this would mean that broodstock could potentially be collected from areas that support the highest population densities, such as from below Bonneville Dam where the population is considered to be quite healthy. Additionally, the Yakama Nation is currently evaluating the genetics of broodstock and recent offspring that are currently in captivity at Yakama Nation white sturgeon facilities. Use of these fish as broodstock, as either a short-term or long-term option, is being considered.

In the past, white sturgeon progeny reared at the Kootenay Trout and Sturgeon Hatchery and the Kootenai Sturgeon Hatchery facilities were held separately based upon parentage to maintain genetic distinctiveness while under hatchery care. Familial segregation was maintained until the juvenile fish were large enough to be PIT- tagged (approximately 30 to 45 g), at which point the families were combined. This segregation of family groups at the hatchery required additional holding capacity. Currently, hatchery practices in the Kootenay and Kootenai hatcheries have adopted a maternal family-based program where family lines are drawn from a single female's offspring that uses several sires (see below). There is increasing recognition among sturgeon researchers that available or projected future monitoring information such as DNA evidence will likely be insufficient to adequately assess family-specific performance following release. Furthermore, concerns related to future sibling matings in the hatchery (after first generation hatchery fish mature) can be avoided by not pairing fish from the same year class (year classes will remain identifiable from marks and tags). This is additionally served by using the factorial mating scheme described below to ensure genetic diversity within the cultured sturgeon population.

After a review of breeding plans, both the Kootenai and Upper Columbia hatchery programs now use mixed family rearing. This reduces additional holding capacity requirements and the potential for undesirable hatchery selectivity associated with culling. Mixing families allows for more efficient use of hatchery space and a greater ability to grade fish of different sizes and increase the growth of the smaller fish in each family. Culling based on size is avoided and potential post-release survival differences of different-sized fish are also avoided. Culling can occur at younger ages and smaller sizes where it is more likely to be random. These practices marry fish culture capability and preserve genetic diversity within the wild populations.

For the purpose of the WSMP, the holding capacity of the required hatchery facility and associated cost estimates are based on the following assumptions:

- Capacity for a maximum of 12 adult white sturgeon (six male, six female) to be used annually for broodstock. Preference and priority would be collection of these fish from Priest Rapids and Wanapum reservoirs, although other collection sites and broodstock sources are likely to be considered as appropriate options.
- Full or partial factorial mating design;
- Male broodstock will be held separately from female broodstock ;

- The progeny will be divided into a maximum of six families (1,700 progeny from each family for a total of 10,000 juveniles);
- The progeny from each family will be held separately and raised for 8 to 12 months; and,
- All fish will be marked with a PIT tag and a secondary mark (scute removal) prior to release.

4.0 Hatchery Practices

Development of a conceptual plan for a white sturgeon hatchery requires a basic understanding of sturgeon aquaculture procedures. These are outlined below and have been derived largely from current practices employed at the Nechako, Mid and Upper Columbia River white sturgeon recovery initiatives.

4.1 Broodstock Collection

White sturgeon broodstock are best collected directly from the spawning grounds during the spring spawning migration when both male and female fish are mature. During this period, pre-spawn fish typically congregate in defined staging areas before final maturation begins and fish move to spawning areas. In comparison to brood capture earlier in the season, fewer fish need be captured and assessed for maturation in the staging areas due to the higher percentage of mature fish. This strategy is currently used to obtain broodstock for the Columbia, Kootenai and Nechako recovery initiatives and for a commercial white sturgeon hatchery (Pelfrey's Sturgeon Hatchery). Near mature broodstock are captured in the spring (end of May) using set lines set overnight or by angling in areas of known staging. Some operators use gill nets in the Bonneville Dam tailrace area and captured fish are held for approximately 3 weeks to support this program (Henry Pelfrey, Pelfrey's Sturgeon Hatchery, pers. comm. 2002). However, set lines using circle hooks and up to 50 ‘rigs’ are preferred because they limit damage to the fish and allow for respiration while being retained. Detailed broodstock collection and handling protocols are provided in Appendix A.

Collection and long-term holding of wild broodstock for involvement in captive breeding programs is also an option. These broodstock can be collected by the methods described above during the fall or winter prior to the following spring/summer spawning period. When collecting broodstock from non-spawning areas, large numbers must be captured and examined to obtain sufficient mature sturgeon that have the potential to spawn within 6 months of capture. This strategy was used for an experimental white sturgeon propagation program run jointly by WDFW and CRITFC in the middle Columbia River. In this program, non-ripe sturgeon broodstock were collected from the McNary Reservoir using baited set-lines then held for several months at McNary Dam (Brad Cady and Brad James, WDFW, and Blaine Parker, CRITFC, pers. comm. 2002). In consideration of all sources and methods to acquire broodstock and/or seed, there are four suggested methods.

1. Self-sufficiency: Capture the required mature fish in spawning condition from the project area waters, transport them to the hatchery, spawn them and return them to the reservoirs.

2. Augmentation: Capture some mature fish in spawning condition in the project area waters, transport them to the hatchery, spawn them and return them to the

reservoirs. To meet the egg quota, augment the number of either adults or eggs from above or below the project area by either capture of adults or source eggs from other recovery facilities.

3. Purchase: Acquire seed as in Item 2 above and make up any shortfall by purchasing commercial-source eggs.

4. Captive broodstock: Reach quota by any of the means above and retain spawned fish, recondition these fish and hold in perpetuity for seed source. Alternatively, capture fish during the calendar year and if they are of a sufficient size and age, hold these fish until they mature, spawn in captivity, and release after spawning.

Self-sufficiency is the preferred mechanism and is the standard by which other methods of obtaining broodstock seed are measured. It is widely accepted that a natural diet and ambient water conditions are best for maturing fish to yield high-quality eggs. Conversely, fish reared in captive conservation breeding programs may be compromised in their fitness and potentially artificially adapted to the captive environment (Frankham, 2008). This risk needs to be considered relative to conservation goals. .Further, the Upper Columbia White Sturgeon Recovery Initiative Technical Working Group has demonstrated that final maturation and egg quality is negatively impacted by early spring capture followed by several months of captivity prior to the normal spawning period. Fish captured within a month of the natural spawning event have an increased chance of completing final gonad maturation and a decreased risk of gonad reversion and loss of spawning potential, although this still may happen in some cases. Therefore, the most desired practice is capture mature fish in staging areas or on the spawning grounds and transfer these fish to the hatchery.

By using local waters as the main source of annual brood and seed supply, returning brood fish to the receiving waters also assists with maximizing natural production. During the hatchery procedures, female fish are not depleted of all their eggs. When female fish are returned quickly to local waters, they retain the ability to spawn further in the season and potentially contribute to natural recruitment. This is not possible in other scenarios.

In concern for fish health, it is advisable from a biosecurity standpoint to not hold adult, larvae and juvenile fish in a single facility on the same water supply and drainage. By capturing and returning adult fish, the exposure risk of naive fish to pathogens which may be present on or in immuno-competant adult fish is decreased. In addition, the stress of prolonged captivity on adult fish is known to weaken fish immune systems, thereby increasing the risk that long-held adult fish could act as vectors to younger, naive fish. By limiting the length of exposure of the incoming adults to the hatchery environment, fish health risks are mitigated by appropriate biosecurity measures. In terms of the adult fish, replacement to the natural environment and natural feeding mitigates the risk of immuno-compromising adult fish through stress of prolonged captivity.

Finally, there are considerable labor and infrastructure savings to be realized by returning adults quickly to the project area waters. When adult fish do not require labor and space, more attention can be paid to the tasks of incubation and preparation for early larval rearing. In addition, there is a biosecurity risk of staff caring for recovering or captive broodstock and then changing tasks to attend to eggs and larvae.

The above scenario of obtaining brood and seed, namely capturing fish in late maturation, spawning fish and an expedient return to natal waters, optimizes conditions for the adult fish, the progeny, the hatchery and the natural environment. It is the least demanding and most cost effective from a financial and natural perspective. However, a system that relies on a long-term self-sustaining brood supply is incumbent on first determining the abundance and availability of broodstock in the project area. This can be determined by assessment and monitoring of the standing population as suggested in Part C of this document. Early indications are favorable that the abundance of candidate fish will be sufficient to meet broodstock collection requirements from local waters (Golder, 2003).

The decision to adopt the Augmentation method rests on an accurate assessment of the breeding population potential and the obtaining of six male and six female fish in spawning condition each spring. Should the assessment figures indicate that collection quotas are unlikely to be met or the failure to capture brood candidates occurs in a given year, the Augmentation scenario should be implemented. Implicit in this is that provisions for augmenting seed supply are accounted for in the broodstock management plan. That is, there are predetermined steps that hatchery staff can take should broodstock or egg supply be insufficient. This can occur in advance, such as: a) when *in situ* brood assessments come back with unfavorable predictions (low brood of the year numbers) or b) during the failure of the capture crew to obtain fish or c) low productivity from spawning candidates (regression, atresia, low fecundity, low fertility, *et cetera*). Should any of these conditions occur, an augmentation plan should be in place that enables the hatchery staff to access a continued supply of juvenile yearling fish for release into the project area.

Augmentation plans can take many forms. These can range from pre-determined capture sites up- or down-stream of the study area to a resource sharing agreements with other Columbia white sturgeon facilities that encompass the collection or production of gametes, juveniles or adults. It is putatively accepted that the Mid Columbia white sturgeon population is in effect, one population of a single genetic origin. That is, populations separated by anthropogenic barriers like dams are not genetically distinct; sharing white sturgeon gametes among sturgeon recovery facilities does not constitute a threat to genetic distinctiveness of the stocks. Therefore, trading or sharing gametes, juveniles or adults for replacement into the project area does not confer a genetic risk to the population. Indeed, sharing sturgeon genetic materials between facilities serves to broaden any genetic bottleneck and introduce alternative sources of genetic diversity.

In the first case where an assessment of broodstock (adult) population abundance suggests that maturing fish will be in short supply, the project hatchery staff need make arrangements with up- or down-stream facilities to pool resources and ensure that targets of up to 10,000 juveniles per year can be grown for release from the facility. As a rule of thumb, the staff of the Kootenay Sturgeon Hatchery (KSH) of the Freshwater Fisheries Society of BC obtains approximately 200,000 – 250,000 green eggs from six female sturgeon to produce 150,000 hatched eggs for further production of 4,000 juveniles per family that with further culling are reduced to 1,500 fish per family for final release to the Columbia River. In following this scenario, hatchery staff should be prepared to have advance arrangements with adjacent facilities to secure up to 250,000 eggs from six maternal families. If males are plentiful and produce viable milt, project area fish can supply milt for fertilization of the eggs. Conversely, there may be need for milt only if females are plentiful and the gamete sourcing arrangement should be flexible to accommodate this scenario.

As an additional precaution to an event that may compromise release targets, the Kootenai Tribe of Idaho Hatchery in Idaho take the measure of having the Kootenay Sturgeon Hatchery in British Columbia rear a duplicate population of juvenile sturgeon at the facilities of the latter hatchery. This is to ensure supply should some catastrophic or biological event decimate the Kootenai hatchery. In the Mid Columbia, it may be advisable to cultivate relationships with other sturgeon hatcheries to rear juveniles in abundance in case of unforeseen events.

The acquisition of mature, near-spawn brood has been thus far concerned with collection from the immediate project area. To determine the feasibility of this approach, a broodstock abundance assessment will be conducted above and below the PRPA (see Part C). Should this study indicate brood fish cannot be acquired in the PRPA, it may be possible to capture, transport and spawn fish from other adjacent areas. If the occasion should arise that capture efforts or broodstock abundance does not meet the need for egg supply, mature sturgeon from outside the immediate project area could be caught and transported to the hatchery and used as per their local counterparts.

Again, there are two decision points for determining the need to augment sturgeon brood and seed supplies from areas outside the project area. These are an unfavorable assessment of mature fish abundance within the PRPA or failure at the time of brood capture to secure enough mature fish for the project needs. In the first case a plan to acquire gametes to fill stocking requirements need be designed, negotiated and secured in advance. A first stage of this action would be to increase fishing efforts and broaden the area of brood capture to secure the required number of brood fish, followed by a plan to acquire eggs and milt from other sources on the Columbia should the first actions fail. In the latter case, a contingency plan to broaden the area of brood capture would first be enacted followed by a default to the first case where additional sources of gametes would be used. In either situation, a fail-safe supply of gametes need be identified in advance.

The purchase of white sturgeon eggs from private sources cannot be ruled out as means of meeting the production needs of the hatchery. These offspring might be considered semi-domestic or of compromised genetic contribution to the wild populations due to the captive nature their progenitors. This supposition would need to be determined by more in-depth analysis before commercial sources of seed were used. In addition, health checks on contributing male and female spawners should be mandatory to preserve biosecurity measures of the project facility. Sourcing of commercially-produced eggs should be considered to a second-order contingency to sourcing of wild sturgeon eggs.

Captive broodstock are an alternative source for securing gamete supply. However, egg quality needs to be monitored as past work has shown that egg quality, particularly marine source Omega-3 fatty acid content can vary with feed source (Gessner et al. 2008; Caprino, et al. 2008) and can differ between wild and captive stocks (Chen et al. 1994). Furthermore, care must be taken in consideration of genetic effects of adaptation to the captive environment when rearing brood fish for extended periods, particularly as the offspring will be released to the wild

(Frankham 2008). For these reasons, captive brood can be considered secondarily to a wild source supply for seed.

Adult white sturgeon require changing environmental conditions and habitats to optimize growth and development of high-quality gametes. These exact conditions are still largely unknown for wild white sturgeon and cannot be supplied in their entirety in an artificial setting of a hatchery tank. There is an undeniable health risk to wild-caught adult sturgeon imposed by continuous captivation from starvation, infection, stressed-induced immuno-suppression, fin and pelvic/pectoral girdle wear and a host of other pathogens or conditions. Further, little is known of the dietary requirements of maturing white sturgeon and these diets may or may not be able to be duplicated in such a fashion as to grow and yield the high-quality gametes required by this program. While it is biologically possible to keep wild white sturgeon in captivity and have them reproduce after several years in captivity, it may be considered by some groups to be ethically irresponsible to treat threatened and endangered fish in this manner.

Captive broodstock programs are practiced at some facilities in the Columbia River basin, (e.g., Yakima Nation facilities), but these holding conditions have been determined specifically for each facility; the learning curve for the current program would be steep. It may be more propitious to seek an agreement with current captive broodstock programs to supply gametes rather than to build an additional captive broodstock facility. From a genetics perspective, out-crossing milt or eggs from captive brood facilities may be considered as a means to increase the effective breeding population in the event of a gamete shortfall.

Captive sturgeon can assume a three to five year breeding cycle that can be interrupted by any number of events. Should prospective spawning adult fish be removed from the natural system and placed in tanks, the spawning cycle of the fish could be interrupted or delayed. This would mean assuming a restrictive pressure on genetic diversity to the effective breeding population as a whole. Further, near-spawning wild caught fish held in captivity for short periods generally have superior gamete quality and fecundity compared to fish held for long periods in captivity. By placing fish in captivity for long periods, there is a risk to gamete quality that can have profound effects throughout the subsequent production cycle.

The physical plant required to hold captive broodstock can more than double the demands for water supply, floor space and labor. A simple comparison of biomass production for larvae or juvenile sturgeon compared to holding adult sturgeon gives the following:

- 6,500 – 10,000 50 g juveniles at release (500 kg biomass) held at a density of 35 kg/m3 yields 14 m3 of volume required at release
- At peak biomass before culls (750 kg biomass) the volume needed is about 20 m3, the equivalent of two 8 foot tanks.

Obviously, the six pre-spawning females at 80-120kg each would not fit into two eight foot circular tanks and production of six families requires six eight foot tanks, but the point is apparent: broodstock need room and water flow. In addition, captive broodstock are held for repetitive years, which further increases physical plant demands.

In summary, clearly it is prudent and parsimonious as a first step to assess the feasibility of broodstock capture from the PRPA and develop a self-sustaining spawn and return program. This notwithstanding, contingency plans for the acquisition of spawning adults and gametes should also be made, whether from public or private sources. In addition, it is likewise prudent to plan and consider that situations may dictate that a captive breeding program may have to be developed and implemented.

4.1.1 Capture

White sturgeon do not exhibit sexual dimorphism; therefore, both sex and maturation status must be determined via physical examination at capture. With practice, capture crews become adept at identifying candidates for spawning by subtle external signs of abdominal roundness, size, and changes in the vent. Until this time, individual spawning candidates collected from spawning areas must be assessed using surgical examination. Male sturgeon captured on spawning staging areas are assessed as candidates by the presence of flowing milt. Commonly, male fish are more abundant in these areas, are easier to catch and to check for maturity. The maturation state of the female gonad is determined by biopsy; an incision through the abdominal wall and viewing the gonad using an otoscope (see Appendix A). By this method, only ripe, or late-stage maturing fish are transported to the hatchery for holding, inducing, and spawning. As well, mature (running milt) males are transported to the hatchery in numbers greater than their female counterparts. These practices have been shown to increase the number of successful spawning events in the upper Columbia, Nechako and Kootenai sturgeon hatcheries and maximize genetic variability of the offspring.

Confirmation of the preliminary assessment for egg development in captured females is done by examining the polarization index (PI) of the nucleus in eggs sampled at the time of biopsy. In this practice, eggs are boiled in Ringer's salt solution, cooled and sectioned along the midline of the egg across the animal-vegetal axis. The egg is then viewed under a dissecting microscope. This procedure is most commonly done after the fish is transported to the hatchery, but can be done on site if the equipment is available. A PI of less that 10% is considered ready to induce; typically females with eggs of a PI of 35% or lower are considered candidates for spawning within 30 days and are held in captivity for maturation.

Collection of additional females over and above the target number is encouraged. As the final stages of maturation can only be determined accurately through inspection of the PI, the capture, biopsy and collection of fish in excess of target numbers is advised. Some gonad regression is to be expected due to stress associated with capture, transport, and holding.

Handling and transport of large sturgeon in the field requires specialized equipment and operators. The most obvious equipment is the capture gear and the boat. The set lines and rigs are of a commercial quality commonly used in the halibut industry. The boat is of sufficient size to accommodate a working crew of 5-6 personnel on an open, working deck and equipped with a davit and winch to move captured fish. A stretcher for handling fish in and out of the water is attached to the davit and winch and is fitted with a cowl complete with couplings to permit water flow for gill irrigation when the fish is out of the water. Further discussion of the required equipment appears below (Part B, Section 3.3).

4.1.2 Spawner Assessment

A program to assess the adult population for growth, reproductive capacity, and to track spawning history is an essential component of the sturgeon recovery plan. This is accomplished by morphometric assessment and tagging. Sturgeon become complacent when placed in an inverted position (ventral side up) and with their head in darkness. This is done by using the stretcher fitted with a cowl and maintaining water flow over the gills. At this time, the fish is weighed by scale attached to the winch; length and pectoral girth are measured and recorded. Next, the fish is palpated to determine if it is a spermiating ('running') male or a female candidate. An incision is made in the ventral wall, adjacent to the third scute and midway between the midline and ventral scute line. The otoscope (below) is inserted through the incision and the state and type of the gonads are determined. If indicated, eggs are removed for PI determination. After the biopsy is complete, the incision is sutured closed using commercial sutures. Two scutes are removed from the lateral scute line corresponding to a pre-established code for future visual identification. A PIT-tag is inserted into the dorsal musculature and the alphanumeric code recorded for that fish. These identification methods will provide a life-long identifier for this fish and will allow tracking growth, reproductive history, and fish health. At this point, the fish is either held for transport to the hatchery or is released back to the water.

In the upper Columbia and Kootenai populations, the locations where spawners occur each year are putatively known and obtaining spawners is relatively straightforward (but not guaranteed) at present. The Kootenai program captures and holds only females at the hatchery facility; the males are captured on an as-needed basis during the spawning season with milt being collected on the river and transported to the hatchery. The upper Columbia breeding program captures both males and females and transports both to the hatchery for spawning. Flowing males are typically easier to obtain than ripe females. Work previously conducted in the Priest Rapids Project area supports the notion that there is a high likelihood that spawner capture will be successful and brood capture targets can be met.

Some spawning failures due to poor egg viability or the inability to stimulate ovulation have been experienced in both the upper Columbia and Kootenai programs. However, the practice of inspecting the maturation state of the female gonad by biopsy has increased the identification of fish with developing or viable ova. By this method, only ripe, or late-stage maturing fish are transported to the hatchery for holding, inducing and spawning. As well, only mature (running milt) males are transported to the hatchery in numbers greater than their female counterparts. These practices have been shown to increase the number of successful spawning events in the upper Columbia and Kootenai sturgeon hatcheries and maximize genetic variability of the offspring.

4.1.3 Transport

After capture and assessment on the river, male and female fish deemed to be in spawning condition and candidates for spawning are put back in the water with a tail noose that is attached to the boat rail to prevent escape, but permit respiration (Appendix A). Fish are kept in this condition until the boat can deliver the fish to a trailer-mounted transport tank. Fish are transferred to the transport tank using the stretcher, again with the fish in an inverted position.

The water in the tank is of river origin and is aerated or oxygenated. Salt (up to 10%) may be added to the transport water to relieve stress. Fish are transported to the hatchery immediately. Once at the hatchery, fish are transferred to holding tanks with water that is matched in temperature to the water of origin and transport water.

Sturgeon may be given a prophylactic salt treatment when they are first delivered to the hatchery facility to reduce stress-related effects. Broodstock do not have to be fed during captivity although male fish will take food if it is provided. Currently, only adult male broodstock are fed live fingerling trout at the Kootenay Sturgeon Hatchery (Ron Ek, FFSBC, pers. comm., 2008).

4.2 Hatchery Procedures

Sturgeon hatcheries may be required to deal with three categories of broodstock depending on the circumstances surrounding brood abundance: 1) wild-caught, ripe fish that are close to spawning, 2) wild-caught, non-ripe (‘green’) fish that require holding and further maturation in captivity and 3) juvenile hatchery-reared fish that are being raised as future broodstock (captive broodstock). The complexity and cost of holding these three categories of broodstock are incremental and relate to water availability, infrastructure, and labor. The need to increase culture capability is driven by access to wild mature fish in spawning condition and likewise dictates the dedication and commitment to more progressive complex infrastructure.

In addition to the duration of broodstock holding, three types of hatchery operations are indicated according to water quality, favorable environments to mature fish, and cost. These are: 1) flow through systems, 2) well-water systems and 3) re-circulating aquaculture systems (RAS). Flow-through systems are the most economical method provided the hatchery has a gravity fed supply of water. Water quality is not controlled and if temperature needs to be regulated for spawning or growth, heating the water becomes important as does heat recovery. Well water systems require a 24h power supply to maintain water flows and likewise require complex water delivery systems to ensure pressure, degassing of subsurface waters, and proper oxygenation. Water quality can be somewhat controlled with the injection of oxygen to maintain levels and by adding water conditioning chemicals to optimize hardness, pH, and dissolved minerals. RAS are closed-loop systems where up to 99% of the water used is recaptured, reconditioned, and reused. RAS provides optimal environments for fish culture to maximize growing conditions. Return on investment through savings of pumping cost and water treatment for a RAS is within 5-7 years, depending on the level of culture required.

Along the lines of holding captured broodstock, pre-spawning broodstock may also be collected during the fall or winter prior to the spring/summer spawning period. To reiterate, when collecting broodstock from non-spawning areas, large numbers must be captured and examined to obtain sufficient mature sturgeon that will spawn within 6 months of capture. In the Columbia Basin sturgeon hatchery programs it was formerly a common method to collect non-ripe broodstock in April and May. This method was likewise considered in the conceptual plan as a broodstock collection strategy. However, in the Upper and Mid Columbia programs, collecting spawning fish closer to the normal spawning period has been shown to substantially increase the numbers of fish successfully spawned and the quality of the spawn. As a result, current practices reflect that it is more effective and productive to hold fully-mature fish in captivity. These practices are discussed below.

Irrespective of the hatchery culture system used, water level and oxygen alarms are an integral part of any water delivery system. In addition, water quality testing equipment and the qualified staff to operate and service this equipment are required. To effectively manage the complexity of sturgeon culture and the water delivery systems, qualified staff are needed to operate the systems and care for the animals. In progression from flow through to RAS, staff training requirements are similar and do not increase in complexity, but the emphasis on equipment care and maintenance changes.

4.2.1 Spawning

Because of inherent differences in sperm and egg structure, physiology, and biochemistry, the techniques for fertilizing sturgeon eggs differ from those used with salmonids. In the hatchery, ovulation of female white sturgeon is induced by the administration of gonadotropin-releasing hormones once final egg maturation has been achieved (see below). In addition to hormonal treatment, male sturgeon are subjected to thermal treatment where the temperature of the water is increased to 17°C from ambient (usually 10°C) at the time they receive the LHRHa injection. The females are kept separate from males to prevent spontaneous spawning and to facilitate thermal/hormonal treatments and handling. Additional differences between salmonid and sturgeon gametes are that the mature ovum or sturgeon is heavily pigmented and approximately 3.7 to 4.0 mm in diameter, much smaller than salmon ova. In males, sturgeon sperm differ from salmonid sperm in a number of ways including morphology and a longer duration of motility.

A portion of the females selected during the primary field examination and held at the hatchery for further development may not progress to the ripe stage due to handling stress. Therefore, prior to choosing a female for spawning induction, a second biopsy is performed to determine final oocyte maturation. The progress of the PI values will indicate the readiness to induce spawning.

To spawn sturgeon successfully in captivity, individuals are induced to ovulate (females) or spermiate (males) with exogenous intramuscular hormone injections of luteinizing hormone releasing hormone analogue (LHRHa; D-Ala6-Pro9-NEt mGnRH). In females, spawning induction includes two injections of the hormone preparation; an initial loading dose is separated from the second resolving injection by 12 hours. Ovulation can be expected between 20 to 40 hours after the resolving injection depending on the size of the fish, maturation state and the water temperature.

Unlike female sturgeon, male fish can be brought into spawning condition repeatedly throughout the normal spawning season. This can be accomplished by a single intramuscular LHRHa injection given 24h prior to use, provided that the temperature of the holding water has been at 17°C for 72h prior.

Milt is extracted from males using a 30 or 50cc syringe and tubing inserted into the vent and withdrawing the milt in a measured volume. Milt is stored over ice in coolers or refrigerated in the dark until used. Eggs are first expressed from the vent to obtain fully ovulated, mature eggs. For hatchery programs that do not require large numbers of eggs, sufficient numbers may often be obtained through this method. If volumes of expressed eggs are not sufficient for target needs, more eggs can be obtained surgically. Once collected, eggs are drained of ovarian fluid and kept in a cool location away from contamination and are volumetrically apportioned into lots for later fertilization by individual males.

