UPPER COLUMBIA RIVER WHITE STURGEON
RECOVERY PLAN

Technical Appendices

November 25, 2002

DISCLAIMER

Recovery plans delineate reasonable actions that are believed necessary to recover or protect the species. This plan has been prepared as a cooperative effort among Canadian and U.S. Federal, Provincial, and State agencies, Canadian and U.S. tribes, and other stakeholders. Objectives will be obtained and any necessary funds made available subject to budgetary and other constraints affecting parties involved, as well as the need to address other priorities. The recovery plan does not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation. The plan is subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

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1.0HABITAT RESTORATION

1.1 INTRODUCTION

The Upper Columbia River White Sturgeon Recovery Team (hereafter referred to as the Recovery Team) is responsible for development and implementation of a recovery plan for the imperiled Upper Columbia white sturgeon populations. The Recovery Team assigned responsibility for developing habitat restoration components of the Recovery Plan to a Habitat Restoration Sub-Committee. Terms of Reference (ToR) for the Habitat Restoration Sub-Committee (HRSC) are provided in Appendix A of this document.

The ToR for the HRSC outlined an ambitious set of tasks contributing to the development of a Recovery Plan. In realty, the HRSC soon realized that many of the tasks formed part of a short and long-term research program to be incorporated in the Recovery Plan. To that end, the HRSC redrafted the ToR tasks for this component of the plan. The steps in development of this plan included the following:

i) Assemble baseline data from the literature on white sturgeon life history, and where possible define known habitats within the geographic range of the Recovery Plan used by white sturgeon.

ii) Using the information gathered in the summary review, draft a set of Potential Impact Hypotheses which identify potential habitat changes that have likely occurred in the basin and which may have contributed to recruitment failure.

iii) With the Hypotheses as a basis, provide a list of potential options to enhance, recover, or restore habitat conditions and increase sturgeon production.

iv) Undertake a gap analysis to assist with the development of research tasks designed to better develop habitat restoration techniques.

v) Summarize the information gathered into a Habitat Restoration Options Evaluation Matrix.

vi) Develop a timeline of research tasks and related restoration options related to the UCSWRI short, medium and long term objectives and targets.

Step i) is near completion with development of the White Sturgeon Habitat Summary database tables (Appendix B) and related graphs and maps (Figures 1-4). Steps ii) through vi) are developed in this report. The main emphasis of the hypotheses focuses on early life stage habitat requirements (spawning and rearing) where the major bottlenecks to production were considered most likely to occur. The Matrix developed in step v) was used to subjectively rank hypotheses as to probability that the potential effect of the hypothesis was real and the response was technically feasible.

1.2 POTENTIAL IMPACT HYPOTHESIS

Based on the information developed and provided in the White Sturgeon Habitat Summary database tables (Appendix B), a series of hypotheses were developed. The hypotheses are based on the changes to important white sturgeon habitat that have likely occurred in the Upper Columbia River over the last five decades and the effect these changes may have had on survival and recruitment success of the white sturgeon populations downstream of Revelstoke and

Keenleyside dams. Response options are outlined for each hypothesis and a series of research tasks are briefly recommended to evaluate the potential for the options described. As these tasks are undertaken and completed, decisions can be made regarding the more suitable early, medium and long term habitat restoration techniques and programs initiated to provide for those techniques selected.

1.2.1 HYPOTHESIS 1:

River regulation (possibly in combination with other factors such as global warming and logging) has altered natural temperature regimes of rivers prior to and during the white sturgeon spawning period, and has impacted juvenile survival, growth and maturation through effects on seasonal metabolic rates. The greatest effects have likely occurred in river segments downstream from major storage reservoirs (i.e., Kinbasket, Arrow and Kootenay and Pend d'Oreille river reservoirs). These temperature changes may have adversely affected the timing of spawning and the variously metabolic rates, growth, and survival of egg, post-hatch larvae, post-yolk sac larvae, young-of-year and juvenile life stages.

Discussion: The spawning area for the Columbia River white sturgeon population is located at the confluence of the Columbia and Pend d'Oreille rivers (the Waneta area). The spawning area for the Arrow Lakes population is located below Revelstoke Dam (the Revelstoke area). Larvae hatched at these sites drift downstream to settle in rearing areas in the upper Roosevelt and upper Arrow Lakes reservoirs, likely where velocities decrease in those zones of interface that geographically shift dynamically between river and reservoir. Young-of-the-year and juvenile sturgeon also rear in these areas and others in the river and reservoir as they explore and redistribute themselves.

Waneta Area

The timing and success of sturgeon spawning and incubation at Waneta is potentially influenced by water temperature regimes in both the Columbia and Pend d'Oreille rivers. Historical temperature data does not appear to be available from the lower Pend d'Oreille River and as a result, effects of river regulation on water temperatures or warming rates are unknown. A reasonable assumption, however, is that logging in the watershed, the increased surface area of the river (due to the formation of numerous run-of-the-river reservoirs), and global warming have combined to produce warmer water temperatures in May to July and this has accelerated the warming rate over the spring period. Assuming these changes have occurred, an accelerated warming rate during the spawning season would reduce the length of time when "optimal" water temperatures (14 to 16 °C) for egg development would be available. This would have negative impacts on egg to fry survival rates and also may effect subsequent survival of early larval stages.

The temperature regime of the Columbia River in the Waneta area also has been altered by flow regulation. Keenleyside Dam, located 56 km upstream from the Waneta area impounds Arrow Lakes Reservoir, a large storage reservoir. Regulation of the Kootenay River also affects water temperatures in the Columbia River below Keenleyside Dam. The main effects of upstream flow regulation on water temperatures in the Columbia River below Keenleyside Dam has been a significant warming during the winter period; effects on mean monthly water temperatures during the May to July period are less apparent and may not have changed significantly following regulation. However, possible changes to warming rates during these months have not been determined.

Available data suggests that most white sturgeon that spawn in the Waneta area are exposed only to those temperature cues that are provided within the Columbia River mainstream. If warming rates in the Columbia River below HLK have been altered by upstream regulation, then this may affect the timing of white sturgeon vitellogenesis and spawning activity in the Waneta area. If this effect has resulted in delays in spawning activity, then this may explain why a large portion of spawning events in the Waneta area occur at above optimal temperatures for egg development.

Regulation of the Columbia and the Pend d'Oreille rivers and the formation of Lake Roosevelt may have increased water temperatures in Lake Roosevelt during the late spring and summer periods. If so, early life stages of sturgeon that rear under these elevated water temperatures would experience increased metabolic rates. This increase in metabolic expenditure of energy could result in starvation if as postulated in Hypothesis 6, food resources are limited in habitats where post-hatch white sturgeon settle and commence exogenous feeding activities.

Revelstoke Area

The temperature regime of that section of the Columbia River between Revelstoke Dam and Arrow Lakes Reservoir also has likely been altered by upstream regulation. Hypolimnetic releases from both Mica and Revelstoke dams have resulted in warmer winter water temperatures and colder summer temperatures and may have prolonged the warming rate of the river below Revelstoke Dam during the April to August period. The latter changes may have altered timing of sturgeon vitellogenesis and spawning. This could account for the documented spawning event in late August, which is substantially later than has been recorded for any other spawning population.

The withdrawal of hypolimnetic waters from Revelstoke Dam has also potentially decreased water temperatures within rearing habitats in Arrow Lakes Reservoir during the juvenile period. Larval and fry rearing at reduced temperatures would exhibit reduced metabolisms and growth rates, which would increase the length of time these life stages would remain at a high risk to predation.

Options for Mitigation/Enhancement: Possible options to modify temperature regimes in critical rearing habitats used by early life stages of white sturgeon would be the same as those suggested to modify temperatures in sturgeon spawning areas.

In the Pend d'Oreille River, options to alter water temperatures during the spawning and egg incubation period are not available since all of the lower reservoirs are run-of-the-river with isothermal temperature profiles.

Options to regulate water temperature in the Columbia River could theoretically be achieved by selective water withdrawals at Mica, Revelstoke, and Keenleyside dams. At present, none of these facilities has the capability to control downstream water temperatures through selective withdrawals, except by the use of spillways and in most years, water levels in these reservoirs in May and June are too low to use spillway releases.

Hugh L. Keenleyside Dam (HLK) has the capacity to discharge water from either spillways or low level ports and in the near future will have an additional option of discharging flow through the new Arrow lakes Generating Station (ALGS) powerplant. However, during licensing of the ALGS, the regulatory agencies required that the powerplant intake be designed so there would be no net change in downstream water temperatures when the plant was operational. Temperature measurement programs and concurrent modeling exercises, designed to ensure any temperature differences caused by the operation of the powerplant can be detected, have indicated that the mode of water release from HLK does not substantially influence downstream water temperatures.

The thermal stratification properties of Arrow Lakes Reservoir and the volume of water being discharged at HLK are the main determinants of downstream temperature. Several options appear feasible, although possibly impractical, as responses to the need to decrease or increase temperature regimes below HLK.

i) Increasing the discharge of warmer surface waters from upstream reservoirs (i.e., Kinbasket and Revelstoke) through the selective withdrawal of surface waters, may increase the thickness of the warmer surface layer in Arrow Lakes Reservoir that in turn, may increase overall temperatures below HLK.

ii) Maintaining higher reservoir levels over the winter and into the spring could result in earlier stratification of water within the reservoir such that surface waters would warm more quickly and develop into a thicker water layer that could be selectively withdrawn to increase downstream temperatures. ***This option should be explored in more detail in the WMSC report.***

iii) Surface withdrawals from both Keenleyside and Revelstoke dams during the winter period also could potentially reduce winter temperatures to near pre-regulated levels in downstream areas where pre-spawning sturgeon stage over the winter.

Selective withdrawal of surface waters from Revelstoke Reservoir could also have significant effects on immediately downstream water temperatures, and could be used to increase both the warming rate and the daily temperature maxima in the Revelstoke spawning area during the sturgeon spawning period.

None of the suggested changes in reservoir operations and surface withdrawal preferences, or development of selective withdrawal processes should be considered until the feasibility and practicality of the options are determined. This requires a series of research tasks, which are outlined below.

Research Needs: Given the highly complex interaction between inflows, water levels, flow through rates, and dam discharge modes on the thermal regimes of the reservoirs, the development of options to enhance sturgeon spawning, incubation and rearing temperatures will require additional study.

A sequence of research topics are recommended which include:

i) Review historic data to define pre-impoundment temperature regime in the Columbia upstream of Arrow Lakes and downstream of HLK. Sources may include WSC, BCH and government reports, and the Arrow Lakes Reservoir Fertilization Program. If adequate data are not available, collect data from upstream inflow sources and simulate a likely seasonal temperature regime. ***This task will require 1 year of effort and should be initiated during the first year of studies to support Hypothesis 1.***

ii) Assess temperature effects on incubation success and survival in the hatchery. If the historical temperature regimes are shown to have changed significantly, it would be prudent to understand the effect on naturally incubating sturgeon eggs. If historic temperatures have not changed appreciably to post-impoundment, then it worth determining if sturgeon in the area are adapted to a species non-preferred thermal range during incubation. Either way, the results will assist the optimal operation of the hatchery. ***This task may require 3-5 years of study and should be initiated following the completion of task i) above.***

iii) Assess the feasibility and practicality of reservoir operations and selective withdrawal options suggested under Hypothesis 1. If research task i) indicates a deviation in temperature regime associated with impoundment and dam operations, then it would be prudent to determine if any of the options suggested are possible under operational restrictions, cost effective or in general practical. If not, then the research emphasis shifts to understanding how temperature will affect other recovery approaches such as conservation culture or habitat enhancements. ***The task should be initiated following completion of task i) and should take a year.***

iv) Assess temperature effects on egg maturation in and egg release from spawning adults. This task deals with understand the effects of temperature on adult staging and spawning, and its influence on wild broodstock. The task will require further literature review and discussion with experts in the field of sturgeon conservation, and will require field and hatchery data collection to further define effects. ***The task is viewed as a long term study which may require 10 years of study; the work should however, be initiated following the completion of task i) above and in parallel with task ii).***

v) Determine the effects of the annual temperature regime on the metabolic demand of juvenile and adult sturgeon. This task will likely require an energetics modeling approach. Along with an understanding of the capacity of available habitat, the information would be of use in assessing probable juvenile survival for different release strategies, and long term reproductive potential. ***The task is viewed as a long-term study and should be undertaken when time and resources allow.***

1.2.2 HYPOTHESIS 2:

Regulated flows have reduced the suitability of white sturgeon spawning substrates. Substrates in regulated systems typically become embedded or imbricated, which reduces the availability and suitability of interstitial spaces that are required for the protection of developing sturgeon eggs and early post-hatch larvae.

Discussion: Although dam construction and reservoir formation may have flooded some historic white sturgeon spawning areas, those areas that are presently used (i.e., the Waneta area and the Revelstoke area) provide the coarse substrate types that are in the optimal size range for use by spawning sturgeon. The presence of suitably sized substrate, however, does not necessarily mean the substrate provides the interstitial spaces necessary for the protection of developing eggs and post-hatch larvae. Substrates in regulated systems typically become embedded or imbricated which reduces both the availability and the suitability of interstitial spaces.

In the Waneta area, observations by divers indicated that substrates in the egg deposition zone are coarse, angular, and not heavily embedded in finer substrates. This suggests that available substrates likely provide suitable interstices for the protection (both from velocity and predation) of incubating eggs and post-hatch larvae. The relatively “natural” freshet patterns that still occur in the Pend d’Oreille system (due to the absence of large storage reservoirs in the system) result in frequent spates that would help maintain substrate interstices by providing flushing flows that scour and transport fine materials out of the area.

In the Revelstoke spawning area, large volume flood events are rare due to the capture of the majority of the spring runoff peak in Kinbasket Reservoir. Although the size of substrate in the river downstream from Revelstoke dam is considered within the optimal range for sturgeon spawning, the riverbed has become armoured, with coarser substrates becoming embedded in a matrix of finer gravels and sand. As a result, sturgeon eggs spawned in this area may drift for considerable distances downstream before becoming lodged in an interstitial space that affords some protection from the current and from egg predators. This source of protection is likely more critical in the Revelstoke area given that discharge from Revelstoke Dam during the egg incubation period are often reduced to zero on a daily basis. During these reduced flow periods, egg predators (e.g., suckers and northern pike minnow) would have relatively easy access to incubating eggs.

Options For Mitigation/Enhancement: Enhancement of the suitability of the Revelstoke spawning area to increase the survival of life stages from the egg to the swim-up stage could be achieved by several options both operational and structural.

i) Introduce clean, coarse, angular substrates into the known spawning area near the confluence of the Jordan River, and combine substrate enhancement with increased minimum daily flow releases from Revelstoke Dam during the spawning period.

ii) Provide occasional flushing flows from Revelstoke Dam to help maintain the high quality of the substrate (i.e., by removing accumulated fines)

iii) Undertake structural modifications such as modifying the existing Revelstoke spawning area (i.e., to provide greater depths and faster flows in combination with introduction of coarse substrates) or constructing an artificial spawning channel along the lines of those constructed in Russia for other sturgeon species.

iv) Develop, test and install a prototype of the removable artificial spawning substrate recently designed by Russian sturgeon scientists.

The first three options are proposed only for the spawning site downstream of Revelstoke dam. Option iv) could be developed for both the Revelstoke and Waneta spawning sites.

Research Needs: As a preamble to selection and development of spawning habitat enhancement, literature review, site evaluation and feasibility assessments of design options are recommended.

i) Review Russian literature to determine the potential suitability for the Columbia of various methods developed and/or used in that country. ***This task should take place and be completed in the first year of recovery.***

Continue to monitor spawning incidence at the Revelstoke site for 3-5 years over a range of flow regimes to determine existing reproductive potential. Assess the flow regimes during those years monitored to date and designate flow regimes still requiring monitoring. ***Additional years of monitoring are required and should bracket flow regimes as yet not monitored.***

ii) Assess the Revelstoke spawning site conditions to include depth, velocity and substrate conditions. These data will be useful in comparing the existing conditions to optimal ones, and determining design requirements for the different options. ***This task will require 1-3 years and should follow the completion of task i) and parallel the remaining years required for task ii).***

iii) Undertake geotechnical surveys and pre-construction engineering evaluations of the three structural options (rock placement, channel recontouring and spawning channel development). Assess the Revelstoke area for location, site availability, cost and general practicality. ***This task should follow completion of task ii) and will require 1-2 years.***

1.2.3 HYPOTHESIS 3:

River impoundment has created nutrient sinks that reduce productivity in reservoirs and in sections of flowing river below dams. In addition, dams in the US have blocked salmon runs, which would have formed an important historical source of food and nutrients. This reduction in food supply and nutrients has reduced white sturgeon growth rates, increased their age-at-maturity, and increased the interval between spawning events, factors that singly or in combination have reduced recruitment.

Discussion: Aquatic productivity is not usually considered a physical habitat variable. In the Columbia River, however, the large-scale physical habitat change brought about by river regulation has had a substantial influence on productivity and for this reason, is included in this evaluation.

White sturgeon populations in all areas of the Upper Columbia Basin exhibit considerably slower growth rates than their counterparts in the lower Columbia or the Fraser rivers, populations with access to the ocean and anadromous food resources. Growth rate has a direct influence on age-at-maturity, spawning periodicity, and fecundity and all of these factors can affect recruitment. Prior to construction of Grand Coulee Dam, annual runs of salmon into the upper Columbia River Basin likely formed a very important food source for the resident sturgeon population. The loss of this food source, coupled with increased nutrient trapping by subsequent reservoir formation in the upper watershed, has likely reduced sturgeon growth. More recently, the reduction in nutrient inputs to the Columbia River (i.e., through the clean-up of municipal sewage inputs and the reduction in phosphorous loading from the Cominco fertilizer plant at Trail) have further reduced productivity of the system from HLK to Grand Coulee Dam.

A reduction in growth rates is not considered as a primary source of sturgeon recruitment failure for upper Columbia populations. However, environmental factors that increase age-to-maturity, increase the interval between spawning events for individual fish, or reduce the fecundity or fitness of the spawning cohort, all have the potential to result in reduction in recruitment that has the potential for cumulative interaction with other, more direct limiting factors.

Options For Mitigation/Enhancement: Available options for large-scale increases in productivity of the upper Columbia Basin are likely limited to nutrient enrichment programs such are currently being conducted in both Kootenay Lake and Arrow Lakes Reservoir. These programs are directed at increasing kokanee abundance in these systems and if successful over the long-term, should help increase white sturgeon growth rates since kokanee are an important prey item.

Response options designed to address nutrient loss and related reduction in productivity include:

i) Maintain and expand large lake or reservoir nutrient addition programs. The fertilization programs underway in Kootenay Lake and Arrow Lakes reservoir should be maintained. In addition, fertilization of Lake Roosevelt reservoir could be conducted to provide juvenile and adult sturgeon in the border population with improved habitat productivity.

ii) Resume but control nutrient releases from point sources such as Cominco or Celgar, provided unacceptable organic and heavy metal contaminants can be removed. It has been suggested that condition factor and growth rate in adult sturgeon has declined since the Cominco nutrient effluent was discontinued.

iii) Undertake localized embayment fertilization programs designed to enhance productivity on a seasonal basis in important feeding areas such as Beaton Flats in the upper Arrow Lakes reservoir and Kettle Flats in upper Lake Roosevelt. Localized fertilization programs in Scandinavia have been used to support endemic fish in reservoirs. If combined with a flow regime providing early flooding of embayment treatment sites, localized improved productivity of rearing sites could increase juvenile growth and survival.

Research Needs: To provide the background required to assess the above options, the following tasks are recommended.

i) Compare growth data for sturgeon found in locations with nutrient addition programs (Kootenay Lake and Arrow Lakes reservoir), non-fertilized areas (upper Roosevelt Lake), and generally natural sturgeon populations to assess the value of fertilization programs. ***This is a one-year task that should take place during the first year of recovery.***

ii) Evaluate the potential (pros and cons, costs and interest) for a large system fertilization program in Lake Roosevelt. ***To follow completion of task i) (likely start in year 2) and can be completed in 1 year; this task should only advance if the US representatives on the Recovery Team indicate an interest.***

iii) Evaluate the potential that Cominco and Celgar effluent outfalls could provide point sources of nutrient addition without contaminants. The CRIEMP program would provide a reasonable forum for examination of this option. ***Discuss with CRIEMP before advancing; should take one year to complete; likely in second year of recovery.***

iv) Identify and survey embayment fertilization candidate sites for a pilot test. Review annual water level patterns at the sites and assess the feasibility of ensuring suitable seasonal flooding conditions. Survey sites for substrate condition, water quality, temperature regime, invertebrate community etc. ***This task should start in the second year of recovery and will take 2-3 years to complete.***

v) Design, implement and monitor a pilot program to assess the feasibility of embayment fertilization. Such a pilot is envisaged to involve mesocosm assessment in the early stages, leading to a large-scale test. ***This task will follow completion of task iv) (year 5) and will require 1 year to complete. Implementation of the pilot program would occur in years 5-10.***

1.2.4 HYPOTHESIS 4:

Prior to regulation, the Columbia River system was turbid in the spring and retained a glacial colouration well into the summer. Impounded sections of the river now trap river borne sediments, resulting in higher water clarity throughout the system. White sturgeon are a species that has adapted to spawning in turbid river environments. The increased water clarity and reduced spring freshet flow volumes that have occurred in the Columbia system following river regulation has adversely affected sturgeon recruitment by increasing predation rates on both the egg and early life stages.

Discussion: White sturgeon are broadcast spawners whose life history strategy relies on the production of large numbers of eggs and fry to overwhelm predators, and a long life span with numerous spawning events to ensure the replacement of each individual in the population. This strategy is aided by the dark colouration of both the eggs and the early larval stages, an adaptation more suited to a turbid water environment. In addition, the egg and larval stages are both relatively large and while this likely has advantages in terms of early development and growth rates, it is a disadvantage in avoiding predation particularly in a clear water environment that supports high densities of predators that locate their prey visually.

Reductions in freshet volumes reduce water velocity and turbidity in the egg incubation areas. This allows easier access into egg incubation areas by egg predators and increases the risks of eggs being found and eaten.

The downstream dispersal stage where the post-hatch larvae enter the water column and passively drift downstream to suitable rearing habitats is a highly vulnerable stage of the species early life cycle. Any factors that increase water clarity or reduce the volume of water through which a predator is required to search in order to locate it's prey, would result in increased predation related mortalities. These same factors also would increase vulnerability to predation of young-of-the-year sturgeon.

Dam construction and regulation on the Columbia River has decreased the volume of the spring freshet and increased water clarity. These changes, which have affected habitat conditions within the sturgeon spawning areas at both Revelstoke and Waneta and within rearing habitats downstream from these areas, have a high potential to reduce recruitment success for both the Arrow lakes and Columbia River populations.

Options For Mitigation/Enhancement: Downstream drift and survival of post-emergent white sturgeon larvae could be enhanced through the provision of increased flows during the hatch and downstream transport phases of their early life history. An increase in the turbidity levels of flows during the larval drift phase would benefit early life stage survival by reducing the ability of visual predators to locate young sturgeon during their drift, hiding, and early feeding stages.

i) Increase the spring freshet volume during the spawning, incubation and larval drift stages below HLK and REV. An increase in larval drift rate would have the potential to benefit larval sturgeon survivals by reducing the time spent in the water column during their downstream transport to suitable rearing habitats. If the freshet volume were significantly increased, it could increase erosion rates in some areas, which could contribute to increases in turbidity. ***This option should be explored in more detail in the WMSC report.***

ii) Make best use of natural turbidity sources to provide cover especially during larval drift to suitable settlement areas. An example may be the turbid inflows from the Illecillewaet River, which could provide cover for drift larvae settling in braided areas downstream to and surrounding the Revelstoke airport. Combined with the provision of stable water levels, natural turbidity sources could be expected to improve the suitability and availability of rearing habitats.

iii) Artificially reduce water clarity through the introduction of materials, which naturally increase turbidity. A material for possible consideration would be bentonite, a naturally occurring colloidal clay that remains in suspension for long periods and requires the addition of only a small amount in water to substantially reduce clarity.

Research Needs: The United States Geological Survey (USGS) is in the process of determining potential species that prey on white sturgeon and examining the relationship between predation rates and water clarity. Results of these studies are expected in 2002 and would be required to form the basis of any additional experimental programs that may be proposed.

i) Review natural sources of turbidity in the study area, monitor the levels present and assess the likelihood of increased turbidity and transport to potential settlement areas using flow management. If sources are located, design a pilot test to assess feasibility. ***This task should be initiated in the first year of recovery; pilot test design and implementation would require several years.***

ii) Assess the feasibility of candidate materials for artificially reducing water clarity. Evaluate (i.e. conduct an EIA) the pros, cons, costs, legislative barriers, and environmental and social impacts of introduction. ***Undertake during the first year of recovery; should take 1-2 years to complete.***

iii) Model dispersion dynamics of acceptable candidates materials for artificial reduction of water clarity to identify coverage. ***This task will follow completion of task ii) (year 2) and should require 1-2 years to complete.***

iv) Assess the effects of increased turbidity on natural ecosystems. Initial stages of this work could include comparisons between clear and turbid systems using literature sources of data. Subsequent phases may use mesocosm techniques.

This task would likely be initiated starting in year 3 of recovery; the literature review and comparison should require no more than 1 year to complete, while subsequent phases would require 3-5 year of effort.

v) Investigate the relationship between water clarity and predation on early juvenile sturgeon life stages to determine the size and turbidity levels at which predation rates decline and no longer influence recruitment. This work will require lab or mesocosm facilities and would follow on the work being currently conducted by the USGS. ***This task would likely parallel the effort devoted to task iv).***

1.2.5 HYPOTHESIS 5:

The construction of dams, formation of reservoirs, and regulation of flows have altered the former riverine ecosystem and resulted in an increase in the abundance of predators such as suckers, northern pike minnow, and peamouth that prey on the eggs and larval stages of white sturgeon. In addition, the introductions of exotic piscivores (e.g., walleye, bass, sunfishes) into the system also have resulted in an increase of potential predators that prey on early life stages of sturgeon.

Discussion: An increase in predators combined with an increase in water clarity (see Hypothesis 4) would have a substantial negative incremental cumulative effect on sturgeon recruitment success for both the Arrow Lakes and Columbia River white sturgeon populations. Reservoir formation often results in substantial changes to fish species assemblages and relative abundance with a shift to greater abundance of non-sport species. Increased water clarity following regulation typically results in a shift to those species (both sport and non-sport) that rely on vision to locate and capture their prey. Both of these factors would tend to reduce the recruitment success of species such as white sturgeon that are adapted to spawning and rearing in turbid, large river environments. The introduction of piscivores, such as walleye and bass into the system, would also tend to increase the abundance of predators that could potentially feed on early life stages of white sturgeon during the early feeding stages.

Options For Mitigation/Enhancement: Alternative responses to predator influences on sturgeon recruitment involve methods to provide for predator exclusion from spawning, drift and rearing areas, as well as predator control/removal responses.

i) Increase flows during the incubation to early juvenile life history stages to exclude predators from key habitats. This technique would likely be most applicable to species exhibiting a low tolerance for higher velocities such as sucker spp. Increased flows during the egg incubation period would have the added benefit of transporting post-hatch larvae more quickly from the spawning area to suitable rearing habitats. ***This option should be explored in more detail in the WMSC report.***

ii) Selectively remove predators using capture/population control programs, which target species identified as sturgeon predators (e.g. suckers, northern pike minnow and possibly walleye). Such programs have shown low success rates, but a control program for sturgeon could be modeled after similar programs in the US to control predators of downstream migrating salmon smolts.

