CHAPTER 3: ROCKY REACH WHITE STURGEON MANAGEMENT PLAN

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EXECUTIVE SUMMARY

Biologists believe that construction of the dams along the middle reaches of the Columbia River has created "isolated" populations of white sturgeon in the mid-Columbia River Basin. However, the population dynamics and factors regulating production of white sturgeon within these isolated populations have been poorly understood. Therefore, Douglas, Chelan, and Grant Public Utility Districts (Mid-Columbia PUDs) each initiated studies of white sturgeon through, or in preparation for, the process of relicensing of their respective hydroelectric dams (Golder Associates 2003a, Shane Bickford, personal communication). The information gathered from these studies was intended to help relicensing decision-makers understand basic white sturgeon life history information, distribution, and current population sizes in the mid-Columbia region.

In 2001, Chelan PUD contracted with R.L. & L. Environmental Services Ltd. (now Golder and Associates) to conduct a white sturgeon investigation in the Rocky Reach Hydroelectric Project Reservoir (Reservoir). The objectives of the investigation were to determine the presence or absence of white sturgeon in the Reservoir, and to investigate general characteristics of any white sturgeon population identified in the Reservoir, including distribution, growth rate, size and age-class composition, weight, sex ratio, genetic characteristics, and relative abundance.

In 2002, Chelan PUD commissioned a more detailed, systematic study of white sturgeon in the Reservoir (Golder, 2003a). For the combined 2001 and 2002 studies, 24 white sturgeon were marked in the Reservoir. Because only four sturgeon captured in 2001 were recaptured in 2002, it was only possible to estimate the total population in the Reservoir within a broad range. Consequently, Golder and Associates estimated that there are 50-115 white sturgeon in the Reservoir, and unlikely that there are more than 300.

The overall goal of this Rocky Reach White Sturgeon Management Plan (WSMP) is to promote white sturgeon population growth in the Reservoir to a level commensurate with the available habitat based on monitoring results. This is to be accomplished by meeting the following objectives: 1) increasing the population of white sturgeon in the Reservoir through implementing a supplementation program to a level commensurate with available habitat and allowing for appropriate and reasonable harvest; 2) determining the effectiveness of the supplementation program; 3) determining the carrying capacity of available habitat in the Reservoir; and 4) determining natural reproduction potential in the Reservoir, and then adjusting the supplementation program accordingly.

The WSMP calls for Chelan PUD to implement the following Protection, Mitigation, and Enhancement measures (PMEs), described in Section 4:

1) Prepare a brood stock collection plan within year one of the effective date of the New License and, if feasible, begin brood stock collection in year two of the New License;

2) Implement a white sturgeon supplementation program by releasing up to 6,500 yearling white sturgeon into the Reservoir each year for three years, with subsequent annual release levels to be determined by the RRFF, based on monitoring results;

3) By year seven of the New License, in consultation with the RRFF, determine a long-term source of fish to be used for continuing the supplementation program throughout the term of the New License;

4) Conduct an initial three-year index monitoring program for juvenile and adult sturgeon in the Reservoir to determine age-class structure, survival rates, abundance, density, condition factor, growth rates, and to identify distribution and habitat selection of juvenile sturgeon;

5) Continue index monitoring every third year over the term of the New License to monitor age-class structure, survival rates, abundance, density, condition factor, growth rates; identify distribution and habitat selection of juvenile sturgeon; and direct the supplementation program strategy;

6) Conduct tracking surveys of juvenile white sturgeon released with active tags as part of the supplementation program to determine emigration rates from the Reservoir;

7) Compile information on other white sturgeon supplementation programs in the region; and

8) Capture, insert active tags, and track reproductively viable adult white sturgeon for the purpose of identifying potential spawning locations, or, if no viable adult spawning white sturgeon are active-tagged as part of indexing program, place egg collection mats below Wells Dam to evaluate spawning activity and habitat utilization.

SECTION 1: INTRODUCTION

The relicensing process for the Rocky Reach Hydroelectric Project (Project) brought fisheries agencies, tribes, and interested parties together in a Natural Resources Working Group (NRWG) that provided an opportunity for comprehensive review of current and future management priorities for fish resources potentially impacted by ongoing Project operations. The NRWG was established to identify issues, develop study plans, review study reports, and develop long-term management plans for fish and wildlife species. The NRWG consisted of representatives from the USDA Forest Service, U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), the Washington Department of Ecology (Ecology), Washington Department of Fish and Wildlife (WDFW), the U.S. Bureau of Land Management (BLM), Colville Confederated Tribes (CCT), Yakama Nation (YN), Columbia River Inter-Tribal Fish Commission (CRITFC), and other interested parties.

Technical groups were formed for each comprehensive plan e.g., white sturgeon, bull trout, Pacific lamprey, resident fish, and wildlife due to the complexity of issues surrounding each species and so that agency experts could focus on meetings pertaining to their specific expertise. A subgroup of the NRWG, the White Sturgeon Technical Group (WSTG), comprised of the USFWS, Ecology, WDFW, YN, CRITFC, and Chelan PUD, completed this White Sturgeon Management Plan (WSMP). Upon the effective date of the New License, the Agreement's Rocky Reach Fish Forum (RRFF) will assume responsibility for meeting to share information, coordinate efforts, and make recommendations and decisions regarding the implementation of this WSMP, which will be reviewed, in consultation with the RRFF, on a periodic basis to allow for planning and future adjustments during the term of the New License and any subsequent annual licenses.

The WSTG collaborated during 2004 and 2005 on the development of goals and objectives, and, subsequently, developed Protection, Mitigation, and Enhancement measures (PMEs) to address white sturgeon within the Project boundary. During this process, the WSTG determined that white sturgeon life history characteristics and the limited number of fish estimated to exist in the Reservoir made it impractical to complete a definitive assessment of ongoing Project effects on white sturgeon. Therefore, the WSTG concluded that efforts should focus, initially, on increasing the number of fish in the existing population through supplementation, assessing natural recruitment, and then investigating the potential for natural reproduction once a population of sexually mature white sturgeon is established in the Reservoir.

This WSMP contains sections that describe the background knowledge of white sturgeon (Section 2); the relicensing and other studies conducted to determine ongoing Project-related impacts, if any, on white sturgeon (Section 3); and PMEs developed for achieving the goals and objectives to be implemented during the term of the New License and any subsequent annual licenses (Section 4).