Milt may be collected several hours before fertilization but care must be taken to prevent contaminating the sperm with water or other contaminants. Milt samples are always examined for motility before use. Activation of sperm occurs on contact with water and once activated, the sperm must be used within a few seconds. Sturgeon ovarian fluid decreases fertilization rate and is therefore decanted prior to adding milt. The eggs are fertilized by adding the diluted milt solution directly to measured volumes of eggs in containers according to the breeding matrix (Table 3). The eggs are then stirred gently by hand for up to 3 minutes and then the de-adhesion process is begun. De-adhesion of fertilized sturgeon eggs is critical to prevent clumping. This is accomplished by occlusion of the sticky surface with Fuller's Earth (potter's clay). The solution is added to the egg container and stirred by hand or with a large feather until the eggs no longer stick to each other; this may take as long as 1 hour (see Part B, Section 3.2).

All broodstock should be permanently marked, sampled for tissue (for future DNA identification) and released back into the wild once they have been spawned. Work at the University of California at Davis (J. Van Eenennaam, pers comm.) and at the University of Florida, Gainesville (Chapman and Park 2005) describes that recovery and healing from invasive spawning (Caesarean section) begins within 48 hours. Fish need only be held for this period before release to the river to ensure against any adverse effects of treatment. Typically, supplementation programs requires only a small portion of the total number of eggs present in any given female; therefore, it is advisable to return the fish back into the river in spawning condition as quickly as possible. The return of a female sturgeon to the spawning area where she was captured while she is still in spawning condition serves to enhance the possibility of natural spawning and recruitment and increases the possibility of increased genetic diversity if the female spawns successfully with a male in a natural spawning event.

Given that white sturgeon have the potential to contribute to future generations throughout their life span, subsequently re-captured broodstock can be considered for broodstock after five years (Kincaid 1993) if no other fish are available. Ideally, no individual fish should be spawned more than twice throughout the duration of the program to ensure genetic contributions to the next generation are equalized as much as possible (Kincaid 1993). If this situation is not plausible in that large enough numbers of females are not available, or recaptured, or are new captures in successive years, repeat spawns can be considered provided females are not spawned with previous sires.

1.1.1. Fertilization

Timing is critical to the successful fertilization of white sturgeon eggs. Generally, sturgeon eggs must be fertilized by viable milt soon after they are harvested. To facilitate this, all equipment and protocols necessary to complete the steps leading to egg incubation must be understood and prepared in advance. Rapid and irreversible changes occur to both sperm and eggs upon contact with freshwater, e.g., hydration of the adhesive jelly layer and loss of motility in sperm once activated with diluent. To control these processes in the hatchery, gametes are collected without contacting water in clean containers and are kept free of contamination.

Once fertilized and exposed to ambient water, sturgeon eggs are adhesive. In nature, this serves to attach them to rocks and substrate in areas of high flow that have the best oxygen exchange and protection from predation. In the hatchery, this condition is not a benefit because of the intensive nature of egg incubation. Once fertilized, sturgeon eggs are mixed with Fuller's Earth to remove the adhesive nature of the egg and permit intensive culture in incubation. This treatment does not affect the fertility or survivability of the egg. This permits the egg to be exposed to oxygenated water in the confines of an incubation vessel.

After de-adhesion is finished, eggs are rinsed several times to remove any free clay particles. Eggs are then left to sit in disinfectant solution, commonly a pH-balanced iodophore solution for ten minutes. The eggs are rinsed further and are ready for incubation.

4.2.2 Incubation

The disinfected, cleaned, and fertilized eggs are transferred to vertical upwelling incubation containers called MacDonald jars. The jars are each loaded with the eggs of one cross of the breeding matrix (Table 3) that developmental stage. Each trough or tank will have the other remaining matrix crosses also emptying into them. Sturgeon eggs are highly susceptible to fungal infections and MacDonald jars provide gentle agitation to minimize fungal-related losses. Ultraviolet treatment of the water source is recommended to prevent fungal spores, hyphae, and bacteria from infecting the eggs.

At 4-6 hours post fertilization, a subsample of eggs can be removed and viewed under the dissecting microscope. The fertilized eggs will have reached the 4-8 cell stage and are clearly visible. The next milestone of development is neurulation where the primitive notochord (spine) is formed at about 8-9 days post fertilization. At this time, a sub-sample of eggs are removed (n=100) and enumerated for dead and viable. This percentage of neurulation is closely linked to the hatching percentage and is a benchmark of fertilization efficacy. Eggs remain in the incubation containers until hatching at about 14-17 days at which time newly hatched sturgeon larvae move upward and vertically in the water column to pass from the incubation containers to fry collection troughs or tanks.

The rate of embryonic development of white sturgeon is influenced by water temperature. Optimal temperatures in the range of 14 to 17°C reduce the time required for development but must remain within this range to permit normal egg to larval survival. External feeding begins approximately 10 days after hatching when the larvae measure approximately 23 mm. Larvae delivered to the tanks soon after hatching will generally swim freely throughout the water column.

4.2.3 Early Larvae

Early larval culture tanks may be circular or rectangular; circular self-cleaning tanks are preferred. Stocking density should be approximately 15 to 20 yolk sac fry/L. Culling is not usually necessary, but should be conducted to maintain a density of 3 to 5 g/L. Within 5 to 6 days after hatching, larvae will exhibit a strong negative phototaxic response and aggregate at the bottom of the tank. At this point, shrouds are placed over the troughs or tanks to provide darkened areas and refuge. Approximately 3 to 5 days after this transition from pelagic to benthic behavior, larval development is near completion and the fry begin exogenous feeding and disperse throughout the tank.

Sturgeon fingerling production is one of the most difficult aspects of the hatchery system. Once larvae absorb their yolk sacs, survival is dependent upon both the hatchery system and nutritional input. The presentation of feed should begin before yolk sac absorption is complete. Both prepared rations and natural feeds such as tubificid worms are commonly used to nourish sturgeon fry during the first two months. Feeding rates are typically 25% of the tanks total biomass every 24 hours partitioned into 2 to 3 hour intervals. Mechanical feeders are successfully used at sturgeon hatcheries and can result in a significant reduction in person-hours devoted to feeding fry. The early feeding period must be monitored continuously and feeding rates adjusted accordingly. Other critical periods occur during ration transitions.

4.2.4 Fish Health

Diseases observed in sturgeon hatchery programs include myxobacteriosis, columnaris, *Costia*, and external fungus. Treatments for these are identical to those used for salmonids. Outbreaks of white sturgeon Iridovirus have also been known to impact sturgeon hatchery programs in the Columbia Basin. Most diseases are waterborne in nature and if indicated, water treatment with UV, ozone or closed RAS may be employed once the pathogen load of the incoming water is determined. For reasons of biosecurity and differences in species susceptibility to common disease, it is strongly recommended that sturgeon culture be kept distinct and separate from salmonid culture. This includes buildings, equipment, and staff.

Fish husbandry over the course of fry development consists of routine feeding, cleaning, and observing the fish. Mortality levels in the populations will drop off and remain low after fish are up and feeding actively. At this point the fish can be moved onto successively larger commercial feeds as indicated. When mortalities are low and regular, the deformed and very small fish can be culled out from the population. When the fish reach a mass of greater than 15 grams, families can be equalized by culling randomly and prepared for release. At this point, fish are PIT tagged, weighed, measured and scute marked. At this stage of development the fish are usually robust and can tolerate repeated handling.

Generally, once fish reach a length of 15 cm they can be released into the natural environment. The overwintering of fish to a size greater than 100g dramatically increases their chances chance of survival. However, facility requirements to incorporate overwintering must be factored into the overall objectives of the plan.

4.3 Breeding Matrix

The following guidelines were initially adapted for the upper Columbia and Nechako Sturgeon Recovery Initiatives based on work done by Kincaid (1993) and reviewed by the Technical Working Groups of those initiatives. In this plan, families are formed based on maternal lines; a family is the sum of all crosses of one female fish irrespective of how many males contributed to fertilize her eggs. In practice, incubation units individually contain the eggs of one male by female cross and all the eggs for one female from a single spawning event fertilized by various males in the matrix; there are usually three to four incubation jars that empty into one primary incubation unit depending on the spawning matrix (see Table 3 below).

At hatching, half-sibs are immediately combined to form one family held in one incubation unit. Blending of families occurs much later in the lifecycle, usually at the time of equalizing families and PIT tagging just prior to release. Ideally, families are equalized (to plus or minus 20%) prior to blending to ensure equal genetic contribution of families to the next generation. The intention here is to maximize the genetic effective population size (N_e) which is particularly important when very limited genetic material is initially available.

By hatching out all of one female's eggs into a communal primary fry incubation unit and forming one family, the contribution of each male/female paring is conserved on a more or less equal basis. The rearing of individual sub-families based on single cross is not advised because small clutches of eggs and fry are difficult to rear and are under environmental selection pressures that are obviated by the above method.

In the factorial mating plan, families may not be completely equalized in number prior to release. As an example, to achieve 'complete equalization' in the case where one maternal family may have suffered losses due to disease or mishap and is below the release target, the other families would have to be culled to match the lower survival number of the impacted family. When combining juveniles prior to release, complete equalization by family will, in all cases, reduce the total number of fish available for release. This may compromise the objectives of a supplementation/recovery program by reducing the ability of monitoring programs to accurately determine post-release survival rates of hatchery-produced progeny released into the wild or may result in the failure to meet annual stocking targets required to achieve long-term population goals. Therefore, if a family is low on numbers compared to other families through disease or other losses, the other families are not culled to match the lowest common denominator. Factorial mating serves to compensate from minor losses among families.

4.3.1 Factorial Mating Scenarios

The following recommendations on mating scenarios for the Priest Rapids WSMP have been adopted from the breeding plan of the UCWSRI and Nechako White Sturgeon Recovery Initiative and assume that maturation of most fish can be synchronized with hormone injections and temperature manipulations. The factorial breeding plan for the WSMP calls for the spawning of six male and six female fish. It is unlikely that a full 6X6 factorial breeding plan can be accomplished at one spawning event given the biological and logistical implications. More likely is the two – 3X3 breeding matrices scenario described below.

Where brood capture is successful and at least three male and three female fish are retained to spawn at any one time, the partial factorial matrix shown in Table 3 will be employed. In a full factorial design, all six males would be crossed with all six females and *vice versa*. This would maximize genetic diversity in the breeding design. However, as Busack and Knudson (2007) note, a lesser increase in genetic gain for the breeding population potential is realized by a full factorial matrix increase of 5X5 to 10X10 than can be achieved by an increase from a 2X2 to a 5X5 matrix; the relationship of efficiency is not linear. They also note that in hatchery situations, large full factorial breeding matrices are often impractical. In the scenario where conservation release numbers are capped at the levels of thousands of juveniles, the practicality of dividing a single clutch of eggs into six even groups per female becomes difficult and onerous and small-batch handling effects may negatively influence survival outcomes; it is best to handle eggs effectively and safely to optimize results. To this end for the 6X6 breeding matrix is divided to two partial 3X3 matrices.

In Table 3, three female fish are spawned with each of three males and *vice versa*. If one or more females do not spawn at the same time, fertilization of her/their ova may be completed at a later date providing that the matrix is completed using all the males in the partial matrix. In the end, families will be grouped and cultured by maternal family and therefore there is no need to be temporally synchronized. In this regard, the milt from the male fish may have to be retained and stored under conditions that permit optimal fertilization in the final event, or the male will need to supply additional high-quality milt on a later occasion. If one or more males do not supply milt for a later spawning event to complete the matrix, the default position is to substitute male milt from other donors not currently in the matrix. Imperative here is the preservation of the genetic variability within the maternal family; of secondary importance is the completion of the full factorial matrix as written.

Table 3 Idealized partial factorial breeding design in a 6 female-by-6 male scenario resulting in the production of 6 discrete families and 18 half-sib families.

Female	1	2	3	4	5	6
Male 1						
Male 2						
Male 3						
Male 4						
Male 5						
Male 6						

4.3.2 Non-factorial Circumstances

The scenario where few fish in breeding condition are captured and retained in captivity, or where fish undergo gonad regression, fewer than three fish of either gender may be available. In this circumstance, the matrix should be followed as completely as possible to maximize the genetic diversity in the captive-bred fish. For example, if one of three female fish regress or fail to spawn, then the remaining two viable females should be crossed with the three males. This means a 2 female X 3 male matrix would be followed as opposed to a 2X2 matrix. Other subsequent female fish captured and induced to spawn will also be crossed with the three males to round out the breeding matrix, milt quality providing. In the case where only two female fish are captured or otherwise only two female fish are available to provide viable gametes, the breeding matrix should be followed to breed each of the two female fish with all three males in the part matrix.

The flexibility of the factorial mating design is further illustrated in a scenario where only four or five spawning female sturgeon are captured. The matrix can be adapted to have a 4 female X 6 male or 5 female X 6 male breeding plan to produce 4 or 5 families with 24 and 30 half-sib families, respectively. This flexibility gives the hatchery the maximum capability to produce genetically distinct families to maximize the genetic diversity of juvenile sturgeon entering the system.

In a breeding population of restricted-access sturgeon, conditions may dictate that mature sturgeon cannot be accessed and brought to the hatchery. In the circumstance of not meeting the proposed six breeding pairs of sturgeon, there are options to ensure that hatchery-produced juveniles do not negatively impact the genetic variability of the wild population. This is accomplished by importing milt and ova from other populations of Columbia white sturgeon from either wild or captive populations. Collaborative agreements to trade gametes could be made in advance of the spawning season to share spawning information and provide viable gametes as requested. Studies have demonstrated that genetic distinctiveness of Columbia River white sturgeon is confined to the former natural range of the species. By using milt and ova from other reaches of the Columbia, genetic diversity of the population is preserved.

4.4 Equipment

A partial list of necessary equipment required to set up and run a sturgeon hatchery is provided below. This list is preliminary and is intended to present a general idea of necessary items. Most of these items are recommended by Conte et al. (1988). The list is reasonably comprehensive but the reader should note that not all of these items would necessarily be required. For example, adult broodstock capture could be accomplished through sub-contract or other means in which case a capture boat (Item 1) would not be necessary. Although ultraviolet treatment (Item 7) of incubation water is used at other Columbia Basin sturgeon hatchery facilities this would not be necessary if pathogen-free well water or recirculation (RAS) were used.

1. Capture Boat. Used to capture and collect sturgeon broodstock. The boat must also have a davit and winch to swing overboard and lift the captured fish in a modified stretcher.

2. Transportation Truck and Tanks. Used to transfer adult fish to the hatchery from capture sites and transfer juveniles from the hatchery to release sites. Trailers should be heavy duty, double-axle and rated at 4 ton minimum. An insulated aluminum or fiberglass 1500 L tank with an attached cover is recommended for transporting adult fish. Tanks should be equipped with an aeration system and backup. A maximum loading density of 150 kg/m3 is recommended for adult fish.

3. Support Equipment. Used to handle large sturgeon, move them safely and efficiently, and hold them during surgical examinations and gamete removal and includes:
    - tube nets that are used to move fish to and from capture boat, and at the hatchery to move fish between tanks or onto stretchers;
    - stretchers to transport larger fish short distances around the work area and to hold fish during examination and processing; and,
    - a 2.5 cm diameter Tygon® tube connected to a source of non-chlorinated water positioned in the sturgeon's mouth to provide flow of oxygenated water over the gills during long periods (in excess of 3 minutes) when the fish is out of water for examination or processing.
4. Short-Term Adult Holding Tanks. Individual sturgeon may be held in tanks containing non-aerated water for up to 30 minutes although aeration should always be used when available. Holding temperatures should be 15 to 17ºC.
5. Mid-Term Adult Holding and Transport Tanks. Recommended rectangular tank 1.8 to 2.1 m long, 0.46 to 0.91 m wide, and 0.61 to 0.91 m deep with a 500 to 1500 L capacity. The tank should be provided with a water exchange system to maintain a minimum dissolved oxygen concentration at 7 mg/L. A maximum loading density of 150 kg/m3 is recommended.
6. Maturation and Spawning Tanks. Designed for 6-8 weeks maintenance of broodstock. Recommended design is a 4- 6.1 m circular design, fiberglass tank (center drain) with a maximum capacity of 40 000 L and a minimum water depth of 1 m that provides a working capacity of 20,000 L. Water exchange is provided at 76 L/min minimum and a forced air system designed to maintain minimum dissolved oxygen concentrations of >7 mg/L. Water should be introduced at an angle to promote flushing and aid in removing waste through the center drain. The tank should be covered to reduce fish stress. To ensure adequate oxygen content in the tank, the effluent should be maintained at a 5 mg/L minimum. Water exchange rate should be at least 10 to 15 volumes/day when loaded to capacity. Capacity loading is about 3-4 male fish per tank and 1-2 female fish per tank. Water temperatures should be maintained at about 10 to 15ºC with the ability to heat water to 17°C to thermally induce males. Even though larger diameter holding tanks are recommended, 3 m diameter circular holding tanks are used to hold adult broodstock at McNary Dam and at the Kootenai Sturgeon Hatchery for short periods of time (<4 weeks).
7. Ultraviolet Treatment System. Used to sterilize incoming incubation water.
8. Modified MacDonald Jars. Used for the egg incubation to hatch stage.
9. Fry Collection Tanks or Troughs. Used to hold newly hatched sturgeon fry.
10. Circular Fry Culture Tanks. Used to hold sturgeon fry during the rearing phase. Usually 1.2m in diameter, 46 cm deep, flat-bottomed, equipped with a centered and screened standpipe, a spray-bar water delivery system and air stone system. Water depth is maintained at 30.5 cm with an inflow of 8 to 19 L/min. Dissolved oxygen levels should be maintained at 5 mg/L minimum.
11. Mechanical Fish Feeders. Used to feed sturgeon fry.

12. Miscellaneous Surgical and Laboratory Equipment. Used during surgical examination procedures to determine sex, maturity, etc. and includes an otoscope (used during surgical procedures to examine gonads) and a microscope (used to examine sperm for motility/viability and PIs).
13. Biosecurity Materials. Used to maintain safe, secure rearing environments that separate fish by species (in this case from salmon) and year class. This includes cleaning and disinfecting equipment in addition to ancillary support such as dedicated nets, rubber boots and other culture equipment.
14. Thermal Valve System. Used to mix different water sources (e.g., river water and well-water) to desired temperatures.

4.5 Water Source

Specific water volume and water quality criteria for sturgeon hatcheries have not been defined for North American species. However, the chemical and physical criterion established for salmonids provides a reasonable base until specific criteria for sturgeon are established (Conte et al. 1988). A decline in white sturgeon broodstock health has been observed when holding temperatures exceed 17ºC (Ron Ek, FFSBC, pers. comm., 2002). Maintaining a water temperature range of 10 to 17ºC appears to be suitable for all hatchery operations based upon the information sources queried. Dissolved oxygen concentrations should not fall below 7 mg/L (Conte et al.1988) although >7 mg/L is the minimum criteria used at the Canadian sturgeon facilities.

Water hardness as defined by calcium carbonate ($CaCO_3$) and associated pH levels are integral to sturgeon culture success. Columbia white sturgeon are semi-anadromous fishes and as such, grow better in environments with higher dissolved minerals and the stabile pH that results from higher mineral content. Hatchery rearing water of >150ppm $CaCO_3$ and pH.7.0 are desired. Fluctuations in hardness and pH are to be avoided as these can effect development of eggs, larvae and juveniles. Water quality testing and profiles of ground or surface water are a matter of routine.

A hatchery site with several water sources of varying temperatures is an important consideration because the ability to blend water with thermal valves is less expensive than mechanically heating or cooling water to the proper temperature. Natural populations of sturgeon in the Sacramento River system spawn between 13 and 17ºC with peak spawning occurring at 15ºC. Male captive reared white sturgeon have successfully matured in California hatcheries using this criteria. Heating water during winter periods is necessary to maintain good growth of juveniles at the Canadian facilities and constitutes a major cost of the facility operation (Ron Ek, FFSBC, 2008).

The Kootenai Sturgeon Hatchery produces approximately 12,000 juvenile white sturgeon annually, a production goal similar to that anticipated under this conceptual plan. The Kootenai Sturgeon Hatchery receives an inflow of 0.98 m3/min to conduct basic hatchery operations with maximum inflows of approximately 1.89 m3/min occasionally needed for brief periods (John Siple, Kootenai Tribe of Idaho, pers. comm., 2002). Based on this experience, an inflow of 1.89 m3/min should be adequate to support a similar sturgeon hatchery program at either a new or modified existing facility in the mid-Columbia area. Noteworthy is that this facility is for the short-term holding of sturgeon; long term conditions may demand other water flow parameters.

Water sources for existing hatchery programs vary by location; e.g., the Kootenai Sturgeon Hatchery is run entirely on river water whereas Pelfrey's Sturgeon Hatchery is run entirely on well water. Controlling water temperature is a vital aspect of a sturgeon hatchery program. For the purposes of this document, we assumed that use of both well and Columbia River water would be desirable to negate the need for mechanical water heating or cooling. We further assumed that full use of either water source would at times be necessary, e.g., use 100% well water during the fall/winter incubation/rearing period. This plan therefore includes a 1.89 m3/min river pump and intake system and a 1.89 m3/min well.

4.6 Hatchery Building

All established sturgeon production facilities in the Columbia Basin (Kootenay Trout Hatchery, Kootenai Sturgeon Hatchery, and Pelfrey's Sturgeon Hatchery) maintain their facilities in an enclosed building(s). An exception to this was the CRITFC/WDFW experimental program in which adult broodstock are held outside in 3 m-diameter, circular raceways on the McNary Juvenile Fish Facility grounds. For consistency with current established sturgeon hatchery programs, all hatchery facilities proposed for the Grant PUD program will be enclosed.

The Kootenai Sturgeon Hatchery utilizes three insulated, metal pole buildings totaling 557 m^2 in floor space. This includes office and restroom space. A similar sized facility would likely be necessary to conduct a mid-Columbia River Program.

5.0 Site Options

5.1 New Site Development

Development of a sturgeon production program will likely entail either building a totally new facility or extensive modifications to an existing facility. The following discussions focus on modifications to existing hatchery facilities in the vicinity of the project area. Modifications are required to convert or expand these facilities for sturgeon production and biological and biosecurity concerns surrounding the cohabitation of sturgeon and salmonids must be addressed. Each species will require separate well-defined and biosecure culture areas. This includes rearing area, equipment and staff.

5.2 Existing Site Development

5.2.1 Priest Rapids Hatchery

Grant PUD is currently evaluating potential applications for the Priest Rapids Hatchery to serve as a primary facility for white sturgeon production. Grant PUD and the Priest Rapids Fish Forum also recognize that other existing and potential facilities may be available and desirable, particularly in light of the fact that both FERC relicensing efforts of Chelan and Douglas County PUDs will also obligate similar and additional mitigation in mid-Columbia river reservoirs immediately upstream of the Priest Rapids Project Area. And, as indicated earlier in this document, the Yakama Nation Fisheries Resource Program and the Columbia River Inter Tribal Fish Commission are also in initial phases of developing Master Plans for additional Columbia River Basin white Sturgeon facilities. Although this document does not address these other activities specifically, the PRFF and more specifically the fisheries co-managers (Yakama Nation and the Washington Department of Fish and Wildlife) have long recognized financial efficiencies and biological benefits to white sturgeon to integrate Priest Rapids production obligations with other regional interests.

The Priest Rapids Hatchery is located on the northeastern shore of the Columbia River immediately downstream from Priest Rapids Dam. This facility, which began continuous operation in 1963, was constructed by the Grant PUD to partially mitigate fall Chinook losses after the construction of Priest Rapids and Wanapum dams. Originally, this facility consisted of an 1844 m concrete channel to provide spawning habitat for adult fall Chinook. The facility was later developed into a fully operational hatchery in the 1970s. Currently, mitigation production is set at a minimum of 45.36 MT of juvenile fall Chinook annually which equates to releases of 5 to 7 million smolts. The hatchery is funded by the Grant PUD and operated by WDFW personnel.

The hatchery consists of the original concrete spawning channel, a 372 m^2 hatchery/incubation building containing 80 stacks of vertical incubators, one large concrete adult holding pond, and 12 vinyl-lined raceways with approximate dimensions of 30.5 m long, 2.4 m wide, and 1.2 m deep. Water is obtained from the Columbia River and six on-site wells. Maximum inflow to the hatchery is 2.9 m^3/s from the river and 30.23 m^3/min from the six wells. Two additional wells exist adjacent to the other six but are not used, apparently because their use reduces the output of the original six.

The current annual schedule for fall Chinook production is as follows:

- September through November. Collect, hold, and spawn adult fall Chinook.
- November through June. Incubation and rearing. Transfer of Chinook fry to the vinyl raceways typically begins in early March. These fish are later transferred to the partitioned concrete spawning channel in May. All smolts are released from the channel directly to the Columbia River by the end of June; the facility is empty in July and August.

By comparison, a tentative annual sturgeon production schedule might resemble the following:

- May through July. Collect and spawn adult broodstock and hold at Priest Rapids Hatchery. Return spawned fish to Columbia River.
- August through March. Incubate and rear juvenile sturgeon.
- May - August. Release juvenile sturgeon.

Modifications to the Priest Rapids Hatchery to accommodate sturgeon culture, while appearing an attractive and logical alternative to building an entirely new hatchery, are not without significant challenges. In addition to requiring dedicated rearing space for all aspects of sturgeon culture, the above schedules indicate an overlap between the fall Chinook program and the sturgeon program would occur in all months except July and August. Incubation of sturgeon eggs and fry required separate covered and temperature-controlled rearing facilities with a dedicated water supply to ensure biosecurity. However, other factors to consider are: 1) the overall hatchery building could be reduced in size as restrooms/offices already exist in the current hatchery, 2) additional river pump and intake system would not be necessary, 3) although not advisable, four of the existing vinyl-lined raceways could potentially, but not ideally be used to hold adult broodstock to reduce holding tank and building space requirements, and 4) an additional well may not be needed.

A further consideration is staffing requirements. Salmon hatchery staff and sturgeon hatchery staff are not interchangeable on a daily routine basis. For reasons of biosecurity and continuity, sturgeon culture requires dedicated hatchery staff. Exceptions to this are seasonal activities such as brood capture/release and staff relief or the establishment of strict biosecurity protocols with SOPs for disinfection of personnel and equipment.

For Priest Rapids Hatchery staff and operator training, it is recommended that an individual from the Priest Rapids Hatchery be involved in other white sturgeon recovery programs (Nechako and, Upper Columbia White Sturgeon Recovery Initiatives) to participate in key activities, namely:

- capturing, assessing, handling and transporting of spawners
- spawning – PI determination, milt quality determination, fertilization, disinfection, de-adhesion and incubation
- hatching, ponding and first feeding,
- grading and juvenile feeding
- marking and tagging of juveniles, and
- releasing juveniles and adults.