Research Needs: The research presently being conducted by the USGS (see Hypothesis 4) would likely be sufficient to address questions as to potential predators on egg, larval, and early juvenile life stages of white sturgeon and the relative degree of risk these predators pose to various early life stages. Additional studies are required to determine current velocity responses of predators and effects on habitat, as well as assessing the likely success of predator control measures.

i) Review information on predator efficiencies with respect to sturgeon life history stages through literature review and expert interviews. Predator selected for attention need to be identified. If this proves impossible, further effort on predator control is not likely to be successful. ***This task should be completed in the first year of recovery; it should not await completion of the USGS studies.***

ii) Determine key predator habitats in the study areas through review of data and where necessary field inventory updates. Once the predators are identified, there is a need to determine if they are present in areas of concern during the periods sensitive sturgeon life stages are present. ***The literature review portion of the task can be completed in the year following completion of task i); if field work is needed to determine habitats and additional 1-2 years will be required.***

iii) Assess current velocities necessary to exclude identified predators from key habitat (e.g. bottom habitat for incubating eggs, and mid-water column habitat for larvae) using swimming performance studies. Some data may be available in the literature. ***Initiate task in the 3rd year of recovery; task will require up to 3 years of lab studies depending on the number of species to be assessed.***

iv) Model the probable effects of proposed current velocities on habitat conditions. Need to determine whether velocities may detrimentally effects habitat conditions for sturgeon such as reducing refugia or dispersing larvae away from suitable habitats. ***This task should be conducted concurrently with task iii).***

v) Evaluate the likelihood of successful predator control/removal. Review other predator control programs for success or failure. Develop a control program modeled on those programs shown to be successful. ***This task should require 1 year of effort unless field work is required to determine if selected predators are feeding on sturgeon in the recovery area. If field work is required, up to 3 years of additional work will be necessary.***

1.2.6 HYPOTHESIS 6:

The suitability of early life stage rearing habitats for white sturgeon has been reduced due to factors such as substantial winter draw down regimes in reservoirs or by the introduction and continued presence of toxic or physically abrasive substrates.

Discussion: The typical winter draw down regimes of large storage reservoirs like Arrow Lakes Reservoir and Lake Roosevelt annually expose large areas that have the potential to be used for rearing by early life stages of white sturgeon. Post-hatch larval white sturgeon in the drift phase would likely tend to settle out of the drift in upper areas of the river-reservoir interface zone. In both the Arrow Lakes and Lake Roosevelt, these areas would have been the last to be rewetted during reservoir filling and as such, would likely exhibit the lowest densities of potential invertebrate prey items. If sufficient food is unavailable to young sturgeon during the shift to exogenous feeding, then they would be forced to re-enter the drift and seek more suitable rearing habitats. This would expose these individuals to increased risk of predation and even those young that escaped predation may eventually starve if suitable feeding areas were not found prior to the expenditure of their endogenous food resources.

In Lake Roosevelt, the benthic habitat may also be unsuitable for those invertebrates preferred as sturgeon prey items because of potential high organic or heavy metal contamination of the sediments. Mortality of young sturgeon may also result from the contaminant content of reservoir substrates in suitable rearing habitats. An additional source of larval mortality may arise from the high slag content within reservoir substrates. This material is extremely sharp and angular and young sturgeon that burrow into this material during their hiding phase could experience physical damage to the skin or gill membranes. The presence of this slag may also discourage colonization of the substrate by tube dwelling amphipods, which are a primary food source of young white sturgeon.

Options For Mitigation/Enhancement: Possible options to improve conditions within potential rearing habitats include the maintenance of higher reservoir elevations over the winter. This would allow a greater area of substrate to remain wetted over the winter and increase the chances of young white sturgeon settling into areas with sufficient food resources.

Other options would involve physical modifications to potential rearing habitats.

i) Recontour large historical side- and back-channel habitats in such a way as to ensure long term flooding and/or water retention. This technique may be especially effective in those habitats associated with tributary or groundwater sources of water.

ii) Develop off-channel micro-habitat rearing sites for use by young-of-the-year hatchery sturgeon or as settlement areas for drift larvae from improved spawning habitat. The technique of using off-channel habitats, such as 'catfish ponds', to semi-naturally rear hatchery juveniles has met with some success in the US.

iii) Remove contaminated substrates or cap toxic/abrasive sediments with more suitable substrates. This technique would be applicable in the upper Lake Roosevelt area, but would likely be very costly and would result in significant environmental disturbance.

Research Needs: To develop a rearing habitat restoration or enhancement program the main rearing areas where young sturgeon initially settle out and commence rearing activities need to be defined for both the Arrow Lakes and Columbia River populations. Further a clearer understanding of rearing habitat conditions is required. For example, preliminary research by USGS suggests that the hiding instinct is so strong that if only silt substrate is provided to larval sturgeon during this phase, the larvae will burrow into the substrate and suffocate due to an inability to maintain sufficient water exchange for respiration.

i) Review aerial photographs and maps from pre- and post-impoundment periods to identify likely candidate side- and off-channel sites. Pre- and post-impoundment digitized maps could be overlaid to help identify candidate sites. ***This task***

should be initiated in the first year of recovery and should take 1 year to complete.

ii) Track larval dispersal and juvenile habitat selection patterns to better determine available and suitable rearing locations. This task will require close tracking and monitoring of juvenile cultured sturgeon releases. ***This task will require the release of cultured juveniles; it should be delayed until a suitable release strategy can be arranged and will then require 2-3 years.***

iii) Assess existing conditions (substrate type, contamination, benthic densities and species assemblage) within candidate habitats to determine suitability for restoration/enhancement. Compare conditions to relatively unimpacted rearing areas to determine what changes are required to restore a high level of rearing habitat suitability and availability. ***This task follows completion of task i) and as much of task ii) as feasible; the work will likely start in year 2 of recovery and require 2-3 years.***

iv) Survey and map slag depositional sites, sample particle size/structure and model sediment dynamics in Lake Roosevelt reservoir to better understand the distribution of contaminated sediments at present and in the future and where these overlap with potential rearing sites. ***This task should parallel task iii).***

v) Undertake lab studies to assess habitat and food preferences of juvenile sturgeon. Laboratory studies should be conducted to determine what types of substrates and what types of food items larval sturgeon prefer during their hiding and early rearing phase and whether these substrates and food items are available in the Kettle Falls and Beaton Flats areas. ***This task should follow the early stages of task iii), likely in year 3-4 and should require 2 years to complete.***

vi) Evaluate the effects of contaminants on early life stages of sturgeon. ***The Contaminants Sub-committee should develop this task in more detail. The task could be initiated by year 2 of recovery.***

vii) Select sites, design and implement pilot off-channel pond experiments to test the technique for semi-natural rearing of cultured young-of-the-year sturgeon. ***This task should be initiated in year 4-5 of recovery and is expected to require 2-3 years of effort.***

viii) Evaluate benthic invertebrate recolonization rates in side- and off-channel sites to assess the capability of these habitats to be productive in a hydro-operated system and one expected to support juvenile sturgeon. ***This task will likely follow initial stages of task vii), starting in year 5 and requiring 2-3 years of study.***

ix) Assess the potential for benthic invertebrate culture to provide prey for off-channel habitats. The feasibility of culturing suitable benthos and using these organisms to "re-seed" areas immediately following inundation should be investigated. ***This task should parallel task viii) studies as there is certain amount of overlap in information used***

x) Identify potential sites for removal or capping of toxic or abrasive sediments. If areas of high contaminant concentration are recorded, means to cap or remediate (e.g., through the introduction of organic materials to condition the substrate) these areas should then be investigated. ***This task is viewed as a long-term future target for study.***

2.0 WATER MANAGEMENT

DATE: May 13, 2002

TO: Upper Columbia White Sturgeon Recovery Initiative Recovery Team

FROM: Water Management Sub-committee

RE: ***Recommendations re: water management measures required to support spawning and early life stage survival – Arrow and Transboundary Reach populations***

The purposes of this memo are:

- To propose hypotheses regarding significant impacts of Columbia River flows, reservoir levels and water temperatures on white sturgeon spawning and early life stage survival; and
- To propose recovery measures for investigating these hypotheses and subsequently implementing, as appropriate, flow, reservoir level and water quality management prescriptions required to support, in conjunction with other measures, the recovery of upper Columbia white sturgeon populations.

This memo is provided for the Upper Columbia White Sturgeon Recovery Team to consider incorporating the recommended measures into a draft Recovery Plan for the Upper Columbia White Sturgeon.

There are many other hypotheses regarding anthropogenic (and other) impacts on white sturgeon reproduction and recruitment. A wide range of these were considered during a joint meeting of the Habitat and Water Management Sub-committees in December 2001. The Habitat Sub-committee is addressing a number of the hypotheses in their recommendations; others were deemed to be unlikely to significantly affect sturgeon production.

These hypotheses and related investigations are proposed on the understanding that operational or structural modifications, which may be recommended as a result of these investigations, will be considered in the Upper Columbia White Sturgeon Recovery Initiative, by responsible authorities and other impacted stakeholders with consideration of environmental (including bio-diversity), social and economic benefits and costs. Most investigations proposed include feasibility assessments, which would include cost considerations.

Hypotheses and associated recommendations are presented for two areas where white sturgeon spawning has been observed: (i) the transboundary reach area (Hugh Keenleyside Dam – Roosevelt reservoir; and (ii) the Revelstoke reach – upper Arrow reservoir area.

2.1 TRANSBOUNDARY REACH

White sturgeon spawning events have been observed annually (by means of egg collection) in the Columbia – Pend d'Oreille confluence (Waneta) area since 1993

An experimental Pend d'Oreille flow management program is being implemented pursuant to the review and approval of the Waneta Upgrade Project. This program provides for minimum day- (10,000 cfs) and night-time (5,000 cfs) discharges (subject to water availability) during the sturgeon spawning period to provide for egg dispersal and protection of eggs and larvae from predation. The program also includes five years of sturgeon reproduction and egg incubation monitoring to be conducted in years encompassing low and high flow conditions. Two of the five years of monitoring have been completed, corresponding to medium and high flow conditions.

While white sturgeon spawning events have been observed annually, survival past the larval stage has not been demonstrated through the capture of sub-yearling or yearling white sturgeon. Spawning and pre-spawning behaviour has not been detected in either of two other possible spawning areas: (i) the Brilliant tailrace/lower Kootenay River; or (ii) the Keenleyside tailrace. In consideration of these factors, potential water management manipulations for this area should be focused on increasing early life stage survival downstream of the Columbia – Pend d'Oreille confluence.

2.1.1 Temperature impacts on spawning and early life stage survival

The Habitat Management Sub-committee has developed hypotheses and recommendations with respect to water temperature effects, based on their extensive experience in the area.

2.1.2 Water velocity and turbidity impacts on predation on eggs and larvae

We hypothesize that upstream river regulation has increased water clarity (reduced sediments loads/turbidity) and reduced spring and early summer flows and water velocities in the Columbia River downstream of the Pend d'Oreille confluence and that these changes have increased rates of predation on early white sturgeon life stages.

The lines of evidence which support this hypothesis are as follows:

1. Reduced late spring – early summer flow volumes are a paramount objective of the Columbia River Treaty and Treaty flood control operations. Korman and Walters (1999) shows average and maximum Columbia River discharges for the June 15th – July 20th period for the period from 1938 to 1997, encompassing the pre- and post-impoundment periods.
2. Impoundments typically result in settlement of suspended sediments and reduced downstream suspended sediment and turbidity levels.
3. Gadomski and Parsley (2001) reported on a laboratory study in which predation of white sturgeon yolk-sac larvae by prickly sculpins was significantly higher at low turbidities (0 and 20 NTU) in comparison to high turbidity levels (60 and 180 NTU.)
4. Observed turbidity levels in the Columbia River at Birchbank are typically less than 1 NTU and always less than 5 NTU (Holms, 1999)
5. The observed preference of white sturgeon for spawning in and upstream of areas with high water velocities and/or turbidities (e.g. Parsley *et al*, 1993)
6. . (LH note: I'm not sure that we have the data to support this assumption. It may be more a reflection of a critical turbidity threshold since the successful spawning you refer to occurs in the Columbia River downstream of the Snake River, where turbidity levels are lower than historic levels but still much higher than in upstream areas)

In addition, the proliferation of exotic predators in Roosevelt reservoir and the transboundary reach suggests that predation on white sturgeon eggs and larvae may be a significant recruitment-limiting factor.

2.1.3 Proposed Recovery Measures:

(***1) Evaluate and if appropriate, implement turbidity augmentation to reduce predation on eggs and larvae (Short term).***

(2) Evaluate the feasibility of improving natural recruitment using flow augmentation while minimizing impacts on other uses of basin waters (Short term).

(3) Define flow requirements that promote natural spawning, incubation, rearing, recruitment and survival of Columbia River white sturgeon (Medium term.)

(4) Modify dam operations to achieve flow requirements for natural spawning, incubation, rearing, recruitment and survival of Columbia River white sturgeon in most years. (Medium - long term)

More specifically, he following sequence of investigations is proposed with respect to the above hypothesis:

1. *The results of US Geological Survey studies of the effects of water clarity on predation of sturgeon should be reviewed, and a determination made regarding the need for additional studies (e.g. mesocosm studies). Results from turbidity (or TSS) monitoring in the transboundary reach should be compared to threshold levels suggested from these studies.* **March - June, 2002.**
2. *IF research indicates that turbidity is a significant determinant of predation success on white sturgeon eggs and larvae, and that turbidity levels in the Columbia River downstream of Waneta are generally less than predation-reducing threshold levels, THEN: The feasibility of increasing turbidity above threshold levels through the addition of turbidity-inducing substances (e.g. bentonite) should be investigated. Feasibility investigations should include: quantities required, handling and dispersion, costs and impacts to downstream aquatic communities, and regulatory concerns.* **September, 2002 - March, 2003**
3. *Available literature and information on velocity preferences of likely predators should be reviewed.*
4. *The feasibility of modifying spawning and post-spawning Columbia River flow patterns through the management of Keenleyside (Columbia River), Brilliant (Kootenay River) and Waneta (Pend d'Oreille) discharges should be investigated. The objective of flow pattern modifications would be to maximize flows downstream of the Pend d'Oreille confluence during the spawning and post-spawning period. Consideration should be given to the relative values of short-term (multi-day) peaks vs. longer-term peak flows. Feasibility investigations should include: Columbia River Treaty limitations (and opportunities), other constraints (e.g. Kootenay Lake IJC Order, permits and licences), costs (reduced power revenues), and impacts on other ecosystem components.* **September, 2002 - March, 2003**

5. *Based on consideration of the above feasibility investigations, chose, design and implement either a turbidity or flow augmentation or combined turbidity/velocity experimental program.* **March, 2003 - June, 2004**

It is important to note the regulatory concerns associated with turbidity augmentation, and that strong evidence will be required regarding both turbidity benefits and impacts before regulatory approval can be considered.

2.1.4 Dissolved gas impacts on drift larvae

We hypothesize that increased gas pressures resulting from dam operations (e.g. spill) reduces the survival or rate of normal development of drift larvae. This hypothesis is based on the following lines of evidence:

1. Sustained periods of high (greater than 118% saturation) dissolved gas concentrations in the transboundary reach and in the Pend d'Oreille River plume through the sturgeon spawning and downstream drift periods.
2. Observations of Gas Bubble Trauma (GBT) in larval white sturgeon exposed to water at 118% gas saturation (see appendix 1).
3. The inability of drift larvae to actively sound to reduce the physiological effects of high dissolved gas concentrations, combined with the observation of positive larval buoyancy during a portion of the drift phase.
4. Dissolved gas concentrations in the transboundary reach often exceed 120% during the sturgeon spawning and early life stage period. This compares to dissolved gas levels effectively managed to 115% (forebay) and 120% (tailwater) maxima in the lower Columbia River (downstream of McNary Dam), where successful sturgeon recruitment occurs. (Aquametrix, 1994; Holms, 1999;

2.1.5 Proposed Recovery Measure:

Investigate impacts of high dissolved gas concentrations on larval white sturgeon and continue to implement measures that reduce total gas pressure (Short - long term)

A laboratory investigation is proposed involving exposure of treatment groups of immediate post-hatch larvae to a variety of dissolved gas concentrations greater than 115% saturation and monitoring of larval behaviour and survival.

Significant reductions in dissolved gas concentrations are anticipated from operation of the Arrow Lakes Generating Station and of the proposed Brilliant and Waneta Expansion powerplants. Threshold dissolved gas concentrations determined from laboratory investigations can be compared in the future with Columbia River and Pend d'Oreille dissolved gas concentrations during the spawning and post-spawning periods following start-up of these two projects. Spillway and tailrace modifications may be necessary to further reduce dissolved gas concentrations. There may be opportunities to pursue these modifications both at Canadian and US (Pend d'Oreille) facilities.

2.1.6 Dewatering of rearing habitats

It is possible that juvenile white sturgeon may be killed or have insufficient food organisms as a result of rearing habitat dewatering caused by Lake Roosevelt winter drawdowns.

2.1.7 Proposed Recovery Measure:

Assess impacts of reservoir operations on white sturgeon early life stages (Medium term)

Initially, these possibilities should be investigated by: (i) reviewing available literature on depth and habitat preferences of sub-yearling white sturgeon; (ii) determining habitat preferences of sub-yearling white sturgeon, through laboratory and possibly subsequent mesocosm/enclosure studies. 2003 – 2005

2.2 REVELSTOKE REACH – UPPER ARROW RESERVOIR

There are a number of hypotheses about potential anthropogenic impacts on white sturgeon spawning, egg incubation and larval development in the Revelstoke Reach – Upper Arrow reservoir area. There are two immediate problems, which will make investigation of these impacts challenging:

1. The lack of consistent, year-to-year spawning events which is probably a result of: (i) a small population size of female sturgeon; and (ii) marginal water temperature conditions for the promotion of spermatogenesis, vitellogenesis and spawning;
2. The problem of detecting successful egg and larval survival (including to the yearling or sub-yearling stage) even when spawning events have occurred. This problem is related to: (i) small numbers of larvae potentially distributed over a large area; and (ii) lack of methods for capturing sub-yearling (and possibly yearling) white sturgeon from the Revelstoke Reach – Upper Arrow reservoir area.

These two problems have to be addressed – that is, we need to be able to consistently produce large numbers of eggs or larvae in the Revelstoke reach (including through hatchery releases), and we need to develop effective methods for detecting egg and larval survival – before water management experiments in support of egg and larval survival can be designed and considered.

2.2.1 Temperature impacts on spawning and early life stage survival

We hypothesize that ‘Regulation of the Columbia River has decreased water temperatures prior to and during the spawning season; this has affected spawn timing and survival of eggs and larval stages.’ (RL&L, 2001). This hypothesis is based on the following observations:

- Water temperatures in the Columbia River downstream of Revelstoke dam during white sturgeon spawning events in recent years have been much lower (approx. 10 ^{0} C.) than optimum and preferred spawning temperatures observed elsewhere in the Columbia River system (see appendix 1);
- White sturgeon spawning events in the Revelstoke reach have occurred in late July and August, significantly later than in other white sturgeon spawning locations in the Columbia, Kootenay and Fraser. This may be a result of the slow rate of water temperature increase in the Revelstoke reach not triggering final maturation of gonadal materials and spawning at a more typical time;

- Water temperature appears to be a significant spawning cue for white sturgeon – either the rate of temperature increase or exceedance of a specific water temperature (e.g. 14 ^{0} C.);
- Water is withdrawn from both Mica and Revelstoke reservoirs from hypolimnetic structures, with the result that summer downstream water temperatures are cooler than corresponding reservoir surface temperatures;
- Abnormal and delayed egg and larval development has been observed to occur at low water temperatures.
- It is important to note, however, that existing evidence indicates that the present thermograph is not highly dissimilar from the historic thermograph (McAdam, 2002).

2.2.2 Proposed Recovery Measure:

Assess impacts of low water temperatures on spawning and early life stage survival and if necessary, increase summer water temperatures in the Revelstoke Reach (Short - long term)

The following sequence of investigations is recommended

1. *The current program of monitoring water temperatures and spawning activity (with egg collection mats) in the upper Revelstoke reach must be continued;* **Ongoing**
2. *Determine if pre-impoundment summer water temperature conditions in the Revelstoke reach were measurably warmer than current conditions. This will involve analysis of available temperature data to determine if the relationship between upstream (of Kinbasket reservoir) and downstream (of Revelstoke dam) temperatures has been changed by the creation of the Kinbasket and Revelstoke reservoirs* **May – July, 2002**.
3. *Determine, through a literature review and laboratory (hatchery) research projects, if low water temperatures increase rates of abnormal embryonic and larval development and larval mortality, and/or if low rates of water temperature increase impede spermatogenesis and vitellogenesis.* **July, 2002 – March, 2003**

If pre-impoundment summer water temperature conditions in the Revelstoke reach were measurably warmer than current conditions, and if low water temperatures result in high rates of larval mortality or low rates of water temperature increase result in reduced sperm or egg production and/or viability, then a study of the feasibility of constructing and operating selective depth withdrawal structures at Mica and Revelstoke dams should be undertaken. This study should assess engineering feasibility, capital and operating costs and water temperature benefits. **Conditional: September, 2003 – December, 2004**

2.2.3 Water velocity and turbidity impacts on predation on eggs and larvae

We hypothesize that upstream river regulation has increased water clarity (reduced sediments loads/turbidity) and reduced spring and early summer flows and water velocities in the Revelstoke reach and that these changes have increased rates of predation on early white sturgeon life stages.

The lines of evidence outlined for this hypothesis for the transboundary reach also apply to the Revelstoke reach area.

This hypothesis is a priority for investigation in the transboundary reach, where population size and environmental conditions provide for more consistent year-to-year spawning and more spawning events per year. The results from the investigations proposed for the transboundary reach should be considered in planning for further investigations of this hypothesis in the Revelstoke reach.

2.2.4 Reservoir elevation impacts on larval transport/fry settlement

We hypothesize that high Arrow reservoir levels in some years may impair transport of drift-phase larvae to suitable rearing habitats. This hypothesis is based on two lines of evidence:

1. The Arrow population was probably supported historically (pre-impoundment) by spawning upstream of Arrow Lake with drift larvae transported downstream to suitable rearing habitats in the complex river habitats downstream of Revelstoke; and
2. For many sturgeon populations, high velocity conditions appear important for dispersal of eggs and drift larvae (see appendix 1).

This hypothesis can also be considered for further investigation pending consistent spawning and/or ability to detect larval survival. One possible research project involves releasing hatchery-produced juveniles into the Revelstoke reach at progressively decreasing ages from year to year in an attempt to determine survival bottlenecks.

2.2.5 Load-shaping impacts on sturgeon spawning, egg stranding and larval transport

In some years, Revelstoke generating capacity may be being used for load factoring operations during the sturgeon spawning period, with the result that flows are reduced, in some cases to zero powerplant discharge, during the evening and maintained at these levels through the night.

We propose a series of hypotheses regarding Revelstoke Generating Station load-shaping impacts:

- That zero or low discharge events delay or inhibit spawning;
- That zero or low discharge events increase the ability of predators to locate and prey upon drift larvae;
- That zero or low discharge events result in stranding and desiccation of eggs; and
- That evening flow reductions may reduce effective transport of post-hatch larvae to suitable rearing areas. This hypothesis is based simply on the observation that hatching of drift larvae typically occurs during night-time (Hildebrand, pers. comm.)

2.2.6 Proposed Recovery Measure:

Evaluate restrictions on Revelstoke Generating Station daily load shaping operations to reduce impacts on white sturgeon early life stages (Short - medium term)

With respect to the first and second hypotheses, we recommend a review of the Russian (and other) literature. **September – December, 2002**

With respect to the third hypothesis, we recommend a research project involving deployment of egg collection mats at a variety of depth intervals to determine the vertical distribution of eggs under varying discharge conditions. **April – December, 2003**

The fourth hypotheses can also be considered for further investigation pending development of consistent spawning and/or ability to detect larval survival.

2.3 SUMMARY

Within the transboundary reach, we recommend the following priorities:

1. Investigations proposed with respect to dissolved gas impacts on drift larvae;
2. The sequence of investigations proposed regarding velocity and turbidity impacts on predation on eggs and larvae.

For the Revelstoke reach, we recommend the following investigations in order of priority:

1. The sequence of investigations proposed with respect to temperature impacts on spawning and early life stage survival; and
2. Investigations regarding load-shaping impacts on spawning and egg stranding.

2.4 LITERATURE REVIEW

This appendix summarizes information from the scientific literature regarding water velocities and associated water quality parameters for successful spawning and early life stage survival (1 mo.) of white sturgeon. It also summarizes information on depth and substrate requirements associated with spawning water velocities. In preparing this information review, the Water Management Sub-committee (of the Upper Columbia White Sturgeon Recovery Team) recognizes that it is likely that a wide diversity of factors are affecting white sturgeon production, and that this review is limited, by the sub-committees terms of reference, to water level, flow and quality effects. It is anticipated that all factors that potentially limit or affect white sturgeon production will be considered by the Recovery Team in the development of a Recovery Plan.

2.4.1 Background

In general, white sturgeon broadcast spawn in the spring or early summer. The first month post-spawning includes: (i) immediate post-spawning dispersion, settlement and adhesion of eggs to bottom substrates; (ii) incubation of eggs on the river bottom from the time of egg settlement to hatch; (iii) hatching and further downstream dispersal of larval sturgeon to benthic feeding habitats. This information review, in accordance with the terms of reference of the committee, deals with the stages of spawning through hatch and downstream dispersal of larvae.

2.4.2 Water velocity – spawning

High water velocities during the spawning period may be needed to provide immediate post-spawning dispersion of fertilized sturgeon eggs and to promote final stages of gamete development and release. Egg dispersal may also be related to total discharge (volume/time) as opposed to or in addition to velocity.

There are only 3 independent, comprehensive sets of observations of water velocities associated with successful sturgeon spawning within the range of white sturgeon:

- Research in the lower Columbia (downstream of McNary Dam), in both riverine reaches and impoundments (Parsley, Beckman and McCabe, 1993) between 1985 and 1991 indicates that: (i) spawning occurred in water velocities (mean column) between 1.0 and 2.8 m/sec. in riverine sections (mean 2.1); (ii) spawning occurred in water velocities between 0.8 and 2.1 m./sec. in impoundment sections; (iii) spawning was generally more successful in higher velocity habitats in riverine reaches; (iv) more sturgeon eggs are collected during years of average river discharge than during years of low river discharge. The investigators concluded by recommending flows in sturgeon spawning habitats greater than 1.7 m./sec. in order to support sturgeon spawning.
- Research in the lower Fraser River (Perrin, Heaton and Laynes, 2000) in 1999 observed sturgeon spawning in habitats with flows of between 0.5 and 2.2 m./sec. It should be noted that turbidity levels in the lower Fraser River are substantially higher than those normally observed in spawning areas in the upper Columbia.
- Research in the Kootenai River downstream of Libby Dam in the US (Paragamian, Kruse and Wakkinen, *in press*) indicates that, between 1991 and 1998, sturgeon spawning occurred at (mean column) water velocities between 0.19 and 0.83 m./sec. However, Paragamian (1997) reports that the low velocities at which sturgeon spawning has been observed in the Kootenay River are likely to be less than optimal spawning velocities.

