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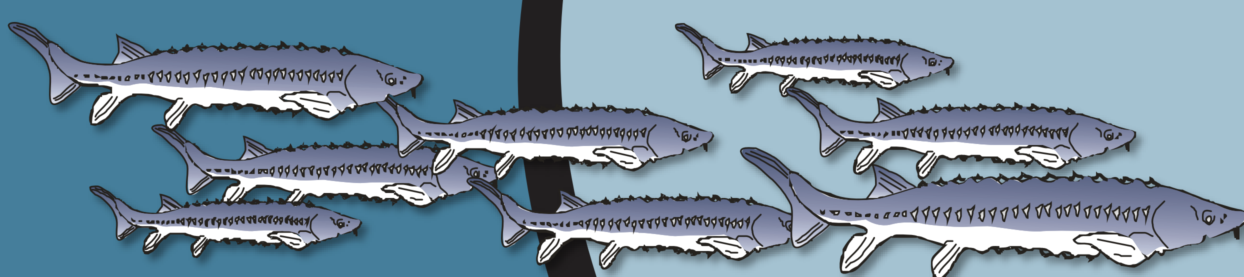
WHITE STURGEON HATCHERY MASTER PLAN
Lower Columbia & Snake River Impoundments

Step I Revised

PREPARED BY

The Columbia River Inter-Tribal Fish Commission



Preface

The Columbia River Tribal Fish Commission (CRITFC) prepared this Master Plan to address Step I of the Northwest Power and Conservation Council's (NPCC or Council) review requirements for artificial propagation projects involving new construction and/or programs that will produce fish for reintroduction. This plan describes an artificial production program and facilities needed to meet mitigation goals for White Sturgeon in lower Columbia River basin impoundments from Bonneville Dam to Priest Rapids and Lower Granite dams.

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1 SUMMARY

Construction and operation of the hydropower system has substantially reduced White Sturgeon productivity and fishery opportunity throughout the Columbia and Snake River systems. Sturgeon occur throughout most of their historical range but current production is far below the historical level. Low numbers severely limit sturgeon harvest opportunities throughout the basin, particularly for impounded populations upstream from Bonneville Dam.

Current status, limiting factors, and conservation, restoration, and mitigation efforts are detailed for White Sturgeon throughout the Columbia Basin in a Planning Framework prepared at the direction of the Northwest Power and Conservation Council (Beamesderfer & Anders 2013). This document was prepared by participants in Council-funded sturgeon projects with input from a series of regional workshops and identified a series of findings and recommendations which provide guidance for sturgeon programs and projects throughout the region. The framework found that careful use of sturgeon hatcheries has the potential to help perpetuate declining wild populations and mitigate for lost natural production in many impounded areas.

Consistent with regional sturgeon framework recommendations, the Columbia Inter-Tribal Fish Commission prepared this Master Plan describing a sturgeon hatchery program designed to help mitigate impacts of development and operation of the Federal Columbia River Power System on sturgeon population productivity and fishery opportunities in lower mid-Columbia River and lower Snake River reservoirs.

Figure 1. Juvenile sturgeon being loaded into tank truck prior to release (*photo by D. Miller*).

Sturgeon hatchery program goals include:

1. Enhance commercial, subsistence and recreational fisheries for impounded subpopulations of sturgeon consistent with habitat capacities.
2. Conduct sturgeon enhancement in a manner which ensures protection and conservation of natural populations and the ecosystem.
3. Employ hatchery-produced sturgeon as an experimental tool for applied research on limiting factors, habitat capacity, broodstock limitations, population parameters, and immigration/entrainment in natural populations.

Objectives were identified based on goals to provide explicit criteria by which success of the hatchery program will be measured:

1.1. Increase harvest of White Sturgeon in commercial, subsistence and recreational fisheries for impounded lower Columbia River subpopulations by 100% or more consistent with constraints of existing habitat capacity.

1.2. Increase abundance of White Sturgeon in lower Snake River reservoirs by 100% or more to enhance fishery quality and potential harvest opportunity consistent with constraints of existing habitat capacity.

2.1. Limit sturgeon biomass in enhanced subpopulations to levels consistent with those of productive impounded subpopulations in order to ameliorate risks of significant ecological impacts on wild sturgeon demographics and sensitive ecosystem components.

2.2. Achieve an effective population size of at least 500 sturgeon adults per 25-year generation for hatchery broodstock in order to avoid undesirable genetic effects of propagation.

2.3. Achieve proportionate natural influence of 67% or more in productive (primary) sturgeon subpopulations and 50% or more in limited-productivity (contributing) sturgeon subpopulations (as per HSRG guidance for salmonids).

2.4. Continue to limit to effective lifetime exploitation rate of fisheries for enhanced sturgeon subpopulations to no more than 60% in order to sustain significant natural broodstock recruitment.

3.1. Increase precision and reduce bias in estimation of limiting factors, habitat capacity, broodstock limitations, population parameters, and immigration/entrainment of natural sturgeon subpopulations.

The following implementation strategies were identified to achieve program objectives while also controlling associated ecological, demographic, genetic, and uncertainty risks:

1. Release hatchery-reared sturgeon in impounded reaches of the lower Columbia and Snake rivers where natural production is not adequate to utilize the existing habitat capacity, with a primary focus on John Day Reservoir.
2. Scale and adjust release numbers to optimize sturgeon production and fishery benefits in target areas while avoiding significant, density-related, intra-specific impacts or inter-specific ecological risk.
3. Hatchery releases will occur annually and all hatchery releases will be marked to facilitate evaluations of hatchery effectiveness.
4. Use a combination of conventional wild broodstock and wild larvae collection for initial production and refine approach based on relative effectiveness and efficiency in achieving program goals.
5. Use sturgeon originating from the mid-Columbia Genetic Management Unit for hatchery production with a preference for sources with a lower probability of successful natural reproduction.
6. Utilize only wild-origin sturgeon for hatchery broodstock.
7. Employ best management practices to integrate hatchery sturgeon with the natural genetic and life history diversity of wild-spawning sturgeon.
8. Design hatchery facilities and employ practices to minimize disease risks which might impair hatchery effectiveness or health of wild sturgeon.
9. Hatchery sturgeon will be produced at one primary facility and possibly one or more companion facilities.
10. Hatchery supplementation will be conducted in an experimental framework that includes a strong monitoring and evaluation program, established benchmarks for the evaluation of benefits and risks, and a clear decision structure for future adaptive management.
11. Fisheries for supplemented populations will continue to be regulated to provide adequate recruitment of sturgeon to broodstock sizes in order to sustain significant natural recruitment wherever possible.
12. Implement the sturgeon hatchery mitigation program in conjunction with continuing efforts to protect and restore habitat and environmental conditions suitable for natural recruitment.

The following production targets are identified for this program based on hatchery implementation strategies described above.

	Conventional	**Wild larvae**
Annual releases	Columbia: ≤5,000 (Fall @ age 0+), ≤20,000 (Spring @ age 1), ≤1,500 (Summer @ age 1+) Snake: ≤5,000 (Spring @ age 1)	
Size at release	15-20 g (age 0+), 100-150 g (age 1), 250-350 g (age 1+)[a]	
Broodstock	20 per year	--
Families	50 total (2 x 5♂x5♀) 10 maternal families/ year	(many)
Eggs	≤1,000,000	--
Fry	≤150,000	≤20,000
Fish / ♀ family	Columbia: ≤2,650 Snake: 500	(few)

[a] *A random sample across available programs will be selected for each target size release.*

This production is projected to increase total abundance of sturgeon (all sizes) in Zone 6 by 35,000 to 120,000 depending on post-release survival of hatchery-origin sturgeon. Hatchery-origin sturgeon might ultimately comprise 7-26% of the Zone 6 sturgeon population depending on actual survival rates, if current wild numbers remain stable. Projected sturgeon standing crop (lb/acre) in John Day Reservoir would likely be similar to that of current subpopulations in Bonneville and The Dalles reservoirs. In both cases, fish density (number/acre) in John Day (51,900 acres, 21,000 ha) would remain substantially below that of Bonneville (20,800 acres, 8,400 ha) and The Dalles (11,100 acres, 4,500 ha) reservoirs. Hatchery sturgeon are projected to increase annual harvest in John Day Reservoir by about 40-140%. Initial release numbers are designed in part to facilitate evaluation of program effectiveness and will inevitably be adjusted in the future based on monitoring results. Hatchery sturgeon are also projected to increase total numbers of adult sturgeon in John Day Reservoir by about 75-250%, depending on realized survival rates of hatchery fish. The nature of the spawner-recruitment of sturgeon is unknown. It remains to be seen whether more spawners will result in more recruitment.

This plan includes a conceptual plan for construction and operation of sturgeon hatchery facilities for consideration as Step I under the Northwest Power and Conservation Council's three-step Hatchery Master Planning Process. The primary sturgeon production facility will be located at Marion Drain on the Yakama Reservation. A hatchery is already operated by the Yakama Nation at this site to produce sturgeon for release in upper mid-Columbia Public Utility District reservoirs.[1] Companion facilities will also be developed at the Walla Walla South Fork Hatchery

[1] *Existing hatchery facility and production at Marion Drain is supported with funding by the Yakama Nation and contracts with the Public Utility Districts.*

operated by the Confederated Tribes of the Umatilla Indian Reservation and the Walla Walla Water Resource Center. This plan includes preliminary cost estimates for the primary production facility based on the conceptual design. Detailed costs estimates for the companion facility or facilities will be identified in the next step of this planning process after Marion Drain costs are developed further.

Table 1. Cross reference to NPCC Step I review elements.

	Step Process Element	Plan Reference
1	Eight Scientific Principles	Section 5.8.1 – Fish & Wildlife Program Scientific Principles
2	Link to other projects & activities	Section 4 – Programmatic Guidance Section 4.8 – Related Projects
3	Biological objectives	Section 5.2 – Objectives
4	Project benefits	Section 5.6 – Expected Outcomes
5	Implementation strategies	Section 5.4 – Implementation Strategies
6	Habitat strategies	Section 5.8.2 – Fish & Wildlife Program Strategies
7	Alternative measures	Section 2.3 - Alternatives Considered
8	Historical & current status	Section 3.2 – Aquatic Ecosystem Section 3.3 – Sturgeon Life History Section 3.4 – Sturgeon History Section 3.5 – Current Sturgeon Status
9	Current & planned management	Section 9.2 – Fishery Regulation Section 9.3 – Management Goals Section 9.4 – Management Process Section 9.5 – Management Objectives
10	Consistency with recovery plans	Section 10.2 – Endangered Species Act
11	Environmental assessment	Section 10 – Environmental Compliance
12	Monitoring & evaluation plan	Section 8 – Monitoring & Evaluation Plan
13	Items & costs for 10 years	Section 11 – Cost Estimates & Assumptions
14	Artificial production policies & strategies	Section 5.8.3 - Artificial Production Policies
15	Hatchery genetic management plan	Section 13.2 – HGMP
16	Harvest plan	Section 9 – Harvest Plan
17	Assessment of existing facilities	Section 13.1 – Inventory of Potential Hatchery Sites
18	Conceptual design	Section 7 – Conceptual Facility Design

2 PROGRAM JUSTIFICATION

Construction and operation of the hydropower system has substantially reduced White Sturgeon productivity and fishery opportunity throughout the Columbia and Snake River systems[2]

2.1 NEED

The Columbia basin historically supported a large and productive population of White Sturgeon with access to hundreds of miles of the Columbia and Snake rivers from the Pacific Ocean upstream far into Idaho and Canada. The historical sturgeon population was depleted by overfishing during the late 1880s but dam construction and operation are currently the primary impediment to rebuilding sturgeon populations and the fisheries (Beamesderfer et al. 1995; Devore et al. 1995; Beamesderfer & Anders 2013).

Mainstem dams block sturgeon movement as fish ladders and downstream bypass systems for salmon are not effective for sturgeon (North et al. 1993; Warren & Beckman 1993; Parsley et al. 2007; Beamesderfer & Anders 2013). Bonneville Dam prevents movement into spawning, incubation and rearing areas upstream and increases vulnerability to sea lion predation (DeVore et al. 1995; ODFW 2011b; Beamesderfer & Anders 2013). Habitat fragmentation, inundation, and flow regulation upstream from Bonneville Dam results in poor or inconsistent natural production of most impounded subpopulations (Parsley & Beckman 1994; Counihan et al. 1999; Parsley & Kappenman 2000). Dam operations also directly impact sturgeon through mortality in draft tubes and fishways during maintenance, and in turbines during passage.

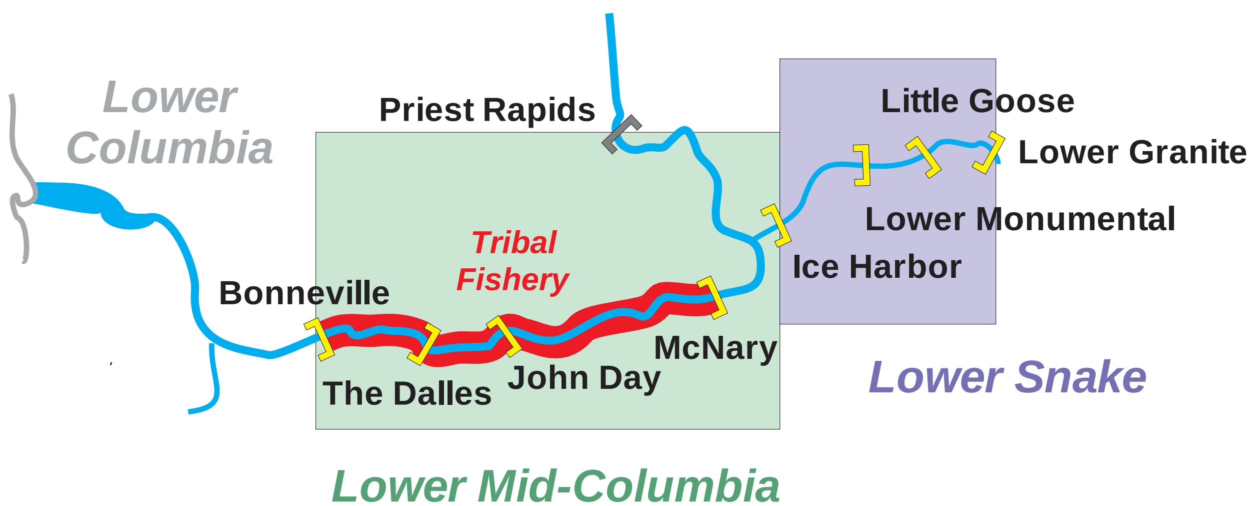

Figure 2. Lower mid-Columbia and lower Snake sturgeon subpopulation areas considered in this plan.

[2] *Beamesderfer et al. 1995; Beamesderfer & Anders 2013; UCWSRI 2013.*

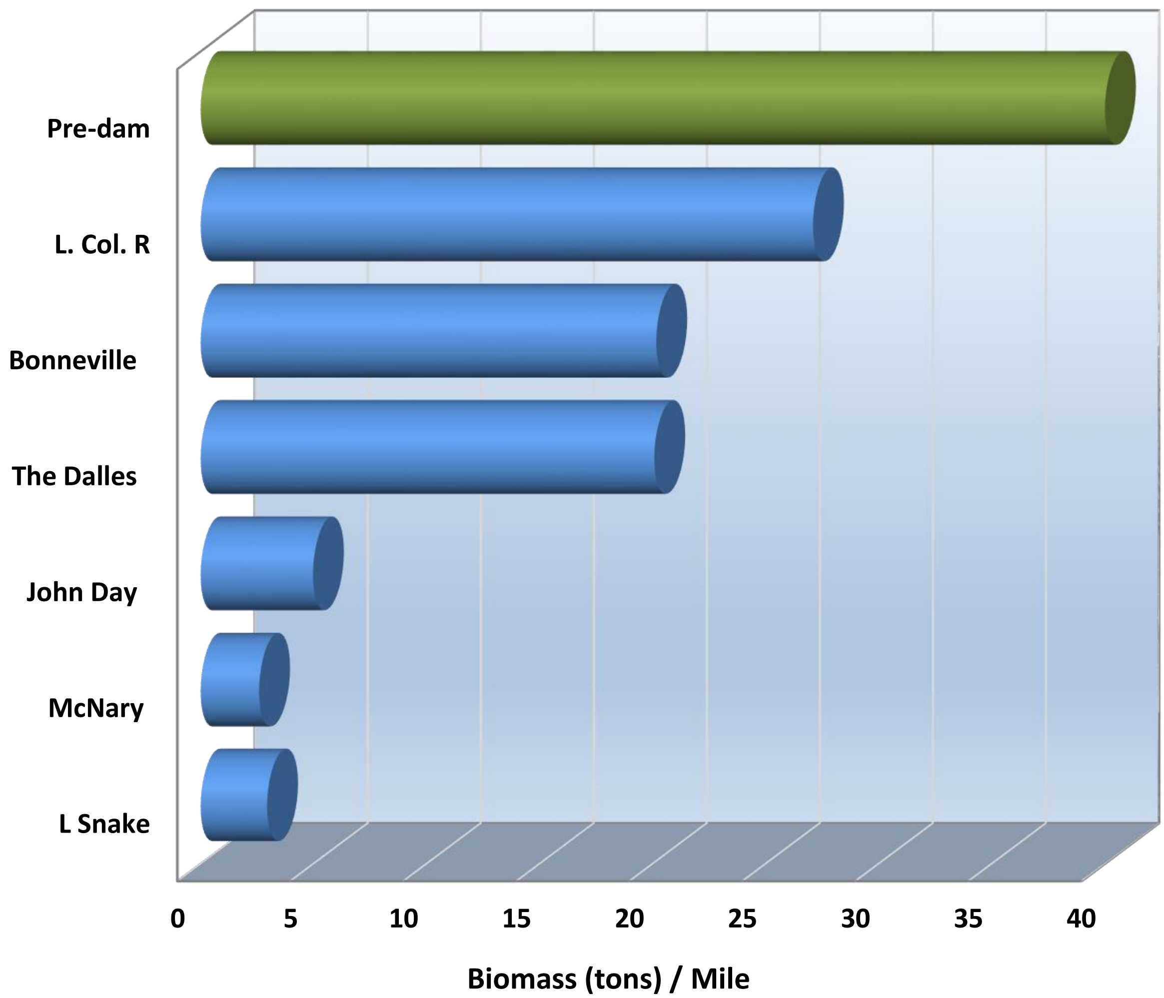

Figure 3. Estimated sturgeon standing crop per mile of river or reservoir for lower Columbia and Snake River subpopulations relative to historical population levels throughout the lower Basin. Current numbers are based on population estimates and size composition. Historical levels are based on pre-1900 harvests as described in Beamesderfer et al. (1995).

Sturgeon still occur throughout most of their historical range but current production is far below the historical level (Figure 3). Low numbers severely limit sturgeon harvest opportunities throughout the basin, particularly for impounded populations upstream from Bonneville Dam. Small tribal subsistence, tribal commercial fisheries, non-tribal recreational fisheries occur upstream from Bonneville Dam. Current fisheries are highly regulated in order to maintain small levels of harvest consistent with current productivity (Rieman & Beamesderfer 1990; Beamesderfer & Anders 2013). However, harvest, yield and opportunity is nowhere near the historic or current potential (Beamesderfer et al. 1995; Beamesderfer & Anders 2013).

2.2 PURPOSE

This program will utilize hatchery production to help mitigate impacts of development and operation of the Federal Columbia River Power System on sturgeon population productivity and fishery opportunities in lower mid-Columbia River and lower Snake River reservoirs.

Dedicated research, evaluation and management efforts in lower Columbia and Snake river impoundments since 1987 have:

1. provided a fundamental understanding of the biology, population dynamics and habitat requirements of this unique species,
2. estimated status and productivity of impounded populations;
3. identified key life stages and factors limiting most subpopulations;
4. evaluated sturgeon passage at dams;
5. documented impacts of flow regulation on spawning habitat availability and annual recruitment;
6. employed regular stock assessments to optimize harvest within the constraints of existing production;
7. evaluated feasibility and efficacy of transplants and hatchery production; and
8. begun to explore the feasibility and effectiveness of protection, mitigation, restoration alternatives.

However, these research and management efforts have not restored natural productivity or substantially increased fishery opportunities for mid-Columbia and lower Snake sturgeon because fundamental causes of resource limitation have not been remedied or mitigated (NPCC 2004; Mallette 2014; Beamesderfer & Anders 2013). Natural production is limited primarily during the incubation, early life, and young-of-the-year life stages, which appear to require very specific combinations of conditions that are rarely met in today's impounded and regulated system.

Many reservoir and river segments upstream from Bonneville Dam have the potential to support more numerous sturgeon populations and greater harvest potential if sturgeon movements were not constrained by dams or natural if recruitment was not impacted by local habitat and flow conditions. The lack of effective sturgeon passage also prevents sturgeon from redistributing within and among favorable habitats. However, when favorable habitats have been effectively seeded, substantial numbers of White Sturgeon can be produced. Stock assessments of impounded populations have found good survival, growth, and condition of resident sturgeon (Beamesderfer et al. 1995; Beamesderfer & Anders 2013). Thus, unseeded or under seeded habitats provide a significant opportunity for improving sturgeon numbers.

Impoundments may provide large areas of habitat suitable for juvenile, subadult, and adult sturgeon (Parsley et al. 1993; Parsley & Beckman 1994). Parsley & Beckman (1994) suggest that hydroelectric development in the Columbia River Basin may have resulted in an increase in the

amount of rearing habitat suitable for young-of-the-year and juvenile White Sturgeon in the impounded reaches of the Columbia River. Impoundments currently provide much greater water surface areas and volumes than were available previously.

The Columbia River Treaty Tribes have determined that substantive sturgeon mitigation action is long past due and that a sturgeon hatchery provides a clear avenue for increasing sturgeon fisheries until such time as other effective alternatives might be identified. Other potential mitigation alternatives are not being implemented because pathways for successful implementation remain unclear even after 25 years of dedicated research on these impounded sturgeon populations.

A primary goal of the proposed hatchery program is to enhance commercial, subsistence and recreational fisheries for impounded subpopulations of sturgeon consistent with habitat capacities. This will require substantive increases in sturgeon numbers. This goal goes well beyond simply maintaining viable wild sturgeon populations at some reduced level as might be achieved through fishery regulation and opportunistic supplementation with wild-caught larvae or transportation of young fish from existing populations.

A hatchery program is the only realistically feasible and cost-effective alternative for providing significant sturgeon fishery mitigation in lower Columbia and Snake River reservoirs within a determinate time period based on what we know at this time. No other potential alternative provides a similarly high likelihood of success at a reasonable cost. Feasibility, benefits or costs of potential alternatives including passage, transplants, flow augmentation and habitat restoration make each of these much less realistic options in the current situation. This conclusion is readily apparent in a qualitative comparison among alternatives. In most cases, the presumed benefits of other potential alternatives are so uncertain as to preclude any type of reasonable quantitative analysis.

2.3 Alternatives Considered

Seven alternatives were considered for sturgeon restoration and mitigation in the development of this hatchery master plan:

1. No action (Continued Monitoring & Optimization)
2. Passage
3. Transplants
4. Flow Augmentation
5. Habitat Restoration
6. Hatchery Supplementation

These options are not mutually exclusive. Hatchery supplementation is being pursued in concert with other actions.

Table 2 summarizes the pros, cons, relative benefits, likelihood of success, relative cost and relative risk of each alternative. A more detailed discussion of each alternative may be found in following sections. Pros and cons include the primary advantages and disadvantages of each

alternative relative to the mitigation purpose of this program. Relative benefits are described in terms of the ability to provide significant sturgeon fishery mitigation on a qualitative high, moderate and low scale. Likelihood of success is similarly rated based on the degree of uncertainty associated with the expected outcome. Costs are rated on a qualitative scale from a low of approximately $1 million or less per year to very high representing tens of millions of dollars per year. Risk categories were based on the potential for negative or unintended demographic, genetic or ecological effects.

Flow augmentation during spring has a high likelihood of substantially increasing natural recruitment but costs and conflicts with competing water uses would be very high.

Hatchery supplementation has a high likelihood of producing at least moderate benefits for the upfront cost of hatchery facilities and a manageable level of risk to wild sturgeon and other species.

Transplants would provide marginal benefits albeit with low risk of negative impacts. The greatest transplant risk would be multi-years costs and further delays in pursuing more meaningful mitigation.

Passage improvements would appear to provide a marginal likelihood for substantially improving sturgeon productivity at a very high potential cost of facility modifications at mainstem dams and a high risk of unintended impacts on salmonid passage.

No Action (status quo of current program) has helped maintain reservoir sturgeon populations as sustainable levels and optimize fishery values of existing production but does not achieve mitigation goals.

Habitat restoration would produce unknown benefits at a potentially substantial cost because potentially effective methods have yet to be identified. Channel alternation in tailraces for sturgeon may also risk creating favorable habitat for salmonid predators.

Table 2. Comparison of potential mitigation alternatives for subpopulations of sturgeon in lower Columbia and lower Snake river reservoirs (ranked by scale of benefit and likelihood of success).

Alternative	Pros	Cons	Benefit	Likelihood of success	Cost	Risk
Flow Augmentation	Substantial improvement in natural production in all reservoirs	Very high costs and conflicts with competing water uses	High	High	Very High	Moderate
Hatchery	High likelihood of substantial benefit within prescribed time period	Potential for undesirable demographic, genetic or ecological impacts	Moderate	High	Moderate	Low to Moderate
Transplants	Controlled distribution of sturgeon among upstream reservoirs	Fish no longer available from below Bonneville & marginal value of among reservoir transplants	Low	Moderate	Low	Low
Passage	Potentially restores ability for sturgeon to distribute among upstream reservoirs	Spawner migration to unproductive reservoirs & interference with salmon passage	Low	Low	Very High	High
No action	Optimizes harvest from existing populations	Does not meet mitigation needs in reservoirs	Low	None	Low	Low
Habitat Restoration	Potential for improving natural recruitment	Effective measures have not been identified.	Unknown	Unknown	High	Low to moderate

2.3.1 No Action (Continued Monitoring & Optimization)

The "No Action" option would involve maintenance of the current program which is being jointly implemented by the Tribes and States under the auspices of *U.S. v. Oregon* and the NPPC's Fish and Wildlife Program.[3] This includes monitoring of annual recruitment patterns and population status, and management of fisheries to maintain sustainable harvest levels consistent with fish availability. This is essentially the status quo where a significant monitoring and evaluation is implemented to optimize sustainable harvest from impounded populations.

Annual recruitment among impounded sturgeon subpopulations currently varies from reservoir -to-reservoir and year-to-year due to differences in habitat suitability for recruitment, and flow effects on habitat suitability. Periodic recruitment appears sufficient to maintain modest sturgeon populations and fisheries in some areas (e.g., Bonneville and The Dalles reservoirs). In other areas (John Day Reservoir, McNary Reservoir, lower Snake reservoirs), sporadic recruitment success causes abundance and harvestable numbers to ebb and flow over time as large year classes move through the population. Harvest, which is managed based on fixed exploitation rates to ensure that a consistent fraction of each cohort recruits to adulthood, increases when large year classes grow into the harvestable size slot and decreases following intervals of poor year classes.

The current program can be expected to maintain subpopulations at existing levels of viability which vary considerably among subpopulations. However, existing productivity results in inconsistent fisheries among areas and across years. This variability requires fairly-intensive stock and fishery monitoring efforts in order to provide some harvest opportunity and avoid overfishing of relatively unproductive subpopulations. Production and harvest in many areas falls well short of the historical potential if the absence of dam effects and the current potential if the available habitats were fully seeded by natural recruitment. Variable harvest levels over time do not provide recreational or commercial fisheries of consistent quality. Different harvest levels among reservoirs pose management challenges, particularly in the tribal fishery between Bonneville and McNary dams. Individuals fish only in specific areas and so disparate harvest opportunities among reservoirs limits access to the fishery.

Dam construction and operation has substantially reduced productivity and harvest of impounded sturgeon populations relative to that of an unimpounded system. It should also be noted that dam construction also appears to be contributing to reduced productivity of sturgeon downstream from Bonneville Dam by precluding upstream migration past rapids that historically excluded large numbers of sea lions from significant spawning and rearing areas. No-action fails to address mitigation needs and requirements for sturgeon.

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[3] Includes activities funded by Bonneville Power Administration under Project 1986-50.

2.3.2 Passage

Passage improvements might theoretically, under certain circumstances, increase gene flow, productivity, and fishery opportunity for sturgeon impoundments (Jager et al. 2000, 2001; Jager 2006a, 2006b).While fish ladders have proven effective for passing adult salmon and steelhead upstream, these methods are generally not effective for sturgeon. Some attempts were made to pass sturgeon upstream in fish elevators at Bonneville Dam after completion in 1938 until 1956 (Warren & Beckman 1993). However, use of elevators was discontinued as ladders proved to be much more efficient for upstream passage of salmonids. Small numbers of sturgeon use the south ladder at The Dalles Dam, apparently because of its deep entrances and large entryway (Parsley et al. 2007), but numbers are small in relation to sturgeon abundance. Downstream passage of juvenile salmonids occurs through dam spillways and various bypass systems, but downstream passage of juvenile sturgeon via these structures is relatively low.

Dam passage improvements are not the key to higher sturgeon productivity as is the case for salmon. Juvenile and subadult sturgeon are not migratory like salmon but instead disperse opportunistically among favorable habitats. Significant numbers of sturgeon do not use fish ladders because ladders are designed primarily with surface attraction, entrances and configurations effective for salmon. There are no easy or cheap fixes for improving sturgeon passage at fish ladders of mainstem Columbia system dams. Ladders would require costly modification and effective designs for attracting and passing sturgeon are not well-established at this time. Extensive research, trial and error would be required to develop effective design standards for sturgeon. Existing systems have been modified and tuned for decades to effectively pass salmonids. Passage improvements for sturgeon would also need to be achieved without corresponding declines in passage efficiency for salmonids.

Even if we were able to design and build ladders conducive to passing sturgeon, there is no guarantee that sturgeon would utilize them in significant numbers. Even if sturgeon did use ladders, unbalanced upstream and downstream passage is just as likely to reduce productivity as improve it. Juvenile sturgeon using ladders to disperse upstream could allow them reverse downstream gene flow and utilize underseeded habitats. However, adult sturgeon using ladders to migrate into upstream reservoirs for spawning would be moving from areas of high to low likelihood of reproductive success. Due to particularities of spawning habitats in each reservoir, natural recruitment rates are progressively lower in each successive system upstream. The Dalles is less favorable than Bonneville, John Day less than The Dalles, McNary less than John Day, and the lower Snake worst of all. Thus, net sturgeon recruitment and abundance would likely be reduced by improved dam passage of adult sturgeon. Theoretical studies of river fragmentation by dams and its effects on White Sturgeon populations by Jager et al. (2000, 2001) and Jager (2006a, 2006b) with a metapopulation model demonstrate the potential for negative impacts of unbalanced upstream and downstream migration for sturgeon.

Current information on sturgeon passage in the Columbia Basin was examined at a 2012 workshop (Beamesderfer & Anders 2013). Workshop participants generally concluded that too little is yet known regarding passage requirements, benefits, and risks to support the need for

large-scale sturgeon passage improvements at Columbia River dams at this time. A number of passage-related issues or activities were identified that warrant further development:

1. Clarify specific goals and objectives for subpopulations based on current natural recruitment potential, habitat productivity, and limiting factors to provide guidance on potential benefits and risks of increased upstream or downstream passage on a case-by-case basis.
2. Consider additional analysis or research of larval and juvenile downstream passage and mortality to better understand tradeoffs between upstream and downstream subpopulations.
3. Include detailed evaluations of costs, benefits and risks of passage improvements relative to other potential strategies including habitat improvement, flow management, fishery regulation and hatchery supplementation in sturgeon mitigation, conservation and restoration plans.
4. Consider opportunities for incorporating sturgeon-friendly features in existing fish ladders during future ladder designs and planned modification where consistent with sturgeon population goals and objectives.
5. Consider opportunities for non-volitional passage by taking advantage of fish trapped in dewater draft tubes or fish ladders during maintenance. These fish can be released back downstream from dams or transplanted upstream. Fish could also be tagged as a means to gain information on sturgeon behavior and movement in and around dams. This would be cost effective since it occurs with planned maintenance. There is also a need for better communication/coordination with maintenance operations so we can take advantage of these instances as they occur.
6. Review current protocols used to prevent fish stranding/mortality during planned maintenance activities (such as dewatering draft tubes) to determine if the level of protection/prevention is adequate and whether improvements could be made. Where appropriate and feasible, improve prevention/control of existing sources of mortality caused by the projects either from dewatering mishaps or blade strikes associated with turbine starts. For instance, powerhouse upgrades to digital controls would allow “slow roll” starts to be used for all turbine starts throughout the year.

These findings have been incorporated into guidelines for sturgeon in the draft 2014 NPCC Fish and Wildlife Program. Each of these activities is currently in some stage of consideration or development, but passage improvements are not expected to provide significant improvements in current sturgeon production in the near term due to high costs, uncertain benefits and the risks of unintended consequences.

2.3.3 Transplants

Sturgeon transplants were explored from 1994-2005 as an alternative to traditional dam passage. At the time, this option was regarded as one of the best sturgeon mitigation options. Transplants avoid the potential problem of unbalanced volitional passage because collection and release locations can be controlled. Advantages of transplant supplementation include immediate augmentation of multiple year classes, representation of a wide range of natural genetic diversity, and an increase in upstream gene flow.

A “trawl and haul” program transplanted 42,098 sturgeon (30-90 cm FL, 1-6 years old) in 1994 through 2005 from downstream of Bonneville Dam into The Dalles and John Day reservoirs (Rien & North 2002; Rien 2006, 2007; Farr & Jones 2014). Evaluations showed that transplanted sturgeon: 1) survive, grow and distribute themselves similar to resident counterparts, 2) contribute to both commercial and recreational fisheries, and 3) are eventually likely to recruit to the spawning population. The transplant program was suspended after 2005 due to funding constraints, increasing difficulty in capturing adequate numbers of fish below Bonneville, and concern for impacts on the unimpounded population (Rien 2007).

The transplant strategy requires a robust source population. The original transplant program was predicated on an assumption that consistently strong sturgeon recruitment below Bonneville produced a surplus of juvenile sturgeon that could be mined to augment more limited production in impoundments upstream. This assumption is no longer valid as recruitment downstream from Bonneville has declined, the fishery has been closed to sturgeon retention, and current production is dedicated toward stabilizing and rebuilding that population (ODFW 2011b). Significant numbers of juvenile sturgeon are no longer available for transplant from below Bonneville.