By participating 'hands on' with experienced staff the technology transfer from existing to the new hatchery is facilitated. This technology transfer can be done during the spring 2009 season for the Nechako and Columbia sturgeon projects.

Modification of the existing well-water system to provide necessary inflows may also be possible. Using river water for the sturgeon program is another option, but would most likely require mechanical heating/cooling and filtering capability and possibly an ultraviolet treatment system. In addition, the hatchery water distribution system may require substantial modifications to accommodate additional hatchery operations. Finally the hatchery drainage system at the Priest Rapids Hatchery may not allow hatchery operations to expand beyond their present levels, i.e., the system may be inadequate to support an additional sturgeon program. In this event, major modifications to the drainage system would be necessary.

6.0 Monitoring and Evaluation

The following section provides M&E programs for juvenile sturgeon rearing, marking, and stocking, as well as programs necessary to monitor white sturgeon supplementation efforts in Priest Rapids and Wanapum reservoirs.

6.1 Hatchery Rearing

The hatchery program has been carefully designed to successfully rear and monitor the production of hatchery-raised white sturgeon as well as ensure that genetic diversity of the existing population is maintained. Culture methods and techniques will be constantly updated and refined to ensure high-quality sturgeon production and maintain fish health. Hatchery-reared juvenile sturgeon will be monitored continuously for disease, growth, and deformity. Diseased or abnormal fish will be culled to ensure the healthiest individuals are released into Priest Rapids and the Wanapum reservoirs. To provide a fail-safe for each brood year in the event of an emergency, provisions for the development and maintenance of back-up production facilities will be investigated in the second year of the hatchery program.

6.2 Juvenile Marking

Hatchery-reared juveniles will be marked (to differentiate them from wild stock) and programs developed to:

- effectively monitor natural recruitment;
- evaluate hatchery fish survival, growth, contributions of different release groups, and regulation of future broodstock use;
- assess sources contributing to recruitment failure and provide feasible alternatives for restoration of suitable conditions for natural recruitment;
- identify limiting life stages, critical habitats, food habits, contaminant uptake; and,
- fine-tune stocking strategies to optimize survival.

Hatchery-reared juvenile fish will be marked with uniquely numbered ISO-compliant PIT tags and year-specific scute removal patterns. In the upper Columbia River, scute marks are used to provide a rapid visual assessment of hatchery origin and brood year. The use of scute marks will be coordinated with other sturgeon culture facilities for easy identification of hatchery facility origin and to monitor movements. Selected juveniles will also be held in the hatchery longer to attain sizes necessary for sonic tag implantation to further assess entrainment and immigration into and out of the Priest Rapids Project.

PIT-tagging and scute marking will be done on juvenile fish at the time of equalization of families. In this practice, fish are within two weeks to one month of release and they are of a sufficient size to accept a PIT tag and recover quickly from scute removal. Fish will be anaesthetized and a PIT tag inserted into the dorsal musculature on the left side of the fish midway between the later scute line and the dorsal crest. Sequentially, two scutes are removed from the left side of the fish according to the year. From 2001 – 2010, Columbia River fish are, by convention, scute marked on the left side of the fish. After 2010, the marking returns to the right side, as was done before 2000. For the year 2008, the first and tenth scutes are removed exposing eight scutes to correspond to ’08; nine scutes between removed scutes designates 2009, *et cetera*.

As indicated, families will be equalized immediately prior to release to evenly distribute the probable genetic contribution of each female spawner. For the WSMP, the front loading of 10,000 juveniles annually for 5 years indicates that approximately 1,700 fish from 6 families will be required each year. Typically, MacDonald jars are stocked with 1.0 - 1.4 L of fertilized eggs at a count of 20,000 – 23,000 eggs per liter (69,000 eggs per family). As survival to neurulation and hatch are very close and are typically in the 80-90% range (55,200 eggs hatch), losses from hatch to first feeding including culls are typically 25% (41,000 to first feed) with further culling and normal losses to give about 30,000 juveniles per family heading into the first winter. Culling continues on a non-biased basis to reduce the population on hand to 1.25 to 1.5X the stocking amount by November. At this point, a final assessment of fish health and stocking numbers are determined and fish are fed to attain the mass required for scute marking and PIT tagging which is done in late winter or early spring. Excess fish are marked and tagged to accommodate losses. Just prior to release, each fish is checked for the PIT tag and measured for length. Weight is calculated either directly or is assumed as a function of length using a nomogram.

Although not previously mentioned in the WSMP, grading for size is required to separate fast-growing fish from slow-growing fish. Sturgeon are sensitive to loading density and will not grow in a uniform manner if densities or other environmental parameters are not optimized. Although different fish may have genetic predispositions to rearing and growth, culling is not done on this basis. Rather, groups of fish are graded and provided the opportunity to 'catch up' to their fast growing cohorts in an environment that supports their need. This process is effective and fish respond well to this treatment, often achieving weights comparable to their cohorts in the faster growing groups. At the time of final preparation for release, fish are taken from all groups on an equal and balanced basis to form the final familial representation in the release population. At this point, the fish are tagged and marked as described.

As indicated in Part A, at least 65 fish per year (11 fish per family) will be grown to sizes sufficient to receive a sonic transponder. It is anticipated that these fish will be raised for an additional 4-6 months to attain the extra size relative to cohorts. New technologies notwithstanding, this will require that these fish will need to be cultured for a longer period of time in order to accept the larger sonic tag.

6.3 Stocking

Previous movement studies conducted in the upper and middle Columbia River suggest that juvenile white sturgeon are located in the same habitats as adults (Golder 2003). Based on previous capture and movement studies conducted in Priest Rapids and the Wanapum Reservoirs, hatchery-reared juveniles should be released in the following areas:

- Goose Island (RM 398);
- downstream of Lake Geneva (RM 404);
- downstream of Lower Crab Creek (RM 409);
- downstream of Wanapum Dam (RM 414 to 415);
- Columbia Cliffs (RM 442);
- Sunland Estates (RM 429);
- Below Rock Island Dam (RM 453); and,
- near Vantage bridge (RM 421).

Release sites can be modified as necessary through the use of juvenile monitoring programs such as those suggested below in Part B, Section 5.5. The number of juveniles initially released into these Reservoirs can be divided evenly among each site listed; this can be modified if juvenile monitoring studies determine higher survival rates are specific to particular sites.

6.4 Adult Assessment and Habitat Use

Assessment and monitoring of the adult white sturgeon population in the PRPA is a long-term requirement of the WSMP. Information on adult population trends, in terms of abundance, growth, and spawning periodicity, is required to assess broodstock availability and assess the carrying capacity of Priest Rapids and the Wanapum Reservoirs. Such information is critical in determining the success of the supplementation program and whether modifications are necessary to the overall plan (e.g., more/less production required to achieve goals). Capture (adult and juvenile) programs will enable calculation of more accurate population estimates, allow for monitoring of the existing and hatchery cohorts, and further assess age, growth, survival and mortality. Previous telemetry programs conducted in Priest Rapids and the Wanapum Reservoirs identified movements related to spawning, overwintering and feeding, and provided information on the location of critical habitats, and habitat use. These programs could be used to monitor future hatchery-releases and determine if these fish are using similar habitats as ‘wild’ fish. Telemetry programs could also monitor entrainment and immigration in the existing and hatchery cohorts. Spawning habitats that were identified in Priest Rapids and the Wanapum Reservoirs (Golder 2003) could be monitored to determine spawning periodicity and intensity, especially upon maturation of the hatchery cohort. Habitats previously identified during telemetry and spawning programs can be further assessed (e.g., velocity, depth, substrate) to develop area-use curves for determining habitat availability in Priest Rapids and the Wanapum Reservoirs and identify limiting habitats for various life stages.

A detailed examination of the status of the existing white sturgeon population is scheduled to commence in 2009. Details of this program are provided in Part C. Future programs to monitor the status of the adult population have been tentatively scheduled at three year intervals, although the exact timing will depend on findings of the 2009 study and results of future broodstock collection programs. For future adult assessment study programs, detailed plans will be developed for review by the PRFF early in the in the year of the planned study.

6.5 Juvenile White Sturgeon Indexing Program

A juvenile indexing program, similar to that used in the upper Columbia River to monitor juvenile sturgeon released into the Columbia River between Grand Coulee Dam and Keenleyside Dam, is required to assess the success of the white sturgeon supplementation program in the PRPA. The indexing program would involve regular studies to determine juvenile abundance, distribution, growth, and survival. Such a program would be conducted annually for the first 5 years of juvenile stocking into the PRPA and thereafter, at regular intervals (assumed to be 3 year intervals at present; see Part A, Table 1).

The following discussions outline the suggested methods that will be used to index and monitor white sturgeon hatchery and wild juveniles in the PRPA. The methods chosen are based on the best information available at this time and to the degree possible, have been selected as the most appropriate to conditions in the PRPA. These methods will likely change over time as additional information is collected from the area or is obtained from similar programs elsewhere. Consequently, this document provides an overview of the indexing program; detailed study plans will be developed in 2010 for implementation in 2011 and will incorporate any advances in sampling technology developed in the interim.

6.5.1 Objectives

The objectives of the proposed juvenile white sturgeon monitoring program will be to develop a long-term indexing protocol to monitor and assess individual growth, condition, maturation, and survival of each juvenile cohort release group as part of the overall compensation objective to restore a naturally self-sustaining viable white sturgeon population within the PRPA. Rapid growth, high condition factor, high survival, and early maturation would be indicators of a successful hatchery release program. Ideally, the indexing protocol would be effective in the early identification of density dependent effects, such as reduced growth, which would suggest that population densities are approaching a habitat carrying capacity and an upper limit to the number of white sturgeon the habitat can support. An equally important component of the indexing program would be the capture and identification of wild juveniles to assess reproductive potential of the wild population and help determine the potential for natural reproduction in the future.

In the Canadian and US portions of the upper Columbia River, juvenile white sturgeon indexing programs have been developed that have recently begun to obtain statistically meaningful estimates of growth, condition, and survival. Accurate estimates of these parameters require that an adequate proportion of released fish are captured to allow calculation of robust estimates with low variance levels. Low capture success of juvenile white sturgeon can generally be attributed to three main reasons:

1) fish are abundant within the system but sampling methods are not effective at obtaining sufficient sample sizes;
2) high mortality rates from starvation or predation reduce the population size available for capture; and
3) high emigration rates out of the study area (due to unsuitable habitat conditions or food availability) reduce the population size available for capture.

The effectiveness of sample methods can be assessed in part through use of multiple physical capture methods (e.g., gill net, set line, angling, traps, etc.) in conjunction with visual observations of the area sampled (e.g., snorkel/diver surveys, underwater cameras, DIDSON sonar, etc.). Predation levels can be ascertained from creel surveys, from predator control programs, and general fish capture programs where predators are sacrificed and stomach contents analyzed. The extent of emigration can be estimated through telemetry and tag detection systems (e.g., sonic telemetry, PIT detection arrays) installed above and below the dams that bound the release locations.

The following sampling methods have been used to effectively sample for juvenile white sturgeon or have been shown to be effective for the capture of other deep water species like burbot (*Lota lota*). These sampling methods also assume that all hatchery released white sturgeon are marked upon release (PIT tag, external secondary mark, sonic tags) so they can be differentiated from wild fish.

6.5.1.1 Upper Columbia River Juvenile White Sturgeon Index Monitoring

Juvenile white sturgeon indexing methods in the upper and lower Columbia River and in the Kootenai River are based primarily on focused or systematic sampling using small mesh gill nets to provide data on distribution, growth, survival, and movements. To a lesser extent, set lines and angling have also been used to obtain this data. On the lower Fraser River, sturgeon angling guides are equipped with PIT tag applicators and readers and have voluntarily participated in a multi-year data collection program that monitors both adult and juvenile components of the population. The following provides a summary of information on juvenile sturgeon indexing that has been obtained over the past seven years by the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI).

Movements related to short-term dispersal of hatchery fish after release and longer term movements related to adaptations to the new environment and changes in feeding habitat over time have been monitored using acoustic telemetry tracking. These programs generally involve equipping a proportion of the hatchery releases with implanted coded acoustic tags and continued implantation of telemetry tags into juveniles as they age and mature.

Habitat typing and behavioral observations have been obtained mainly through the use of divers or ROVs equipped with underwater cameras. These methods are only useful in systems with high water clarity.

The sample methods used have been effective in determining growth rates for each cohort, condition factors, dispersal and movement, habitat selection, and behavior. The primary limitation of the indexing protocol was relatively limited success in estimating survival and abundance for each age-cohort due to low capture numbers and multiple confounding variables in terms of the number of capture methods used and environmental variables.

Gill nets are the most effective method for sampling early age classes (i.e., up to age-5) of juvenile white sturgeon. However, it is unclear when the fish will become too large to be effectively or safely sampled (without undue mortalities) using this method. Gill nets are more effective on smaller fish, whereas larger juveniles are more effectively sampled with hook and line methods. This capture bias must be considered in long-term sampling programs. Since young fish will continue to be added to the population over many years and the fish already present continue to grow, over time it will be necessary to use a greater variety of capture methods and expend more sample effort in order to obtain sufficient samples from all age-classes. A drawback of this adaptation, however, is that the use of different methods can also increase the variables (and potential biases) that must be accounted for in future survival and population estimates.

Variations in spatial and seasonal distribution of juvenile white sturgeon also occur and tend to increase over time as fish grow and are capable of using different habitats and using different food resources. This results in the need to sample more areas on a seasonal basis. This also raises the question as to whether areas where juveniles have not previously been captured should continue to be sampled, or whether effort should be concentrated in the areas of highest density in order to capture the highest number of fish possible. Data collected during the UCWSRI studies suggest that consideration should be given to additional seasonal sampling. A downside to this modification however, is that sampling during different times of year also increases the variables involved in calculating survival estimates.

The typical clumped distribution of juvenile white sturgeon also creates difficulties in developing a long term indexing protocol. Underwater video observations confirmed that juvenile white sturgeon often aggregate in dense groups of 200 to 300 individuals on the river bottom. Consequently, capture efficiency very inconsistent in that a gill nets set in the same location may catch 20 fish one day and zero the next, depending on the location of the net relative to the aggregation. If a net is set near a large aggregation of fish and the fish move towards the net, large numbers will likely be captured. Conversely, if the fish move in the other direction or remain stationary, fewer fish will be captured. The large aggregations of juveniles recorded in some areas have been observed to move from day to day in response to flow changes. Therefore, the behavior of these aggregations, as influenced by the size of the aggregation and it's movements as influenced by factors such as flows and the entrainment of prey items, can have significant influences on catch-rates.

6.5.2 Sample Methods

A key finding of the UCWSRI juvenile white sturgeon indexing program to date has been the need for standardized methods consistently applied at regular sampling intervals. Standardized methods involve standard release times and locations of the juvenile fish, maintenance of constant sampling sites each year, and ensuring the gear type (e.g., gill net mesh size) deployed and the length of time the gear is deployed are constant. If specific hypotheses are forwarded that are to be subsequently tested by field sampling data, the power to detect an effect of a given magnitude with an assumed sample size should first be determined through appropriate statistical means; this exercise should be conducted as an essential component of field program development. Hatchery and monitoring programs with too many variables, such as time of release, location of release, location of capture, and capture methodology, are less able to effectively determine the influence of these variables on key life history parameters.

The goal of long-term indexing program should be the unbiased collection of large numbers of fish (increase the rate of encounter), in order to improve the accuracy of the population metrics examined. Survival is one of the key variables required to accurately determine the numbers of released fish that are needed to achieve the desired population target.

Capture methods that are currently used in existing white sturgeon recovery programs and alternate methods that are proposed for future consideration in the PRPA are discussed in the following sections.

6.5.2.1 Gill Nets

As a capture method, gill nets have low species selectivity but are very size selective for a wide variety of fish species. The main ways that this method can be used to maximize the capture of white sturgeon and limit the incidental capture of non-target species is:

- through the use of a specific mesh size to target specific size-classes of juvenile white sturgeon;

- through the placement of gill nets in locations where the juvenile white sturgeon are most likely to occur, (e.g., bottom sets in deep water areas and backeddy habitats); and
- by adjusting the time of deployment and deployment duration to match periods when the juvenile white sturgeon are most likely to active and most susceptible to the sample gear.

However, even when the above adjustments to the method are applied, incidental captures of other species will still occur. In general, for short duration sets deployed in known habitats where juvenile white sturgeon are known to occur, the number of incidental fish caught and mortality tends to be low. In new locations, where general fish abundance and species assembles are uncertain, incidental catch can be unpredictable. When working in areas with endangered or listed species, incidental capture and mortality of these species may not be acceptable at any level. Finally, retrieval of a gill net is not always certain and the loss of an entire net or portion of net is possible. If lost, a gill net has the potential to continue to capture fish until the net fills with debris and settles to the river bottom.

Despite these limitations, gill nets are the main sample method, as well as the most effective, that have been used to capture juvenile white sturgeon in several studies on the Columbia and Kootenay rivers in Canada and the United States (Elliot and Beamesderfer 1993; Lee and Underwood 2002; Neufeld and Spence 2002, 2004; Young 2002; Ireland et al. 2002; Golder 2007). During a study that compared the efficiency and selectivity of gill nets, set lines, and angling at capturing white sturgeon in The Dalles Reservoir (308 to 347 km upstream from the mouth of the Columbia River), gill nets captured the highest percentage (approximately 60% of the total gill net catch) of juvenile white sturgeon between 30 and 70 cm FL (Elliot and Beamesderfer 1993). Juvenile white sturgeon are generally caught by their mouth parts or fins as opposed to their gills, and therefore, are nearly always alive even after several hours in the net. UCWSRI studies indicated highest catch rates occurred when nets were set overnight versus daytime sets (Golder 2007); however, the most significant incidental catches and mortalities also occurred during night sets. Another complication is that both adult white sturgeon are typically found in the same habitat as juveniles and although relatively rare, mortalities of adult white sturgeon as a result of entanglement in a gill net have been recorded (Golder 2007).

The UCWSRI recently conducted a review of the juvenile white sturgeon gill net program and recommended a standardized deployment configuration for all gill nets. The nets recommended for use were multi-filament, horizontal gill nets of two sizes: 1.8 m deep by 15.2 m long (27.9 m^2) and 1.8 m deep by 45.7 m long (83.6 m^2; each consisted of three equal size panels of differing mesh size (5.1 cm, 10.2 cm and 15.2 cm stretch measure). Panel area was 9.3 m^2 for the small nets and 27.9 m^2 for the large nets. Gill nets are deployed at the bottom of the water column, with a float and float line and anchors attached to each end of the net. The nets are set in areas with low velocities and uniform substrates to prevent the nets from drifting or snagging on the bottom. The mesh size that each fish is captured in is recorded, along with set depth and orientation to flow. To minimize spatial effects on key life history parameter estimates, it was recommended that sampling effort should be proportionate to abundance and this stratification of effort should be part of the pre-season study design, based on either previous year's catches or other data sources. Once a sampling program is established, the sampling effort should not be modified by in-season gill net catch-rates (i.e., do not increase sample effort in a given area in response to catches). If additional areas of aggregation of juvenile sturgeon are located by alternative methods, these sites can be added to the sampling program as supplements and should be systematically sampled in all subsequent years of sampling. If subsequent analysis suggests minimal size/age segregation by sampling area, these sampling standards could be relaxed.

6.5.2.2 Underwater Surveys

Underwater video surveys have been used by the UCWSRI with great success as a reconnaissance method to determine fish use in suspected white sturgeon habitat. As part of juvenile white sturgeon monitoring in the upper Columbia River, underwater video survey have been conducted using a towed underwater cameras, to conduct initial reconnaissance surveys, followed up by a more thorough survey with a remotely operated underwater vehicle (ROV) equipped with a video camera.

Initial reconnaissance surveys with a towable camera, such as an Aqua-Vu SV-120TM, are conducted to locate concentrations of juvenile white sturgeon. This unit consists of a compact camera in a rubber underwater housing, a 120 foot cable, and a weatherproof monitor. The camera is equipped with multi-colored lights and a directional sensor. The video feed is recorded directly onto tape or digital media that allows audio commentary. The camera is fixed to a 100 pound lead sounding weight which can be raised and lowered using a sounding reel. The apparatus is lowered to the desired depth (just above the bottom) and towed through these areas to search for juvenile white sturgeon. The observation of juveniles in an area leads to follow up surveys with an ROV.

The most effect method to conduct underwater surveys was with a ROV, such as a SeaBotix Little Benthic Vehicle 300TM (LBV). The features of the LBV include: a four thruster configuration (2 forward, 1 lateral, and 1 vertical), 270° field of vision, 180° camera tilt, 2 video cameras (0.3 lux colour and 0.03 lux low-light black and white), halogen lights that track the cameras, dual scaling lasers (to aid in determining the size of objects/fish observed), and sensors for depth, heading, and temperature. Images captured by the cameras were transferred to the surface monitor via a fiber-optic cable enclosed in an 8.4 mm diameter 300 m umbilical cord. When deployed, the LBV300TM can maneuver in any direction(s) to obtain footage of habitat and fish. The unit can operate at a depth of 300 m and in current speeds of up to 150 cm/s (3 knots), although its mobility decreases as current speed increases (mainly due to increased drag on the umbilical).

Underwater surveys and the LBV in particular are an effective, low disturbance method of observing aggregations of juvenile white sturgeon to determine approximate abundance, behaviour, and habitat use. This method is very effective in systems like the upper Columbia that exhibit high water clarity and where aggregations of juvenile white sturgeon occur in localized habitats with deepwater areas and lower velocities relative to mainstem flows. While the LBV allows direct observation of behavior and habitat use, and is very useful as a reconnaissance tool, it is less useful in assessing population metrics. In general, underwater video is best suited for follow-up confirmation of fish presence should unexpected changes in catch by systematic index sampling methods suddenly change. For example, if the catch of larger juveniles in gill nets suddenly declines, underwater video surveys can be conducted to determine if these age-classes are present in the sample area.

6.5.2.3 Hook and Line Methods

During previous white sturgeon studies in Wanapum Reservoir, several white sturgeon that would be consider as juveniles (i.e., n = 10, ranging between 48 and 64 cm fork length) were captured during systematic setline sampling for adult white sturgeon. In the upper Columbia River, since the initial release of hatchery fish in 2002, the number of juvenile white sturgeon caught by angling during the annual adult broodstock collection program has increased with each successive year sampled. The catch of juvenile white sturgeon using angling is expected to continue to increase as juvenile white sturgeon increase in size and recruit to the gear. This has been supported by the steady increase in the number of recreational anglers that report incidental catches of juvenile white sturgeon when angling with bait for walleye or rainbow trout. Since larger juveniles are less effectively sampled by gill net, the use of angling and modified set lines (with small hook sizes to capture juveniles) will be incorporated into future systematic index monitoring programs. In the PRPA, this is expected to occur after Year-4 of the hatchery release program.

6.5.2.4 Underwater PIT-Tag Detection

Passive Integrated Transponders (PIT) tags are used as long-term identifiers of individual fish and will be implanted in every juvenile white sturgeon released into the PRPA. The ability to uniquely identify an individual over its entire life allows the estimation of population metrics derived from recapture frequency. Since PIT tags transmit a coded signal in response to stimulation by an electrical field, the potential exists to detect and identify individual fish by remotely scanning for the PIT as opposed to directly catching the fish. Ideally, such a detection system would allow large numbers of fish to be quickly and easily identified to develop a mark-recapture assessment that would approach a total census of each release cohort.

Unfortunately, there are presently several limitations with the technology that reduce the ease of remote underwater detection and it’s applicability on large river or reservoir systems. The full-duplex tags, which are currently the only PIT tags small enough to be implanted within a juvenile white sturgeon, can only transmit a coded signal across a maximum distance of approximately 20-30 cm from the tag to the antenna. Recently developed half-duplex tags, which can be detected up to distances of 1 m from the antenna, are presently too large to implant in younger juvenile white sturgeon, but could be used in older juveniles and adults. Another limitation is that the receiving antenna both energizes and receives the PIT signal and requires a moderate amount of power. This can pose logistical difficulties for use in remote areas. The most common PIT tag detection systems presently in use are shore-based, typically deployed across a narrowing in a stream channel, in a fish ladder, or in an intake where fish will move inn close proximity to the antenna. However, given the substantial advances that have been made in this technology in only the past few years, there is a reasonable chance that a suitable system may be available for use in the early stages of the PRPA juvenile indexing program.

6.5.2.5 Baited Pot Traps

In the event that the presence of listed salmon species in the PRPA precludes the use of gill nets, baited pot traps could provide an alternate method to capture juvenile white sturgeon. These traps are effective on species such as sablefish (*Anoplopoma fimbria)* and catfish*,* both of which have body forms similar to white sturgeon, are benthic dwelling species, and respond to bait trails. Although specific reference as to the effectiveness of baited traps to capture juvenile white sturgeon was not be found in the literature, white sturgeon are effective attracted to baited set line hooks and therefore, may also be attracted to a baited trap. Baited pot traps would likely be most effective at capturing younger, smaller age-classes.

The pot traps would be baited and deployed at depth in habitats frequented by juvenile white sturgeon. Potentially, large number of traps could be deployed and set relatively easily and quickly. Assuming set duration of 24 hours or less, fish caught within the traps would remain alive and undamaged. Since white sturgeon have a physostomous air bladder, which maintains a connection to the digestive tract and allows pressure equalization, the trap and fish can be retrieved without risk of bursting the air bladder.

Overall, compared to other sampling methods, such as gill nets or set lines, baited pot traps would be size and species selective, would likely have very low incidental catch (and mortality), and could easily be deployed in rough terrain, deep water, and in the vicinity of obstructions and obstacles (such as basalt pillars) that would prevent deployment of gill nets or a set line. Traps could be modified with a degradable panel (e.g., an untreated cotton panel or a galvanic timed release gate) so that if a trap is lost a section of the trap wall opens to allow fish to escape and deactivates the trap.

6.6 White Sturgeon Passage Evaluation

One of the objectives of the WSMP is the identification of upstream and downstream migration by adult and juvenile white sturgeon through or over the intervening dams. The intent of this study program is to provide safe, effective, and timely volitional passage for white sturgeon, if reasonable and feasible passage means can be developed.

The extent of existing migration past the dams in the PRPA by the resident wild white sturgeon population will be initially assessed using sonic telemetry. Up to 50 wild fish will be equipped with sonic tags during the 2009 study program described in Part C. Movements of these fish through or over Rocky Reach, Wanapum, and Priest Rapids dams will be determined using sonic receiver stations positioned above and below each of these dams. Additional information on movements of hatchery releases out of the reservoirs where they were released will be obtained by equipping up to 50 juveniles annually for the first five years with sonic tags and monitoring their movements using the same receiver array. This study program is only intended to determine if fish have moved upstream or downstream past a particular dam and the data will be used as a rough indication of the degree of emigration and allow for coarse adjustments to population and survival estimates. Some information on downstream passage survival also may be obtained through this study. Information on the mode of movement (whether via spillways, turbine passage, or fish ladders) will not be obtained using this method. In the event that substantial emigration or immigration occurs, additional plans would be developed in consultation with the PRFF to identify the avenues of passage and obtain more detailed information on survival rates.