In addition, (Parsley et al, 2000) proposed the following relationship between sturgeon spawning habitat suitability and water velocity based on lower Columbia observations:

- Suitability of 0 below 0.7 m./sec.;
- Linear increase in suitability from 0 at 0.7 m./sec. to 1 at 1.8 m./sec.
- Suitability of 1 from 1.8 to at least 3.0 m./sec.

R.L&L (1996), in reviewing available information on sturgeon spawning requirements, recommended water velocities of greater than 1.5 m./sec. to provide for sturgeon spawning. RL&L (1997) also summarized four years of sturgeon egg collection and noted that the number of eggs collected in 1996 was '…the highest recorded since use of this technique was initiated in 1993' and that 1996 was the '…highest water year in which spawning investigations have been conducted.' The report shows a strong relationship between annual peak discharges from the Waneta Dam and sturgeon egg catch rates (eggs/24 hr.) at a specific sampling site and at all sites combined. However, this relationship may reflect benefits of higher flows for eggs and larvae (increased egg dispersion and reduced predation), rather than preferred conditions for spawning. It is important to note in this respect that this observation pertains to discharge as opposed to water velocity, and that the relationship between discharge and mean velocity is generally not linear.

2.4.3 Water velocity – incubation

Near substrate water velocity may be an important determinant of incubation survival as high velocities may reduce the impact of predation on incubating eggs. Near substrate is defined as within 20 cm. of the bottom.

There are four sets of observations of white sturgeon incubation conditions, of which one is from the Kootenai River. The Kootenai River observations should not be considered because only very low levels of juvenile recruitment from Kootenai River spawning events have been observed, and that these levels are inadequate to support the population.

- Near substrate velocities of between 0.06 and 2.4 m./sec. in riverine habitats with successful egg incubation in the lower Columbia River (Parsley *et al*, 1993);
- Near substrate velocities of between 0.52 and 1.62 m./sec. in impoundment habitats with successful egg incubation in the lower Columbia River (Parsley *et al,* 1993)
- Near substrate velocities of between 0.03 and 1.75 m./sec. in areas from which incubating eggs were collected in the Columbia – Pend d'Oreille confluence area (RL&L, 1997.)

With respect to the lower Columbia observations, the authors note high egg mortalities in impoundments but not in free-flowing reaches. Foster et al (2001) suggest a possible link between pollutant accumulations in impoundments and poor white sturgeon reproductive success.

The data indicate that viable eggs are found with near substrate water velocities ranging between 0.03 and 2.4 m./sec However, this does not mean that egg survival is high through the entire range of observed water velocities. There is inadequate data to draw conclusions with respect to water velocities required for acceptable incubation survival rates. This is an important area of uncertainty.

2.4.4 Water velocity – larval development

Water velocity may be an important factor in controlling transport and dispersion of larvae to suitable benthic habitats. It is likely that the relationship between water velocity and successful larval transport to suitable rearing areas is site-specific, determined by the distance between incubation and rearing areas. Only one investigation has reported on observations of water velocities in areas supporting larval development and dispersal (Parsley *et al*, 1993). In this study:

- Mean column velocities ranged from 0.7 to 2.7 m./sec. (mean 2.7 m./sec.) in the lower river study area in the lower Columbia River;
- Mean column velocities ranged from 0.41 to 2.1 m./sec. (mean 1.2 m./sec.) in impounded reaches of the lower Columbia River.

2.4.5 Temperature – spawning

Suitable water temperatures may be important for final maturation of white sturgeon oocytes and sperm and fertilization (as well as dispersal and larval development.) There are many observations of water temperatures during spawning events, as summarized in the following table:

Observed range (^{o} C.)	Preferred (^{o} C.)[1]	Years	Location	Reference
12 – 20	13 – 14	87 – 91	L. Columbia impoundments	Anders and Beckman, 1993
10 – 18	14		L. Columbia – lower river	Parsley *et al*, 1993.
12.5 – 15.5		97	L. Fraser	RL&L, 1998
8 – 22	10 – 17	98	L. Fraser	Perrin *et al*, 1999
11.3 – 18.4	Not determined	99	L. Fraser	Perrin *et al*, 2000
15.5 – 17	Not determined	93	Col.-Pend d'Oreille confluence	Hildebrand and Mckenzie, 1994
14.5 – 19	Not determined	94	Col.-Pend d'Oreille confluence	RL&L, 1995
14 – 17	14 threshold	95	Col.-Pend d'Oreille confluence	RL&L, 1996
14 – 15	(mean daily)	96	Col.-Pend d'Oreille confluence	RL&L, 1997
16.8 – 21.5	Not determined	98	Col.-Pend d'Oreille confluence	RL&L, 1999

2.4.6 Temperature – incubation

Water temperatures control the rate (and thereby duration) of egg incubation and high water temperatures (> 18 ^{0} C.) are thought to cause high rates of abnormal development. Water temperature measurements during egg incubation have been made in the Kootenai River, the lower Columbia, the upper Columbia and in lab studies. We do not include the Kootenay River results in this review as successful recruitment from spawning events in this system has not been demonstrated.

10 – 18	87 – 91	Lower Columbia riverine sections	Parsley *et al*, 1993
12 – 18	87 – 91	Lower Columbia impoundment sections	Parsley *et al*, 1993
14 – 20.3	96	Col.-Pend d'Oreille confluence	RL&L, 1997

[1] Preferred means the temperature range in which most spawning occurred

In addition, RL&L (1997) reported on an experiment in which wild-caught eggs were incubated *in situ* in capsules. The experiment showed generally higher rates of egg mortality and lower hatch success for eggs incubated at temperatures exceeding 18 ^{0}C.

Wang *et al* (1985) reported on laboratory experiments with white sturgeon collected from San Francisco Bay in which: (i) successful incubation was observed from 10 to 18 ^{0}C; (ii) the optimum temperature range for incubation was between 14 and 16 ^{0}C; (iii) temperatures in excess of 18 ^{0}C caused substantial abnormalities; and (iv) temperatures below 14 ^{0}C. extended incubation and hatching times, but did not result in developmental abnormalities.

2.4.7 Temperature – larval development

There have been no significant observations of temperatures required to sustain larval development and dispersal.

2.4.8 Water depth – spawning

Deep, high velocity water is thought to be important for sturgeon spawning in order to maximize dispersion of fertilized eggs. The following is a summary of spawning water depth observations:

- 3 – 5 m. in the Pend d'Oreille – Columbia River confluence area (RL&L, 1996)
- 4.5 – 25 m. in the lower Columbia (Parsley and Beckman, 1994)
- 2 – 24 m. in the lower Fraser River in 1998 (Perrin et al, 1999)
- 0.5 – 6.5 m. in the lower Fraser River in 1999 (Perrin et al, 2000)

Parsley and Beckman (1994) propose a relationship between suitability for spawning and depth as follows:

- 0 suitability at depths of 2 m. or less;
- Linear increase in suitability from 0 at 2 m. to 1 at 4 m.;
- Suitability of 1 for all depths from 4 to at least 25 m.

In view of the substantial differences between these observations, it is likely that water depth may not be a determinant of egg or larval survival.

2.4.9 Total Gas Pressure (TGP) – spawning, incubation and larval development

There are few observations regarding the relationship between spawning behaviour and success and early life stage survival and TGP. One study (Brannon *et al*, 1985) includes the observation that 'gas supersaturation is more critical for sturgeon than salmonids'. Another (Shrimpton *et al*, 1993) notes that sturgeon are likely to be most susceptible to Gas Bubble Trauma (GBT) during the planktonic, post-hatch life history stage. During this stage, the larvae swim up into the water column and may be present near the surface where hydrostatic pressure is low and will not compensate for excess TGP. Counihan *et al*, observed GBT in larval sturgeon at 118% TGP. Larvae exposed to 118% TGP for 10 days did not exhibit mortalities but at 131% TGP, 50% mortality occurred after 13 days exposure. The authors concluded that the observed signs of GBT resulted in positive buoyancy and alterations in behaviour that may affect the dispersal and predation vulnerability of white sturgeon larvae.

Parsley (2000) reported on a lab experiment in which 1 to 2 day old white sturgeon displayed signs of GBT following a 15 min. exposure to 118% TGP.

TGP levels in the Columbia River downstream of the Keenleyside dam can be above the BC guideline (110%) and the threshold for gas bubble formation (118%) for significant periods of time through the sturgeon spawning and incubation period. For example, even with projected TGP benefits of the Keenleyside and Brilliant Expansion powerplants, simulated TGP levels in the Columbia River at Birchbank exceeded the GBT threshold for between 0 and 80 days per year for the modeled years from 1991 to 1999 (Aspen, 2000.) These exceedances generally occurred between June and September. White sturgeon drift larvae can also be exposed to high TGP levels (up to 138%) in the Pend d'Oreille plume where it enters the Columbia River.

High TGP levels in the transboundary reach may impact on sturgeon larvae **if** they utilize surface waters above the compensation depth. Laboratory or larval cage studies of this potential impact should be pursued as a matter of priority.

2.4.10 Turbidity – spawning, incubation and larval development

High turbidity may benefit sturgeon eggs and larvae by reducing predation. Gadomski and Parsley (2001) reported on preliminary results of laboratory investigations of the effects of turbidity on predation of white sturgeon yolk-sac larvae (1 – 2 wk. old) by prickly sculpins *Cottus asper*. Predation was significantly higher at lower turbidities, 0 and 20 NTU, with prickly sculpins ingesting means of 30 and 23 larvae per trial, respectively. At turbidities of both 60 and 180 NTU, means of 18 larvae per trial were eaten.

The following summarizes observations of turbidity levels in areas where sturgeon spawning and incubation have occurred:

- 6 to 92 NTU in sturgeon spawning areas in the lower Fraser River in 1999 (Perrin *et al,* 2000)
- 2.2 to 11.5 NTU in areas with incubating sturgeon eggs in the lower Columbia River (McCabe and Tracy, 1993.)

Ktunaxa elders report (Bill Green, *pers. comm.)* that they historically observed sturgeon spawning in high turbidity (as opposed to high velocity) environments, including the Columbia River in the Spillimacheen area and in the Kootenai River near Bonners Ferry.

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3.0CONTAMINANTS

Upper Columbia River White Sturgeon

Toxicology Assessment

Prepared for:

Upper Columbia River White Sturgeon Recovery Team

Prepared by:

Sturgeon Contaminants Working Group

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3.1 EXECUTIVE SUMMARY

White sturgeon (Acipenser transmontanus) were designated as vulnerable in 1990 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The upper Columbia River population in British Columbia was assigned to the provincial Red List in 1993 based on a BC Conservation Data Centre (CDC) status review that described the species as "critically imperilled (RL&L Golder, 2002). This population now consists of several known or suspected sub-populations that were isolated from each other and from historical critical habitats by dam construction. Collectively, these sub-populations are considered distinct from other populations in the Columbia River basin and in other western river systems.

Natural recruitment is essentially non-existent for upper Columbia River white sturgeon and an aging cohort of mature fish is gradually declining as fish die. Only the longevity of this species and complete fishery closures have forestalled extinction, which will be inevitable without effective intervention (RL&L Golder,2002).

Multiple stressors have been identified as potential limiting factors impacting white sturgeon recruitment and population perpetuation in the upper Columbia River (RL&L Golder, 2002). The identified stressors include: 1) exploitation and incidental catch, 2) habitat alterations related to construction and operation of dams and reservoirs, channelization, contaminants, timber harvest and agriculture and 3) changes in fish species composition potentially resulting in increased predation and/or decreased nutrient production.

In spite of known sources of pollutants, there is little information on bioaccumulation and the physiological effects of environmental contaminants on reproductive and immune function in white sturgeon. Since pollution has been cited second only to habitat loss as a cause of endangerment for aquatic organisms and the recovery of the sturgeon population in this stretch of the upper Columbia River is critical, contaminant effects should be examined to determine if exposure is potentially contributing to declining population numbers (through reduced survival, growth, reproductive and immune function).

The study associated with this proposal is designed to begin addressing the potential effects of environmental contaminants on upper Columbia River white sturgeon. The Sturgeon Contaminants Working Group has been identified as the group to carry this charge. Members of this group have been extensively involved with management and assessment of the effects of environmental contaminants on sturgeon populations throughout the Columbia River basin. The information gathered from the proposed study will be used to begin answering the question about the degree to which environmental contaminants are impacting the sturgeon and how we can use this information to make management decisions to improve white sturgeon recruitment.

3.2 BACKGROUND AND NEEDS

Natural recruitment of white sturgeon is essentially non-existent for all of the sub-populations in the upper Columbia River and population numbers are declining as the older cohort of fish die (RL&L Golder,2002). Multiple stressors have been identified by the Upper Columbia White Sturgeon Recovery Initiative (UCRWSRI) as potential limiting factors impacting white sturgeon recruitment and population perpetuation in the upper Columbia River (RL&L Golder, 2002). The identified stressors include: 1) exploitation and incidental catch, 2) habitat alterations related to construction and operation of dams and reservoirs, channelization, contaminants, timber harvest and agriculture 3) changes in fish species composition potentially resulting in increased predation and/or decreased nutrient production.

Since pollution has been cited second only to habitat loss as a cause of endangerment for aquatic organisms (Wilcove et al. 1998) and the recovery of the sturgeon in the upper Columbia River is critical, contaminant effects should be examined to determine if exposure is potentially contributing to declining population numbers (through reduced survival, growth, reproductive and immune function).

The Sturgeon Contaminants Working Group (SCWG) was formed as a technical sub-committee to assist the Upper Columbia White Sturgeon Recovery Team with addressing this subject.

The SWCG is a collaboration of researchers and managers from throughout the Columbia River basin (Appendix 1). Members of this group have been extensively involved with management and assessment of the effects of environmental contaminants on sturgeon populations throughout the basin. The information gathered from the proposed study will be used to begin answering the question about the degree to which environmental contaminants are impacting the sturgeon (and potentially other aquatic organisms in the upper Columbia River through the food chain and other forms of environmental exposure) and how we can use this information to make management decisions to improve white sturgeon recruitment.

The Upper Columbia River between the Hugh Keenleyside Dam at Castlegar and downstream to the U.S. border has several point sources of environmental contaminants (AQUAMETRIX 1994 1994). Historic and current industrial activity and residential development on the river have contributed metals (lead, zinc, copper, cadmium, arsenic, thallium and mercury) and a myriad of organic compounds (endocrine disrupting compounds or EDCs, dioxins, furans, resin and fatty acids, chlorinated phenols, PCBs PAHs, and polybrominated diphenyl ethers (PBDEs)) to water and/or sediments. These compounds are potentially bioavailable to fish and other aquatic fauna.

In spite of known contaminant sources, there is very little information on bioaccumulation and physiological the effects of contaminants in Upper Columbia River and Lake Roosevelt sturgeon. There are two treated sewage discharges to the Columbia River, one at Castlegar and another just south of Trail, British Columbia. Celgar Pulp Company in Castlegar discharges secondarily treated pulp mill waste into the Columbia River just downstream of the Hugh Keenleyside Dam. Teck Cominco operations discharge waste and cooling water from their lead/zinc smelter and fertilizer plant into the Columbia River just above Trail.

Tissue levels of dioxin and furan in sturgeon were examined by the Washington Department of Ecology in 1990 (Johnson et al. 1991), and there was limited contaminant data gathered in 1994 on upper Columbia River sturgeon mortalities (Bonnie Antcliffe, unpublished data). However, there has been no substantial assessment of contaminant effects on this imperilled species in the upper Columbia River.

Uptake of and effects from contaminants will vary depending on the type, duration and nature of exposure as well as the life stage fish are exposed (Heath 1994). Exposure at the egg and sperm stage occurs through parental burden. However, in addition to the inherited parental burden, the embryonic and larval phases may also be exposed to contaminants in water, sediment, sediment pore water, suspended sediments and food (i.e. plankton, periphyton and other sentinel fish species). Therefore, it is important to consider contaminant levels in these media as well as levels in sturgeon tissues. Effects can vary from acute (lethal; immediate) to chronic (sublethal; life-long effects). Although acute effects will have an immediate population effect, chronic effects may manifest themselves over time and throughout several generations, potentially altering an organisms behaviour, genetics, reproduction and general ability to function in a "normal" manner (Rand 1995).

The short-term objectives of the SCWG and the study associated with this proposal are to: 1) summarize available historic information about contaminant effects, levels and input to the Upper Columbia River, 2) develop a biomarker-based (non-lethal) study to assess bioaccumulation and potential chronic effects of existing environmental contaminants on Upper Columbia River white sturgeon, 3) assess bioaccumulation and potential chronic effects of existing environmental contaminants on Upper Columbia River white sturgeon, 4) conduct a genotoxicity assessment of Upper Columbia River white sturgeon. These objectives will be achieved through a multi-year, phased-in type of investigation that will use new technology and existing methods (used elsewhere in the Columbia River basin). Contaminant effects on white sturgeon will be examined along with the possible contribution contaminants might have, in combination with other environmental stressors, on the lack of sturgeon recruitment and survival.

Understanding the role of contaminants and how they affect sturgeon will be critical for long-term management of and mitigative actions for sturgeon populations in the Columbia River. Although not previously considered in the management arena, contaminants may be adversely affecting reproduction, development and growth of sturgeon. Therefore, long-term objectives of the SCWG include the development of a program for monitoring contaminant levels and effects on sturgeon and the provision of management recommendations (pertaining to environmental contaminants) to assist with recovery of the upper Columbia River white sturgeon. The information from this study will provide sturgeon resource managers with the tools to make adaptive management decisions pertaining to contaminants in the upper Columbia River.

3.3 METHODOLOGY, BUDGET AND DELIVERABLES

When coupled with other physical habitat alterations, the introduction of xenobiotic compounds or environmental contaminants into aquatic systems may increase stress and negatively impact reproductive processes, viability, survival, growth and development of aquatic organisms (Bickham et al. 1998; Hall et al. 1989; Saunders 1969). The white sturgeon, a long-lived, late-maturing, bottom-dwelling species that represents the end of the food chain within its habitat (Dettlaf et al. 1993) is therefore highly susceptible to exposure and bioaccumulation of contaminants. Physiological biomarker research is an effective method for determining contaminant effects in aquatic ecosystems and in most cases can be conducted without the excessive mortality associated with standard chronic and acute mortality tests (Ward 1998). This approach incorporates tissue and environmental contaminant residue information as well as laboratory testing with measurements of physiological functions in organisms.

Prior to collecting samples for contaminant analysis, existing data and potential sources of contaminants will be assessed to narrow the scope of analysis. In addition to contaminant levels in media and tissues, measurement of non-lethal physiological indicators of exposure and stress in the various life stages will be assessed. Several physiological indicators that can be measured include: 1) fertility, sperm motility and viability, 2) fecundity and egg size, 3) growth and development, 4) survival, 5) behaviour, 6) hormone, protein and enzyme levels and production, 7) physical appearance and organ development, 8) genetic attributes, 9) diseases and disease tolerances, 10) time to embryonic hatch, 11) mortality associated with initiation to feeding, and 12) sexual dimorphism (Ward et al. 1998). Many of these physiological indicators or biomarkers can be measured in-situ or in a laboratory setting. However, a combination of both in-situ and laboratory studies is most desirable. Coupled with this, new techniques are becoming available that will allow us to understand and link a known physiological effect at the genetic level with contaminant exposure.

This study will incorporate program reassessment and new technology with as many of the above-mentioned biomarker measurements as possible throughout the multi-year study. However, the initial scope will be narrowed to fit an available budget. Presently the SWCG has approximately 50K (US funds) available from various matching sources for 2002. The following proposed initial tasks associated with objectives are also summarized in Table 1.

3.3.1 Objective 1

Summarize available historic information about contaminant effects, levels and input into the upper Columbia River

Task 1: Gather existing data on contaminant levels in aquatic media.

An overview of recent contaminant data in water, sediment and tissues (fish and other aquatic organisms) collected in the reaches between the Lower Arrow Lake and Coulee Dam will be conducted. Much of this data exists in individual reports and some has already been summarized. However, the data will be put into one concise document with recommendations as to what contaminants are present and appropriate for further study in sturgeon. Data gaps will be identified where applicable.

Task 2: Gather existing data describing contaminant levels in upper Columbia River white sturgeon.

Contaminant data pertaining to upper Columbia River sturgeon will be summarized and compared with available data from other populations throughout the Pacific NW and the world.

Lead: Julia Beatty (task to be contracted out)

Timing: To start immediately, completion March 2002.

Cost: 2K (US funds)

Deliverables: Study Proposal, Summary of existing information

3.3.2 Objective 2

Develop a biomarker-based (non-lethal) study to assess bioaccumulation and potential chronic effects of existing environmental contaminants on upper Columbia River white sturgeon

Task 1: Gather existing information specific to in-situ and laboratory studies on effects of environmental contaminants on white sturgeon or other sturgeon species

Data will be summarized and recommendations made regarding methods, sample preparation, preservation and handling to ensure the data is comparable with other suitable study results (e.g. Lower Columbia, Kootenai or Fraser rivers). Development of a study design specifically targeted at contaminant issues on the Columbia River associated with industrial activities in the region (heavy metals from mining and smelting and persistent organic compounds from pulp and paper mills).

Lead: Julia Beatty (task to be contracted out)

Timing: To start immediately, completion March 2002.

Cost: 3K (US funds)

Deliverables: Study proposal and presentation for funding solicitation

3.3.3 Objective 3

Assess bioaccumulation and potential chronic effects of existing environmental contaminants on Upper Columbia River white sturgeon

This objective will target the implementation of a contaminant and toxicology assessment on upper Columbia River (and Lake Roosevelt) sturgeon. Assessment of liver tissues could be an integral part of this study, so the first task will include determination of the feasibility for non-lethal liver biopsies. Non-lethal methods and hatchery-reared fish (where feasible) will be used to assess contaminant levels in various tissues (gonadal, muscle, liver and blood). Assessment of other health factors will incorporate samples taken from brood stock and hatchery fish or sturgeon from other recruitment assessment studies. Where necessary, concurrent sediment, periphyton, suspended sediment analysis will also be conducted. Most of the cost will be associated with laboratory analyses of heavy metals, mercury, dioxins, furans, PCBs and PAHs in tissues.

Task 1: Conduct a laboratory assessment of sturgeon survival following liver biopsy.

There is a need to assess the effect of taking a 1, 5 and 10 gram sample of sturgeon liver on the survivability of individual sturgeon at various size/age classes. This work will be conducted prior to any "non-lethal" sampling of wild sturgeon populations to assess contaminant levels.

Lead: Molly Webb and Gretchen Kruse

Timing: 2002

Cost: 5K (US funds; match from Oregon State University and Kootenai Tribe of Idaho)

Deliverables: Annual and final report to UCRWSRT including management recommendations, Refinement of methodology, Publication and scientific contribution

Task 2: Conduct non-lethal sampling of adult and juvenile sturgeon

The SCWG will conduct the following analyses on wild sturgeon stocks captured in the upper Columbia River during brood stock collection and data gathering (e.g. disease screening). Analyses completed during year-1 will depend on available funding. Liver, gonad and whole-body tissue will also be collected from wild adult or juvenile sturgeon mortalities (when feasible).

Lead: Molly Webb, Gretchen Kruse

Timing: Beginning in the summer of 2002

Cost: 70K (US funds)

Deliverables: Annual and final reports to UCRWSRT including management recommendations, Publication and scientific contribution

Sub-task 2.1) Collect and assess blood plasma parameters

Blood plasma will be collected from the ventral caudal fin to assess levels of reproductive hormones (a progestin, 17β-estradiol, 11-ketotestosterone and testosterone), vitellogenin (yolk precursor protein), and stress hormones/proteins (cortisol, cholinesterase, acetyl AChE, glucose, lactate). These parameters will be measured along with other blood plasma indicators (triglycerides, total plasma calcium) to detect potential disruption of normal endocrine processes.

Sub-task 2.2) Collect skin mucous

Lectin, a mucous protein linked with immune function, will be measured concurrently with other blood plasma and tissue assessments. Measurement of lectin will provide information about innate immune function.

Sub-task 2.3) Collect gonad tissue

Gonad tissue (sperm, ovarian tissue, eggs and embryos) will be collected for histopathology, and contaminant analysis (metals, PCB congeners and total organochlorines, PCDD/PCDF, and other compounds based on 2001 sediment analysis results from upper Columbia and Kootenay rivers). Number of eggs per ml, hatching rate, embryo survival, mortality at initiation to feeding and growth, and analyses to look at the correlation with parental and embryo contaminant load will also be assessed pending available funds.

Sub-task 2.4) Collect liver tissue samples for histopathology

Completion of this task will depend on the outcome of Task 1. Hatchery reared and released as well as wild sturgeon liver tissues will be biopsied over the summer of 2002 at key locations in the upper Columbia River. Tissues will be analyzed to assess histology (% lymphocytes, eosinophils, macrophage aggregates, gross lesions), detoxifying proteins and monooxygenases (P-450's – EROD and AHH, MFO, metallothionein) as well as contaminant concentrations (in pooled liver samples).

Sub-task 2.5) Record and assess other concurrent and pertinent data

Other data that is collected on fish captured through brood stock collection (ie. age, length, weight, condition factor etc.) will be important to overall assessment of sturgeon health.

3.3.4 Objective 4

Develop genetic monitoring techniques for white sturgeon

Task 1: Develop a sturgeon cDNA microarray that will aid in determining possible stressors to the population.

As a first step, one naturally spawned hatchery sturgeon from the upper Columbia River will be used to begin to build a database of functional sturgeon gene sequences for genes that are affected by contaminants. Genes to be sequenced include: vitellogenin, metallothoinein, key hormones and enzymes, and stress-related factors. This preliminary gene sequencing from sturgeon liver will form the basis for further assessment to build a microarray (DNA chip). These new genotoxicity techniques are now available through, and would be conducted at, the federal Environment Canada Pacific Environmental Science Centre (PESC) Laboratory in North Vancouver. This work would be carried out jointly by Graham vanAggelen, Heather Booth, Joy Bruno at PESC and Dr. Matt Vijayan at the University of Waterloo.

Task 2: Using the cDNA microarray, assess the effects of contaminants and contaminant mixtures on wild and hatchery reared sturgeon.

Early life stage bioassay (approximately 65-day egg-alevin-fry) conducted at the PESC laboratory, or in conjunction with in-situ bioassays using hatchery sturgeon will be used to accomplish this task. It is possible that non-destructive sampling of wild sturgeon by taking small liver tissue plugs (biopsy) may also be used to establish physiological effects on sturgeon from exposure to contaminants in the Columbia River.

Contact Person: Graham vanAggelen, Head of Environmental Toxicology; Heather Booth and Joy Bruno, PESC Environment Canada, (604) 924-2500

Timing: First step could begin immediately with further work done in 2002-2003

Cost: 32K (US funds)

Deliverables: White sturgeon microarray, Annual and final reports to UCRWSRT including mangement recommendations, Publications and scientific contribution

3.3.5 Objective 5

Develop a program for long-term monitoring and potential remediation of contaminants effects on sturgeon

Task 1: Design and implement a long-term assessment and monitoring program specific to the Upper Columbia River. Reassess program on a regular basis to update goals, objetive and tasks based on new technology and developments.

Task 2: Provide protection for important habitat areas.

Task 3: Work to develop a policy to ensure risk assessment prior to introductions of new industries, developments or use of chemical compounds.

Task 4: Remediate sources of contaminants where feasible.

3.3.6 Objective 6

Contribute to development of a toxicology assessment program for sturgeon.

Task 1: Publish literature and a manual to assist program development and field assessments for determining contaminants effects on sturgeon.