Bonneville Reservoir was also considered as a potential source of fish for transplant into other impoundments if juvenile life stages are considered. Natural recruitment is consistently strong in Bonneville Reservoir due to favorable spawning and incubation habitat conditions under wide range of flow conditions. As a result, Bonneville supports the highest sturgeon densities among impounded subpopulations. Production appears to be in excess of that required to seed the available habitat. Lower growth rates and condition factors of fish present in the Bonneville Reservoir are associated with higher fish density. If Bonneville Reservoir is currently at habitat capacity, juveniles could theoretically be transplanted into less productive reservoirs with a relatively small impact on numbers of sturgeon available for harvest in Bonneville Reservoir. In theory removals might even be compensated by density-related improvements in growth and condition of the sturgeon remaining in Bonneville Reservoir. Fish transferred to other reservoirs could augment existing populations and harvest and augment stagnant immediate upstream genetic diversity (Drauch Schreier et al. 2013). Fisheries in other reservoirs would also benefit from access to Bonneville-origin sturgeon.

Transplants from Bonneville reservoir to John Day reservoir were rejected because movement of fish among areas within the current tribal fishery zone does not substantially increase net harvest yields. No new fish are being produced. The same fish transplanted and harvested from

Bonneville would eventually have recruited to harvestable sizes in Bonneville Reservoir. There might be some marginal yield value in improved growth and condition of fish left in Bonneville and Bonneville fish transplanted to John Day. However, capture and transplanting of meaningful numbers of juvenile fish from Bonneville Reservoir may not be cost effective and removal of juvenile sturgeon are unlikely to be sufficient in number to stimulate an improvement in growth and improve condition factors for remaining sturgeon in the in Bonneville Reservoir. Further, growth benefits of transferring individual sturgeon to underseeded reservoirs may be partly offset by any handling mortality that might occur.

2.3.4 Flow Augmentation

River flows during spring and early summer (the spawning time of White Sturgeon in the Columbia River basin) are highly correlated with recruitment of Age-0 White Sturgeon in lower mid-Columbia populations (Parsley & Beckman 1994; Mallette 2008, 2013). Research has identified flow conditions in most dam tailraces that mimic the natural condition and can produce significant sturgeon recruitment. Section 3.3.3 of this plan summarizes the reservoir-specific correlations between average annual river discharge in spring and annual recruitment of sturgeon. Large year classes in Bonneville, The Dalles, and John Day reservoirs require spring discharge averaging at least 225, 250 and 350 kcfs, respectively in order to provide optimal flow conditions for spawning in the tailraces. Discharge at McNary Dam has averaged approximately 250 kcfs from 1989-2012 (Cox & Schade 2014).

Most impounded sturgeon populations in North America are recruitment-limited due to a lack of suitable spawning habitat or flow conditions suitable to produce significant recruitment in the available habitat (Parsley & Beckman 1994; Counihan et al. 1999; Parsley & Kappenman 2000; NPCC 2004). White Sturgeon spawn in high velocity habitats (> 3 ft. / sec.) which are generally limited to dam tailraces (Parsley et al. 1993; Perrin et al. 2003). Historical spawning areas for White Sturgeon in the Columbia River system were probably located at the downstream end of falls, cascades, and rapids. Spawning habitat in impoundments is now limited to the high-energy zones of dam tailraces which provide suitable combinations of velocity and substrate. Differences in tailrace morphology account for differences in habitat suitability and effects of flow on recruitment in different tailraces (Parsley et al. 1993; Parsley & Beckman 1994). Greater flows typically improve spawning suitability but flow thresholds for successful spawning vary in the tail races from reservoir to reservoir.

The draft 2014 NPCC Fish and Wildlife Program calls for operation of the FCRPS to provide flow rates consistent with the needs of productive sturgeon populations including increased spring and summer flows and spill rates where feasible. Flow measures are being implemented for the endangered Kootenai sturgeon but no flow measures have been implemented to date or are planned for the specific benefit of impounded sturgeon populations in the mid-Columbia and lower Snake Rivers (Beamesderfer & Anders, 2013). Sturgeon spawning needs regarding flow requirements must compete with other water use needs including power generation, irrigation, and potentially conflicting measures for the benefit of ESA-listed species such as salmon and

steelhead. To date, consistent recruitment of juvenile sturgeon has not been restored by moderated flow or other operational measures implemented for salmon (Mallette 2008).

Hatchery supplementation is being proposed for sturgeon mitigation rather than flow augmentation due to the wide disparity in associated costs and competing values of water use. We did not estimate the costs of significantly increasing spring discharge for sturgeon but foregone power costs would be surely run in the many millions of dollars per year even if the water were available. By contrast, the sturgeon hatchery development and construction is less than $10 million with annual operating costs including monitoring of approximately $1 million per year.

2.3.5 Habitat Restoration

Because recruitment limitation appears related to flow-mediated habitat conditions, it is possible that habitat measures can enhance natural recruitment. Habitat suitability appears to be a function of water velocity, temperature, substrate, and channel morphology. It follows that site-specific habitat measures such as substrate enhancement or channel restoration might be viable alternatives for improving natural recruitment in some Columbia Basin sub-populations.

The basin-wide sturgeon framework calls for implementing experimental habitat restoration measures to address limiting factors for White Sturgeon where appropriate (Beamesderfer & Anders 2013). The draft 2014 NPCC Fish and Wildlife Program calls for investigation of site-specific habitat measures for sturgeon such as substrate enhancement and channel restoration as viable alternatives for improving natural recruitment in some areas. Habitat measures are being explored in limited areas of the upper basin including the Kootenai and transboundary upper Columbia, but benefits remain to be determined through future monitoring and evaluation efforts.

Site-specific habitat measures have not been identified, planned or implemented for lower mid-Columbia or lower Snake sturgeon subpopulations owing to speculative benefits and the difficulty of implementation in a large mainstem river system. Specific habitat requirements for successful sturgeon reproduction are only broadly known. Sturgeon are spawning in specific hydraulic conditions of the thalweg of the river mainstem and spawning substrate appears suitable throughout dam tailraces where spawning occurs. Costs of undertaking even small-scale experimental habitat measures in the mainstem Columbia are daunting particularly given uncertainty in habitat requirements, limitations and benefits of any specific measure. Additional research of a basic nature is clearly needed to provide direction for any future consideration of habitat restoration actions for sturgeon.

2.3.6 Hatchery Supplementation

The Columbia River basin experience with salmon hatcheries has highlighted the potential risks to wild subpopulations associated with hatchery impacts. Any consideration of the potential benefits of hatchery sturgeon must be tempered with careful calculation of the related conservation risks (Anders 1998; Secor et al. 2002; Jager 2005; Beamesderfer & Squier 2013). Significant risks identified can include genetic mining or direct mortality of wild broodstock, increased incidence of disease, domestication, behavioral and genetic impacts, mixed hatchery-wild stock fishery effects, competition, density-dependent impacts due to habitat carrying capacity limitations, and ecosystem effects.

The draft 2014 NPCC Fish and Wildlife Program calls for considering sturgeon hatcheries as a mitigation strategy to supplement populations where natural recruitment is currently severely limited. Careful use of sturgeon hatcheries has the potential to help perpetuate declining wild subpopulations and mitigate for lost natural production in many impounded areas; aquaculture is regarded as a stop-gap or interim strategy while other alternatives continue to be explored. Prudence dictates that hatchery augmentation must include a dedicated monitoring, evaluation and adaptive management component.

Effective hatchery methods have been widely adapted and applied to North America sturgeons (Conte et al. 1988; Munro et al. 2007). Sturgeon hatchery production in the Columbia Basin began in 1990 with an experimental program for Kootenai sturgeon (Apperson & Anders 1990; KTOI 2007). Conservation hatchery programs are currently being used to address chronic habitat-related recruitment failures in the Kootenai River (Duke et al. 1999; Ireland et al. 2002a, 2002b; Paragamian & Beamesderfer 2004; Paragamian et al. 2005; KTOI 2007) and the transboundary upper Columbia River (Hildebrand et al. 1999; UCWSRI 2002, 2013; NRTWS 2006; Irvine et al. 2007) and Nechako River (NWSRI 2014). Sturgeon mitigation hatchery programs have been implemented in upper mid-Columbia reservoirs operated by the Public Utility Districts beginning in 2011. These programs have demonstrated the feasibility of artificially propagating sturgeon using wild parents or wild-spawned larvae to supplement failed natural recruitment and increase abundance in certain situations. Hatchery-based research may also prove useful for evaluating limiting factors, habitat carrying capacity, broodstock limitations, population parameters, and immigration/entrainment in natural populations.

While some level of risk and uncertainty is inherent in any hatchery program, the sturgeon hatchery plan includes an assessment of related ecological, demographic, genetic and implementation risks, and specific strategies designed to manage these risks. Clear and quantifiable benefits of hatchery supplementation substantially outweigh subjective risks. The fundamental viability of supplemented sturgeon subpopulations and their ecosystem is not at risk. The scale of hatchery supplementation is being limited to population levels that occur naturally in other parts of the system. Hatchery effects are also limited to specific reservoirs where endemic subpopulations do not represent unique locally-adapted metapopulations where damage or loss would be irrevocable.

3 BACKGROUND

3.1 Area Description

This master plan addresses White Sturgeon mitigation in two of the nine sturgeon management areas (Figure 4) identified in the regional sturgeon framework (Beamesderfer & Anders 2013):

1. The Lower Mid-Columbia River Management Area includes the Columbia River mainstem from Bonneville Dam to Priest Rapids Dam and contains the reservoirs of the Bonneville, The Dalles, John Day, and McNary dams. It also includes the reach of the lower Snake River from the confluence of the Columbia and Snake Rivers to the Ice Harbor Dam. This area also overlaps with the primary Treaty Tribal fishing area for sturgeon between Bonneville and McNary Dams.
2. The Lower Snake Management Area includes the Snake River mainstem from the Ice Harbor Dam (RM 9.7, RKM 15.6) to Lower Granite Dam (RM 107.5, RKM 173) and contains the Lower Monumental Dam (RM 41.6, RKM 70.0) and Little Goose Dam (RM 70.3, RKM 113.2).

White Sturgeon management units in the Columbia/Snake River system represent areas of similar biological, genetic, physical and jurisdictional characteristics and were delineated by participants in a 2009 White Sturgeon Strategic Planning Workshop in Boardman, Oregon (Beamesderfer & Squier 2010). Lower mid-Columbia and lower Snake sturgeon management units are the focus of this master plan because they: 1) are within the Federal Columbia River Power System (FCRPS), 2) are subject of joint assessment and research efforts by Oregon, Washington and the Treaty Tribes under funding by the Bonneville Power Administration, 3) include sturgeon populations and fisheries co-managed under U.S. v Oregon agreements between Washington, Oregon and the Columbia River Treaty Tribes. Proposed hatchery activities will address mitigation needs throughout this area although specific activities will occur only in portions of these management units where appropriate.

The lower mid-Columbia and lower Snake sturgeon management units include seven reservoirs and river segments separated by mainstem hydropower dams (Table 3).

Table 3. Reservoir and river segments included in the lower mid-Columbia and lower Snake river sturgeon management units.

		Length (miles)		Area (acres)	
	Area	Total	Reservoir	Total	Reservoir
Columbia	Bonneville Reservoir	45	45	20,800	20,800
	The Dalles Reservoir	24	24	11,100	11,100
	John Day Reservoir	76	76	51,900	51,900
	McNary Res. & Hanford Reach	105	64	50,200	38,800
Snake	Ice Harbor Reservoir	32	32	8,400	8,400
	Lower Monumental Reservoir	29	29	6,600	6,600
	Little Goose Reservoir	37	37	10,000	10,000

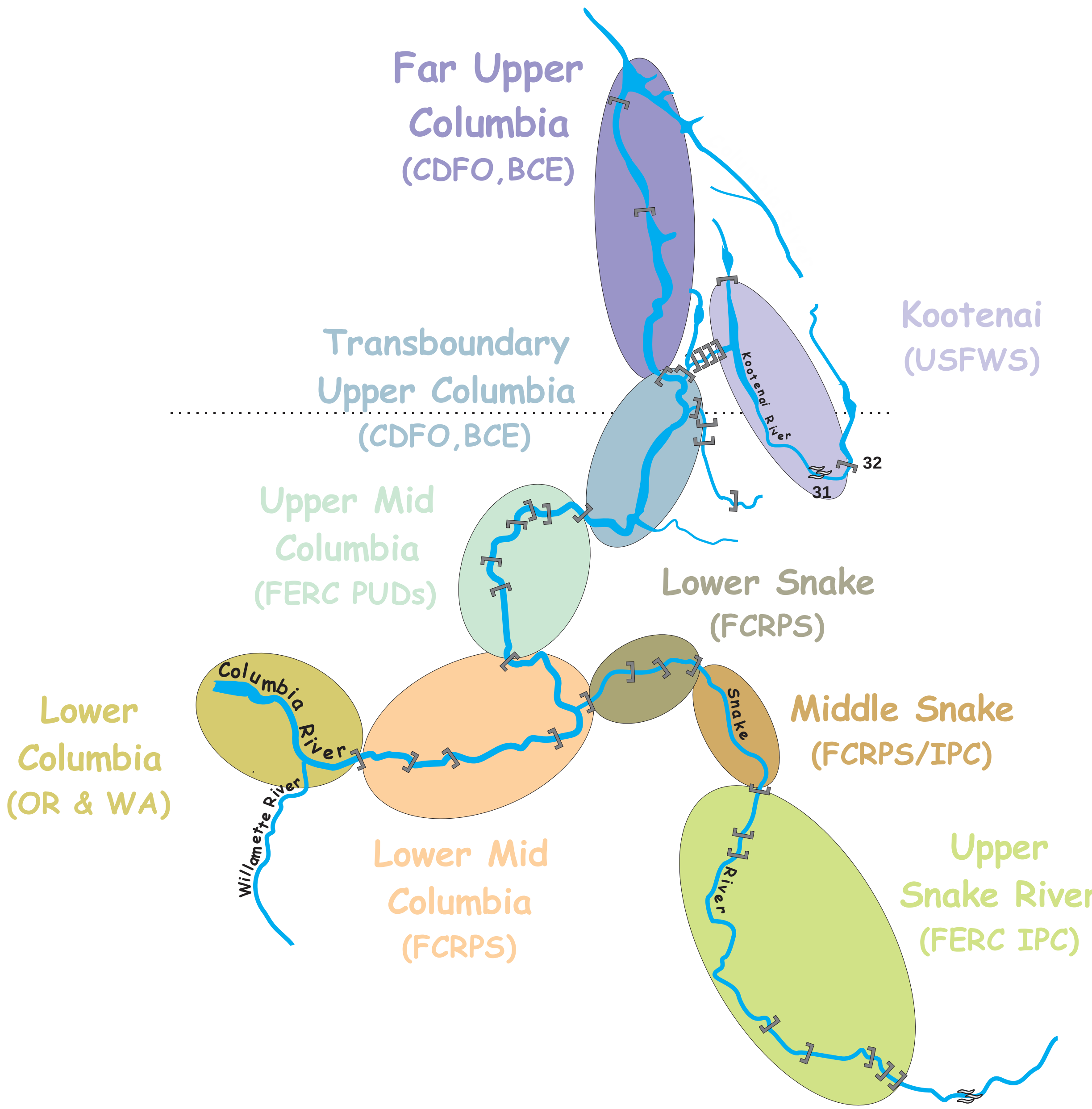

Figure 4. **Sturgeon management areas identified by the Basin-wide Sturgeon Framework (Beamesderfer & Anders 2013). Primary management entities are identified for each (OR = Oregon, WA = Washington, FCRPS = Federal Columbia River Power System, FERC = Federal Energy Regulatory Commission, PUD = Public Utility District, IPC = Idaho Power Company, USFWS = U. S. Fish and Wildlife Service, CDFO=Canadian department of Fisheries and Oceans, BCE= British Columbia Ministry of Environment).**

Hydroelectric development has transformed mainstem riverine habitats into reservoir impoundments with the exception of the Hanford Reach upstream from McNary Dam (NPPC 2004). Today's run-of-river reservoirs have some characteristics of both riverine systems (e.g., replacement of water within a short time period, limited stratification) and lake environments (e.g., relatively deep water, flows slow enough to allow extensive sedimentation, and warming during the summer months; ISAB 2011).

Large seasonal and annual flow fluctuations defined historical habitat conditions for sturgeon. Spring freshets have been reduced by more than 50% and winter flows increased by 30%, as water is now managed for flood control, power generation, navigation, irrigation, anadromous fish passage, and recreational use. Discharges at McNary Dam may range from 500 kcfs in spring to 70 kcfs in autumn.

Impoundment has substantially increased summer water temperatures from historical levels. Maximum water temperature established by the states of Washington and Oregon for the Columbia River downstream from Priest Rapids Dam is 20°C (68°F) is often exceeded during the warmest parts of the summer. Water temperatures in the lower Snake River often warm up to 22°C to 24°C (72 to 75°F) by mid to late July and remain above 20°C (68°F) until late September. In contrast, reservoirs have drastically reduced turbidity in the Columbia and Snake rivers. Dam construction and operation has increased dissolved gas to supersaturation levels as water plunging from spillways entrains air, which dissolves into the water at depth. Large storage reservoirs have also altered temperature profiles with corresponding impacts on sturgeon maturation and spawning.

3.2 AQUATIC ECOSYSTEM

The NPCC (2004) Lower Mid-Columbia Mainstem Subbasin Plan reports that 51 species of fish from 14 families have been identified in the lower mid-Columbia River mainstem. Thirty of these species are native, including at least five anadromous fish species. Most of the fish species observed in the reservoirs remain in the impounded reaches throughout their life cycle or, like White Sturgeon, because they are largely constrained within the barriers presented by the dams.

The lower mid-Columbia and lower Snake Rivers serve as a migratory corridor and rearing area for salmon and steelhead traveling between the Pacific Ocean and tributary spawning and rearing grounds. Native anadromous fish species include spring/summer/fall Chinook Salmon (*Oncorhynchus tshawytscha*), summer Steelhead (*O. mykiss*), Sockeye Salmon (*O. nerka*), Coho Salmon (*O. kisutch*), Chum Salmon (*O. keta*) and Pacific Lamprey (*Lampetra tridentata*). Large numbers of Chinook Salmon historically spawned in the river mainstem but spawning areas are now largely inundated by sediments and deep water except for areas of the Hanford Reach which continues to support a productive Fall Chinook stock. Abundance of anadromous fish including salmon, Steelhead and Lamprey has been reduced substantially following dam construction although large numbers of non-native anadromous American Shad utilize the reservoirs for spawning and rearing.

Before reservoir construction, the dominant resident species included White Sturgeon, Whitefish, Rainbow Trout (*Oncorhynchus mykiss*), and cool water non-game species such as Northern Pikeminnow (*Ptychocheilus oregonensis*), sculpin (*Cottus* sp.), Redside Shiners (*Richardsonius balteatus*), Peamouth Chub (*Mylocheilus caurinus*), Chiselmouth Chub (*Acrocheilus alutaceus*), Largescale Sucker (*Catostomus macrocheilus*) and Bridgelip Sucker (*Catostomus columbianus*). Today, through changes in habitat brought about by impoundments have also favored increased abundance of non-native fishes including Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*Micropterus dolomieu*), Channel Catfish (*Ictalurus punctatus*), Common Carp (*Cyprinus carpio*), Black Crappie (*Pomoxis nigromaculatus*), White Crappie (*Pomoxis annularis*), Yellow Perch (*Perca flavescens*), Walleye (*Sander vitreus*), and American Shad (*Dorosoma sapidissima*). Impacts on sturgeon from changes in the resident fish community are poorly understood, but predation and competition have likely increased on some areas. For example, species such as Northern Pikeminnow, suckers, and walleye may prey on White Sturgeon eggs, larvae, and small juveniles. Resident fish also likely compete with sturgeon for food and over-wintering habitat.

Substantial changes in aquatic ecosystem and associated food webs have accompanied impoundment (ISAB 2011). Prior to impoundment and flow regulation, the riverine system productivity was dominated by periphyton and detrital pathways (Figure 5). The benthic invertebrate community was dominated by lotic taxa including caddisflies, mayflies, dipterans, mollusks and gammarid amphipods. White Sturgeon were likely a top predator due to the large size of adults.

Food webs in the reservoirs have now shifted toward native and non-native species adapted to lacustrine conditions (Figure 6), and as such, productivity has now shifted to more of a lentic system founded on phytoplankton production (ISAB 2011). As a result, conditions in the reservoirs do not favor the establishment of periphyton and macrophytes at most locations, which impact juvenile White Sturgeon rearing habitat and recruitment. Benthic fauna in soft sediments of the reservoirs are primarily oligochaetes (segmented worms) and immature dipterans (chironomid midge larvae). Other abundant benthic invertebrates are the estuarine amphipods *Corophium spp*. and the Asian clam *Corbicula fluminea*.

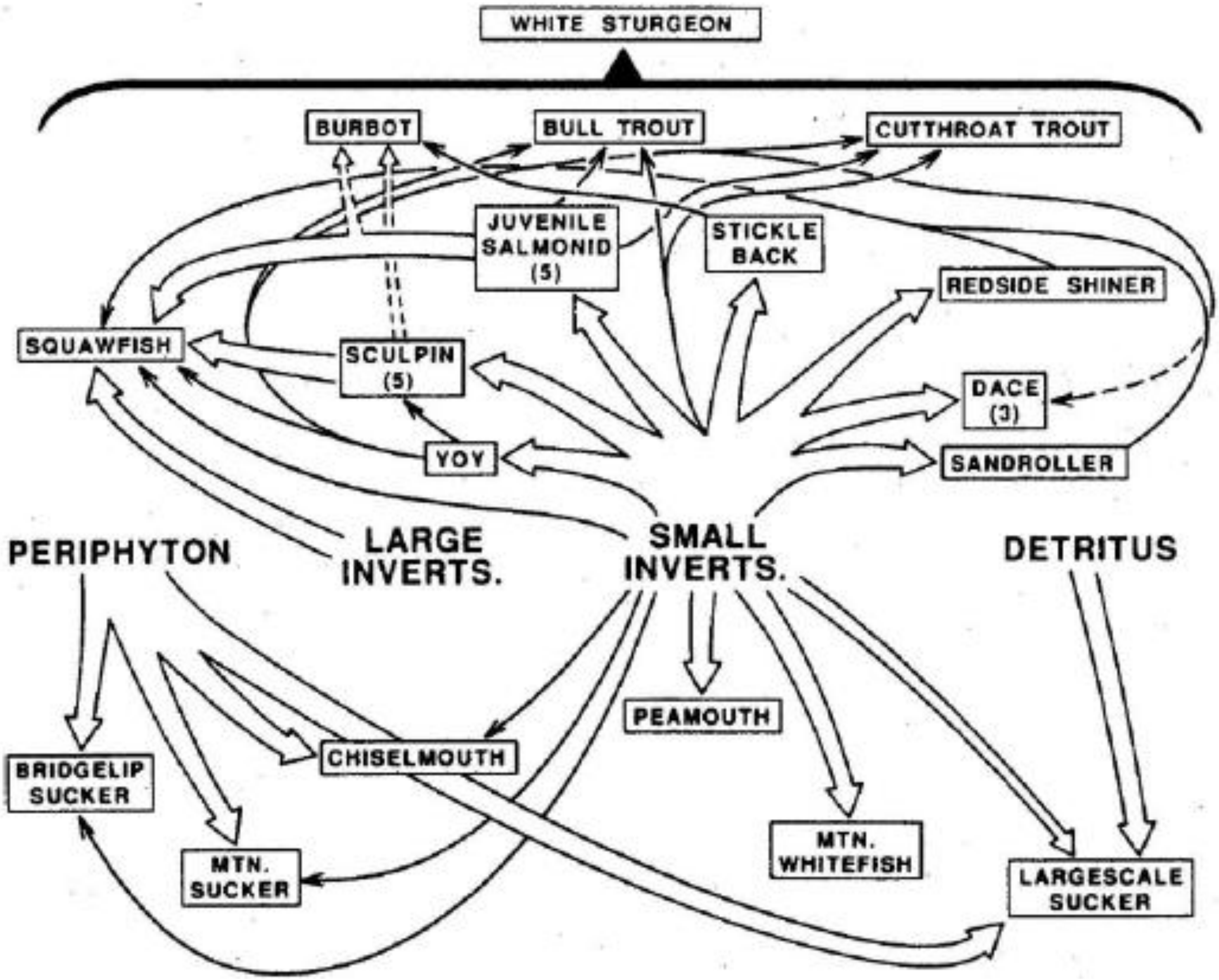

Figure 5. **Hypothetical food web of the lower and middle Columbia River before 1800 (ISAB 2011).**

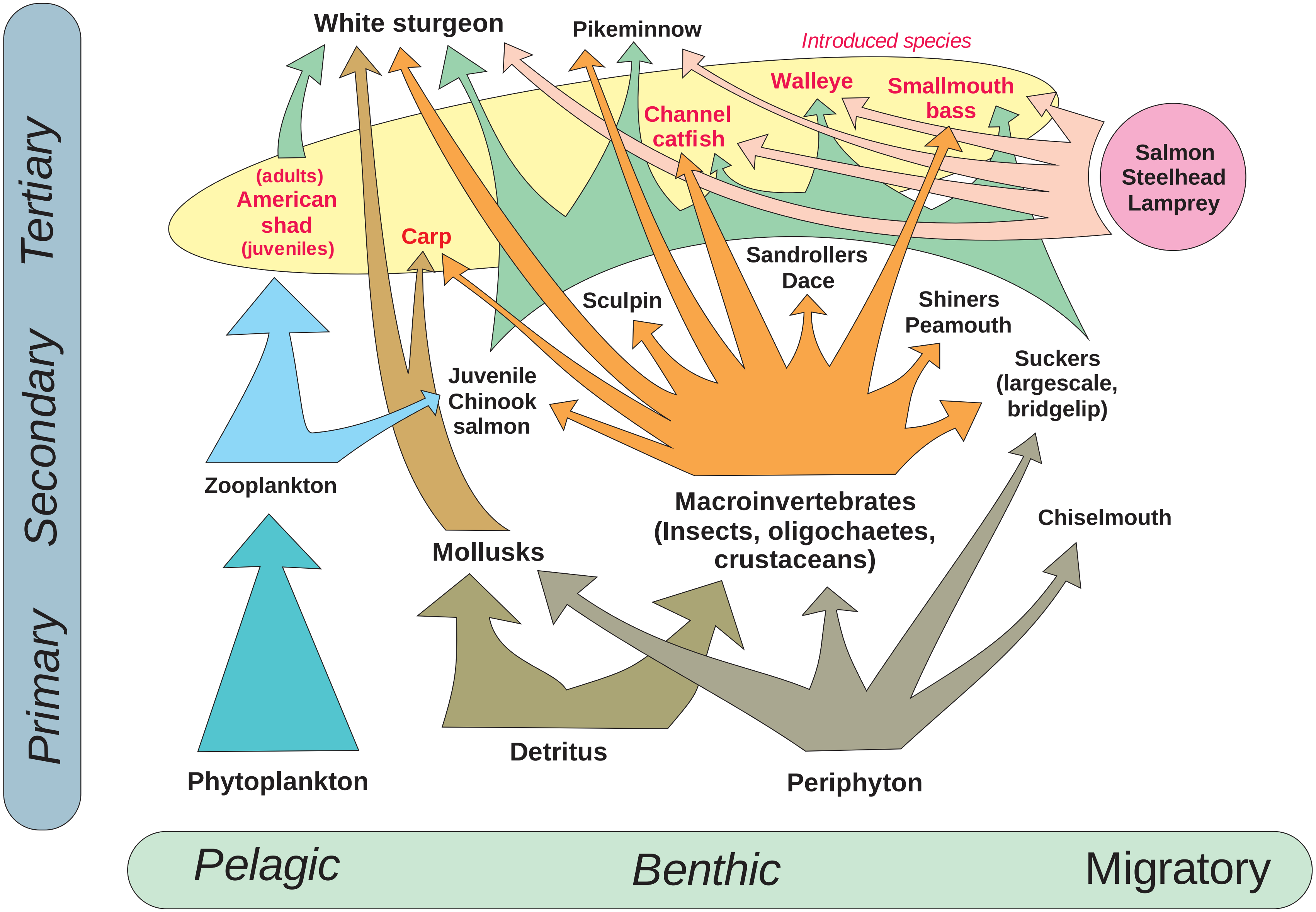

Figure 6. Current aquatic food web in lower Columbia River mainstem impoundments.

3.3 STURGEON LIFE HISTORY

White Sturgeon life history has been studied extensively throughout the Columbia Basin, particularly since the 1980s. Detailed descriptions of White Sturgeon life history and related studies may be found in the Columbia Basin White Sturgeon Planning Framework document (Beamesderfer & Anders 2013). This information is summarized below.

For descriptive purposes, we have identified eight phases of the White Sturgeon life history (Figure 7). Phases are distinguished by differences in development, size, age and ecology. Four phases encompass the early life history. The yearling age class is distinguished because year class strength appears typically to be established during the first year of life. Juveniles include fish up until approximately the size where White Sturgeon are physiologically capable of ranging into salt water. Fish are this size have also largely transitioned from a benthic invertebrate to a fish diet. Adults include fish that are sexual mature. Size and age of sexual maturity of White Sturgeon varies considerably among individuals.

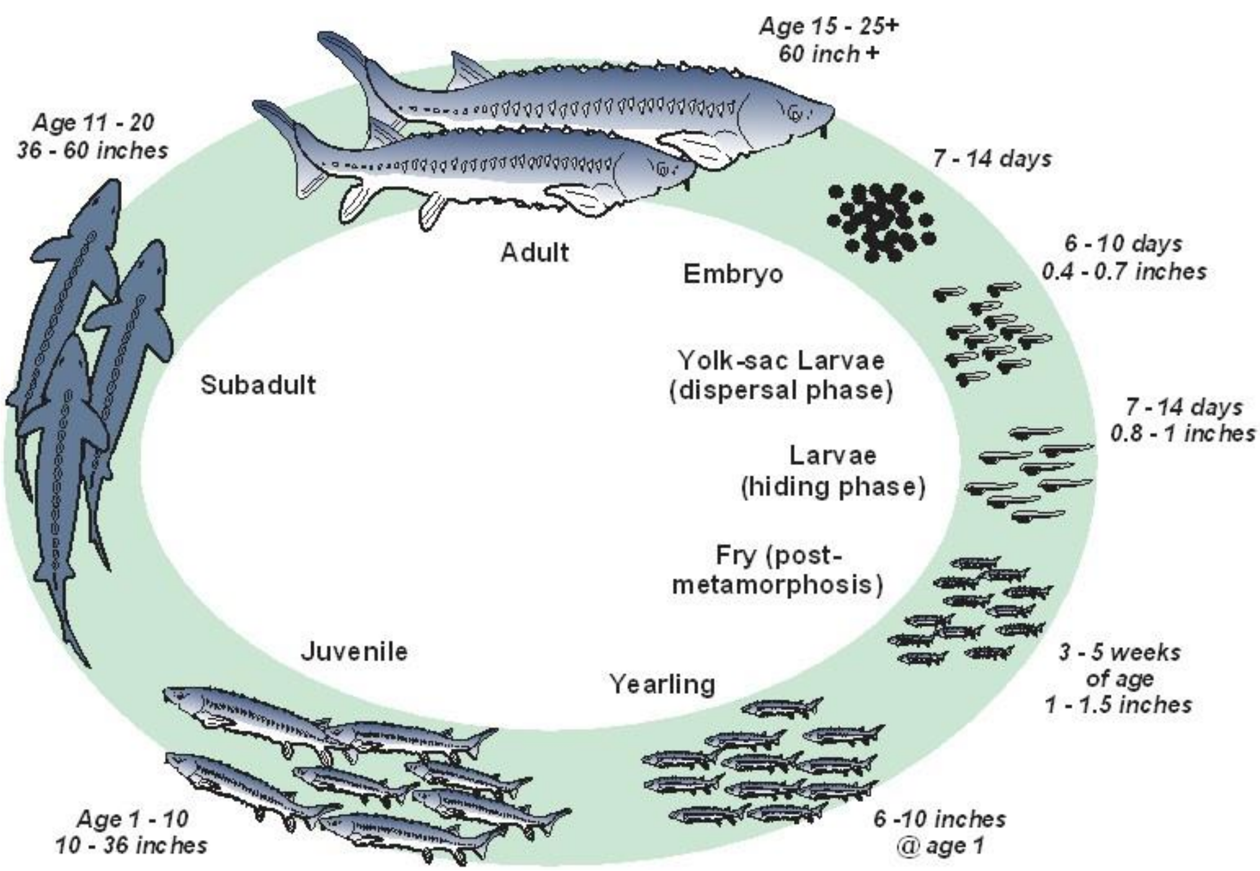

Figure 7. Life cycle of Columbia River white sturgeon.

3.3.1 Spawning

In lower Columbia River impoundments, spawning is concentrated in dam tailraces (Parsley et al. 1993). Spawning occurs during spring when water temperatures reach about 57°F (14°C) and typically extends from May through June in the lower Columbia Basin (Parsley & Beckman 1994). White Sturgeon are broadcast spawners, releasing their eggs and sperm into the water column over clean boulder and cobble substrates where fertilization occurs. Spawning typically occurs in turbulent areas associated with moderate to high water velocities, often in close proximity to deeper, slower-moving "staging" or "resting" areas." Preferred water velocities for spawning appear to be 2.6 to 5.6 ft /s (0.8 - 1.7 m/s) and preferred depths are 13 ft (4 m) or greater (Parsley & Beckman 1994).

3.3.2 Incubation & Early Life History

Egg incubation typically lasts 7–14 days, depending on temperature. The optimum temperature range for incubation is 57–61°F (14–16°C) and successful incubation has been observed from 50–64°F (10–18°C). A dispersal phase occurs over 5 or 6 days after hatching when free-swimming embryos are suspended in the water column (Brannon et al. 1985b; Conte et al. 1988). In the lower Columbia River, dispersing embryos have been collected at depths of 13–190 ft (4–58 m) over a variety of substrates (Parsley et al. 1993). Following dispersal, White Sturgeon enter a 20 to 25 day hiding phase in which they avoid light and seek refuge in the substrate until the yolk is absorbed (Parsley et al. 2002).

3.3.3 Recruitment

Recruitment refers to the successful production of an annual year class from spawning through early life history to age 0 or 1. Recruitment is related to a complex of interacting abiotic and biotic factors that influence spawning and cause mortality of embryonic, larval and juvenile life stages (Parsley et al. 2002). Annual sturgeon recruitment in lower Columbia and Snake river impoundments is indexed based on catches of age 0+ fish in standardized gillnet sets during the fall (Table 4). The annual recruitment index is based on the proportion of gillnet sets that captured at least one sturgeon (Counihan et al. 1999).