The information from this program would be used to assess the feasibility of providing effective and safe passage for white sturgeon in the PRPA.

7.0 Conclusion

This plan has included a short summary of sturgeon life history, a brief history of sturgeon aquaculture, a concise statement as to what will be required from the regulatory agencies, a review of basic sturgeon hatchery practices including a list of necessary equipment, a discussion of hatchery site options, and a summary of juvenile white sturgeon indexing methods.

The use of hatchery programs to restore or supplement sturgeon populations in the Columbia Basin hydroelectric reservoirs is still in its infancy. Sturgeon research is ongoing and many critical uncertainties exist. Policies pertaining to sturgeon supplementation will continue to evolve as new information becomes available. Changes in policy or new information on white sturgeon population metrics or genetics may also dramatically affect the direction of sturgeon supplementation programs based on the assumptions used in this plan. For example, if the white sturgeon populations inhabiting the entire mainstem Columbia River were determined to be genetically homogeneous, then use of broodstock from other locations where they are much more abundant might be possible.

Supplementation using local broodstock has to date been the preferred strategy to assist in sturgeon recovery efforts elsewhere in the Columbia Basin. Assuming genetics considerations allow the classification of middle Columbia River white sturgeon populations as the same stock, a centralized sturgeon production facility could potentially be established in the middle Columbia River basin to provide fish for mid-Columbia River reservoirs and also for Snake River reservoirs where similar isolated, poorly reproducing populations exist. Such a facility would require production capability (and costs) well in excess of those outlined in this plan.

A sturgeon supplementation program should include a monitoring and evaluation component to assess the overall success of the program and direct program changes as needed. Suggestions have been made for options to develop these monitoring programs, however, specific plans will not be completed until the hatchery program is nearer to completion. Because of the longevity of white sturgeon, future monitoring and evaluation efforts must be considered long-term and planned accordingly.

Literature Cited

Anders, P.J., and M.S. Powell. 2001. Genetic impact of proposed white sturgeon supplementation in Rock Island Reservoir. Memorandum to BPA Project 86-50 Cooperators. February 28, 2001.

Anderson, R.S. 1988. Columbia River Sturgeon. Washington Sea Grant. Marine Advisory Services. Columbia River Series. WSG-AS 88-14.

Caprino, F., Moretti, V.M., Bellagambaa, F., Turchini, G.M., Busettoa, M.L., Giania, I.,

Paleari, M.A. and Pazzaglia, M. 2008. Fatty acid composition and volatile compounds of caviar from farmed white sturgeon (*Acipenser transmontanus*). Anal. Chem. Acta. 617: 139-147.

Chadwick, H. K. 1959. California sturgeon tagging studies. California Fish and Game 45(4): 297-301.

Chen, I. C., Chapman, F.A., Wei C., Portier, K.M. and O'Keefe, S.F. 1994. Differentiation of cultured and wild sturgeon (*Acipenser oxyrinchus desotoi*) based on fatty acid composition. Annual Meeting of the Institute of Food Technologists, Atlanta, GA, June 1994.

Conte, F.S., S.I. Doroshov, P.B. Lutes, and E.M. Strange. 1988. Hatchery Manual for the White Sturgeon Acipenser transmontanus Richardson. With application to other North American Acipenseridae. University of California, Davis.

Elliot, J.C., and R.C. Beamesderfer. 1993. Comparison of efficiency and selectivity of three gears used to sample white sturgeon in a Columbia River reservoir. Report A. Pages 17-27. *In* R.C. Beamesderfer and A.A. Nigro (editors). Volume II. Status and habitat requirements of the white sturgeon populations in the Columbia River downstream from McNary Dam. Final report to Bonneville Power Administration, Portland, Oregon.

Frankham, R., 2008. Genetic adaptation to captivity in species conservation programs. Molecular Ecology 17:325-333.

Gessner, J., Würtz, S., Kirschbaum , F. and Wirth, M. 2008. Biochemical composition of caviar as a tool to discriminate between aquaculture and wild origin. Journal of Applied Ichthyology 24: 52-56

Golder Associates Ltd. 2003. White sturgeon investigations in Priest Rapids and the Wanapum

Reservoirs on the Middle Columbia River, Washington, U.S.A. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 002-8817F: 85p. + 6 app.

Golder Associates Ltd. 2007. Upper Columbia River juvenile white sturgeon monitoring: Phase 5 investigations, November 2006. Report prepared for BC Hydro, Revelstoke, B.C. Golder Report No. 06-1480-049D: 64 p. + 6 app.

Howell, M.D. and J.G. McLellan. 2007. Lake Roosevelt white sturgeon recovery project. Annual Progress Report, April 2005 – March 2006. Report submitted to the U.S. Department of Energy, Bonneville Power Administration by Washington Department of Fish and Wildlife, Spokane WA. 106 pp.

Ireland, S.C., J.T. Siple, V.L. Paragamian, V.D. Wakkinen, and R.C.P. Beamesderfer. 2002. 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., J. T. Siple, R. C. P. Beamesderfer, V. L. Paragamian, and V. D. Wakkinen. 2003. Success of hatchery-reared juvenile white sturgeon (Acipenser transmontanus) following release in the Kootenai River, Idaho. Unpublished Manuscript.

Irvine, R.L., D.C. Schmidt, and L.R. Hildebrand. 2007. Population Status of White Sturgeon in the Lower Columbia River within Canada. Transactions of the American Fisheries Society. Vol 136, No. 6:1472-1479.

Kynard, B. and E. Parker. 2005. Ontogenetic Behavior and Dispersal of Sacramento River White Sturgeon, Acipenser Transmontanus, with a Note on Body Color. Environmental Biology of Fishes. Volume 74, Number 1:19-30.

Lee, C., and K. Underwood. 2002. Lake Roosevelt white sturgeon juvenile sampling. Report prepared for B.C. Ministry of Water, Land and Air Protection. 8 p.

Neufeld, M.D., and C.R. Spence. 2002. Kootenay River white sturgeon studies juvenile sampling, 2001. Report prepared for the Bonneville Power Administration (Columbia Basin Fish and Wildlife Authority). 39 p. + 10 app.

Neufeld, M.D., and C.R. Spence. 2004. Kootenay fisheries investigations sturgeon and burbot progress, 2002-03. Report prepared for the Bonneville Power Administration (Columbia Basin Fish and Wildlife Authority). 52 p. + 11 app.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada. Bulletin 184. 966 pp.

Young, W.T. 2002. Juvenile habitat use and growth of white sturgeon in the Kootenai River. M.S. Thesis. University of Idaho.

PART C: 2009 WHITE STURGEON MONITORING PROGRAM

1.0 Introduction

On April 14, 2008, Grant County Public Utility District (Grant PUD) was issued a 44 year license by the Federal Energy Regulatory Commission for the Priest Rapids Hydroelectric Project (FERC No. 2114) located in the middle Columbia River. The Priest Rapids Hydroelectric Project, (referred to as "the Project") consists of two hydroelectric developments, Wanapum Dam and Priest Rapids Dam built in the late 1950s and early 1960s, respectively.

As part of the licensing process, biological studies were conducted to assess the impact of the Project on fish and wildlife. The effect of the project on white sturgeon (*Acipenser transmontanus*) was identified as an important area of investigation, and specifically, the impact of the Project footprint and Project operations that could potentially block upstream feeding and spawning migrations, alter or destroy critical spawning, feeding, or rearing habitat, or alter food availability and natural flow patterns. Prior to 1999, preliminary surveys and investigations in the Project area indicated that white sturgeon populations were present in both Wanapum and Priest Rapids developments; however, information on the biology, life history, and habitat requirements of these white sturgeon populations was limited and was based mainly on angler reports and limited survey results conducted by Grant PUD in 1999. Spawning areas for this white sturgeon had not been identified in the Project area. As a result, the available information was insufficient to accurately assess the status of the populations in each reservoir or determine what affects the Project may have had, or presently is having, on the health of these populations.

In 2000, Grant PUD requested that R.L. & L. Environmental Services Ltd. (now Golder Associates Ltd.), conduct surveys within both the Priest and Wanapum reservoirs to determine the abundance, distribution, population dynamics, bio-physical attributes of preferred habitat, seasonal movement patterns, and spawning characteristics of white sturgeon. These surveys were completed in 2002 and provided an initial estimate of the white sturgeon population and identified possible effects of the Project on white sturgeon.

Primary objectives of studies conducted from 2000 to 2002 included:

- describe the distribution and movement patterns (spawning and general) of white sturgeon and relate these movement to habitat selection and dam passage requirements;
- determine if white sturgeon spawn below Rock Island and Wanapum dams, and if spawning occurs, assess spawning success;
- assess the reproduction potential and recruitment of white sturgeon;
- assess the population status of white sturgeon in the Project area and determine growth rate, size and age-class composition, abundance, and sex ratio;
- identify important habitats used by white sturgeon and describe the physical attributes of these habitats;
- based on information obtained during the above, identify differences in white sturgeon population parameters between reservoirs; and

- identify and evaluate potential mitigation and enhancement options to address project effects on white sturgeon.

The 1999 to 2002 research programs represented the first comprehensive studies conducted on white sturgeon in Priest Rapids and Wanapum reservoirs. A brief summary of the 1999 to 2002 study results for both the Priest Rapids and Wanapum reservoirs is provided below (Table 4). Overall the study succeeded in meeting most of the study objectives and provided sufficient information to allow identification of potential negative effects of the Project on white sturgeon population and development of the White Sturgeon Management Plan (WSMP; see Part A) to restore populations of white sturgeon in the Project area to levels commensurate with the carrying capacity of available habitats.

Grant PUD recognizes other ongoing and expanding long-term White sturgeon monitoring and research programs occurring within the Columbia River Basin implemented by the WDFW and the CRITFC. In addition Chelan County PUD and Douglas County PUD will soon be implementing white sturgeon supplementation and associated monitoring and evaluation programs within the reservoirs behind the Rocky Reach and Wells hydroelectric projects, respectively. As supplementation and conservation efforts substantially expand within the Columbia River Basin, Grant PUD also recognizes an enhanced need to work collaboratively with the State and Tribal fisheries managers in developing a cost-efficient research, monitoring and evaluation program that is consistent and complimentary with other regional interests.

The present status of white sturgeon populations in both reservoirs is still uncertain, particularly within the Priest Rapids Reservoir where the apparent absence of juveniles and a 2:1 female to male ratio was most likely due to the low number of fish captured. Albeit unlikely, the systematic sampling program conducted in 2000 – 2002 may have also missed critical habitats containing substantial numbers of adult and juvenile fish. Finally, changes in the white sturgeon population and proportion of juveniles to adults in Wanapum and Priest reservoirs may have occurred since 2002 and a re-assessment of population abundance and structure should be performed. These issues will be addressed by the proposed 2009 study program.

An additional data deficiency that will be addressed by the 2009 study program is the availability of adult broodstock in the project area. Broodstock collection from the Project area has been identified as the preferred option in the WSMP (see Part B, Section 3.1) but presently there in no information available on where broodstock can be effectively captured in the Project area or if sufficient numbers of mature pre-spawning males and females are present in a given year.

Finally, the 2009 program will provide information on present levels of white sturgeon spawning activity in the Project area. This information is required to assess the potential for achieving a naturally self sustaining population in the Project area.

1.1 Study Objectives

Based in part on the information provided by the 2000 to 2002 white sturgeon surveys, the relative low abundance of adult and juvenile white sturgeon has been identified as a high priority issue to be addressed. At other locations on the Columbia River in both United States and Canada, hatchery- based juvenile white sturgeon release programs have been used successful to increase white sturgeon population. A supplemental hatchery release program was identified during the FERC review process as a main compensation objective and, if feasible, would likely be the most effective method to enhance the white sturgeon population in the Project area.

Table 4 Summary of study results obtained during white sturgeon investigations conducted in Priest Rapids and Wanapum reservoir from 2000 to 2002 (Golder 2003).

Life History Attribute	Priest Rapids Reservoir	Wanapum Reservoir
Estimate Population Size and Age Structure	143 individuals, likely all older adults Female to male ratio approximately 2:1, but based on low capture numbers	398 to 881 individuals, mix of adult, sub-adult, and juvenile fish. Female to Male ratio approximately 1:1 Juvenile white sturgeon composed 20% of total study catch.
Recruitment	Reduced recruitment after 1961, with apparently no recruitment after 1984. Possibly related to: • dam construction • seasonal droughts • lack of larval settling areas and subsequent drift entrainment through Priest Rapids Dam	Episodic recruitment evident from 1964 to 1997. Decline in recruitment between 1987 and 1994, possibly due to drought. Moderate to high recruitment success in 1997 during record high flows
Growth	Insufficient data. One individual grew 2.5 cm in 1 year	Average growth was 6.5 cm/year
Adult Female Fecundity[7]	39% Pre-vitellogenic (3-4 yrs to spawn) 23% Late vitellogenic (1 yr to spawn) 15% Pre-vitellogenic with attritic oocytes (post-spawner) 23% Maturity unknown Based on low sample size (n = 11)	30% non-reproductive 8% Pre-vitellogenic (3-4 yrs to spawn) 27% Early vitellogenic (2 yr to spawn) 19% Late vitellogenic (1 yr to spawn) 3% Ripe (less than 1 yr to spawn) 8% Pre-vitellogenic with attritic oocytes (post-spawner) 5% Maturity unknown (n = 35)
Adult Female Fecundity[8]	39% Pre-vitellogenic (3-4 yrs to spawn) 23% Late vitellogenic (1 yr to spawn) 15% Pre-vitellogenic with attritic oocytes (post-spawner) 23% Maturity unknown Based on low sample size (n = 11)	30% non-reproductive 8% Pre-vitellogenic (3-4 yrs to spawn) 27% Early vitellogenic (2 yr to spawn) 19% Late vitellogenic (1 yr to spawn) 3% Ripe (less than 1 yr to spawn) 8% Pre-vitellogenic with attritic oocytes (post-spawner) 5% Maturity unknown (n = 35)
Spawning	Verified below Wanapum Dam in 2000, 2001, and 2002. Earliest start of spawning recorded: June 28, 2002 Latest start of spawning recorded July 26, 2001	Verified below Rock Island Dam in 2000, 2001, and 2002. Earliest Spawning recorded: June 29, 2002 Latest start of spawning recorded: July 28, 2001
Seasonal Movement	Seasonal movement between spawning and over wintering areas recorded. Fish generally remain stationary and movement was limited during overwintering period from September to May	Seasonal movement between spawning and over wintering areas recorded. Fish generally remain stationary and movement was limited during overwintering period from September to May
Habitat	Location of overwintering, spawning, and feeding habitat identified within reservoir. Juvenile rearing habitat may be limited	Two important overwintering habitat locations identified. Spawning habitat and several other locations suitable as potential feeding habitat identified. Seven locations suitable as potential juvenile rearing habitat identified.

[7] Ovary maturation time estimates are variable and provided to facilitate comparison and interpretation.
[8] Ovary maturation time estimates are variable and provided to facilitate comparison and interpretation.

To achieve this objective, the collection of additional white sturgeon life history data to supplement the 2000-2002 study and improve the overall understanding of white sturgeon population dynamics within the Project area would also be required. As an initial step to meet this objective, Grant PUD requested that Golder develop a study plan for implementation in 2009 to update data on white sturgeon spawning activity, population metrics, and life history data and assess the feasibility of collecting white sturgeon broodstock. These study objectives will be achieved through completion of the following tasks:

- Task 1: Conduct a white sturgeon brood stock capture program prior to the 2009 spawning season. Record morphometric data for all fish captured and mark all fish. Determine the reproductive status of all mature fish captured and implant these fish with a 10-year sonic tag.
- Task 2: Monitor spawning in the tailrace of Rock Island Dam and Wanapum Dam following methods and procedures used during the 2002 study. All eggs will be enumerated and developmental stage identified. A proportion of the eggs will be incubated to confirm viability.
- Task 3: Deploy an array of sonic receivers in both the Priest Rapids and Wanapum reservoirs at the same locations used in the 2000-2002 study to track seasonal movements of sonic-tagged fish. Arrange select components of the array to determine movements of white sturgeon past the Wanapum and Priest rapids dams.
- Task 4: Conduct a systematic capture and tagging program of adult and juvenile white sturgeon based on the same methods and procedures used during the 2000-2002 study. All fish captured will be examined for sexual maturity and implanted with 10 year Vemco coded sonic tags.

A full description of the methodology and schedule for each of these tasks is provided in the following sections.

2.0 Study Area

The Priest Rapids Project is located on that portion of the mid-Columbia River that makes up the western boundary of Grant County and also forms partial boundaries of Yakima, Kittitas, Douglas, and Chelan counties in the state of Washington. The Project includes two hydroelectric developments, Wanapum and Priest Rapids, built in the late 1950s to the early 1960s. The Priest Rapids development includes Priest Rapids Dam, located 635 km (397 mi) above the mouth of the Columbia River, and Priest Rapids Reservoir that extends for 29 km (18 mi) upstream from the dam. The Wanapum development includes Wanapum Dam, located 664 km (415 mi) above the mouth of the Columbia River and Wanapum Reservoir that extends for 61 km (38 mi) upstream from the dam.

3.0 Study Approach and Logistics

3.1 Rationale for Proposed Study Approach

The 2009 study will draw extensive on the experience gained and lessons learned during the 2000 to 2002 study and will replicate the methodology and sampling design used so that the result 2009 data can be fully integrated with previous data.

In the eight years since the start of the 2000-2002 study, general knowledge white sturgeon life history, hatchery conservation techniques, and sample methods has increased substantially due to the efforts of numerous federal, state, provincial, industry, and tribal stakeholders to recover white sturgeon populations throughout their range. These advances in knowledge have been incorporated into the approach and methods that will be used in the 2009 study.

Golder staff was instrumental in developing the original protocols used for broodstock collection by the UCWSRI and in cooperation with BC Ministry Environment and BC Hydro, have further developed methods for white sturgeon adult capture, assessment, and data collection. This has formed the basis for the PRPA white sturgeon broodstock capture, handling, assessment, and documentation protocol provided in Appendix A that will be used during both the 2009 spring broodstock assessment (Task 1) and fall population assessment component (Task 4).

3.2 Study Design and Schedule

The 2009 study program will consist of the following four tasks. The anticipated effort and schedule for each task is provided in Table 5.

Table 5 Proposed sampling schedule for the 2009 PRPA white sturgeon monitoring program

Field Sample Period	Study Task
June 9 and June 29, 2009	Task 1: White sturgeon brood stock assessment program (spring 2009)
June 4 to August 1, 2009	Task 2: Spawning monitoring in the tailrace of Rock Island Dam and Wanapum Dam
June 4 to August 1, 2009	Task 3: Deployment of sonic receivers in both the Priest Rapids and Wanapum reservoirs (spring 2009)
September 3 to September 25, 2009	Task 4: White sturgeon population assessment and tagging program of adult and juvenile white sturgeon in Priest Rapids and Wanapum Reservoir (Fall 2009)

3.2.1 Task 1: White sturgeon brood stock assessment program

A three-person capture team will deploy up to six setlines at suitable locations downstream from Priest Rapids, Wanapum, and Rock Island dams (Part C, Section 4.2). Initially, exploratory sampling would be conducted in the 2 to 3 mile section of river/reservoir habitat below each dam to look for suitable habitats that may be used for staging by pre-spawning white sturgeon. Set lines with baited hooks would be deployed overnight in each suitable area and checked daily for two consecutive days. To ensure sampling is conducted under approximately the same environmental conditions in both reservoirs, sampling will be rotated alternately below each of the three dams after the second day of sampling when the set lines are retrieved. The broodstock crew will consist of a project biologist, a senior technician, and an intermediate or junior level technician.

Each fish captured will be processed following general processing methods outline in Appendix A; variances from this method specific to the study are outlined in Part C, Section 4.2. Tags applied during the brood stock assessment will increase the total number marked individuals at-large in the white sturgeon populations within the Wanapum and Priest Rapids reservoirs. This will assist in the subsequent mark-recapture and population analysis that will be conducted during the fall (Task 4). For adults, after the sex and maturity of fish has been determine and gonadal samples taken (if required), each fish will be implanted with 10 year Vemco V16-6H 69 kHz coded sonic tag. Up to 40 sonic tags will be deployed in 2009 during both the broodstock assessment or during the fall population assessment session (Task 4). In the event relatively few sonic tags are deployed during the first half of the broodstock assessment, consideration will be given to implanting up to 10 sonic tags in larger juvenile white sturgeon.

Previous broodstock capture efforts in the upper Columbia River and Kootenai River have identified that the period prior to the start of spawning, when fish are staging near the spawning grounds, as the optimum time to capture and assess broodstock availability (see Section B). High capture success has also been recorded after spawning commences (B. Chapman, Golder Associates, Senior Fisheries Technician, January 23 2009, pers. comm.). In 2002, the earliest evidence of spawning was first recorded on June 28 in the Priest Rapids Reservoir downstream of Wanapum Dam. Based on this date, the broodstock assessment sampling will be conducted from June 9 and June 29, 2009 in order to maximize the opportunity to capture broodstock.

3.2.2 Task 2: Spawning monitoring

Spawn monitoring in 2009 will follow the same methodology and sampling locations used in the 2000-2002 study (Part C, Section 4.5). Egg collection mats will generally be deployed as single mat sets within or immediately downstream of previously identified white sturgeon spawning areas in the tailrace of Wanapum and Rock Island dams. The total number of egg collection mat deployed during the 2000-2002 study was dependent in flow conditions and number of obstructions present (e.g., basalt pillars). During very low flows in 2001, a maximum of only 21 mat sets could be safely deployed and retrieved. In a typical flow year, up to 30 egg collection mats can be deployed in each tailrace sampling area. If additional egg collection mats are available and if logistically feasible, these mats may be deployed if other suitable sampling sites are later identified. The three-person spawn monitoring crew will consist of a project biologist and two intermediate and/or junior technicians. Captured white sturgeon eggs will be staged at the end of the day or on days when eggs are not captured and the crew has additional time.

Based on the 2000 to 2002 spawning monitoring results, spawning in the PRPA commenced as early as June 28 in 2002 and a late as July 28 in 2001. In other white sturgeon spawning locations in the Columbia River with similar seasonal flows and water temperature, the start of spawning has generally been recorded in early to mid-June. Spawn monitoring will therefore be conducted in the PRPA from June 4 to August 1, 2009 in order to encompass the entire potential spawn season and reduce the possibility of missing the first spawning event. Crew changes will occur at two week intervals and a total of four crew changes will be required.

3.2.3 Task 3: Deployment of sonic receivers

Twelve Vemco VR2W sonic receivers will be initially deployed in the PRPA, seven in Wanapum Reservoir, four in Priest rapids Reservoir, and one in the tailwater area of Priest Rapids Dam. The deployment locations will be similar to those used in the 2000 to 2002 study (Part C, Section 4.4.1). Compared to the Vemco VR1 receivers used during the previous study, the newer VR2Ws have significantly better battery life (15 months), larger storage capabilities, and more advanced data download and handling capabilities.

The VR2W stations will be installed by field crews conducting either the broodstock assessment or spawn monitoring study components (i.e., on short field days when either fish or eggs are not captured). Ideally, the opportunity to deploy the station will occur during the first two weeks of the broodstock assessment program. This will allow the stations to be established prior to deployment of most if not all of the sonic tags, without additional expense to the project in terms of crew time. Installation of the VR2W monitoring stations is described in Part C, Section 4.4.1. Downloading of each of the station will be conducted by the spawning monitoring crew in late July, and the again in late September during systematic sampling under Task 4.

3.2.4 Task 4: Population Assessment

A single session of systematic capture and tagging of white sturgeon throughout both reservoirs will be conducted in 2009. White sturgeon capture and handling procedures will be identical to those used during the Task 1 (Broodstock Assessment; see Appendix A and Part C, Section 4.2). Set lines will be deployed in approximately the same locations as in the 2000 to 2002 study, at one mile intervals along both banks and perpendicular to the bank whenever possible. The sample team will use two boats with three crew members per boat. Each crew will consist of a project biologist, an intermediate technician, and a junior technician. The crew will deploy six set lines each day and each location will be sampled daily for two consecutive days, with setline line deployed overnight for approximately a 24 hour set duration. On the third day, the set lines are pulled and reset upstream. During the sampling, in addition to marking all first capture fish, the balance of the V16-6H tags will be deployed in adult white sturgeon. Up to ten V13-1L tags will also be deployed in juvenile white sturgeon.

A review of white sturgeon capture data from the 2000 to 2002 study clearly indicates that highest white sturgeon capture rates during systematic sampling of both reservoirs was recorded in early fall from September to October as opposed to earlier sampling effort in spring (i.e., fall 2000 total captures = 46, spring 2000 total capture = 21). Fall 2001 captures were similar to the fall 2000 total captures. The higher captures rates in fall were assumed to relate to warmer water temperature, dispersal of fish after spawning, and a higher propensity to feed and therefore greater recruitment to the sampling gear. Based on the previous study, both reservoirs can be sampled in 23 days (including travel). Tentatively, the 2009 sample session will be conducted from September 3 to September 25, 2009. Three contingency days have been budgeted in the event weather or operating conditions prevent access to the reservoirs.

3.3 Data Management

All hand-written data associated with each Task will be recorded on waterproof task specific datasheets. Datasheets will be photocopied at the end of each day and copies kept in a secure file. A sufficient numbers of low capture, “short” days should be available to allow field crews to enter data into either an Excel spreadsheet for later important into an Access database. Electronic data entries will be verified by a second person. Whenever possible, all discrepancies in the data will be addressed and documented by field staff during the sampling session. All electronic files created during data entry or downloaded from acoustic receivers will be posted on daily basis as they are obtained to an internet collaboration workspace and back-up copies will be kept on both the field computer and an external flash memory drive.

4.0 Study Methods

4.1 Temperature and Discharge

We assume that temperature and discharge data for Rock Island and Wanapum dams will be readily available from GCPUD, from Chelan PUD, and from on line sources. Inexpensive self contained digital temperature loggers will be deployed on each of the VR2W sonic receiver stations. The temperature loggers would be downloaded concurrently when the VR2W station are downloaded ad serviced in late July and September 2009.

4.2 White Sturgeon Capture

4.2.1 Set Line Deployment and Retrieval

Set lines will be the main method used to capture white sturgeon during the Task 1 and Task 4 present study. Appendix A provides a detailed description of the equipment and deployment methods to be used. During Task 1 (Broodstock Assessment), only the larger size 3 (16/0) hooks will be deployed to maximized adult white sturgeon capture and minimize capture of juveniles. The number of hooks on each line will depend on the size of the staging area being sampled.