Table 1. Upper Columbia River sturgeon contaminant study: Short-term objective, task and outcome summary

Objective	Tasks	Outcome	Projected Cost (US funds)
Objective 1	1) Historic Data Summary	Identify contaminant sources and data gaps	2K (available)
Objective 2	1) Study design development	Study plan to assess environmental contaminant effects on upper Columbia River white sturgeon	4 K (available)
Objective 3	1) Assess feasibility of non-lethal liver biopsies 2) Conduct non-lethal sampling of adult and juvenile sturgeon	Information about the potential effects of existing environmental contaminants on upper Columbia River white sturgeon	80K (15K matching available)
Objective 4	1) Develop a sturgeon cDNA microarray 2) Gene microarray assessment	Determination of molecular (genetic) effects of environmental contaminants on sturgeon	32K (25K matching available)

3.4 COOPERATORS

Oregon Department of Environmental Quality
Pacific University
Oregon State University
USGS, CRRL
Free Run Aquatic Research
British Columbia Ministry of Water, Land and Air Protection, Environmental Quality Section, Nelson BC
Canadian Federal Government, Pacific Environmental Science Center (PESC)
RL&L Golder
City of Castlegar, BC, Canada
Kootenai Tribe of Idaho
Columbia River Integrated Environmental Monitoring Program (CRIEMP)
(list inconclusive)

3.5 TIMELINE

This project is designed to gather baseline data and then develop a long-term monitoring and evaluation program that will provide a potential measurement of contaminant effects on Upper Columbia River white sturgeon. Due to the long life cycle of white sturgeon and the need to assess contaminant effects over many life stages and generations, the SWCG anticipates that this program will continue for at least 10 years or the duration of time it requires to recover the Upper Columbia River white sturgeon to a sustaining population. Table 2 summarizes a timeline of events for project implementation during the initial scope of the project in 2002. A five-year timeline of objectives and tasks is outlined in Table 3.

Table 2. Timeline for proposed objectives and tasks, 2002.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Objective 1: Summarize available historic information about contaminant effects, levels and input to the Upper Columbia River												
Task 1: Gather existing data on contaminant levels in aquatic media.	*	*	*									
Task 2: Gather existing data specific to contaminant levels in Upper Columbia River white sturgeon.	*	*	*									
Objective 2: Develop a biomarker-based (non-lethal) study to assess bioaccumulation and potential chronic effects of existing environmental contaminants on Upper Columbia River white sturgeon												
Task 1: Gather existing information specific to in-situ and laboratory studies on effects of environmental contaminants on white or other sturgeon	*	*	*									
Objective 3: Assess bioaccumulation and potential chronic effects of existing environmental contaminants on Upper Columbia River white sturgeon												
Task 1: Conduct a laboratory assessment of sturgeon survival following liver biopsy.		*	*	*	*	*	*	*	*			
Task 2: Conduct Non-Lethal Sampling of adult and juvenile sturgeon			*	*	*	*	*	*				
Objective 4: Conduct a genotoxicity assessment of Upper Columbia River white sturgeon.												
Task 1: Develop a sturgeon cDNA microarray that will aid in determining possible stressors to the population.												
Task 2: Assess what gene microarrays in wild and hatchery reared sturgeon are being turned on or off in the presence of contaminants and contaminant mixtures.									*	*	*	*

Table 3. Timeline for proposed objectives and tasks, 2002-2006.

	2002	2003	2004	2005	2006
Objective 1: Summarize available historic information about contaminant effects, levels and input to the Upper Columbia River					
Task 1: Gather existing data on contaminant levels in aquatic media.	*				
Task 2: Gather existing data specific to contaminant levels in Upper Columbia River white sturgeon.	*				
Objective 2: Develop a biomarker-based (non-lethal) study to assess bioaccumulation and potential chronic effects of existing environmental contaminants on Upper Columbia River white sturgeon					
Task 1: Gather existing information specific to in-situ and laboratory studies on effects of environmental contaminants on white or other sturgeon	*				
Task 2: Reassessment and update of program goals, objectives, and tasks		*	*	*	*
Objective 3: Assess bioaccumulation and potential chronic effects of existing environmental contaminants on Upper Columbia River white sturgeon					
Task 1: Conduct a laboratory assessment of sturgeon survival following liver biopsy.	*				
Task 2: Conduct in-situ bioassays of liver tissue		*			
Task 3: Conduct Non-Lethal Sampling of adult and juvenile sturgeon	*	*	*	*	*
Task 4: Conduct laboratory and in-situ studies to assess contaminant effects on adult and juvenile sturgeon		*	*	*	*
Objective 4: Conduct a genotoxicity assessment of Upper Columbia River white sturgeon.					
Task 1: Develop a sturgeon cDNA microarray that will aid in determining possible stressors to the population.	*				
Task 2: Assess what gene microarrays in wild and hatchery reared sturgeon are being turned on or off in the presence of contaminants and contaminant mixtures.	*	*			
Task 3: Reassess importance of established microarrays in contaminant assessment and develop additional gene microarrays as necessary		*	*	*	*
Objective 5: Develop a program for long-term monitoring and potential remediation of contaminants effects on sturgeon					*
Objective 6: Contribute to development of a toxicology assessment program for sturgeon.					*

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4.0GENETICS

The genetics sub-committee was formed to provide meaningful discussion, scientific review and recommendations on issues such as the presence and implications of population substructure, the genetic hazards and risks associated with endangerment, and the development of a breeding plan to guide fish culture activities. Sub-committee activities were focussed primarily on the development of the breeding plan, with other sub-committee goals addressed through informal communication and discussions within the recovery team as a whole. The activities of the sub-committee are presented here as a short description of genetic issues and the decisions reached within the recovery team. The breeding plan is included as a stand alone document.

4.1 STOCK STRUCTURING

The presence and significance of population substructure was discussed during early stages of the recovery planning, and is supported by two lines of evidence. First the hypothetical historic distribution outlined by Hildebrand and Birch (1996) suggests that prior to impoundment there may have been discrete groups which are now characterized as the Waneta group, Keenleyside group, and the Kootenay group. Currently these groups are mixed within the section of river from Keenleyside Dam downstream due habitat fragmentation caused by dam construction. It is hypothesized that prior to impoundment each of these groups occupied areas that contained all required habitats. By extension this suggests these groups may have formed distinct breeding groups prior to impoundment.

The second line of evidence was provided by genetics analysis reported by Nelson et al. (1999) and Smith (2001). Their studies indicated the presence of differentiation within the Canadian section of the Columbia River based upon analysis of both nuclear and mitochondrial DNA. Samples from the Arrow Reservoir, Kootenay River downstream of Brilliant Dam and the Columbia River below Keenleyside Dam provide an indication that fish in these areas are distinct. Non-statistically significant differences ($\alpha = 0.05$) were noted using Chi-squared analysis RFLP data, however, these differences would be significant if sample sizes were doubled (all other factors remaining equal). Analysis of microsatellite data showed that results are closer to Hardy-Weinberg equilibrium when these three sites are analyzed separately than when analyzed together, which is a further indication of sub-structuring. However, both studies also stated that sample sizes are too small for definitive conclusions. Further analysis would be required to examine this question, but was not pursued due primarily to the complexities of the management implications that would be required to address multiple distinct stocks on such a small geographic scale.

4.2 MANAGEMENT IMPLICATIONS

Due to concerns about the genetic implications of some previous hatchery practices with other species the RT had a strong desire to be conservative in the approach taken within recovery planning. However, at the same time there are significant difficulties recovering one group of fish, and the recovery of more than one group of fish could very easily make the problem intractable. The RT therefore decided to not explicitly address the potential for population sub-structuring in the area between Keenleyside Dam and the border (including the lower Kootenay River). This decision was made based on the assumptions that the genetic diversity obtained by combining potentially distinct groups, the reduction of negative effects due to small populations, and the practicality of working with 1 rather than 3 groups, would offset potential losses incurred by ignoring potential substructuring.

The fish within Arrow Lakes Reservoir were address similarly to those downstream of HKD. The current population estimate for this area (RL&L 2001) is 38 fish (95% CI=23 to 78), and although these fish may be distinct, their long term viability as a separately managed population is questionable. Therefore within the conservation fish culture program ALR fish would be crossed if Arrow x Arrow pairings are available. Otherwise ALR fish will be paired with fish from HKD to the border. With respect to releases, the offspring from broodstock taken from other areas will be released within ALR. Similar to the logic noted above the benefits of introducing genetic diversity are believed to outweigh the risks currently associated with such small population size.

While the geographic area of concern within this planning process extends downstream to Grand Coulee Dam, discussions of potential population substructuring focussed on fish in the Canadian section of the Columbia River since some information was available for that area. There may have been some substructure prior to impoundment as movement data suggests relatively little movement across the border. Kettle Falls may also have formed a seasonal hindrance to migration that could have promoted substructuring. However, management implications of this understanding were not developed in detail. More detail may be added once the sturgeon recovery initiative and related research spreads into the U.S. portion of the river and Roosevelt Reservoir.

4.3 PARENTAGE ANALYSIS

Monitoring of spawning activities at Waneta since 1993 provides an estimate the annual number of spawning events based on collection of discrete pulses of eggs. The number of spawning events in turn provides an estimate of the minimum number of adults that spawn each year. However, group spawning may occur as it has been observed at other white sturgeon spawning locations, but not confirmed at Waneta. Therefore genetic markers are being used to examine the number of adults contributing to each spawning event. This analysis is being done by Bernie May's lab (UC Davis) using markers proprietary to that lab. Wild spawned eggs were collected during the 2001 spawning season and then hatched and reared at the Hill Creek Hatchery. Juveniles will be raised to a size sufficient to allow tissue sampling, and all egg and juvenile mortalities were saved for analysis. This analysis will be conducted during the spring/summer of 2002, and details of the analytical procedure will be provided at that time. Clarification of whether group spawning occurs could be very significant, because its absence would indicate a very long interspawning interval (interspawning interval=number of females / females spawning per year) which would be a significant conservation concern.

Placeholder from Steve: We had a bit of a debate in our office about generation time last week. It turns out the IUCN proposes a formula to calculate it (the mean age of mature individuals). We've been using a value of about 30 years, which is actually the minimum generation time Using the IUCN value this value would change to something more like 50 years. While both of these are beyond normal planning horizons they may have a small bearing upon the plan. Some clarification may be required from IUCN (e.g. re: differential male/female maturity, senecense, etc.), if we choose to apply this measure. I was hesitant at first, however, I now feel that using a generation time of 30 years may lead us to "under plan".

5.0FISH CULTURE

5.1 INTRODUCTION

The Upper Columbia River White Sturgeon Recovery Team is responsible for developing and implementing a Recovery Plan for imperiled Upper Columbia white sturgeon populations. The Recovery Team delegated responsibility for fish culture components of the Recovery Plan to an Fish culture Sub-Committee (terms of reference provided in Appendix A of this document).

The Fish culture Sub-Committee provided the bulk of it's input to the Recovery Plan in the form of responses to a series of specific questions from the Recovery Team. These responses are summarized in this report. The report contains a number of recovery measures to reflect recommendations of the sub-committee. A number of additional recovery measures presented in the Recovery Plan were developed by the Recovery Team as a whole, outside the scope of the Fish culture Sub-Committee work.

5.2 SUB-COMMITTEE PRODUCTS

5.2.1 Hill Creek Hatchery Sturgeon Production Capabilities

A review of the current and potential capabilities and limitations of Hill Creek Hatchery (HCH) was undertaken by the sub-committee. These descriptions reflect the status of the facility as of late winter 2002.

Current Hatchery Capacity

The HCH facility was modified and developed as a pilot facility for the upper Columbia white sturgeon recovery initiative. HCH was developed from an existing bull trout facility, constructed originally in compensation for habitat losses incurred as a result of the construction of Revelstoke Dam. Modifications to the facility were made in late 2000 and early 2001 to allow production of white sturgeon instead of bull trout, reflecting the high degree of urgency posed by the sturgeon conservation problem.

At present, sturgeon production at HCH is primarily limited by the amount of well water available for culture purposes (350 lpm). Using a loading factor of 0.75kg/lpm, 350 lpm permits rearing of approximately 250 kg of sturgeon. Four 10-foot circulars (6000 liters each), four six-foot circulars (2000 liters each) and four five-foot circulars (1500 liters each) are available for grow-out. Note that, with the current water supply, current rearing space is not a major limiting factor in itself.

To achieve maximum production, fish would be reared exclusively on well water (heated to 15°C) until approximately December 15 or until the fish attain an individual average weight of 20 g. Any surplus fish would be removed from the facility well before December 15. After December 15, rearing water would consist a mix of well water heated to 15 C and surface water at ambient temperatures. The creek would supply up to 40% (or 230 lpm) of the total rearing water.

Current maximum sturgeon production at HCH is 12,000 30 g yearlings (assuming May stocking). As well, 12000 10g fish could be produced for a Nov release date as well as an undetermined number of unmarked swim-up fry for release at a very small size in

Sept. (The maximum number of families to be separately cultured is six (fewer than six families may be of course cultured). Other options might involve raising less families. For example, five families of 2400 fish per family or four families of 3000 fish per family can be raised.

Hatchery Limitations and Expansion Potential

At the time of development, HCH provided the only option that would meet the very tight time lines around BC Hydro funding for the sturgeon program. HCH was not necessarily seen as a permanent location for the Columbia River white sturgeon culture program because of the following operational limitations:

- HCH is a 6 hour round-trip drive from the broodstock capture and release sites located on the lower river. Fish transfer costs are high. As well, while staff attend to fish transfer tasks, the hatchery facility is at increased risk in the event of an emergency.
- The remote location means long travel distances for service technicians (electricians, plumbers, control technicians). This makes servicing the facility more expensive and at times slow.
- HCH is a 12-hour round trip drive from Kootenay Sturgeon Hatchery, where supervisory and management personnel are based. As a result, administration costs are higher and opportunities to provide cost efficiencies between the two programs are limited.

A variety of other factors currently limit the potential for sturgeon production at HCH. The amount of well water available for culture purposes is presently limited to 450 lpm. Well-water heating and aeration systems are only adequate to provide production noted in the previous section. If an increase in production is required, heating and aeration systems may require additional building space to house new, larger equipment.

If the total amount of well water required also increases, and new wells are installed, there could be some interference between the wells. In that event, they could not be operated at the same time and thus the potential for additional well water is unknown. Presently, heating creek water is not operationally possible. New and expensive creek-water filtration would be necessary to provide heated creek water.

The present rearing space of 38,000 liters is adequate to produce the production figures stated in the previous section. However, to substantially increase production, new and larger ponds would need to be purchased. More building space would also be required. In the "as built" configuration, space within the existing building is fully utilized - any program expansion will require additional room (new building or expand current building). Other limitations and problems with the existing facility include the need for a new roof on the building and limited emergency electrical generation capacity.

The recovery team requested an estimated cost to double existing sturgeon production at HCH. Based on a rough assessment of the aforementioned limitations, this cost would be in order of $1.5 – 2.0M.

Recovery Measure

If sturgeon production beyond the capacity of HCH is required, options for developing a stand-alone facility in the Castlegar area and/or a program that could be piggybacked on to the existing Kootenay sturgeon facility should be examined.

5.2.2 Review of Marking Options

A range of marking options were considered by the sub-committee in response to a request from the Recovery Team. Marking of juvenile sturgeon is required to identify fish of hatchery origin and to determine the brood year of recaptured fish for evaluation purposes. As well, marking is needed to identify the family background of individual fish to prevent the acceleration of inbreeding in future fish culture operations.

In this review, we assumed the physical size of sturgeon to be marked would be either yearling sturgeon (~ 30 grams) for May release, or sub-yearlings (~ 10 grams) for November release. We assumed tag requirements as follows:

- Long-term readability/retention time - must retain codes for > 50 years
- Small - must implant in small specimens

Non-lethal identification - must be able to differentiate brood year and family origin without termination of specimen.

Coded Wire Tags (CWTs) with Scute Removal

CWTs are tiny (1.1 mm) magnetic non-visible tags injected under scutes or into the snout. They can be detected by hand-operated detectors, but carry a physically etched code requiring removal of the tag to de-code. However, non-lethal family identification may be possible tagging is combined with scute removal (indicating brood year and hatchery origin) and the CWTs are injected under specific dorsal scutes (indicating family origin). The CWTs and tagging equipment are supplied by Norwest Marine Technology (NMT), Inc., Shaw Island, WA.

Tagging rates were estimated to be on the order of 50-100 specimens per hour. Fingerling lake sturgeon (10-15 cm) injected in the snout and 6th dorsal scute with CWTs had a double tag retention rate of >99% over 90 days (Schram et. al 1999). Start up costs for CWTs are high but can be reduced (short-term) if the marking equipment is rented (even less if acquired on loan).

	Start-up cost (purchase equipment):	Start-up cost (rent equipment):
Tagging unit	$6,800.00	$900.00 ($/mnth)
Wand detector	$7,100.00	$7,100.00
12,000 tags	$1,080.00	$1,080.00
Total costs (US $)	**$14,980.00**	**$9,080.00**

PIT Tags with Scute Removal

PIT tags are non-visible glass encapsulated transponders that emit 10 digit codes when energized by radiowaves emitted from a reader. PIT tags would be injected under epidermis into muscle of sturgeon. If combined with scute removal (indicating hatchery origin), PIT tags will provide non-lethal, individual fish identification.

PIT tags are supplied by a number of companies. Two major suppliers are:

1. VID markets microchips, implanters and Power Tracker ll & V readers. Tags are 125 and 134.2 kHz.
2. Mark markets implantable glass tags (125, 134.2 & 400 kHz), many readers, implanters, and data collection software.

The tag implant rate is approximately 150 specimens per hour. Start-up costs are high due to costs of tags. Investigation into pricing revealed that BPA is able to obtain special bulk prices for 134.2 kHz PIT tags (current ISO standard). This option could lower the cost of marking considerably from the figures noted below.

	Start-up cost (AVID):	**Start-up cost (BioMark):**
Tag Reader	$0	$0
Tag Implanters	$100.00	$100.00
12,000 tags	$37.8 K	$46.8 K
Total costs (US $)	**$37.8K**	**$46.8 K**

Elastomeric (Colored Latex) Tags

Elastomeric tags are visible short-term tags made of fluorescent elastomer material. This material is injected under translucent tissue as a liquid, which then cures into a pliable solid. They are usually used for family identification within a controlled or hatchery setting. Tissue overgrowth obscures tag visibility and therefore these tags are not useful for long-term release/recapture strategies.

These tags are available from two companies:

1. NMT markets Visual Implant Fluorescent Elastomer tags (VIE).

2. Advanced Biometrics International Ltd. markets photonic tags.

The tag rate is 200-250 specimens tagged per hour and start-up costs are relatively low.

Start-up cost VIE tags:		**Start-up cost Photonic tags:**	
Tagging kit	$1,150.00	Tagging unit	$550.00
(includes tags)		Colored latex tags	$750.00
Total cost (US $)	**$1,150.00**	**Total cost (US $)**	**$1,300.00**

Tag Suitability

The sub-committee discussed the above juvenile sturgeon tagging options with specialists from a variety of agencies, including Brad James (Washington Department of Fish and Wildlife), Vaughn Paragamian (Idaho Department of Fish and Game), and Sue Ireland (Kootenai Tribe of Idaho). Based on these discussions and information from the suppliers, the following pros (+) and cons (-) were determined for each marking strategy noted above.

<u>Coded Wire Tags</u>

+ Long-term tag retention.
+ Can tag small sturgeon (10-15cm)
– Not externally visible, presence detected through magnetic detectors.
– Decimal coded for individual or family identification, however, fish must be terminated to read decimal codes. Can be used in combination with scute removal for family identification (non-lethal). Requires laborious tag application and complex recording.
– Start-up costs high, equipment can be rented.
– Fish Culture has no experience with CWTs combined with scute removal for brood year identification.

<u>PIT tags</u>

+ Long-term tag retention
+ Can tag ~10 gram sturgeon (pers. comm. Jack Siple, Kootenai Tribe of Idaho). Tag retention and survival unproven when tagged at this size.
– Not externally visible, presence detected by tag reader. Can be combined with scute removal for visible detection.
+ Alphanumeric code for individual recognition.
– Start-up costs high.
+ Fish Culture has experience with PIT tags and scute removal to identify hatchery origin.

<u>Elastomeric tags</u>

– Short-term tag retention, less than one year. Not suitable for long-term release strategies.
+ Can tag small sturgeon (<2 cm.)
+ Externally visible, visibility/detection obscured with tissue overgrowth, visibility enhanced with fluorescence.
+ 6 colors available for separating families
+ Start-up costs low.

Recovery Measure

Yearling sturgeon should be marked with PIT tags and scute removal, used in combination. Scute marks will provide a rapid indication of hatchery origin and brood year and PIT tagging will allow identification of individuals and families. This would required growing the fish to a size of about 30 g. For sub-yearling sturgeon, tagging trials at Kootenay Trout Hatchery indicated that PIT tagging of 10 g sturgeon may compromise tag retention and fish survival. Therefore, alternative tagging would likely be required for any sub-yearling fish unless the growth of these fish can be accelerated to a size of at least 15 g. The combination of scute removal (to indicate brood year) and CWT under specific dorsal scute (family identification) may have potential but remains untested at this time.

5.2.3 PIT Tag and Scute Removal Marking Strategy

As a result of the sub-committee marking review described above, a strategy for PIT tagging and scute marking all sturgeon released from the Hill Creek Hatchery was required. This marking strategy enables tracking of survival, movement, growth, and recaptures of tagged fish. As well, a variety of studies relating to time and size at release could be facilitated. Identification of family origin in recaptured hatchery-produced mature sturgeon will also allow avoidance of sibling crosses and acceleration of inbreeding in future hatchery operations.

The marking plan provides redundancy if one of the marks was to fail. Pending further studies of tag retention and mortality in smaller fish, it is recommended that the majority of the fish are > 30 g when marked if good survival and tag retention are to be ensured. Any undersized fish should be held until they reach a sufficient size for PIT tagging. Existing fish culture staff involved in the program have experience with PIT tagging/scute removal and thus the learning curve would be minimal.

Recovery Measure

The scute removal pattern and PIT tag pattern recommended by the sub-committee is outlined in Table 1. The scute pattern would identify each brood year starting with the 2001 brood currently on hand at Hill Creek Hatchery and slated for release in summer 2002. Removal of at least two scutes was recommended to provide a "landmark" for the scute pattern; this was suggested as a result of difficulties experienced elsewhere in assessing which scute is the first in the lateral scute row. PIT tags would be injected into the same side of sturgeon as the scutes are removed to facilitate locating and reading during recaptures.

Table 1. Recommended scute and PIT tag marking strategy for hatchery-origin upper Columbia white sturgeon.

Year	Side of fish	Scutes removed		PIT Tag Location
2001	Left	1st & 3rd.	Leaving 1 scute between removed scutes.	Upper Left
2002	Left	1st & 4th	Leaving 2 scutes between removed scutes.	" "
2003	Left	1st & 5th	Leaving 3 scutes between removed scutes.	" "
2004	Left	1st & 6th	Leaving 4 scutes between removed scutes.	" "
2005	Left	1st & 7th	Leaving 5 scutes between removed scutes.	" "
2006	Left	1st & 8th	Leaving 6 scutes between removed scutes.	" "
2007	Left	1st & 9th	Leaving 7 scutes between removed scutes.	" "
2008	Left	1st & 10th	Leaving 8 scutes between removed scutes.	" "
2009	Left	1st & 11th	Leaving 9 scutes between removed scutes.	" "
2010	Left	1st & 12th	Leaving 10 scutes between removed scutes.	" "
2011	Right	1st & 3rd	Leaving 1 scute between removed scutes.	Upper Right
2012	Right	1st & 4th	Leaving 2 scutes between removed scutes.	" "
2013	Right	1st & 5th	Leaving 3 scutes between removed scutes.	" "
2014	Right	1st & 6th	Leaving 4 scutes between removed scutes.	" "
2015	Right	1st & 7th	Leaving 5 scutes between removed scutes.	" "
2016	Right	1st & 8th	Leaving 6 scutes between removed scutes.	" "
2017	Right	1st & 9th	Leaving 7 scutes between removed scutes.	" "
2018	Right	1st & 10th	Leaving 8 scutes between removed scutes.	" "
2019	Right	1st & 11th	Leaving 9 scutes between removed scutes.	" "
2020	Left	1st & 2nd	Leaving 0 scutes between removed scutes.	" "
2021	Left	1st,2nd, & 4th	Leaving 1 scute between removed scutes.	Upper Left
2022	Left	1st,2nd & 5th	Leaving 2 scutes between removed scutes.	" "
2023	Left	1st,2nd, & 6th	Leaving 3 scutes between removed scutes.	" "
2024	Left	1st,2nd, & 7th	Leaving 4 scutes between removed scutes.	" "
2025	Left	1st,2nd, & 8th	Leaving 5 scutes between removed scutes.	" "
2026	Left	1st,2nd, & 9th	Leaving 6 scutes between removed scutes.	" "
2027	Left	1st,2nd, & 10th	Leaving 7 scutes between removed scutes.	" "
2028	Left	1st,2nd, & 11th	Leaving 8 scutes between removed scutes.	" "
2029	Left	1st,2nd, & 12th	Leaving 9 scutes between removed scutes.	" "
2030	Left	1st,2nd, & 13th	Leaving 10 scutes between removed scutes.	" "
2031	Right	1st,2nd, & 4th	Leaving 1 scute between removed scutes.	Upper Right
2032	Right	1st,2nd, & 5th	Leaving 2 scutes between removed scutes.	" "
2033	Right	1st,2nd, & 6th	Leaving 3 scutes between removed scutes.	" "
2034	Right	1st,2nd, & 7th	Leaving 4 scutes between removed scutes.	
2035	Right	1st,2nd, & 8th	Leaving 5 scutes between removed scutes.	
2036	Right	1st,2nd, & 9th	Leaving 6 scutes between removed scutes.	
2037	Right	1st,2nd, & 10th	Leaving 7 scutes between removed scutes.	
2038	Right	1st,2nd, & 11th	Leaving 8 scutes between removed scutes.	
2039	Right	1st,2nd, & 12th	Leaving 9 scutes between removed scutes.	
2040	Right	1st,2nd, & 13th	Leaving 10 scutes between removed scutes.	

5.2.4 PIT Tag Frequencies

PIT tags have been manufactured in three frequencies: 400, 125, and 134.2 kHz. The 400 kHz PIT tags were the first tags produced and are currently being phased out of production. Readers for the 400 kHz tags are not readily available. PIT tags at 125 kHz were first used in the Pacific Northwest in 1984-85. They were commercially available in 1990. These tags and readers will continue to be produced for the foreseeable future. ISO 134.2 kHz PIT tags are the newest tags produced and form the international standard for PIT tagged animals.

In the upper Columbia, sturgeon have been implanted with PIT tags for about 10 years. It is probable that both 400 and 125 kHz frequency PIT tags are implanted in Upper Columbia white sturgeon. Reports that newer tags (125 kHz) are much easier to read than existing tags on older fish in the recovery area (likely 400 kHz) support the theory of two tag frequencies. The AVID Power Tracker II readers are designed to read at the 125 kHz frequency but can read 400 kHz tags at a lower efficiency (if placed directly over the tag). This is also true for the Destron-Fearing 125 kHz tag readers.