Impounded populations are characterized by periodic strong year classes and cyclical population patterns. Spawning occurs annually in all areas containing adult sturgeon but recruitment appears to be regulated at one or more points before fish reach one year of age. The scale and frequency of recruitment is the primary factor determining the status of subpopulations throughout the basin. A life history strategy involving episodic recruitment is consistent with the longevity, delayed maturation, large fecundity, inter-generational spawning, and iteroparous characteristics of all sturgeons. However, the more abundant populations in the region are associated with a pattern of consistent annual recruitment (McCabe & Tracy 1994; Chapman & Weaver 2006).

Recruitment in lower Columbia River impoundments has been positively correlated with high spring flows and corresponding amounts of suitable spawning habitat (Parsley et al. 1993; Parsley & Beckman 1994). Further, differences in recruitment among several subpopulations were

related to channel morphology effects on velocity at different flows. Positive effects of increased flows on natural production may be related to: 1) increased availability of suitable spawning sites; 2) reduced predation on eggs; 3) decreased predation on yolk sac embryos, larvae and juveniles; 4) dispersal to productive mainstem rearing areas; 5) increased flooding of side channel and slough areas that provide higher quality rearing habitats than mainstem areas; or 5) effects of related conditions such as temperature.

Table 4. Recruitment index (proportion of positive sets; EP) for age-0 (≤12 in, 30 cm FL) White Sturgeon in Columbia River and Snake River reservoirs, 1997-2014 (ODFW 2015).

Year	Bonneville[a]	The Dalles	John Day	McNary	Ice Harbor	Little Goose
1997	--	0.74	0.53	--	0.00	--
1998	--	0.65	0.08	--	--	0.32
1999	--	0.67	0.22	0.08	0.03	0.08
2000	--	0.14	0.00	0.00	0.00	0.00
2001	--	0.00	0.00	0.00	0.00	0.00
2002	--	0.17	0.00	0.06	0.00	0.00
2003	--	0.00	0.00	0.00	0.00	0.00
2004	--	0.06	0.00	0.00	0.00	0.00
2005	--	0.03	0.00	0.03	0.00	0.00
2006	0.69	0.47	0.13	0.06	--	--
2007	0.31	0.14	0.00	0.06	--	--
2008	0.59	0.31	0.00	0.06	--	--
2009	0.51	0.42	0.13	0.06	--	--
2010	0.34	0.36	0.08	0.00	--	--
2011	0.41	0.61	0.46	0.26	--	--
2012	0.08	0.53	0.10	--	--	--
2013	0.18	0.19	0.00	--	--	--
2014	0.37	0.14	0.00	--	--	--

[a] *Prior to 2006, USGS conducted age-0 trawl surveys in Bonneville Reservoir.*

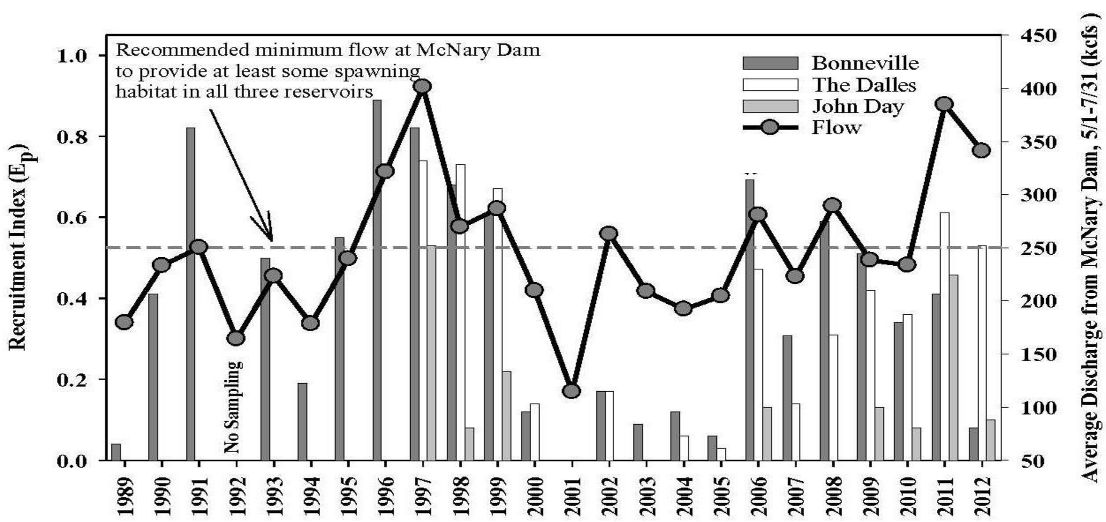

Figure 8. Recruitment index (Ep; proportion of sets capturing one or more age-0 fish) for White Sturgeon in Bonneville, The Dalles, and John Day reservoirs, and average daily flow at McNary Dam (May-July) through 2012 (Cox & Schade 2014).

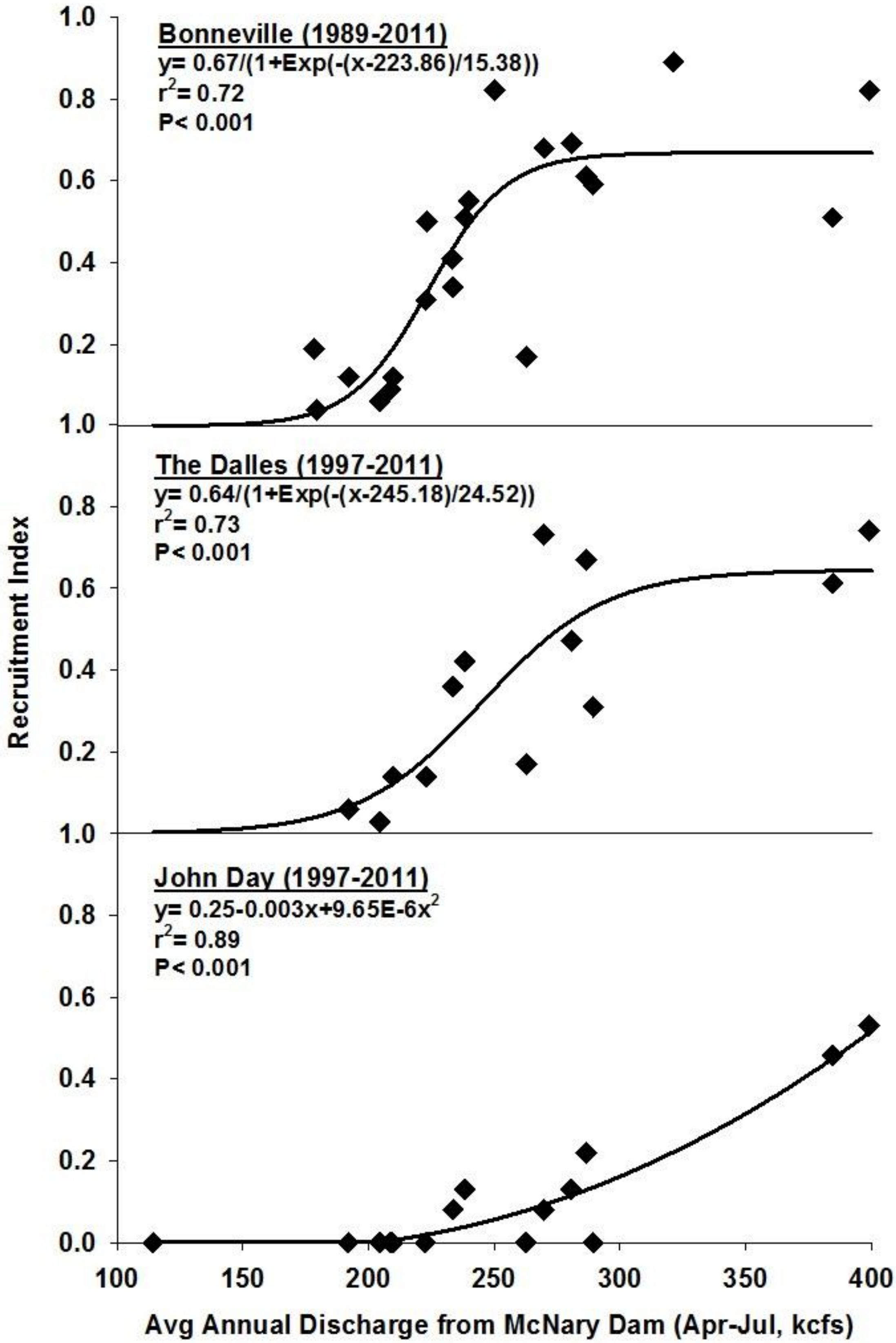

Figure 9. **Relationship between annual recruitment index values and average discharge from McNary Dam (April-July) for Bonneville, The Dalles, and John Day reservoirs (ODFW unpublished).**

3.3.4 Size & Age

This historical record includes a number of photos of large sturgeon from the Columbia River in the 600–900 lb (270–410 kg) range. A 1,500 lb (700 kg) sturgeon was documented in the Snake River (Anderson 1988). Currently, fish up to about 10.5 ft (3 m) total length[4] and 400 lb (180 kg) have been measured in stock assessment sampling (Beamesderfer et al. 1995; Farr & Jones 2014). Larger fish are periodically reported by anglers but have proven difficult to sample with stock assessment gear. As with most fish, weight increases exponentially with increasing length (Figure 10). Differences in condition factor have been documented among subpopulation with Bonneville sturgeon tending to weigh less for their length than The Dalles or John Day fish.

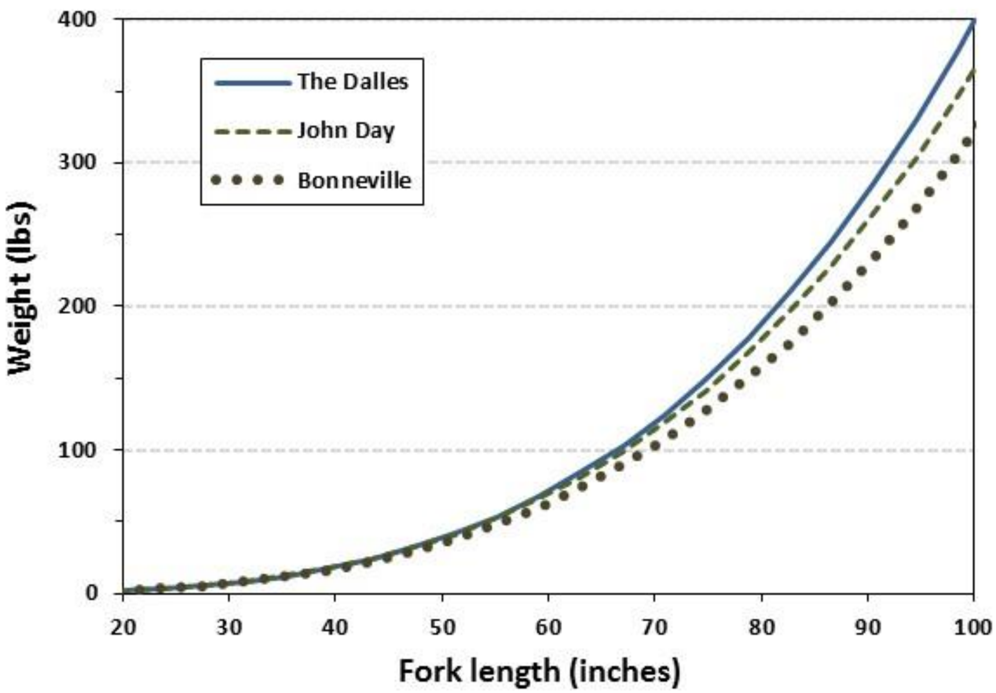

Figure 10. Average length-weight relationship for White Sturgeon based on lower Columbia River (Beamesderfer et al. 1995).

Large sizes of White Sturgeon are the product of rapid growth rates and longevity. Ages as old as 104 have been reported for Columbia River White Sturgeon, but fish over 70 or 80 years of age are rare (Rien & Beamesderfer 1994). Ages are typically read from fin-spine sections but age validation studies have found that the fin ray method consistently underestimates true age (Rien & Beamesderfer 1994; ODFW 2002).

Growth has been estimated based on fin ray ages and mark-recapture data. Impounded sturgeon typically grow 6–10 in (15–25 cm) in their first year and 1–3 in (3–8 cm) per year thereafter from ages 1 through 20 (Figure 11). Annual growth increment by length peaks at around 48 – 60 in

[4] *Total length is typically about 11% greater than fork length (Beamesderfer 1993).*

(120-160 cm) fork length (Figure 12). More typically, growth increments by length of fish decrease progressively with increasing size as represented by a standard von Bertalanffy function (Storch et al. 2009). The atypical growth pattern among impounded sturgeon appears to reflect differences in food availability at different life stages as larger fish are increasingly piscivorous. Annual growth increments of fish larger than 48 in (122 cm) decline when measured by length but continue to increase when measured by weight as is typical of fish.

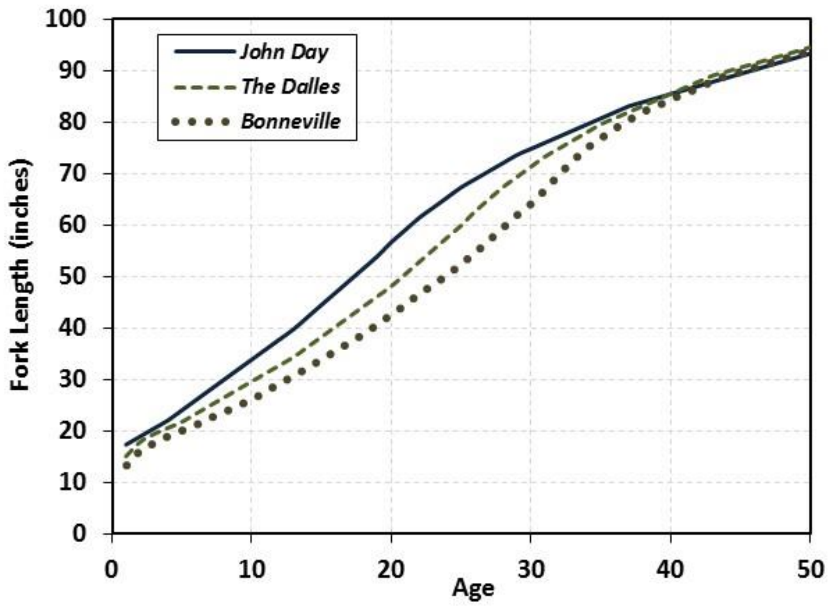

Figure 11. White Sturgeon age-length relationships for White Sturgeon in lower Columbia River impoundments (ODFW unpublished data). Relationships are based on a combination of bias-corrected age estimates and mark-recapture data.

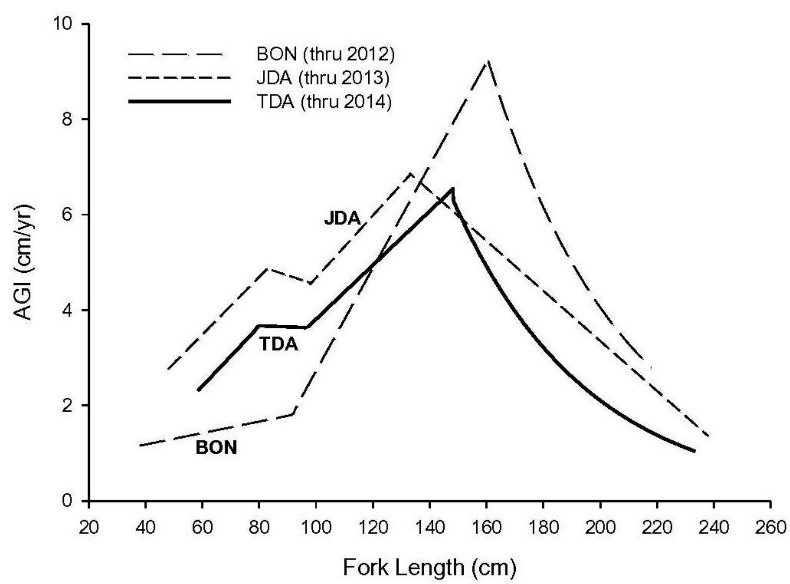

Figure 12. Patterns of annual growth increments in lower Columbia River reservoirs based on mark-recapture data (ODFW 2015).

Table 5. Size and age parameters for White Sturgeon subpopulations in lower Columbia and Snake river reservoirs.

Reservoir	Years	Maximums			Length-weight[a]		Condition	Age-length relationship[c]			Reference
		Size (FL in)	Weight (lb)	Age (year)	α	β	Wr[b] (%)	L_{inf} (FL cm)	k	t0	
Bonneville		106					103				Malm 1979
	1987-91	115	354		3.11E-06	3.19	99	311	0.022	-2.4	Beamesderfer et al. 1995
	1994	106	396	25	3.79E-07	3.17	107	--	--	--	North et al. 1996
	1999	94	286		2.01E-06	3.27	88	346	0.019	-2.4	Kern et al. 2001
	2003	102	264	40	--	--	94	354	0.016	-2.4	Kern et al. 2005
	2006	60	73	42	--	--	95	159	0.044	-2.4	Weaver et al. 2007
	2009	107	238		5.35E-06	3.09	100	--	--	--	Chapman & Jones 2011
	2012	101	172	--	1.99E-06	3.27	87	--	--	--	Cox & Schade 2014
The Dalles	1987-91	109	396		1.35E-06	3.38	96	340	0.023	-2.4	Beamesderfer et al. 1995
	1988-91			104	--	--	--	--	--	--	Rien & Beamesderfer 1994
	1994	102	330	22	7.70E-06	3.02	105	--	--	--	North et al. 1996
	1997	90		--	1.40E-06	3.49	106	--	--	--	North et al. 1999
	2002	98	264	46	4.20E-06	3.15	107	356	0.021	-2.4	Kern et al. 2004
	2005	92	211	40	--	--	108	289	0.022	-2.4	Chapman & Hughes 2007
	2008	95	297		3.47E-06	3.18	101	--	--	--	Chapman & Jones 2010
	2011	100			9.94-06	2.94	95	--	--	--	Farr et al. 2013
	2014						93	--	--	--	ODFW 2015
John Day	1987-91	100	244		2.40E-06	3.26	100	382	0.022	-2.4	Beamesderfer et al. 1995
	1996	94			3.17E-06	3.19	98	--	--	--	North et al. 1998
	2001	98	220	49	--	--	99	366	0.018	-2.4	Kern et al. 2003
	2004	89	220	57	--	--	103	367	0.016	-2.4	Kern et al. 2006
	2007	92	185	61	--	--	103	192	0.048	-2.4	Storch et al. 2009
	2010	109	139	--	1.23 E-05	2.92	105	--	--	--	Chapman et al. 2012
	2013	107	275	--	3.42E-06	3.19	105	--	--	--	Cox 2015
McNary	1993	91	264	63	2.38E-06	3.27	103				North et al. 1995
	1995	107	308	50	2.47E-06	3.23	97				Rien et al. 1997
	2011	103	211	--	3.73E-05	2.71	109	--	--	--	Farr et al. 2013
Ice Harbor	1996	96	238	47	6.85E-06	3.02	92	488	0.012	-3.4	DeVore et al. 1998
L. Monumental	1997	87	196	34	7.61E-06	3.01	99	596	0.01	-5.7	DeVore et al. 1999
	2012	85	114		2.34E-05	2.80	104	--	--	--	Cox & Schade 2014
Little Goose	1997	94	275	58	1.31E-05	2.91	97	278	0.034	-1.2	DeVore et al. 1999
	2012	95	246		1.61e-05	2.88	102				Cox & Schade 2014

[a] *Weight(kg) = α Length(cm)* $^{\beta}$

[b] *Relative weight index (Wr) describes fish condition relative to a standard weight equation equivalent to the 75th percentile of populations (Beamesderfer 1993).*

[c] *Length =* $L_{inf}\,[1-exp^{-k\,(age - t0)}]$

Differences in growth have been documented among subpopulations. Individual growth rates are highly variable and fast growing individuals can be several times larger than slow growing individuals of the same age. Male and female White Sturgeon differ in size-at-age after about 15 to 20 years of age due to sex differences in size and age of maturity. Males are typically smaller because earlier maturation diverts energy from somatic growth into reproduction.

3.3.5 Movements & Habitat Use

Sturgeon are typically distributed throughout mainstem reservoirs but are most abundant in the more-free flowing upper reaches. Juvenile and sub-adult White Sturgeon occupy a wide variety of depths (7–130 ft, 2–40 m; Parsley et al. 1993; Parsley et al 2008). Juvenile and sub-adult White Sturgeon exhibited often exhibited diel movement into shallower water at night (Parsley et al. 2008). Fish appear to prefer habitats with moderate riverbed roughness and slope (Hatten & Parsley 2009). Movement and migration patterns also appear related to feeding.

3.3.6 Food & Feeding

White Sturgeon are primarily benthic feeders on invertebrates and fish. Individuals are also regularly observed actively pursuing prey throughout the water column (S. King, ODFW, personal communication). Juvenile White Sturgeon in the lower Columbia River have been reported to feed mainly on benthic invertebrates, including amphipods (*Corophium sp*.) mysids, Asian clams, snails, and small fish such as sculpins and assorted fry (McCabe et al. 1993; Romano et al. 2002). White Sturgeon develop more diverse diets as they grow, as allowed by the available prey base. Larger White Sturgeon are increasingly piscivorous, feeding on eulachon, northern anchovy, American shad, lamprey, Pacific herring and various salmonids (McCabe et al. 1993; Sprague et al. 1993). Diet composition can vary substantially throughout the year as White Sturgeon take advantage of seasonally abundant prey items, especially where anadromous and estuarine fishes are available.

3.3.7 Maturation & Fecundity

Compared to other fishes, initial sexual maturity of White Sturgeon does not occur until relatively large sizes and advanced ages. Males typically mature at smaller sizes and ages than females (Bajkov 1949; Scott & Crossman 1973; Galbreath 1985). First maturity in White Sturgeon is related to both size and age (Conte et al. 1988). Males may be sexually mature between 40–60 in (100–150 cm) FL and ages 12–25. Females typically mature at 47–70 in (120–180 cm) FL and ages 15-30.

Female maturation has been assessed in the lower Columbia River and lower mid-Columbia reservoirs based on surgical biopsy of fish caught and released during long-term stock assessment sampling and from dissection of fish sampled from the fishery harvest (Welch & Beamesderfer 1993). Median sizes of female maturation have been reported to range from 63–76 in (160–194 cm) FL (Figure 13). Differences in growth rates among subpopulations can result in differences in maturation size. The smallest mature females were observed in the Bonneville Reservoir where growth was relatively slow.

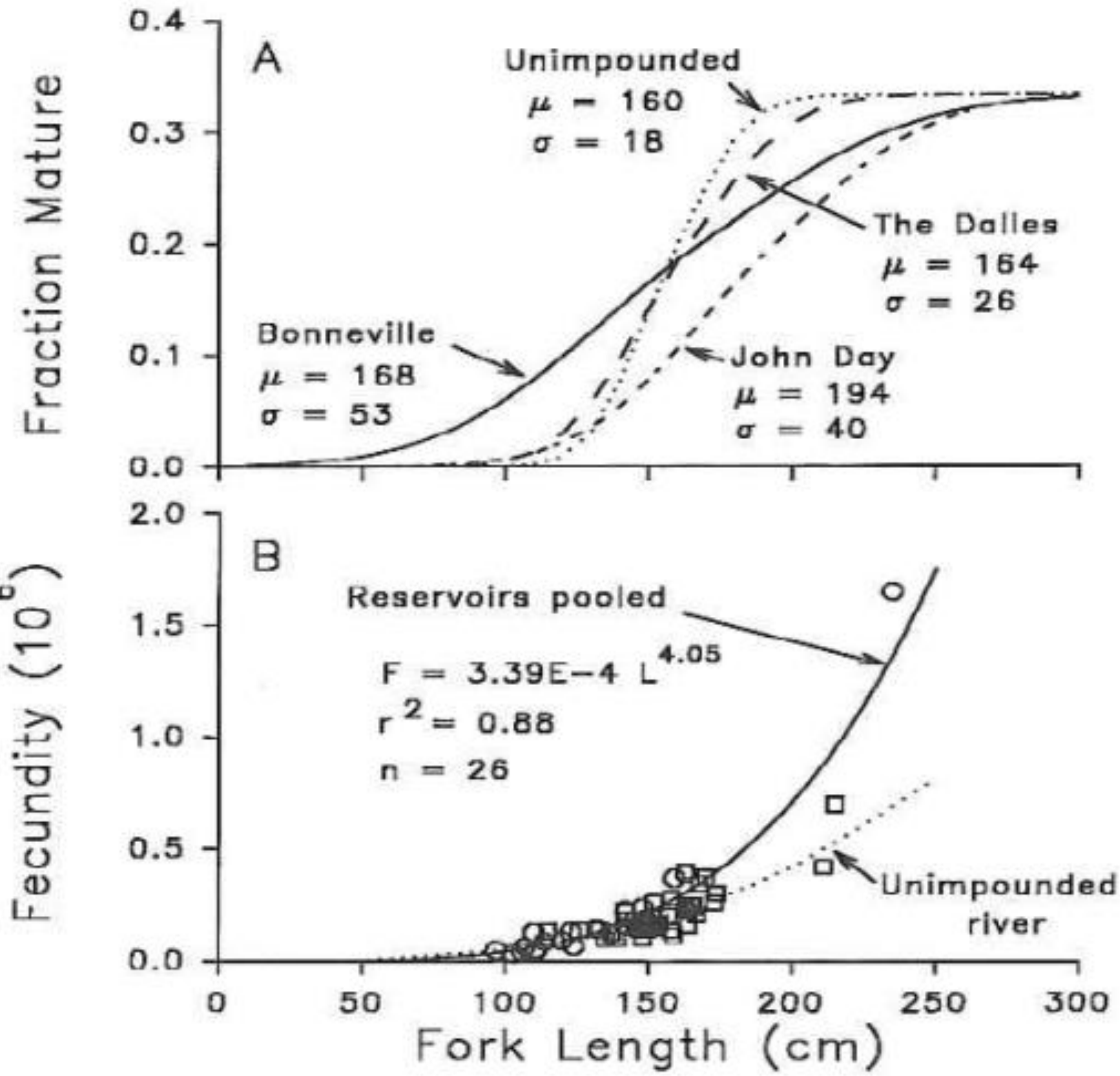

Figure 13. (A) Maturity and (B) fecundity (millions of eggs) versus size of female White Sturgeon in three reservoirs and the unimpounded lower Columbia River (from Beamesderfer et al. 1995).

Adult white sturgeon, particularly females, do not spawn annually even after sexual maturity (Webb & Kappenman 2013). The multi-year reproductive periodicity of females is due in part to the metabolic demands of their cyclical reproductive process (vitellogenesis), which requires 16 months or more to complete under conditions in the wild (Conte et al. 1988, Detlaff et al. 1993, Doroshov et al. 2002). As a result of this protracted maturation cycle, females sampled in any given year may include ripe, developing, and resting gonadal stages (Welch & Beamesderfer 1993). Females may also reabsorb eggs in some years rather than spawning although this follicular atresia is relatively rare in the wild.

Research on the spawning interval of White Sturgeon in the Columbia River has been underway downstream from Bonneville Dam (Webb & Kappenman 2013). From 2000 through 2012, 758 adult White Sturgeon have been tagged and examined for sex and stage of maturity. In 2011, over half of the adult sturgeon captured had also been captured and tagged in previous years.

Webb & Kappenman (2013) reported that using the shortest maturation cycle assigned, a 2-year or longer maturation cycle was possible in 12% of the females, a 3-year or longer cycle was possible in 35% of the females, a 4-year or longer cycle was possible in 29% of the females, and a 5-year or longer cycle was possible in 12% of the females in 2011. A 1-year or longer maturation cycle was possible in 33% of the males, a 2-year or longer cycle was possible in 22% of the males, a 3-year or longer cycle was possible in 33% of the males, and a 4-year or longer cycle was possible in 10% of the males in 2011.

Female White Sturgeon are very fecund, particularly at large sizes. Fecundity of lower Columbia White Sturgeon was reported to range from 32,000 to 1.65 million with numbers increasing exponentially with fish size (North et al. 1993). North et al. (1993, 1999) also reported that egg diameter increased with increasing fish size.

3.3.8 Survival/Mortality

The longevity of sturgeon is clearly associated with low natural mortality rates beyond the first few years of age. Annual survival rates for long-lived fish like White Sturgeon are typically high in the absence of fishing and often exceed 90% (Semakula 1963; Cochnauer 1983; Kohlhorst et al. 1991; Beamesderfer et al. 1995; DeVore et al. 1995). Annual mortality estimates for Columbia basin White Sturgeon are summarized in Table 6. Because sturgeon are so long-lived, population trends are extremely sensitive to small changes in survival rates of only a few percent. Most methods of estimating survival are not accurate enough to discern differences this small.

Table 6. Mortality estimates reported for Columbia and Snake river white sturgeon.

Location	Stage	Includes	Value	Method	Source
L. Col. River	37-68 on FL	Natural	0.09	Catch curve	DeVore et al. 1995
	Ages 10+	Natural	0.07	Pauly method	Beamesderfer et al. 1995
L. Col. reservoirs	Ages 1-10	Natural	0.21	“	“
	Ages 10+	Natural	0.04-0.05	“	“
U. Snake – Bliss reach	Adults	Total	0.06	Catch curve	Cochnauer 1983
U. Snake – Bliss reach	Adults	Total	0.16	Catch curve	Lepla & Chandler 1997
U. Col. transboundary	Adults		0.03	Mark-recap	UCWSRI 2013
Kootenai	Adults	Total	0.09	Mark-recap	Paragamian et al. 2005
Kootenai	Adults	Total	0.06	Mark-recap	Beamesderfer et al. 2014a

3.4 STURGEON HISTORY

Late this evening Drewyer arrived with a most acceptable supply of fat sturgeon…

March 2, 1806 – The Journals of the Lewis and Clark Expedition

3.4.1 1880 – 1950: Market Fishing & Collapse

Because sturgeon can live to 100 years or more, current status and problems reflect current limitations and lingering effects of historical impacts and activities. Sturgeon thrived throughout the waters of the Columbia Basin and the unexploited population included large numbers of very large adults. Intensive commercial fisheries developed in the mid to late 1800s for sturgeon and salmon with the advent of a fish canning industry (Craig & Hacker 1940; Galbreath 1985). The sturgeon population and fishery collapsed during the 1890s as unregulated harvest mined out the adult population. Sturgeon are very susceptible to overfishing due to their longevity and late maturation (Rieman & Beamesderfer 1990; Boreman 1997). Gear and minimum size regulations were finally enacted for the commercial fishery in the early 1900s, almost too late to save the population which remained at very low numbers for the next half century.

3.4.2 1950 – 1980: Enlightenment & Rebuilding

Basic research on sturgeon biology by Alexander Bajkov of the Oregon Fish Commission during the 1940s led to protection of spawning adults with a 72 in (183 cm) TL maximum size limit in 1950 (Bajkov 1951; ODFW & WDFW 2002). A minimum size limit of 30 in (76 cm) TL was adopted in 1959 and changed to 36 in (91 cm) TL in 1958. The 36–72 in (91–183 cm) TL slot limit remained in place until 1986. These regulations helped to protect the most productive members of the Sturgeon breeding population.

Sturgeon harvest in sport, commercial and treaty tribal fisheries gradually increased from 1970 until the 1980s as the population expanded following broodstock protection and anglers increasingly turned to sturgeon as salmon fisheries declined (Figure 14). By far the large majority of the harvest occurred downstream from Bonneville Dam where habitat favors consistent recruitment and fish continue to have access to estuary and ocean resources. By 1987, harvest peaked at almost 90,000 sturgeon after which a series of more conservative regulations were adopted to maintain sustainable harvest levels. Harvests of about 50,000 sturgeon per year were maintained until the early 2000s.

3.4.3 1980 – 2014: Modern Problems

Above Bonneville Dam, many populations increased during the 1960s and 1970s in response to harvest regulations enacted in the 1950s. However, recovery was limited by the habitat conditions available to subpopulations fragmented by dam construction between 1933 (Rock Island Dam) and 1975 (Lower Granite Dam). Sturgeon harvest from impoundments never rebounded to levels comparable with the lower river. While the 145 mi (233 km) of unimpounded Columbia River downstream of Bonneville Dam supported harvests of 50,000 sturgeon per year over an extended period until the advent of recent production problems, the 145 mi (233 km) of reservoirs between Bonneville and McNary dams are currently providing fewer than 5,000

sturgeon for harvest per year (Figure 15). While dam construction was not completely responsible for the historical decline of White Sturgeon, impoundments have proved to be the primary impediment to rebuilding of inland populations (Beamesderfer et al. 1995).

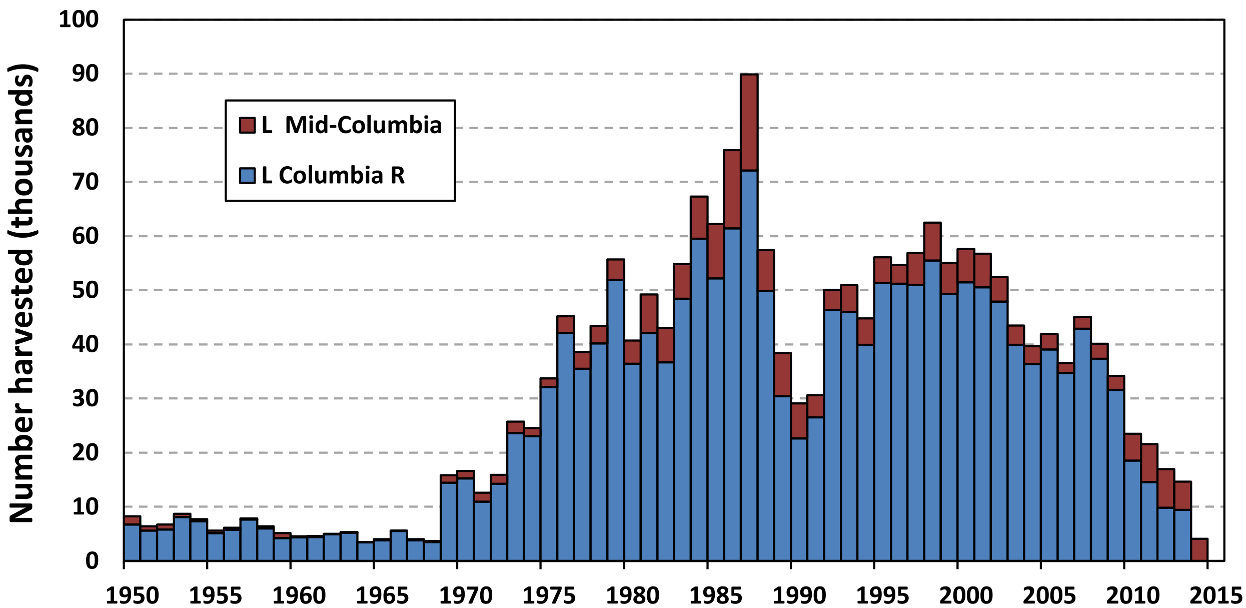

Figure 14. Total annual harvest of White Sturgeon in lower Columbia and lower mid-Columbia sport, commercial, and treaty tribal fisheries, 1950-2013.