During Task 4, a variety of hook sizes will be used [7 (12/0), 5 (14/0), and 3 (16/0)] to allow capture of a greater range of size-classes. Ten hooks of each size will be placed in random order on each line. The barbs on all hooks were removed to facilitate fish release and reduce the severity of hook-related injuries. Set line hooks will be baited with commercially available pickled squid. This is the same bait that was used during the 2000 to 2002 study.

Set lines will be deployed and set overnight at every river mile (RM) on both the left and right banks. The lines will be pulled, cleaned, re-baited and reset daily, and will be fished at each location for two nights. Two crews will set and retrieve six set lines per day in order to sample the entire length of the study area in approximately 21 days. Set and retrieval methods are outlined in Appendix A.

In general, set lines will deployed from a boat and set either parallel to the shore in slow flowing water areas or perpendicular to the shore in calm water. Prior to each set, water depth will be determined by echo sounder, and this information will be used to select a float line of appropriate length. An anchor and float line will be attached to each end of the mainline. The line will be deployed by reversing the boat in the direction of current, matching the pace of the line setters in order to keep the mainline straight and avoid dragging the anchor. One crew member will feed out the mainline while another attached pre-baited hook lines at regular intervals as the mainline is deployed. When the opposite end of the mainline was reached, the second anchor and float line are connected. An additional anchor will be connected to the ends of the mainline in areas with discernibly faster water velocities to ensure the mainline stays in position and the hooks remain on the bottom

The retrieval procedure involves lifting the downstream anchor using the float line, until the mainline is retrieved. The anchor and float line are fed into a plastic tub, followed by the mainline, and the boat is then idled forward along the mainline and each hook line is removed. If a fish was on the line, the boat was stopped while the fish is removed. Under most conditions, the lines are most effectively and safely retrieved by hand, however, if required, a rope winch on the bow of each boat can be used to assist in retrieval of the lines. To facilitate the recovery of set lines that may have become lost (i.e., due to float lines being cut by boat propellers or vandals), a sonic tag (Sonotronic EMT-01-1 Pinger) will be attached to the middle of each set line. These pingers are acoustic and can be located with a directional hydrophone.

4.2.2 Fish Handling

Since the 2000-2002 study, several changes in fish handling have been developed by broodstock collection programs other areas of the Columbia River basin. Many of these changes have been implemented to reduce handling stress and total handling time from initial capture to release. These fish handling procedures are outlined in Appendix A. These procedures, however, were developed primarily for the collection of broodstock and assume that fish are captured in a nearby staging area, usually a relative calm backwater feature where the boat can either be anchored or be allowed to drift. The methods were also developed in the Canadian portion of the upper Columbia River where the bank to bank river width and total discharge is considerably less than the section of the Columbia River encompassed by the Project. Also, strong wind and large wave conditions can occur frequently and unexpectedly within the PRPA. With this understanding, a maximum wind and wave criteria will be established during which setline deployment, retrieval and fish processing will not be conducted. That said, the ability to conduct sampling during low or moderate wind and wave conditions is a necessary requirement in order to conduct an effective sampling program in a timely, cost effective manner and eliminate undue stress on captured fish. Under low to moderate wind and wave conditions, once the fish are secured, the crew has the option to move the boat slow into calmer water to process the fish.

Fish removed from the set line will be tethered to the boat by means of a 2.5 cm thick soft-lay cotton rope looped around the caudal peduncle. The tether length will be long enough to ensure the fish remains fully submerge but still a sufficient distance away from the rear of the boat and the propeller. Generally, fish tethered in this manner remain quite docile. Under most conditions, the entire mainline will run until all fish and hooks are removed. In the event a mainline cannot be easily retrieved without substantial use of the boat engine, the line will be redeployed by backing up the boat and any fish captured at this point will be processed and released prior to a second attempt to retrieve the set line.

Once removed from the set line, fish will be brought on board for processing and subsequent release following procedures in Appendix A. High ambient air temperatures and low humidity levels, a common condition in the Project area, can cause additional stress on fish during processing. A hood on one end of the stretcher protects the head of the fish from exposure to direct sunlight and also retained a sufficient amount of water to allow the fish to respire during processing. Wet towels will also be placed over the body of the fish to keep the skin cool and moist and to protect it from the sun. Fresh river water will be continuously pumped over the gills during the period the fish remains in the stretcher. All fish will be fully recovered and able to swim away under their own volition prior to release.

4.3 Life History Collection

White sturgeon processing and life history data collection during 2009 will be nearly identical to the methods used during the 2000 to 2002 study. Again, based on broodstock capture work conducted since the original study, some modifications and improvement to the data collection procedure have been made and will be implemented during the 2009 study. All data collection procedures and datasheet examples are provided in Appendix A. The specific data to be collected in 2009, the applicable sections in Appendix A, and differences between 2000 to 2002 methods and the proposed 2009 methods are provided in following sections.

4.3.1 Examination for Pre-Existing Marks and Tags

All white sturgeon will be scanned for PIT tags and checked for marks indicating the fish has been previously captured (i.e., scute and fin ray removals; see Appendix A, Section 4.2). Fish captured during the previous study in 2000 to 2002 were marked by removing the ninth right lateral scute, and the second left lateral scute was removed if the fish was implanted with a PIT tag (Golder 2003a). A functioning test PIT tag must be available to check if the PIT tag reader is working properly and the entire surface of the fish must be scanned. All fish from 2000 to 2002 were implanted with a 125 kHz PIT tag. The AVID Power TracKer VIII Multi Mode Readers are capable of the detecting and decoding the 125 kHz PIT tags as well all the newer 134.2 kHz ISO PIT tags and will be used in the present study. Three PIT tag scanners will be available; one for each crew with the third unit to serve as backup in case one of the primary scanners fail.

4.3.2 Length and Weight

Length and weight measurements will be collected using the methods provided in Appendix A, Section 4.2.

4.3.3 Collection of Ageing Structures

Pectoral fin rays will be collected from all fish captured following the procedures outlined in Appendix A, Section 4.3. Typically, the left pectoral fin ray will be collected unless deformities or damage to the left pectoral fin are evident.

4.3.4 Sex and Maturity

The assessment of the sex and maturity of captured will adhere to the methods outlined in Appendix A, Section 4.5. Overall, the surgical and examination procedure to be used in 2009 will be very similar to the procedure used in 2000 to 2002 with the exception of the following changes:

1. During Task 1 (Broodstock Assessment) prior to conducting a surgery, the extraction of milt from the urogenital duct will be attempted using methods proscribed in Appendix A, Section 4.5. Flowing ripe males typically will not be operated on unless the objective is to increase the number of sonic tags deployed. During Task 4 (Population Assessment), this procedure will not be effective and internal examination will be performed on all new

fish (not previously captured and examined that year) over 59 inches and all recaptured fish tagged during the 2000 to 2002 studies.

2. Gonad maturity classifications will be based on the revised rating system provided in Appendix A, Section 4.5, Table 4.1. The revised classification system has better descriptions and more accurately reflects the most commonly observed features associated with male and female gonads than the previous classification system used from 2000 to 2002.

The use of 2-0 Polydioxanone violet monofilament (PDX) sutures will be used in 2009 instead of absorbable chromatic gut sutures. Synthetic PDX sutures do not wick water, but are also fully absorbable. Surgical tissue adhesives, such as Vetbond™ were found to impair healing and are no longer used directly on the incision; however, such adhesive will still be applied to the suture knots as a safety precaution again premature loss of the suture. Oxytetracline will be applied by syringe into the body cavity to facility healing and reduced the possibility of infection.

4.3.5 Genetic Analysis

A sample of soft tissue will collected for molecular genetic DNA analysis from all white sturgeon captured in the PRPA. The tissue sample will be removed from the distal end of the pelvic fin, cut into thin sections using surgical scissors, and preserved in labeled vials containing 99% ethanol. The DNA samples will archived for future analysis.

4.3.6 Fish Marking and Tagging

During the 2009 study all first capture fish will be marked or tagged by Passive Integrated Transponder (PIT) tags and the removal of lateral scutes. All adults and selected juveniles will also be marked by the implantation of coded acoustic tags.

Insertion of PIT tags will general follow the basic procedures on Appendix A, Section 4.7; however, due to the presence of a recreation food fisheries on white sturgeon in lower reaches of the Columbia River, PIT tags will be injected subdermally behind the posterior edge of the bony plate on the head. Care will taken to angle the syringe needle so the tag is perpendicular along the longitudinal axis of the fish within the subcutaneous layer.

An enduring and noticeable mark on white sturgeon results from the removal of a section of the first pectoral fin ray for ageing purposes. This mark persists for several years and can easily be identified by experienced samplers. Re-growth of soft tissue within the missing fin ray section occurs within a few months of ray removal. This soft tissue can easily be differentiated from the hard bone in uncut fins and, therefore, provides a persistent mark that can be used to identify recaptured fish.

In the 2000 study year, the ninth right lateral scute was removed from all white sturgeon captured during the spring sample session. In 2001, ninth left lateral scutes were removed from captured white sturgeon. The removal of a scute to identify the year of first capture will be done only if required by the Washington Department of Fish and Game. Lateral scutes will be removed according to the procedures in Appendix A.

4.3.7 Sonic Telemetry Tagging

Up to 40 Vemco V16-6H 69kHz coded sonic tags will be surgically implanted in adult white sturgeon during Task 1 and Task 4. The tags will be programmed to transmit at a 180 second burst interval and will have a life expectancy of ten years. Up to 10 smaller V131L 69 kHz coded tags will be deployed in suitable juvenile white sturgeon. These smaller tags will be programmed to transmit at 240 second burst interval and will have a life expectancy of 5 years. At Interval times of 180 seconds and greater, the chance of signal collision is reduced and detection rates of at least one detection per hour for up to 36 fish within the signal range of a receiver will be possible. This detection resolution will be of benefit during the overwintering period when potential large number of tagged white sturgeon may aggregate at a single location.

Prior to implantation, all sonic tags will be tested to ensure that they have properly activated and are transmitting normally. Prior to implantation, the tag type, serial number, and code will be recorded.

4.4 Acoustic Telemetry Tracking

Mobile telemetry tracking will not be conducted in 2009 and locations of sonic tagged fish will be determined solely by detection on the stationary VR2W underwater receivers deployed at locations throughout both reservoirs. These locations will typically be at locations where white sturgeon are known to aggregate or at narrow sections of the reservoir where detection rates of fish moving past are increased.

During the previous study, acoustic receiver stations were positioned above and below Priest Rapids Dam (n=4), at Goose Island (n=1), and in the tailrace of Wanapum Dam (n=2). In Wanapum Reservoir, remote stations were positioned in Wanapum forebay (n=2), at Sunland Estates (n=1), at Crescent Bar (n=2), and in the tailrace of Rock Island Dam (n=1). Data from these monitoring locations will be used to identify monitoring locations for the present study program. Stations where limited data were obtained will not be considered.

4.4.1 VR2W Remote Telemetry Receiver Stations

Similar to the VR1 used during 2000 to 2002 study, a VR2W is a submersible, single channel acoustic receiver capable of identifying coded Vemco sonic transmitters. Each receiver operates on a set frequency (69 kHz) to decode the sonic transmitters. The receiver is housed in a cylindrical high pressure plastic case, and incorporates an integrated hydrophone mounted at one end of the case. The VR2W records the code number and date/time of each valid detection, as well as temperature and depth data from acoustic sensor tags. Compared to the VR1 unit, considerable improvements have been made with the development of the VR2W. Each receiver can store up to 1 million detections on an 8 MB flash memory card. Data is download directly to a portable computer very rapidly (more than 20 time faster than a VR1) over Bluetooth™ wireless interface. Each VR2W is powered by 3.6-volt Lithium cell battery with an operating life of 15 months, five times longer than a VR1.

Each VR2W station will be installed in a manner suitable to its deployment location. Due to the interference caused by turbulence, VR2Ws will not be deployed in turbulent water. Where possible, each VR2W will be deployed suspended vertical in the water column at a depth between 4 to 5 m with the hydrophone directed downward. In anticipation of long-term deployment and potential vandalism, the proposed deployment configuration will consist of a150 lb bottom anchor attached to length of ¼" stainless steel cable suspended by LD2 float. A metal crimp and cable clamps will be used all connection points and cable loops. A sufficient amount of cable will be deployed to provide enough slack at all reservoir elevation to allow the receiver to be lifted to the surface for downloading and servicing. The VR2W will be attached to a loop in the suspension cable located 4 m below the float. A short length of stainless steel cable, threaded through the body of the VR2W and secured by a crimp and cable clamps, will be used to securely attach the VR2W to the suspension cable. Band clamps and cable ties will then be used attach the lower portion of the unit to the suspension cable. A small weight may be attached to the suspension cable below the unit so that the unit remains vertical in the water column. A small second foam core float, inline and beneath the primary float may be used to provide additional flotation and serve a safety backup in case the primary float is punctured (e.g., knife, bullets). If possible, a shore line may be attached to the bottom anchor as a secondary method of retrieval in case of loss of the primary float.

4.5 Spawning

4.5.1 Egg Collection Mats

Egg collection mats will be deployed to capture eggs or larval stages of white sturgeon and determine spawn timing, frequency, and to delineate white sturgeon spawning and egg incubation habitats. This technique has been used successfully to identify white sturgeon spawning areas and monitor spawning intensity and success in the Columbia and Kootenay rivers in British Columbia, Canada. The mats are constructed of filter material (latex-coated animal hair) cut into 76 cm by 91 cm sections and secured within an angle iron frame with strips of flat bar. The strips are secured within the frame by bolts to allow removal of the filter material for cleaning and replacement. Two sections of filter material are placed back to back within each frame. This ensures that one side of the filter material always faces up, regardless of how the frame rests on the river bottom. Short sections of rope attach the frame to an anchor, which holds the egg collection mat and frame in place on the bottom. A float line is attached to the egg collection mat to mark its location in the river and allow for the retrieval of the unit. All floats will be labeled with the deployment location site name. For mats set within 50 m of the shore, an additional anchor rope is affixed to the shore as a back up to reduce the chances of losing the mat. During the 2000 to2002 study, mats without a shoreline were often displaced downstream during high flow. In 2009, additional weight will be added to the anchors of mats located in high velocity locations.

Measurements taken after each deployment of the egg collection mats will include set and pull times, date, mean depth (measured by an echo sounder), and water clarity (measured by a Secchi disk). Prior to each deployment, the mats will be inspected and the filter material replaced as required. UTM coordinates will be recorded after each deployment and retrieval. All data is recorded on water-proof datasheets. The number of mats deployed will depend upon channel configuration, water elevation, and flow hazards. Where possible, egg collection mats will be deployed at locations where eggs were previously captured during the 2000 to 2002 study.

A three-person crew, consisting of a boat operator and two crew members, is required to safely deploy and retrieved egg collection mats. Mats tied to shore are retrieved by first untying the shore line and the retrieving the mat, followed by the float line; all others are retrieved by the float line, Careful control and management of rope during the deployment and retrieval process is a critical safety requirement. An electric winch mounted on the bow of the boat will be used to assist in the retrieval of the egg collection mats.

All egg collection mats will be inspected visually for white sturgeon eggs. If eggs are observed, all eggs will be enumerated and 1 in every 10 eggs will be preserved for stage identification. Preserved eggs will initial be placed in a fixative for several hours and later transferred to label storage vials containing 70% ethanol. All vials will have an internal and external label identifying the site, date, number of eggs, and location. The remainder of the eggs will be kept in a water fill cooler and either used for the egg incubation study or returned to the water downstream of the egg collection mat deployment location. White sturgeon eggs will be staged at the end of the day or on days when eggs are not captured. Egg staging will conducted using a stereoscope and will be based on egg stages identified in Wang et al (1985).

4.5.2 Egg Incubation

A proportion of the eggs captured will be incubated to hatch to confirm that the eggs are fertilized and viable. The incubation cassettes consist of a three separate Plexiglas ¼" thick plates, 5"wide by 8" long, perforated with up to 30 holes 3/16" in diameter and held together by six screws with wing nuts. Fine mesh screen in attached to he inside surface of the front and back Plexiglas plates, creating a small chamber in the inner plate, in which a white sturgeon egg is placed for incubation. After being loaded with eggs, the cassettes are deployed on a float rope suspended in the water column.

Literature Cited

Golder Associates Ltd. 2003. White sturgeon investigations in Priest Rapids and Wanapum reservoirs on the Middle Columbia River, Washington, U.S.A. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 002-8817F: 82p. + 6 app.

Wang, Y.L., F.P. Binkowski, and S.I. Doroshov. 1985. Effect of temperature on early development of white and lake sturgeon, Acipenser transmontanus and A. fulvescens. Environmental Biology of Fishes 14:43-50.

Appendix A
White Sturgeon Broodstock Collection Protocol

White Sturgeon Broodstock Collection Protocol

December 2008

Table of Contents

List of Tables

List of Attachments

1.0 Introduction

The requirement for a consistent, well documented approach to broodstock collection activities was identified by the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI) as a necessary component of the Recovery Plan. To this end, the "Upper Columbia River Adult White Sturgeon Capture, Transportation and Handling Manual" was developed to provide a standardized methodology for the capture, transport, and handling of adult white sturgeon broodstock (Golder 2006). Numerous people contributed to the production of this manual including staff from BC Hydro, Freshwater Fisheries Society of BC, BC Ministry of Environment, Oregon Department of Fisheries and Wildlife, Oregon University, Washington Department of Fish and Wildlife, and Golder Associates Ltd.

The broodstock collection methods described below have been adapted from the UCWSRI manual, for use in the PRPA. In addition, standard white sturgeon sample techniques used throughout the Columbia River and Kootenay River by researchers in Canada and the United States have been incorporated as appropriate.

Broodstock collection efforts in the PRPA will initially focus on the collection of pre-spawning adults from known spawning areas below Rock Island Dam, Wanapum Dam, and Priest Rapids Dam. Sampling in these areas will initially occur in spring 2009 to assess the feasibility of obtaining broodstock from the PRPA. Details of the sample program are provided in Part C. Assuming the results of the initial study support the feasibility of obtaining broodstock from within the PRPA, the following protocols will be implemented for the capture, handling and transport of white sturgeon broodstock.

2.0 Capture Techniques

2.1 Set Line

Set lines are the main method used to capture white sturgeon broodstock (see Section 2.3 for bait requirements). This method provides high catch-rates of white sturgeon, is less size selective than other sample gear, and rarely captures non-target species (Elliot and Beamesderfer 1990). In Idaho, the Kootenai River white sturgeon recovery efforts have had the greatest success using set lines to capture female white sturgeon (Sue Ireland, Kootenai Tribe of Idaho, pers. comm., 2001). A long line configuration, similar to that developed by the Oregon Department of Fish and Wildlife (ODFW) and the Washington Department of Fish and Wildlife (WDFW), is preferred for capture of white sturgeon in the lower Columbia River (Nigro et al. 1988). This type of gear was used successfully during white sturgeon studies in the Wanapum, Priest Rapids and Rocky Reach Reservoirs in 2000 – 2002 (Golder 2003a, Golder 2003b) and will be used to capture white sturgeon in Wanapum and Priest Rapids Reservoirs during the present study program.

2.1.1 Configuration

Typically, long lines are the preferred configuration. Long lines measure 600.4 ft in length and consist of a 0.25" diameter nylon mainline with 30 circle halibut hooks attached in the middle of each 20 ft section (i.e. first hook attached at 9.8 ft, then at 20 foot intervals thereafter). A medium line configuration (131.2 ft mainline; 8 hooks) is used in areas that are too small to deploy long lines (i.e. small eddies). Hook lines consist of a 0.25 inch stainless steel swivel snap, for attachment to the mainline, and a 2.3 ft long ganglion line tied between the swivel and the hook. Previously, hook sizes used were 7 (12/0), 5 (14/0), and 3 (16/0). Ten hooks of each size were attached in random order to long lines and two or three hooks of each size are attached to medium lines in random order at equal intervals. As hatchery released juvenile sturgeon begin recruiting to set lines, size 3 (16.0) hooks will be used exclusively to limit the catch of sturgeon not yet at reproductive age. The barbs on all hooks are removed prior to use to facilitate fish release and reduce the severity of hook-related injuries. Hooks are checked regularly and sharpened as necessary.

2.1.2 Deployment

Set lines are deployed from a boat and set either parallel to the shore in flowing water or perpendicular to the shore in calm water. The preferred orientation to flow is perpendicular, which results in a wider area of dispersal of the bait scent and, therefore is more likely to attract fish. Steel railway "fish plates" or concrete anchors (approximately 11 lbs) and float lines are attached to each end of the mainline. Prior to each set, water depth is determined by echo sounder and this information is used to select a float line of appropriate length. In most situations, the set line is secured to shore with a shore line; in low water velocity areas, the set line can be deployed without being attached to shore. The set line is deployed by reversing the boat, matching the pace of the line setters in order to keep the mainline straight and avoid dragging the anchor. One crewmember feeds out the mainline and attaches pre-baited hook lines, passed by a second crewmember, at regular intervals as the mainline is deployed. When the mainline is fully deployed, the second anchor and float line are deployed. In areas with faster water velocities or when no shore line is used, additional anchors are connected to the ends of the mainline to ensure the mainline remains in position and hooks remain on the bottom. Set lines are usually set overnight at each selected site.

2.1.3 Retrieval

The retrieval procedure involves lifting one anchor using the float line, until the mainline is reached. In slower water velocity environments, the near shore float line is lifted and the mainline is fed through an open pulley-system connected to the boat davit with the anchor on the shore line side of the pulley. The boat then follows the mainline as it is retrieved and each hook line is removed. In higher velocity areas, the mainline must not be fed through the pulley-system of the boat davit due to the dangers posed by current and possible snags on debris in the river. The anchor and float line are fed into a plastic tub, followed by the mainline, and the boat is idled forward along the mainline and each hook line is removed. This allows for rapid redeployment of the set line if complications arise.

If a fish is suspected to be on a set line, the set line is pulled slowly to enable white sturgeon to vent expanding gas from the swim bladder or 'burp'. For all set line site conditions, once the fish is at the boat, the boat is stopped or held in position and the fish is removed from the mainline (see Section 3.1). The entire mainline is run until all fish and hooks are removed. This method is preferable to the option of sampling each fish as it is brought to the boat. The time required to sample each fish can be lengthy; fish that remain on the line continue to struggle, increasing the possibility of inflicting additional hook damage and stress. Old bait is removed and the hook lines are re-baited daily prior to resetting each line.

2.1.4 Data Recording

Data entry is to be completed during set line deployment and retrieval (Attachment A). Data recorded at each set line also includes personnel, location (river Mile), site description, date and time set, date and time pulled, water temperature, minimum and maximum depth, number and size of each hook used and bait type. At newly established sample locations, Universal Transverse Mercator (UTM) coordinates must be recorded using a Global Positioning System (GPS) unit. To assure reasonable accuracy, an average will be for approximately 2 minutes or 30 points will be collected, if possible. A site sketch is also produced at newly established sites. Whenever possible, data are recorded directly into an electronic database on board the boat. This limits transcription errors and allows for items such as sample locations to be selected from drop down menus to reduce data entry replication. When more than one crew is recording data electronically, databases will be synchronized daily so the most recent data are available to each crew.

2.2 Angling

Angling is also an effective means of capturing white sturgeon. This method is less size and species selective than set lines but, if the proper gear is used, reduces capture stress and injury. Angling may be conducted supplementary to the use of set lines when time permits or where set lines are deemed ineffective (i.e., inappropriate habitat for set lines). Angling gear consists of a single shank stainless steel hook and 100 to 128 lb test braided or monofilament line. The line is weighted so that the bait rests near the bottom.

Data recorded during angling includes personnel, location (river Mile), site description, UTM coordinates, date and time set and pulled for each angling rod used, water temperature, water depth, and type of angling (i.e., boat or shore, as discussed in Attachment A). As with setline data, it should be recorded electronically when possible with data from multiple crews synchronized daily.

2.3 Bait

Set line hooks will be baited with commercially available pickled squid, which has been used successfully in recent years by Washington Department of Fish and Wildlife (WDF&W) to capture white sturgeon in other areas of the Columbia River.

3.0 Fish Handling

3.1 Hook Removal and Tether Lines

As the set line is retrieved, hooks and lines are removed from the set line. The hooks that are holding sturgeon are left attached to the fish and then affixed to an elasticized tether or “snubber” suspended from the gunwale. The elastic in the tether reduces risk of the hook causing further damage to the mouth of the fish. The tether should be of a length that permits the fish to remain fully submerged but be high enough in the water to not allow normal swimming position. In this position the sturgeon tend to remain docile and not fight against the tether. If the hook is not adequately secure in the fish or has the potential to cause increased damage to its mouth, the fish should be secured with the use of a tail tether. This tether line (1 inch thick soft-lay cotton rope) is placed around the caudal peduncle of captured white sturgeon. A ‘hose noose’ (i.e., rope fed inside a garden hose to prevent rope-on-skin abrasion) can also be placed around the pectoral girdle, so that one crewmember can manoeuvre the fish, while another member lifts the tail and places the tether line around the caudal peduncle. The tether should be snug enough around the tail to prevent the fish from escaping, but not so tight as to cause abrasion. Once the tether line is placed on the fish, secure the free end to the boat gunwale. The hook and line are carefully removed from the mouth of the fish either by hand or with needle nose pliers. The tether line must be of sufficient length to allow the entire body of the fish to remain submerged. Fish tethered in this manner usually remain quite docile. In the case of high total dissolved gas conditions, special procedures can be used to hold the fish below the compensation depth (see Section 5.3.3).

3.2 Transferal to Hooded Stretcher

White sturgeon remain in the water until they are ready to be processed. Fish less than 330 lbs in weight or 8 ft in length are guided into a 6.6 ft long by 3.3 ft wide, hooded stretcher constructed of a waterproof plastic laminate material. The stretcher also consists of two 8.2 ft poles, which rest on a notched rack or saw horse on the gunwale of the boat to support the fish during examination. The head of the fish is placed inside the hooded portion of the stretcher. The stretcher is raised into the boat by means of a winch and davit assembly. The hood on one end of the stretcher protects the head of the fish from exposure to direct sunlight and also serves as a respiration chamber when flooded with water. Wet towels are placed over the body of the fish to keep the skin cool and moist and reduce exposure to the sun. Fresh river water is continuously pumped over the gills during the period that the fish remains in the stretcher. After processing, the fish is returned to the water and remains in the stretcher until ready to swim away. Fish over 330 lbs in weight are also placed in the stretcher, but the stretcher is not brought aboard the boat. In this case, the stretcher serves mainly to restrain the fish and the work-up of the fish is conducted in a shallow-water area with a smooth bottom configuration. When fish are processed in shallow water, the tether can be secured to the boat, a tree or nearby rock as a safeguard against escape.