Newer ISO 134.2 kHz tags are being produced to provide a consistent frequency that can be read by various agencies or groups using the ISO 134.2 kHz reader. The ISO 134.2 kHz readers apparently have better reception capabilities and larger antennae which is a benefit for fixed reading stations. The new readers such as the AVID Power Tracker V and the Destron-Fearing FS2001F/ISO can read both 125 and 134.2 kHz frequency tags but not 400 kHz tags. Thus, the use of the new 134.2 kHz tags and readers in Upper Columbia white sturgeon has the potential to exclude data from fish implanted with 400 kHz tags.

The majority of PIT tags implanted into existing, wild Upper Columbia white sturgeon are probably 125 kHz. Readers for 125 kHz can also read 400 kHz tags. Thus, the sub-committee recommended that, for wild fish already in the system, the program should continue to use tags and readers that do not exclude the older 400 kHz tags already in many of these fish. However, over the longer term, there are advantages in switching to the ISO compliant 134.2 kHz tags for sturgeon produced at the hatchery. The most compelling reason is that these tags are available through BPA at a preferred rate 40% cheaper than the older tags. Even over the short term, the cost savings would be enormous. Although different readers would be required to read the combination of wild and hatchery fish that will result, these fish will be readily distinguishable by their scute marks. Starting in the first year of hatchery production with the ISO compliant tags has the additional advantage of having all hatchery fish with that style of tag, reducing the level of marking complexity.

Recovery Measure

PIT tags and readers operating at 125 kHz should continue to be used for wild fish already in the upper Columbia recovery area. This will allow for continued collection of data from fish already implanted with 400 kHz tags. However, for all hatchery fish, the program should immediately begin to use ISO compliant 134.2 kHz tags and readers to take advantage of reduced costs and new, internationally recognized technology.

5.2.5 Cryopreservation

Cryopreservation was reviewed as a possible tool to maximize the potential for use of sperm from all male sturgeon obtained during broodstock collection operations. This technique, although still underdevelopment for sturgeon, shows promise as a means of safely storing sperm over long periods. Potential uses include mating of non-synchronous fish (fish culture tool), gene conservation (stock rebuilding) and preservation of specific lines (fish culture).

Sturgeon sperm cryopreservation involves:

- harvesting the sperm – as usual, gonadotropins are used to induce spermiation;
- preparing the sperm for freezing – adding cryprotectant and extenders;
- a 3-step freezing process – must be slow enough to allow for water to diffuse into the extracellular spaces and fast enough to protect the intracellular components from the increased concentration of salts; and
- storage at –196 oC.

Considerable variation in results can be expected. The highest quality sperm must be used in order to optimize fertilization rates using cryopreserved sturgeon sperm. Fertilization rates will range between 25-50% of non-frozen control sperm fertility (J. Cloud, University of Idaho, pers. comm.).

Two significant cryopreservation applications have been identified for Upper Columbia white sturgeon recovery. As a fish culture tool, cryopreservation would provide sperm during years when ripe males are not readily obtained in adequate numbers. Non-synchronous gamete production was not an issue in year 1 of operations at Hill Creek Hatchery. Sperm production did not limit production and, in fact, some males were induced to spermiate a number of times. However, if the induction of spermiation in mature males becomes problematic in the future, cryopreservation may be required for the mating of non-synchronous fish. The technique may also reduce be useful in reducing annual broodstock collection needs if sperm from more than more than one year's requirement for males can be obtained in a single broodstock capture year.

The other potential use for cryopreservation is in gene conservation. If the number of mature adults becomes a limiting factor in the future, cryopreservation must be considered. Sperm (male genetic component) can be frozen and held in perpetuity until needed.

Equipment	**Start-up costs (US$):**
Straw filling/sealing machine	$4,000
Liquid nitrogen freezing/storage unit	$2,537
Photometer – sperm cells/ml	$2,205
Liquid Nitrogen supply/yr	$3,000
Disposables	
Straws, cryoprotectant, extender,	
misc equipment (tongs, hemacytometer, pipettes, etc.),	
and safety equipment (gloves, apron, glasses)	$2,500
Total cost	**$14,242**

Recovery Measure

Although the sub-committee recommended that the use of this technique be put on hold for the next year because sperm supply is currently not limited, regular review is strongly suggested. The technique must be applied proactively and needs to be considered as such in the event that the availability of males declines rapidly.

5.2.6 White Sturgeon Broodstock Options Review

Conservation fish culture activities currently underway at HCH have dealt with only one year of broodstock capture and spawning to date. As a result, methods of obtaining broodstock and fertilized eggs for this program are under review, and a contract was completed to review options for that component of the program. Options reviewed included:

1. *Wild egg collection* – modified substrate mats could be deployed at Waneta or Revelstoke to collect wild, fertilized eggs and transport these (or the resulting larvae) to a hatchery for rearing.
2. *Broodstock obtained ripe* – fish could be obtained on spawning sites, allowing immediate spawning without extended holding or use of stimulating hormones.
3. *Broodstock obtained green* – fish could be obtained well in advance of the spawning season and held at facilities where the onset of maturity would be controlled by hormone injections and controlled temperatures.
4. *Broodstock or brood obtained elsewhere* – either adults, their hatchery offspring or possibly even wild juveniles could be brought in from other locations to supplement the population.
5. *Combination* – some combination of the above-noted options could be implemented.

An assessment of the benefits, risks, logistics and costs for each option was developed, along with a survey of practices at other sturgeon hatchery programs throughout North America (Appendix B). Each broodstock collection alternative was found to have it's strengths and weaknesses, suggesting the most effective approach would be to employ a combination of these options.

Recovery Measure

For initial operations at Hill Creek Hatchery, employ a combination of broodstock collection alternatives as described in Appendix B. This blend of methods may ultimately prove to be the best way to balance the strengths and weaknesses of the different options. Use of a combination of approaches complicates operation of the hatchery program but may optimize the chances of successful conservation and restoration of upper Columbia River sturgeon.

5.3 REFERENCE

Schram, S.T., J. Lindgren, and L.M. Evradd. 1999. Reintroduction of Lake Sturgeon in the St. Loius River, Western lake Superior. North American Journal of Fisheries Management. 19:815-823.

5.4 TERMS OF REFERENCE

5.4.1 Background

The Upper Columbia White Sturgeon Recovery Team (hereafter referred as the Recovery Team or RT) is responsible for development and implementation of a recovery plan for the imperiled Upper Columbia white sturgeon populations. The following are some of the tasks assigned to the recovery team:

i. assembling accurate baseline data and reviewing reasons for populations declines;

ii. defining the longer term recovery goal and short term objectives for white sturgeon recovery;

iii. establishing criteria to evaluate the recovery plan and to define success;

iv. designing technical strategies (options) and supporting research programs to achieve the recovery goals and objectives; and

v. establishing priorities for recovery implementation based on technical criteria and the input form the Action Planning Group

With a view to undertaking the tasks, the recovery team decided in early November that sub-committees were required with respect to genetics, research/management, flows and water management, conservation fish culture and habitat restoration. The conservation fish culture program will include protocols for broodstock collection and holding, propagation, rearing, fish health, and operation and management of fish culture operations. This terms of reference is to advise the RT on issues related to conservation fish culture.

5.4.2 Mandate

The conservation fish culture sub-committee will provide input to the recovery team related to the capabilities of the conservation fish culture program to undertake the reproduction of adult white sturgeon and the production of juveniles for conservation and research purposes.

5.4.3 Inputs

The recovery team will outline its requirements for the production of juvenile sturgeon through its ongoing activities, and ultimately within the recovery plan. A primary guiding document within the recovery plan will be a breeding plan, which will outline a breeding strategy, which considers genetic requirements of the population.

5.4.4 Tasks

The conservation fish culture sub-committee will advise the Recovery Team on aspects of the recovery planning related to the conservation fish culture component of recovery planning, such as:

1. Conservation culture requirements to support the population recovery objectives of the Recovery Team.

2. Broodstock requirements (timing, and number of fish) in order to complete the requirements of the conservation fish culture program.
3. Techniques to be used in the maintenance and spawning of white sturgeon.
4. Techniques to be used in the rearing of juvenile sturgeon.
5. Expected production levels by family group and age from culture operations.
6. Procedures to be used to if the numbers of fish produced exceed target outputs.
7. Procedures to comply with genetic tracking requirements of a conservation fish culture plan.
8. Fish health permitting and management requirements.

5.4.5 Membership

Steve McAdam, Don Peterson and Bryan Ludwig (chairs)	BC Ministry of Water, Land and Air Protection
Tim Yesaki	BC Ministry of Water, Land and Air Protection
Colin Spence	BC Ministry of Water, Land and Air Protection
Ron Ek	BC Ministry of Water, Land and Air Protection
Joel Van Eenennaam	UC Davis
Sue Ireland	Kootenai Tribe of Idaho
Terry Patterson	College of Southern Idaho

5.4.6 Reporting

The work of the committee will be accomplished primarily through informal communication between committee members. Reporting to the Recovery Team on an ongoing and as needed basis.

5.4.7 Sunset

The sub-committee will continue as long as required by the Recovery Team.

6.0BROODSTOCK OPTIONS

The Recovery Team for Upper Columbia River White Sturgeon has determined that fish culture will be a key element in the conservation and restoration of upper Columbia white sturgeon. A sturgeon hatchery program has been initiated at Hill Creek Hatchery on Arrow Reservoir and several alternatives for broodstock collection are being weighed. This review includes a discussion of four broodstock collection alternatives (Appendix Table 1) and a survey of practices at other sturgeon hatchery programs throughout North America (Appendix Table 2).

Each broodstock collection alternative has it's strengths and weaknesses (Appendix I). Wild egg collection maximizes opportunities for preserving the genetic diversity of the wild population but can be labor intensive and costly. Broodstock obtained ripe can provide large numbers of eggs with relative ease of handling but ripe males and females can be difficult to obtain at the same time especially as the population continue to decline. Broodstock obtained green require holding for up to one year in the hatchery with concurrent costs, mortality risks, and maturation risks but provide insurance in case ripe fish cannot be captured. Progeny imported from non-local broodstock can be readily obtained from a variety of sources but are likely of a different genetic composition and should be considered only for reintroduction purposes should conservation efforts fail.

We identified 26 significant sturgeon hatchery facilities or programs in North America (Appendix II). White, shortnose, shovelnose, pallid, lake, gulf, and Atlantic sturgeon are being cultured at a variety of government, tribal, private, and university facilities. Green sturgeon propagation is also planned at UC Davis. Most programs were relatively small in scale and research or experimental in nature. Conservation or restoration programs are releasing white, pallid, lake, and shortnose sturgeon. Current programs have successfully adapted all broodstock collection alternatives considered in this review but different options were appropriate in different situations.

Use of a combination of broodstock collection alternatives may ultimately prove to be the best way to balance the strengths and weaknesses of the different options. Use of a combination of approaches complicates operation of the hatchery program but may optimize the chances of successful conservation and restoration of upper Columbia River sturgeon.

Appendix Table 1. Evaluation of sturgeon broodstock collection alternatives.

	Alternative	Genetic risk	Mortality or natural spawn risk	Numbers provided	Operational ease	Cost per egg
A	Wild egg collection	Low	Low	Low	Low	High
B	Broodstock obtained ripe	Medium	Medium	High	Medium	Medium
C	Broodstock obtained green	Medium	Medium	High	Low	Medium
D	Imported	High	None	High	High	Low
E	Combination	Low	Low	High	Low	High

Appendix Table 2. Review of North America sturgeon hatchery programs.

Species	Hatchery Name	State	Agency	Purpose	Broodstock Option	Production
White	Hill Creek Hatchery	British Columbia	BC Fisheries	conservation / recovery	TBD	4,000 – 5,000 age 1
White	Kootenai Sturgeon Hatchery	Idaho	Kootenai Tribe of Idaho	conservation	Ripe wild adults	4,000-12,000 age 1 or 2 / year
White	Kootenay Trout Hatchery	British Columbia	BC Fisheries	conservation	Ripe wild adults	?
White	CRIEP	Washington	Columbia River Intertribal	research	Green wild adults	29,000 young of year
White	The Fishery	California	Private	commercial	Imported	50,000 1-150 lbs
White	Stolt Sea Farms	California	Private	commercial	Captive broodstock	not available
White	Pelfry Sturgeon Hatchery	Oregon	Private	commercial	Green wild adults	250,000 post hatch
White	Target Marine Hatchery	British Columbia	Private	aquaculture	Captive broodstock	not available
White	Malaspina College	British Columbia	Malaspina College	education / aquaculture	Captive broodstock	1,000 - 2,000 sack fry / year
White	U.C. Davis	California	University	research	Captive broodstock	10,000 - 20,000 larvae
White	Walter R. Priebe Hatchery	Idaho	College of Southern Idaho	recovery / restoration and research	Captive broodstock & Green wild adults	10,000 - 100,000 larvae
Pallid	Gavins Nat. Fish Hatch.	S. Dakota	USFWS	recovery / restoration	Green wild adults	2,000 - 3,000
Pallid	Garrison Dam Nat. Fish Hatch.	S. Dakota	USFWS	recovery	Ripe wild adults	12,000 10"
Pallid	Bozeman Fish Health Center	Montana	USFWS	research	Captive broodstock	None
Pallid, Shovelnose	Natchitoches Nat. Fish Hatch	Louisiana	USFWS	restoration	Ripe wild adults	35
Lake	Genoa Nat. Fish Hatch.	Wisconsin	USFWS	recovery / restoration	Wild Eggs	20,000 5"-8"
Lake	Wild Rose Fish Hatch.	Wisconsin	Wisconsin DNR	restoration	Wild Eggs	250,000 fry, 50,000 fingerlings, 1,000 yearlings
Lake	Neosho Nat. Fish Hatch	Missouri	USFWS	restoration	Wild Eggs	60,000 2" – 6"
Lake	Pittsford Nat. Fish Hatch.	Vermont	USFWS	recovery	Ripe wild adults	5,000 5"
Lake	Red Cliff Fish Hatch.	Wisconsin	Red Cliff Tribe	recovery / restoration	Wild Eggs	5,000 - 20,000 fry
Lake	Bad River Fish Hatch	Wisconsin	Bad River Tribe	recovery / restoration	Wild Eggs	variable
Lake, Gulf, Shortnose,	Warm Springs Nat. Fish Hatch.	Georgia	USFWS	research	Captive broodstock	5,000 Lake 4" - 7"
Gulf	Welaka Nat. Fish Hatch.	Florida	USFWS	research	Imported	none
Shortnose	Bears Bluff Nat. Fish Hatch.	South Carolina	USFWS	recovery	Captive broodstock	100,000 4"
Shortnose	Orangeburg Nat. Fish Hatch	South Carolina	USFWS	research	Captive broodstock	none
Atlantic	Lamar Fish Technical Center	Pennsylvania	USFWS	research	Captive broodstock	none

6.1 OPTION A: WILD EGG COLLECTION

Wild, fertilized eggs can be collected after spawning and removed to the hatchery for incubation, hatching, and rearing. This approach originated with collection of eggs from substrate mats and transferal to *in situ* incubation capsules to determine fertilized egg viability. The feasibility of a similar, larger scale operation involving transfer to a hatchery was demonstrated in 2001 by successful collection and hatching of eggs collected in substrate mats deployed at Waneta.

6.1.1 Benefits

1. Maximizes opportunity to maintain existing genetic diversity by ensuring that naturally-spawning parents contribute to the next sturgeon generation. Natural production would otherwise be wasted because of little or no recruitment of wild-spawned progeny.
2. Avoids any potentially confounding genetic effects of artificial hatchery mating practices.
3. Avoids risks of capture and hatchery rearing and ensures that some offspring of each parent will have the opportunity to survive if favorable natural conditions occur or are restored.
4. Naturally-produced eggs might ultimately be the only available source of eggs as collection of ripe or even green adults becomes increasingly difficult as the population continues to decline. Previous work indicates that eggs can be obtained from all or most spawning events. In contrast, only a fraction of the available spawners can be captured prior to spawning.

6.1.2 Risks

1. Labor-intensive handling of wild-collected eggs can increase costs and/or reduce numbers of juvenile sturgeon that can be produced in the hatchery.
2. Collection and rearing methods for wild caught eggs may result in poor survival. Survival of juveniles from wild-caught eggs was poor in 2001 although it is unclear if this was the result of collection or rearing methods.
3. Unknown parentage of wild eggs will make it difficult to balance or even evaluate parental contributions to the sturgeon population. It might be assumed that balance is accomplished by natural mating processes but the hatchery provides absolute control over mating combinations and release numbers. The appropriate approach might depend on how confidently we feel controlled practices emulate the desired condition.

6.1.3 Logistics

1. Deploy substrate mats in Waneta spawning area during mid June through late July. Numbers of fish in Arrow Reservoir are too small ($n<40$) to warrant developing a similar program in the Columbia at the Revelstoke spawning area. Collection of large numbers of eggs will require more egg mats and labor than
2. Periodically retrieve mats to check for eggs.
3. Pick eggs from mats and transport to hatchery for jar incubation or transport mats with eggs to hatchery for tank incubation en mass.

4. Consider development of a larger array of mats or other apparatus (RL&L 2001) to obtain eggs more efficiently.

6.1.4 Costs

Mats per crew day = 20 (10 paired sets) [Egg mat cost (each) = $150.00]

Eggs per mat = ~1 egg / mat / day observed, range = 0–625. (We assumed average egg count would increase to 10 eggs / mat / day with increased effort.)

Boat & cost per crew day = ~ $2000

Cost per egg = $10

6.2 OPTION B: BROODSTOCK OBTAINED RIPE

This option involves capture of ripe sturgeon at or near spawning sites and stimulation of spawning within a short period using hormones.

6.2.1 Benefits

1. Provides large cohorts of eggs which enables production of large numbers of sturgeon.
2. Hatchery methods for spawning and incubation of eggs from ripe broodstock are well developed and easy to implement.
3. Produces extra eggs, larvae, and juveniles which can be used for research or experimental purposes or to establish failsafe populations in other areas.
4. Minimizes expense and risk of holding sturgeon for extended periods or of handling wild-collected eggs.
5. Negates need for use of hormone treatments to induce ovulation and spermatogenesis.
6. Broodstock collection efforts also provide current population data useful for monitoring status and population dynamics.

6.2.2 Risks

1. It can be difficult to capture females and males that are ripe at the same time especially as sturgeon numbers decline. Reduced feeding by ripe fish around the time of spawning can also reduce capture efficiency with baited setlines which is the primary capture method. Use of tangle nets is possible but could damage fish. Cryopreservation of sturgeon sperm has not yet been perfected but alleviate this risk in the future.
2. Requires artificial control of mating and release numbers which could affect future genetic stock composition if based on faulty assumptions. Extensive debate of appropriate mating and culling strategies highlights the fact that long term genetic risks of artificial mating and selection practices are poorly understood.
3. Injury or mortality is always a risk of fish capture and artificial spawning. Mortality risks can be reduced by careful handling and spawning. For instance, hand striping

appears less risky than C-section. However, mortalities are likely to occur on occasion despite even the most careful practices.

4. Opportunities for successful natural spawning are foregone when spawners are removed to the hatchery although this is a risk only if favorable natural spawning conditions are restored. However, reduced numbers of natural spawners will also make it more difficult for the monitoring program to identify suitable spawning conditions should they occur because there may be too few natural spawners to take advantage of favorable conditions.

6.2.3 Logistics

1. Deploy setlines in staging areas during spawning periods (mid June – late July).
2. Biopsy female sturgeon to ascertain sex and stage of maturity. If ripe, sperm can be drawn from vent of males using a syringe.
3. Transport ripe males and females to the hatchery for short term holding and inducement of spawning.

6.2.4 Costs

Days fished per ripe female = 8.0 (2001 Columbia R. broodstock collection)

Boat & cost per crew day = ~$2000

Eggs per female spawned = ~6400 eggs taken / female (total available is 25,000 – 50,000)

Cost per egg = $2.5 (Cost may be reduced where additional eggs collected per female)

6.3 OPTION C: BROODSTOCK OBTAINED GREEN

Maturing females can be collected up to one year prior to the spawning season and held until ready to spawn. Spawning induction and methods would then follow those used for ripe broodstock obtained just prior to the spawning season.

6.3.1 Benefits

1. This option provides many of the same benefits obtained by ripe broodstock including large cohorts of eggs, ease of hatchery spawning and incubation, surplus production that can be used for a variety of purposes, and collection of concurrent population data.
2. Green female broodstock can be collected with the same sampling effort used to obtain ripe broodstock for the current year's production with little or no additional sampling costs. Uncertainties over determination of male maturity may preclude use of this "2 year in 1" option for both sexes.
3. Retention of green broodstock for the following year during ripe broodstock sampling may actually reduce sampling costs because fewer ripe fish would be needed every year. Green broodstock may be more easily captured on baited setlines because they feed more readily than ripe fish.

4. Retention of green broodstock for the following year can provide insurance should ripe broodstock collection efforts fail to capture the desired number of fish.

6.3.2 Risks

1. Facility, care, and feeding costs are associated with extended holding of green broodstock. Added costs depend on largely on whether additional space would be required or fish could be supported in the current adult holding space which is otherwise unused during most of the year.
2. Extended holding increases risks of injury (eroded fins, worn extremities) or mortality during captivity or of failure to mature as expected.
3. Presence of wild adults on station can also increase risk of horizontal disease transfer to juvenile sturgeon if adult holding and juvenile rearing systems are not separate.

6.3.3 Logistics

1. Green females would be collected with the same methods and effort used to collect ripe fish.
2. Females identified by biopsy as maturing but not likely to spawn until the following year would be transferred to the hatchery for holding.
3. Alternatively, sturgeon sampling could be initiated in fall or winter rather than late winter and early spring to collect broodstock several months prior to spawning and extend the duration of the broodstock collection opportunity in any given year.

6.3.4 Costs

Days fished per green female = 6.4 (2001 Columbia R. broodstock collection)

Boat & cost per crew day = ~$2000

Eggs per female spawned = ~6400 eggs taken per female

Cost per egg = $2

Any additional costs required for holding and facilities not included.

6.4 OPTION E: BROODSTOCK OR BROOD OBTAINED ELSEWHERE

White sturgeon broodstock or juveniles could potentially be imported from other wild sources or hatchery programs.

6.4.1 Benefits

1. Juvenile outplant needs can be easily accommodated by obtaining excess eggs, larvae, or juveniles from the Kootenai or Columbia River Intertribal Experimental Program (CRIEP) hatchery programs. Eggs, larvae, or juveniles can also be purchased from the private sturgeon hatchery operated in the lower Columbia River.

2. Sturgeon broodstock needs might be accommodated by collection of ripe fish from other portions of the basin where they are more abundant.
3. Outside sources could be used to reintroduce white sturgeon into the upper Columbia River should conservation efforts fail.

6.4.2 Risks

1. Introduction of sturgeon from other parts of the basin would likely dilute or replace the endemic stock. Genetic differences among sturgeon substocks in the Columbia and Snake River basins are unclear although the Kootenai population is known to be unique. The upper Columbia sturgeon stock is also likely to be genetically different from sturgeon elsewhere in the basin. Sturgeon from other parts of the basin may be poorly adapted to conditions in the upper Columbia River and may be even less productive than the endemic stock.
2. Imported sturgeon can pose disease risks to local stock in the hatchery and potentially the wild.

6.4.3 Logistics

1. Importing non-local stock would require concurrence from the Provincal and Federal agencies and also fish transportation and CITES permits from state and Federal U.S. agencies.
2. Arrangements would also need to be negotiated with agencies providing the sturgeon or regulating the source population.

6.4.4 Costs

Kootenai stock: eggs, larvae and small juveniles may be available at no additional cost

CRIEP (mid-Columbia stock): likely to be available at no cost when as program continues to develop.

Lower Columbia stock: juveniles available from private sturgeon hatchery at approx. $0.50 (CDN) per cm. ($30,000 CDN to purchase 4,000 15-cm fish)

6.5 OPTION F: COMBINATION

Rather than selecting any single broodstock option, the program may elect to use a combination of the alternatives or to change options in the future as the program develops and the wild sturgeon population continues to decline.

6.5.1 Benefits

1. Use of a combination of broodstock collection alternatives balances the strengths and weaknesses of the different options.
2. Collection of ripe broodstock from current year collections and green fish from prior year collections may provide a hedge against difficulties in capture of ripe fish while

also reducing effort and cost of broodstock collection efforts. Net program costs might also be reduced if costs of holding green broodstock are nominal.

3. Supplementation of ripe and green broodstock with wild egg collection also provides a way to optimize the preservation of existing genetic diversity in the wild population while also ensuring that sufficient juveniles are released.
4. A combination approach might also optimize use of available space and preclude the need for additional hatchery facilities to meet minimum conservation requirements.

6.5.2 Risks

1. Use of a combination of approaches complicates operation of the hatchery program and may not be feasible if space and personnel needs conflict.
2. There is a likely a tradeoff between total hatchery production of sturgeon and use too many broodstock methods. Numbers of juveniles that can be reared will likely be greatest when operations are limited to the most efficient alternative (ripe broodstock) as long as this alternative continues to provide a ready source of fish.
3. Heavily loading the hatchery space and system with a complicated combination of approaches increases risks of operational and disease problems and reduces the flexibility to deal with those problems when they occur.

6.5.3 Logistics

As per individual alternatives.

6.5.4 Costs

As per individual alternatives.