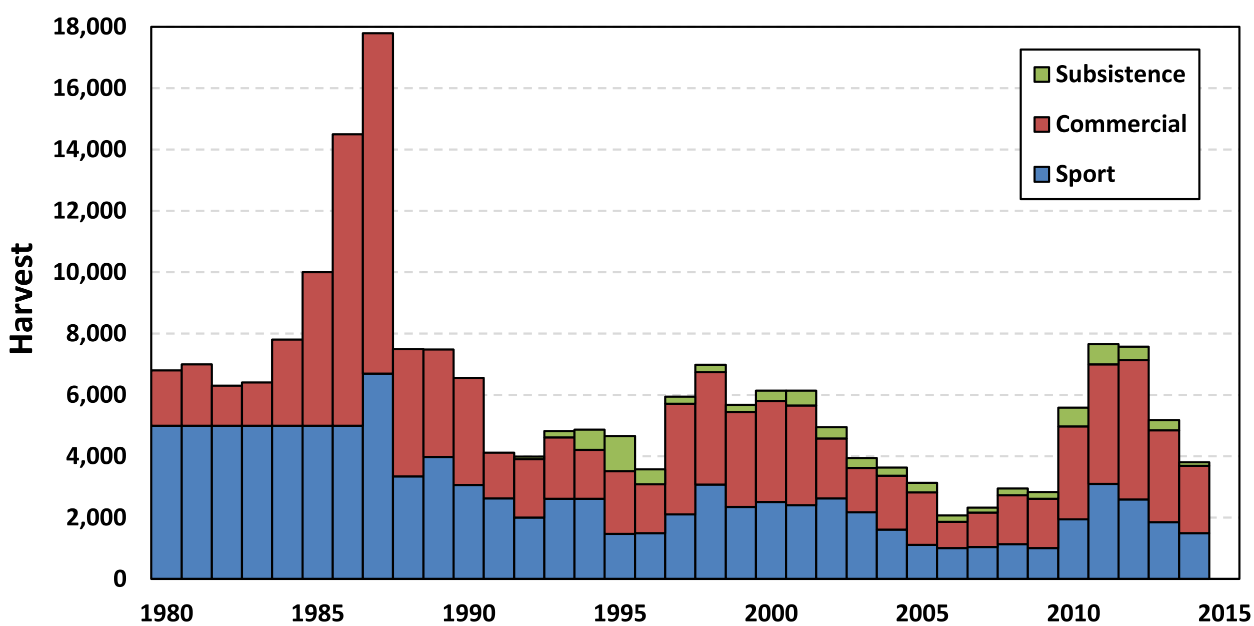

Figure 15. Total annual harvest of White Sturgeon in lower mid-Columbia sport, commercial, and subsistence fisheries, 1950-2014.

Impounded sturgeon populations did not attract much sport fishery attention until the late 1970s. From 1980 through 1987, expanding sport and commercial fisheries between Bonneville and John Day dams mined the standing stock which had been building over several decades. As a result, the fishery declined precipitously from 1987 through 1991 (Figure 15). Sustainable fishing guidelines were established beginning in 1991 following the implementation of regular stock assessments during the late 1980s. Current harvest levels are constrained by habitat-related recruitment limitations and annual harvests vary over time in response to varying abundance based on year class strength.

Downstream from Bonneville Dam, harvest levels were steadily reduced beginning in 2003 in response to an observed decline of natural recruitment detected in the early 1990s. While a substantial White Sturgeon population remains in the lower Columbia, fishery was closed effective January 1, 2014 in an attempt to stabilize the current population.

The causes of declining sturgeon numbers in the lower Columbia River downstream from Bonneville Dam are unclear. Potential factors include some combination of increased mortality due to sea lion predation and reduced recruitment due to environmental factors perhaps including those related to hydrosystem operation (ODFW 2011b). Productivity might also have been affected by high historical rates of harvest which potentially reduced the spawning stock size (see Section 9.6.6). The relative importance of each of these factors on the observed decline in sturgeon downstream from Bonneville Dam is uncertain.

The decline in sturgeon abundance in the unimpounded river coincided with a growing influx of sea lion predation into the Lower Columbia River and the Bonneville Dam tailrace. Sea lion numbers in the lower Columbia were substantially reduced by decades of control efforts by historical commercial fishing interests. Following adoption of the Marine Mammal Protection Act in 1972, sea lion numbers have steadily rebounded. Numbers have increased greatly in the lower Columbia River since the late 1990s (Stansell et al. 2014). Sturgeon are a significant food item of pinnipeds including California and Steller seas lions, particularly in sturgeon spawning areas in the Bonneville Dam tailrace (Stansell et al. 2014). Oregon's lower Columbia River sturgeon conservation plan suggests that pinniped predation is elevated over historic levels and substantially greater river-wide than estimates based on monitoring at Bonneville Dam (ODFW 2011b). We know that sturgeon abundance is extremely sensitive to even small incremental changes in mortality by virtue of their longevity and delayed maturation.

Sea lion predation may also be disrupting normal behavior of sturgeon, potentially including spawning. Large seasonal aggregations in off channel areas have been observed during winter after never having been reported previously. Significant numbers of sturgeon have also been documented residing in the lower portions of fish ladders at Bonneville Dam where they were not observed in similar numbers previously.

The decline in lower Columbia River sturgeon and the closure of fisheries to sturgeon retention highlights the importance of the hatchery mitigation program upstream. Bonneville Dam may

well be contributing to limitations on sturgeon productivity downstream by preventing upstream migration of adults to spawn above rapids that were historically impassable to pinnipeds.

3.4.4 1980 – 2014: Research, Monitoring & Evaluation

By the early 1980s, the Washington and Oregon Departments of Fish and Wildlife and the U.S. Fish and Wildlife Service had initiated limited surveys of impounded populations (Malm 1978; King 1981; Stockley 1981; Macy et al. 1997). However, basic information was lacking on sturgeon biology, ecology, limiting factors, habitat requirements, status, and population dynamics.

In 1983, concern for sturgeon populations' downward trends and information gaps led the Columbia Basin Fish and Wildlife Council's Resident Fish Technical Committee and the Bonneville Power Administration (BPA) to organize a regional workshop on research needs. This was the first sturgeon-related activity under the newly-formed Northwest Power Planning Council's developing fish and wildlife program and from this, proceedings were published in 1984 (Fickeisen et al. 1984). The need for research to determine the impacts of development and operation of the hydroelectric power system on sturgeon was recognized in the 1984 Fish and Wildlife Program adopted by the then Northwest Power Planning Council. A White Sturgeon research program implementation plan was completed in 1985 (Fickeisen 1985a, 1985b). Objectives included: 1) assessment of current status, 2) evaluation of the need for protection, mitigation, and enhancement, 3) evaluation of potential methods for protection, mitigation, and enhancement, and development of tools to assess the effectiveness of efforts.

An annual sturgeon stock assessment program was initiated in 1986 downstream from the Bonneville Dam by ODFW and WDFW using agency funds (ODFW & WDFW 2014). This program estimated annual abundance of harvestable sizes of sturgeon based on mark-recapture studies and harvest of sturgeon based on sport and commercial fishery sampling.

In 1986, BPA also funded a study to address research needs regarding the status and habitat requirements of White Sturgeon populations in the Columbia River downstream from McNary Dam BPA (Project 1986-50). The research findings from this study formed the basis for the hatchery proposal identified in this Master Plan. The study was implemented cooperatively by the Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, U. S. Fish and Wildlife Service, and National Marine Fisheries Service. Phase I of this project focused on assessment of stock status and habitat limiting factors was completed in 1993 (Beamesderfer & Nigro 1993a, 1993b). Phase II of this project in the mid-Columbia began in 1992 based on recommendations of Phase I research and is ongoing (Beamesderfer & Nigro 1993c; Mallette 2014). Phase II is focused on mitigation and evaluation activities. More detailed descriptions of project activities and objectives may be found in Section 4.8 Bonneville Power Administration – Related Projects on page 89.

3.4.5 1980 – 2014: Sturgeon Hatchery Development

The development of effective sturgeon hatchery methods is a relatively recent development, but sturgeon hatcheries are increasingly utilized for conservation or mitigation purposes in the Columbia basin. As of 2013, sturgeon hatcheries were planning to release about 48,000 fish per year into three main areas (Table 7). About 427,000 juvenile hatchery sturgeon have been released into the Columbia and Snake rivers by various parties since 1990 (Figure 16).

Early Efforts

Sturgeon culture techniques were relatively unknown in North America prior to 1980 when Dr. Serge Doroshov established a research program at the University of California-Davis building on sturgeon hatchery practices he had learned in the Soviet Union prior to emigration to the United States from Russia. Dr. Doroshov demonstrated that White Sturgeon could be produced by catching adults in the wild, hormonally inducing ovulation and sperm production, artificially spawning eggs harvested by cesarean section, and rearing fry in fingerlings on artificial feed (Dorohsov et al. 1983; Doroshov & Lutes 1984; Anderson 1988; Conte et al. 1988).

Commercial White Sturgeon aquaculture companies began in California and Idaho during the early 1980s, and have now become well established. Several of these private hatchery operations were established using broodstock captured from the Columbia River below Bonneville Dam. Agreements with state agencies allowed wild broodstock collection in exchange for provide mitigation fish to the state for stocking or research. One such small private aquaculture facility was operated on the lower Columbia River from 1981-2008 that used wild broodstock collection and spawning to produce and rear juveniles for private sale under permit by Oregon. Mitigation fish provided by the hatchery were primarily stocked by Oregon in the Willamette River upstream from Willamette Falls, but 1,019 juveniles were also marked and released into John Day Reservoir near Irrigon, Oregon in May 2005 (Parker 2006).

Table 7. Annual hatchery release objectives for Columbia Basin White Sturgeon hatcheries as of 2013.

Program	Facility	Operator	Release location	Number
Kootenai [a]	Bonners Ferry	KTOI	Kootenai R. (US)	6,000
	Ft. Steele	FFSBC	Kootenay R. (Can)	8,000
U. Columbia	Ft. Steele	FFSBC	Transboundary (US)	4,000
	Sherman Cr.	WDFW	Transboundary (Can)	4,000
	Ft. Steele	FFSBC	Arrow Lakes	8,000
U. Mid-Columbia				
Grant Co. PUD	Marion Drain	YIN	Priest Rapids, Wanapum	6,500
	Columbia Basin	WDFW		
Chelan Co. PUD	Chelan	WDFW	Rocky Reach	6,500
Douglas Co. PUD	Wells	WDFW	Wells	5,000[b]
Total				***48,000***

[a] *Current plans call for increasing releases to 20,000-40,000 following completion of Twin River Hatchery in 2014.*

[b] *Planned for 2014.*

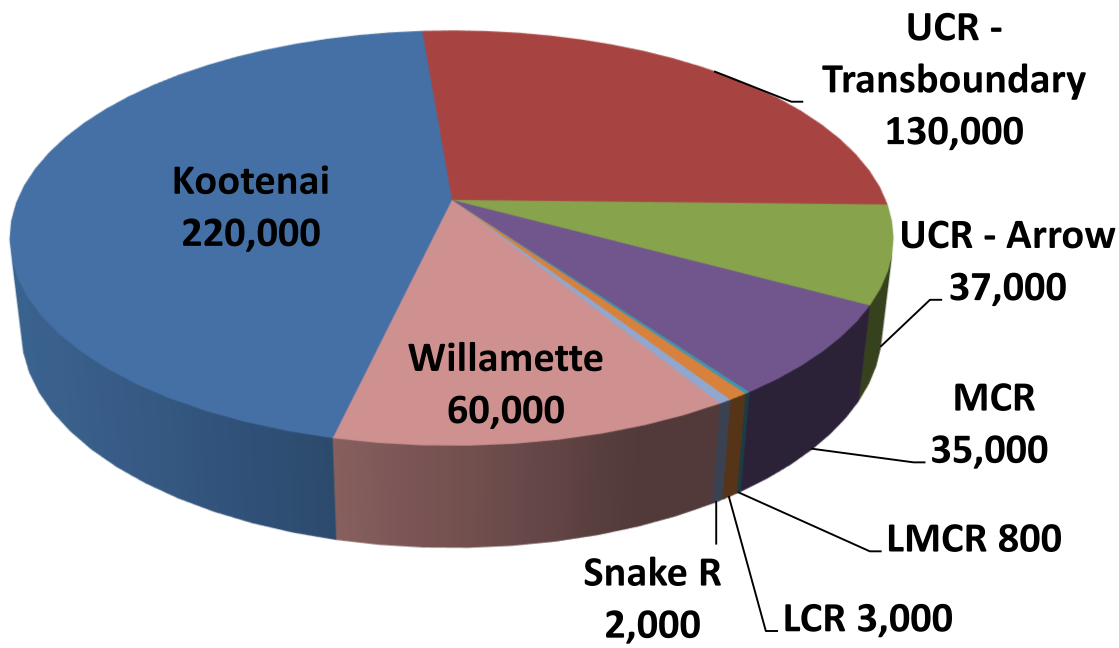

Figure 16. Cumulative total releases of juvenile hatchery sturgeon in the Columbia and Snake river basins from 1990-2013 (Beamesderfer and Squier 2013).

Small-scale hatchery research projects were conducted by the University of Idaho under the NPPC Fish and Wildlife Program with BPA funding during the early 1980s. Initial efforts focused primarily on laboratory work to describe early life history and population genetics (Brannon et al. 1985a, 1985b, 1986, 1987, 1988; Setter 1989; Setter & Brannon 1992).

Kootenai Program

The first significant sturgeon aquaculture program in the Columbia basin was initiated in 1990 for Kootenai sturgeon by the Kootenai Tribe of Idaho and the Idaho Department of Fish and Game (Apperson & Anders 1990; KTOI 2007). The Kootenai sturgeon culture program has subsequently evolved from an experimental program into a full scale conservation effort designed to avoid extinction of this unique headwater population which has been isolated since the last ice age. The population has been dwindling following a complete failure of natural recruitment and was listed as endangered under the USA in 1994 (Paragamian et al. 2005).

The Kootenai Tribal Hatchery facility has operated near Bonners Ferry, Idaho since 1991. The first artificial spawning of wild Kootenai White Sturgeon occurred in 1990, initial hatchery construction was completed in 1991, the first hatchery releases occurred in 1992, a genetic breeding plan was established in 1993, disease management strategies were formalized in 1999 and the program was subsequently expanded as other efforts to restore natural recruitment have failed (Kincaid 1993; LaPatra et al. 1999; KTOI 2007; Ireland et al. 2002a, 2002b; Paragamian & Beamesderfer 2004; Paragamian et al. 2005). Failsafe rearing has been conducted at the Kootenay Trout and Sturgeon Hatchery near Ft. Steele, British Columbia since 1998. A new Tribal hatchery facility (Twin Rivers) has been completed upstream from Bonners Ferry to

accommodate the demands of this sturgeon conservation program (KTOI 2010). Operation began in 2015. Through 2013, the Kootenai sturgeon conservation aquaculture program had released 220,000 juveniles produced from over 300 wild broodstock and documented significant survival and growth of these fish in the wild (Ireland et al. 2002b; Justice et al. 2009; Beamesderfer et al. 2014b). Together, these efforts illustrate the needs of others to replenish White Sturgeon populations throughout their natural range and restore historical abundance for the benefit of all stakeholders.

Upper Columbia Program

A sturgeon conservation aquaculture program began in the Canadian Upper Columbia River in 2000 to address measures identified in an upper Columbia White Sturgeon recovery plan and the listing of Upper Columbia River White Sturgeon under the Canadian Species at Risk Act in 2003 (UCWSRI 2002, 2013; Golder Associates 2007; Wood et al. 2007). The program began with the modification of a Provincial trout hatchery (Hill-Mackenzie Creek) located on upper Arrow Lake in British Columbia. Broodstock collection and spawning began in 2001 and juveniles were first released in 2002 (UCWSRI 2013). In 2003, the program was transferred to the larger Kootenay Trout Hatchery near Cranbrook, BC.

The program was expanded to the U.S. portion of the transboundary reach (Roosevelt Dam in WA to Hugh L. Keenleyside Dam in B.C.) by the WDFW beginning in 2004 (Beamesderfer and Justice 2008). Juvenile sturgeon from the Canadian facility were transferred to Moses Lake Hatchery in February 2004 for rearing and subsequent release. The U.S. program began collecting its own broodstock in 2006 (UCWSRI 2013). Portions of this program are now operated at the WDFW Sherman Creek Fish Hatchery.

Since 2011 the U.S. program has collected wild larvae in the upper Roosevelt reach, raised them in a hatchery setting, and released them back into the river as juveniles. Adult broodstock collection has now been discontinued by the U.S. program. The feasibility of a wild larval collection program in the Canadian section of the transboundary reach and rearing of these larvae in facilities adjacent to the Columbia River is also being investigated by the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI).

From 2002 to 2011, 122,555 juveniles have been released in the transboundary reach (93,524 in Canada and 29,031 in the U.S.). Monitoring studies have indicated these juveniles released from the hatchery have survived in significant numbers, are growing normally and to date, do not show any signs of density related changes in growth or survival rates (BC Hydro, unpublished data; UCWSRI 2013). An additional 1.5 million larvae have been released in the transboundary reach and 36,643 juveniles have been released into the Arrow Lakes upstream from the transboundary reach.

Upper Mid-Columbia Programs

Hatchery juvenile sturgeon have been released beginning in 2010 as mitigation for hydro effects as per current FERC license agreements with the Grant, Douglas and Chelan County Public Utility Districts (PUDs). Through 2012, approximately 15,500 juvenile sturgeon had been stocked in the

Priest Rapids and Rocky Reach project areas as part of the mitigation programs. Fish were produced by artificial spawning of wild broodstock and by hatchery rearing of wild larvae collected from mid-Columbia and lower mid-Columbia reservoirs. Captive spawning of wild broodstock occurs at the Yakama Nation Marion Drain White Sturgeon Hatchery for all three PUD programs. For the Chelan County PUD, fertilized embryos and larvae are transferred to WDFW's Chelan Falls and Columbia Basin hatcheries for rearing to age 1 year. For the Douglas County PUD, fertilized embryos are transferred to WDFW's Wells Hatchery for rearing to age 1 year. For the Grant County PUD, rearing occurs at the Marion Drain Hatchery. Wild-caught larvae are also being reared at Marion Drain for the GCPUD. Related white surgeon monitoring and evaluation activities are ongoing or planned in all project areas (GCPUD 2009; Golder Associates 2003a, 2003b, 2007).

Lower Mid-Columbia Programs

Limited releases of hatchery-reared sturgeon have occurred in this region in the past as part of an experimental feasibility study, but no hatchery releases currently occur. Previous releases were part of an evaluation of potential use of supplementation as an enhancement tool in mid-Columbia reservoirs were conducted under Phase II of the BPA-funded 85-50 sturgeon project from 1999 to 2003 by the Columbia River Intertribal Fish Commission and the U. S. Fish and Wildlife Service (Kappenman & Parker 2001, 2002, 2003, 2004, and 2005).

Research in this project focused on developing protocols for capture and maturation of pre-spawn adults, culture and rearing technology, and evaluating release size strategies. Wild broodstock were collected primarily from Bonneville and McNary reservoirs and spawning and rearing occurred at a temporary facility at McNary Dam and at the Abernathy Fish Technology Center near Longview WA (Kappenman & Parker 2005). A total of 93 adults were collected for broodstock and eight females were spawned successfully (Table 8). A total of 20,600 juveniles from these efforts were released in 2003 into Rock Island Reservoir near Wenatchee, WA. Rock Island was the primarily focus of this experimental effort because the local population had been practically extirpated. An additional 739 juveniles were released into John Day reservoir (450 in fall 2002 and 289 in 2005). Budget constraints in 2003 forced an early termination of this effort and resulted in the release of 48,000 unmarked young-of-the-year into the upper Willamette River (Kappenman & Parker 2005).

Subsequent monitoring has since documented significant survival and growth in of the hatchery juveniles released in Rock Island Reservoir, but also resulted in significant numbers of these fish recaptured in downstream reservoirs including Wanapum, Priest Rapids, McNary, and John Day (Parker 2006). Hatchery-produced fish currently dominate the catch of juvenile sturgeon during population assessment work in Rock Island, Wanapum, and Priest Rapids reservoirs. The McNary population in 2011 included an estimated 3,500 hatchery sturgeon which had moved downstream from their original release point in Rock Island Reservoir by CRITFC in 2003.

Kappenman and Parker (2004) concluded that: 1) sturgeon hatchery supplementation is a promising strategy for experimentation, restoration or population augmentation; 2) objectives

and risks of hatchery supplementation need to be clearly articulated and carefully evaluated, 3) spawning and rearing success in the hatchery will depend on the availability of adequate amounts of water and the ability to regulate water temperatures, 4) use of fish collected during spawning will be more successful than collection and extended holding of fish prior to spawning, and 5) low numbers of adults in reservoirs require significant effort to collect adequate numbers of ripe males and females.

The CRITFC hatchery research effort also highlighted the pitfalls of attempting to implement a project with minimal facilities and staff. The research effort was hampered by a series of problems in obtaining adequate numbers of broodstock from depleted populations to ensure synchronous spawning of males and females sexual maturation of adults collected prior to spawning, limitations of temporary facilities, and stress-related fish health outbreaks. Based on these efforts, Kappenman and Parker (2004) concluded that development of an effective sturgeon hatchery program will require: 1) significant multi-year investments, 2) the availability of both adequate facilities and sturgeon culture expertise, and 3) an adaptive approach to refinement of culture methods specific to the facility and application.

3.5 CURRENT STURGEON STATUS[5]

Population status for each impounded White Sturgeon subpopulation in the lower mid-Columbia and lower Snake management units has been monitored periodically since 1987. Currently, abundance and population of White Sturgeon populations in each of the three reservoirs between Bonneville and McNary dams are estimated every three years to monitor the effects of hydro-system operations and fishery management strategies. Subpopulations in lower Snake River reservoirs are assessed less frequently because they are not currently the focus of significant fisheries. Mark-recapture population estimates are derived using directed sampling with gillnets and setlines. Annual year class strength is monitored with small mesh gills nets in most subpopulations for evaluation of flow effects.

Sturgeon populations trapped between the different mainstem Columbia and Snake River dams complete their life cycle in the fragmented river segments. Barred from historical habitats in the ocean and estuary, they must rely primarily upon the resources in the location where they have been trapped. Today, most impounded populations are recruitment-limited due to a lack of suitable spawning habitat or flow conditions suitable to produce significant recruitment in the available habitat (Parsley & Beckman 1994; Counihan et al. 1999; Parsley & Kappenman 2000; NPCC 2004). Substantial differences in population characteristics have been documented among impounded subpopulations due to habitat-related differences in annual recruitment (Table 9).

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[5] Detailed descriptions of sturgeon life history, population dynamics and limiting factors may be found in the regional sturgeon framework document (Beamesderfer & Anders 2013).

While sturgeon were historically highly migratory and continue to be so downstream from Bonneville Dam, the subpopulations trapped in impoundments are effectively considered closed populations. Status of each subpopulation is determined by conditions in each reservoir. Movements upstream and downstream among impoundments have been documented but the incidence is very low in relation to local production. The exception is reservoirs like Little Goose where local production is negligible but significant production occurs upstream (in Hells Canyon) and a sizable percentage of the local population appears to have originated from the upstream subpopulation. That is not the case for any of the lower Columbia River reservoir populations.

The following sections summarize current status of impounded subpopulations in the lower mid-Columbia and lower Snake River based on information identified in Beamesderfer and Anders (2013).

Table 8. Summary of experimental sturgeon hatchery evaluation activities for the lower mid-Columbia River conducted under Phase II of the 1986-50 project funded by Bonneville Power Administration (Kappenman & Parker 2001, 2002, 2003, 2004, 2005).

	Activity
1999	9 broodstock were collected (1♀ from Wanapum Reservoir, 2♀ & 6♂ from McNary Reservoir) A temporary facility was built at Abernathy Hatchery to hold broodstock 1♀ & 1♂ subsequently matured but at different times. No fish were produced All McNary broodstock were released in McNary, the Wanapum fish was held over for 2000
2000	16 broodstock were collected (2♀ & 14♂ from McNary Reservoir) One ♀ captured at Wanapum Reservoir in 1999 was held for spawning in 2000 Maturation of broodstock held at Abernathy Hatchery was not successful - constant cold temperature of the well water at that facility was subsequently determined to be the cause All broodstock were released in the area of origin
2001	27 broodstock were collected (4♀ & 23♂ from McNary Reservoir) A facility was developed at McNary Dam to hold and spawn fish at ambient river temperatures 1st successful spawning for this project, a 1x2 mating produced 104,000 eggs & 32,000 larvae Only 900 subyearlings were reared by Abernathy Hatchery due to disease & bird predation losses All broodstock were released in the area of origin
2002	21 broodstock were collected (1♀ & 19♂ from McNary Reservoir & 1♀ from below Bonneville Dam) Spawning occurred at the McNary Dam temporary facility one 1x4 mating produced 84,700 eggs & 22,640 fry 50,000 larvae were also obtained in June 2002 from 1x1 mating of broodstock collected by the Pelfry sturgeon hatchery below Bonneville Dam 21,700 subyearlings were reared at Abernathy Hatchery 450 BY 2001 yearlings released into John Day Reservoir in fall All broodstock were released in the area of origin
2003	20 broodstock were collected from McNary (2 ♀, 17♂) & Bonneville (1 ♀) reservoirs Spawning occurred at the McNary Dam temporary facility One 1x1 mating produced only 4 larvae due to poor egg quality from rapid increase in water temperature. Unsuccessful spawning required the purchase of fertilized eggs from the private sturgeon hatchery to complete program objectives. 20,600 BY 2002 juveniles released into Rock Island Reservoir (12,000 @ 9 mo. in April 2003, 8,600 @ 13 mo. in Sept.) Water system problems at McNary Dam resulted in mortality of 2 ♂ broodstock Budget constraints result in termination fish spawning and rearing activities 48,000 remaining BY 2002 juveniles released into the Willamette River
2005	289 age 1, 2, 3, and 4 year olds were released into John Day Reservoir (BY 2000-2003)
2006	Winter gill net sampling was conducted in Wanapum, Rock Island, and Priest Rapids reservoirs to monitor growth, survival, condition, distribution, and downstream migration of Rock Island releases. Cold water temperatures and macrophyte drift clogging the nets yield poor results. Summer long line sampling in Rock Island, Wanapum and Priest Rapids reservoirs, yielded over 100 hatchery sturgeon recaptures, confirming growth, movement, and survival assumptions about the 2003 releases.
2008	26 remaining subadults transferred from Abernathy Hatchery to the Yakama tribal hatchery

Table 9. White Sturgeon sub population characteristics in lower mid-Columbia reservoirs, 2011-2013 (Cox 2013; Farr et al. 2013; Cox & Schade 2014), and lower Snake River reservoirs, 1996-2012 (DeVore et al. 1998, 1999; Cox & Schade 2014).

	Characteristic	Units	Lower Mid-Columbia River				Lower Snake River		
			Bonneville	The Dalles	John Day	McNary[a]	Ice Harbor	L. Monumental	Little Goose
Population	Abundance[b]	≥21in FL	220,000	110,000	40,000	7,000	4,800	4,300	6,500
	Biomass	Tons	900	500	400	200	80	75	130
	Standing crop	lb./acre	90	90	17	7	19	23	27
	Recruit threshold	Flow kcfs	≥ 220	≥ 250	≥ 280	na	na	na	Na
	Recruit frequency	freq.[c]	60%	50%	20%	<10%	<10%	na	<10%
Size	≥ 42 in. FL	% by no.	3%	4%	17%	53%	46%	45%	44%
	Avg. size	lb	8.2	8.7	19.3	43.8	33.4	35.0	40.8
	Growth	In/year	1-3	1.6-3	2-3	3	2-3	2-3	2-3
	Condition	W_r[a,d]	97%	101%	102%	103%	--	101%	100%
Fishery	Slot limit	Inches FL	38-54	43-54	43-54	43-54	43-54	43-54	43-54
	Age to reach	years	18	18	15	≤15	na	na	na
	Years in slot		8	5	5	≤5	na	na	na
	Current guideline	Fish/year	2,200	1,300	1,500	--	--	--	--
	Harvest avg.	1999-2013	2,300	1,400	900	280		280 combined	
	Harvest rate	Annual %[e]	18%	40%	40%	12%		5%	
	Yield	lb/acre/year	2.5	3.9	0.6	0.2		0.3	

[a] *Includes Hanford Reach.*

[b] *Recent 10-year average.*

[c] *Percentage of years where significant recruitment occurs.*

[d] *W_r is relative weight where 100% represents "good" weight for length values equivalent to 75% of White Sturgeon populations throughout their range.*

[e] *Relative to abundance in harvestable size slot. Includes Tribal subsistence harvest (guideline includes only commercial and sport).*

na = not available

3.5.1 Bonneville Reservoir

Bonneville Reservoir supports the largest sturgeon subpopulation in the impounded management area due to consistent levels of natural recruitment under a wide range of spring flow conditions.[6] The morphology of the tailrace of The Dalles Dam is such that favorable spawning and/or incubation conditions are provided at a relatively low spring flow level of about 220 kcfs or more which occur in approximately 60% of years (Figure 17).

At the same time, recruitment varies from year to year as high and low runoff years tend to occur in series (annual weather patterns are auto correlated). Abundance fluctuates in response to annual recruitment patterns, although nowhere to the same degree in Bonneville Reservoir as in other impounded subpopulations. Abundance in Bonneville Reservoir generally increased from 1989 through 2009 following a series of high recruitment years (Figure 18). Abundance began to decline by 2012 as strong cohorts moved through the population and the effects of diminished recruitment from 2000-2005 were observed.

As a result of regular recruitment, juvenile and subadult fish less than 38 in (96 cm) FL currently comprise the large majority (93%) of the Bonneville sturgeon population by number in 2012 (Figure 19). Small fish size groups are well-represented due following a series of recruitments in 2006-2011. Fish in the harvestable size slot of 38–54 in (96–137cm) FL comprise only 6% of the population total.

While sturgeon of all sizes are relatively abundant in Bonneville Reservoir, growth and condition are among the poorest observed in the lower Columbia River basin. Annual growth increments are particularly small (<1 in/year) for fish 20–38 in (51–96 cm) FL and increase progressively to about 3 in/year (7 cm) by 60 in (152 cm) FL. Sturgeon in Bonneville Reservoir are believed to recruit to the harvestable size range at about 18 years of age and are vulnerable to the slot-size fishery for an average of 8 years.

It is unclear whether relatively poor growth and condition are density-related responses to competition for limited food resources or result from changes to specific habitat conditions. Biomass per unit area in Bonneville Reservoir is among the highest of any impoundment and large numbers of juvenile and subadult may be competing for food. However, Bonneville Reservoir is generally shallower, bottom substrates are finer and aquatic macrophyte growth is greater than the other reservoirs. Regardless, Bonneville Reservoir may not be a good candidate for hatchery supplementation because natural recruitment is consistently significant and the existing population may well be fully utilizing the available habitat.

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[6] *The recruitment index is the proportion of trawl or gillnet sets where age 0+ White Sturgeon are captured in standardized time and area samples from each reservoir (Counihan et al. 1999; Mallette 2014).*

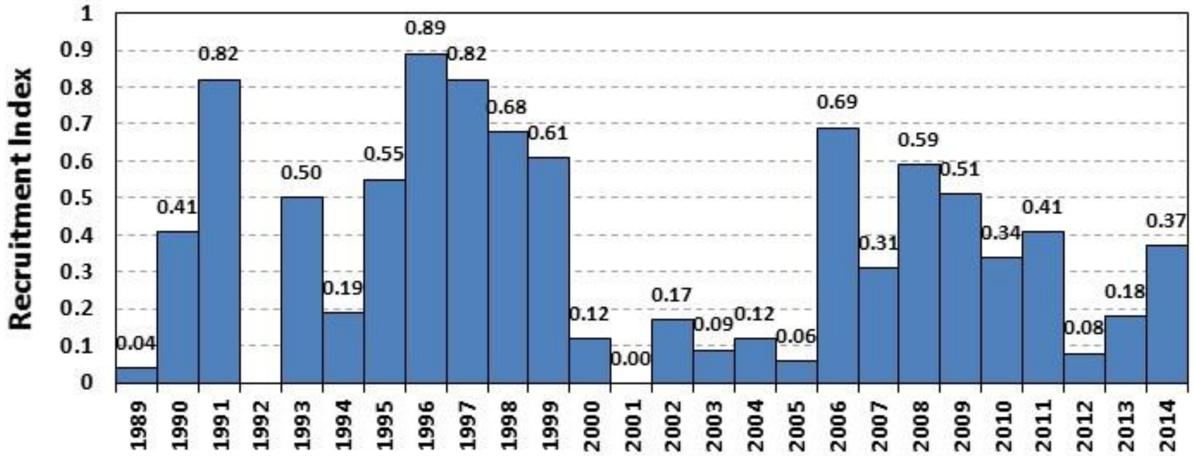

Figure 17. Annual estimates of sturgeon recruitment in Bonneville Reservoir.

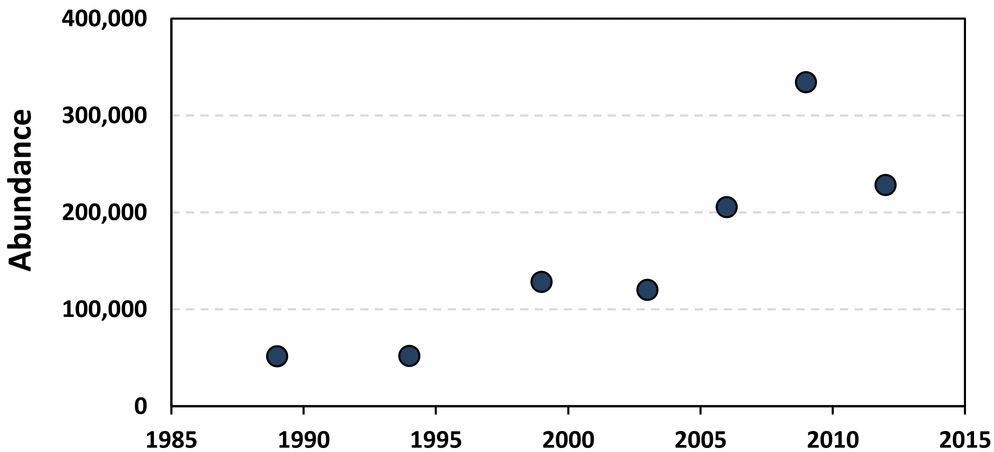

Figure 18. Periodic estimates of sturgeon abundance in Bonneville Reservoir.