SECTION 2: BACKGROUND

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

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

2.1 <u>White Sturgeon Management Plans in the Columbia Basin</u>

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

2.1.1 Kootenai River White Sturgeon Recovery

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

By the mid to late 1980s, it was obvious that the near total recruitment failure of what is termed the "Kootenai White Sturgeon" stock (which includes the British Columbia portion of the drainage, i.e., the lower Kootenay River above Kootenay Lake, Kootenay Lake and the Kootenay River downstream of Nelson to Bonnington Falls) required aggressive intervention to ensure that this species did not disappear (US Fish and Wildlife Service 1999). A pilot hatchery was designed and constructed near Bonners Ferry, Idaho, with funding provided by the Bonneville

Power Administration (BPA). This mini-hatchery was run by the Kootenai Tribe of Idaho (KTOI), with technical direction provided by the IDFG.

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

A major habitat restoration focus of the Kootenai White Sturgeon Recovery Plan has been to increase the extent and duration of spring freshet flows in the Kootenai River. Essentially, this is provided through releases from the US Army Corps of Engineer's Libby Dam in Montana. To date, the results of these increased flows have been inconclusive; i.e., there is as yet no indication that high flows during the spring translates into increased survival of white sturgeon eggs and/or fry (J. Hammond, pers. comm., 2003). This assessment must be tempered, however, because of the difficulties of sampling young-of-the-year (YOY) white sturgeon fry. At present, white sturgeon must be a minimum of one to two years of age before they can be captured adequately by standard sampling gear (C. Spence, pers. comm., 2002). As a consequence, it is difficult to assess the relationship between flows and recruitment.

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

One of the ongoing issues regarding the Kootenai White Sturgeon Recovery Plan is potential genetic swamping of the "wild" sturgeon by those produced and stocked from the hatchery. A breeding plan was developed in the mid-1980s that focused on determining an appropriate method of breeding fish to maximize the genetic diversity of hatchery-produced fish (Kincaid 1993). The approach was based on conservative estimates of survival, distribution, sexual maturity, and availability of breeding fish. Some of these assumptions have since been judged as either erroneous or overly conservative. As a consequence, the Kootenai White Sturgeon Recovery Plan was rewritten in order to incorporate the newest and best available data.

Another major uncertainty in the Kootenai White Sturgeon Recovery Plan implementation centers on stocking rates and fish size at release. In the absence of empirical data or, at a minimum, acceptable biostandards, these uncertainties cannot be resolved since "historical" levels of white sturgeon abundance and recruitment in the river and the lake are unknown. Changes to the Kootenai River ecosystem from regulation by Libby Dam further complicate this problem. To date, the approach has been to annually revisit the stocking number and fish size issue based on the most up-to-date information on juvenile survival and growth rates. This type of adaptive management approach also incorporates new information on natural spawning success collected during annual monitoring programs.

2.1.2 Upper Columbia River White Sturgeon Recovery

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

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

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

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

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

A monitoring program is ongoing (on both sides of the international border), and the main focus is the development of a juvenile index monitoring program to assess growth, survival, health, distribution, and relative abundance of released juveniles. The information collected by this program is essential to monitor the success of the hatchery stocking program and provide information on any natural recruitment that may occur.

2.2 Status and Information Needs for the Rocky Reach Reservoir

Historical angler reports indicated that white sturgeon were previously captured in the upper portion of the Rocky Reach Reservoir, above the confluence of the Chelan River. More recently, the presence of white sturgeon in the Rocky Reach Reservoir was confirmed below Wells Dam, based on captures of this species during northern pikeminnow control activities conducted by Douglas County in the upper portion of the Reservoir (Golder 2003a).

Since little information existed on the status of white sturgeon populations in the mid-Columbia, Chelan, Douglas, and Grant County PUDs each initiated studies of white sturgeon through their current or upcoming process of relicensing their hydroelectric dams. (Golder Associates 2003a, Shane Bickford, personal communication). The information gathered from these studies is intended to help relicensing decision-makers understand basic white sturgeon life history information, distribution and current population sizes in the mid-Columbia region. Study results are discussed in the Section 3.

SECTION 3: STUDIES AND EVALUATION OF PROJECT EFFECTS

The presence of white sturgeon within the Reservoir was first confirmed during northern pikeminnow control activities conducted by Douglas PUD in the upper portion of the Reservoir, in the Wells Dam tailrace (Golder 2003a). Additionally, historical angler reports indicated that white sturgeon were captured previously in the upper portion of Reservoir above the confluence of the Chelan River. The available information, however, is not sufficient to assess accurately the status of the populations within the Reservoir, or to comprehensively determine what effects ongoing Project operations may have on the health of those white sturgeon populations.

Since available data on the status of the white sturgeon population were very limited, the NRWG identified data collection as a priority for the relicensing process.

*3.1 **Relicensing Studies***

In 2001, Chelan PUD contracted with R.L. & L. Environmental Services Ltd. to conduct a white sturgeon investigation in the Reservoir (R.L. & L. 2001). The objectives were to determine the presence/absence of white sturgeon in the Reservoir and to investigate general population characteristics of the white sturgeon observed, including distribution, growth rate, size and age-class composition, weight, sex ratio, genetic characteristics, and relative abundance.

An extensive capture effort in 2001 consisted of 153 total overnight net sets at 75 stations over three seasons (spring, summer, and fall). These efforts resulted in the capture of 18 white sturgeon, ranging in age from four to 48 years. Seven of these fish, ranging in age from four to six years, were identified as juveniles. All of the fish were tagged with Passive Integrated Transponder (PIT) tags, and five were tagged with sonic tags. The significant percentage of juveniles (39 percent) collected indicated some level of recent recruitment to the Reservoir population. These data suggest that one, or both, of the following has occurred: 1) spawning in the Reservoir; or 2) downstream movement of juveniles from points upstream of Wells Dam.

In 2002, Chelan PUD commissioned more detailed, systematic studies of white sturgeon in the Reservoir (Golder, 2003a). The 2002 study plan was based on the R.L. & L. study from the previous year. The objectives of the 2002 investigation were to systematically survey the distribution of white sturgeon throughout the Reservoir, and to obtain additional information on the general characteristics of the Reservoir population.

During the 2002 white sturgeon study, Chelan PUD contractors spent approximately 130,000 hook-hours of set line sampling effort in the Reservoir. This effort resulted in the capture of 10 white sturgeon that ranged in age from five to 24 years. Eight of these fish were identified as juveniles. Fork length of the ten fish captured ranged from 37 to 94 inches, and weights ranged from nine to 185 pounds.