6.6 REVIEW OF STURGEON HATCHERY PROGRAMS

6.6.1 White Sturgeon

Name: Hill Creek Hatchery ***Species:*** White
Purpose: conservation/recovery
Production: 4-5 families per year, 1,000 age 1 juveniles released per family
Broodstock: Annual collection from ripe wild
Background: Carefully controlled releases, mating protocols, and rearing methods
****
Name: Kootenai Fish Hatchery ***Species:*** White
Contact: Sue Ireland ***Phone:*** 208-267-3620
Purpose: conservation/recovery
Production: 4-12 families per year, up to 1,000 age 1 or 2 juveniles released per family
Broodstock: Annual collection from ripe wild
Background: Carefully controlled releases, mating protocols, and rearing methods
****
Name: Kootenay Trout Hatchery ***Species:*** White
Purpose: conservation/recovery
Production: Variable
Broodstock: Annual collection from ripe wild
Background: Fail safe facility for Kootenai Fish Hatchery
****
Name: Columbia River Intertribal Experimental Program (CRIEP)
Contact: Blaine Parker ***Phone:*** 503-235-4228
Purpose: supplementation research
Production: First year on this project, Hatched 29,000 fish on June 1,2001
Plan to raise 3 yr classes 0+, 1+, and 2+ for release back into the wild
Broodstock: Don't hold any broodstock, collect, spawn and then release
Catch fish @ McNary Reservoir between the Dam and Sanke River. Hold near the dam using river water in 10ft circular tanks. Collect in March or April and release before September. Allow fish to mature naturally and then induce with hormone. Follow similar protocol as Kootenai, Supply live suckers as feed,
Hand strip females
1 radio tagged female (held 17 months) – currently tracking
Background: No cost info broken down, Draft EIS available from Colleen Spearing w/BPA
****
Name: The Fishery, CA ***Species:*** White
Contact: Ken Beer ***Phone:*** 916-687-7475
Purpose: food, caviar
Production: 50,000 all sizes, 2-15 lbs – meat fish to Japan, 15-20 lbs – meat fish, 50-150 lbs – caviar fish
Broodstock: none
Contract spawning out to Stolt Sea Farm, Sell Caviar to Stolt
Background: none
****

Name: Stolt Sea Farm, CA ***Species:*** White
Contact: Peter Strofenager ***Phone:*** 916-991-4420
Purpose: Food, Caviar
Production: not available
Broodstock: number of broodstock not available
Raised from eggs - most progeny of domestic females x domestic males, some wild females x domestic males, and some wild females x wild males
Spawn via C-section, Regulate spawn timing with temperature and hormones
Background: Large scale, high tech effort
****
Name: Pelfry Sturgeon Hatchery ***Species:*** White
Contact: Henry Pelfry ***Phone:*** 503-669-8000
Purpose: commercial
Production: 250,000 post hatch
Broodstock: 2-3 females per year from wild
Background: Hold over from early CA facility need to import juveniles from wild broodstock
****
Name: Target Marine Hatcheries ***Species:*** White
Contact: Joyce Francis ***Phone:*** 604-885-4688
Purpose: private aquaculture
Production: not available
Broodstock: number not available, spawn via C-section, use hormones,
Previously worked in cooperation with Malaspina College
****
Name: Malaspina College ***Species:*** White
Contact: David Lane ***Phone:*** 250-741-8764
Purpose: education, commercial aquaculture
Production: eggs for Target Marine Hatchery and M. and E.
Few thousand sack fry of each year class for education
Broodstock: 1 to 2 females / year, captive broodstock originally from Fraser River Stock
c-section, similar method to U.C. Davis, use LHRH, spawn in stretcher,
hold in 44,000L tank for majority of year, move to 10ft circular prior to spawning, finally move to 2.5ft x 2.5ft x 8 ft tank at the last minute prior to spawning.
Background: has published reports in the past, nothing recently
****
Name: University of California, Davis ***Species:*** White and Green
Contact: Joel Van Eenennaam ***Phone:*** 530-752-2058
Purpose: research and development, Currently researching the effects of strontium on reproduction
Production: 10,000-20,000 larvae this yr, Production depends on the project, Sometimes produce up to 50,000
Broodstock: 40 adult white sturgeon raised from eggs
Spawning depends on project – usually c-section (100% survival rate)
Green Sturgeon – raising yr. Classes to broodstock
Background: Annual Reports (14 yrs) given to California Fish and Game
Numerous research specific reports available
****

Name: College of Southern Idaho ***Species:*** White
Contact: Terry Patterson ***Phone:*** 208-733-3972
Purpose: restoration - stock into Snake R., working with IDFG and commercial aquaculture
Research – potential for aquaculture
Production: 10,000 – 100,000 larvae / yr, Released into wild as yearlings
Broodstock: 300 adults – progeny of wild captures since 1979
Also capture wild brood from Snake River
Capture 1 year prior to spawning using hook and line, hold for up to 2 months after spawning
Regulate spawning using LHRH and temperature, Spawn via C-section unless able to hand strip
Background: IDFG has publications, Dr. Scott La Patra, WSIV
****

6.6.2 Other species

Name: Gavins Point National Fish Hatchery – S. Dakota
Species: Pallid, Shortnose (in the past)
Contact: Herb Bollig ***Phone:*** 605-665-3352
Purpose: mitigation stocking – tribal lands, military lands, endangered sp., some research
Production: No shovelnose – used as surrogate species
Pallid – currently fighting iridiovirus working with FHC, not stocking right now
Usually producing 2,000 – 3,000 for stocking
Broodstock: Collected from Yellowstone and Missouri R. using sinking gill nets, trammel nets
Hold 8 months prior to spawning and 4 – 12 months after
Hand strip, use LHRH, don't use c-section because of high mortality
Future broodstock – 330 14" –32"
Background: Steve Krentz, N. Dakota for info or reports on Pallid sturgeon - 701-250-4419
****
Name: Garrison Dam NFH ***Species:*** Pallid
Contact: Rob ***Phone:*** 701-654-7451
Purpose: recovery
Production: variable, Now 12,000 on hand, usually 10", Release to wild
Broodstock: trammel net above Ft. Peck in Montana, and the mouth of Yellowstone and Missouri rivers
Have collected in fall (low water) and held over winter, or in April and release in 2-3 weeks, This year collected immediately prior to spawning, spawned on river and then released next day, Use LHRH and GNRH
Background: Have annual reports if interested
****
Name: Bozeman FHC ***Species:*** Pallid
Contact: ***Phone:*** 406-582-8656
Purpose: research – iridioviral agent presence in broodstock, yearling and young of year
Production: Do not raise any fish
Broodstock: 300 captive sturgeon monitored for viral presence
****

Name: Natchitoches NFH- Louisiana
Species: Pallid, Shovelnose
Contact: Jan Dean
Phone: 318-352-5324
Purpose: restoration
Production: variable, in 1998 produced 35, haven't successfully spawned since
Broodstock: Collect wild stock from Mississippi River, use gill nets, in March and April
Capture just before spawning, hold 2-3 weeks, small fish 4-10 pounds,
Use water temp and LHRH – priming dose to M & F, resolving dose 12 hrs later to F, spawn 20-72 hrs after initial dose.
Use Russian spawning technique, nick membrane with scalpel and massage eggs out.
Background: Also working on wild populations looking at hybridization, mark recapture study, 50-60 fish per month for 6 months, hold fish for 10 days, take measurements, do genetic studies.
Have annual report – request from Karen Kilpatrick (mgr)
****

Name: Genoa NFH – Wisconsin
Species: Lake
Contact: Rodger Gordan
Phone: 608-689-2605
Purpose: restoration
Production: 20,000 5"-8" juveniles, Release into tribal waters for stock enhancement – in areas where the wild stock need supplementation or no wild fish
Broodstock: No broodstock, Collect wild eggs using salmon landing net
Background: none
****

Name: Wild Rose Fish Hatchery, WI
Species: Lake
Contact: Steve Fajfer
Phone: 920-622-3527
Purpose: recovery – re-establish into native ranges (Wisconsin and Minnesota)
Production: Highly variable due to small populations and limited availability
250,000 fry, 50,000 fingerlings (3"-8"), 1,000 yearlings (10"-12"), release in wild
Broodstock: No broodstock, Collect eggs from wild close to where desired population will be established
Background: Feed costs - $.20 - $.30 per fingerling
Dry food does not work on Lake Sturgeon – no commercial products work
Published in Progressive Fish Culturists – article on fish tank densities
****

Name: Neosho NFH – Missouri
Species: Lake
Contact: Dave Hendricks
Phone: 417-451-0554
Purpose: restoration / recovery
Production: 60,000 total this year, 40,000 2", 18,000 6" released in Round Lake and White Earth Lake in Minnesota on the White Earth Indian Reservation
Broodstock: None
Eggs come from the Rainy River strain in Canada
Background: USFWS has a pamphlet published called "Lake Sturgeon: Giants of the Great Lakes" available on their website
****

Name: Pittsford NFH – Vermont ***Species:*** Lake
Contact: Doug Lawson ***Phone:*** 802-483-6618
Purpose: recovery, Research – practice sturgeon culture for future recovery in Lake Champagne area
Production: Produced fish for 2 yrs, 5,000 - 5" 1st year, 2,500 – 5" 2nd year
Wild released into Black River, Black Lake, Cayuga Lake, St. Lawrence River
Broodstock: Collected from the St. Lawrence River. Caught with seine net, injected with hormone, small incision made and eggs
Spawned in tanks on the bank during spawning season, collected throughout the day, Held 2-3 days total
Last year took all eggs from one female, some went to a state hatchery in New York and the rest went to Pittsford – all fry (both locations) died, wouldn't absorb yolk sack, thought to be a genetic problem
Background: Working on report to publish in PFC journal, also have video of spawning techniques, Call for more information.
****
Name: Red Cliff Tribe, WI ***Species:*** Lake
Contact: Greg Fisher ***Phone:*** 715-779-3728
Purpose: restoration
Production: 5,000-20,000 fry to yearlings (up to 12")
Broodstock: None, collect wild eggs, raise fish and restock into same watershed
****
Name: Bad River, WI ***Species:*** Lake
Contact: Rick Huber ***Phone:*** 715-682-7105
Purpose: restoration
Production: varies from year to year depending on demand, usually release as sack fry to 8"
Broodstock: None, collect wild eggs, raise fish and restock into same watershed, on the reservation
Background: Working with Genoa, Neosho, Wild Rose, Red Cliff, Ashland Fishery Resources – Great Lake Sturgeon Project.
****
Name: Warm Springs National Fish Hatchery ***Species:*** Lake, Shortnose, Gulf, Atlantic
Contact: Brian Hickson ***Phone:*** 706-655-3382
Purpose: Research, reintroduction
Production: variable – depends on project, Lake – 5,000 4"-7" for reintroduction
Broodstock: Shortnose – Broodstock 20-30 awaiting permits prior to breeding, limited release of radio tagged fish, all domestic – initial take in the late 1980's
Gulf – 20 brood stock, F1 generation, collected as adults by U. of Florida
Strip spawn – 5-7 strips throughout cycle
Background: Found that strip spawning works better for them
Experimenting with hormone therapies, currently using carp pituitary – works well
Experimenting with Triploids – successfully produced
Use live feed for juveniles
Adult fish go off feed after spawning – experimenting with nutrition
Numerous reports available on Broodstock experiments – call for more info.
****

Name: Welaka National Fish Hatchery (NFH) - Florida ***Species:*** Gulf
Contact: Alan Brown – mgr ***Phone:*** 386-467-2374
Purpose: research - diet, density, sterilization of radio tagged fish
Production: Produce 10-12,000 fish/ yr. – destroyed after research is completed
Have 300 fish ages 0-7yr
Broodstock: Have older fish – not broodstock, Collect fish form Suwanee R. using gill nets
Work with USGS lab in Gainesville
Surgical spawning, Use hormones
Background: Panama City Fish Offices has written a paper on spawning techniques
Warm Springs Regional Fish Center can provide more information on sturgeon programs.

****

Name: Bears Bluff National Fish Hatchery ***Species:*** Shortnose
Contact: Kent Ware ***Phone:*** 843-559-2315
Purpose: recovery – endangered species
Production: 100,000 4" fish / yr, shipped out for research - not released in wild
Broodstock: 80 fish raised in captivity, Hand strip spawning using carp pituitary hormone
Conditioned by temperature from October to February – spawn in March
Background: report available on spawning protocol – request from Warm Springs

****

Name: Orangeburg National Fish Hatchery – S. Carolina ***Species:*** Shortnose
Contact: Willard ***Phone:*** 803-534-4828
Purpose: development and technology research
Production: maintain broodstock – no release into wild
Broodstock: 500-1000 fish, Originally from Savannah river, some F2 and F3 generations
Collected by net (didn't specify what type), Spawned using C-section and hand striping
Background: no published reports, have records and data

****

Name: Lamar Fish Technical Center ***Species:*** Atlantic
Contact: Bill Fletcher ***Phone:*** 570-726-4247
Purpose: research – culture techniques, work with ASMFC
Production: No production for release in the wild, work with small hatcheries to provide fish
Example – New York tagged 4,500 fish for population estimates
Maryland tagged 3,000 fish for population estimates
Have 5 yr. Classes from captured wild broodstock
Broodstock: Captured wild stock from Hudson River using gill nets
1998 last year they spawned fish, use hormones, Caesarian – vent entry
Background: Have numerous published papers on sturgeon culture
Draft of culture manual – contact Jerre Mohler ext. 29

****

7.0BREEDING PLAN

Upper Columbia White Sturgeon Conservation Fish Culture

March 2002

By Susan Pollard

7.1 ACKNOWLEDGEMENTS

Special thanks are extended to Colin Spence and Steve McAdam for providing much of the background information necessary to complete this document. In addition, their comments throughout the development of the document were extremely useful. Thanks are also extended to Paul Anders, Ray Beamesderfer and Bernie May for their supportive reviews and useful comments and suggestions.

7.2 INTRODUCTION

Recent studies by British Columbia and U.S. fisheries agencies indicate that the Columbia River white sturgeon population above Grand Coulee Dam is in serious decline. In British Columbia, the Canadian portion of this population was listed as “endangered” in 1994 by the Conservation Data Centre, primarily based upon the observed recruitment failure in the Columbia River downstream of HKD. Damming of the Columbia River has led to numerous changes to white sturgeon habitat including fragmentation, altered river hydrology, loss of riverine habitat, altered water quality and system productivity. , These effects have been exacerbated by impacts such as pollution and waterfront developments. The net result of these impacts is a white sturgeon population that is declining due to recruitment failure.

A joint US-Canada recovery planning process is underway for the Upper Columbia white sturgeon population above Grand Coulee Dam. The purpose of the recovery initiative is to stabilize the remaining populations and prevent further declines and extinction, ultimately to rebuild a self-sustaining population. At present, it is unclear what factor or combination of factors is producing the recruitment failure observed in the Upper Columbia population. However, studies of the Kootenai River white sturgeon population and other sturgeon populations worldwide suggest that major physical alterations to habitat (e.g. associated with hydroelectric and flood control facilities) result in major ecological alterations that can result in recruitment failure.

The current demographics of the population further emphasize the need for immediate action. The oldest documented individual in the upper Columbia population is 65 years of age and the average age at first maturity for females is estimated at 30 years (RL&L 1994, 1996a, 1996b). Assuming a typical mortality curve, the average age of parents is likely 40-45 years (RL&L 1995). The current size of the population is estimated to be 1,100, and only very limited natural recruitment has been observed since the mid-1970’s. Thus, more than 3 decades have passed with very limited or no population replacement, resulting in a significant gap in the age structure of this population. Based on these parameters, and continuing decline if recruitment failure continues indefinitely, the sub-population can be expected to reach extinction in about 50 years. Functional extinction will be reached much sooner, and the smaller remnant populations in the lakes are expected to disappear much faster.

Recruitment failure does not appear to be associated with the lack of spawning as spawning events have been documented regularly. Extensive study has confirmed spawning by upper

Columbia white sturgeon at two locations. The vast majority of documented spawning occurs at the Pend d'Oreille-Columbia confluence (Waneta tailrace) area near the Canada-US border (RL&L 1994, 1996a, 1996b). Spawning at this site has been identified annually since 1993 - the first year spawning studies were initiated. The number of spawning events has varied between four and nine over the years of study, providing some indication of the minimum number of females involved in these activities each year. In 1999, a second spawning area was documented in the upper Columbia in the Columbia River just upstream of Arrow Reservoir (RL&L 2000). Spawning was not detected at this site in 2000.

Despite the regularity of spawning events, age structure analyses show that recruitment began to decline in 1969, and has failed entirely since 1985 (RL&L 1994). Changes in the length-frequency distribution follow a similar pattern, with a dramatic reduction in representation by smaller fish in ongoing sampling programs (RL&L 1996a; BC Ministry of Water, Land and Air Protection, data on file). Sampling in Lake Roosevelt in Washington State, although less intensive, shows a similar pattern (DeVore et al 1999; Spokane Tribe, data on file).

Although there is clear evidence that recruitment in the upper Columbia white sturgeon population has failed completely, little information exists regarding the nature of the survival bottleneck. Preliminary hatchery releases of juvenile sturgeon in other rivers have found that cultured sturgeon released at one or more years of age have high post-release survival rates (Ireland and Beamesderfer, unpublished data). Therefore, it is believed that recruitment of wild sturgeon is failing at some point between fertilized egg and one year old juveniles. This conclusion is consistent with declines observed in other North American sturgeon populations (Anders et al. *in press*, Secor et al. *in press*).

A key task identified in the Upper Columbia Recovery Plan currently under development is to implement a conservation fish culture program similar to that developed for the Kootenai River white sturgeon population. Such a program can act immediately, serving as an interim measure to preserve the population's genetic and demographic structure. In addition, rebuilding the age structure will increase the probability of future natural recruitment by ensuring the availability of reproductively viable individuals. Finally, cultured fish can facilitate a variety of research initiatives that help reduce the uncertainty associated with many components of the recovery program, as well as sturgeon management in general.

Following a review by the BC Ministry of Water, Land and Air Protection's Fish Culture Section early in 2000, the Hill Creek Hatchery near Nakusp was selected as the location for development of a pilot conservation fish culture facility for the Upper Columbia sturgeon. The existing Hill Creek Hatchery, originally designed to culture bull trout, underwent extensive facility modifications to accommodate an experimental sturgeon culture program. Broodstock collection began in early 2001 with first cultured progeny expected to be ready for release as yearlings in the spring of 2002.

7.3 GOALS OF THE CONSERVATION FISH CULTURE PROGRAM

The two main goals of the conservation fish culture program for Columbia white sturgeon are:

I. *Conservation goal* - to prevent extinction and preserve genetic variation of the population in the short-term, and restore age structure and maintain genetic variation over the longer-term

II. *Research goal* - to provide juvenile white sturgeon to assist in identifying life stages(s) where recruitment failure may be occurring and specific mechanisms responsible for this failure

Both goals are high priorities and will be simultaneously implemented. In the near future, the only significant source of recruitment for the Columbia River population will be from the culture program. Therefore, the size of the program must be adequate to address the genetic and demographic issues related to a very limited population size. This program will provide a stop-gap measure to re-establish age structure and preserve genetic variation. However, longevity and delayed onset of sexual maturation (i.e. approximately 30 years for first female reproduction) necessitate a long-term commitment for the hatchery program for at least a generation in the continued absence of natural recruitment. Secondly, the experimental release of tagged individuals at various juvenile stages followed by post-release evaluation is essential to determine the most appropriate age for release and to help to determine the reason for recruitment failure.

The following section outlines a breeding plan for a Columbia River white sturgeon conservation fish culture program from brood collection to juvenile releases. Many of the concepts in this plan are based on the concepts outlined in the *Breeding Plan to Preserve the Genetic Variability of the Kootenai River White Sturgeon* (Kincaid 1993) but have been adapted to suit the specific population characteristics of Upper Columbia River white sturgeon. The recommendations in this breeding plan take into account the constraints associated within uncertainty about juvenile survival rates and the likelihood of decreased broodstock availability over time. However, the plan does not attempt to account for facility constraints such as hatchery capacity. The purpose of this plan is to highlight the important concepts of conservation fish culture and to provide guidelines to fisheries managers for the Upper Columbia White Sturgeon Conservation Fish Culture Program.

7.4 BREEDING PLAN

7.4.1 Duration

The conservation fish culture program is considered temporary although it will require a long-term commitment given the delayed maturation of white sturgeon. The program will be terminated when natural reproduction is successful enough to consistently maintain the desired population size. This goal needs to be quantified (i.e. define how consistently, etc.). However, this is beyond the current state of knowledge, and the scope of this plan.

The recovery program must commit to maintaining the breeding program annually for a minimum of one generation to re-establish age structure. Generation length is defined as the average age of spawning. For the Upper Columbia white sturgeon population this period is conservatively estimated to be 50 years (value provided to IUCN, C. Spence, pers. comm.). Although the approximate age of first maturity in the Upper Columbia population is 27 for the youngest female (30 years is probably closer to the average) and 16 for the youngest male (20 years is probably closer to the average), the mean age of parents is closer to 40-45 years or more (RL&L 1994, 1996a). If after one generation, natural reproduction is still not restored, the conservation fish culture program must be re-evaluated to determine the appropriateness of the goals and the likelihood of success (although earlier evaluation is also essential).

7.4.2 Recruitment Goal

The recruitment goal of the Kincaid plan (1993) is "4-10 adults" per family. This goal was established to ensure a slowly expanding population size that would not overwhelm the mature natural population in terms of recruits per family and was designed to compensate for nearly 20 years of failed recruitment. However, this conservative approach needs to be weighed against the risk of losing the Columbia population through demographic extinction. Recruitment in the Upper Columbia River has failed entirely for at least 15 years, and was in rapid decline for at least another 15-20 years beforehand. The breeding program should be designed to create an adequately-sized founder population upon which all future recruitment will depend. Therefore, the breeding program must be designed to (1) protect the genetic diversity in the remaining Upper Columbia population and (2) ensure that enough individuals will be available for the next generation to avoid small population demographics (including genetic bottlenecks). By the time the released progeny have reached maturation, there may be too few mature individuals remaining of the natural population to contribute significantly to natural recruitment since the youngest of these fish will be at least 50-60 years of age.

A more aggressive approach is recommended for the Upper Columbia population at least initially to "jump-start" the rebuilding process. This will help mitigate the possibility that fewer reproductively viable sturgeon will be available for the program in the future as the population continues to decline. In addition, this approach will help address the lack of information regarding survival rates for hatchery-produced fish.

The recruitment goal for the breeding plan can be equated to the recovery goal for the Upper Columbia white sturgeon population. The recovery goal has been set at 2,500 adults of breeding age (based on COSEWIC determination stated the main recovery plan objectives), which is slightly double the current estimated population. If the breeding program is run for a minimum of 50 years, a minimum of 50 adults per year for 50 years will be required to meet the recovery goal.

7.4.3 Effective population size and Recruitment

To prevent short-term genetic losses associated with inbreeding and random genetic drift, geneticists recommend a minimum effective population size (N_e) of 200 adults (100 females and 100 males) per generation to sustain a hatchery population (Allendorf and Ryman 1987). However, in order to maintain the original level of genetic variation (including rare alleles) and its long-term adaptive potential, a minimum N_e for an isolated population is more in the order of 500 (Franklin 1980). Based on several years of sampling, natural recruitment of the Upper Columbia population appears to be effectively zero (RL&L 1996a, 1996b, 1994). Given that the future genetic potential of the Upper Columbia sturgeon population will be entirely dependent on hatchery production in the near future, using 500 adults over the course of 50 years is more appropriate. In addition, the removal of wild fish for broodstock will not need to be limited to avoid impacts to natural reproduction (since none is successful). Realistically, it may be impossible to collect 500 wild spawners over 50 years but efforts should be made to approach this goal. This goal should be re-evaluated if and when natural reproduction does begin to contribute to recruitment.

7.4.4 Recruitment Constraints

The annual recruitment goal (50 adults/year) does not take into account the possibility of few or no broodstock in later years of the breeding program. To address this issue, a higher recruitment goal during the first half of the program is recommended to capitalize on the availability of broodstock and to ensure the 2,500 goal can be met. In addition, the annual mortality rate expected for hatchery-raised adults (after they have reached maturity) needs to be incorporated into the annual recruitment goal.

7.4.5 Broodstock Collection

Spawner numbers

A minimum number of fish to protect existing genetic variation is 5 pairs of brood fish per year (= desired N_e of broodstock/generation length = 500/50). Ideally, this number would be consistently collected every year (i.e. broodstock would remain easy to capture) with all matings successful. Such a scenario is unrealistic for the Upper Columbia system and involves many unpredictable variables. For example, population projections suggest that the wild population will continue to decline making broodstock collection more difficult over time. In fact, there may be an extended period where very few remaining wild spawners exist and the first cohorts from the hatchery production are not available. Therefore, this recovery initiative should focus on maximizing the number of broodstock collected per year initially, at least while no natural recruitment is occurring. In terms of genetic conservation, it is better to produce more families with fewer individuals, than fewer large families. The rearing facility will likely be the major constraint limiting rearing capacity. The annual broodstock goal will require adjustment if natural recruitment becomes evident and when the hatchery cohorts are recruited into the spawner population.

Spawner accessibility

The situation for the Upper Columbia population is similar to the Kootenai population in that the locations where spawners occur each year are known, and spawners are relatively straightforward to obtain presently. 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, milt is collected on the river and transported to the hatchery. However, there were problems initially with this technique (P. Anders, personal communication), and its reliability needs to be confirmed before the Upper Columbia breeding program can consider becoming dependent on this method as a source of milt. Some spawning failures due to egg viability were encountered for the Kootenai program. In addition, the first year of the Upper Columbia program suggested that some variability among females may exist[2]. It is recommended that as many females as possible be collected. Similarly, it is presently unknown whether there will be greater spawning success associated with males captured and held in captivity (and induced to spawn) or males captured during the spawning season. Until more information is available, it is recommended that as many males as possible be collected annually. Cryopreservation is a definite option to preserve any excess milt available (but see discussion further on).

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[2] Hill Creek Hatchery 2001 results based on 6 families using 2 females and 4 males indicated that hatch rates associated with families from female 2 were in excess of 95% (4 families) while those associated with female 1 were 30% and 40% (2 families). However, the lower survival rates for female 2 may also be associated with other factors. For example, one of the males was used on July 30 with female 2 and then again a month later with female 1 on August 23.

Sex skewness

Most white sturgeon studies report a bias towards males in collections. Females in spawning condition appear to be the limiting factor in the Kootenai program (Kootenai Tribe of Idaho 2000). However, the sex ratio observed in the Upper Columbia appears to be less biased – 1.35 males: 1 female (n=94). Sex bias may be less of an issue for the Columbia program although estimates from field sampling may differ considerably from sex ratios associated with spawning individuals within a given year. Information on sex ratios will become available as the recovery program progresses.

Survival in captivity

Long-term (up to 2 years) maintenance of wild-caught adult sturgeon in captivity is conducted regularly for Snake River white sturgeon at the College of Southern Idaho for conservation and aquaculture purposes (Terry Patterson, pers. comm.). However, it has only been carried out on an experimental basis in B.C. (Malaspina College). This option should probably be avoided given the uncertainties and costs associated, unless yearly broodstock goals become impossible to meet.

Based on recent experience and success expected in meeting pilot project white sturgeon broodstock goals for the Upper Columbia program (Colin Spence, pers. comm.), it is unlikely that adults will need to be held long-term. However, some consideration may be given to holding females for up to a year if they cannot be induced to spawn in the first year. Similar to long-term captive breeding, this option should also be avoided given the uncertainties and costs associated, unless yearly broodstock goals become impossible to meet.

Percent to spawn in captivity

At present, it is unknown how many individuals will actually contribute to spawning activities each year of the program. For example, a significant proportion (30-40%) of non-ripe females brought into captivity may not progress to ripe stage because of physiological changes associated with the stress of capture (Conte et al. 1988). As mentioned above, some failure associated with females occurred with the Kootenai program, possibly due to the inability to control water temperatures at the Bonners Ferry hatchery. Since temperature can be strictly controlled at Hill Creek Hatchery, this may not be a problem but needs to be confirmed. For reference, fertilization and hatching rates have ranged from 6% to >99% and 1% to 90%, respectively, among years for the Kootenai breeding program to date. Similarly, Hill Creek results for 2001 indicate hatch rates of approximately 30% to >95% (D. Koller, pers. comm.). Average egg to larval survival rates range from less than 1% to 73%, the higher values occurring in more recent years (Kootenai Tribe of Idaho, 2000 data).

7.4.6 Broodstock Maintenance

A secure, short-term holding facility for spawners, particularly females, and initially males is required to induce spawning. Induction involves a combination of temperature/ photoperiod/hormone treatments and will require a fairly sophisticated physical plant/hatchery facility and a high degree of technical expertise with the support of professional fish culture biologists, technicians and managers to succeed. A more extensive facility including maturation tanks may be required if fish are to be held for up to a year or more.

7.4.7 Mating

Mating schemes are designed to maximize the genetic effective population size N_e, thus reducing the likelihood of inbreeding. This is particularly important where the broodstock size is small. One primary goal is to equalize genetic contributions of all spawners. The simplest plan is to conduct 1:1 spawning where each male and each female are only used once. However, where gamete viability is variable or unknown, sex ratios are unequal, or numbers are critically lower than facility capacity (e.g. each individual represents >10% of the total broodstock), variations on the 1:1 plan are recommended.