4.0 Life History Collection Procedures

4.1 Data Recording

A detailed description of each portion of the life history section, including associated codes and abbreviations, of the white sturgeon broodstock data sheet is provided in Attachment B. A list of sampling equipment and surgery supplies is provided in Attachment C.

4.2 Size, Weight and Marks

White sturgeon are scanned for PIT tags and checked for marks indicating the fish has been previously captured (i.e., scute and fin ray removals). Fish captured during the previous study in 2000 to 2002 were marked by removing the ninth right lateral scute, and the second left lateral scute was removed if the fish was implanted with a PIT tag (Golder 2003a). A functioning test PIT tag must be available to check if the PIT tag reader is working properly and the entire surface of the fish must be scanned. There are three types of PIT tags (400 kHz, 125 kHz, and 134.2 kHz ISO, listed in chronological order of deployment and representing changes in technology over time) potentially active in sturgeon in the Columbia River. As some current PIT tag readers are incapable of detecting 400kHz PIT tags, ensure that a PIT tag reader capable of detecting 400 kHz PIT tags (eg. AVID Power TracKer VIII Multi Mode Reader) is used when scanning for tags.

All white sturgeon are measured for fork length, with the start of the measuring tape held perpendicular to the tip of the snout (not wrapped around to the tip) and running along the lateral surface of the sturgeon to the fork in the caudal fin. Additional measurements that may be collected (although not currently collected) include total length (as with the fork but with the tape bending at the caudal peduncle and following along the upper lope of the caudal fin to the tip), head length (from tip of snout to the front of the trunk behind the gill opening), and snout length (from tip of snout to the front of the eye), and girth (just behind the pectoral fins). All measurements are made to the nearest 0.2”.

Each captured white sturgeon is examined externally. Features such as colouration, deformities (either genetic or mechanical injury related), lesions, cysts, external parasites, and body form anomalies are recorded. Weight is determined while the fish is in the stretcher, suspended from the winch and davit assembly, using a 300 lb capacity spring scale accurate to ±5 lbs (remember to tare the scale with the stretcher attached or subtract the weight of the stretcher). Fish greater than 330 lbs cannot be weighed, without specialized equipment (e.g., larger scale and stable boat), and fish less than 22 lbs are weighed using a 11 to 22 lb spring scale. All data noted above are recorded electronically or on the data sheets in the spaces provided (see Attachment A and B).

4.3 Age and Growth

Pectoral fin rays are the preferred non-lethal structure for ageing white sturgeon. Fin ray sections are obtained by making two cuts with a sterilized hacksaw. The first cut is made approximately 0.4” distal from the point of articulation (knuckle) of the pectoral fin and the second is made approximately 0.4” distal from the first cut. Sections are separated from the fin with a sterilized surgical knife and placed in an envelope marked with the appropriate information. Dispose of the used blade in a Sharps container. Swab the area where the fin section is removed with an antiseptic, and if there is any bleeding apply pressure to the wound until bleeding stops. If bleeding does not subside, apply Quickstop™ powder or a gauze pad to the wound.

Oxytetracyline (OTC) can be used as a marker on bony structures (i.e., fin rays) for future age-validation studies and is applied to select fish for this purpose. Administer OTC at a dosage of 0.2 mL Liquamycin-LP per kilogram of body weight (Attachment D) and inject this intraperitoneally through an incision (see Section 4.5; Apperson and Anders 1991; R.L. & L. 1996). If surgery is not performed on a fish, OTC can also be injected intramuscularly anterior to the dorsal fin. Refer to Section 4.7.3 for marking procedures related to OTC application. To prevent the chemical breakdown of OTC, keep the bottles in a cool area, protect them from direct light, and note the expiration date.

The possible combinations fin ray section removal and OTC application procedures are:

1. No procedure.
2. Remove fin ray section.
3. Apply OTC.

4. Remove fin ray section and apply OTC.

Removal of fin ray sections and/or application of OTC are determined as follows:

For fish with a fork length (FL) of less than 49” with;

- both fin rays intact and OTC has not been applied, procedure 4.
- both fin rays intact and OTC has been previously applied, procedure 2.
- one fin ray intact and OTC has not been applied, procedure 3.
- one fin ray intact and OTC has been applied <10 years previously, procedure 1.
- one fin ray intact and OTC has been applied >10 years previously, procedure 2.
- no intact fin rays, procedure 1.

For fish with a FL of greater than 49” with;

- one or both fin rays intact and OTC has not been applied, procedure 3.
- one or both fin rays intact and OTC has been applied <10 years previously, procedure 1.
- one or both fin rays intact and OTC has been applied >10 years previously, procedure 2.
- no intact fin rays, procedure 1.

Ensure that the fin ray is placed in an envelope marked with the date, capture location, fork length, weight, sex and maturity stage (see Section 4.5), Passive Integrated Transponder (PIT) number (see Section 4.7), sample type (i.e., pectoral fin clip), crew members, and contractor project number. Record on the data form (Attachment A) whether the left or right pectoral fin ray was removed.

4.4 Contaminants Sampling

When captured white sturgeon are to be sampled for the presence of contaminants, follow the procedures outlined in Attachment E. Record any external anomalies and whether blood, mucous, urine, and gonads were sampled from each captured fish electronically or on the field data form (Attachment A).

4.5 Sex and Maturity

If a PIT tag has been detected in a captured white sturgeon, check the capture history of the fish to see what information is available for determination of the best course of action for further sex and maturity assessment. Based on what is known about a fish from previous handling, it may be determined that the fish is not a candidate for use as broodstock (e.g. Female known to have spawned recently, previously used to produce a family, etc.). If broodstock collection is at a point where only females are needed, the basic body shape provides an additional clue on the need for surgery (i.e. mature females have very full and firm abdomens). If the fish is a first time capture (i.e. no previous tag detected) or the past capture history is inconclusive (e.g. no sex and maturity determination previously, verify if they are ripe (or flowing) males by inserting a tygon tube (1/8” inside diameter; 3/16” outside diameter) into the posterior orifice of the urogenital opening. A syringe is attached to the free end of the tygon tube for suction. If white fluid (i.e., milt) is obtained by this method, then the fish is a ripe male and surgery is not performed. If clear fluid is obtained, and there is a requirement to capture or identify ripe or maturing females, a surgery must be performed on sturgeon greater than 59” FL to determine the sex and maturity of the fish. The surgical procedures recommended are similar to those developed for white sturgeon by Beamesderfer et al. (1989). All surgical and other support equipment should be laid out beforehand. The necessary surgical and support equipment is listed in Attachment C.

The fish is positioned on its back in the stretcher and fresh water is continuously pumped over the gills. The ventral surface of the fish around the incision area (three to four ventral scutes anterior to the urogenital opening) is swabbed with Betadine and then covered with a sterile surgical drape, while the remaining exposed area of the body of the fish is covered with wet towelling to keep the fish cool and the skin moist. Keep all surgical instruments and gloved hands sterile to avoid contamination of the incision. All instruments are sterilized in a Germiphene solution (16 ml Super Germiphene concentrate to 1 Litre of distilled water). Sterile latex gloves are worn during the surgery. Appropriate chemical gloves (latex, vinyl, or nitrile) are worn when handling Betadine or Germiphene.

A 0.6 to 0.8” long incision is made with a sterile scalpel through the body wall just off the mid-line. Lift the body wall with tissue forceps while cutting to pull it away from the organs. If the fish is a ripe female, the ripe oocytes (eggs) will appear as large, 0.12 to 0.16” diameter, dark-pigmented spheroids in the area of the incision. Occasionally these oocytes are obscured by blood in the body cavity. In the event that the gonads are not visible due to the presence of blood, attempt to aspirate through a length of 0.16” internal diameter tygon tubing. If the fish is a ripe female, the ova will be free of the ovarian tissue and will be easily drawn into the tubing. Ripe testes can also be recognized through a small incision as white spermatogenic tissue (Conte et al. 1988). Immature gonads or those in early stages of maturation are smaller and more difficult to find. If the gonad is not visible through the incision, an otoscope equipped with a veterinary head and speculum should be inserted into the incision to examine the gonads (Attachment C). Maturity stage is assessed according to the qualitative histological classifications described by Bruch et al. (2001; Table 4.1). Record the sex and maturation stage code in the appropriate section of the electronic or field data form and write a short description of the left and right gonad (where possible) in the comments section provided for each fish captured (Attachment A).

After examination and removal of a sample of the gonad (see Section 4.5), the incision is closed using a half circle, CP-1 reverse cutting-edge needle, swedged to a 2-0 Polydioxanone violet monofilament suture (PDS). When the body wall is thick (greater than 0.2”), a vertical mattress stitch may be used (Dr. Peter Mylechreest pers. Comm.). For thinner body walls, a simple stitch (Conte et. al. 1998) is sufficient. Sutures are spaced approximately 0.4” apart and sufficient slack (approximately 0.08 to 0.16”) provided in the sutures to prevent tissue damage caused by swelling during the healing process. The used needle is placed in a sharps container. After the surgery, the fish is lowered overboard in the stretcher and released once normal orientation, swimming movements, and gill activity are sufficiently restored. Captured white sturgeon deemed suitable for broodstock (i.e., ripe stages of maturation; Table 4.1) are transferred to a holding sleeve in the river (where appropriate) and then to a holding tank prior to being transported to the hatchery (see Section 5.0).

4.6 Genetic Analysis

In the event that there is a need to collect genetics data during the white sturgeon broodstock program, a sample of soft tissue is removed for molecular genetic DNA analysis from newly captured white sturgeon. A small tissue sample is removed using surgical scissors from the distal end of the pectoral fin, cut into thin sections, and preserved in labelled vials containing 99% anhydrous ethyl alcohol. Ensure appropriate chemical gloves (i.e. Nitrile) are worn when handling ethyl alcohol. Insert a waterproof label (write in pencil) directly into the vial and that the vial is placed in a labelled envelope. All labels and envelopes must be marked with the date, capture location, fork length, weight, sex and maturity stage (see Section 4.4), PIT tag number (see Section 4.7), sample type (i.e., DNA fin clip), crew members, and contractor project number. Record the type of DNA sample (i.e. tissue or blood) taken from the fish electronically or on the field data form (Attachment A).

Table 1 Sexual Maturity Codes for White Sturgeon (adapted from Bruch et al. 2001).

Sex	Code	Developmental State Description
Male	Mv	**Virgin male juvenile**; Testes are ribbon-like in appearance with lateral creases or folds , dark grey to cream coloured attached to a strip of adipose fat tissue.
	M1	**Developing male**; Testes are tubular to lobed, light to dark grey, and embedded in substantial amounts of fat. Testes moderately to deeply lobed have distinct lateral folds.
	M2	**Fully developed male**; Testes large, cream to whitish in colour, deeply lobed and filling most of the abdominal cavity. If captured during active spawning, may release sperm if stroked posteriorly along the abdomen.
	M3	**Spent/recovering male**; Testes size are much reduced, with very distinct lobes and whitish to cream colour.
	M0	**Male based on previous capture**; general unknown maturity
Female	Fv	**Virgin female juvenile**; small feathery looking, beige ovarian tissue attached to a thin strip of adipose fat tissue.
	F1	**Early developing female**; pinkish/beige ovarian tissue with brain-like folds and smooth to rough surface, imbedded in heavy strip of fat tissue. The visible whitish eggs are <0.5 mm in diameter. Ovarian tissue of F1 females that have previously spawned is often ragged in appearance.
	F2	**Early "yellow egg" female**; Yellowish/beige ovarian tissue with deep "brain-like folds embedded in extensive fat tissue giving it a bright yellow appearance. Eggs, 1 to 2 mm in diameter with no apparent greyish pigmentation.
	F3	**Late "yellow egg" female**; large yellowish ovaries with deep lateral folds and reduced associated fat. Yellow/greenish to grey eggs 2.5 mm in diameter. May indicate next year spawning.
	F4	**"Black egg" female**; Large dark ovaries filling much of the abdominal cavity. Exhibiting a distinct "bulls-eye". Very little fat, Eggs are still tight in the ovary, dark grey to black, shiny and large, >3 mm in diameter.
	F5	**Spawning female**; Loose flocculent-like ovarian tissue with eggs free in body cavity shed in layers from deep ovarian folds. Eggs large, from grey to black, similar to F4.
	F6	**Post spawn female**; ovaries immediately after spawning are folded with a mushy pinkish and flaccid appearance, with little or no associated fat. Post spawn females display a characteristic abdominal mid-line depression. Large dark degeneration eggs buried amongst small oocytes.
	F0	**Female based on previous capture**; general unknown maturity
Unknown	97	adult based on size, (i.e. 1.5 m FL or greater) no surgical examination
	98	juvenile/sub-adult based on size, (i.e. no surgical examination
	99	gonad undifferentiated or not visible during surgical examination

4.7 Fish Marking

To maximize the information obtained from recaptured fish (e.g., growth rate, movements, maturation), white sturgeon are marked by: i) 134.2 kHz ISO PIT tags; ii) the removal of a section from the first ray on the left pectoral fin (i.e., used for ageing purposes); and, iii) the removal of lateral scutes (i.e. identify PIT tag application and OTC injection). Any white sturgeon that PIT tags with older frequencies should be re-marked with a 134.2 kHz ISO PIT tag.

4.7.1 Pit-Tags

PIT tags are injected subdermally on the left lateral surface of the fish midway between the dorsal fin and the lateral scutes. These tags are digitally coded to allow the identification of individual white sturgeon. Prior to inserting a PIT tag, scan the tag and record the number electronically or on the field data sheet (Attachment A), and immerse both the tag and the tagging syringe in an antiseptic solution (Germiphene). When handling Germiphene wear appropriate chemical gloves (i.e. Nitrile). As PIT tag read range is substantially improved where the antenna is perpendicular to the PIT orientation (Brian Beckley, Biomark inc.; pers. comm.), angle the syringe needle so the tag is deposited in the subcutaneous layer along the striations in the musculature to accommodate proposed fixed PIT tag detection stations. Once the PIT tag has been inserted, scan the fish to ensure that the tag is functional. Read the number to the data recorder for verification.

4.7.2 Pectoral Fin Ray

The removal of the leading pectoral fin ray section for ageing purposes results in an enduring and noticeable mark on white sturgeon that can be easily identified by experienced samplers. Re-growth of soft tissue within the missing fin ray section occurs within a few months of ray removal. This soft tissue can be differentiated from the hard bone in uncut fins and used to identify recaptured fish. Fin clip marking has been used in the Columbia River system since 1990. Pectoral fin ray removal procedures are discussed in Section 4.3.

4.7.3 Lateral Scutes

Lateral scutes are removed using a sterilized knife in a manner consistent with the marking strategy employed by Washington Department of Fish & Wildlife (WDF&W) and Oregon Department of Fish & Wildlife (ODF&W). The number and position of lateral scutes removed will be specific to year in hatchery reared white sturgeon but not to wild fish. One scute is removed from wild stocks of white sturgeon based on processing procedure, and include (T. Rien, Oregon Department of Fish and Wildlife, pers. comm., 2003):

- Processing Descriptions:
- PIT tag & OTC Injection – 2nd right lateral scute
- PIT tag only – 2nd left lateral scute

Record the appropriate lateral scute removal code(s) electronically or on the field data form (see Attachment B). As inconsistencies in this procedure have occurred over sampling years, this mark can not be used to determine conclusively whether OTC has been previously applied.

4.8 Telemetry

To monitor white sturgeon movements within the study area, selected white sturgeon may be equipped with radio tags and/or sonic tags. Radio transmitters are externally mounted on white sturgeon and are attached to the anterior dorsal scutes of the fish, using the method described by Haynes et al. (1978). A battery-operated drill is used to make a 0.6” diameter hole through two dorsal scutes. The radio transmitter attachment cables are then passed through the holes in the scutes and fastened against a plastic backing plate on the opposite side with crimps appropriate for the cable diameter. Record the tag type, frequency, and identification number electronically or on the field data form (Attachment A).

Sonic tags are generally the preferred method used to track sturgeon. The sonic tags are typically surgically implanted in the abdominal cavity as described by Hildebrand and English (1991; see Section 4.5). Record the tag type, frequency, and identification number electronically or on the field data form (Attachment A).

5.0 Temporary Holding and Transport

5.1 River Holding Sleeve

Captured white sturgeon that are suitable for use as broodstock are held in a cylindrical nylon sleeve (9 ft in length and 25.6" in diameter) and secured in the river. The ends of this sleeve are constructed of heavy-duty, knotless (marquisette-style) net and stainless steel loops. The sleeve is also affixed with a heavy-duty, full-length zipper, two zips, and four carrying handles. The fish is lowered into the water by the stretcher-davit assembly and guided into the holding sleeve by a tether line attached to its caudal peduncle. Once the fish is inside the holding sleeve, the tether is removed and the holding sleeve is secured in the river to a large rock or a section of rebar pounded into the substrate. The holding sleeve is placed parallel to the current to ensure the fish has a continuous supply of fresh water. Prior to transferring the fish to the holding tank/transport vehicle, guide the fish into a stretcher which is used to carry the fish to the holding tank. Depending upon the size of the fish, two to four crew members are required used to transfer it safely.

5.2 Boat Holding

When possible, it is preferable to transport the fish immediately via boat to the location of the holding tank/transport vehicle. This is accomplished by keeping the fish in the hooded stretcher onboard the boat. A wooden bracket mounted on the gunwale supports one end of the stretcher and the winch-davit assembly supports the other end. Two persons continuously monitor the fish during transport. The sturgeon irrigation pump cannot be operated while the boat is under power, therefore buckets of fresh river water are added to the stretcher frequently during transport. The boat is stopped to allow buckets to be refilled as required. The sturgeon irrigation pump is reactivated as soon as the boat reaches the boat launch. One person remains with the fish while the other crew members prepare the transport tank. When more than one crew is working in close proximity, a sturgeon deemed to be suitable broodstock can be transferred between boats to expedite transfer to the holding tank (i.e. when the capture boat has more fish to process and the second boat in available as a transport vessel).

5.3 Holding Tank/Transport Vehicle

White sturgeon suitable for use as broodstock are transported or held in small tanks containing well-aerated river water. Holding tank water temperatures should not exceed 63°F (Conte et al. 1988). The minimum size of the holding tank is slightly larger than the fish; it should be fitted with a cover and provided with enough water to fully support the animal to prevent bruising and internal injury (Conte et al. 1988). Detailed instructions for the addition of salt and oxygen to the water in the holding tank are provided in Section 5.3.2.

5.3.1 Fish Transfer

The transfer of white sturgeon from the boat or river holding sleeve to the holding tank/transport vehicle is facilitated by the use of a stretcher. Two to four crew members (dependent upon the size of the fish) are required to safely carry the stretcher containing the fish to the holding tank/transport vehicle. The stretcher is lowered into a 16 ft^3 aluminum tank (mounted on a 4.8 m flat deck trailer), the sturgeon is guided out, and the stretcher is then removed from the tank.

5.3.2 Water & Oxygen Supply

Prior to transferring the fish into the holding tank, the tank is filled with river water by a fire hose and water pump system. Two 23.6" flush-mounted oxygen diffusers supply oxygen from three size 15 oxygen cylinders. Maintain 90% to 100% oxygen saturation in the water with respect to air during transportation (M. Webb, Department of Fisheries and Wildlife, Oregon State University, pers. comm., 2003). Oxygen saturation must not exceed 110%; this can result in oxygen receptors on the gills sending a message to the brain to slow down respiration and thereby cause build up of CO_2 (hypercapnia), which can be lethal (M. Webb, pers. comm., 2003). Oxygen is supplied by the holding tank's oxygen diffusers and monitored to maintain 10 to 15 ppm during transport. Rock salt can be added to water in the holding tank to a concentration of 5 to 10 ppm to prevent osmotic stress during transport (M. Webb, pers. comm., 2003), and to treat bacterial and fungal infections (R. Ek, Freshwater Fisheries society of BC, Wardner, pers. comm., 2003). Two removable tank lids are secured to the tank prior to transport. The trailer must be equipped with surge or electric brakes for safe transport.

5.3.3 Total Gas Pressure

High levels (above 120%) of total gas pressure (TGP) often occur in regulated river systems, especially below hydroelectric dams. These levels of TGP have been noted to adversely affect some fish species. During periods of higher TGP levels, spot measurements may taken at each sample site and extra precautions followed to reduce stress on captured white sturgeon (see recommendations below). In the Columbia River, TGP levels above 120% can occur during periods of spill in the system, which can often occur during freshet (May to July).The following protocols are recommended to limit the effects of TGP on white sturgeon broodstock:

- Hold captured white sturgeon below the compensation level (3.3ft per 10% saturation; D. Schmidt, pers. comm., 2003).
- Use a creek as a water source to fill the holding tank prior to transporting the fish (provided the difference in water temperatures between the river and tank does not exceed 5°F).
- Strip gases out of supersaturated water prior to filling holding tank (e.g., use a spray nozzle attached to the fire hose).
- Collect fish prior to increased TGP levels
- Avoid sampling when TGP levels are over 125%.

To date there has been no evidence that TGP levels have had negative effects on either broodstock or other sturgeon handled during the sturgeon broodstock and stock assessment program. As such, while it is advisable to be aware of trends in TGP levels while sampling sturgeon in the study area, the above recommendations are not currently utilized.

5.3.4 Fish Transport & Elevation

Although transport can be a stressful event, a change in elevation (i.e., driving over a mountain pass) should not play a major role in the health of the fish (M. Webb, pers. comm., 2003). The change in hydrostatic pressure when a fish is brought up from depth may cause greater stress on the animal than that of elevation (M. Webb, pers. comm., 2003). If a fish is suspected to be on a set line, the set line should be pulled slowly to enable white sturgeon to de-gas or ‘burp.’

6.0 Regional Sturgeon Database

In 2001, the UCWSRI commissioned the development of a regional white sturgeon database. This database incorporates datasets from various agencies and consultants collected since the early 1990s. Since 2001, participants in the upper Columbia River broodstock collection program have utilized this database to assist in the collection of broodstock by providing quick access to information collected during previous captures of sturgeon within the collection area. This reduces the number of surgical examinations required, thereby allowing increased sampling effort and reducing unnecessary stress on the fish.

Beginning in 2005, data entry is conducted in the field. This reduces transcription error and office time. Drop-down boxes and input masks reduce entry error. Data entry forms are designed for each database users (including broodstock collection crews), providing specific entry fields and prompts appropriate to their needs. Prompts currently in use for broodstock include a fish lookup window which appears when a capture code is entered that indicates a recaptured fish, and a fish external assessment form appears when fish life history data are committed to the database. Data collected by multiple crews are synchronized with the master database at the end of the day. Each crew begins the day with the latest version of the database.

Specific instructions for operating the database are not included in this document as the database is at a stage in development where protocols are still in the process of refinement.

Literature Cited

Apperson, K.A. and P.J. Anders. 1991. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report to Bonneville Power Administration, Portland Or. FY 1990: 67 p.

Beamesderfer, R.C., J.C. Elliot, and C.A. Foster. 1989. Report A. Pages 5-52 In: A.A. Nigro (ed.). Status and habitat requirements of white sturgeon populations in the Columbia River downstream from McNary Dam. Annual Progress Report to Bonneville Power Administration, Portland, Or.

Beamesderfer, R.C.P., T.A. Rien, and A.A. Nigro. 1995. Difference in the dynamics and potential production of impounded and unimpounded white sturgeon populations in the lower Columbia River. Transactions of the American Fisheries Society. 124:857-872.

Bruch, R.M., T.A. Dick, A. Choudhury. 2001. A field guide for the identification of stages of gonad development in lake sturgeon, (Acipenser fulvescens Rafinesque) with notes on lake sturgeon reproductive biology and management implications. 38 p.

Conte, F.S., S.I. Doroshov, P.B. Lutes, and E.M. Strange. 1988. Hatchery manual for the white sturgeon, Acipenser transmontanus Richardson with application to other North American Acipenseridae. Cooperative Extension, University of California, Division of Agriculture and Natural Resources, Publication 3322: 103 p.

Elliot, J.C. and R.C. Beamesderfer. 1990. Comparison of efficiency and selectivity of three gears used to sample white sturgeon in a Columbia River reservoir. California Fish and Game. 76:174-180.

Golder Associates Ltd. 2002. White sturgeon spawning at Waneta, 2001 investigations and historical data summary. Report prepared for Columbia Power Corporation, Casltegar, B.C. Golder Report No. 0128966F: 46p. + 7 app.

Golder Associates Ltd. 2003. Columbia River Adult White Sturgeon Capture, Transport and Handling Manual, May 2003 Version. Prepared for Upper Columbia White Sturgeon Recovery Initiative. Golder Associates Ltd. Report No. 03-1480-003: 19p + app.

Hildebrand, L. and K. English. 1991. Lower Columbia River fisheries inventory, 1990 studies. Volume I. Main Report. Report prepared for BC Hydro, Environmental Resources by R. L. & L. Environmental Services Ltd. R. L. & L. Report No. 330F: 170p. + 7 app.

Haynes, J.M., R.H. Gray, and J.C. Montgomery. 1978. Seasonal movements of white sturgeon (Acipenser transmontanus) in the mid-Columbia River. Transactions of the American Fisheries Society. 107(2): 275-280.

Nigro, A.A., B.E. Rieman, J.C. Elliot, and D.R. Engle. 1988. Status and habitat requirements of white sturgeon populations in the Columbia River downstream from McNary Dam. Annual Progress Report (July 1987-March 1988) to Bonneville Power Administration, Portland, Or. 140 p.

Northcote, T. C. 1973. Some impacts of man on Kootenay Lake and its salmonids. Great Lakes Fishery Commission, Technical Report No. 2.

Parsely, M.J. and L.G. Beckman. 1994. White sturgeon spawning and rearing habitat in the lower Columbia River. North American Journal of Fisheries Management. 14: 812-827.

R.L. & L. Environmental Services Ltd. 1994. Status of white sturgeon in the Columbia River, B.C. Report Prepared for B.C. Hydro, Environmental Affairs, Vancouver. R.L. & L. Report No. 377F: 101 p. + 5 app.

R.L. & L. Environmental Services Ltd. 1996. Columbia River white sturgeon investigations. 1995 study results. Report Prepared for B.C. Hydro, Kootenay Generation, Vancouver, B.C. and BC Ministry of Environment, Lands and Parks, Nelson Region. R.L. & L. Report No. 96-377F: 94 p. + 6 app.

Upper Columbia River White Sturgeon Recovery Initiative (UCWSRI). 2002. Upper Columbia River white sturgeon recovery plan. Draft document prepared by UCWSRI. 86 p.