For the combined 2001 and 2002 studies, 28 white sturgeon were marked. The number of recaptures was very low (n=4), or approximately 16 percent. As a result, population estimates exhibited wide confidence intervals. Mark-recapture data were used to generate a preliminary population estimate for white sturgeon in the Reservoir.

3.1.1 Population Characteristics

Using the Schnabel population estimation method (Krebs, 1989), the white sturgeon population in the Reservoir was estimated within a range of 50 to 115 fish, with a 95-percent confidence interval of 23 to 698 fish (Golder, 2003a). While the accuracy of this estimate is very uncertain, comparisons with other reservoir-based populations in the middle Columbia River suggest it is unlikely that the population is greater than 300 fish.

Juveniles are much more abundant in the Reservoir than they are in either the upper Columbia River or in the nearby downstream Wanapum and Priest Rapids reservoirs. This could be the result of successful spawning by the population residing in the Reservoir, but that has not yet been verified.

3.1.2 Sex Ratio and Reproductive Potential

The sex ratio of white sturgeon sampled in the Reservoir was 1:1; this was similar to sex ratios reported for white sturgeon populations in the free-flowing section of the Columbia River below Bonneville Dam (a non-impounded reach; DeVore et al., 1993), in the Wanapum Hydroelectric Project reservoir on the middle Columbia River (Golder, 2003c), and in the lower Snake River (Lepla et al., 2001).

Of the eight ovaries examined in the Reservoir, 37% were classified as non-reproductive, 37% as pre-vitellogenic (pre-productive), 13% as early vitellogenic (the early stages of productive), and 13% as ripe (productive). Similar proportions of ripe females were observed within the present white sturgeon population and populations on the Kootenai and lower Snake rivers.

Male white sturgeon mature at different rates and spawn over different intervals compared to females, and on average spawn every one to three years (Chapman 1989, Beamesderfer et al., 1995). Welch and Beamesderfer (1993) reported that large females (i.e., greater than 166 cm/65 in. FL) appear physiologically capable of spawning about every three years, with the spawning cycle consisting of a two-year period of oocyte development and a one-year resting period prior to re-initiation of gonadal development. Based on banding patterns on bony structures, other researchers have suggested five to seven year maturation intervals for female white sturgeon (Semakula and Larkin 1968, Chapman 1989, Beamesderfer et al. 1995). Based on this information, the number of females capable of spawning each year in the Reservoir is likely low.

3.1.3 Spawning and Recruitment

Assuming a maximum population size of 300 fish (of which 50% are mature) and a sex ratio of 50% females, there could be up to 75 mature females in the Reservoir population. Estimates of the annual proportion of females in a population that are capable of spawning (ripe) in a given year range from 2% in the unimpounded section of the Columbia River below Bonneville Dam to 13% in the Kootenay River. Applying this range to a population of 75 mature females suggests that potentially between two and ten females could be capable of spawning in any given year.

Based on percentages of ripe females recorded in other Columbia River populations (that range from 2% to 4%), the 2% estimate is more likely. Information from the results of spawning activities for white sturgeon populations in the Kootenai River in Idaho and the upper Columbia

River between HLK and Grand Coulee dams suggests that this level of spawning activity does not provide the strong recruitment pulse observed for the Rocky Reach Reservoir population during the late 1990s. The Kootenai River and upper Columbia River populations, which consist of approximately 900 to 1100 fish, are composed primarily of adults and exhibit annual spawning activity (Golder, 2002). The levels of recruitment observed in these two more northerly populations have never approached the recruitment pulse recorded in late 1990s in the Rocky Reach Reservoir. In Grant County PUD’s Wanapum Reservoir, approximately 21 miles downstream from the Rocky Reach Dam, a recruitment pulse was observed in the 1990s. This pulse, however, was one third the magnitude of the white sturgeon population recruitment pulse (i.e. an influx of fish into a geographic area) observed in the Rocky Reach Reservoir.

Another possible explanation for the high levels of recent recruitment in the Rocky Reach Reservoir may be related to juvenile immigration. These juveniles would most likely originate from populations in upstream reservoirs. Limited support for this hypothesis was provided by the documentation of one sonic-tagged juvenile white sturgeon that moved downstream from the Rocky Reach Reservoir through Rocky Reach Dam and into the upper section of the Rock Island Reservoir. The passage route of this fish through Rocky Reach Dam (i.e., spillway, turbine, or upstream fishway) was not determined. White sturgeon have been documented to use upstream fishways at lower and mid-Columbia River dams for both upstream and downstream passage, but, for reasons that are still poorly understood, the use of these fishways is highly variable among dams even though the fishways are similarly designed (Lepla et al., 2001). Juvenile white sturgeon have been documented to migrate downstream during winter and early spring months; these movements may be related to feeding activities (Bajkov, 1951).

Based on available data, recruitment to the Reservoir population has been sporadic and apparently limited to a strong recruitment period between 1995 and 1997 (and particularly 1997), and a lesser degree of recruitment between 1982 and 1987. Higher levels of recruitment may be associated with high flow events that transport young sturgeon into the Reservoir from upstream spawning areas. Flows in excess of 200,000 cubic feet per second were released from upstream projects in 1981, 1982, 1990, 1991, 1996, and 1997. High flows in these years could have transported young sturgeon produced in upstream reservoirs to the Reservoir. Such occurrences would also be dependent on strong recruitment from natural reproduction in these upstream habitats in the years during or preceding the high flow events. In addition, high flows could be associated with sporadic periods of successful reproduction of sturgeon within the Reservoir. In either case, the incidence of high flow years has been more frequent than the incidence of high recruitment of sturgeon to the reservoir. Whether from immigration or reproduction within the Reservoir, or both, the years with strong recruitment and gaps in recruitment are not entirely explained by flow conditions.

Historical recruitment trends based on assigned ages of white sturgeon should be interpreted with caution, since the use of fin rays to age white sturgeon is not very precise or accurate for larger individuals, and assigned ages tend to underestimate their true age (Rien and Beamesderfer 1994). However, since aging methods for younger sturgeon are more precise, the identification of the strong 1997 year-class in the Reservoir has a high probability of being accurate. The large number of fish captured during the present study from the 1997 year-class corresponds to the highest flow year on record since 1961 (Golder 2003a); this may suggest that high water years increase the survival and recruitment of juvenile white sturgeon, possibly because high flows provide increased turbidity or water volume, which enhances predator avoidance or improves the quality or quantity of rearing habitat. However, since it is not known if spawning occurs in the Reservoir, the strong year-class may be from reproduction that occurred in upstream reservoirs and reflected high flows that flushed young white sturgeon out of upstream habitats.