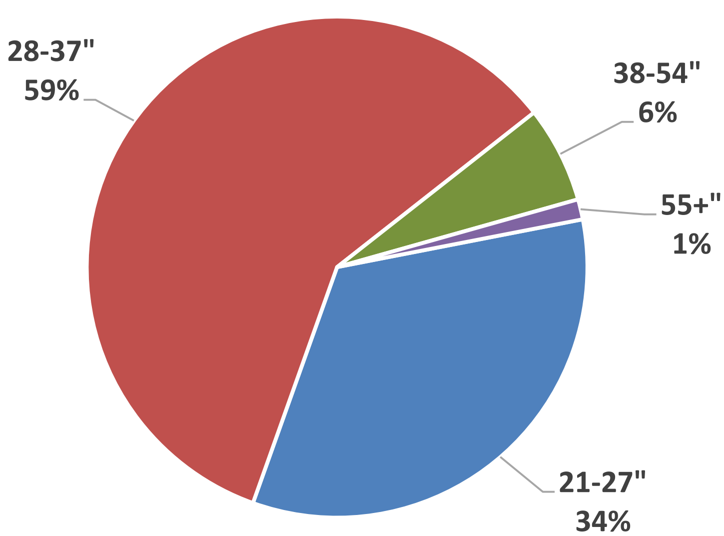

Figure 19. Current (2012) size composition of sturgeon in Bonneville Reservoir by fork length.

Fishery guidelines and harvests vary as sturgeon abundance changes when strong year class cohorts recruit into the harvestable size slot (Table 10) and are typically revised at three-year intervals following updated stock assessments. In Bonneville Reservoir, tribal (48%) harvest and non-tribal (52%) shares are similar. Annual exploitation rates of the resource have averaged 18% of the 38-54 in (96–137cm) FL sturgeon abundance in Bonneville Reservoir from 1999-2013. The minimum size in Bonneville Reservoir (38 in, 96 cm FL) is lower than in The Dalles and John Day reservoirs (43 in, 108 cm FL) due to the slower growth rate in Bonneville.

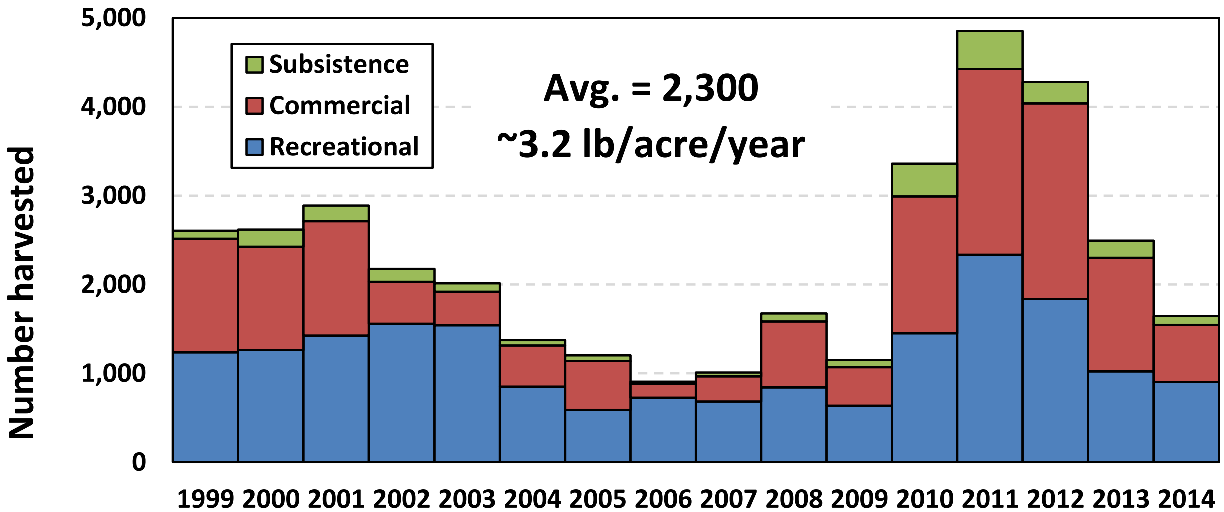

Figure 20. Recent annual sturgeon harvest by fishery in Bonneville Reservoir.

Table 10. Recent annual sturgeon harvest guidelines and numbers in Bonneville Reservoir.

	Abundance	Guideline				Harvest			
Year	(38-54 in FL)[a]	Sport	Comm.	Subsis.	Total	Sport	Comm.	Subsis.	Total
1999	14,700	1,520	1,300	--	2,820	1,235	1,280	90	2,605
2000		1,520	1,300	--	2,820	1,262	1,165	191	2,618
2001		1,520	1,300	--	2,820	1,426	1,287	174	2,887
2002		1,520	1,300	--	2,820	1,560	472	146	2,178
2003	6,900	1,700	1,200	--	2,900	1,542	379	93	2,014
2004		700	400	--	1,100	852	464	60	1,376
2005		700	400	--	1,100	588	550	66	1,204
2006	6,200	700	400	--	1,100	727	153	28	908
2007		700	400	--	1,100	682	285	44	1,011
2008		700	400	--	1,100	841	744	88	1,673
2009	29,600	700	400	--	1,100	638	431	83	1,152
2010		1,400	1,400	--	2,800	1,451	1,540	368	3,359
2011		2,000	2,000	--	4,000	2,334	2,089	429	4,852
2012	14,200	2,000	2,000	--	4,000	1,836	2,203	238	4,277
2013		1,100	1,100	--	2,200	1,022	1,277	194	2,493
2014		1,100	1,100	--	2,200	903	644	97	1,644

[a] *Size regulation for sport and commercial fisheries in Bonneville Reservoir.*

3.5.2 The Dalles Reservoir

The Dalles Reservoir supports a substantial sturgeon population despite being the smallest of the reservoirs in the management area. Natural recruitment is more variable than in Bonneville Reservoir but, more consistent than in John Day Reservoir and reservoirs upstream. The morphology of the tailrace of John Day Dam is such that favorable spawning and/or incubation conditions are provided at a relatively low spring flow level of about 250 kcfs or more which occur in approximately 50% of years (Figure 21).

Variable recruitment drives variation in abundance in this reservoir. Sturgeon numbers generally increased from 1993 through 2008 following a series of good recruitment years in the 1990s (Figure 22). Abundance is expected to decline over the next decade as effects of poor recruitment from 2000-2005 are observed.

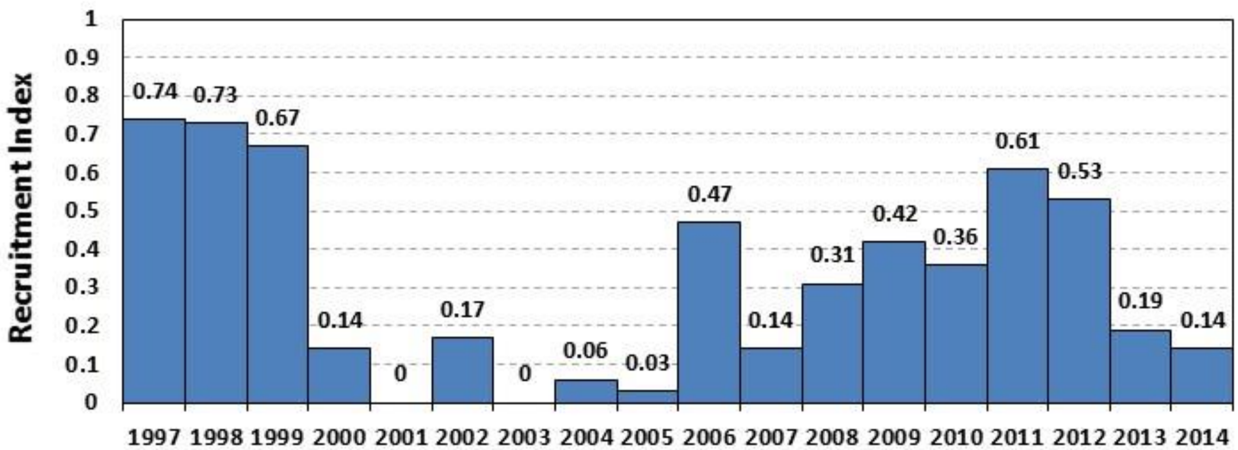

Figure 21. Annual estimates of sturgeon recruitment in The Dalles Reservoir.

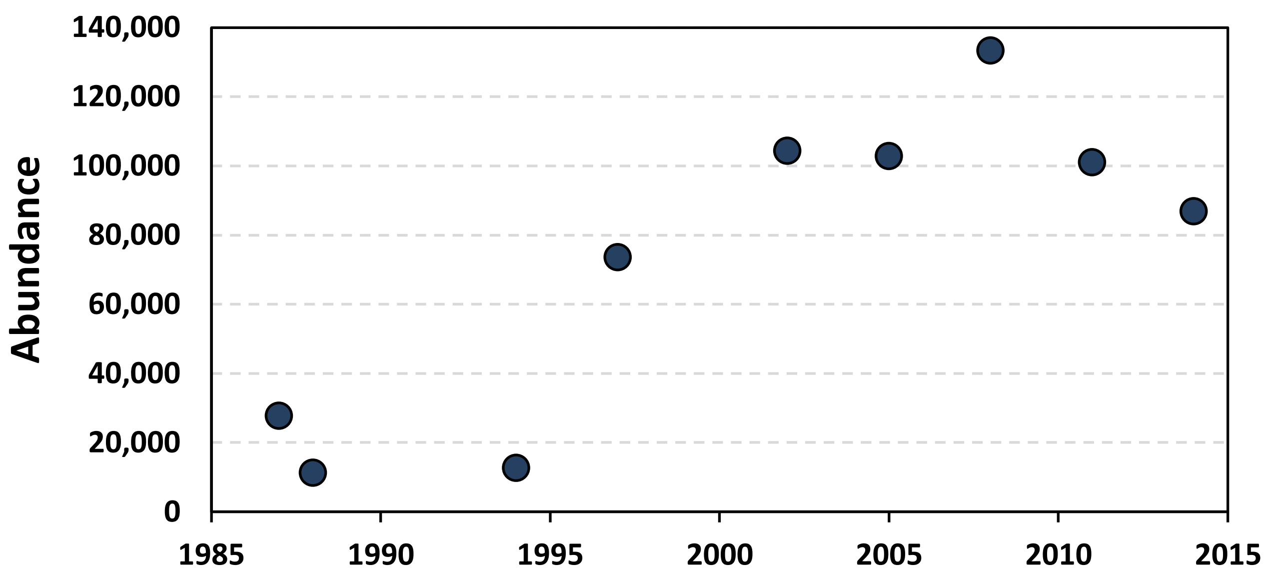

Figure 22. Periodic estimates of sturgeon abundance in The Dalles Reservoir.

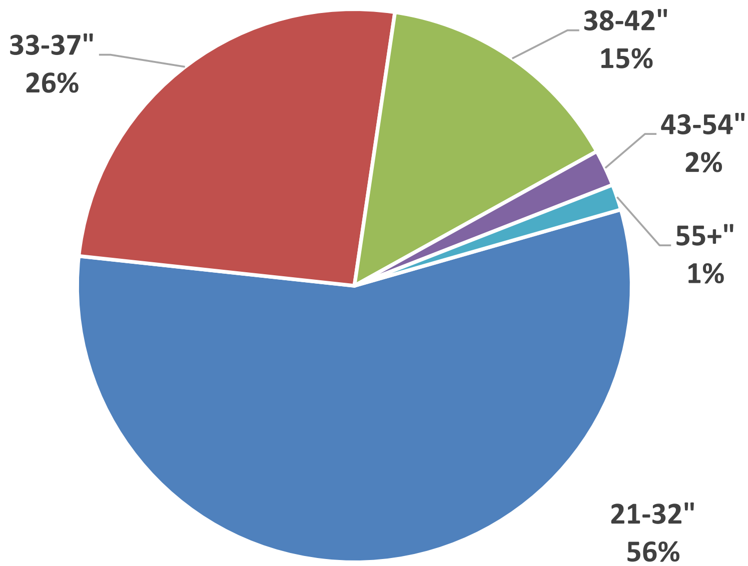

Figure 23. Recent (2014) size composition of sturgeon in The Dalles Reservoir by fork length.

As a result of periodic recruitment, juvenile and subadult fish less than 38 in (96 cm) FL comprised about three quarters of this sturgeon population by number in 2011 (Figure 23). Fish in the 38–42 in (96–107 cm) FL size range were well represented. Fish in the harvestable size slot of 43–54 in (109–137 cm) FL were only 2% of the population total. As with all impounded sturgeon subpopulations, fish larger than 55 in (140 cm) FL comprise a very small percentage of the total.

Biomass per unit area in The Dalles Reservoir is high for an impoundment and comparable to that of Bonneville Reservoir. High standing crop does not appear to have depressed growth or condition in The Dalles as is hypothesized in Bonneville. Sturgeon growth and condition factor in The Dalles are average for the lower Columbia River basin fish. Annual growth increments are about 1 to 2 in/year for fish 16–39 in (40–100 cm) FL and increase progressively up to about 3 in/year (8 cm) by about 55 in (140 cm) TL. Sturgeon typically recruit to the harvestable size range at about 18 years of age in The Dalles Reservoir and are vulnerable to the fishery for an average of 5 years.

Fishery guidelines and harvests in The Dalles Reservoir vary as sturgeon abundance changes when strong year class cohorts recruit into the harvestable size slot (Table 11). Harvest guidelines are typically revised at three-year intervals following updated stock assessments. Harvest shares in The Dalles Reservoir are split approximately 70:30 between Tribal and non-tribal fisheries when subsistence harvest is included. Annual exploitation rates have averaged 48% of the 43-54 in (109–137cm) TL sturgeon abundance in The Dalles Reservoir from 1999-2014.

Fisheries in The Dalles Reservoir might be stabilized at consistently higher levels with hatchery supplementation to compensate for periodic natural recruitment failures, however current population densities are relatively high and supplementation benefits might be eroded if they trigger density-related decreases in growth or condition.

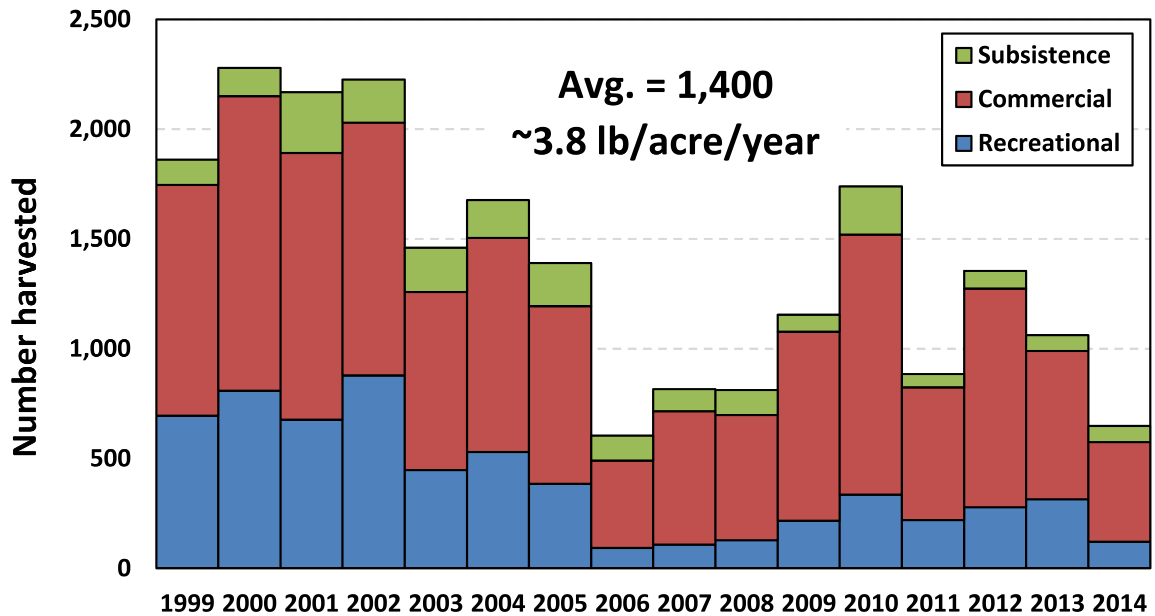

Figure 24. Recent annual sturgeon harvest by fishery in The Dalles Reservoir.

Table 11. Recent annual sturgeon harvest guidelines and numbers in The Dalles Reservoir.

	Abundance	Guideline				Harvest			
Year	(43-54 in FL)[a]	Sport	Comm.	Subsis.	Total	Sport	Comm.	Subsis.	Total
1999		800	1,200	--	2,000	695	1,051	116	1,862
2000		800	1,200	--	2,000	809	1,342	128	2,279
2001		700	1,100	--	1,800	677	1,215	276	2,168
2002	6,000	700	1,100	--	1,800	878	1,152	197	2,227
2003		400	900	--	1,300	447	811	202	1,460
2004		400	900	--	1,300	530	975	172	1,677
2005	1,150	400	900	--	1,300	384	809	196	1,389
2006		100	550	--	650	93	397	115	605
2007		100	550	--	650	108	607	100	815
2008	1,700	100	550	--	650	128	571	113	812
2009		300	1,000	--	1,300	216	862	77	1,155
2010		300	1,000	--	1,300	336	1,184	220	1,740
2011	2,700	300	1,000	--	1,300	220	604	60	884
2012		300	1,000	--	1,300	278	996	81	1,355
2013		300	1,000	--	1,300	314	676	72	1,062
2014	1,900	300	1,000		1,300	121	454	74	649

[a] *Size regulation for sport and commercial fisheries in The Dalles Reservoir.*

3.5.3 John Day Reservoir

John Day Reservoir sturgeon subpopulation is substantially smaller than those of Bonneville and The Dalles, despite John Day's larger size. Natural recruitment is much more sporadic in John Day (Mallette 2014). The morphology of the tailrace of John Day Dam is such that favorable spawning and/or incubation conditions are provided at a relatively low spring flow level of about 280 kcfs or more which occur in just 20% of years (Figure 25).

Abundance varies with recruitment in this reservoir. Numbers of juvenile sturgeon generally increased from 1999 through 2007 following recruitment in the late 1990s (Figure 26). Abundance is projected to decline over the next decade as effects of poor recruitment from 2000-2008 are observed.

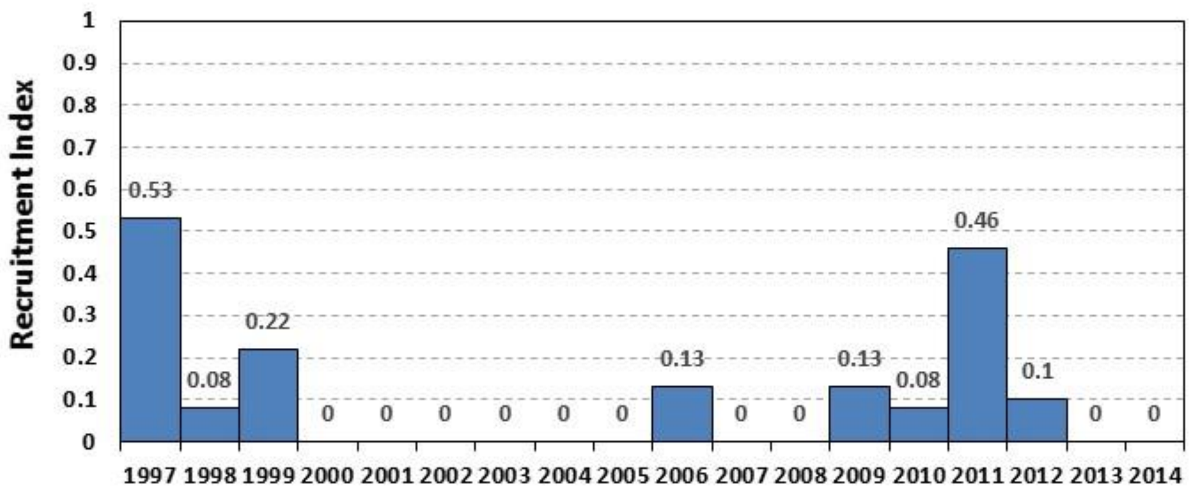

Figure 25. Annual estimates of sturgeon recruitment in John Day Reservoir.

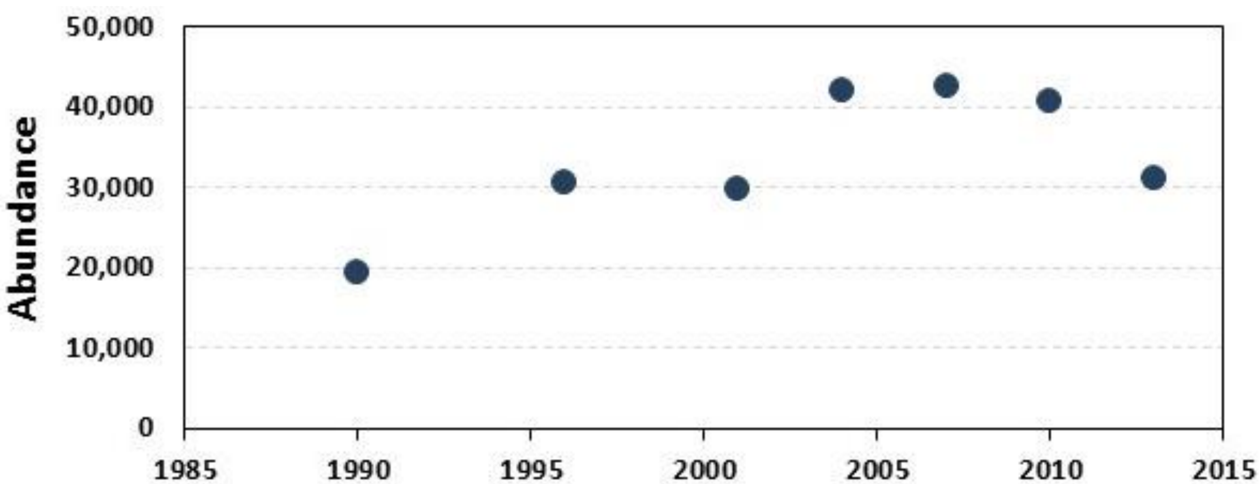

Figure 26. Periodic estimates of sturgeon abundance in John Day Reservoir.

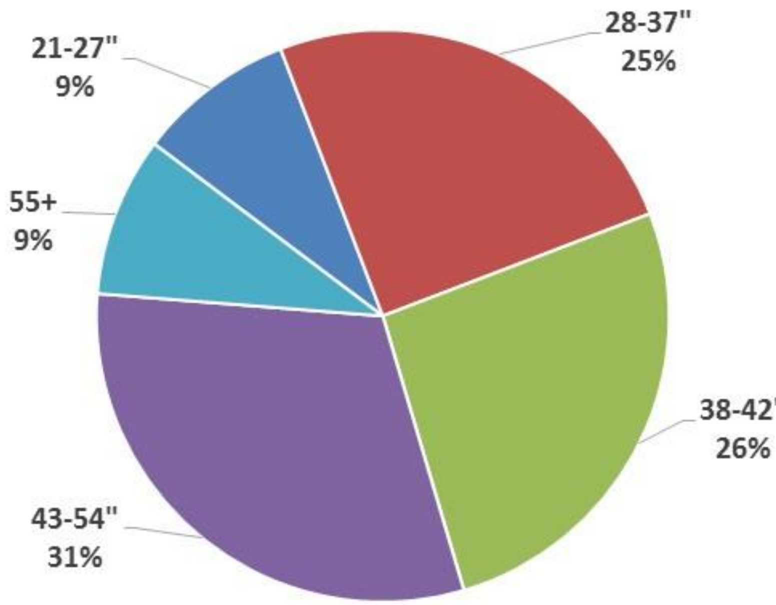

Figure 27. Current (2013) size composition of sturgeon in John Day Reservoir by fork length.

Inconsistent recruitment in John Day produces a subpopulation that is heavily skewed to larger fish than in the more productive Bonneville and The Dalles reservoirs. Juvenile and subadult fish less than 38 in (96 cm) FL comprised just 34% of this sturgeon population by number in 2013 (Figure 27) in comparison with 93% in Bonneville and 76% in The Dalles. Fish in all other size categories were well represented.

Biomass per unit area in John Day is a fraction of Bonneville and The Dalles Reservoirs. Sturgeon growth and condition factor in John Day are above average for the Lower Columbia River basin fish. Annual growth increments are about 2 in/year (5 cm) for fish 15–40 in (38–102 cm) FL and increase progressively up to about 3 in/year (8 cm) by about 55 in (140 cm) FL. Sturgeon typically recruit to the harvestable size range at about 15 years of age in John Reservoir and are vulnerable to the fishery for an average of 5 years.

Fishery guidelines and harvests in John Day Reservoir vary substantially as sturgeon abundance changes when strong year class cohorts recruit into the harvestable size slot (Table 12). Harvest guidelines are typically revised at three-year intervals following updated stock assessments. Harvest shares in John Day Reservoir are split approximately 70:30 between Tribal and non-tribal fisheries when subsistence harvest is included. Annual exploitation rates have averaged 40% of the 43-54 in (109–137 cm) FL sturgeon abundance in John Day Reservoir from 1999-2013.

Fisheries in John Day Reservoir might be stabilized at substantially higher levels with hatchery supplementation to compensate for periodic natural recruitment failures. Current population densities are substantially less than in other reservoirs while growth and condition are optimal. John Day Reservoir will be a primary focus of hatchery supplementation efforts identified in this Master Plan because of the poor recruitment in most years and available habitat.

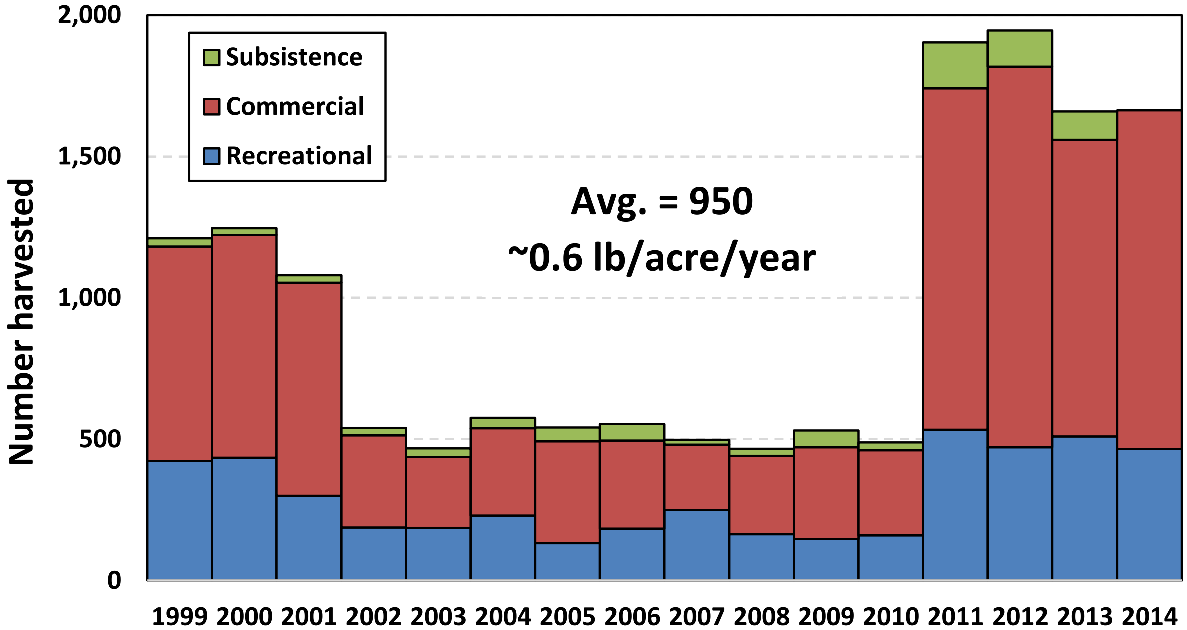

Figure 28. Recent annual sturgeon harvest by fishery in John Day Reservoir.

Table 12. Recent annual sturgeon harvest guidelines and numbers in John Day Reservoir.

	Abundance	Guideline				Harvest			
Year	(38-54 in FL)[a]	Sport	Comm.	Subsis.	Total	Sport	Comm.	Subsis.	Total
1999		560	1,160	--	1,720	422	760	28	1,210
2000		560	1,160	--	1,720	434	788	24	1,246
2001	1,100	560	1,160	--	1,720	299	755	26	1,080
2002		165	335	--	500	187	326	27	540
2003		165	335	--	500	186	251	30	467
2004	1,100	165	335	--	500	229	309	37	575
2005		165	335	--	500	132	360	49	541
2006		165	335	--	500	183	312	58	553
2007	1,600	165	335	--	500	249	232	17	498
2008		165	335	--	500	164	277	25	466
2009		165	335	--	500	146	325	59	530
2010	4,350	165	335	--	500	159	302	28	489
2011		500	1,000	--	1,500	533	1,208	163	1,904
2012		500	1,000	--	1,500	471	1,347	128	1,946
2013	9,600	500	1,000	--	1,500	509	1,050	100	1,659
2014		500	1,000	--	1,500	465	1,198	99	1,762

[a] *Size regulation for sport and commercial fisheries in Bonneville Reservoir since 2009. Regulations were different in previous years but numbers are standardized here for comparative purposes.*

3.5.4 McNary & Hanford Reach

The McNary Reservoir and Hanford Reach supports a relatively small sturgeon population despite its large size and habitat diversity. Abundance was estimated at approximately 8,000 to 9,000 sturgeon in 1995 and 2011 (Mallette 2013). The population currently includes approximately 3,500 hatchery sturgeon which had moved downstream from their original release point in Rock Island Reservoir in 2003 (approximately 17% of the total release of 20,600). Biomass (200 ton, 182,000 kg) and density (8 lb/acre, 4 kg) are the lowest of any population in the lower mid-Columbia management area. Natural recruitment rates are consistently low (Figure 29). All size groups are represented in the population but average individual size is larger than in the other Lower Mid-Columbia River reservoirs (Figure 30). Because sturgeon live so long, populations tend to be dominated by larger, older individuals when recruitment is poor. Similarly, abundance and size composition remain stable and in equilibrium with current levels of recruitment and mortality.

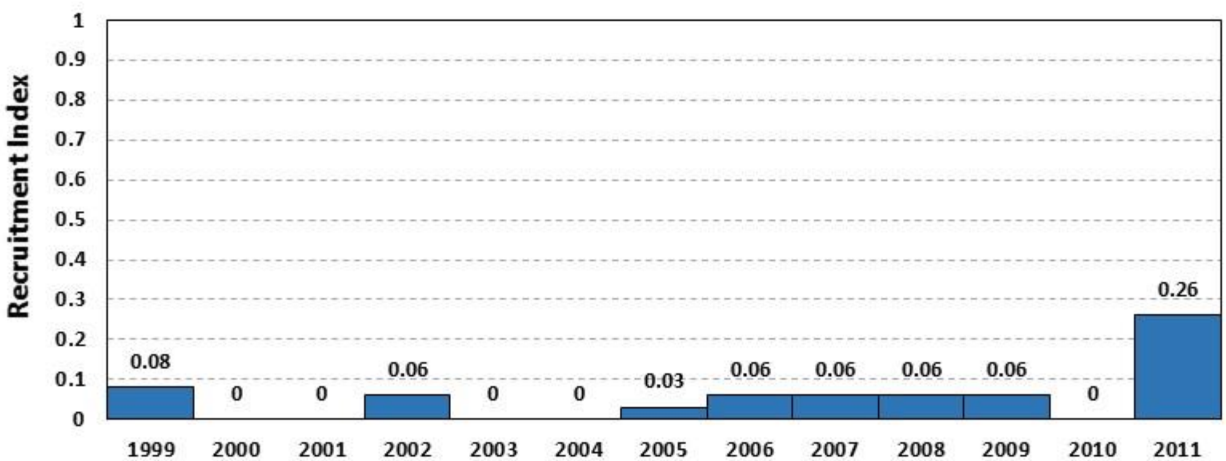

Figure 29. Annual estimates of sturgeon recruitment in McNary Reservoir and Hanford Reach.

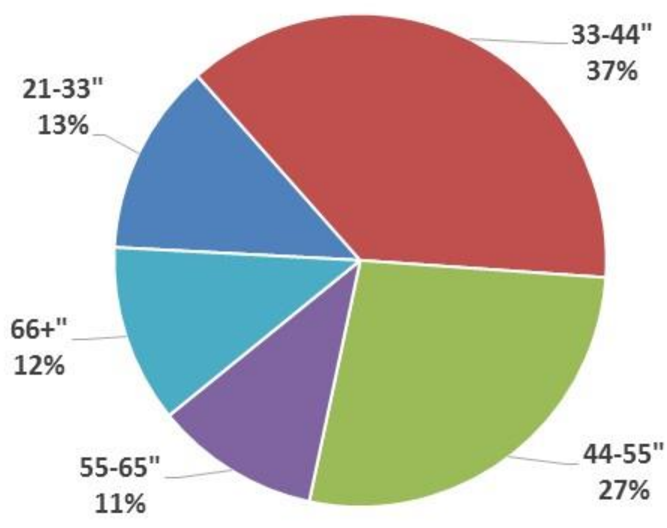

Figure 30. Current (2013) size composition of sturgeon in McNary Reservoir by fork length.

Growth rates and condition factors are comparable in this reach in relation to downstream reservoirs, as might be expected given the low densities in the McNary/Hanford area. Recaptures of hatchery sturgeon that had moved downstream from Rock Island since 2003 averaged about 40 in (102 cm) FL, having grown about 3 in /year (8 cm) since release. Recent assessment data demonstrated that the weight of all fish averaged about 110% (Mallette 2013) compared to fish downstream which was comparable to the 112% reported by DeVore et al. (1995) in fish downstream of Bonneville Dam.

Sturgeon harvest in the McNary/Hanford area is limited to recreational fisheries because treaty fisheries are restricted to Zone 6 between Bonneville and McNary dams. Historically, the fishery was open for retention year round, but the retention season has recently been restricted to February 1 through July 31. Harvest has averaged 280 fish per year from 2002–2011 (range: 140-450). These harvest levels are equivalent to an annual exploitation rate of about 12% of the 43–54 in (109–137 cm) sturgeon abundance (see Section 9.6 Biological Basis of Management). This fishery is likely similar to that of John Day Reservoir where recruitment to the harvestable size range is about 15 years of age and fish are vulnerability to harvest for an average of 5 years.