There has been some failure associated with egg viability in the Kootenai culture program, gamete splitting is recommended to ensure that each male and female has more than one opportunity to reproduce[3]. Such designs can create a number of half-sib families in offspring that could potentially increase inbreeding levels in the next generation if the half-sibs were to mate. However, this is an acceptable risk to take. Maximizing the total number of contributing individuals each year is the most important goal. In addition, the possibility of half-siblings mating in the future is probably very low given the life history of white sturgeon. Both sexes of white sturgeon have different spawning periodicities, are iteroparous, have highly overlapping generations and are broadcast, communal spawners. These traits increase the effective population size of spawners for any given year and reduce the likelihood of half-sib matings.

It is recommended that all broodstock be marked or permanently tagged, sampled for tissue (for DNA identification) and released back into the wild once they have been spawned (although reconditioning, including return to fish-based diet, should be considered if spawners were taken off a natural fish diet). Given that sturgeon likely contribute to the next generation multiple times throughout their life span, re-captures in future broodstock collections can be considered for broodstock after 5 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).

The following guidelines were adapted from Kincaid (1993), and Miller and Kapuchinski (in press). Ideally, equal numbers of males and female broodstock would be captured and successfully mated every year, with equal numbers of families contributing from year to year, and equal numbers of progeny per family released. This would equalize family contributions and prevent the over-representation of some families or individuals. However, the availability of spawners will vary from year to year and is expected to decrease over time. In addition, survival rates of progeny upon release are currently unknown. The situation for the Upper Columbia white sturgeon population is far from ideal and the priority is to ensure that adequate numbers of individuals are present in the next generation. This goal may comprise equalization goals, at least initially while questions regarding survival remain.

The capacity of the rearing facility at Hill Creek Hatchery presently limits the number of progeny that can be raised to 12,000 30 g fish (approximately 1 year old), and the maximum number of families that can be raised separately is 4 (D. Koller, pers. comm.). This capacity is below that recommended to meet genetic requirements but will be discussed later. The

[3] Note that 6 of 8 families created for the Kootenai program in 1999 (using 4 females and 8 males) had a high rate of early survival during the onset of self-feeding, and hatch success averaged nearly 80% for these families. The remaining 2 families had extremely low rates of success (less than 200 individuals).

guidelines include scenarios greater than and within this capacity. Rearing will be discussed in the following section. These recommendations assume that maturation of most fish can be synchronized artificially with hormone injections of LHRHa (lutenizing hormone releasing hormone analogue). However, if synchronization is impossible, each group of spawners will have to be treated separately. Techniques to store milt over the spawning period should be investigated.

Mating Scenarios

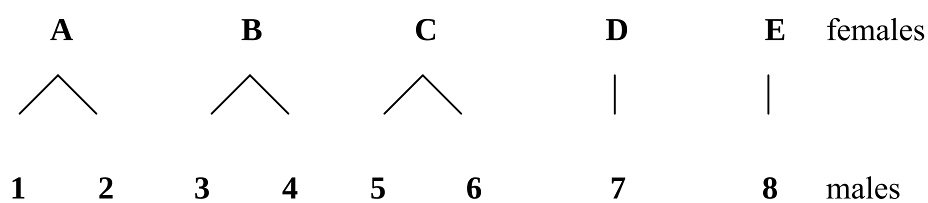
(a) 10 or more males and females available

Conduct 1:1 matings unless more than 20% of either sex is expected to be infertile. If males are in excess of females, split eggs of females so that each male contributes at least once. Similarly, if females are in excess of males, split milt of males so that each female contributes at least once. If infertility of either sex exceeds 20%, both milt and eggs should be spilt to create a minimum of two half-sib families per parent.

(b) 5-9 males and 5-9 females

Conduct 1:1 matings unless more than 10% of either sex is expected to be infertile. If males are in excess of females, split eggs of each female so that each male contributes once. If infertility of either sex exceeds 10%, both milt and eggs should be spilt to create a minimum of two half-sib families per parent.

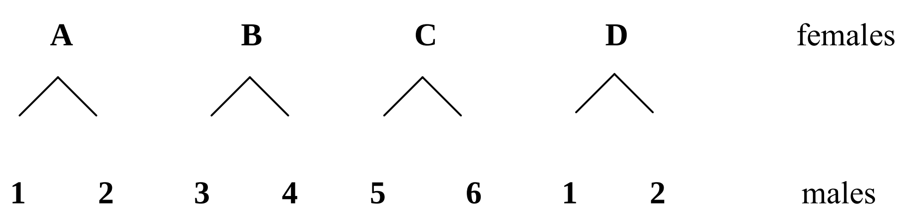
e.g. 8 males, 5 females



(c) 5-8 males, 3-4 females

Ensure that each female's eggs are split at least twice and use each male at least once. If there is a concern regarding using some males more than once (over-contribution), wait to see if there are any infertility issues and if no problems occur, or if space is an issue, destroy half-sib families.

e.g. 6 males, 4 females (could destroy A2 and D1 if no infertility issues arise)

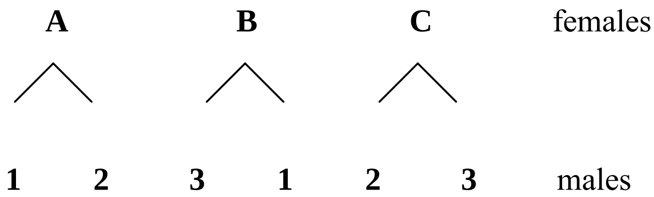


Note: Kincaid (1993) recommends that males be used only once in each case, even when numbers are extremely low. However, Kincaid's plan was based on the fact that the capture of ripe males was fairly straightforward. It is too risky at present to assume that every male will successfully spawn or that more ripe males can easily be obtained in-season for the Columbia program.

(d) Equal sex ratio – 3-4 of each sex

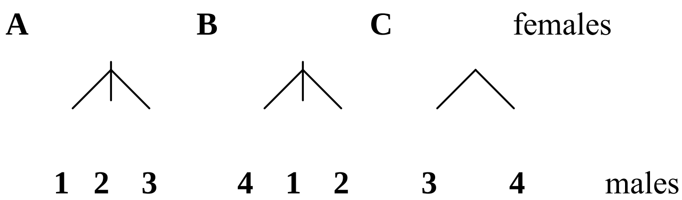
To ensure all individuals have at least one chance to contribute, a number of half-sib families can be created by splitting each egg batch in half and fertilizing with a different male. Each individual makes an equal contribution.

e.g. 3 males, 3 females

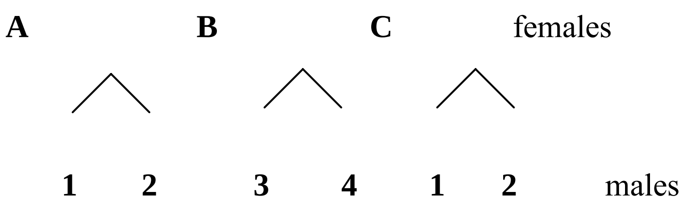


(e) 4 males, 3 females

Split eggs so that each male can make contributions to at least 2 females' eggs.



or

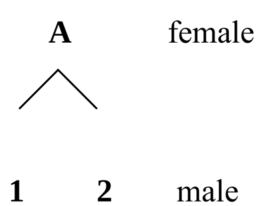


In both cases, once fertility for all families is confirmed, extra half-sib families may be destroyed after incubation so each male only contributes once if over-contribution of males is a concern or space is an issue.

(f) Equal (1-2 of each sex) or skewed ratio (only 1 or 2 females)

Ensure each female mates with each male. Kincaid (1993) recommends no spawning when only one female is available. Given the uncertainty with obtaining spawners on the Columbia, spawning should be attempted if possible for each year even if only one female is obtained.

e.g. 2 males, 1 female



Asynchrony in Spawners

Given the preliminary results of the broodstock collections in 2001 for the Upper Columbia (Ron Ek, pers. comm.), it is quite likely that not all broodstock will be ready to spawn at the same time. The limiting factor will probably be the females. To simplify the spawning design, efforts should be made to synchronize spawning. However, if this is not possible, spawning can be modified using the above scenarios depending on the number of males and females available.

Sperm can be kept viable for 4-5 days using refrigeration and oxygen (Ron Ek, pers. comm.). Mature females take 20-40 hours to spawn after induction (Conte et al. 1988). In theory, mature captive female sturgeon should not be induced to spawn until preferably two (although one may be the extreme case) ripe males can be confirmed. Realistically, it may be difficult or impossible to get successful ovulation at the desired time. For example, the two females used in the Upper Columbia program in 2001 were spawned almost a month apart (July 30 and August 23). This component will need some experimentation, and consultation with experts in the field is recommended.

7.4.8 Rearing and Release

Family equalization

Ideally, families will be equalized prior to mixing and release to ensure equal genetic contribution of families to the next generation. This will maximize the genetic effective population size N_e which is particularly important when a very limited of genetic material is available initially. Specifically, each family should be reared separately until early mortality tails off at which point inventory reduction should take place to begin to equalize families. Prior to release, families should be equalized to plus or minus 20%.

Interestingly, it appears that for the Kootenai Hatchery fish, captive fitness traits (including size and growth rate) do not appear to correlate with post-release survival (R. Beamesderfer, pers. comm.). This is important because it demonstrates that selective pressures associated with captivity are different from natural selection pressures in the wild. This observation emphasizes the need to equalize family contributions and avoid selective culling procedures (removing small, slow-growing fish) , and to try to maximize the survival of all individuals (e.g. rear separately according to size).

Family marking

Individual families should be tracked to compare early survival rates, variance in male and female fertility, growth rates and other performance measures. Once fish reach approximately 20 grams individual fish/families can be PIT-tagged and scutes can be removed (to visually identify hatchery year class). Upon tagging (tag number should be related to family), sturgeon can be pooled into larger holding facilities. This assumes that variance in mortality rates among families after this time will be minimal. Prior to pooling, family numbers should be documented.

Release goals

The release goals will be complicated by the fact that two goals (conservation and research) are to be addressed simultaneously. In addition, post-hatchery survival rates at different stages are presently unknown for the Upper Columbia system. Future, release goals will vary as more information becomes available.

Releases for research purposes should be conducted at different juvenile life history stages, and at different times and locations. A number of parameters can be measured including a variety of performance measures (growth, survival, etc.), habitat use, movement and distribution. All research releases should include equal numbers of offspring from each family where possible, or at least avoid the use of only one family per year to differentiate between environment and genotype effects. As research releases will likely vary in numbers and life history stage from year to year, yearly contributions will be impossible to equalize but should be monitored.

Ideally, releases for conservation purposes should be equalized across families within each year. However, equalization may not be compatible with attaining desired release goals, at least initially. In addition, it will be difficult to optimize actual stocking rates until survival rates and bottlenecks to recruitment are known. To date, the Kootenai program has released a range of ages that vary from 3-12 day old larvae to 4 year old fish. Average survival rates for the Kootenai program are approximately 60% for first year post-release and 90% per year for subsequent years (R. Beamesderfer, pers. comm.).

The release goals for conservation should be established to meet recruitment goals (i.e. approximately 50 adults per year). At present, it is impossible to determine a specific number for release because post-release survival for Upper Columbia hatchery-produced progeny is unknown. Table 1 illustrates how different survival rates can significantly affect the number of adults recruited into the breeding population. The sensitivity to slight changes associated with delayed maturation emphasizes the importance of using experimental releases to confirm post-release survival rates. Table 1 should only be used to illustrate how survival can change recruit numbers significantly, not as a guideline to initiate the program.

Constraints

Depending on a number of factors, family equalization may actually compromise the recovery program for two reasons. Equalization will reduce the total number of fish available for release. First, this may reduce the ability to detect a "signal" for the experimental goal, therefore reducing the ability to accurately determine survival rates of hatchery –produced progeny. Secondly, small population demographics can increase genetic risks for the future generation(s). Insufficient availability of mature fish produced from the hatchery in any given year (especially considering the periodicity of females) can result in the development of a genetic bottleneck and eventually extinction. Finally, the number of individuals that are available for release once equalization has been completed may consistently fall short of annual targets to meet the long-term goal of 2,500 adults.

Another major constraint is the current rearing facilities at Hill Creek Hatchery. At present, only 4 families can be reared separately. This number falls below goals for conservation purposes. While it is very important to rear families separately until they can be marked and equalized, it is probably more important to maximize the number of adults that contribute each year. Facility expansion should be pursued. Until that time, separate family rearing may have to be compromised so that more than one family is held in each rearing tank. Half-sib families in particular could be grouped. These family "groups" should still be marked to differentiate groups and not pooled until absolutely necessary.

Conclusion

The number of juveniles per family to maintain and release will depend on:

1) Early survival in captivity;
2) Post-release survival to maturity;
3) Numbers of families raised;
4) Numbers required for experimental purposes; and,
5) Annual recruitment goal for the next generation.

Until many of the questions regarding survival are addressed, it may be most appropriate to rear as many fish as possible from as many families as possible up to current facility constraints. If this option is selected, it becomes even more important to maximize the broodstock numbers available each year. Future culling is possible if families are individually marked. Released individuals can be re-captured from the population and culled if numbers far exceed release goals. As more information is obtained over the next several years, the program can adopt a stronger emphasis on family equalization. It is always better to use a design that incorporates more families and fewer individuals per family, than more individuals per family and fewer families. If the program appears to be successful in its ability to rear and release fish, the expansion of the facility to maintain more families should be seriously considered.

7.4.9 Record Keeping and Monitoring

Given the experimental nature of this program, detailed records of all stages of broodstock collection, mating, culture and releases must be kept. The program should be monitored with regular updates to evaluate short-term (yearly) and long-term goals of the program.

All wild-caught broodstock should be individually tagged to track contributions over time. In addition, lengths, ages and a tissue sample (for DNA characterization) should be collected from each individual. Similarly, all juvenile fish released should be tagged and length, weight, age and release location recorded to assist with evaluation.

7.5 EXPANDING THE OPTIONS

7.5.1 Cryopreservation

Cryopreservation of milt is a viable option to preserve male gametes and should be researched further. Cryopreservation trials should be initiated to develop appropriate protocols. Cryopreserved gametes could be extremely valuable in the future as broodstock become more and more scarce. As hatchery-produced cohorts mature, females' eggs could be crossed with cryopreserved sperm to maintain a wild component to the program. This is assuming natural recruitment has not occurred by this time.

Cryopreservation should be conducted particularly in years that the number of ripe males exceeds the capacity of the spawning facility. However, efforts should be made to use all available males each year.

7.5.2 Wild-Origin Eggs

Significant numbers of wild-caught viable eggs have been collected previously at the Waneta spawning site. This source of genetic material could add significantly to that captured in the wild broodstock. Obviously, the number of spawning events or adults that these eggs represent is difficult to determine at present but genetic fingerprinting techniques may provide these answers (tests are under consideration). It is recommended that this source of eggs be incorporated into the breeding program. The benefit of these eggs is that they are the product of natural mate selection and mating. The eggs could be reared as a separate "family" and should not affect the number of hatchery-produced families produced. This genetic source can only benefit the program by increasing the amount of variation preserved. Experimentation will be required to maximize the survival of fish from this source. However, initial collections from the Upper Columbia River indicate that the proportion of wild-caught eggs collected in 2001 that survived to 100 g fish weight was approximately 50% (D. Koller, pers. comm.).

7.6 SUMMARY OF KEY IDEAS

In summary, the primary goal of the breeding program is to restore and maintain the genetic and demographic integrity of the Upper Columbia River white sturgeon population. In the absence of any natural recruitment, this goal will be entirely dependent on the breeding program. Therefore, the size and design of the program must be adequate to address demographic and genetic issues associated with a small founder population.

The recovery recruitment goal is 2,500 adults per generation. This equates to approximately 50 adults per year for 50 years ideally. The appropriate number of adults required to meet this goal from a genetic perspective is at least 500 (or 5 pairs of breeders per year for 50 years). The breeding and release designs should aim to maximize the effective population size N_e which will help minimize inbreeding and genetic drift. From a demographic perspective, the breeding and release designs should ensure that adequate numbers of individuals survive to adulthood. In addition, the experimental goal requires an adequate number of released fish to obtain a strong signal.

Meeting genetic and demographic (and experimental) goals may not be simultaneously possible under existing conditions. Family equalization is strongly recommended; however it may undermine the recruitment goals and experimental objectives. In the initial years while experimentation is being conducted to understand survival rates, equalization may need to be compromised to optimize the number of individuals released for experimentation. The number of released individuals per family must be monitored, and family-specific tags will enable later identification if the culling of "excess" adults is deemed necessary.

Specific mating designs will depend on the number of broodstock collected annually. As many wild broodstock as possible should be collected each year to maximize the representation of genetic diversity while broodstock is still fairly accessible from the wild. The main objective of the mating strategies is to ensure every individual gets at least one opportunity to contribute its genes. The splitting of gametes is recommended where sperm/egg viability is variable or the numbers of broodstock are low. The existing hatchery facility may constrain the number of families that can be reared separately. Efforts to expand the facility must be pursued. In the meantime, some pooling of families (especially half-sib groups) may be deemed necessary to ensure all broodstock are represented each year. In addition to the mating strategies outlined, cryopreservation of milt and the collection and rearing of wild-origin eggs are recommended to supplement the genetic component.

Release goals will be managed adaptively according the annual recruitment goals. Initially, more fish per family may be released to address the experimental goal, as well as address the possibility of fewer available broodstock to meet the overall recruitment goal of 2,500 adults. However, release goals should be established annually and not be affected by the production of excess progeny.

7.7 CONCLUSIONS

It is important to recognize that the proposed conservation fish culture program for Upper Columbia white sturgeon population is an interim measure that may temporarily address the consistently observed recruitment failure in the system. This program must be considered experimental as similar conservation programs involving white sturgeon have not been conducted over long enough timeframes to evaluate success. However, if successful, this program will help preserve this population's demographic and genetic integrity and restore the age structure of the natural population while the problems for decline are identified and addressed.

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7.9 PERSONAL COMMUNICATIONS

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Table 1. Examples of recruits at 30 years of age (average first age of maturity for females) using a range in survival rates at different life history stages, starting with 10,000 fertilized eggs. Shaded areas indicate years spent in hatchery. In-river rates of survival come from ranges provided Kincaid (1993) and observed post-release survival rates for the Kootenai program* (see first column).

2 years in hatchery						
	Scenario 1		Scenario 2		Scenario 3	
Age	Annual survival*	# of fish	Annual survival	# of fish	Annual survival	# of fish
0-1	.5	5000	.3	3000	.5	5000
1-2	.9	4500	.75	2700	.9	4500
2-3	.6	2700	.3	810	.5	2250
3-4	.9	2430	.5	405	.6	1350
4-5	.9	2187	.6	243	.7	945
5-10	.9	1291	.75	57.7	.8	309.7
10-20	.9	450	.75	3.3	.8	33.3
20-30	.9	**157**	.75	**<1**	.8	**3.6**

1 year in hatchery						
	Scenario 1		Scenario 2		Scenario 3	
Age	Annual survival*	# of fish	Annual survival	# of fish	Annual survival	# of fish
0-1	.5	5000	.3	3000	.8	8000
1-2	.6	3000	.1	300	.4	3200
2-3	.9	2700	.5	150	.6	1920
3-4	.9	2430	.6	90	.7	1344
4-5	.9	2187	.7	63	.8	1075
5-10	.9	1291	.8	20.6	.9	635
10-20	.9	450	.8	2.2	.9	221
20-30	.9	**157**	.8	**<1**	.9	**77**

8.0COMMUNICATIONS PLAN

PROJECT FOR INTER-AGENCIES AND
THE ACTION PLANNING GROUP (APG)

Working Version – Updated November 4, 2002

The Action Planning Group developed the first working version over the 2000-2001 fiscal year, which was completed during September 2001.

This update reflects the activities that have been undertaken since then with information on next steps through 2002-2002 and 2002-2004.

WORKING DOCUMENT – for use as a guideline

8.1 ISSUE

Several Columbia Basin region organizations have partnered together to implement the Upper Columbia White Sturgeon Recovery Initiative. Started in during the summer 2000 and led by the Province of British Columbia, the project has brought together representatives from regulatory agencies, regional governments, First Nations, public and industrial stakeholders, and U.S. regulatory and tribal agencies.

White sturgeon in the upper Columbia River have been declining steadily over the last decade. The white sturgeon populations(s) that utilize the Canadian portion of the Columbia River (and reservoirs) is considered distinct from other populations and, based on detailed research, has shown no significant evidence of successful reproduction since the early 1970's.

The Communications Plan has provided and continues as working guideline to provide background information and direction to guide participating organizations and committees in promoting and educating communities about the status of the endangered Upper Columbia white sturgeon population.

8.2 BACKGROUND

White sturgeon are an ancient species that first appeared in the fossil record 175 million years ago. They are North America's largest freshwater fish species, reaching a maximum size of up to 6 metres (19 feet) and 800 kilograms (1,800 pounds). White sturgeon can live up to 100 years or more.

Fisheries and Oceans Canada, BC Ministry of Environment, Lands and Parks, BC Fisheries and BC Hydro signed a Letter of Understanding (LOU) August 17, 2000 to formalize their common commitment for a white sturgeon recovery program. Since that time, these lead agencies, and several participating organizations have undertaken a variety of environmental initiatives on the Columbia River. The Upper Columbia White Sturgeon Recovery Initiative includes stakeholder involvement, which is consistent with federal and provincial obligations under the National Accord on Species at Risk and proposed SARA legislation.

The project comprises two principle committees. The Action Planning Group draws on local, regional, traditional, industrial knowledge to develop a common vision for sturgeon recovery and assist the Recovery Team by acting as public advocate to achieve buy-in from the various players in the basin. The Recovery Team brings together technical experts in relevant areas to develop and oversee implementation of the Recovery Plan. The Implementation Team, a sub-group of the main Recovery Team of specialists will implement the approved recommendations, which are deemed technically, economically and socially feasible.

During 2000-2001, an existing fish culture hatchery (Hill Creek Hatchery, Nakusp, BC) was converted to a conservation hatchery to rear sturgeon. (Previously it produced various salmonids including bull trout, kokanee, and rainbow trout). Progeny from the facility will be used in research projects aimed at determining the nature of bottlenecks affecting the survival of young sturgeon. In addition, the facility will serve as a conservation tool to ensure the population does not go extinct while the causes of reproductive failure are being determined and addressed.

Between December 2000 to present date, the Recovery Team and the Action Planning Group have held regular meetings in the Columbia River basin area to address: the development and delivery of a draft Recovery Plan; planning, implementation, and management of technical research studies and fish culture work; and, communications, public education and outreach activities.

The Initiative brings the combined interests of government, aboriginal, industry, environmental groups, and others to the challenge of building a future for the white sturgeon in the upper Columbia River in British Columbia and across the border in the United States. Since the inception of the Recovery Team and the Action Planning Group, the memberships have experienced some membership changes by representative organizations and a few additional partner who have committed financial and in-kind support. A list of all parties involved to date, is provided in Appendix A. Membership lists for the Action Planning Group and the Recovery Team are provided in Appendix B.

8.3 STRATEGY GOALS

- To raise awareness in the Columbia River Basin area and gain long-term support for the Recovery Plan, while managing expectations by advising the public that the project will take time to show tangible results.
- To encourage collaborative efforts as much as possible among participating groups and make every reasonable effort to share information. In doing so, this action will ensure consistent regional messaging by all involved parties.
- To provide the communications materials and guidance for participating organizations in order that each may promote the objectives and messages for the Upper Columbia White Sturgeon Recovery Initiative consistently.
- To develop a network of involved parties to pursue funding sponsorship opportunities from government and non-government organizations that can contribute financial support for developing and implementing the recovery initiative.

8.4 TACTICS

8.4.1 Near Term/Ongoing - Spring to Fall 2001:

- Development of first Communications Plan, completed in September 2001
- Production of White Sturgeon Recovery Initiative T-shirts for use by involved members providing outreach and education. The white sturgeon artwork from the initial fall 2000 public workshop, along with a new project initiative logo was used.
- Development of key background information and planning for the purposes of producing a first UCWSRI information brochure.
- Logo – for greater project recognition, and use by sponsor organizations to promote the recovery initiative
- Display Materials – backgrounder information and modest signage to apprise the public at fishing symposia, public events, and tourism centres (BC Hydro, CKFRP/Habitat Stewardship Program, Action Planning Group)

- Website - profile the project through various partner websites by means of an initiative 'homepage' and common web links. Include background information and Terms of Reference documents, general information for technical, environmental, and traditional group interests. Development of the concept and content for construction in 2002. Interim site was used during 2001 through the Province of British Columbia.
- Media package – Developed media release information, still photos files, an informational backgrounder, and media contact list to assist to promote the Initiative.
- Continuing Education – Developed an informational white sturgeon life history power point presentation for the public outreach education. Organize public tours of some white sturgeon sites of interest, in the longer term.
- Development of unique white sturgeon artwork for use and application in public education and outreach communication materials. The Province of BC coordinated an artist to design and produce an original image and electronic version for communications applications during December 2001.
- White Sturgeon Educational Model – produced life-size fiberglass sturgeon during winter 2001, which has been used by APG members with displays at public events.
- Development and submission of news articles about the activities of the Initiative to the local Basin area media outlets at key milestones.
- Contracts undertaken to utilize the services of a professional writer and a professional photographer to assist in word smything text for communications materials and developing a photographic inventory of images for future updating presentations and displays.

8.4.2 Ongoing - January to December 2002:

- Production and distribution of the UCWSRI Information Brochures, issued February 2002 and distributed at public events, tourism centres and ferry landings, on parks pathways and trails, other venues. A second updated Information Brochure was completed in September 2002, to coordinate with public outreach and education related to communicating the Recovery Plan.
- Planning and development of materials for a public educational display at Hill Creek Hatchery i.e., display panels, outdoor informational signage, improving security access to the culture areas while offering opportunities for public viewing. The work was undertaken during the new year/spring months however by early summer was suspended. Concerns about public regularly visiting the hatchery became a safety issue for the fish culture program. Given only limited pre-scheduled access was possible, the resources were redirected to address other outreach activities.
- Production of magnets to ask the public to report white sturgeon carcasses or incidents of illegal fishing; temporary tattoos and fish stampers for youth presentations; two versions of bookmarks (Feb 2002, Oct 2002); and, raw footage of the August 20^{th} juvenile and adult release of white sturgeon near Castlegar.
- Provide outreach presentations to local community groups, agencies, school and public events, using the white sturgeon model, two different wall displays, brochures, mementos etc., to educate the public about the Initiative i.e., transboundary

conference in April 2002; West Kootenay Naturalists, Parks events, elementary schools and community youth and adult clubs etc.

- Ongoing development and refinement of suitable presentation information materials to provide for varied audiences, seminars, and events to provide information on white sturgeon life history, the Initiative, and the recovery planning process. The adult oriented PowerPoint CD presentation produced in fall 2001 is regularly used by APG and RT members during the winter, spring and fall months.
- Development of an educational Power Point CD presentation about white sturgeon for a youth audience between Grades 4 - 7. Completion anticipated for early December 2002.
- Development and installation of a new dedicated white sturgeon telephone Hot Line in coordination with the CKFRP office in Castlegar – 1-888-358-3474 (FISH) and acquisition of a dedicated web site address for the Initiative – **www.uppercolumbiasturgeon.org,** in readiness for full site development during November to late December.
- Promote initiative through newspaper and radio advertisements, local cable networks and interviews, community service announcements. Use designated spokespersons from the Recovery Team and Action Planning Group.