3.1.4 Growth

Information on growth of white sturgeon in the Reservoir was limited to one recaptured juvenile white sturgeon (82.0 cm/32.3 in. FL; age-5 at initial capture). This individual exhibited an incremental growth-rate of 23.5 cm (9.3 in.) after approximately one year at-large. Observed growth-rates tend to be higher for smaller-sized white sturgeon and vary depending upon age. For example, growth-rates of older juvenile white sturgeon below Hells Canyon on the Snake River averaged between 3.3 and 9.0 cm (1.3 and 3.5 in.) per year (Lepla et al., 2001), whereas hatchery-raised juvenile white sturgeon (age-1) released into the upper Columbia River below Keenleyside Dam demonstrated an average growth of approximately 0.1 cm (0.04 in.) per day for an average of 127 days at-large (summer and fall seasons only; Golder 2003c). In comparison, average growth-rates for older fish (sub-adults and adults) were 10.0 cm (3.9 in.) and 6.5 cm (2.6 in.) per year in the Bonneville and Wanapum hydroelectric project reservoirs, respectively.

Significant, observed changes in growth rate, called inflection points in the growth curves of fish, are commonly associated with changes in physiology, habitat, and food resources (Moreau 1987). For white sturgeon in the Reservoir, the inflection point in the growth curve was obscured and could not be determined because intermediate age-classes were not well represented in the sample, and because of the wide variation in length-at-age for younger year-classes. Inflection points in the Wanapum Reservoir on the mid-Columbia River (Golder 2003c) and on the Snake River were identified at age 10 (Lepla et al. 2001). Tracy and Wall (1993) found an inflection point at age eight for a population of white sturgeon below Bonneville Dam, and indicated that the von Bertalanffy growth functions were not well represented for fish under eight years old.

3.1.5 Movements

Movement information recorded for sonic tagged white sturgeon in the Reservoir is considered preliminary since observations were based on only one early overwintering period (October 2002 to January 2003). Sonic-tagged (tags that emit a signal that can be detected from long distances) white sturgeon used overwintering habitats located downstream of the Entiat River (RM 482.4), upstream of the Chelan River (RM 506.0), and downstream of Wells Dam (RM 513.0). Approximately 60% of sonic tagged fish were relatively inactive over the duration of this early overwintering period; these fish did not move more than 0.2 miles and usually remained in the same general area. Two males, however, moved approximately 30 miles between adjacent overwintering areas, possibly in response to changes in water temperature or food supply.

Studies conducted in other mid-Columbia River reservoirs (e.g., Priest Rapids, Wanapum, and McNary) also indicated that fish remained relatively inactive (i.e., did not move more than 0.2 miles) during the overwintering period, and few movements were observed between adjacent overwintering areas (Haynes et al. 1978, Golder 2003c). In the upper Columbia River (i.e., Lake Roosevelt, WA, and downstream of HLK Dam, British Columbia) and in free-flowing sections of the Snake River, between 60% and 90% of sonic tagged white sturgeon also selected specific overwintering areas and generally remained in these areas all winter (R.L.&L. 1994, Whittmann-Todd et al., 2001).

3.2 Findings to Date

The two years of white sturgeon study conducted for relicensing in the Reservoir in 2001 (R.L. & L. 2001) and 2002 (Golder 2003a) and review of existing information resulted in the following key findings:

- The white sturgeon population in Reservoir is currently low, estimated a range of 50-115 fish (95% confidence interval (CI) = 23-698);
- White sturgeon have not been observed in the Rocky Reach Dam upstream fishways (no documented upstream movement);
- Juveniles pass downstream through Rocky Reach Dam via the spillway, the powerhouse, and/or the juvenile bypass system;
- Multiple age classes (7 – 50 years old) are present in the Reservoir; and
- Age and growth in the Reservoir are within the range reported for populations in other parts of the Columbia River Basin, although data available on these factors is limited.

SECTION 4: PROTECTION, MITIGATION AND ENHANCEMENT MEASURES

The goal of the WSMP is to promote growth of the white sturgeon population in the Reservoir to a level that is commensurate with the available habitat by year 30 of the New License. To meet this goal, Chelan PUD is proposing a supplementation program to increase the population through use of hatchery-reared fish or fish that have been trapped in the lower Columbia River for direct release into the Reservoir (trap and haul), or other methods recommended by the RRFF. The PMEs of the WSMP are designed to meet the following objectives:

Objective 1: Increase the white sturgeon population in the Reservoir through supplementation to a level commensurate with available habitat and allowing for appropriate and reasonable harvest;

Objective 2: Determine the effectiveness of the supplementation program;

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

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

This WSMP will use Adaptive Management and is also intended to be consistent with other white sturgeon management plans in the mid-Columbia region, as well as any future white sturgeon management plans created by the WDFW**.**

The WSTG developed the objectives and activities described in this section. The effectiveness of each strategy will be determined through the monitoring and evaluation program. Once the results of the monitoring and evaluation program have been considered, Chelan PUD shall determine, in consultation with the RRFF, any appropriate and reasonable next steps, which may include adjusting the supplementation level.

Due to the adaptive nature of this program, the schedule for implementation of specific measures can only be estimated at this time. Table 3-1 provides an estimated schedule for implementing each activity, which will be adjusted through consultation with the RRFF, as new information becomes available.

4.1 Objective 1: Increase the White Sturgeon Population in the Rocky Reach Reservoir

Chelan PUD shall, in consultation with the RRFF, initiate an Adaptive Management, long-term, white sturgeon supplementation program in the Reservoir within one year after the effective date of the New License. Primary components of the proposed supplementation program are developing and implementing a broodstock collection plan, stocking juvenile white sturgeon in the Reservoir, determining long-term supplementation program production goals and facilities, establishing an appropriate and reasonable harvest rate, and implementing a rigorous monitoring program to determine age-class structure, survival rates, abundance, density, condition factor, growth rates, and to identify distribution and habitat selection of stocked juvenile sturgeon, emigration rate from the Reservoir, Reservoir carrying capacity, supplementation program efficacy, and natural reproduction potential. The stocking program is intended to be commensurate with the available habitat, and is not intended to create a "put-and-take" fishery. The following sections describe the components, timing of implementation, and decision-making process of the proposed supplementation program in detail.