The McNary Reservoir and Hanford Reach appear to be considerably underseeded by current natural recruitment based on low numbers, low standing crop, high growth rates, and good condition. Sturgeon fisheries for all stakeholders in this area have the potential to benefit significantly from hatchery supplementation although benefits would be limited to the sport fishery since treaty fishing does not currently occur in this area.

3.5.5 Lower Snake River Reservoirs

The three lower Snake River reservoirs, Ice Harbor, Lower Monumental, and Little Goose, support small populations of approximately 4,800, 3,700 and 6,500 sturgeon respectively, based on stock assessments in 1996-1997 (Ward 1998). Standing crop (23 lb/acre, 10 kg) was substantially less than in Bonneville and The Dalles reservoirs but greater than in John Day and McNary/Hanford. Natural recruitment is generally poor and occurs infrequently. Young-of-the-year sturgeon were observed in only one of eight years in Ice Harbor and two of eight years in Little Goose between 1997-2005 when index sampling occurred. Recruitment problems are characterized by the relative lack of juvenile fish and a skewed age structure with proportionally more, older individuals (Figure 31).

Stock assessments in 2012 found substantially lower catch per unit effort in setline samples for Lower Monumental and Little Goose reservoirs compared to 1997. The size distribution of fish observed in 2012 was comprised of a higher proportion of larger fish than observed in 1997. These trends are indicative of recruitment-limited conditions and fishery impacts that may exceed sustainable levels.

Sturgeon growth rates and condition factors in these reservoirs are comparable to those of other low-density subpopulations. Annual growth increments average 2 – 3 in/year (5–8 cm) for up to 40 in (102 cm) FL. Relative weight of all fish averaged about 102% - 103% compared to the average for sturgeon in the Lower Mid-Columbia reservoirs.

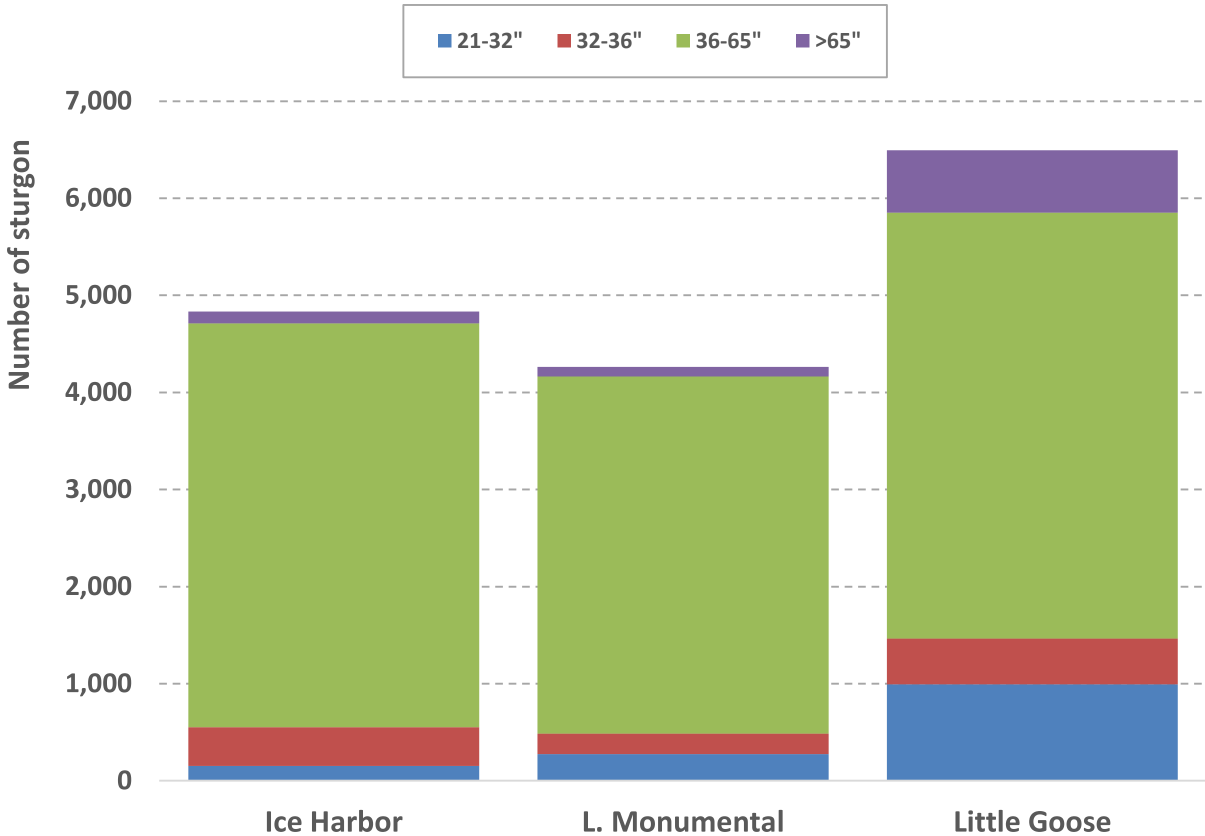

Figure 31. Abundance of sturgeon by size category in lower Snake River reservoirs, 1996-1997.

Sturgeon harvest in the lower Snake River is limited to recreational fisheries as treaty fisheries are restricted to Zone 6 between Bonneville and McNary dams. Small retention fisheries occurred for 43–54 in (109–137cm) FL sturgeon with annual harvest averaging about 280 fish per year from 2002-2011 (range: 150-480). These harvest levels were equivalent to an annual exploitation rate of about 5% of the 43-54 in (109–137cm) FL sturgeon abundance. WDFW permanently closed the Snake River upstream from Ice Harbor Dam to sturgeon retention effective July 1, 2015.

The Lower Snake reservoirs appear to be considerably underseeded by current natural recruitment based on low numbers, low standing crop, high growth rates, and good condition. Sturgeon fisheries in this area have the potential to benefit significantly from hatchery supplementation although benefits would be limited to the sport fishery since treaty fishing does not currently occur in this area.

3.6 GENETIC STOCK STRUCTURE

Genetics are an important consideration in defining appropriate sturgeon management units to address specific sturgeon issues in different portions of the basin. Genetic population structure can also have important management implications, particularly for hatchery or relocation activities (e.g., broodstock selection, effective population sizes and mating protocols).

White Sturgeon genetic studies have consistently documented small genetic differences in the Columbia Basin with diversity decreasing with distance upstream (Bartley et al. 1985; Brannon et al. 1987; Brown et al. 1992; Setter & Brannon 1992; McKay et al. 2002; Anders & Powell 2002; Rodzen et al. 2004; Drauch Schreier et al. 2011, 2012, 2013; Matala 2013, 2014, 2015). This weak genetic differentiation among sturgeon samples from the lower, middle, and upper Columbia River is consistent with the lack of historically significant migration barriers to sturgeon in the Columbia River between the ocean and Canada, and the wide-ranging life history pattern of this species. Small genetic differences between lower Columbia, mid-Columbia, and upper Columbia samples did not represent enough genetic distance to base a strong argument for consideration as separate stocks (e. g. Figure 32). It is also unclear whether the current genetic composition is representative of the historical type or if it has been unintentionally altered by overexploitation and population fragmentation.

Matala (2013, 2015) concluded that the majority of the evidence points to kinship as the overarching influence on observed genetic variation that has been revealed to-date among the lower Columbia River and four Mid-Columbia impoundments. He also noted that divergence among fragmented sturgeon populations in the Columbia River may be associated with diminished rearing and/or spawning habitat caused by passage and movement issues. While current genetic data indicates no significantly distinct stocks among the Mid-Columbia impoundments, limited gene flow may occur predominantly in a downstream direction (Matala 2013, 2014, 2015). It will be important to discern the difference between truly discrete population segments (warranting conservation) and genetic structure characterizations resulting from demographic constrictions (warranting supplementation).

Participants in a 2010 Lower Columbia and Snake River Sturgeon Workshop delineated genetic management units (GMUs) for White Sturgeon in the Columbia River basin based on their expert opinion and the available information on genetic population structure (Beamesderfer et al. 2011). Genetic management units were defined as areas of similar genetic characteristics that may warrant some consideration in implementation of sturgeon conservation and management measures. Workshop discussions highlighted the difficulty of attempting to delineate distinct units where the genetic diversity declines from the river mouth to headwaters. Five genetic management units were identified consistent with recommendations of the workshop participants (Figure 33). Boundaries of the mid-Columbia unit were drawn overlapping adjacent units to reflect the observed gradation in genetic characteristics from area to area. Nonetheless, with the possible exceptions of these overlapping GMU boundary areas, genetic signatures of White Sturgeon were more similar within than between GMUs.

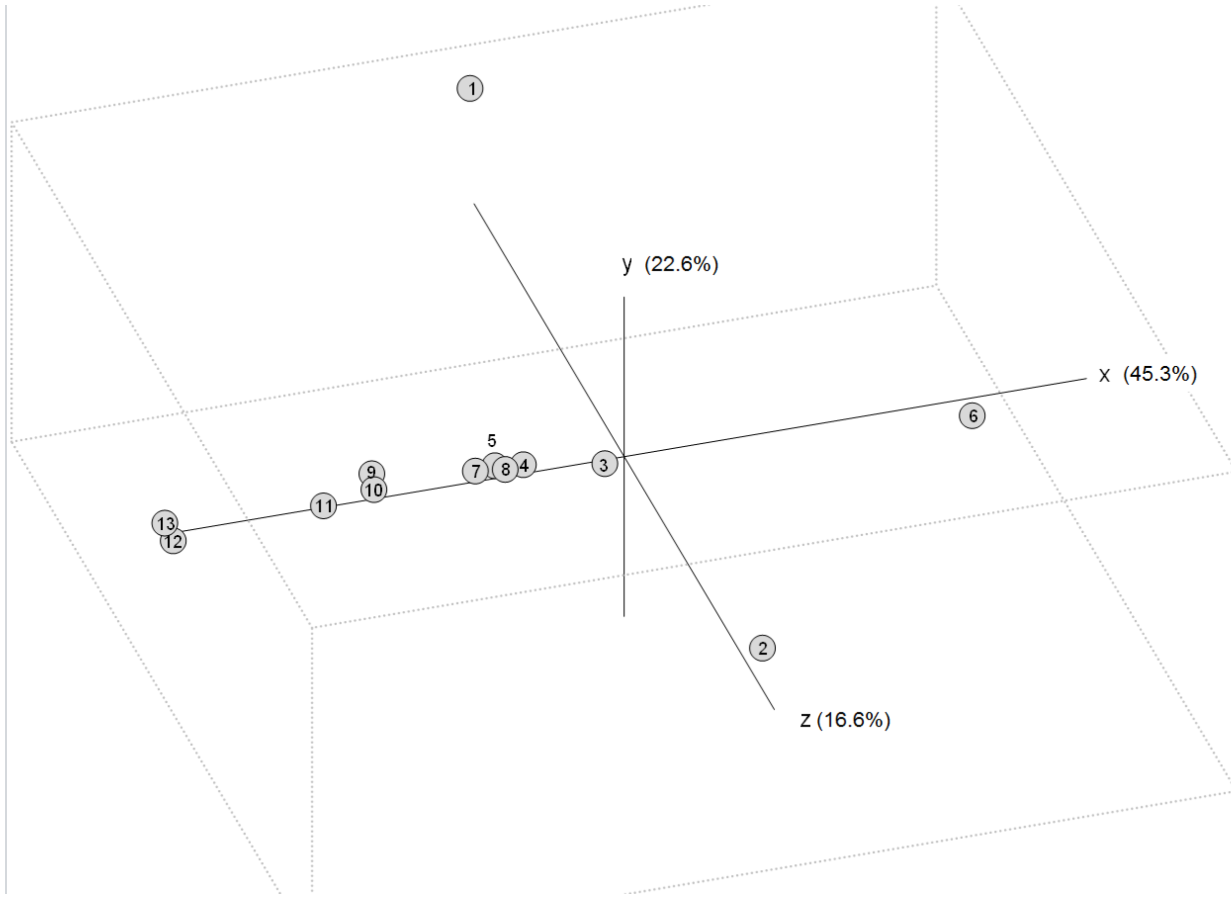

Figure 32. Principal Coordinates Analysis (PCA) plot. Clustering results identify group distinctions among impoundment collections, Snake River collections and outlier/reference collections. Total variation explained by the first three axes is 84.5%. Groups are defined as: 1 – Yakama Hatchery Broodstock, 2 – Abernathy Fish Technology Center Hatchery Broodstock, 3 – LCR (below Bonneville Dam), 4 – Bonneville, 5 – The Dalles, 6 – John Day 2010, 7 – John Day years combined, 8 –McNary, 9 – Lower Monumental, 10 – Little Goose, 11 – Lower Granite Dam to Hells Canyon Dam, 12 – Bliss, and 13 – Blind Canyon Aqua-Ranch. (Figure 6 in Matala 2013).

All sturgeon subpopulations in the lower-mid Columbia and lower Snake River management areas addressed by this hatchery master plan occur in the mid-Columbia genetic management unit. The mid-Columbia GMU overlaps with the lower Columbia GMU in the area of the Bonneville, The Dalles and John Day reservoirs.

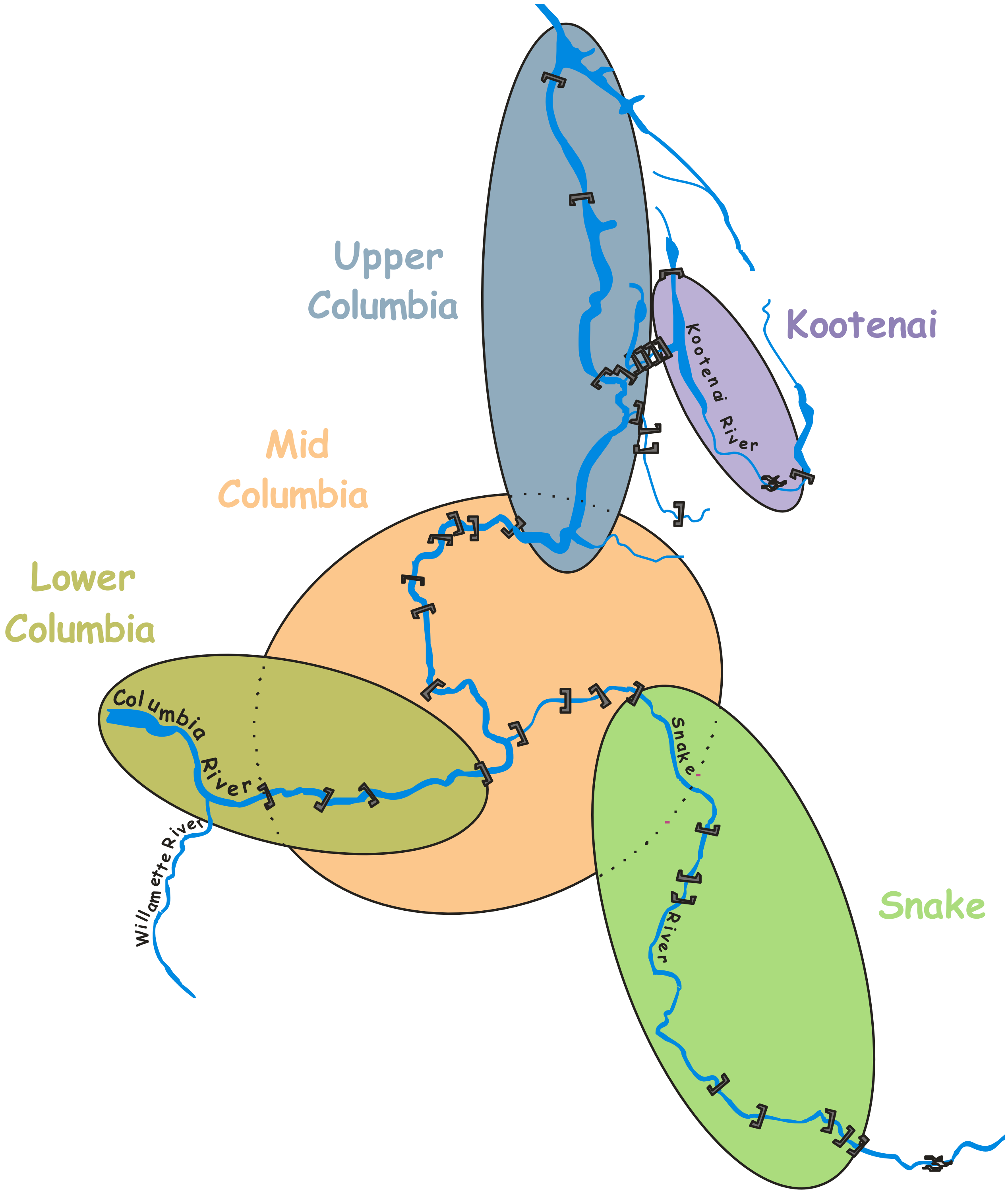

Figure 33. The five Columbia Basin White Sturgeon Genetic Management Units (GMUs).

4 PROGRAMMATIC GUIDANCE

A number of related regional planning efforts provide guidance that direct or influence management and mitigation activities for lower mid-Columbia and lower Snake White Sturgeon.

4.1 NORTHWEST POWER & CONSERVATION COUNCIL

4.1.1 Hatchery Master Planning Three-Step Process

The Northwest Power and Conservation Council (Council) follows a three-step review process to evaluate projects requesting funding for implementation. The step review process helps the Council fulfill direction under the Northwest Power Act of 1980, which charged the Council to develop a program to protect, mitigate and enhance fish and wildlife that have been affected by the development of hydropower dams in the Columbia River Basin. The Council's funding recommendations to the Bonneville Power Administration (BPA) are based on the Fish and Wildlife Program.

The Council's three-step review process links environmental reviews and funding to specific phases of project development and planning. It includes a thorough review by the Independent Scientific Review Panel (ISRP) and the Council at three phases: master or conceptual planning, preliminary design, and final design. A project does not move forward from one step to the next step without favorable review.

- Step 1 examines a master, or conceptual, project plan. This is the preliminary, or feasibility stage and identifies all major components and elements. It also shows the initial layout of components at the proposed site and/or within the proposed plan. Conceptual designs and associated cost estimates are expected to have a variance of plus or minus 35 to 50%. The concept of the proposed project is described in a master plan (this document), which is submitted to the NPCC for review and approval.
- Step 2 evaluates a refined proposed project design. A proposal is also submitted for environmental review under the National Environmental Policy Act (NEPA), usually as an environmental impact statement or environmental assessment. Step 2 is the "progress review phase" when any major difficulties in the design and program are identified. Review at this step helps assure that the project is economically viable, financially responsible and meets the intent and scope of the previous decision. Expected variance in cost estimates from Step 2 design to final design is plus or minus 25 to 35%. At this stage, any changes to the proposed project between Steps 2 and 3 should be minor. NPCC approval at this phase allows the project proponent to proceed with Step 3.
- Step 3 reviews a detailed, final project design. Final designs are provided for all facilities, with an expected variance of plus or minus 10 to 15%. The developed cost assumptions represent the best available estimate of construction costs for the project. The NEPA review is finalized in this stage. Program, research, and monitoring and evaluation costs are also presented as final estimates.

This Master Plan is CRITFC's Step 1 submittal describing the artificial propagation facilities necessary to implement a White Sturgeon Mitigation Hatchery Program for White Sturgeon in the lower mid-Columba and lower Snake Rivers.

4.1.2 Fish & Wildlife Program

Sturgeon Guidance

Every NPPC Fish and Wildlife Program since 1984 has recognized the need to address impacts of development and operation of the hydroelectric power system on sturgeon (NPPC 1984, 1987, 2000; NPCC 2009, 2014).

The 2009 Fish and Wildlife Program included White Sturgeon in its resident fish section with the following objective:

> *Enhance the abundance and productivity of White Sturgeon in the mainstem in order to rebuild and sustain naturally produced populations of sturgeon and sustain an annual harvest of sturgeon. Operate the hydropower system to maximize spawning and rearing success of White Sturgeon in reservoirs, while operating in concert with the needs of salmonids.*

Specific strategies included evaluations of effects and mortality of dam passage and removable spillway weirs, the importance of connectivity among populations, population isolation effects and evaluation of the feasibility of mitigation.

The May 2014 draft of the Fish and Wildlife Program identifies a specific strategy for sturgeon:

> *Implement actions that result in increased abundance and survival for Columbia River Basin Green and White Sturgeon, including habitat actions, dam operations and passage, hatchery considerations, monitoring populations, and research to improve understanding of how the development and operation of the Federal Columbia River Power System affect survival and growth of sturgeon.*

Principles direct that a viable Columbia River Basin sturgeon mitigation program should include a combination of monitoring, research, habitat actions, dam operations and passage, adaptive management, natural production, potential use of hatcheries, collaboration, coordination, and evaluation. Specific measures also address use of sturgeon hatcheries:

> *Consider hatcheries for sturgeon as a mitigation strategy to supplement populations where natural recruitment is currently severely limited. If and when the strategy is contemplated, and through the Council's Step-review process for hatchery proposals, this strategy shall:*
>
> - *Be conservative and responsible in establishing protocols for source populations and numbers of hatchery fish released;*
> - *Build on knowledge gained from ongoing hatchery efforts in other areas;*
> - *Utilize experimental hatchery releases and monitoring to assess ecological factors and population productivity limitations; and*

- *Optimize hatchery production and practices consistent with monitoring natural production and environmental carrying capacity, which will most effectively be identified using an experimentally adaptive approach.*

Fish & Wildlife Program Scientific Principles

The 2014 Fish and Wildlife Program identifies six guiding scientific principles which must be addressed by any hatchery project. These include:

1. Healthy ecosystems sustain abundant, productive, and diverse plants and animals distributed over a wide area
2. Biological diversity allows ecosystems to adapt to environmental changes
3. Ecosystem conditions affect the well-being of all species including humans
4. Cultural and biological diversity is the key to surviving changes
5. Ecosystem management should be adaptive and experimental
6. Ecosystem management can only succeed by considering people

The relationship and consistencies of the proposed sturgeon hatchery program to the scientific principles is detailed in Section 5.7 on page 141.

Fish & Wildlife Program Strategies

The 2014 Fish and Wildlife Program identifies a series of strategies for achieving basin wide goals and objectives. Relationships to these strategies must be addressed by the hatchery plan. Strategies include:

A. Ecosystem Function: Protect and restore natural ecosystem functions, habitats, and biological diversity wherever feasible consistent with biological objectives in the program.

    1. *Habitat*: Protect, enhance, restore and connect aquatic and terrestrial habitat. Protecting existing quality habitat is as important as enhancing degraded habitats.
    2. *Strongholds*: Acknowledge and encourage efforts to designate and conserve stronghold habitats and their populations of native, wild, and naturally spawning fish, as well as areas managed for wild fish.
    3. *Non-native & invasive species*: Prevent the introduction of non-native and invasive species in the Columbia River Basin, and suppress or eradicate non-native and invasive species.
    4. *Predator control*: Improve the survival of salmon and steelhead and other native focal fish species by managing and controlling predation rates.
    5. *Protected areas and hydroelectric development and licensing*: Protect fish and wildlife from the adverse effects of future hydroelectric project construction and operations.

6. *Water Quality*: The Council supports providing flows and habitat conditions of adequate quality and quantity for improved survival of anadromous and native resident fish populations at and between hydroelectric facilities on the mainstem Columbia/Snake Rivers, as well as improving water quality in basin tributaries, to promote healthy and productive populations of anadromous and native resident fish and wildlife.

7. *Climate change*: Better understand how the effects of climate change may impact fish and wildlife populations and mitigation and restoration efforts implemented under the program in the Columbia River Basin. Evaluate fish and wildlife investments and their ability to perform in the face of future climate conditions.

8. *Mainstem hydrosystem flow and passage operations*: Manage dams and reservoir operations to protect and restore ecosystem function and habitat, and to improve fish passage and survival through the hydrosystem. Analyze the power system effects of operations for fish, and recommend adaptations to the power system so that these operations may be delivered in a reliable manner while the region continues to have an adequate, economic and reliable power supply.

9. *Estuary*: Restore ecosystem function to protect and enhance critical habitat and spawning and rearing grounds in the estuary and lower Columbia River.

10. *Plume and nearshore ocean*: The Council supports monitoring of ocean conditions and related salmon survival and endorses mitigation and management actions that improve the survival, growth, and viability of Columbia River fish in varying ocean conditions.

11. *Wildlife Mitigation*: Mitigate wildlife losses caused by the development and operation of hydropower dams in the Columbia River Basin.

B. Hatcheries: The Council supports using hatcheries as a tool to help meet the mitigation requirements of the Northwest Power Act. The Council also acknowledges the commitments made by federal, state, and tribal governments in other laws, and in on-going court cases, including U.S. v Oregon.

1. *Segregated hatchery programs*: The purpose of the segregated approach is to produce fish for harvest with a hatchery population that is genetically distinct from the local naturally spawning population.

2. *Integrated hatchery programs*: The purpose of an integrated production approach is to contribute harvest opportunities while complementing habitat improvements by providing a demographic boost for native populations well within the sustainable carrying capacity of the habitat.

3. *Reintroduction*: The purpose of hatchery production for reintroduction is to return lost salmon and steelhead into blocked areas or re-establish a population in watersheds where remnant populations at high risk of extirpation barely persist or where populations have been extirpated.

C. Other Strategies

1. *Wild fish*: Wild fish provide important opportunities to rebuild and reintroduce populations. If properly protected, they may be able to provide harvest opportunities. The Council recognizes that hatcheries are a primary tool for mitigating the hydro system's impact on wild fish. However, native, wild or naturally spawning fish and the ecosystems they rely on must be protected, mitigated and enhanced as they constitute an important, genetically diverse, biological resource for the Basin.
2. *Anadromous fish mitigation in blocked areas*: Mitigate through implementation of a variety of actions that may include passage investigation, reintroduction of anadromous fish, habitat improvements, and harvest opportunities for the loss of salmon and in blocked areas of the Columbia Basin that historically had runs of anadromous fish.
3. *Resident fish mitigation*: For resident fish and other aquatic species impacted by the hydrosystem, protect and mitigate freshwater and associated terrestrial habitat, and native fish populations.
4. *Sturgeon*: See Section 4.1.3
5. *Lamprey*: Implement actions that result in increased abundance and survival for lamprey eels, including habitat actions, dam operations and passage, monitoring populations, and research to improve understanding of how the development and operation of the Federal Columbia River Power System affect migration success, survival and growth of lamprey.
6. *Eulachon*. Increase understanding, protection and required restoration of eulachon for the Basin, estuary and ocean ecosystems. Better understand how the development and operation of the Federal Columbia River Power System affects eulachon spawning, egg, and larvae survival and migration patterns.

D. *Adaptive Management*: The Council is committed to an adaptive management approach that uses research and monitoring data to understand, at multiple scales, how program projects and measures are performing, and to assess the status of focal species and their habitat.

E. *Public Engagement*: On an ongoing basis, the Council will educate and involve Northwest citizens to develop, implement, and improve understanding of the fish and wildlife program and the Council, and to promote successful ecosystem management.

Artificial Production Policies

In 2000, the NPCC formulated ten policies governing the use of artificial propagation in the Columbia Basin. Relationships to these policies must be addressed by the hatchery plan. Policies incorporated guidance from a comprehensive review of hatchery production throughout the basin (ISRP 1999) and included:

1. The manner of use and the value of artificial production must be considered in the context of the environment in which it is used.
2. Artificial production must be implemented within an experimental, adaptive management design that includes an aggressive program to evaluate benefits and address scientific uncertainties.
3. Hatcheries must be operated in a manner that recognizes that they exist within ecological systems whose behavior is constrained by larger-scale basin, regional and global factors.
4. A diversity of life history types and species needs to be maintained in order to sustain a system of populations in the face of environmental variation.
5. Naturally selected populations should provide the model for successful artificially reared populations, in regard to population structure, mating protocol, behavior, growth, morphology, nutrient cycling, and other biological characteristics.
6. The entities authorizing or managing an artificial production facility or program should explicitly identify whether the artificial propagation product is intended for the purpose of augmentation, mitigation, restoration, preservation, research, or some combination of those purposes for each population of fish addressed.
7. Decisions on the use of the artificial production tool need to be made in the context of deciding on fish and wildlife goals, objectives and strategies at the subbasin and province levels.
8. Appropriate risk management needs to be maintained in using the tool of artificial propagation.
9. Production for harvest is a legitimate management objective of artificial production, but to minimize adverse impacts on natural populations associated with harvest management of artificially produced populations, harvest rates and practices must be dictated by the requirements to sustain naturally spawning populations.
10. Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement must be fully addressed.

Specific principles are identified in the 2014 Program regarding integrated hatchery programs like this sturgeon plan:

- Integrated populations should match and maintain the genetics, behavior, and life history types of the populations they are trying to increase or maintain
- In a properly integrated population, habitat and natural influences drive the fitness of the composite population. For the primary populations targeted in an integrated program, the Hatchery Scientific Review Group (HSRG) recommended achieving and maintaining a proportion natural influence (PNI) value of 0.67 or greater.

- Fish production -- species, major population group, and population scales -- should be well within the carrying capacity of the habitat that is intended to support increasing numbers of naturally spawning populations
- Adverse ecological interactions such as density dependence, straying, predation, and disease, must be minimized
- Fish produced as part of an integrated program must be visibly marked.
- Preservation/conservation/safety-net programs involving the use of techniques such as captive propagation should be reserved for those situations in which, the population will be extirpated and the genetic resource lost. A preservation action should be a short, temporary emergency measure, accompanied by an explicit recovery plan with a compressed timeframe for return of the fish to the wild and an effective plan for dealing with the underlying habitat or management problems.
- Fish produced in integrated hatcheries should become naturally self-sustaining when good quality habitat is available

4.1.3 Subbasin Plans

The Fish and Wildlife Program adopted subbasin plans in 2004-05 and 2010-11 which provide more specific direction for each of 59 areas within the basin. Three subbasin plans address the area affected by this hatchery master plan: Columbia Gorge Mainstem Subbasin Plan, Lower Middle Columbia Mainstem Subbasin Plan, and the Lower Snake Subbasin Plan.

Columbia Gorge Mainstem Subbasin Plan. White Sturgeon are a focal species for this subbasin which includes the mainstem Columbia River between Bonneville and The Dalles Dams. Objectives include maintaining sustainable levels of production and consumptive harvest of sturgeon. Plan strategies include considering transplants into Bonneville Reservoir or hatchery supplementation if prolonged recruitment failures pose risks to White Sturgeon productivity in Bonneville Reservoir.

Lower Middle Columbia Mainstem Subbasin Plan. White Sturgeon are a focal species for this subbasin which covers the mainstem Columbia from The Dalles Dam (RM 192) to the mouth of the Walla Walla River (RM 315) including The Dalles, John Day and McNary Dams. Plan objectives call for increasing abundance of White Sturgeon. Corresponding strategies include continuing to develop hatchery technology and methodologies, and considering use hatchery fish to supplement populations including McNary, The Dalles and John Day populations.

Lower Snake Subbasin Plan. This subbasin includes the mainstem Snake River from its confluence with the Columbia River in the southeastern corner of Washington State to Lower Granite Dam in Idaho. Four dams impound the mainstem Snake River in this river reach: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. The Lower Snake Subbasin Plan designates White Sturgeon as an aquatic “species of interest” but not enough information was available to support its selection as focal species. The plan referenced a sustainable harvest goal of 5 kg/ha/year (27

lb/acre) for Snake River sturgeon identified in the 1987 subbasin plan (CBFWA 1997). Specific measures for achieving this goal were not identified for sturgeon in the current subbasin plan.

4.1.4 Columbia Basin Fish Accords

In 2007-2008, BPA and other agencies of the federal government also agreed to implementation commitments built on the broader planning foundation established by the NPCC. These commitments funded an extensive set of actions over the next 10 years to benefit listed and unlisted anadromous fish, resident fish, and wildlife across the Columbia River Basin. These included mainstem, estuary and tributary habitat, production, harvest, and monitoring actions. The agencies committed to these actions as part of the consultation resulting in the 2008 Biological Opinion for the Federal Columbia River Power System (FCRPS BiOp), and in the Columbia Basin Fish Accords (Accords) executed with several Indian Tribes and states. This Hatchery Master Plan was included in projects funded under these accords.

4.1.5 Sturgeon Framework

Current status, limiting factors, and conservation, restoration, and mitigation efforts are detailed for White Sturgeon throughout the Columbia Basin in a Planning Framework prepared at the direction of the Northwest Power and Conservation Council upon the recommendation of the ISRP (Beamesderfer & Anders 2013). This document was prepared by participants in Council-funded sturgeon projects with input from a series of regional workshops from 2009-2013 (Beamesderfer & Squier 2010, 2013; Beamesderfer et al. 2011, 2012).

The framework identified a series of findings and recommendations which provide guidance for sturgeon programs and projects throughout the region.

The following 20 to 50 year vision was identified for White Sturgeon in the Columbia Basin:

> *Abundant and diverse White Sturgeon populations and optimum sustainable fisheries throughout the historical range, achieved by a combination of natural production and careful supplementation, and supported through an adaptive, collaborative, coordinated, science-based mitigation, management, monitoring, and evaluation program.*

Three goals identified during the White Sturgeon workshops define further direction to help attain the shared regional vision.

1. Viable, persistent populations throughout their historical range, where feasible.
2. Significant, stable and sustainable fisheries and harvest.
3. Diverse, functional ecosystem supporting essential habitat, conditions, and resources

With regard to hatcheries, the framework suggests that careful use of sturgeon hatcheries has the potential to help perpetuate declining wild subpopulations and mitigate for lost natural production in many impounded areas but aquaculture should be regarded as a stop-gap or interim strategy while other alternatives continue to be explored.

4.2 COLUMBIA RIVER TREATY TRIBES

The project directly addresses objectives identified in Wy-Kan-Ush-Mi Wa-Kish-Wit (The Spirit of the Salmon), the Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs and Yakama Tribes. This plan provides a framework to restore Columbia River salmon, sturgeon, and lamprey (CRITFC 1995, 2014). The goals of this adaptive management plan are to: 1) restore anadromous fishes to the rivers and streams that support the historical cultural and economic practices of the tribes (generally areas above Bonneville Dam), 2) emphasize strategies that rely on natural production and healthy river systems to achieve this goal, 3) protect tribal sovereignty and treaty rights, and 4) reclaim the anadromous fish resource and the environment on which it depends for future generations. Specific to sturgeon, the plan contains two objectives: 1) within 7 years, halt the declining trend of sturgeon populations above Bonneville Dam and 2) within 25 years, increase sturgeon populations to naturally sustainable levels that also support tribal harvest opportunities.

4.3 STATE OF OREGON

The Oregon Department of Fish and Wildlife (ODFW) has identified White Sturgeon as a conservation priority based on their ecological, economical, and social importance. The species is not formally designated as sensitive on the state list but has been identified as a “data gap” species. In 2011, ODFW released a conservation plan for the lower Columbia River sturgeon population (ODFW 2011b). Oregon is currently engaged in a State Conservation planning effort for impounded sturgeon populations from Bonneville Dam upstream to the Washington border in McNary Reservoir.