Golder Associates Ltd. 2003a. White sturgeon investigations in Priest Rapids and Wanapum reservoirs on the Middle Columbia River, Washington, U.S.A. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 002-8817F: 85p. + 6 app.

Golder Associates Ltd. 2003b. Rocky Reach White Sturgeon Investigation: 2002 Study Results. Report Prepared for Public Utility District No. 1 of Chelan County, Wenatchee, Washington. Golder Associates Ltd. Report No. 022-8041: 30p. + 3 app.

Attachment A
Data Sheet Examples

Year
Female Pit tag #
Capture Date **Capture Location**
Weight (kg) **Fork Length (cm)**
G.V. position at Capture **Temp** **Est. Spawn Week**
Check G.V. position **Date** **Temp** **Est. Spawn Week**
Check G.V. position **Date** **Temp** **Est. Spawn Week**
Check G.V. position **Date** **Temp** **Est. Spawn Week**

LHRHa Priming Injection Date **Time** **Amount**
LHRHa Resolving Injection Date **Time** **Amount**
Eggs first observed **Date** **Time**

Spawning (Egg take) **Date** **Time Begin**
Time End
Water Temperature
Number of Eggs Taken **Volume(mls)**
 # Eggs per ml
De-adhesion Time Begin **Time End**
Genetic Sample (DNA)
Ovarian Sample (FHU)
Vemco Tag Implanted **Tag Serial Number**
Tag ID Code

MATINGS
Family # **Male Pit Tag #**
Upweller #
Volume of Eggs (mls) **Eggs Size (#eggs per ml)**
Number of Eggs **Neurolation %**
Number of Larvae
Comments
Family # **Male Pit Tag #**
Upweller #
Volume of Eggs (mls) **Eggs Size (#eggs per ml)**
Number of Eggs **Neurolation %**
Number of Larvae
Comments
Family # **Male Pit Tag #**
Upweller #
Volume of Eggs (mls) **Eggs Size (#eggs per ml)**
Number of Eggs **Neurolation %**
Number of Larvae
Comments
Family # **Male Pit Tag #**
Upweller #
Volume of Eggs (mls) **Eggs Size (#eggs per ml)**
Number of Eggs **Neurolation %**
Number of Larvae
Comments

COLUMBIA WHITE STURGEON

Adult Spawning

	Female
Female Injection - Initial Dose	Captured
Total dose will be 50 ug/kg	lbs/kg
Initial injection (10%) = 5 ug/kg	Pond

The Female Resolving Dose Stock is at

2 ml diluent and 5 mg (5000 ug) LHRH = 2500 ug/ml

To 1 ml of Resolving Dose add 4 mls saline = 500 ug/ml

Example:

DATE ____________

DOSE ____________

Body Wt (kg)	**LHRH amount Initial Dose at 5 ug/kg**	**Injection Amount Dose at 500 ug/ml to inject (mls)**
40	200	0.40
41	205	0.41
42	210	0.42
43	215	0.43
44	220	0.44
45	225	0.45

Calculation

Body wt kg	LHRH ug	Injection ml
	0	0.00

input body weight in kgs

Female Injection - Resolving Dose

Total dose will be 50 ug/kg

Resolving injection (90%) = 45 ug/kg

To one vial add: 5 mg (5000ug) LHRH
2 ml diluent
to equal 2500 ug/ml (if 100% active)

Example:

DATE ____________

DOSE ____________

Body Wt (kg)	**LHRH amount Resolving Dose at 45 ug/kg**	**Injection Amount Dose at 2500 ug/ml to inject (mls)**

40	1800	0.72
41	1845	0.74
42	1890	0.76
43	1935	0.77
44	1980	0.79
45	2025	0.81

Calculation		
Body wt	LHRH	Injection
kg	ug	ml
	0	0.00

input body weight in kgs

Upper Columbia White Sturgeon

FEMALE:

Adult Holding - females

#	ID	Captured Location	Captured Date	Pond	Floy	Size LBS	Size KGS	Size Cm

Water Temperature Changes

Date	From	To	Comments

Egg Biopsies

Date	Egg Size	Mean PI	Comments	Progesterone Assay Control	Progesterone Assay Prog #1	Progesterone Assay Prog #2

Injections - LHRH

Date	Initial Dose Date	Initial Dose Amount	Resolving Dose Date	Resolving Dose Amount	Egg releases Date	Egg releases Time	Spawn Date	Spawn Time

Antibiotics/Treatments/Condition

Date	Amount	Condition

Spawning

Date	Male	Upweller	weight of eggs

Attachment B
Data Recording – Upper Columbia White Sturgeon Set Lining

Following is an explanation of codes to be used on the data sheet. Please use appropriate codes. Explanations of some of the items, which seem obvious, have been omitted.

A: PHYSICAL SAMPLING INFORMATION

Page ___ of ___: Indicates if more than one data sheet was required for the site to accommodate capture of more than 8 fish or additional space for biological data and comments.

Station: Combines:

1) **Sample method** – SSL = Sturgeon set line.
   AB = Angling with bait.

2) **River km** – measured downstream from HLK to 1 decimal place.

3) **Channel Location** L – Left bank when facing upstream.
   M - Mid channel.
   R – Right bank when facing upstream.

Example of station = SSL56.5L

Site Description: Brief written description of the site (i.e., location in relation to nearest landmark) so that it can be easily identified.

Set/Pull: Date format = DD/MMM/YY (e.g. 01Jan01 - do not use numerals for month)
Time format= 24 hour clock (e.g. 1324)

Visibility: Measured with a secchi disk to nearest 0.1 m. This measurement should be taken on the shaded side of the boat.

Depth: Minimum and maximum depth along set line measured to the nearest 0.1 m.

Gear Type: LL = Long line (30 hooks)
ML = Medium line (8 hooks)

No. Hooks Set (Lost): Number of hooks which actually go on the line (i.e. count hooks, don't assume).
Lost = number set minus number retrieved (again, don't assume).

Baitless #: Hooks which catch fish are not counted as baitless.

Bait types: Identify as kokanee, squid, lamprey, etc.

No. Hooks Fouled: Hooks not fishing at time of retrieval (e.g. embedded in log, rope, etc.)

Sampling Efficiency: 1 = no problems.
2 = minor problems but mostly fishing.
3 = major problems, still partly fishing.
4 = major problems (e.g. line sitting on shore).

Typically, where efficiency is rated at 3 or 4, the data is discarded. Also, if problems are caused by fish struggling on the line, this is scored no worse than 2.

B: BIOLOGICAL DATA

No: Refers to fish ID number on that setline. Two lines are assigned per fish: the second dedicated to observations such as descriptions of gonads, abnormalities, injuries, etc.

Sex and Maturity Code: See Table 4.1.

Lengths: All lengths to be measured to the nearest 0.5 cm from the tip of the snout:
Snout – to pre ocular (front of eye).
Head – to most posterior point of opercular opening.
Fork - to the fork in the caudal fin.
Total – to the tip of the upper lobe of the caudal fin.

Girth: The distance around the trunk, measured immediately behind (touching) the insertion of the pectoral fins. This is measured to the nearest 0.5 cm.

Weight: To the nearest 0.5 lb (weights are converted to kg before entered into the database).

Workup: B = basic life history.
S = basic life history plus surgery performed.
R = basic life history plus surgery performed and radio or sonic tag applied.

Fate: A = released alive.
D = dead.
H = transported to hatchery.

Tags @ Capture: A three character code describing the status of tags on a fish at the time of capture (Floy, PIT and radio or ultrasonic transmitter). Any deviations from these codes are noted in comments.

First character is a dorsal tag (Floy):
U – Unknown, no information.
N – No tag present; no indication of previous Floy tagging.
P - Floy tag present.
M – Missing – tag scar or fin clip indicates previously tagged.
O – Other tag. Describe in comments.

Second character is PIT tag:

U – Unknown, no information.

N – No tag present; no indication of previous PIT tagging.

P - PIT tag present.

M – Missing – PIT tag missing, not functioning; records indicate fish was previously tagged.

Third character is radio or ultrasonic transmitter:

U – Unknown, no information.

N – No tag present; no indication of previous radio or ultrasonic transmitter.

P - radio or ultrasonic transmitter present.

M – Missing; radio/ultrasonic transmitter missing or not functioning; records indicate fish was previously tagged.

Tags @ Release: A two character code describing the tags applied to a fish during processing and the tagging status of the fish at release.

First digit is Floy tag:

U – Unknown, no information.

N – No tag applied.

F1 – Floy tag applied (not previously tagged)

F2 – Floy tag applied (old tag removed or lost, new tag applied)

Second digit is other tags applied:

U – Unknown, no information

N – No other tags applied.

P – PIT tag only applied

R - Radio/ultrasonic transmitter applied

B – transmitter and PIT tag applied

Marks @ Capture: A two-character code describing marks found at time of capture.

The first character indicates fin mark:

U – Unknown, no information or uncertain

N – No previous fin clip

L – Left pectoral fin ray section previously clipped

R – Right pectoral fin ray section previously clipped

B – Both pectoral fin ray sections previously clipped

The second entry indicates previous scute marks. Letters indicate presence/absence and which set of scutes:

U - Unknown, no information or uncertain

N – No previous scute removal

L – Left lateral

R – Right lateral

D – Dorsal

Number indicates position relative to the head. (e.g. L4 indicates the 4th lateral scute on the left side of the fish is removed).

Marks @ Release: Marks applied at time of capture.

The first character indicates fin mark:

- U – Unknown, no information or uncertain
- N – No previous fin clip
- L – Left pectoral fin ray section removed
- R – Right pectoral fin ray section removed
- B – Both pectoral fin ray sections removed

The second entry identifies scute removal. Letters indicate presence/absence and which set of scutes:

- U - Unknown, no information or uncertain
- N – No previous scute removal
- L – Left lateral
- R – Right lateral
- D – Dorsal

Number indicates position relative to the head. (e.g. L4 indicates the 4th lateral scute on the left side of the fish is removed).

Tag Numbers

Floy: C = colour of tag (first letter of colour).
PIT: S = Size of tag: L = Large S = Small

DNA
Type of sample taken.

- T – Tissue (taken from pectoral fin)
- B - Blood

UMGB - Urine, mucus gonad and blood samples taken for Oregon State University sex/maturity assay studies.

- Y – Yes
- N – No

If not all samples can be obtained record in the comments which ones and why.

INCIDENTAL SPECIES
Capture Code:

- 0 – first capture released alive
- 1 – first capture sacrificed or succumbed to sample methods
- 2 – recapture released alive
- 3 - recapture sacrificed or succumbed to sample methods

Attachment C
White Sturgeon Sampling and Surgery Supply List

Conte, F.S., S.I. Doroshov, P.B. Lutes, and E.M. Strange. 1988. Hatchery manual for the white sturgeon, Acipenser transmontanus Richardson with application to other North American Acipenseridae. Cooperative Extension, University of California, Division of Agriculture and Natural Resources, Publication 3322: 103 p.

Surgery equipment for ovarian examination should include instruments preferred by the individual who will perform the operation. The following is a list of instruments and materials used at the UC Davis sturgeon hatchery when this surgery is performed:

- Scalpel, #3 handle, #10 or 15 blade
- Forceps, Adison-Brown tissue
- Forceps, needle (with carbide teeth inserts)
- Surgical needle, reversible cutting OS-4, curved (Ethicon brand)
- Suture material, 'Ethibond' green braided polyester #1 (4.0 metric) gauge, nonabsorbable, swedged onto surgical needle
- Absorbent pads
- Otoscope
- Sterile pads
- Iodophore for disinfection
- 1 – 3mm diameter tubing 40cm long for egg sampling
- Scoopula for sampling
- Containers (25ml) sealable for egg samples.

Attachment D
OTC Dosage Information

Oxytetracycline Dosage Information	
Objective/purpose:	Oxytetracycline (OTC) injectable therapy to control mortality caused by certain bacterial diseases.
Drug name:	Liquamycin® LA-200®
Source of drug:	Pfizer, Inc.
Address:	Pfizer Animal Health 700 Portage Road RIC-190-43 Kalamazoo, MI 49001-0199
Contact:	Dr. Mark Subramanyam Phone: 269-833-3388 Fax: 269-833-2707 Email: mark.subramanyam@pfizer.com
Target pathogen(s):	Bacterial pathogens susceptible to oxytetracycline.
Method of administration:	IP or IM injection
Treatment dosage:	20 milligrams OTC per kilogram body weight
Treatment regimen:	***Option A:*** Single injection (all salmonids) ***Option B:*** Single injection (all non-salmonids)
Withdrawal period:	30 days No withdrawal period is required for treated fish that will not be susceptible to legal harvest for at least 30 days post-treatment.
Limitations or restrictions on use:	Drug discharge must be in compliance with local NPDES permitting requirements.

Attachment E
Contaminants and Blood Sampling Procedures

Sturgeon Contaminants Sampling Protocol
Broodstock Collection 2003

- ***External Fish Examination*** *(♀or ♂)*

- Body surface: examine all surfaces for sores, open wounds, tumours, gross deformities, lesions or parasites and enter in data sheet.
- Score health of eyes, opercles, gills, fins, scutes, mouth and barbels as on data sheet (see scoring system on datasheet in Attachment A).

- ***Surgical Biopsy*** *(♀or ♂)*

- Using forceps detach 1cm^3 sample of ovarian (20-30 follicles)/testicular tissue and place into histology vial containing formalin.
- Label vial with date, PIT # and capture location.
- Store vial in cool, dark location.

- *For flowing ♂:*
  - Draw 30 mL of sperm.
  - Divide sample into 3 portions, placing 15 mL and 10 mL each into certified clean glass jars, and 5 mL into a plastic falcon tube with cap.
  - Label jars and tube with date, PIT # and capture location.
  - Store jars in dry ice or ethanol slush until able to store in chest freezer.
  - Store tube above wet ice in a cooler (4 to 12^{o}C), and if possible check motility using a microscope ASAP.

- ***Blood Sample*** *(♀or ♂)*

- At capture collect 1 full vacutainer of blood from the caudal vasculature.
- See blood collection procedures below
- Label with date, PIT # and capture location.

- *Whole Blood:*
  - Wearing sterile gloves, pipette 0.5 mL of whole blood into a 1.5 mL vial.
  - Label vial with date, PIT # and capture location.
  - Place vial on dry ice or ethanol slush.
  - Freeze at -20 ^{o}C.

- *Add Aprotinin:*
  - Hold up guide (marked vacutainer) to estimate the volume of blood.
  - Wearing sterile gloves, add 50 uL of aprotinin solution for every 1 mL of blood (directly into the heparinized vacutainer).
  - Cap the vacutainer and invert several times to mix. Store the blood on wet ice until ready to centrifuge.

    - Write the volume of blood and volume of aprotinin added to the blood on the data sheet provided. Note: it's important to be as accurate as possible in estimating the blood volume and adding the correct amount of aprotinin.
    - Keep whole blood cool until ready to centrifuge.
- *After centrifugation*:
  - Wearing sterile gloves collect plasma into 1.5 mL vials with disposable pipette.
  - Label vials with date, PIT # and capture location.
  - Store vials on dry ice or ethanol slush until able to transfer to chest freezer.

▪ ***Mucous Sample** (♀or ♂)*
- Collect 1 mL of mucous using clean metal weigh spatula and place in 1.5 mL vial.
- Label with date, PIT # and capture location.
- Place on dry ice or ethanol slush.
- Clean spatula with disinfectant between samples.
- Freeze samples upon return in chest freezer.

▪ ***External Parasites** (♀or ♂)*
- Remove 3-6 parasites with forceps or scalpel.
- Place in vial with formalin.
- Label vial with date, PIT # and capture location.
- Store in cool, dark location.

▪ ***Urine Sample** (♀or ♂)*
- Squeeze bulb on plastic pipette and insert into vent.
- Release pipette bulb and withdraw. Place urine into 1.5 mL vial.
- Label vial with date, PIT# and capture location.
- Wait a few minutes and try again if you only get a little bit the first time.
- Store vials on dry ice or ethanol slush until able to transfer to chest freezer.

Upon return to lab store whole blood, plasma, mucous, sperm samples in chest freezer. Keep histology vials in cool, dark location. Do motility analysis as soon as possible.

▪ ***Ovulated Eggs at Spawning***
- Collect ovulated eggs from each spawned ♀.
- Calculate number of eggs per mL by counting eggs in triplicate 1 mL samples.
- Place 15 mL and 10 mL eggs each into certified clean glass jars.
- Label jars with date, PIT # and capture location.
- Store vials on dry ice or ethanol slush until able to transfer to chest freezer.

▪ ***Sperm at Spawning***
- Collect 30 mL of sperm from ♂ at spawning.
- Divide sample into 3 portions, placing 15 mL and 10 mL each into certified clean glass jars, and 5 mL into plastic falcon tube.
- Label jars and tube with date, PIT # and capture location.
- Store vials on dry ice/ethanol slush until able to transfer to chest freezer.

- Keep tube above wet ice for motility analysis ASAP.

White Sturgeon Blood Sampling Procedures

The following procedure was outlined from M. Webb (Oregon Department of Fisheries and Wildlife, Oregon State University).

- Wear gloves.
- Blood is taken from the caudal vein/artery (it does not matter which) located just behind the anal fin.
- Sturgeon should be ventral side up.
- Take vacutainer holder with needle screwed in tightly in one hand and the labelled vacutainer in the other hand (do not puncture needle into rubber stopper on vacutainer until the needle is in place or the seal of the vacutainer will be broken and it will not pull blood).
- You may put the needle in at a slight angle or straight down, but it is critical to do so exactly on the mid-line of the caudal peduncle making sure that you continue directhe needle will go in approximately 2 to 3 cm.
- It is really by feel that you know that the needle is in place (you will feel the pop through the skin, then it will be easy, then you will feel a little bit more resistance and you will pop through the vein/artery; stop there).
- Holding onto the vacutainer holder (never let go of this because the fish jerks, the needle and holder may go flying), push the vacutainer into the holder and into the needle.
- If you are in the vein/artery you will see blood entering the vacutainer immediately; if you are not, slowly and carefully move the needle slightly down or up watching for blood to enter the vacutainer (if you still do not see blood check to see that you are directly mid-line).
- If you need to try again, remove the vacutainer before removing the needle from the fish or the seal will break in the vacutainer. It is possible that you may also need to replace your needle as it may be clogged.
- Fill the entire vial with blood.
- On the vial label record the date, fish id number, fork length, weight, and the catch location (reservoir, river mile, channel location).

Appendix B
Comment Letters and E-Mails Received

Hi Tom-

Per Public Utility District No. 2 of Grant County's (Grant PUD) request, below are the U.S. Fish and Wildlife Service's (Service) comments on the Bull Trout Monitoring and Evaluation Plan, Pacific Lamprey Management Plan, and the White Sturgeon Management Plan to be filed with the Federal Energy Regulatory Commission. We reserve the right to provide further comments on these plans during subsequent discussions between the Service and Grant PUD. We request that all the following comments below be incorporated in the formulation of the final drafts of these respective plans:

BULL TROUT MONITORING AND EVALUATION PLAN:

The Service has recently finished its five year status review of bull trout. We suggest that Grant PUD include a discussion of this recently-completed process within section 2.0 Bull Trout Listing, Critical Habitat, and Recovery Planning (pages 1-2);

Section 4.1 Movement and Migration Patterns in the Vicinity of the Priest Rapids Project (pages 4-6) discusses a radio-tagged bull trout that was detected at Wanapum and Priest Rapids dams. Grant PUD states in the plan: "This fish was presumed to be a mortality based on review of telemetry data (Bryan Nass, LGL Limited, personal communication." Whereas, BioAnalysts, Inc.'s 2004 report summarizing bull trout movements in the Columbia River indicates that this same fish was not a mortality. Clarification on this point would be useful.

Section 4.1.1 Assessment of Project Effects on Movement of Bull Trout in the Vicinity of the Priest Rapids Project (page 6) states: "Passage routes at mid-Columbia dams provide bull trout unlimited access to all areas of the mainstem Columbia River and tributaries. While this statement is mostly factual, there are seasonal timeframes (i.e., winter maintenance periods) in which the mid-Columbia hydroelectric projects do not provide unlimited access through all existing upstream fishways. Adding the phrase "with the exception of winter maintenance periods" to the end of the aforementioned sentence would provide further clarity.

Section 4.1.1 Assessment of Project Effects on Movement of Bull Trout in the Vicinity of the Priest Rapids Project (page 6) does not reflect all years of bull trout use at the Project's fish passage facilities. For example, four adult bull trout passed upstream through the Project's Priest Rapids Dam during 2008. Providing all fish passage data through 2008 would provide further clarity.

Grant PUD states in Strategy 1-2 (page 15) that it will continue the counting and reporting of all bull trout life stages moving past Wanapum and Priest Rapids dams between April 15 and November 15 of each year, for an experimental period of five years. The Service suggests adding the following language to account for years beyond year five of this counting and reporting process: "The Service, in coordination with the Priest Rapids Fish Forum, will discuss whether or not to continue the counting and reporting of all life stages moving past Wanapum and Priest Rapids dams beyond year five for the duration of the new license." We also suggest inserting this language into Strategy 2-1 located in section 6.2.1 Strategies for Objective 2 (page 15).

Strategy 2-2 describes an eventual process in which Grant PUD would assess passage and survival of bull trout at Wanapum and Priest Rapids dams. We suggest adding the following language at the end of strategy 2-2 to capitalize on the use of other bull trout in the Columbia River that have been tagged through other similar studies: "Grant PUD will coordinate these assessments with the Service and other mid-Columbia public utility district's."

Strategy 2-7 (page 16) states: "Grant PUD, in coordination with the USFWS, will report incidental take as precisely as possible through the use of empirically collected data including PIT-tagging, radiotelemetry, or other appropriate technology." The Service would like to remind Grant PUD that incidental take needs to be reported on an annual basis. We would also like to discuss other methods in which to report incidental take with Grant PUD. For example, the use of bull trout fishway counts may prove useful over the course of the new license term in determining the presence of take at the Project's two dams.

Strategy 2-8 (page 16) states: "If information shows that incidental take of bull trout occurs due to hydrologic variation impacts, Grant PUD in coordination with the USFWS, will develop a collaborative plan to minimize the effect (where reasonable and feasible) of such incidental take." The avenue in which this information is collected is not specified within this strategy. We suggest the possibility of Grant PUD conducting monitoring at specific areas within the action area to decipher the presence of any hydrologic variation on bull trout during appropriate seasonal timeframes.

PACIFIC LAMPREY MANAGEMENT PLAN:

Section 4.2.8 (page 14) involves an evaluation and efficacy of reducing fishway flows at night at Wanapum and Priest Rapids dams. Since bull trout migrate predominantly during the night time, we suggest that Grant PUD, in coordination with the Service and the Priest Rapids Fish Forum, examine all relevant data to ensure that a potential reduction in flow within the Priest Rapids Project fishways does not interfere with upstream bull trout passage at the Project.

Section 4.2.10 Regional Studies (page 14) describes a process in which Grant PUD would coordinate its information regarding lamprey with other entities involved in similar work. We also suggest that Grant PUD coordinate its radio-telemetry work with the Service's Fisheries Resource Office in Leavenworth, Washington once tagged individuals enter associated tributaries to assess the presence of any effects to Pacific lamprey spawning. Therefore, we suggest that the second sentence of this section to read in the following manner: "For instance, when fish tagged under Grant PUD studies or studies conducted by other entities enter the project area or associated tributaries, Grant PUD will conduct and participate in these studies by monitoring and reporting on movement of tagged individuals within and through the project area in addition to associated tributaries."

Protection, Mitigation, and Enhancement (PME) measure 4.3.1 Identification and Mitigation of Project Effects on Juvenile Pacific Lamprey (page 15) appears to be unclear in terms of which downstream passage alternatives will be available for juvenile lamprey. We recommend that PME 4.3.1 be divided into two measures which define: 1.) all current downstream passage alternatives for juvenile Pacific lamprey and 2.) identification of project effects on juvenile Pacific lamprey.

Section 4.4 Objective 4: Avoid and Mitigate Project Impacts on Rearing Habitat (page 16) entails the determination of juvenile lamprey presence/absence, habitat use, and relative abundance in the project area. We suggest adding a PME 4.4.2 which obligates Grant PUD, when feasible, to contribute towards restoration projects designed to provide benefits to Pacific lamprey. The Service would work with Grant PUD to determine the feasibility of this measure in addition to the scope of funds that would be contributed to this effort.

WHITE STURGEON MANAGEMENT PLAN:

In general, an important piece of information missing from this document is the upstream passage counts of white sturgeon through the Priest Rapids and Wanapum dams. Passage counts will provide context in terms of shaping Grant PUD's future implementation of the White Sturgeon Conservation Aquaculture Plan. In part, this information will assist in defining how white sturgeon utilize both of the Project's reservoirs.

Recently, Tribal entities have released numerous juvenile white sturgeon into the Rock Island reservoir. We suggest that Grant PUD reassess its current level of white sturgeon within the Wanapum and Priest Rapids reservoirs in order to fine-tune its current level of white sturgeon to be released into these reservoirs due to possible downstream migration of white sturgeon from the Rock Island Reservoir.

Biological objective #3 on page ii includes: "Adult and juvenile upstream and downstream migration: Provide safe, effective, and timely volitional passage, if reasonable and feasible passage means are developed." This objective appears to need clarification as white sturgeon already pass upstream through the existing upstream fishways at the Project.

PME #4 on page iii states that Grant PUD will: "Conduct tracking surveys of juvenile white sturgeon released with active tags as part of the supplementation program to determine emigration rates from Priest Rapids Project." We also suggest that Grant PUD consider a determination of immigration rates for white sturgeon for these assessments.

The Service appreciates the opportunity to comment on these respective plans. If Grant PUD requires clarification on these comments, please contact me at your earliest convenience.

Steve

****
Stephen T. Lewis
Mid-Columbia Relicensing Coordinator
U.S. Fish and Wildlife Service
Central Washington Field Office
215 Melody Lane, Suite 119
Wenatchee, WA 98801
phone: (509) 665-3508 Ext. 14
fax: (509) 665-3523
e-mail: Stephen_Lewis@fws.gov

State of Washington
DEPARTMENT OF FISH AND WILDLIFE
Mailing Address: 600 Capital Way North – Olympia, WA 98501-1091 – (360) 902-2200 – TTD (360) 902-2207
Main Office Location: Natural Resources Building – 1111 Washington Street SE – Olympia, WA

February 27, 2009

Mr. Tom Dresser
Grant County Public Utility District
Natural Resource Building
148 Basin St. N.W.
Ephrata WA 98823

Subject: WDFW Comments on Draft White Sturgeon Management Plan

Dear Mr. Dresser,

WDFW is pleased to provide comments on the most recent draft of Grant County PUD's White Sturgeon Management Plan (Revised 3, Part B, December 2008 draft). This recent version is much improved over previous editions, and has addressed most of the previous shortcomings. With this plan, GCPUD would be able to provide for a capable, stand-alone program.