4.1.1 Brood Stock Planning and Collection

Due to the low population estimates indicated by the 2001 and 2002 white sturgeon investigations, there is a low probability that brood stock from the Reservoir can be utilized as the basis for a long-term supplementation, so other sources of fish must be considered to increase the white sturgeon population (Golder 2003b). Within one year of the effective date of the New License, Chelan PUD shall, in consultation with the RRFF, prepare a brood stock collection plan that considers such factors as genetics and questions of imprinting. Possible sources of brood stock fish include:

- Brood stock collected from the Rocky Reach Reservoir and nearby reservoirs (Priest Rapids, Wanapum, or above McNary) and used in a hatchery supplementation program;
- Brood stock collected from the Columbia River below Bonneville Dam and used in a hatchery supplementation program;
- Excess juvenile production from other compatible supplementation programs;
- Juveniles purchased from a commercial facility for direct release into the Reservoir; and
- Juveniles from new or existing Chelan PUD-funded hatchery facilities retrofitted to accommodate white sturgeon brood stock, egg incubation, and juvenile rearing.

The initial source of brood stock will be determined by the RRFF within one year of the effective date of the New License, and collection will begin in year two of the New License, if fish are available and the RRFF determines that brood stock collection within such a timeframe is feasible (see Table 3-1, footnote 1). If collection is not feasible in year two of the New License, Chelan PUD shall proceed on a schedule to be determined by the RRFF, using Adaptive Management, as reflected in Table 3-1. The intent of brood stock collection is to use the progeny of the initial source of brood stock, if feasible, in the future for the white sturgeon stocking program.

4.1.2 Juvenile White Sturgeon Stocking

By year three of the effective date of the New License, Chelan PUD shall begin releasing up to 6,500 yearling white sturgeon into the Reservoir annually for three years. In consultation with the RRFF, yearling fish will be acquired through one or more of the following: 1) production from a Chelan PUD hatchery or cooperative mid-Columbia hatchery, 2) excess yearling fish production from other compatible supplementation programs, 3) purchase from a commercial hatchery, or 4) other measures identified by the RRFF. Extenuating circumstances, such as problems with hatchery siting, disease, etc., could result in a failure to meet the three year deadline. Chelan PUD shall meet with the RRFF to discuss any circumstances where the deadline will not be met, and, if necessary, alternatives will be developed by Chelan PUD and the RRFF and implemented by Chelan PUD (see Table 3-1, footnote 2).

Chelan PUD shall ensure that all hatchery-reared juvenile white sturgeon released into the Reservoir are marked with Passive Integrated Transponder (PIT) tags (tags that do not emit a signal and must be activated by a reader at very close range, i.e. the fish must be in hand) and year-specific scute marks for monitoring purposes described in Section 4.2 of this plan. In order to allow for tracking of juvenile white sturgeon emigration described under Section 4.2.2, Chelan PUD shall ensure that up to one percent (or a maximum of 65) of the juvenile white sturgeon released into the Reservoir are large enough to allow implantation of an active tag prior to release.

The number of yearlings released in subsequent years (after the initial three year stocking period) will range from 0 – 6,500, based on the results of the indexing program (Section 4.2.1) and/or the evaluation of spawning potential (Section 4.4) and could be adjusted after the evaluation period, in consultation with the RRFF (also see Table 3-1, footnotes 2 and 3).

In addition, following the third year of supplementation (unless Chelan PUD, in consultation with the RRFF, determines more analysis is required), Chelan PUD may elect to release juveniles at an earlier or later life stage in order to compare success of fish released at varying life stages. For example, based on consultation with the RRFF, Chelan PUD may elect to have a proportion of the hatchery-reared juveniles released at differing size intervals (with the minimum size being that which permits PIT tagging), in order to monitor potential differences in survival and growth during future indexing periods (see Section 4.1.1). On a schedule developed in consultation with the RRFF (see Table 3-1), Chelan PUD shall implant active tags in a percentage, to be recommended by the RRFF, of juvenile white sturgeon released as part of the supplementation program, in anticipation of future emigration rate and habitat use tracking surveys (Section 4.2.2).

Annual stocking levels of yearlings or possibly younger age-classes will be adjusted based on monitoring results in any given year. Methods for determining production goals, stocking locations, and breeding plans are described in Appendix A to this Chapter.

4.1.3 Long-term Production

By year seven of the New License, Chelan PUD shall, in consultation with the RRFF, determine a long-term approach (e.g. construct hatchery facilities, long-term contract, other approaches identified by the RRFF) to be used for continuing the supplementation program for the term of the New License. If the RRFF determines that insufficient information is available to determine a long-term decision by year seven, the RRFF will establish an additional evaluation period prior to making such a determination.

4.2 Objective 2: Determine the Effectiveness of the Supplementation Program (Monitoring)

Chelan PUD shall conduct a monitoring program within the Project boundary for the purpose of assessing the effectiveness of the supplementation program described in Section 4.1 and outlined in Table 3-1. Monitoring will include both an indexing program (Section 4.2.1.1) and assessments of emigration rates from the Reservoir, habitat use, and spawning locations through tracking of active-tagged white sturgeon (Section 4.2.2; also Table 3-1, footnotes 3 and 4).

Chelan PUD shall also investigate other white sturgeon recovery programs (e.g., Upper Columbia River, Kootenai River, etc.), that are collecting information regarding white sturgeon supplementation, and use the data to refine the implementation of the monitoring program. The results of this information will assist Chelan PUD and the RRFF to adjust future stocking rates.

4.2.1 Index Monitoring Program

In year four of the New License, or within one year following the initial stocking of juveniles in the Reservoir, whichever comes sooner, Chelan PUD shall begin conducting an initial three-year index monitoring program for juvenile and adult sturgeon in the Reservoir to determine age-class structure, survival rates, abundance, density, condition factor, growth rates, and to identify distribution and habitat selection of juvenile sturgeon. The indexing methods will include using gillnets or other appropriate recapture methods for juveniles and set lines for adults. As a component of the indexing program, Chelan PUD shall implant active tags in a percentage, to be recommended by the RRFF, of captured and released juvenile and adult sturgeon to facilitate the monitoring activities described in Section 4.2.2 (emigration and habitat use tracking of juvenile sturgeon) and Section 4.4 (evaluation of spawning potential of adult sturgeon).