Oregon has formally adopted a fish hatchery management policy by administrative rule (635-007-0542) to provide general fish culture and facility guidelines and measures to maintain genetic resources of native fish populations spawned or reared in captivity (ODFW 2010). This policy directs that hatchery programs shall be managed to provide optimum fishery and conservation benefits while removing any random mortality effects as possible without having any other influence on the natural life or experience of native fish and their habitats.

ODFW shares responsibility for managing White Sturgeon populations in the first three impoundments upstream of Bonneville Dam (the Zone 6 fishing area) with Washington and the Columbia River Treaty Tribes through the U.S. v. Oregon Management Agreement.

4.4 STATE OF WASHINGTON

The Washington Department of Fish and Wildlife (WDFW) manages White Sturgeon as a species on its Priority Habitats and Species List. WDFW included white surgeon on this list after finding that the status of the species meets two criteria. The species is 1) a vulnerable aggregation susceptible to significant population declines within a specific area; and 2) it contains populations of recreational or commercial importance, and used for tribal ceremonial and subsistence purposes, whose biological or ecological characteristics make them vulnerable to decline in

Washington or that are dependent on habitats that are highly vulnerable or are in limited availability.

WDFW's Fish and Wildlife Commission has proposed a policy for hatchery and fishery reform. This policy was developed for salmon and steelhead but might also inform consideration of sturgeon hatcheries. This policy generally directs that WDFG shall promote conservation and recovery, and provide fishery-related benefits by establishing clear goals for each hatchery, conducting scientifically-defensible operations, and using informed decision-making to improve management. Guidelines direct WDFW to work with the tribes in implementing hatchery reform and selective fisheries including acting in a manner that is consistent with *U.S. v. Washington* and *U. S. v. Oregon*.

WDFW shares responsibility for managing White Sturgeon populations in the first three impoundments upstream of Bonneville Dam (the Zone 6 fishing area) with Oregon and the Columbia River Treaty Tribes through the U.S. v. Oregon Management Agreement.

4.5 U.S. v Oregon/ Columbia River Fish Management Plan

Four Columbia River Tribes (Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, and Confederated Tribes and Bands of the Yakama Nation) entered into treaties with the federal government in 1855. These treaties reserved and "secured" their timeless right to harvest salmon for economic, cultural, and subsistence purposes at "usual and accustomed" fishing grounds of the Columbia River and its tributaries. These rights were upheld in the landmark case *United States v. Oregon*, and subsequently, these four tribes gained a co-management role through the Columbia River Fishery Management Plan (CRFMP).

The purpose of the CRFMP is to provide a framework within which the U.S. v Oregon Parties may exercise their sovereign powers in a coordinated and systematic manner in order to protect, rebuild, and enhance upper Columbia River fish runs while providing harvests for both treaty Indian and non-Indian fisheries. Specific to sturgeon, "the intent of the Parties is to manage sturgeon populations in the Zone 6 fishing area to provide long term sustainable harvest opportunities for Indian and non-treaty fisheries. Parties commit to continue ongoing studies to estimate present and optimum population levels, life history characteristics, recruitment, and spawning potential." With respect to sturgeon fisheries management, "the Parties commit to pursuing enhancement activities, along with the necessary funding, for sturgeon populations in the Zone 6 fishing area. Activities considered will include, but not be limited to: artificial propagation, transplantation from other areas, and flow augmentation."

Oregon, Washington, and the Columbia River Treaty Tribes established a joint Sturgeon Management Task Force (SMTF) in 1986 for coordination of Columbia River Fishery Management Plan activities related to sturgeon. The SMTF meets regularly to review sturgeon management issues and establish harvest guidelines for the upcoming year. Estimates of encounters in non-retention recreational activities are also considered. In 2014, the U.S. v Oregon sturgeon

management task force identified the following guidelines regarding the appropriate use of sturgeon hatcheries:

I. The parties support use of hatchery production of sturgeon where it can be effectively used to increase sturgeon numbers and harvest by supplementing poor or inconsistent natural recruitment upstream from Bonneville Dam.

II. Hatchery production of sturgeon is intended to augment rather than replace natural production. Artificial supplementation will be conducted in a manner which ensures protection and conservation of natural populations and production, subject to guidelines identified below.

III. The parties will continue to pursue other alternatives for mitigation and restoration of naturally-produced sturgeon populations including flow management, habitat restoration, and passage, where appropriate. Hatchery production of sturgeon is regarded as an interim mitigation measure until such time as other alternatives are effectively implemented.

IV. FCRPS mitigation responsibilities will be met by a combination of fishery optimization based on monitoring and assessment, hatchery supplementation, and other flow, habitat and/or passage measures as identified by research and evaluation.

V. The parties will evaluate the need for and level of future artificial supplementation based on status of the natural populations. The parties will utilize FCRPS mitigation to continue assessments of natural production and the contribution of hatchery supplementation. The parties will schedule five-year comprehensive reviews of the artificial production strategies for each impounded population upstream of Bonneville Dam.

4.6 U. S. ENDANGERED SPECIES ACT

Kootenai White Sturgeon is listed as endangered under the U. S. Endangered Species Act. Other White Sturgeon in the U.S. portion of the Columbia River and the Snake River are not federally listed. Columbia basin salmon, steelhead and eulachon are listed under the ESA and development of a sturgeon hatchery program will consider any potential impact on these species in a formal consultation under the NEPA process conducted under Step II of the NPCC Master Planning Process.

4.7 HATCHERY SCIENTIFIC REVIEW GROUP

The HSRG is an independent scientific review panel convened to review state, tribal and federal hatchery programs in the Pacific Northwest (HSRG 2004, 2009, 2014). The group was initially established by appropriation of the US Congress to the US Fish and Wildlife Service in 2000 to consider hatchery reform of Puget Sound and Coastal Washington salmon and steelhead hatcheries. In 2005, this effort was extended to the Columbia River Basin. A scientific framework of principles, conclusions and criteria have been established by the HSRG for evaluation of effects

of hatcheries on conservation and recovery of indigenous naturally-spawning salmon and steelhead populations. This framework has been widely incorporated into hatchery-related plans and policies by the NPCC, and Federal and State agencies. For instance, the Washington Department of Fish and Wildlife (WDFW) adopted the HSRG principles in its Hatchery and Fishery Reform Policy (WDFW Commission Policy C-3619), which was approved in November 2009.[7] While not specifically concerned with sturgeon, this framework can inform sturgeon hatchery program efforts.

4.8 BONNEVILLE POWER ADMINISTRATION – RELATED PROJECTS

The sturgeon hatchery project is being implemented as a complementary element of a comprehensive program for conservation, restoration, mitigation and management of lower Columbia White Sturgeon (Figure 34).

4.8.1 Evaluate Sturgeon Populations in the L. Columbia River - Project 1986-050-000

In 1986, BPA funded a study to address research needs regarding the status and habitat requirements of White Sturgeon populations in the Columbia River downstream from McNary Dam BPA (Project 1986-50). The study was conducted cooperatively by the Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, U. S. Fish and Wildlife Service, and National Marine Fisheries Service.

Phase I of this project focused on assessment of stock status and habitat limiting factors was completed in 1993 (Beamesderfer & Nigro 1993a, 1993b). This work:

1. Developed effective sampling and assessment methods (Beamesderfer 1993, Elliott & Beamesderfer 1990, McCabe & Beckman 1990, Rien & Beamesderfer 1994, Rien et al. 1994);
2. Investigated basic biology (McCabe et al. 1993, McCabe 1993);
3. Documented distribution, movements and fishway use (North et al. 1993);
4. Described spawning, early life history, and habitat factors affecting recruitment (McCabe & Tracy 1994, Parsley et al. 1993, Parsley & Beckman 1994);
5. Identified differences in population dynamics and potential production between impounded and unimpounded subpopulations (Devore et al. 1995, Beamesderfer et al. 1995);
6. Began evaluation of restoration and management alternatives (Rieman & Beamesderfer 1990, Beamesderfer & Farr 1997).

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[7] *The Oregon Department of Fish and Wildlife (ODFW) adopted its Oregon Fish Hatchery Management Policy in December 2010 (ODFW 2010). This policy, which has similar objectives as the HSRG framework, does not reference the HSRG quantified criteria, recommendations or management framework (HSRH 2014).).*

Phase II of this project began in 1992 based on recommendations of Phase I research and is ongoing (Beamesderfer & Nigro 1993c; Mallette 2014). Phase II includes evaluations of:

1. Potential mitigation measures for subpopulations downstream from McNary Dam, and
2. Status and habitat requirements in the mid-Columbia River upstream from McNary Dam and in the lower Snake River.

Activities included indexing annual recruitment, periodic stock assessment, fishery monitoring, and trap and transplant of juveniles from below Bonneville into The Dalles and John Day reservoirs (NPCC 2004; Rien 2007; Mallette 2008). To date, this effort has:

1. Quantified flow requirements for sturgeon recruitment by subpopulation based on annual indexing of year class strength;
2. Optimized fishery harvest at sustainable levels consistent with current natural productivity based on catch monitoring and periodic stock assessment;
3. Determined that The Dalles and John Day Reservoirs have the potential to support higher sturgeon numbers and harvests based on experimental fish transplants from below Bonneville Dam (as an alternative to passage);[8] and
4. Explored the feasibility of artificial production of White Sturgeon using wild broodstock collected from lower mid-Columbia reservoirs where natural production is sporadic.
5. Estimated sturgeon status and limiting factors in lower Snake River and McNary reservoirs to provide a foundation for the development of appropriate mitigation goals and objectives.

Hatchery development described in this Master Plan is a next logical step in the development and implication of mitigation activities following research, monitoring and evaluation efforts under project 1986-50. This study provided the foundation for objective and strategies identified in this master plan. Monitoring and evaluation of the efficacy of the hatchery program will be complementary to ongoing activities in continuing phases of the current sturgeon program efforts.

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[8] *Experimental transplant program was discontinued due to limited availability of juvenile and subadult sturgeon following declining natural productivity downstream from Bonneville Dam.*

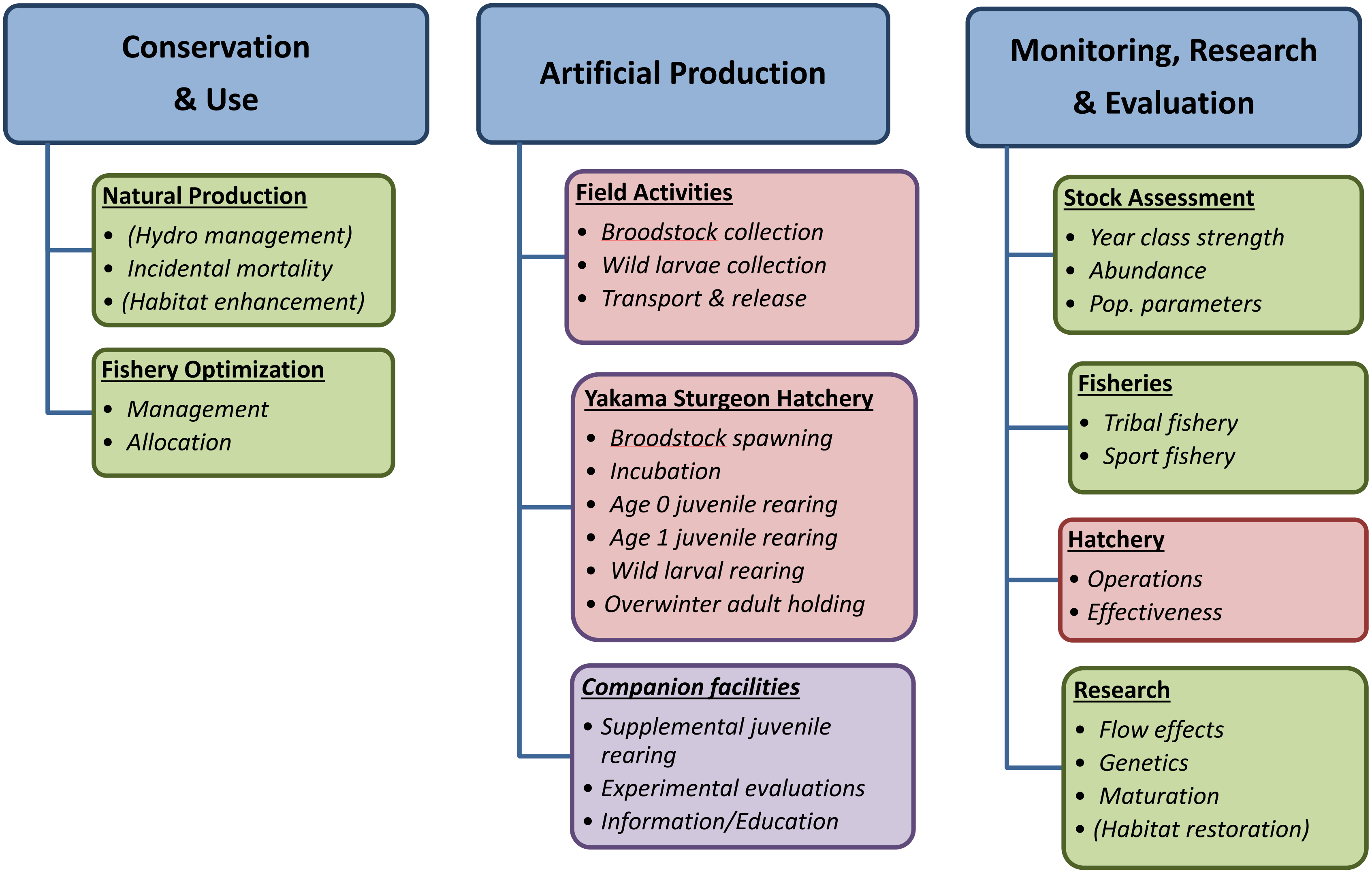

Figure 34. **Activities of the CRITFC/Tribal sturgeon hatchery program in relation to complementary efforts of other projects involved in lower Columbia River White Sturgeon conservation, restoration, mitigation and management. (Items in parentheses have been contemplated but have not yet been implemented.)**

4.8.2 Develop a Master Plan for a Rearing Facility to Enhance Selected Populations of White Sturgeon in the Columbia River Basin - Project 2007-155-00

This primary goal of this CRITFC project was to complete this sturgeon hatchery Master Plan. Specific objectives included:

1. Complete, in conjunction with regional, tribal, state, and Federal management entities, a collaborative and comprehensive strategic plan for sturgeon conservation, restoration and management to include specific objectives, strategies, actions, milestones and schedules for habitat protection and restoration, natural production, hatchery production, fishery management, research, monitoring, and evaluation.
2. Complete a sturgeon hatchery review process to implement hatchery-related actions (if any) identified in the comprehensive strategic plan and consistent with directions provided by the Northwest Power and Conservation Council's three-step review process.
3. Facilitate, monitor and evaluate implementation of appropriate hatchery actions in collaboration with other regional sturgeon conservation, management, and restoration projects.

Objective 1 was addressed by completion of a comprehensive Columbia Basin White Sturgeon Planning Framework document (see Section 4.1.5 on 83). The framework development process provided a regional context, sound technical foundation for the hatchery plan, and broad regional participation for sturgeon mitigation and hatchery planning. The framework document was completed based on a review and synthesis of published and unpublished material regarding sturgeon in the region, proceedings of four regional sturgeon workshops facilitated by this project, reviews by other agencies and tribes with an interest in sturgeon within the region, and a review by the NPCC's ISRP.

Workshops brought together individuals from fish management agencies, tribes, and other involved agencies with technical and scientific expertise and interest in White Sturgeon and their habitats. Other regional experts on White Sturgeon conservation, restoration, and management also participated.

- A December 2009 workshop identified a shared vision, goals, objectives and strategies for sturgeon conservation, management and mitigation efforts in the lower Columbia and lower Snake region which also subsequently served as a basis for the regional framework (Beamesderfer & Squier 2010).
- A January 2011 workshop addressed critical uncertainties highlighted by the IRSP in a review of sturgeon project being implemented in the lower mid-Columbia region – these included natural recruitment limitations, genetic population structure, and sturgeon carrying capacity (Beamesderfer et al. 2011).
- A January 2012 workshop introduced the basin-wide planning framework effort and examined sturgeon passage (Beamesderfer et al. 2012).

- A March 2013 workshop reviewed the draft Framework, vetted regional recommendations regarding sturgeon, and examined risks and uncertainties associated with the potential use of sturgeon aquaculture (Beamesderfer & Squier 2013).

Objective 2 is being addressed by this Master Plan.

Objective 3 will involve future actions undertaken based on outcomes of this Master Planning Process through the completion of the current Columbia Basin accords in 2018.

4.8.3 Sturgeon Genetics - Project 2008-504-00

This 10-year project from the Fish Accords uses genetic markers to evaluate population structure of White Sturgeon in the lower Columbia River and upstream of Bonneville Dam (Matala 2013). The project includes the lower Columbia River downstream from Bonneville Dam; Bonneville, The Dalles, John Day, and McNary reservoirs; and the lower Snake River reservoirs downstream of Hells Canyon Dam.

Specific objectives are to:

1) evaluate population differentiation and migration (gene flow) among reservoirs;
2) determine relatedness and number of spawners (effective population size) within each reservoir; and
3) genetic characterization of individuals captured for future White Sturgeon supplementation efforts based on parentage assignment between young-of-the-year and mature adult individuals.

These three objectives address needs for determining genetic diversity, relative broodstock abundance, distribution and movement, and supplementation efforts. Over the course of this evaluation, these efforts should provide an improved understanding of connectivity among impoundments and adjacent populations, and to gauge temporal changes in diversity affected by the confines of the mid-Columbia impoundments that may result from, or be exacerbated by related anthropogenic interferences or influences (Matala 2013). This effort complements Projects 2007-155-00 and 1986-050-00.

4.8.4 Sturgeon Management - Project 2008-455-00

A Yakama Nation Sturgeon Management Project is closely affiliated and complementary to ongoing sturgeon mitigation and restoration efforts in the Columbia River between Bonneville and Priest Rapids Dams and in the Snake River downstream from Lower Granite Dam, including this effort.

The long-term goal of the Yakama Nation Sturgeon Management Project is to facilitate restoration of viable populations and fisheries for White Sturgeon in mid-Columbia River reservoirs. Phase I of the Yakama Nation Sturgeon Management Project will provide critical input into the hatchery master planning process, help determine the potential suitability of tribal hatchery facilities for sturgeon, and facilitate implementation of appropriate hatchery- related

measures identified during the master planning process. Guidance in this Master Plan will be incorporated into the next phase of the joint Columbia River sturgeon project and further work by the Yakama Sturgeon Management Project.

Specific objectives to address near-term needs in the first phase of this project include:

1. Assist in the development of a recovery, research and monitoring strategy, and hatchery master plan for depleted sturgeon populations in FCRPS portions of the mid-Columbia and lower Snake rivers (facilitated by the CRITFC).
2. Continue to develop critical expertise and refine effective sturgeon culture methodology for spawning and rearing of White Sturgeon using tribal staff, facilities and resources, and captive broodstock currently maintained on the Yakama Reservation at the Marion Drain Hatchery.
3. Identify facility and staff requirements and costs of hatchery alternatives for use in research/monitoring and hatchery Master Plan considerations (based on #2 and #3 above).
4. Develop a detailed implementation plan for production and rearing of juvenile sturgeon as appropriate for use in experimental research and hatchery feasibility evaluations (as identified in #1 above).
5. Assist in the development and implementation of effective experimental research and hatchery feasibility evaluations (as identified in #1 above).

This work is being implemented in a collaborative manner with other regional and local fisheries managers and interests in federal and non-federal portions of the FCRPS system to produce coordinated, complementary, and cost effective outcomes.

5 PROGRAM DESCRIPTION

5.1 GOALS

Three primary goals are identified consistent with the program vision of utilizing hatchery production to help mitigate impacts of development and operation of the Federal Columbia River Power System on sturgeon population productivity and fishery opportunities in lower mid-Columbia River and lower Snake River reservoirs.

Goal 1.	***Enhance commercial, subsistence and recreational fisheries for impounded subpopulations of sturgeon consistent with habitat capacities.***

Enhancement is intended to increase, stabilize and distribute fishery opportunity in selected reservoirs where natural production is not sufficient to fully utilize the available rearing habitat. Sturgeon production will be increased to optimum sustainable levels that can be produced by existing habitats (to be identified based on monitoring and evaluation detailed in Section 8 of this plan). Figure 35 illustrates objective population and fishery levels of this program relative to a spectrum of qualitative biological reference points.

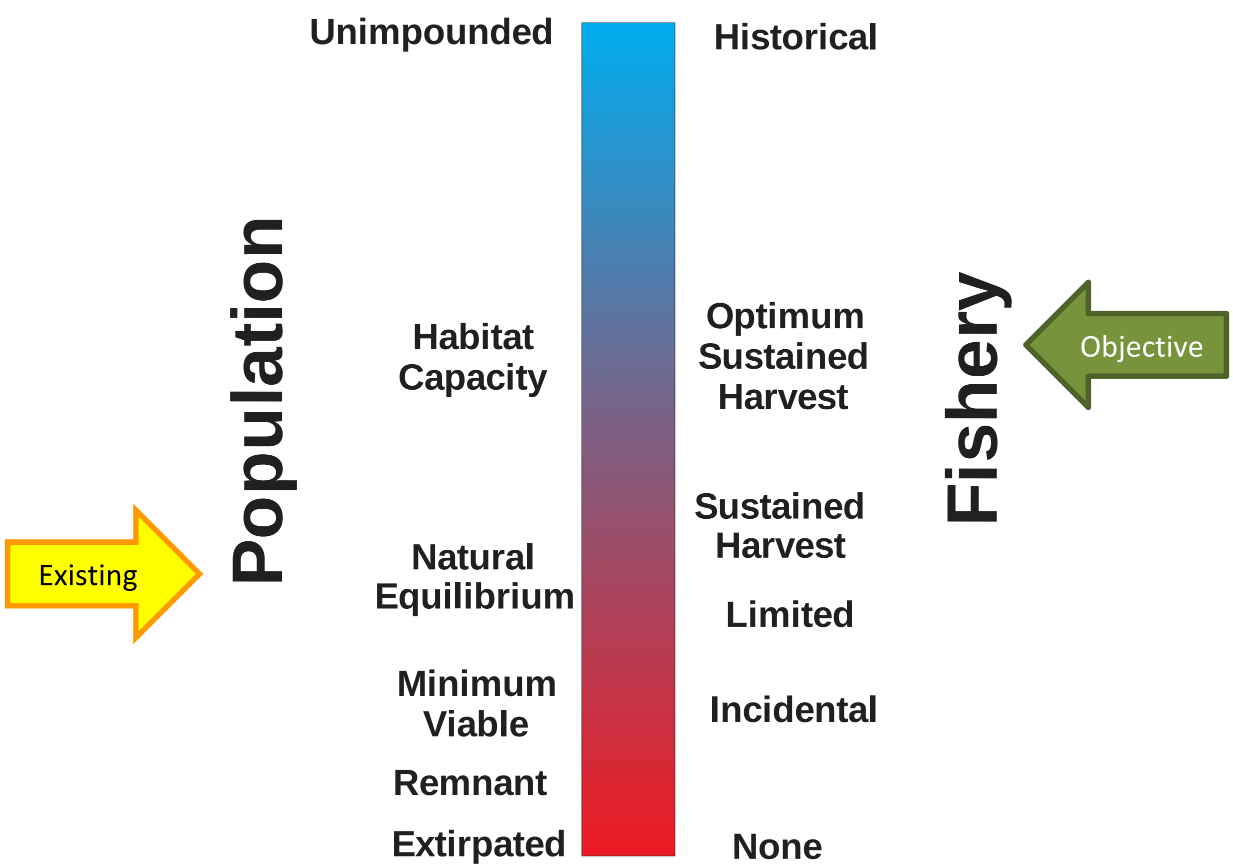

Figure 35. Conceptual depiction of population and fishery status under current and objective sturgeon production levels relative to various biological reference points.

Increased numbers of harvestable sturgeon will allow for larger catch allowances and longer fishing seasons. Depending on reservoir capacity for sturgeon, commercial fisheries ideally regain opportunities to sell sturgeon caught during salmon seasons. Recreational fisheries ideally enjoy more protracted harvest seasons.

Fisheries will be stabilized from year-to-year because large fluctuations due to variable natural year class strength are avoided. Hatchery releases will help replace missing fishery year classes that occur during natural production in low flow years. Hatchery fish will also provide a particularly important bank of fish which can be drawn upon following extended periods of low natural production.

Augmenting weak subpopulations is also expected to distribute fisheries more evenly among areas, with corresponding access, allocation, and anti-crowding benefits. Current fisheries are largely focused on the stronger subpopulations of the lower river, and small areas of unproductive reservoirs where sturgeon are most concentrated. Uneven accessibility is a particular problem in commercial fishery where individual participants fish long-standing sites where sturgeon may be relatively uncommon. Significant sturgeon harvests no longer occur throughout large areas of traditional fishing areas. For instance, tribal members with fishing sites in John Day reservoir typically have much less opportunity for sturgeon harvest than tribal members with fishing sites in Bonneville Reservoir where prior to fragmentation, the access to sturgeon may have been equal. The issue also extends to the sport fishery where people may have to travel long distances through currently-unproductive areas to reach more productive fishing areas.

Goal 2. Conduct sturgeon enhancement in a manner which ensures protection and conservation of natural populations and the ecosystem.

Hatchery production of sturgeon is intended to augment rather than replace natural production. Hatchery supplementation is regarded as an interim mitigation measure until such time as other alternatives for mitigation and restoration of naturally-produced sturgeon populations (e.g.: flow management, spawning and rearing habitat restoration, passage) might be implemented effectively. Section 8.5 of this plan details an adaptive management and decision framework by which future production will be managed.

The need for and level of artificial supplementation will be based on status of the natural subpopulations relative to the available habitat as determined based on monitoring and evaluation. Habitat capacity and ecosystem productivity are finite and releasing hatchery sturgeon surplus to these limitations would be counterproductive if hatchery fish simply replace naturally-produced fish due to competition, overfishing, or any other negative interaction.

Hatchery supplementation will also need to be effectively integrated with features of natural populations which ensure their long term viability. In cases of extreme deletion (e.g., Lower Snake), hatchery supplementation might actually increase viable sturgeon population

parameters over the long term. For instance, increased abundance of spawners might increase natural production in years of favorable environmental conditions. However, the primary objective of this supplementation program is to avoid significant harm to natural production. Harvest strategies will complement the hatchery strategy in order to avoid impacts to natural recruitment.

Goal 3. Employ hatchery-produced sturgeon as an experimental tool for applied research on limiting factors, habitat capacity, broodstock limitations, population parameters, and immigration/entrainment in natural populations.

Many questions on the basic life history of these fish, fundamental to successful management, will be most effectively answered with an experimental approach involving controlled testing of potential management alternatives. A large body of inferential research on existing populations has answered many questions but system manipulations are necessary to address other critical unknowns, including the life-stage specific carrying capacity of impounded reaches of the river.

Monitoring of hatchery sturgeon released in the Kootenai and Upper Columbia has provided critical information on factors limiting natural production, system capacity, and life history bottlenecks (Ireland et al. 2002b; Golder 2007 Associates; Justice et al. 2009). Under current conditions of low recruitment, critical information often cannot be obtained by monitoring of natural populations alone because of low numbers and sampling power. Use of marked hatchery fish will provide a known subject population and structured releases allow for the design of systematic statistical experiments.

A key assumption in any inferences from hatchery to wild fish is that hatchery fish are representative. This is obviously not the case in the first year following release as hatchery survival is typically poor during an adjustment period to natural conditions. After acclimation, it may be more reasonable to assume that hatchery and wild fish behave similarly but this will need to be empirically evaluated as part of the MR&E program. The assumption can be tested to some degree based on a comparison of survival rates, growth rates, condition factor, recapture rates and distribution of hatchery and wild juveniles. The monitoring and evaluation plan includes a substantial increase in monitoring effort for juvenile salmon from current levels. This sampling is expected to provide substantial new information on wild juveniles as well as hatchery juveniles.

5.2 OBJECTIVES

Objectives for the sturgeon fishery, populations and ecosystem were identified based on goals to provide explicit criteria by which success of the hatchery program will be measured (Table 13). In general terms, objectives were defined based on the "Goldilocks Principle." Hatchery production is scaled to provide substantive fishery benefits but limited in order to avoid significant detrimental impacts to natural sturgeon populations or other elements of the aquatic ecosystem. Not too few to make a difference to the fisheries but not so many as to degrade wild sturgeon populations or other components of the ecosystem.

Table 13. Quantitative objectives corresponding to CRITFC sturgeon hatchery program goals.

Goal	Objective
1. Fishery Enhancement	1.1. Increase harvest of White Sturgeon in commercial, subsistence and recreational fisheries for impounded lower Columbia River subpopulations by 100% or more within one sturgeon generation (25 years) consistent with constraints of existing habitat capacity. 1.2. Increase abundance of White Sturgeon in lower Snake River reservoirs by 100% or more within one sturgeon generation (25 years) to enhance fishery quality and potential harvest opportunity consistent with constraints of existing habitat capacity.
2. Wild Sturgeon & Ecosystem	2.1. Limit sturgeon biomass in enhanced subpopulations to levels consistent with those of productive impounded subpopulations in order to ameliorate risks of significant ecological impacts on wild sturgeon demographics and sensitive ecosystem components. 2.2. Achieve an effective population size of at least 500 sturgeon adults per 25-year generation for hatchery broodstock in order to avoid undesirable genetic effects of propagation. 2.3. Achieve proportionate natural influence of 67% or more in productive (primary) sturgeon subpopulations and 50% or more in limited-productivity (contributing) sturgeon subpopulations (as per HSRG guidance for salmonids). 2.4. Continue to limit to effective lifetime exploitation rate of fisheries for enhanced sturgeon subpopulations to no more than 60% in order to sustain significant natural broodstock recruitment.
3. Experimental Evaluations	3.1. Increase precision and reduce bias in estimation of limiting factors, habitat capacity, broodstock limitations, population parameters, and immigration/entrainment of natural sturgeon subpopulations.

1.1. Lower Columbia River Harvest – This plan identifies a corresponding objective of at least doubling harvest for impounded lower Columbia River subpopulations to address the primary fishery mitigation goal of this program. Harvest benefits will be shared by commercial, subsistence and recreational fisheries. Harvest is already relatively low relative to what was likely sustainable in an unimpounded system. The recent 5-year average harvest has been just 6,000 sturgeon per year. This objective recognizes that reservoir rearing capacity for sturgeon will constrain the potential for increasing harvest for some impounded subpopulations.

1.2. Lower Snake River Harvest – Objectives include increasing abundance of White Sturgeon in lower Snake River reservoirs by 100% or more to enhance fishery quality and potential harvest opportunity consistent with constraints of existing habitat capacity. Fishery opportunity in these reservoirs is currently limited to recreational catch and release on the small populations that includes some combination of fish produced prior to impoundment, fish entrained downstream from the Hells Canyon population and sporadic natural recruitment. Increased abundance will increase fishery opportunities either by increasing success rates of the existing fishery or providing expanded opportunity for re-establishing harvest fisheries. More detailed descriptions of current harvest levels and fishing strategies may be found in Section 9.

2.1. Capacity Limitations – In order to avoid significant demographic and ecological risks of sturgeon enhancement, objectives include limiting sturgeon biomass in enhanced subpopulations to levels consistent with those of productive impounded subpopulations. Habitat capacity of impoundments for sturgeon is unknown but standing crops in the more-productive reservoir subpopulations will be used as a reference point until actual capacity might be identified by monitoring changes in population parameters in response to increasing sturgeon abundance. Corresponding reference points for sturgeon standing crop are approximately 90 pounds per acre in Bonneville and The Dalles reservoirs (Table 8). A more detailed discussion of ecological risks related to sturgeon abundance and corresponding program implementation strategies may be found in Sections 5.2 and 5.3 of this plan, respectively.

2.2. Effective Population Size – An explicit quantitative effective population size is identified for hatchery broodstock in order to minimize small population genetic risks of the conventional portion of the hatchery program. Conventional spawning of wild broodstock is one component of the program that also includes collection of wild larvae (the efficiencies of which remain to be determined). An effective broodstock population size of at least 500 sturgeon adults per 25-year generation was identified based on genetic population guidelines identified in the conservation biology literature. A more detailed discussion of genetic risks and broodstock production targets may be found in Sections 5.2 and 5.5.3 of this plan, respectively. It should also be noted that high broodstock numbers are just one of a number of implementation strategies and measures included in this program to manage genetic risks.

2.3. Natural Influence – This objective is intended to limit risks of hatchery supplementation on wild sturgeon population viability and is consistent with outcome guidelines identified for salmon and steelhead by the regional Hatchery Scientific Review Group. For the purposes of this sturgeon

hatchery master plan, recommendations and criteria established by the HSRG for salmonid hatcheries are considered useful guidelines for developing a precautionary sturgeon hatchery strategy with allowances for substantial differences in life history between salmonids and sturgeon. The HSRG recommended limitations on hatchery influence in terms of proportionate natural influence (PNI) of the wild environment on the mean phenotypic values and genetic constitution of the wild population. The HSRG recommended a PNI of 67% or more in high priority (primary) salmon and steelhead populations and 50% or more in moderate priority (contributing) populations. A more detailed discussion of HSRH criteria application to the sturgeon hatchery program is found in Section 5.7.

<u>2.4. Exploitation Rate</u> – In order to sustain significant recruitment of naturally produced fish into the adult spawning population, quantitative objective include continuing limitations on fishery exploitation rates for enhanced sturgeon populations. The objective is to limit effective lifetime exploitation rate of fisheries for enhanced sturgeon subpopulations to no more than 60%. A more detailed discussion of this metric may be found in Section 9.6.

<u>3.1. Research</u> – Use of hatchery fish for experimental evaluations is expected to increase precision and reduce bias in estimation of limiting factors, habitat capacity, broodstock limitations, population parameters, and immigration/entrainment of natural sturgeon subpopulations. Specific quantitative objectives are not identified in this plan.

5.3 RISK ASSESSMENT

Program goals identify the need to control risks of the hatchery mitigation program to wild sturgeon production. Lessons learned from the uses and misuses of hatcheries for salmon provide cautionary instruction in the potential significance of hatchery-related risks. However, fundamental differences in life history and reproductive strategies between sturgeon and salmon must be considered (Anders 1998, 2004). Because of their very long life span (up to 100 years) and late age of maturation (often 25 years for females), a sturgeon hatchery risk assessment must weigh both immediate and long term risks. "Long-term" takes on a special meaning for sturgeon for which planning horizons are expressed in decades or even centuries. Sturgeon life history strategy is characterized by accrued, additive impacts of small incremental effects in patterns that are manifested over a long period. Many hatchery-related risks act similarly with effects accruing slowing as a hatchery-origin population increases and impacts not manifest until hatchery fish reach maturation decades after release. Defining an effective aquaculture strategy for sturgeon is an optimization exercise in balancing the suite of competing benefits and risks over time.