8.5 MESSAGES

8.5.1 Sturgeon – general

- White sturgeon have existed for over 175 million years, or since dinosaurs roamed the planet.
- White sturgeon are North America's largest freshwater fish species, growing to a length of 6 metres (19 feet) and a weight of 800 kilograms (1800 pounds). They can live 100 years or more.
- In the upper Columbia River, female white sturgeon first spawn when they are about 30 years old whereas the males tend to reach maturity somewhat earlier in their early to mid-twenties. Female white sturgeon do not spawn every year; their spawning frequency in this area is unknown but may be in the range of once every five to ten years.
- Historically, white sturgeon were commercially fished in the Columbia River in the U.S., in the Kootenay River, and in the Fraser River in British Columbia. Until recently, white sturgeon were fished recreationally throughout their range. In Canada fishing is now restricted to catch and release in the lower Fraser River; all other areas are closed to fishing.
- In the Canadian portion of the upper Columbia it is closed to any fishing though some catch and release sportfishing still occurs on the U.S. side, where the white sturgeon populations are healthier. Recommendations by U.S. Tribal and Washington State fish managers however, to close this fishery is expected to become effective in May 2002.

- The white sturgeon have long been an important species to BC's First Nations and US tribes, both as a food source and as part of Native cultural heritage.

8.5.2 Upper Columbia sturgeon – reasons for decline

- The geographic area of the upper Columbia white sturgeon is that section of the Canadian portion of the Columbia River watershed. These sturgeon do not migrate to the ocean, but may migrate into U.S. portions of the Columbia River.
- Although the white sturgeon has survived as a species for hundreds of millions of years, recent human development and loss of habitat in the upper Columbia Basin has led to its decline and "critically imperiled" status.
- Estimates have put the upper Columbia white sturgeon population, between Keenleyside Dam and the Canada-US border at approximately 1400 sturgeon, with very few young fish, which indicates that they are not reproducing successfully or contributing to the population at an early life stage.
- The reasons for the decline of sturgeon in the upper Columbia are complex and not yet fully understood.
- Human development, including the large network of dams and dykes throughout the basin, has severely restricted the sturgeon's natural movement, limited its ability to find suitable spawning locations, and has affected the physical and biological environment in which sturgeon exist. In addition, pollution from industrial and municipal sources has degraded water and sediment quality that also may affect sturgeon survival and reproduction.

8.5.3 Conservation Activities

- Research and monitoring of the upper Columbia sturgeon population will allow biologists to better understand what these gigantic fish need to survive.
- The Recovery Team's overall role is to develop, oversee, and implement the Recovery Plan to ensure the recovery of white sturgeon populations within the upper Columbia River.
- In a unique pilot program, the Hill Creek Hatchery has been modified to breed and rear sturgeon to juvenile size, after which the sturgeon will be released into the upper Columbia River.
- Members of the Recovery Team will oversee the pilot sturgeon program at Hill Creek and study the fish once they are released into the Columbia in an effort to understand why sturgeon are failing to reproduce in the wild.
- All breeding and research is done under stringent guidelines set by the Recovery Team.
- Juvenile hatchery sturgeon will be used only as an interim measure to prevent the population from disappearing. Stocking of rivers is not currently accepted as a long-term solution to the sturgeon's decline.

- The goal of the recovery program is "to ensure the persistence and viability of naturally-reproducing populations of white sturgeon in the upper Columbia River and restore opportunities for beneficial use if feasible." (draft Recovery Plan, June 2002)
- During spring 2002 the Implementation Team, a sub-group of the main Recovery Team of specialists, was formed. Once the Recovery Plan has been adopted the Implementation Team will implement the approved recommendations, which are deemed technically, economically and socially feasible.

8.5.4 Public Partnership

- The Upper Columbia White Sturgeon Recovery Initiative (UCWSRI) is a collaboration of concerned groups, including government, aboriginal, industrial and environmental, stewardship groups and citizens, working to ensure the sturgeon continues to live in the Columbia River in BC, and across the border into the United States.
- To help the sturgeon populations recover in the upper Columbia River, environmental, industrial, aboriginal, government, and community groups must collaborate. Community participation and local support are key for success in the Upper Columbia White Sturgeon Recovery Initiative.
- The UCWSRI aims to raise awareness of the white sturgeon's decline in the Columbia River Basin, and to gain long-term support for a Recovery Plan to be developed through discussions between a public-based Action Planning Group and a technical Recovery Team.
- The Action Planning Group's primary task is to develop a common vision for sturgeon recovery and to assist the Recovery Team by acting as public advocate for a long-term sturgeon recovery plan.
- The Action Planning Group will work to increase awareness and support of the Upper Columbia White Sturgeon Recovery Initiative and to inform the public and partners of the Recovery Initiative's work.

8.5.5 Commitment

- This ancient and magnificent species deserves our full attention.
- The Upper Columbia White Sturgeon Recovery Initiative (UCWSRI) is committed to researching the causes and possible long-term solutions to the sturgeon's decline in order to help the upper Columbia white sturgeon population recover.
- The white sturgeon's long life span and the complexity of impacts to the Columbia River means there are no easy answers or quick fixes to the problem of sturgeon decline.
- Results of this initiative will take time. Stakeholders need to support the Initiative and the partner agencies over the long term.
- Many of the white sturgeon residing in the upper Columbia River today are older than you, your parents or even your grandparents. The Upper Columbia White Sturgeon Initiative wants to ensure that juvenile sturgeon today mature to adulthood and

continue to live in the Columbia River long after we are gone, as they have done for millions of years.

- The UCWSRI does not want to see the sturgeon disappear from the upper Columbia River, and we believe others feel the same.
- We encourage everyone to support the studies and research necessary to help the sturgeon recover.
- The Upper Columbia White Sturgeon Recovery Initiative…helping hands for ancients of the deep.
- To help the white sturgeon populations recover in the upper Columbia River, environmental, industrial, native, government, and community groups must collaborate. Community participation and local support are key for success in the Upper Columbia White Sturgeon Recovery Initiative.
- To help protect the white sturgeon, here are some things you can do:
  1. Avoid polluting streams and lakes with garbage, fuel, or other contaminants.
  2. Report any illegal white sturgeon fishing by calling in BC, 1-800-663-WILD (9453), and in Washington, 1-800-477-6224.
  3. What you know about the white sturgeon may be useful for team members to pass along. Dead or dying sturgeon in the Columbia River in the past, particularly near Castlegar and Trail, BC have provided valuable information. Learning more about the Initiative and recent draft Recovery Plan is also important. Team members can visit community groups and update the public about the Initiative and answer their inquiries.
  4. Contact the dedicated white sturgeon Hotline for the Western States and British Columbia, at 1-888-358-3474 (FISH) to report or request information.
  5. Encourage maintenance of long term support for research projects. You can make a tax-deductible donation to the Upper Columbia White Sturgeon Recovery Initiative to sponsor a project by contacting us through the Hotline.
  6. For more information check out: **www.uppercolumbiasturgeon.org** (under construction)

8.5.6 Agencies and involved parties

- Organizations and the public are invited to make financial contributions towards several research studies that have been identified for 2001 and 2002, and towards communications and stewardship activities to promote and educate communities about the status of this endangered species.
- Several organizations are committed to supporting the Upper Columbia White Sturgeon Recovery Initiative either financially or in kind, with several more agencies and corporations committed to provide funds and support to the process in the near future.
- The Upper Columbia White Sturgeon Recovery Initiative's supporting agencies to date include:

Province of British Columbia	Fisheries and Oceans Canada
BC Hydro	Habitat Conservation Trust Fund
Environment Canada	Columbia Basin Trust
Spokane Tribe of Indians	Canadian Columbia Inter-tribal Fisheries Commission
Bonneville Power Administration	US Fish and Wildlife Service
Columbia Power Corporation	Washington Dept of Fish and Wildlife
Colville Confederated Tribes	Celgar Pulp Company
Cominco Ltd.(Trail Operations)	West Kootenay Power
Salmo Watershed Streamkeepers Society	Mountain Valley Sports Fishing
West Kootenay Naturalists	Rivers, Lakes & Lands Environmental Services Ltd.
Lake Roosevelt Forum	Revelstoke Rod and Gun Club
Castlegar and District Wildlife Association	Columbia Kootenay Fisheries Renewal Partnership

A home page for Upper Columbia White Sturgeon is currently under construction and will be available during winter 2002. **www.uppercolumbiasturgeon.org.** A provincial site may also be viewed for general white sturgeon information:

www.bcfisheries.gov.bc.ca/fisherieshabitats/Sturgeon/Sturgeon.htm

8.6 AUDIENCE

8.6.1 Primary Audience

General Public – Canadian/local and US/local Columbia River Basin states – general interest, information to participate and communicate

Indigenous Peoples - First Nations and US Tribes – general information and involvement in recovery planning process. Input on Traditional Ecological Knowledge to the Recovery Plan

Industry – project support by participation and research funding and technical sub-committees i.e., water management, habitat restoration and contaminants

Local conservation, stewardship, and environmental interest groups – require more detailed technical information, and who will likely influence public opinion.

School Aged Children K-12 and College Level Students

Academic – Technical information

8.6.2 Secondary Audience:

Scientific communities, Regulators/Government, Politicians

8.7 SENSITIVITIES

Industrial development is being seen as a factor in the white sturgeon population's decline.

The need may arise for fisheries managers to prohibit fisheries for other species in areas of the upper Columbia heavily used by white sturgeon, in order to protect sturgeon.

BC Hydro has been held accountable for several years in this region, for the destruction of the white sturgeon due to the construction of its dams on the Columbia River. There are several dam owners on the Columbia River. The public needs to understand that all parties share common environmental values, are equally involved in the initiative, and some of them are dam owners.

The upper Columbia white sturgeon is a transboundary population and its recovery is important to both Canada and the United States.

Despite agency commitments, long-term funding for the initiative remains an unresolved issue.

Results from the initiative will be realized over the long term (25 years or more); communications must address the public's desire for visible improvement.

8.8 FOR REVIEW

Action Planning Group (See Appendix B for List)

Recovery Team (See Appendix B for List)

Agency Communications Representatives:

BC Hydro, Vancouver – Sue Heaton / Ruth Major (acting since fall 2001)

Teck Cominco, Trail – Richard Fish until 2001

BC Min. of Water, Land & Air Protection, Nelson- Frances Maika until June 2002

Province of BC – since September 2002, Wayne Stetski

Fisheries and Oceans Canada, Vancouver – Carrie Mishima

Lake Roosevelt Forum, Spokane, WA – Alison Squier to 2001; Andy Dunau

Columbia Basin Fish and Wildlife Compensation Program – Barry Bartlett since April 2002

WDFW, Spokane, WA - Madonna Luers – to spring 2002

8.9 APPROVALS REQUIRED

This Plan will be intermittently updated to include updates to key messages and completed communications activities. Updated versions will involve input from the APG Communications sub-committee and significant changes forwarded to the Action Planning Group for approval and the Recovery Team for advice and technical input where applicable. This version is the first update since the working version of September 2001 was prepared.

8.10 FINAL WORKING DOCUMENT COMPLETED:

July 2001, with minor updates to finalize as a working version, September 2001. This current Update was completed November 2002, in order to update the plan to include actual work or completed to date, and for use in reference material for 2003-2004 funding requests.

8.11 INFORMATION SOURCES

- September 2000, Public Workshop Brochure
- Terms of Reference for Action Planning Group and Recovery Team
- Meeting Notes from: APG, RT, & the AGP Communications Sub-committee from December 2000 to August 2001.
- Meeting Notes from: APG, & APG Communications Sub-committee, spring 2002, September/October 2002.
- February and September 2002 issues of the UCWSRI Information Brochure

8.12 MANAGERS

- BC Ministry of Water, Land and Air Protection – Colin Spence
- BC Ministry of Water, Land and Air Protection – Ted Down
- BC Hydro/CBFWCP – Hugh Smith and Maureen deHaan
- Fisheries and Oceans Canada – Steve Macfarlane

8.13 UPDATED BY

Margaret Birch

(250) 365-0575

8.14 CONTACTS

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8.15 APPENDIX A

8.15.1 Project Initiative Funding and Support

Several organizations are committed to supporting the Upper Columbia White Sturgeon Recovery Initiative, either financially or in kind. Since the initial start in the fall of 2000, additional agencies and corporations have committed to provide funds and support to the process in the near future.

Financial and in-kind commitments that have been made to date include:

Province of British Columbia

Fisheries and Oceans Canada

BC Hydro

The Government of Canada's Habitat Stewardship Program for Species at Risk

Columbia Basin Trust

Habitat Conservation Trust Fund

Canadian Columbia River Inter-tribal Fisheries Commission

Teck Cominco Ltd. (Trail Operations)

Aquila Networks Canada

Celgar Pulp Company

Bonneville Power Administration

Spokane Tribe of Indians

Colville Confederated Tribes

Lake Roosevelt Forum

Washington Dept of Fish and Wildlife

Columbia Power Corporation

Columbia Basin Fish and Wildlife Compensation Program

US Fish and Wildlife Service

Salmo Watershed Streamkeepers Society

West Kootenay Naturalists

Castlegar and District Wildlife Association

Golder Associates

Revelstoke Rod and Gun Club

Columbia Kootenay Fisheries Renewal Partnership

Mountain Valley Sports Fishing

USGS Western Fisheries Research Center

Oregon Department of Fisheries and Wildlife

8.16 APPENDIX B

8.16.1 Action Planning Group (Current Membership)

Member and Affiliation	Member and Affiliation
Ted Down, Ministry of Water, Land and Air Protection	Steve Macfarlane, Fisheries and Oceans Canada
Hugh Smith, BC Hydro	Margaret Trenn, Aquila Networks Canada
Bill Duncan, Cominco Ltd. (Trail Operations)	Fiona Mackay, Celgar Pulp Company
Joan Snyder, West Kootenay Naturalists	Rena Vandenbos, Selkirk College *
Fred Salekin, Castlegar & District Wildlife Association	Llewellyn Matthews, Columbia Power Corporation
Suzanne Rorick, Public *	Maureen deHaan, Columbia Basin Fish and Wildlife Compensation Program
Gerard Nellestijn, Salmo Watershed Streamkeepers Society *	Dwayne D'Andrea, Mountain Valley Sports Fishing
Sabrina Curtis, Columbia Basin Trust	Chris Beers, Columbia Kootenay Fisheries Renewal Partnership *
Clancy Boettger, Revelstoke Rod & Gun Club	Andy Dunau, Roosevelt Lake Forum

* Also an APG Communications Sub-Committee member

8.16.2 Recovery Team (Current Membership)

Member and Affiliation	Member and Affiliation
Colin Spence, Ministry of Water, Land and Air Protection	Dan Sneep, Fisheries and Oceans Canada
Larry Hildebrand, Golder Associates	Gary Birch, BC Hydro
Mike Parsley, USGS Fisheries Research Center	Bill Green, Canadian Columbia River Inter-tribal Fisheries Commission
Molly Webb, Oregon Department of Fisheries and Wildlife	Julia Beatty Spence, Ministry of Water, Land and Air Protection.
Steve McAdam, Ministry of Water, Land and Air Protection	Brad James, Washington Department of Fish and Wildlife
Deanne Pavlik, Spokane Tribe of Indians	Jerry Marco, Colville Confederated Tribes
Bryan Ludwig, Ministry of Water, Land and Air Protection	Scott Bettin, Bonneville Power Administration
Bob Hallock, US Fish and Wildlife Service	

Sub-committees include:

Action Planning Group sub-committee:

- APG Communications

Recovery Team sub-committees:

- RT Contaminants
- RT Water Management
- RT Conservation Fish Culture
- RT Habitat Restoration
- RT Genetics

Terms of references are available for the sub-committees upon request.

8.16.3 Budget

ITEM	DETAILS	COST	TIMING
Completed **February - March 2001**			
Project Initiative logo for use by participating organizations, the Action Planning Group and the Recovery Team	Design and produce electronic version in colour and B/W formats	HSP Funded 00/01	March 2001 *(Completed)*
Display – wall-sized panel, & decorative cardboard barrel to (illustrates actual girth size of full-sized sturgeon)	BC Hydro collaborated with the APG Sub-committee to develop display messaging and utilize a project logo with the BCH logo.	BC Hydro Funded 00/01	March 2001 *(Completed by BCH Corporate)*
White Sturgeon Recovery Initiative T-shirts – bearing juvenile sturgeon and modified from Sept 2000 workshop.	144 T-shirts bearing Upper Columbia White Sturgeon Recovery Initiative for use at special public events.	HSP Funded 00/01	March 2001 *(Completed)*
Complete a number of working Drafts of a Communications Plan for review/approval by the Recovery Team, the Action Planning Group, and the APG Communications Sub-committee	Incorporate all feedback received from the March 5th version by the APG and RT and prepare a final draft Plan	Funded 00/01	February – June 2001 *(ongoing updates are prepared as new information is available)*
Completed **April 1, 2001 to March 2002**			
Coordination and support costs for the Action Planning Group and Recovery Team- meetings, Committee administration.	Committee operations, member expense, contract services for coordination and administration support	$30,000 Funded 01/02	April 2001- March 2002. *Completed* *High Priority*
Complete a final, working Communications Plan for 2001-2002	Prepare drafts to include ongoing input by APG and RT and circulate.	Part of committee support $ Funded	Finalized through summer 2001, working version, Sept 2001 *High Priority*
Initial backgrounder information material developed for public outreach events while Communications and UCWSRI messaging was approved.	Resource time to write, produce and distribute to key locations, for use during summer/fall 2001	Basic material was completed for interim public distribution. Funded.	Develop and plan throughout spring, produce/distribute and made available during 2001 as required. *High Priority*
Funding Sponsorship Drive by Communications Sub-Committee. Ongoing efforts to access funds from foundations, organizations	Upon Plan approval, the sub-committee APG sub-committee would seek support through direct request for support by letters to key organizations.	Sub-Com time/APG support. Funded.	Undertaken during Fall 2001 and Winter 2002 to seek 2002-2003 funds. *High Priority*
Local Area Photographer photography for brood stock activities at Hill Creek Hatchery	Library of photos for uses in future information and display. First of two projects.	$1,000 Funded	Fall 2001 – March 2002 *First Stage Completed* *Medium Priority*

ITEM	DETAILS	COST	TIMING
Continuing Education and Outreach – for an Adult-community audience.	Development, production, materials, logistics, first CD power point presentation for outreach purposes by APG/ RT	$500 and in-kind support Funded	*Completed* Spring 2002 *Medium Priority*
Information Brochure on UCWSRI to be produced based on the approved 2001 messaging from the Communications Plan.	Development, production, distribution	$3,800 3,000 copies Funded	*Completed* and distributed during February through fall 2002 in conjunction with public outreach and display events. *High Priority*
Mementos for public education and awareness e.g., bookmarks, temporary tattoos, magnets, fish stampers and pads.	Develop, design, produce	$3,200 Funded Completed by March 31, 2002	Productions *Completed* between Feb and March 2002 *High Priority*
Hill Creek Hatchery Signage	Display signage with logo and key messages at hatchery location	$3,500 Suspended in March; put on hold Sept 2002	Winter 2001/New year 2002 *Not Completed*
Educational Tools – White Sturgeon Model for displays to illustrate the sturgeon	Investigate possible taxidermy of a large white sturgeon to produce of life-sized model.	$3,800 Funded	October to December 2001. *Completed.* *Medium Priority*
Support resources for community presentations, event participation, awareness events	Travel and expenses, resource support	$2,500. Funded	Ongoing through the fiscal year *Completed*
Produce Updated Display Panel for Public Events	Develop updated messaging and easier to use wall panel display for outreach events and public events.	$10,000 Funded	January 2001 – March 2001 *Completed March 2002*
Completed/In progress **April 2002 – March 2003**			
Coordination and support costs to facilitate the Action Planning Group and provide admin support to the Recovery Team	Operational support, contract services for meeting facilitation i.e., support, admin, travel, meeting venue and meals etc. for the APG/Communications sub-committee.	$26,000 for APG Support $5,000 APG and $5,000 RT In-kind support Funded	Ongoing over 2002 – 2003 fiscal year. *High Priority*
Support resources for community presentations, event participation, awareness events	Travel and expenses, resource support for volunteers	$8,000 Funded and In-kind Support	Ongoing through fiscal year. *High Priority*
Direct radio, newspaper advertisements, new releases, local cable and service networks to advise about the Initiative at key milestones. Placement of Information Brochures where	May 2002 – juvenile release; August 2002 – juvenile and adult releases. Fall/Winter 2002– about incidental catches of white sturgeon and the Initiative in general.	Direct Costs TBA, though some $ covered by in-kind support of partners.	Winter 2002 to spring 2003. *Medium Priority*

ITEM	DETAILS	COST	TIMING
quantities and opportunity exists to notify public.			
Information Brochure on Initiative and progress made to date since 2001, including the Recovery Plan	Develop, design and produce 4,000 copies for public education and outreach events	$6,300 Funded and In-kind Support	*Completed* September 2002 *High Priority*
Provide Recovery Newsletter to further communicate activities i.e., Recovery Plan support, implementation and the UCWSRI	Up to two newsletters produced during the fall 2002 and spring 2003. Design, produce, and distribute.	$11,200 Funded and In-Kind Support	Winter 2002, and March 2003. *Medium Priority*
Mementos for public education and awareness e.g., bookmarks, static clings, posters, temporary tattoos, sturgeon trailer signage.	Update designs from previous work completed and produce based on budget available.	$2,000 Partially Funded	October – November 2002 to be available for outreach in support of Recovery Plan
Sturgeon Hotline – operations and maintenance 1-888-358-3474 (FISH)	Advertise upcoming events about white sturgeon and provide opportunity for public to report illegal fishing or dead carcasses.	$4,500 + (includes advertising) Funded	Initiated August 2002 by partner, CKFRP in Castlegar. *High Priority*
Develop Self-Guided Tour for Hill Creek Hatchery	Improve public entrance away from sensitive areas of hatchery and barrier; create indoor panels, set up aquarium etc.	$4,500 $5,200 Funded, but suspended at Provincial Govt request Sept 02	Work is now on hold. Funds will be directed elsewhere. *Low Priority*
Implement a Web Cam set up at the conservation facility and link to the web site for public access and viewing.	Assess possibility to install web cam at hatchery or link with the underwater camera in use for wild sturgeon in the river.	$ TBA Currently not directly funded.	November 2002 to March 2003 or when web site is operational. *Medium Priority*
Profile Recovery Initiative on various partner web sites; develop linkages to other white sturgeon sites	Interim measure in the absence of an operational web site being available, provide information to other sites i.e., BC Hydro, CKFRP	$ no direct cost	Spring 2002 onward *Medium Priority*
Obtain photographic inventory of white sturgeon images for use in public outreach activities and support material.	Complete further photo collection of life history stages and fish culture work for use in public outreach presentations and communication materials.	$2,000 Funded	Summer 2002 – March 2003. Ongoing. *High Priority*
Public Outreach events in First Nations Communities to obtain feedback on Recovery Plan.	Undertake a meeting series to visit local communities and discuss the Recovery Plan	$6,300 Partially Funded	November 2002 to January 2003 *High Priority*
Support Outreach for Recovery Plan.	Production and distribution costs to disseminate and post the completed working version of the Recovery Plan.	$600 Funded	November 2002 to January 2003 *High Priority*
Implement Initiative Web Site with	Coordinate with Spokane Tribe	Funded	www.uppercolumbiasturgeon.org - to be built Nov

ITEM	DETAILS	COST	TIMING
support of the APG communications sub-committee	of Indians, Lake Roosevelt Forum and sub-committee to complete structure and activate.	$14,000	2002 to Jan 2003 *High Priority*
Develop Video Footage of white sturgeon Initiative activities for use in public events and future communications applications.	Contract video supplier to obtain raw hatchery and release footage of sturgeon Aug 20th release in Castlegar for use at public display events and for education materials.	$1,300 Funded	August – September 2002 *Completed* *Medium Priority*
Development of Youth-aged (Grades 4-7) Power Point CD Presentation about white sturgeon life history and the Initiative for outreach/ stewardship education.	Coordination with Communications sub-committee, schools and APG members to design, develop, produce a module.	$2,500 Funded	Fall to Winter 2002, to be completed by late November 2002 *High Priority*
APG/RT Workshop on Recovery Plan – Fall/Winter 2002	Exchange of information regarding the priorities and implementation of the Plan	Partially Funded. TBA	May not be held as planned but incorporated into meetings instead.
Future – next year(s) **April 2003 – March 2004 and ongoing**		***Funds not committed for 2003-2004***	
Coordination and support costs to facilitate the Action Planning Group and support admin to the Recovery Team	Operational support, contract services (support & admin) for public & technical teams, sub-comm.	$32,000	Ongoing over 2003-2004 fiscal year. *High Priority*
Sturgeon Hotline – operations and maintenance. 1-888-358-3474 (FISH)	Ongoing advertising, support and maintenance of initiative/hotline.	$ 5,500	Ongoing through fiscal year. *High Priority*
Spring/Summer 2003 Information Brochure on UCWSRI, the details of the Recovery Plan, the planned implementation activities, and research/fish culture for 2003	Coordinate, design, and produce up to 4,500 – 5,000 copies.	$6,000	Plan in spring 2003 for June/July issue or August/September issue. *High Priority*
Mementos for public education e.g., static clings, posters, posters, temporary tattoos, signage, etc.	Produce additional supplies as required for outreach	$ 2,500 +	During fiscal year as support available. *Medium Priority*
Web Site support by the APG communications sub-committee	Support and maintenance to update the web site with current information. Update software and local help required for maintaining web site.	$2,400	Ongoing through fiscal year. *High Priority*
Web Cam support and maintenance to provide link for public to view white sturgeon juveniles.	Support and maintenance of a web cam at hatchery or at underwater site with link to partner or Initiative web site.	$ TBA	Through fiscal year if resources permit. *Medium Priority*
Direct radio, newspaper advertisements, news releases, local cable and service networks to	Use media strategies, low and medium cost to promote awareness of the Initiative and	$1,200	Ongoing through fiscal year.

ITEM	DETAILS	COST	TIMING
advise about the Initiative at key milestones	the plight of white sturgeon.		*High Priority*
Support resources for community presentations, event participation, awareness events	Travel and expenses for volunteers undertaking outreach activities.	$3,500	Ongoing through fiscal year. *High Priority*
Support Outreach for promoting the implementation of the Recovery Plan for the UCWSRI	Given the finalization of a working Recovery Plan through 2002-2003, continue to provide outreach to the public on the implementation work.	$4,000	Ongoing through the fiscal year. *High Priority*
Funding Sponsorship Drive by Communications Sub-Committee. Ongoing efforts to access funds from foundations, organizations	Continue to involve APG members to support the Initiative by assisting to seek out funding sources to continue the efforts of recovery.	Seek to obtain contributions between $2,000 and $10,000 or more	Ongoing through fiscal year. *High Priority*
Development of display panels at the Kootenay Trout Hatchery, on the UCWSRI should fish culture for the upper Columbia white sturgeon population is relocated.	Kootenay Trout Hatchery is open to the public. Relevant panels about the UCWSRI could be developed for display.	$ 1,500	Spring 2003 *Medium Priority*
Develop materials on the Initiative using video media approaches.	Acquire and develop educational video footage and media image package for public education and media information purposes	$8,000	Spring – Fall 2003 *Medium Priority*
Public Education Outreach Assessment and Evaluation to determine whether information dissemination is working.	Examine the level of awareness through various means i.e., telephone or mail out survey regarding awareness of the Initiative and the recovery work underway.	$ 3,000	Spring to fall 2003 and as resources permit *Low Priority*
2003 – 2004 Estimated Total		**$ 37,920 plus**	