Beginning in year eight of the New License, Chelan PUD shall continue to conduct one year of index monitoring every third year over the term of the New License, or on a schedule determined by the RRFF. The purpose of the continued index monitoring is to monitor age-class structure, survival rates, abundance, density, condition factor, growth rates; identify distribution and habitat selection of juvenile sturgeon; and direct the supplementation program strategy (see Table 3-1).

4.2.2 Investigation of Emigration Rate and Habitat Use of Supplemented Population

Beginning in year five of the New License, Chelan PUD shall conduct three-year tracking surveys of the juvenile white sturgeon that were released in each of the fifth, sixth, and seventh years of the New License with active tags as part of the supplementation program**.** This will require one percent of each of the first three annual classes of juvenile sturgeon (up to a maximum of 65 fish each year) to be reared large enough to implant an active tag for tracking purposes. The purpose of tracking active-tagged fish is to determine juvenile white sturgeon emigration rates out of the Reservoir, as well as, habitat use within the Reservoir.

Chelan PUD shall repeat the tracking survey for one additional year in years 14 and 20 of the New License, or as recommended by the RRFF (see Table 3-1, footnote 4). Such later year surveys shall track: 1) active tags implanted in a percentage of juvenile fish reared old enough to be released with such tags in the three years preceding the survey (tag life is estimated to be three years); and 2) any juvenile and adult fish implanted with active tags during the last indexing period preceding the survey.

4.2.3 Supplementation Program Review

During the term of the New License, Chelan PUD shall compile information on other white sturgeon supplementation programs in the Columbia River Basin in order to assess whether: 1) Chelan PUD's supplementation program is consistent (e.g. stocking rates, release age and size, brood stock source, and monitoring program) with similar regional programs; 2) improvements to the Chelan PUD program for the Project can be made; and 3) monitoring objectives can be met more economically.

4.3 Objective 3: Determine Carrying Capacity of Available Habitat in Rocky Reach Reservoir

Chelan PUD expects to gather sufficient information through the monitoring activities described in Section 4 to determine, in consultation with the RRFF, the carrying capacity of the Reservoir.

4.4 Objective 4: Determine Natural Reproduction Potential, and Adjust Supplementation Program Accordingly

Chelan PUD shall track reproductively viable adult sturgeon that were captured and implanted with active tags under Section 4.2.1 for the purpose of identifying potential spawning locations. Five additional annual surveys of natural reproduction will occur between years 8 through 18 of the New License, as recommended by the RRFF, based on flow conditions or other data.

An important component of the WSMP is to determine recruitment limiting factors. Methods to determine limiting factors may include:

- Capture, tag, and track reproductively viable adult sturgeon to locate potential spawning locations.

- Conduct spawning surveys. If viable spawning adults cannot be obtained for tagging per the previous task, or if spawning movements cannot be observed, egg collection mats will be placed below Wells Dam (which is a potential spawning area based on habitat conditions) to attempt collection of eggs.

An understanding of habitat limitations that affect the natural population structure (e.g., year/class and age distribution) within the Reservoir is needed to determine the numbers of white sturgeon that should be released to meet habitat carrying capacity.

4.5 Reporting

Each year, Chelan PUD shall provide a report to the RRFF summarizing the year's activities under this WSMP. Such a report shall include a summary of stocking levels, indexing and tracking survey results (if such activities were conducted in such year), and other significant decisions or evaluations made pursuant to this WSMP. The supplementation program review described in Section 4.2.3 shall also be contained in this report, with periodic updates included as appropriate.

4.6 Adaptive Management Implementation Schedule

Chelan PUD and the RRFF shall coordinate during the term of the New License to ensure that the juvenile white sturgeon stocking program, indexing program and associated use of active tags (with limited lives) are coordinated to most effectively meet the overall monitoring goals and schedule. Table 3-1 demonstrates an estimated long-term schedule, subject to Adaptive Management by Chelan PUD, in consultation with the RRFF, to coordinate release, survey, tagging, and monitoring activities. Biological objectives for supporting designated uses for white sturgeon are shown in Table 3-3: 2, and a summary of criteria for achievement of objectives for white sturgeon is shown in Table 3-3: 3.

Table 3-1: Rocky Reach White Sturgeon Monitoring and Evaluation Program

New license year	Collect brood stock[1]	Release fish in Rocky Reach[2]	Indexing[3]	Track marked fish[4]	Assess Natural Production[5]
1					
2	x				
3	x	x			
4	x	x	x		
5	x	x	x	x	
6	x	TBD[2]	x	x	
7	x	"		x	
8	TBD[2]	"	x		TBD
9	"	"			"
10	"	"			"
11	"	"	x		
12	"	"			
13	"	"			"
14	"	"	x	x	
15	"	"			
16	"	"			
17	"	"	x		
18	"	"			"
19	"	"			
20	"	"	x	x	
21	"	"			
22	"	"			
23	"	"	x		
24	"	"			
25	"	"			
Repeat years 23 to 25 through end of license					

1 Collection of brood stock may include capture of mature adults from the lower Columbia River or in the mid-Columbia or Snake River where appropriate and reasonable. The initial source of brood stock will be determined in year one of the program, and collection will begin in year two.

2 A total of 6,500 yearlings will be released in the Reservoir during each of the first three years. Total yearlings released in subsequent years will range from 0 – 6,500, based on the results of the indexing program. Hatchery fish will be acquired through purchase from a commercial hatchery, production from a Chelan PUD hatchery or cooperative mid-Columbia hatchery, or other measures. Breeding plans for all options will be developed, in consultation with the RRFF.

3 Indexing will include monitoring of age, growth, habitat, survival, and condition factors of juvenile and adult sturgeon. Results will be used to determine future stocking rates, locations, and timing. The frequency of indexing may be adjusted in consultation with the RRFF.

4 Active-tagged juvenile and adult sturgeon will be tracked to assess emigration, habitat use, and potential spawning locations.

5 Conduct spawning surveys, as recommended by the RRFF, to identify natural production in the Reservoir. The RRFF may adjust surveys based on flow conditions or other data.