Our largest concern continues to be the lack of regional coordination and integration, because that lack of coordination leads to unnecessary redundancy and inefficiency. It is primarily for this reason that we ask the District to postpone adoption of the plan.

Also, WDFW asserts that not enough information currently exists to evaluate whether the Priest Rapids Project Area contains an adequate number of adult females from which to select broodstock. Genetically, it would be best to obtain spawners from a broad pool of adults, inclusive of multiple downstream populations, since individuals rarely move upstream past dams. WDFW would like to understand how this would impact broodstock collection plans. Clearly, this is one area where regional coordination would improve spawning protocols.

WDFW is also concerned that size-at-release should be evaluated in relation to entrainment rates, especially prior to stocking large numbers of yearlings. Field work should begin immediately to determine 1) entrainment & survival rates, and 2) size-at-release effects on survival & entrainment. It would seem necessary to know the appropriate size of fish to stock to ensure that most remain within the pool. Also, an investigation should be pursued regarding impacts to hatchery capacity requirements under a multi-year rearing period.

Other outstanding issues include:

- Population modeling is being used to inform initial stocking levels. The survival rates used in the modeling exercise may underestimate survival for the Priest Rapids Project Area because entrainment is likely much higher than in the Upper Columbia. The maximum number of fish stocked in any year of the License term should not be limited to the 6,500 fish (1,500 in Priest Rapids and 5,000 in Wanapum) identified through the modeling exercise and currently selected as an initial stocking rate.
- What are the necessary mark & recapture sample sizes that help us estimate survival, and what analysis approach will be employed?
- White Sturgeon Management Plan Part B, Section 2.0, under the title "Supplementary Program Goals and Objectives" should call out the specific biological objectives as outlined in the Priest Rapids 401 Clean Water Certification. We suggest adding the term "biological" in front of objective where appropriate. The 401 Biological Objectives for the White Sturgeon Management Plan are:

  BIOLOGICAL OBJECTIVES

  1) Spawning and rearing in Project area[1]: Natural reproduction potential reached via natural recruitment.

  2) Spawning, rearing, and harvest in Project reservoirs: Increase the white sturgeon population in Project reservoirs to a level commensurate with available habitat.

  3) Adult and juvenile upstream and downstream migration: Provide safe, effective, and timely volitional passage, if reasonable and feasible passage means are developed.

  4) Until reasonable and feasible means for reestablishing natural production and providing support for migration are available, and recognizing that those means appear unlikely in the foreseeable future, the Biological Objective is sustaining a population at a level commensurate with available habitat through implementation of a white sturgeon supplementation program in the Project reservoirs. The supplementation program will provide an initial foundation for the Monitoring and Evaluation Program, which is designed to a) identify existing impediments to achieving the Biological Objectives, b) sustain the populations until the existing impediments can be corrected, and c) mitigate for population losses due to Project impacts. Timelines proposed for implementation of supplementation program implementation measures are reflected in the table below.

  Additional attention should be given to ensuring the terms "objectives" and "biological objectives" are not confused in the document.
- The Priest Rapids 401 Clean Water Certification should be mentioned in the introduction of the document to clarify that development of the White Sturgeon Management Plan originates with the 401; currently the only reference to origin is "As part of the relicensing process…"

- Attachments A (Data Sheets), C (White Sturgeon Sampling and Surgical Supply List), D (OTC Dosage Information), need to be completed.

As mentioned above, WDFW proposes a postponement of adoption of this plan as appropriate given the additional coordination work that is needed. WDFW appreciates the opportunity to comment, and looks forward to participating in a region-wide coordination activity for management of white sturgeon.

Sincerely,

T. Scott

Teresa Scott

Natural Resource Policy Coordinator

Cc: Bill Tweit

Bob Rose

Priest Rapids Fish Forum

>>> Bob Rose <brose@yakama.com> 3/26/2009 11:04 AM >>>
Gents, Good morning,
Attached is the WSMP with edits I'm recommending.
Those areas with red paint are the additions. This is what I want you to look at.
At the beginning of each Sections (A,B, and C) you'll note language including WDFW.
They are still reviewing this - but I wanted to get it in front of you as early as possible -- FYI.
You'll note other sections of red paint that I sent to you a couple weeks ago - acknowledging YN facilities - etc.

Also note some areas with yellow paint dabbled around - these are just miner edits I bring to your attention.
The green paint is just areas where I had a question or two - I think - in some cases I don't really recall the question.

Please note the language indicating there will be field work in 2009 (painted green - beginning of section C) is confusing.
I'm guessing you have this language here as a place holder in the case FERC lets you in the water??

For you gentlemen, I am always available for discussion and enlightenment.
I will be talking lamprey trash with DCPUD this afternoon - but look forward to our next visit.
Best,
Rose

>>> "Verhey, Patrick M (DFW)" <Patrick.Verhey@dfw.wa.gov> 3/31/2009 12:47 PM >>>
The Washington State Department of Fish and Wildlife supports and agrees with the March 26, 2009 edits Bob Rose made to the WSMP. Many of the edits to the plan were jointly create by both WDFW and the Yakama Indian Nation. We want to thank Bob for his time and effort in developing the comments. We specifically support comments that encourage a regional coordination of white sturgeon mitigation efforts. The plan, with Bob's comments is attached to this e-mail.

We encourage the adoption of the WSMP by the PRFF in order to allow Ecology sufficient time to review the plan prior to Grant PUD submitting it to FERC.

Patrick Verhey

WDFW Major Projects

Hydroelectric Mitigation Biologist

(509) 754-6068 ex. 13

WANAPUM

01 April 2009

Public Utility District NO. 2 of Grant County
Attn: Tom Dresser, FWWQ Manager
P.O. Box 878
Ephrata, WA 98823

SUBJECT: White Sturgeon Management Plan

Dear Mr. Dresser,

The Wanapum appreciate the opportunity to review and comment on the White Sturgeon Management Plan and have the following comments. Priest Rapids white sturgeon are an important fish species to the Wanapum for cultural subsistence and ceremonial purposes. We recognize the value of regional coordination to sustain the regional white sturgeon population and a potential fishery it may provide, that the Wanapum would be interested in participating in. The Wanapum recognize the importance of finalizing this plan prior to the April 17, 2009 FERC due date to ensure adequate time to assess the best quality of genetic broodstock available. We would like to see the District move forward with a white sturgeon aquaculture facility at the Priest Rapids Project, specifically, near Priest Rapids Dam which is near the Wanapum Indian Village. In addition, the Wanapum are interested in participating in white sturgeon aquaculture activities, techniques, and fish husbandry methods at this facility.

If you would like to discuss our comments, please contact me at (509) 754-5088 ext. 3113.

Sincerely,

Rex Buck Jr.
Wanapum Leader

>>> Mike Clement 4/7/2009 9:54 AM >>>
This is the last one/email I have.....it would go last and also be attached to the April meeting minutes to show we have a consensus vote. Give me a call if you have any questions.

Mike

>>> <Stephen_Lewis@fws.gov> 4/6/2009 4:20 PM >>>
Mike/Tom-

The USFWS also supports Bob Rose's edits made to the White Sturgeon
Management Plan.

S-

****

Stephen T. Lewis
Mid-Columbia Relicensing Coordinator
U.S. Fish and Wildlife Service
Central Washington Field Office
215 Melody Lane, Suite 119
Wenatchee, WA 98801
phone: (509) 665-3508 Ext. 14
fax: (509) 665-3523
e-mail: Stephen_Lewis@fws.gov

Appendix C
Priest Rapids Fish Forum Meeting Minutes

DRAFT Meeting Minutes

Priest Rapids Fish Forum

Wednesday, April 01, 2009
10:00 – 12:00
Conference Call

Members

Stephen Lewis, USFWS	Patrick Verhey, WDFW
Bob Rose, YN	Carl Merkle, CTUIR
Keith Hatch, BIA	Joe Peone, CCT
Marcie Mangold, WDOE	Mike Clement, GCPUD

Attendees

Patrick Verhey, WDFW	Brad James, WDFW
Keith Hatch, BIA	Marcie Mangold, WDOE
Bob Rose, Yakama Nation	Blaine Parker, CRITFC
Carl Merkle, CTUIR	Jim Powell, Freshwater Fisheries Society of B.C
Alyssa Buck, Wanapum	Mike Clement, GCPUD
Ben Lenz, GCPUD	Debbie Williams, GCPUD
Kevin Malone, Facilitator	

Action Items:

1. **WSMP, Page 19, 3.1.2 - Juvenile White Sturgeon Stocking – telemetry evaluation should be included in the study plan.**
2. **WSMP, Page 47, Powell will provide reference paper to Lenz regarding captive broodstock.**

Agenda Items for Next Meeting:

1. **WSMP Page 21, 3.3 – June 03, 2009 meeting; determine the definition of carrying capacity.**
2. **Bull Trout Hydrologic and Water Quality Study Plan comments.**

Decisions:

1. **PRFF members voted and approved the White Sturgeon Management Plan as edited during today's PRFF conference call.**
2. **PRFF Members agreed not to hold a meeting on May 6, 2009.**

Draft Meeting Minutes

I. **Welcome and Introductions** – Malone welcomed members on the conference line.

II. **Agenda Review** – Malone reviewed the agenda. Protocols will not be discussed today, in order to allow Bob Heinith to participate.

III. **Action Item Review** – No discussion took place.

A **YN/WDFW Sturgeon Discussion Review (Pending 3/23 Meeting Date)** – Edits developed during a meeting with Washington Department of Fish and Wildlife (WDFW) and the Yakama Nation (YN) were sent to Grant PUD prior to today's meeting. See discussion below.

B **YN/WDFW/WDOE/Grant PUD White Sturgeon Management Plan (WSMP) Edits and Update** – Members participated in a Web Ex Conference Call in order to edit comments in real time. Clement explained that all comments will be incorporated into a table, and attached to the plan. Action Item: **Page 19, 3.1.2 - Juvenile White Sturgeon Stocking – telemetry evaluation should be included in the study plan.** Agenda Item: **Page 21, 3.3 – Determine the definition of carrying capacity.** Action Item: **Page 47, Powell will provide reference paper to Lenz regarding captive broodstock.**

Clement assured members that Grant PUD will work towards regional coordination regarding the White Sturgeon Management Plan.

All of the highlighted edited comments provided by WDFW and the YN were approved by Grant PUD, and will be incorporated into the final WSMP. After PRFF approval, the WSMP will be sent to WDOE for approval, then onto FERC for final approval.

Clement motioned to approve the WSMP. PRFF members voted and approved the White Sturgeon Management Plan as edited during today's PRFF conference call. Yes votes were given by Grant PUD, Yakama Nation, Umatilla Indians, Bureau of Indian Affairs, and the Washington Department of Fish and Wildlife. Action Item: Malone will contact Steve Lewis, of the United States Fish and Wildlife Service regarding his vote. Parker and Powell left the call at 11:41 a.m.

IV. **Aquatic Invasive Species (AIS) Update –** Members affirmed an e-mail vote to approve a one year extension of the AIS Plan. Washington Department of Ecology approved the extension on March 31, 2009. Hendrick will work with Allen Pleus, AIS Coordinator for Washington Department of Fish and Wildlife (WDFW) to develop a schedule for the plan over the next several months. A second AIS draft will be provided by September 2009. A 60 day comment period will be provided for review of the second draft. Portions of the plan that will undergo extensive revisions are the rapid response, and zebra muscle sections. Shoreline inspections will take place every two years. Grant PUD will continue to conduct regular zebra muscle monitoring again this year. Hendrick will provide monthly updates.

V. **PRFF Protocol Discussion** –

A **Review of CRITFC Protocol Updates (Bob Heinith edits)** – Protocols will not be discussed today, in order to allow Bob Heinith to participate.

B **Consensus Vote on Protocols** – No vote was taken.

VI. **Management & Monitoring Evaluation Plan Updates**

A **Native Resident Fish update** - The Native Resident Fish Plan was sent to FERC on April 02, 2009.

B **Lamprey Update –** The Pacific Lamprey Plan was approved by the Priest Rapids Fish Forum and Washington Department of Ecology. It was sent to the Federal Energy Regulatory Commission (FERC) on February 19, 2009. Letters supporting expedition of the plan were sent to FERC by WDFW and the Columbia River Inter-tribal. An email from Eric Gaedeke (FERC) indicated they would try to expedite the plan. Grant PUD is in the process of submitting a 3 yr contract to start work on the Lamprey Plan. The work will include installation of plating, and modifications to the fishways. After a contractor is approved, Clement would like to bring the consultant to a PRFF meeting after the contract was in place to discuss the 2010 study plan. 3 Request for Proposals were received, reviewed and scored. After commission approval of the Clement would like PRFF members to discuss the scope of work.

C **Bull Trout Update –** The Bull Trout Hydrologic and Water Quality Study Plan (BTHWQSP) will require an extension. The extension letter will be sent to FERC on April 02, 2009. Agenda Item for the next meeting. Comments on the plan are due prior to May 06.

D **Aquatic Invasive Species Update –** No discussion took place.

VII. **Additional Items** – No discussion took place.

VIII. **Meeting Minutes**

- March 04 meeting minutes will be posted to the website.

IX. **Next Meeting**: PRFF Members agreed not to hold a meeting on May 6, 2009. The June 03, 2009 meeting will be held at the United States Fish and Wildlife Service office in Wenatchee.

Appendix D
Grant PUD's Response to Agency and Tribal Comments

SUMMARY TABLE OF AGENCY/TRIBAL COMMENTS AND GRANT PUD RESPONSES FOR WHITE STURGEON MANAGEMENT PLAN

Submitting Entity	Date Received	Format	Agency Comment	Grant PUD Response
USFWS	17-Sep-09	Email from S. Lewis (USFWS) to T. Dresser/M. Clement (Grant PUD)	An important piece of information missing from this document is the upstream passage counts of white sturgeon through the Priest Rapids and Wanapum dams. Passage counts will provide context in terms of shaping Grant PUD's future implementation of the White Sturgeon Conservation Aquaculture Plan. In part, this information will assist in defining how white sturgeon utilize both of the Project's reservoirs.	Grant PUD has historically and will continue to provide fish counts at both Wanapum and Priest Rapids dams 24 hours/day, 7 days/week from April 15 – November 15 each year. These counts can be viewed at **www.gcpud.org/resFISH/fishCounts.htm**. Any information related to "assisting and defining how WS utilize both Project reservoirs "will be evaluated through the PRFF.
USFWS	17-Sep-09	Email from S. Lewis (USFWS) to T. Dresser/M. Clement (Grant PUD)	We suggest that Grant PUD reassess its current levels of white sturgeon within the Wanapum and Priest Rapids reservoirs in order to fine-tune its current level of white sturgeon to be released into these reservoirs due to possible downstream migration of white sturgeon from the Rock Island Reservoir."	Grant PUD has included this additional request of assessing and evaluating updated stocking levels in Part B, Section 2.0 of the final WSMP.
USFWS	17-Sep-09	Email from S. Lewis (USFWS) to T. Dresser/M. Clement (Grant PUD)	Biological objective #3 on page ii includes: "Adult and juvenile upstream and downstream migration; Provide safe, effective, and timely volitional passage, if reasonable and feasible passage means are developed." This objective appears to need clarification as white sturgeon already pass upstream through the existing fishways at the Project."	Grant PUD has modified Biological Objective #3 of the WSMP to include this request..

USFWS	17-Sep-09	Email from S. Lewis (USFWS) to T. Dresser/M. Clement (Grant PUD)	PME #4 on page iii states that Grant PUD will: "Conduct tracking surveys of juvenile white sturgeon released with active tags as part of the supplementation program to determine emigration rates from Priest Rapids Project." We also suggest that Grant PUD consider a determination of immigration rates for white sturgeon for these assessments."	Grant PUD has included these measures in Part B, Section 5.0 and Part C of the WSMP which proposes activities that will provide the information requested.
WDFW	27-Feb-09	Letter	What are the necessary mark and recapture sample sizes that help us estimate survival, and what analysis approach will be employed?	All activities related to the WSMP, including mark/recapture, survival, etc. will be evaluated through the Priest Rapids Fish Forum.
WDFW	27-Feb-09	Letter	The White Sturgeon Management Plan Part B, Section 2.0, under the title "Supplementary Program Goals and Objectives" should call out the specific biological objectives as outlined in the Priest Rapids 401 Clean Water Certification. We suggest adding the term "biological" in front of objective where appropriate." WDFW proceeds to insert the 401 requirements in the text of the letter then states, "Additional attention should be given to ensuring the terms "objectives" and "biological objectives" are not confused in the document." Also, item 4 states, "The Priest Rapids 401 Clean Water Certification should be mentioned in the introduction of the document to clarify that development of the White Sturgeon Management Plan originates with the 401; currently the only reference to origin is "As part of the relicensing process…"	Grant PUD acknowledges this comment and has verified that the 401Clean Water Certification repeat the objectives as defined by the text of the 401. Further, Grant PUD does not propose to amend the objectives of the 401 and is not proposing to do so, in this plan..
WDFW	27-Feb-09	Letter	Attachments A (Data Sheets), C (White Sturgeon Sampling and Surgical Supply List), D (OTC Dosage Information), need to be completed.	Grant PUD has included these documents in the Appendix of the WSMP.
Yakama Nation	26-Mar-09 and	WSMP Document edit	Pg. 35, Discussion at April 1, 2009 PRFF meeting related to editing text from the need "to construct and operate" to "for".	Grant PUD, in consultation with the PRFF, agrees and has modified the WSMP to

	01-Apr-09 PRFF meeting			reflect this suggestion.
Yakama Nation	26-Mar-09 and 01-Apr-09 PRFF meeting	WSMP Document edit	Pg. 45, Discussion at April 1, 2009 PRFF meeting related to including text "Additionally, the Yakama Nation is currently evaluating the genetics of broodstock and recent offspring that are currently in captivity at Yakama Nation white sturgeon facilities. Use of these fish as broodstock, as either a short-term or long-term option, is being considered."	Grant PUD, in consultation with the PRFF, agrees and has modified the WSMP to reflect this suggestion.
Yakama Nation	26-Mar-09 and 01-Apr-09 PRFF meeting	WSMP Document edit	Pg. 46, Discussion at April 1, 2009 PRFF meeting related to editing text from "a maximum of 12 adult white sturgeon (six male, six female) would be collected from the Priest Rapids and the Wanapum Reservoirs annually for broodstock:" to "capacity for a maximum of 12 adult white sturgeon (six male, six female) to be used annually for broodstock. Preference and priority would be collection of these fish from Priest Rapids and Wanapum reservoirs, although other collection sites and broodstock sources are likely to be considered as appropriate options."	Grant PUD, in consultation with the PRFF, agrees and has modified the WSMP to reflect this suggestion.
Yakama Nation and CRITFC	26-Mar-09 and 01-Apr-09 PRFF meeting	WSMP Document edit	Pg. 47, Edit discussed at April 1, 2009 PRFF meeting regarding inclusion of text related to value of captive broodstock. Clarification of information sources requested by CRITFC.	Grant PUD has modified the text in the WSMP from "Conversely, it is likewise accepted that fish reared in a captive environment are thought to be compromised nutritionally and health-wise by artificial environments." to "Conversely, fish reared in captive conservation breeding programs may be compromised in their fitness and potentially artificially adapted to the captive environment (Frankham, 2008). This risk

				needs to be considered relative to conservation goals." This citation: "Frankham, R., 2008. Genetic adaptation to captivity in species conservation programs. Molecular Ecology 17:325-333." added to citation list on pg. 75.
Yakama Nation and CRITFC	26-Mar-09 and 01-Apr-09 PRFF meeting	WSMP Document edit	Pg. 49 and 50, Edits discussed at April 1, 2009 PRFF meeting regarding the value of captive broodstock. Clarification of information sources requested by CRITFC. CRITFC also commented that the long-term nature of this plan relates to the longevity of this fish species and thus requires long term planning for brood source considerations.	Grant PUD has modified the text in the WSMP from "Captive broodstock is the least desirable alternative for securing gamete supply. There are three reasons for this statement: 1) risk to the adult sturgeon, 2) risk to the gamete supply, and 3) physical plant constraints." to "Captive broodstock are an alternative source for securing gamete supply. However, egg quality needs to be monitored as past work has shown that egg quality, particularly marine source Omega-3 fatty acid content can vary with feed source (Gessner et al. 2008; Caprino, et al. 2008) and can differ between wild and captive stocks (Chen et al. 1994). Furthermore, care must be taken in consideration of genetic effects of adaptation to the captive environment when rearing brood fish for extended periods, particularly as the offspring will be released to the wild (Frankham 2008). For these reasons, captive brood can be considered secondarily to a wild source supply for seed." Also, text changed from "Captive broodstock programs are practiced by some facilities on the Columbia River," to "Captive broodstock programs are practiced at some facilities in

				the Columbia River basin, (e.g., Yakama Nation facilities),". These citations: Caprino, F., Moretti, V.M., Bellagambaa, F., Turchini, G.M., Busettoa, M.L., Giania, I., Paleari, M.A. and Pazzaglia, M. 2008. Fatty acid composition and volatile compounds of caviar from farmed white sturgeon (*Acipenser transmontanus*). Anal. Chem. Acta. 617: 139-147., Chen, I. C. , Chapman, F.A., Wei C., Portier, K.M. and O'Keefe, S.F. 1994. Differentiation of cultured and wild sturgeon (*Acipenser oxyrinchus desotoi*) based on fatty acid composition. Annual Meeting of the Institute of Food Technologists, Atlanta, GA, June 1994., and Gessner, J., Würtz, S., Kirschbaum , F. and Wirth, M. 2008. Biochemical composition of caviar as a tool to discriminate between aquaculture and wild origin. Journal of Applied Ichthyology 24: 52-56 added to the list on page 75.
Yakama Nation	26-Mar-09 and 01-Apr-09 PRFF meeting	WSMP Document edit	Pg. 62, Discussion at April 1, 2009 PRFF meeting related to the text: "Ideally, the facility should be located adjacent to either Priest Rapids or the Wanapum reservoirs and close to the Columbia River to allow ready access to river water as well as juvenile/adult release locations and adult collection sites."	Grant PUD, in consultation with the PRFF, agrees and has modified the text deletion.
Yakama Nation	26-Mar-09 and 01-Apr-	WSMP Document edit	Pg. 63, Discussion at April 1, 2009 PRFF meeting related to inserted text "Grant PUD is currently evaluating potential applications for the Priest Rapids Hatchery to serve as a	Grant PUD, in consultation with the PRFF, agrees and has modified the text insertion..

	09 PRFF meeting		primary facility for white sturgeon production. Grant PUD and the Priest Rapids Fish Forum also recognize that other existing and potential facilities may be available and desirable, particularly in light of the fact that both FERC relicensing efforts of Chelan and Douglas County PUDs will also obligate similar and additional mitigation in mid-Columbia river reservoirs immediately upstream of the Priest Rapids Project Area. And, as indicated earlier in this document, the Yakama Nation Fisheries Resource Program and the Columbia River Inter Tribal Fish Commission are also in initial phases of developing Master Plans for additional Columbia River Basin White Sturgeon facilities. Although this document does not address these other activities specifically, the PRFF and more specifically the fisheries co-managers (Yakama Nation and the Washington Department of Fish and Wildlife) have long recognized financial efficiencies and biological benefits to white sturgeon to integrate Priest Rapids production obligations with other regional interests."	
Yakama Nation	26-Mar-09 and 01-Apr-09 PRFF meeting	WSMP Document edit	Pg. 65, , Discussion at April 1, 2009 PRFF meeting regarding the text changed from "a back-up production facility" to "back-up production facilities".	Grant PUD, in consultation with the PRFF, agrees and has modified this text change.
Yakama Nation	26-Mar-09 and 01-Apr-09 PRFF meeting	WSMP Document edit	Pg. 78, Discussion at April 1, 2009 PRFF meeting regarding inserting text "Grant PUD recognizes other ongoing and expanding long-term White sturgeon monitoring and research programs occurring within the Columbia River Basin implemented by the Washington Department of Fish and Wildlife (WDFW) and the Columbia River Inter-Tribal Fish Commission (CRITFC). In addition Chelan County PUD and	Grant PUD, in consultation with the PRFF, agrees and has modified this text insertion.

			Douglas County PUD will soon be implementing white sturgeon supplementation and associated monitoring and evaluation programs within the reservoirs behind the Rocky Reach and Wells hydroelectric projects, respectively. As supplementation and conservation efforts substantially expand within the Columbia River Basin, Grant PUD also recognizes an enhanced need to work collaboratively with the State and Tribal fisheries managers in developing a cost-efficient research, monitoring and evaluation program that is consistent and complimentary with other regional interests."	
WDFW	March 31, 2009	Email from P. Verhey (WDFW) to T. Dresser (Grant PUD)	The Washington State Department of Fish and Wildlife supports and agrees with the March 26, 2009 edits Bob Rose made to the WSMP. Many of the edits to the plan were jointly create by both WDFW and the Yakama Indian Nation. We want to thank Bob for his time and effort in developing the comments. We specifically support comments that encourage a regional coordination of white sturgeon mitigation efforts. The plan, with Bob's comments are attached to this e-mail. We encourage the adoption of the WSMP by the PRFF in order to allow Ecology sufficient time to review the plan prior to Grant PUD submitting it to FERC.	Grant PUD, in consultation with the PRFF, acknowledges WDFW's supportive comments of the WSMP.
Wanapum Tribe	April 1, 2009	Letter	The Wanapum appreciate the opportunity to review and comment on the White Sturgeon Management Plan and have the following comments. Priest Rapids white sturgeon are an important fish species to the Wanapum for cultural subsistence and ceremonial purposes. We recognize the value of regional coordination to sustain the regional white sturgeon population and a potential fishery it may provide, that the Wanapum would be interested in participating in. The Wanapum recognize the importance of finalizing this plan prior to the April 17, 2009 FERC due date to ensure adequate time to assess the best	Grant PUD acknowledges and accepts the Wanapum's supportive comments related to the WSMP. Grant PUD will continue to work collaboratively with the Wanapum and PRFF to implement the WSMP.

			quality of genetic broodstock available. We would like to see the District move forward with a white sturgeon aquaculture facility at the Priest Rapids Project, specifically, near Priest Rapids Dam which is near the Wanapum Indian Village. In addition, the Wanapum are interested in participating in white sturgeon aquaculture activities, techniques, and fish husbandry methods at this facility.	
USFWS	April 6, 2009	Email-S. Lewis (USFWS) to T. Dresser (Grant PUD)	"The USFWS also supports Bob Rose's", (Yakama Nation). "edits made to the White Sturgeon Management Plan."	Grant PUD, in consultation with the PRFF, acknowledges approval of the WSMP.