Table 3-2: Biological Objectives for Supporting Designated Uses for White Sturgeon

Designated Use	Biological Objective	Evaluation Timeframe	Actions if Objective Achieved	Alternative Management Actions	Plan Action
White Sturgeon Natural Recruitment	Natural reproduction potential	Years 8-10, 13, and 18	Maintain Action. No additional action needed.	Develop and implement a plan, in consultation with the RRFF, to address identified problem(s)	Section 4.4
White Sturgeon Population at Carrying Capacity	Increase the white sturgeon population in the Reservoir through supplementation to a level commensurate with available habitat	Years 3-5, adjust stocking level; years 6 - 50	Maintain Action. No additional action needed.	RRFF to recommend stocking level, broodstock source. Develop and implement a plan, in consultation with the RRFF, to address identified problem(s)	Sections 4.1-4.3; and 4.6
White Sturgeon Harvest	Success in creating population with a stable age-structure that allows for appropriate and reasonable harvest rate	Years 20 - 50	Maintain Action. No additional action needed.	Develop and implement a plan, in consultation with the RRFF, to address identified problem(s)	Sections 4.1-4.6

Table 3-3: Summary of Criteria for Achievement of Objectives for White Sturgeon

Use/ Action	Objective	Measured Parameter	Schedule	Actions if Objective Achieved	Actions if Objective Not Achieved	Plan Action
Juvenile White Sturgeon	Increase white sturgeon population in Rocky Reach Reservoir	Stock 6,500 yearlings	years 3-5, each year	Maintain action. No additional action needed.	Adjust stocking level; alternative broodstock; excess production	Section 4.1.2
	Increase white sturgeon population in Rocky Reach Reservoir	Stock 0-6,500 yearlings	years 6-50	Maintain action. No additional action needed.	RRFF to recommend stocking level	Section 4.1.2
Juvenile and Adult White Sturgeon	Determine supplementation program effectiveness	Indexing: age class structure; survival rates; abundance; density; conditi0on factor; growth rates; tag and track fish; distribution; habitat selection, use, availability, and suitability	years 4-6	Maintain action. No additional action needed.	Develop and implement a plan, in consultation with the RRFF, to address identified problem(s)	Section 4.2.1
	Determine supplementation program effectiveness	Indexing: age class structure; survival rates; abundance; density; conditi0on factor; growth rates; tag and track fish; distribution; habitat selection, use, availability, and suitability	year 8 and then annually every 3rd year for term of license	Maintain action. No additional action needed.	Use Adaptive Management to adjust supplementation program strategy in consultation with the RRFF	Section 4.2.1
	Determine supplementation program effectiveness	Emigration rate and habitat use; track marked fish	years 5-7, 14, and 20	Maintain action. No additional action needed.	Develop and implement a plan, in consultation with the RRFF, to address identified problem(s)	Section 4.2.2
	Supplementation program review	Compile additional information from other programs	years 3-50	Maintain action. No additional action needed.	Develop and implement a plan, in consultation with the RRFF, to address identified problem(s)	Section 4.2.3
	Determine Reservoir carrying capacity	Indexing results, emigration rate results	years 3-50	Maintain action. No additional action needed.	Develop and implement a plan, in consultation with the RRFF, to address identified problem(s)	Section 4.3
Adult White Sturgeon	Natural reproduction potential	Tag adults and monitor through indexing; egg mat placement	years 8-10, 13, and 18	Maintain action. No additional action needed.	Develop and implement a plan, in consultation with the RRFF, to address identified problem(s)	Section 4.4

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APPENDIX A: AUGMENTATION STRATEGIES FOR ROCKY REACH

Brood Stock Collection

The effect of a supplementation/augmentation program on the genetics of wild sturgeon populations is a key consideration when the program goals and operations are planned. Existing programs maintain the genetic integrity of the populations through the use of brood stock obtained directly from the target population and then breeding these individuals according to genetically based breeding plan. Although utilizing brood stock from within Rocky Reach Reservoir would be the preferred option, the Rocky Reach Reservoir has a small resident adult population (Golder 2003a), providing for a low probability that an adequate number of individuals in spawning condition could be obtained.

Seven evolutionary significant units (ESUs) for white sturgeon have been defined (UCRWSRI 2002). The Columbia River white sturgeon population represents two ESUs for white sturgeon in Pacific North America:

i) the upper Columbia River population in Canada and the United States and,
ii) the lower/middle Columbia River in the United States.

Since the lower and mid-Columbia populations are considered to be the same ESU, this provides Chelan PUD with additional options to obtain brood stock. The following is a list of options that will be decided upon through collaboration with the Chelan PUD and the Rocky Reach Fish Forum (RRFF).

1. Collect brood stock from nearby reservoirs (Priest Rapids, Wanapum, McNary) and begin a hatchery supplementation program.

2. Collect brood stock from the lower Columbia River and begin a hatchery supplementation program.

3. Purchase juveniles from a commercial facility for direct release into the Rocky Reach Reservoir.

4. Build or retrofit existing hatchery facilities to accommodate brood stock, egg incubation and juvenile rearing.

5. Trap and haul adult or juvenile sturgeon from the lower Columbia River for direct release into the Rocky Reach Reservoir.

Breeding Plan

The following section outlines a breeding strategy for possible use in the Rocky Reach Reservoir white sturgeon conservation fish culture program from brood collection to juvenile releases. Many of the concepts in this plan are based on the "Breeding Plan to Preserve the Genetic Variability of the Kootenai River White Sturgeon" (Kincaid 1993) and incorporated into the breeding plan for the Upper Columbia White Sturgeon Recovery Plan (UCWSRI 2002) but have been adapted as required to suit the specific population characteristics of white sturgeon in the middle Columbia River. The duration of the supplementation program will be determined by the results of the monitoring and evaluation program and in collaboration with the Rocky Reach stakeholders. The recruitment goal will be set according to what is supportable by the current available habitat.

Brood Stock Targets

In the initial stages of the WSMP (i.e. years 2-4), the goal will be to release up to 6,500 juveniles. After the third year of releases, the target will be revaluated and adjustments made. For the initial stages of the supplementation program, juvenile fish will be acquired through either production from a Chelan PUD hatchery or cooperative mid-Columbia hatchery, excess juvenile production from other compatible supplementation programs, purchase from a commercial hatchery, or other measures recommended by the RRFF. When the decision to acquire brood stock is made, the target will be determined by the number of juveniles required to meet the supplementation program goals.

In the upper Columbia and Kootenai populations, spawning locations are known and obtaining spawners is relatively straightforward (but not guaranteed). The Kootenai program captures and holds only females at the hatchery facility; the males are captured on an as-needed basis during the spawning season with milt being collected on the river and transported to the hatchery. The upper Columbia breeding program captures both males and females and transports both sexes back to the hatchery for spawning; flowing males are typically easier to obtain than ripe females. Some spawning failures, due to poor egg viability or the inability to stimulate ovulation, have been recorded by both the upper Columbia and Kootenai programs. Therefore, Chelan PUD should consider collection of additional females over and above the target number. The collection of additional males also may be warranted, although cryopreservation is a viable option to preserve any excess milt available.

At present, the number of fish that will contribute to spawning activities each year of the program cannot be predicted. For example, a substantial 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, failure to induce ovulation has frequently occurred in both the upper Columbia and Kootenai programs, although the exact reasons for this remain unclear. For reference, fertilization and hatching rates at the KTOIH have ranged from 6% to >99% and 1% to 90%, respectively. 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, unpublished data).

A secure, short-term holding facility for spawners is required to induce spawning. Induction involves a combination of temperature/photoperiod/hormone treatments and requires 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.

Mating

Mating schemes are designed to reduce the likelihood of inbreeding by maximizing the genetic effective population size N_e. A primary goal is to equalize genetic contributions of all spawners. This is accomplished by a 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 brood stock), variations on the 1:1 plan are required.

Due to failures associated with egg viability in other culture programs, gamete splitting is often used to ensure that each male and female has more than one opportunity to reproduce. 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 risk is considered acceptable if maximizing the total number of contributing individuals each year is the most important goal. In addition, the possibility of hatchery half-siblings actually mating in the future is probably very low given the life history characteristics of white sturgeon and may be similar to rates that actually occur in the wild. 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.

All brood stock should be permanently marked, sampled for tissue (for DNA identification) and released back into the wild once they have been spawned (although reconditioning, including return to a fish-based diet, should be conducted if spawners were taken off a natural fish diet). Given that white sturgeon have the potential to contribute to the next generation multiple times throughout their life span, re-captures in future brood stock collections can be considered for brood stock 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 initially adapted for the upper Columbia program based on work done by Kincaid (1993), and Miller and Kapuchinski (in press). Ideally, families were equalized (to plus or minus 20%) prior to mixing and release to ensure equal genetic contribution of families to the next generation. This was intended to maximize the genetic effective population size $N_{e.}$

Depending on a number of factors, however, family equalization may actually compromise some objectives of a supplementation program. Equalization can reduce the total number of fish available for release, which can reduce the ability to accurately determine survival rates of hatchery produced progeny released into the wild. In addition, the number of individuals that are available for release once equalization has been completed may consistently fall short of annual targets required to meet the long-term population goals.

Recent thinking among the upper Columbia and Kootenai recovery teams has shifted as to the relative risks of unequal family releases versus the culling of potential fish for stocking. A greater importance is being placed on the need to maximize the genetic contributions of the existing population and to ensure sufficient numbers of juveniles are stocked to achieve adult population targets and evaluation goals. For the white sturgeon supplementation program in the Reservoir, concerns regarding family equalization need to be balanced against more immediate priorities of ensuring that adequate numbers of individuals contribute genetically to the next generation and that sufficient numbers of juveniles are stocked to meet short-term research needs and long-term population targets.

The following recommendations on mating scenarios have been excerpted from the breeding plan of the UCWSRI and assume that maturation of most fish can be synchronized artificially with hormone injections of LHRHa (luteinizing 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 as a means to facilitate these scenarios, are presently being investigated and should be incorporated into the final Plan.

Mating Scenarios

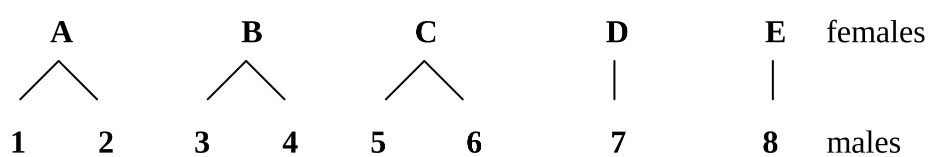
- *10 or more males and females available*

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

- *5-9 males and 5-9 females*

Conduct 1:1 matings unless more than 10% of either sex is infertile. If males exceed 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



- *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)

A **B** **C** **D** females

1 **2** **3** **4** **5** **6** **1** **2** males

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. For the upper Columbia program, it was deemed too risky at present to assume that every male will successfully spawn or that more ripe males could easily be obtained in-season.

- *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

A **B** **C** females

1 **2** **3** **1** **2** **3** males

e.g., 4 males, 3 females

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

A **B** **C** females

1 **2** **3** **4** **1** **2** **3** **4** males

or

A **B** **C** females

1 **2** **3** **4** **1** **2** males

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.

- *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. For the upper Columbia program, given the uncertainty with obtaining spawners, spawning will be attempted for each year even if only one female is obtained.

e.g. 2 males, 1 female

A female

1 **2** male

Asynchrony in Spawners

The results of the brood stock collections for the upper Columbia, indicate that it is unlikely that all brood stock will be ready to spawn at the same time and that the limiting factor will be the females. Therefore, 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. Mature females take 20 to 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, in an extreme case) ripe males can be confirmed. Realistically, is often 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; R. Ek, pers. comm., 2002). This component requires further experimentation and consultation with other experts.

Rearing and Release

Each family should be reared separately until early mortality tails off, at which point inventory reduction should take place to begin to equalize families within the constraints discussed above.

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., 2003). 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 avoid selective culling procedures (removing small, slow-growing fish) and to maximize the survival of all individuals (e.g. rear separately according to size).

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). After tagging, 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.

Ideally, juvenile releases for conservation purposes should maximize genetic contributions from the available adult population. In addition, sufficient numbers should be released to achieve long-term population targets based on conservative assumptions. This approach is best accomplished by achieving the production goals through the use of more families and smaller family sizes as opposed to fewer, larger families. Family equalization should be considered in the release strategy but not at the expense of achieving the first two objectives. Optimization of actual stocking rates will be a process that occurs over several years as better information on survival rates and recruitment bottlenecks become available through the monitoring program. To date, the Kootenai program has released a range of ages from 3 to 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.

In summary, the number of juveniles per family to maintain and release will depend on:

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

Until many of the questions regarding juvenile post-stocking survival are addressed, it may be most appropriate to rear as many fish as possible from as many families within the limits dictated by facility constraints. Future adjustments can be made to either reduce juvenile populations in the event survival is better than predicted or to correct possible genetic effects due to over-stocking of some families. If fish are individually marked or marked to family, selected individuals can be re-captured from the population and culled (either through a research program or a directed fishery). As more information is obtained in the future, the program may be able to adopt a stronger emphasis on family equalization.

Record Keeping and Monitoring

Given the experimental nature of this program, detailed records of all stages of brood stock 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 brood stock 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 post-release evaluation programs.

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