This section details potential risks (Table 14) which are subsequently addressed in program strategies, objectives and practices. Corresponding hatchery strategies to address these risks are detailed in Section 5.4 on page 106.

Table 14. Hatchery-related risks to natural White Sturgeon populations and corresponding aquaculture program strategies to address each.

	Risk	Summary	Term	Strategy [a]
Ecological	Intraspecific interactions	Depression of wild sturgeon survival, growth, maturation, etc. due to competition or predation	Near & Long	1, 2
	Interspecific interactions	Impacts of competition or predation to other components of the aquatic community and food web.	Near & Long	1, 2
	Disease magnification	Increased incidence of disease and associated effects resulting from transmission in the hatchery.	Near	7,9
Demographic	Broodstock mining	Removal to the hatchery of a significant fraction of the annual reproductive population resulting in decreases in natural recruitment in areas and years of favorable conditions.	Near	3, 4
	Spawner mortality or disruption	Mortality or disruption of spawning by wild adults as a result of capture and handing as a result of hatchery broodstock collection activities.	Near	3, 4
	Recruitment overfishing	Natural population decline where overexploitation in the harvestable size slot reduces recruitment to adulthood and subsequent stock-limitations in reproductive potential.	Long	12
Genetic	Loss of diversity	Low effective spawning population size resulting from use of a limited number of broodstock.	Long	4, 5, 7
	Inbreeding depression	Unbalanced contribution of only a few fish to the next generation that accrues deleterious recessive traits and reduces fitness.	Long	4, 5, 7
	Selection	Directional change in genetic composition due to domestication or inadvertent selection over time in the hatchery.	Long	4, 6, 7
	Autopolyploidy	Increase in copies of chromosomes which reduces reproductive fitness of offspring.	Long	8
Uncertainty	Measurement	Uncertainty in estimates of population parameters upon which the hatchery program is scaled (survival, growth, carrying capacity, limiting factors, undocumented harvest, etc.)	Near	10, 11
	Process	Incomplete understanding of limiting factors and population dynamics which can produce unintended consequences.	Long	10
	Implementation	Failure of to operate the sturgeon hatchery program in an effective and timely manner based on best available plans, information and practices.	Near & Long	All

[a] *See Section 5.4*

5.3.1 Ecological Risk

Ecological risks can include intraspecific competition or predation which might reduce wild sturgeon recruitment, survival, growth, or maturation, interspecific competition or predation which might impact other species of the aquatic ecosystem, and disease magnification.

Intraspecific interactions include depression of wild sturgeon survival, growth, or maturation, or reproduction due to competition with or predation by hatchery sturgeon. Competition is the primary concern. Intraspecific predation by sturgeon has not been widely documented. Carrying capacity of the system for sturgeon is a critical issue for this program but is currently unknown and has changed with impoundment and the introduction of non-native species. Reduced growth and condition of sturgeon in Bonneville Reservoir where sturgeon are relatively abundant in comparison with other impoundments, may be indicative of density-related effects. Some evidence of a size-specific decline in survival of juvenile hatchery sturgeon has been reported in the Kootenai River but the evidence is not clear cut (Beamesderfer et al. 2014b). However, the role of density dependence in a normally-functioning natural sturgeon population is unclear. Density-related processes are a normal dynamic in many healthy wild fish populations and density dependence may serve a functional role in sustaining long-term viability. However, density-related reductions in survival, growth or condition can substantially reduce the fishery benefits of hatchery supplementation. At some point, production in every system is ultimately limited by carrying capacity. Increasing numbers of sturgeon must theoretically stimulate a density dependent response at some point.

The diet of White Sturgeon varies with fish size (McCabe et al. 1993; Romano et al. 2002). Juveniles typically rely on benthic invertebrates, while sub-adults consume a variety of benthic organisms of a larger size distribution, and larger White Sturgeon are increasingly piscivorous. Size-related feeding differences mean that different size classes of sturgeon will be limited by different components of the aquatic community available as prey. While juvenile sturgeon might be limited for a time by the productivity and availability of benthic invertebrates, these limitations might be relaxed as fish grow to larger sizes where they may take advantage of more diverse food sources.

System capacity for sturgeon is unknown and cannot be reasonably inferred from existing information. Aquatic food webs of impoundments can be qualitatively described (Figure 6) but production and trophic dynamics have not been quantified. This issue has been explored extensively by the KTOI (2010) with regard to Kootenai sturgeon hatchery production. They found that capacity estimates might be derived using various models, but these inferences are speculative at best, given the broad assumptions required to parameterize the models.

Interspecific interactions involve impacts of competition or predation by sturgeon on other components of the aquatic community and food web. Sturgeon are opportunistic, omnivorous predators that as adults, occupy an upper trophic niche that likely plays an important regulatory role in shaping prey taxa assemblages, affecting food web dynamics. Prey may include juvenile

or adult salmonids or lamprey. The magnitude of this effect is expected to increase with population size.

Information on food habits and potential interspecific interactions of White Sturgeon is incomplete and largely qualitative (Semakula & Larkin 1968; McKechnie & Fenner 1971; Scott & Crossman 1973; McCabe et al. 1993; Romano et al. 2002). Juvenile White Sturgeon (> than 80 cm total length) in the lower Columbia River have been reported to feed mainly on invertebrates, with amphipods (*Corophium* sp.) being the most-often selected prey items (McCabe et al. 1993; Romano et al. 2002). McCabe et al. (1993) also noted that a substantial portion of the diet for White Sturgeon in this size class consists of eulachon eggs, isopods, mysids, Asian clams (*Corbicula*), snails, and small fish (such as sculpins and assorted fry). Larger sturgeon in the Lower Columbia River feed increasingly on fish including eulachon, northern anchovy, American shad, lamprey, Pacific herring and various salmonids (McCabe et al. 1993). Large adult sturgeon are capable of consuming large prey including adult salmon.

Disease magnification involves an increased incidence of disease and associated effects on natural populations resulting from sources originating in the hatchery. Diseases observed in sturgeon hatchery programs include the natural array of pathogens common to those seen in a salmonid hatchery including myxobacteriosis, columnaris, costia and external fungus. Treatments for these are generally similar to those used for salmonids. In addition, the White Sturgeon Iridovirus (WSIV) is endemic to White Sturgeon including the Columbia River population. The primary mode of transmission for this disease is horizontal, meaning from fish to fish, and vertical transmission is also thought to occur (Drennan et al. 2006). The WSIV manifests itself in times of duress and stress and is most virulent in sub-yearling fish. Older fish can harbor the virus without displaying signs of infection and can act as a reservoir of infection. Viral outbreaks can cause large (95%) losses in juvenile stocks and holding infected adults can be a risk for horizontal infection.

Most diseases, including WSIV are believed to be endemic in wild populations. However, increased fish density and stress in the hatchery endured by essentially wild fish in a culture condition compared to natural conditions substantially increases risks of disease outbreaks. An increased incidence of disease among hatchery fish increases subsequent risks of pathogen transfer to naïve, naturally-produced fish in the river with the related productivity effects. Fish health problems in the hatchery can also compound effects of other risks that influence survival. For instance, pathogen outbreaks can cause the loss of an entire brood year's production, selected families or individuals within a family, all of which can impact the genetic diversity of hatchery production by influencing the proportion of fish from a diminishing number of contributing cohorts.

5.3.2 Demographic Risk

Demographic risks of a sturgeon hatchery include changes in survival or reproduction which can affect relative natural population abundance and productivity.

Broodstock mining refers use in the hatchery of mature sturgeon adults which would otherwise have the opportunity to spawn naturally and successfully. This risk is associated with conventional sturgeon hatchery broodstock programs where mature wild fish are collected prior to the spawning season, spawned artificially in the hatchery, and then released back into the wild after spawning. The impact of broodstock mining would be proportional to the percentage of the reproductive population which is utilized in the hatchery given that the wild population has the capacity to spawn and reproduce viable offspring. This effect is primarily a concern for female sturgeon. Removal of females will reduce population fecundity; removal of males is much less of a concern because remaining males should easily be able to fertilize the available females as they mature earlier and with a lower time between spawning events.

The impact of broodstock mining also depends on the likelihood that fish would reproduce successfully in the wild. In subpopulations where natural recruitment is sporadic or negligible, removal of ripe adults to the hatchery would be expected to have little effect on the population due to a low likelihood of successful reproduction. Risks increase where natural production is more consistent up to a point where the available spawners are adequate to fully utilize the available habitat, at which point impacts of removal of some adults are no longer significant.

Sturgeon spawned in the hatchery rather than in the wild, produce hatchery-reared offspring which might effectively replace those that have been produced naturally. However, natural production is believed to be more desirable than hatchery production under most circumstances, due to the added costs of hatchery rearing and other genetic or ecological risks associated with hatchery program.

Spawner mortality or disruption might also occur as a result of hatchery broodstock collection efforts. Some level of handling stress can be associated with sturgeon collection by setline or gillnets. Sturgeon are extremely hardy and handling mortality has been observed to be low, but some mortality might occur. This might include fish caught and release during broodstock collection efforts as well as fish removed to the hatchery for spawning. Not every sturgeon brought into the hatchery for spawning will ultimately ripen and spawn effectively. Thus, capture and handling might preclude effective reproduction by affected individuals even when they survive. As with broodstock mining, the significance of this risk related to the proportion of the population affected, their likelihood of reproducing naturally, and reductions in effective population size.

Recruitment overfishing involves depletion of adult spawners as a result of excessive harvest or harvest-related mortality within the harvestable size slot. Adult spawners are protected by allowing harvest only of subadult sturgeon within a specified size range: 43-54 in (109–137cm) FL in Bonneville and The Dalles reservoirs, 38-54 in (96–137cm) FL in Bonneville Reservoir. Annual harvest number guidelines are established based on fish abundance to maintain exploitation

rates which ensure that sufficient numbers of subadult sturgeon survive their years of fishery vulnerability to recruit to and maintain the adult population. This strategy has been the effective centerpiece of Columbia River sturgeon management since the 1950s. Excessive harvest within the size slot will gradually reduce adult numbers over time as mature fish die and are not replaced. Natural recruitment, on average, should be generally proportional to adult abundance up to the point where the carrying capacity of the system for sturgeon is reached. Thus, overfishing which reduces adult sturgeon abundance risks future declines in natural production.

Recruitment overfishing can happen with or without hatchery supplementation but the concern is that hatchery fish might sustain substantial harvest even in the absence of significant natural production. In this instance, the hatchery program simply replaces natural production and costly hatchery production replaces natural production which is effectively "free" as long as a significant adult population is maintained.

5.3.3 Genetic Risk

Historically, salmon hatchery programs have been widely criticized for failures to adequately protect wild population diversity (NRC 1996). Diversity includes individual and population variability in genetic-based life history, behavioral, and physiological traits. Genetic diversity is related to the variety of alleles and allelic frequencies contained in the parent population and the synergy of allelic combinations expressed through recombination.[9] High genetic diversity allows a species to utilize a wider array of environments, protects species against short-term spatial and temporal changes in the environment, and provides the raw material for surviving long-term environmental changes.

Loss of diversity is thought to reduce productivity by reducing physiological and life history variability that is adaptive in a diverse and variable environment (NRC 1996; McElhany et al. 2000). Hatchery programs have to potential of reducing diversity through founder effects due to low numbers of parents, inbreeding depression due to introduction of large numbers of related siblings, or inadvertent selection over time in the hatchery if these risks are not carefully addressed with hatchery practices.

Loss of diversity may involve loss of unique combinations of genetic-based traits or loss of rare alleles resulting from population bottlenecks or founder effects due to use of a limited number of broodstock. Risks of reduced genetic diversity are inversely related to the effective spawning population size (Ne). The effective breeding number (Ne) for a population is a genetic-based index of the number of individuals in a random breeding population with an equal sex ratio, which would yield the same rate of inbreeding or genetic drift as the population being studied (Falconer 1981; Ryman & Laikre 1991; Kincaid 1993; Anders et al. 2011; Jager et al. 2010). Welsh et al.

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[9] While the same genetic material may be contained in multiple parents, different combinations are expressed among individual siblings, collectively producing the mosaic of diversity for natural selection to act upon.

(2010) adopted genetic guidelines recommending that effective population size (Ne) be increased by increasing the number of parents used for each generation for lake sturgeon stocking.

Box 1. Estimating Effective Population Size (Ne)

The following formula calculates the Ne (effective population size) for populations produced from random mating of Nm male parents and Nf female parents.

$$Ne = (4\ Nm\ Nf) / (Nm + NF).$$

Ideally, Ne is calculated from counts of the actual number of parents that contribute progeny to the next broodstock generation. Because the actual number of individuals contributing progeny to the next generation and the number of progeny each contributes is unknown in most populations, the number of individuals that spawn and produce progeny is generally used in the calculation, i.e., the total number of fish spawned of each sex. For animal species with multi-year generation intervals, Ne is calculated using the sum of all males (Nm) and females (Nf) spawning each year for the number of years in the generation interval adjusted by any difference in sex ratio and the number of individuals that spawn more than once per generation. The generation interval is defined as the average age of females at first maturity, or about 25 years for the Lower Columbia White Sturgeon. The Ne will be the total of all spawners (different fish spawned) over the 25-year generation interval.

Numbers associated with diversity-related risks are theoretical and generally derived from simple population genetics models and conservation biology literature. The conservation science literature typically identifies a minimum viable genetic effective population size of at least 50 to 1,000 adults (Thompson 1991; NRTWS 2009). Because census numbers are typically several times greater than effective population size due to non-random mating, sampling error (not all fish spawning in every year), population abundance targets ranging from 1,000 to 20,000 have been recommended for various species (IUCN 2001; NRTWS 2009).

Inbreeding depression represents an extreme case of reduced diversity where fitness is reduced due to breeding between closely related individuals (for instance, through increased expression of deleterious recessive traits). Risks of inbreeding depression may be increased by disproportionate contributions of only a few adults to the next generation. Jager (2005) used genetic modeling of a hypothetical sturgeon population to demonstrate the risks of genetic introgression over multiple generations when future broodstock derive from hatchery-produced fish and the diversity of the founding population was limited.

Selection is a directed or inadvertent change in a directional change in genetic composition resulting from hatchery practices. In extreme cases, selection over time for characteristics favorable to the hatchery environment can result in domestication (Ford 2002). Selection can result from nonrandom hatchery practices which favor specific traits. Selection can occur at spawning, for instance by favoring early or late spawning individuals. Selection can also occur in

the rearing stage, for instance by selectively grading for fast growing individuals. While some individuals do better in a hatchery environment than others, these same traits did not categorically prove adaptive when fish were released into the wild (Ireland et al. 2002b). Effects of selection may be manifested in the hatchery or following release. Beamesderfer et al. (2014b) reported selective post-release effects of size at release of Kootenai hatchery sturgeon where fish released at small sizes are less likely to survive than fish released at larger sizes. Similar differences in individual growth may occur among wild fish but hatchery fish face additional challenges of having to adapt to wild conditions following release. The disparity in fish sizes can be managed in the hatchery with more frequent grading to get the slower growing fish up to target size but the additional handling associated with grading can stress fish with concomitant effects on health and mortality.

Autopolyploidy is a special case of genetic impact among hatchery-reared White Sturgeon involving an increase in genome size to multiples of 8N (Schreier et al. 2013). Where most fish species are diploid, containing two complements of genetic material (2N), White Sturgeon are polyploid (8N). The mechanism and effects on viability and reproductive development of spontaneous autopolyploidy are poorly understood (Gille et al. 2015). It is believed to result from failure to exclude the second polar body in meiosis II (Gille et al. 2015). Autopolyploidy has the potential of reducing future reproductive fitness. Where an 8N fish mates with a 16N fish, the offspring may have a 12N karyotype (gene pair number) that may not be viable when crossed with an 8N fish. Thus, autoploid fish may not propagate their undesirable genetics but can reduce productivity by "wasting" the reproduction of wild fish with which they mate. Autopolyploidy is not propagated through multiple generations of the offspring of hatchery fish such that the incidence stabilizes or increases over time. Autopolyploidy is effectively selected against over time by reproductive failure. Autopolyploid fish may also compete with other sturgeon for limited resources.

5.3.4 Uncertainty Risk

Measurement error potentially introduces substantial uncertainty into any estimates of population parameters upon which the hatchery program is scaled. These include annual survival rates, growth rates, and age or size of maturation of hatchery fish. For instance, even very small differences in annual survival result in vastly different calculations of release numbers needed to establish any given hatchery population level. A ±1% change in annual survival amortized throughout the sturgeon life span can shift projected adult abundance by thousands of fish positively or negatively (KTOI 2010). These values are well within the range of error of current empirical estimates of stage-specific survival rates in other areas (Beamesderfer et al. 2014b; Beamesderfer & Justice 2008). The sensitivity of abundance to very small variation in survival rates results in low confidence for using release number target back-calculations to accurately predict (and meet) future abundance goals.

Process error involves uncertainty related to our incomplete understanding of limiting factors and population dynamics of sturgeon. Processes that we do not fully understand can produce unpredictable or unintended consequences of hatchery supplementation. Apparent size and

density-related changes in survival of juvenile sturgeon released from the Kootenai hatchery program are an example of a process-related uncertainty with substantial implications to hatchery effectiveness (Beamesderfer et al. 2014b). Recent declines of White Sturgeon populations in the lower Columbia River White Sturgeon parallel a large increase in pinniped abundance and predation on White Sturgeon. These are examples of an unpredictable change in ecosystem processes which fundamentally changed the population status and productivity.

Implementation error involves failure of to operate the sturgeon hatchery program in an effective and timely manner based on best available plans, information and practices. Examples might include not obtaining sufficient broodstock to maintain the spawning protocol, inadequate monitoring from which to make adaptive management decisions or inadequate actions by management agencies contributing to adaptive management decisions. Implementation error may occur due to institutional issues including a lack of funding, commitment or responsibility. The Council's 3-Step hatchery master planning process is intended to reduce risks of implementation error in the design and development of a hatchery program.

5.4 IMPLEMENTATION STRATEGIES

The following implementation strategies were identified to achieve program objectives while also controlling associated risks.

Strategy 1. Release hatchery-reared sturgeon in impounded reaches of the lower Columbia and Snake rivers where natural production is not adequate to utilize the existing habitat capacity, with a primary focus on John Day Reservoir.

Efforts will initially focus on John Day Reservoir which includes a large area of underutilized sturgeon habitat that historically supported a much larger sturgeon population. John Day is the largest of the Zone 6 reservoirs but has the lowest abundance and density of the lower three reservoirs. Here, abundance and productivity are limited by poor recruitment and not by resources. Underutilized capacity in John Day will likely support significant survival, growth and maturation of hatchery sturgeon. Releases in John Day will provide substantial benefits to treaty tribal commercial, tribal subsistence, and non-tribal recreational fisheries in that reservoir.

Unlike John Day Reservoir, current data on population status in Bonneville Reservoir suggests that releases of hatchery sturgeon would likely have little or no benefit and could even be counterproductive. Poor growth rates and fish condition in conjunction with higher sturgeon density in Bonneville Reservoir suggests that sturgeon habitat may currently be at or near rearing capacity. Releasing additional sturgeon in Bonneville might further depress growth and condition which in turn could reduce recruitment into the fishery and yield per fish.

The Dalles Reservoir is not a candidate for hatchery supplementation at this time and monitoring efforts will focus on estimating how many of the hatchery sturgeon released into John Day Reservoir are subsequently recaptured in The Dalles Reservoir. Some downstream movement is expected but the significance can only be determined by monitoring. Long-term stock

assessment studies have shown that small numbers of sturgeon captured and marked in a given reservoir are subsequently recaptured downstream. Whether this represents volitional movement or involuntary entrainment is unknown. Substantial numbers of hatchery sturgeon released by CRITFC in 2003 into Rock Island Reservoir were subsequently observed in downstream areas. This pattern highlights the potential for downstream movement but results may not be representative of other areas due to the small size, high water velocity, and low water retention time of Rock Island relative to other reservoirs in the system and differences in size or time of release. [10] Releases of hatchery sturgeon into The Dalles Reservoir will be considered if continued stock assessments indicate that natural recruitment is not adequate to seed the available habitat and significant downstream movement of hatchery sturgeon does not occur from John Day.

Bonneville and The Dalles reservoirs will serve as buffers to protect the core White Sturgeon population downstream from Bonneville Dam from the potential for unintended and undesirable hatchery supplementation from fish released into Lower Columbia impoundments. Very few hatchery sturgeon released above John Day dam are likely to move downstream past three dams to pass downstream from Bonneville Dam. Wild Fish Policies by the States of Oregon and Washington have assigned a high priority to protecting the wild lower Columbia River White Sturgeon population from hatchery effects. Ongoing stock assessment activities in Bonneville and The Dalles Reservoir will provide for quantitative assessments of the potential for significant downstream movement of hatchery sturgeon and subsequent adaptive management of the sturgeon hatchery program.

Smaller releases will also occur into the three lower Snake River reservoirs (Ice Harbor, Lower Monumental, and Little Goose reservoirs based on poor natural recruitment and current low population densities. A significant sturgeon mitigation opportunity has been identified for this area in the Columbia Basin White Sturgeon Framework (Beamesderfer & Anders 2013). Enhancement of sturgeon populations in the lower Snake River could bolster non-Indian recreational fisheries but these areas are outside of Zone 6 and are not currently managed for treaty commercial fisheries.

Sturgeon subpopulations may be categorized for the purposes of enhancement based on status comparable to primary, contributing and stabilizing population designations in salmon and steelhead recovery plans (LCFRB 2010) used by the HSRG to establish guidelines for hatchery impact consistent with conservation goals. White Sturgeon in the lower Columbia and Snake

[10] *31% of sturgeon sampled in 2011 from McNary Reservoir were hatchery fish released three reservoirs upstream in Rock Island Reservoir in 2003. In contrast, sampling of wild sturgeon PIT-tagged in reservoirs between Bonneville and McNary dams found that fewer than 5% were recaptured one reservoir downstream, and fewer than 1% were recaptured upstream or two reservoirs downstream (Kern et al. 2006).*

rivers are not listed under the ESA but subpopulations exhibit a range of status comparable to that of listed salmon and steelhead.[11]

> "Primary" salmon and steelhead populations are typically the strongest extant populations, those with the best prospects for protection or restoration to high levels of viability, or uniquely representative of all or part of the genetic management unit. For the purposes of this sturgeon hatchery plan, primary sturgeon subpopulations are those where natural recruitment is significant, all size classes are relatively abundant, and natural production provides meaningful harvest opportunity (e.g., Bonneville and The Dalles reservoirs). Primary sturgeon populations are will not be enhanced.
>
> "Contributing" salmon and steelhead populations are typically of low to moderate viability but make a significant contribution to the overall viability of the genetic management unit. For the purposes of this sturgeon hatchery plan, contributing sturgeon subpopulations are those where natural production is impaired, inconsistent natural recruitment limits harvest opportunity, but the available habitat has the capacity to support a substantially higher population and harvest (e.g., John Day, McNary). Hatchery enhancement of contributing sturgeon populations may occur with limits on hatchery contribution to protect the wild subpopulation.
>
> "Stabilizing" salmon and steelhead populations are typically at very low viability and those with poor prospects for substantial restoration. For the purposes of this sturgeon hatchery plan, stabilizing sturgeon subpopulations are those where natural recruitment is minimal, abundance is low, and harvest opportunity is negligible (e.g., Ice Harbor, Lower Monumental, Little Goose). Stabilizing sturgeon populations are open to enhancement with little risk to already-negligible natural production and correspondingly lesser constraints on hatchery contributions.

Strategy 2. Scale and adjust release numbers to optimize sturgeon production and fishery benefits in target areas while avoiding significant, density-related, intra-specific impacts or inter-specific ecological risk.

Optimum benefits of hatchery sturgeon production will occur when fishery benefits are increased to the maximum that can reasonably be expected without serious intra- or intra-specific impacts. Hatchery production must balance competing objectives. Release numbers need to be great enough to provide significant fishery mitigation benefits, yet not be so large as to provoke density-related intra-specific competition which might erode hatchery benefits or negatively impact wild sturgeon populations. Nor should sturgeon hatchery production risk significant inter-

[11] *Sturgeon "subpopulations" in Columbia and Snake river impoundments are not unique locally-adapted populations like those of salmon and steelhead occurring to specific areas but rather subsamples from a larger population that was present before impoundment.*

specific ecological impacts. This calculus is complicated because levels which stimulate undesirable interactions are unclear.

This program will take a phased, adaptive approach to scaling sturgeon hatchery production. Initial release levels will be scaled to: 1) provide substantial fishery benefits given a range of likely survival rates following release; 2) provide sufficient statistical sampling power to accurately assess post-release performance and adjust future production consistent with program objectives; 3) increase sturgeon abundance to levels comparable to other more-productive Lower Columbia populations; and 4) be achievable with a reasonably-size hatchery program.

The only realistic alternative for determining sturgeon carrying capacity is an empirical determination based on changes in population parameters as abundance and density increase. Reservoir habitat capacity is unknown and cannot reasonably be inferred from existing information. Most impounded sturgeon populations are depleted or limited by factors other than habitat capacity. Capacity cannot be inferred from trophic analyses because reservoir productivity and sturgeon utilization of resources have not been quantified. We are not even sure how and where in the life cycle habitat capacity limitations are manifest for sturgeon. Even if we could somehow project habitat capacity, it is not practical to set release numbers based on long term population abundance targets. Uncertain survival rates preclude our ability to establish release number consistent with any specified future abundance. Even very small differences in survival rate of sturgeon compound across ages to produce very large differences in projections or back-calculations.

The more hatchery fish we release, the more likely we will reach capacity and to produce a detectable response. Larger release numbers on the front end will reduce the time interval until a response can be detected. Statistical power and cost-effectiveness of monitoring efforts will be increased because higher sturgeon abundance will increase catch per unit effort, sample size, and precision of growth, condition, and survival estimates based on hatchery fish recaptures. Marginally higher costs of more hatchery production on the front end may be partly or wholly offset by subsequent monitoring program savings.

Hatchery production might be increased or decreased in the future based on evaluations of the effectiveness of initial releases. Basing initial production targets on current sturgeon densities in productive populations that are not candidates for supplementation (e.g., Bonneville and The Dalles Reservoirs) should ameliorate significant ecological risks while also providing a substantial boost to sturgeon fisheries while maintaining a large effective population size. Effective implementation of this hatchery program will include a strong monitoring and evaluation component (See Section 8 Monitoring & Evaluation Plan). The planned release level provides sufficient sample size to allow for statistically-robust evaluations of survival, growth and condition of sturgeon following release from the hatchery. Hatchery fish will also provide test subjects for collecting information which is currently lacking on sturgeon feeding habitats and related inter-specific interactions – hatchery fish may be sacrificed for diet studies without impacting the wild subpopulation.

Consideration has been given to very large hatchery releases in order to take advantage of the high fecundity of sturgeon, produce larger fishery benefits sooner, and plumb the limits of system capacity. However, greater releases may not provide substantially greater fishery benefits if they trigger a density-related population response. Very large release numbers would require additional hatchery facilities and costs which may not ultimately prove to be necessary or appropriate. Greater releases also risk provoking undesirable ecological responses in other high-value fish species such as salmon or lamprey. This program elected to purse an incremental approach to sturgeon production, releasing enough sturgeon to produce meaningful fishery benefits but not so many as to exceed reasonable expectations.

Ecological risks include competition and predation of hatchery sturgeon with wild sturgeon or other components of the ecosystem. Avoiding significant intra-specific competition among sturgeon is an explicit objective of the supplementation program. The monitoring and evaluation program is specifically designed to identify when competitive interactions reach the point of a density-related response and the hatchery supplementation program will be revised accordingly. Ecological effects of sturgeon competition with or predation on other ecosystem components are complex. Sturgeon interact with many different levels of the aquatic community preying on some species but also competitors of those same species. The relative scale and influence of sturgeon on other ecosystem components has not been quantified and may not be quantifiable. The aquatic community in these dynamic run-of-the-river reservoirs is much more likely to be structured by large seasonal and annual variability in environmental conditions than interspecific interactions.

One of the biggest concerns is for the impact increased predation on sensitive species such as salmon or lamprey. Baseline levels of sturgeon predation are unknown. We might speculate that some increase in sturgeon predation will result from increased abundance. However, impacts on salmon or lamprey status would be marginal where background predation levels are low. Sturgeon predation mortality has not been reported to be a significant limiting factor for either salmon or lamprey. A restored sturgeon population may also be a more appropriate reference point for comparison than the depleted population that currently exists.

Strategy 3. Release hatchery sturgeon annually and mark all hatchery releases to facilitate evaluations of hatchery effectiveness.

Hatchery releases are planned in part to compensate for naturally-variable year-class strength related to environmental conditions. This will distribute impacts of broodstock collection across all years. Intermittent hatchery production in only those years of low natural production is neither necessary nor practical. Favorable conditions for recruitment and verification of recruitment success don't occur until after broodstock would need to be collected for a given year. Hence, effort and fish would be wasted if brood year production was contingent on subsequent assessments. Because of their longevity and overlapping sizes of brood year cohorts, sturgeon release strategies can be effectively managed to provide consistent recruitment to the fishery and adulthood. Production from successive brood years essentially melts together by the

time fish reach fishery and adult sizes. It is not realistically practical or cost effective to scale hatchery production on an annual basis up and down in response to the magnitude of natural recruitment in the same year.

Hatchery fish will be marked and tagged to distinguish them from wild fish so that wild status and hatchery effectiveness can be assessed easily and in a recreational fishery. Because of the wild integration strategy of this hatchery, separate management of hatchery and natural fish in the wild is not planned. Tribal fisheries will not be selective for marked hatchery sturgeon, but marking will be essential for evaluations of hatchery performance. Conventional marking practice for hatchery sturgeon in other areas of the basin has involved external marking by removal of a unique pattern of lateral scutes and tagging of all or a representative subsample of releases by injection of individually-identifiable PIT tags. This convention will be followed by the CRITFC sturgeon hatchery program.

Strategy 4. Use a combination of conventional wild broodstock and wild larvae collection for initial production and refine future approach based on relative effectiveness and efficiency in achieving program goals.

Two production strategies are currently employed in other sturgeon restoration efforts and each has its strengths and weaknesses (Table 15). Specific challenges of each strategy can be at least partially mediated by collection and rearing practices, but the most effective strategy will ultimately depend on the particulars of implementation under a specific set of circumstances. This program will initially employ both strategies and refine this approach over time based on results.[12]

The conventional approach to hatchery propagation of hatchery-raised sturgeon involves collecting mature adults prior to the spawning season and transporting them to the hatchery for subsequent spawning. This approach is currently employed by the Kootenai program and has previously be used with good success by the Upper Columbia River program. Captive spawning of females in the hatchery involves assessing the state of maturity and stimulation of ovulation with hormone injections. Male ripening can typically be stimulated with water temperature regulation and augmented by hormone injections. Gametes are generally collected by expression and mating is controlled. Adults are released following spawning. This approach now has decades-long history of demonstrated effectiveness in consistently producing large numbers of fertilized embryos representing diverse combinations of their parent's genetic make-up. However, production is often limited to offspring from a restricted number of parents. Collection of mature fish from the wild requires substantial effort, by catching, handling, and assessing many fish because not every adult sturgeon spawns in every year. Large sturgeon can be difficult

[12] *Cryopreservation strategies were also considered for increasing effective population size of the conventional broodstock program. This technique has been widely explored for sturgeon but success has been limited.*

to move, transport, and hold in the hatchery, which requires substantial space and large tanks. Further, a limited number of individuals may not ripen at the same time, which requires removing several fish from the wild and likely precludes natural reproduction. Unfortunately, broodstock also occasionally succumb to the stress of capture and holding.

Table 15. Attributes of conventional broodstock and wild larvae collection for sturgeon hatchery production.

	Conventional broodstock	Wild larvae
Collection	• Requires sampling substantial numbers of adults to collect mature, ripe fish.	• Requires extensive sampling to identify cost effective times and areas.
Production	• Large numbers can be produced due to high female fecundity	• Substantial sampling effort required to obtain large numbers.
Effective population size	• Large contributions from limited parentage.	• Limited contributions from large parentage.
Challenges	• Genetic founder effect due to limited parentage. • Genetic swamping of wild populations. • Potential for hatchery selection during spawning, rearing and after-release.	• Temporal selection for spawn timing if limited collection season. • Small families and poor survival may erode genetic benefits at maturation. • Disease and mortality associated with capture stress.

An alternative approach involves collecting wild larvae during their dispersal phase (about 10 days post hatch) and removing them to the hatchery for subsequent rearing until release. Larvae are captured alive in large drift nets during a swim-up phase after they emerge from the gravel. This approach was pioneered in the US Upper Columbia River program where it has now replaced the conventional broodstock strategy. Larval collection provides a diverse sample from a large number of adults produced through natural processes of mating, spawning and incubation. This provides better genetic representation of the parent population and reduces chances for artificial selection in the hatchery and selective pressures brought to bear by the hatchery system itself. However, collecting significant numbers of larvae can be challenging in these large river systems and identifying effective sampling locations can involve substantial trial and error. Genetic diversity of larvae may be limited because, while larvae represent greater numbers of parents, contributions from individual parents may be very small or even nil. As a result, the genetic diversity of the hatchery population at maturation might be substantially lower than that of the

parent population.[13] Sampling problems may also limit the utility of this method because stress of larval capture and handling can cause fish health problems and reduce survival.

Because of potential genetic benefits and lower costs, larval collection may ultimately prove to be the most desirable production strategy if collection and survival problems can be effectively addressed with hatchery practices. However, these issues may preclude significant sturgeon production from wild larvae during the initial phases of the Lower Columbia program. This program will include a preference for collection of wild-origin larval White Sturgeon produced by naturally spawning adults where effective and appropriate, in conjunction with a conventional wild broodstock collection and spawning program as needed to meet program objectives.

Strategy 5. Use sturgeon originating from the mid-Columbia Genetic Management Unit for hatchery production with a preference for sources with a lower probability of successful natural reproduction.

The Mid-Columbia Genetic Management Unit (GMU) includes the Columbia River from Bonneville Dam to Grand Coulee Dam and the Snake River from its confluence with the Columbia upstream to Lower Granite Dam (see Section 3.6 Genetic Stock Structure). This GMU includes sturgeon subpopulations in the area of supplementation. Genetic analyses based on allozymes, mitochondrial DNA, and microsatellite DNA conducted since the 1980s have found that genetic characteristics of populations in adjacent mid-Columbia and Lower Snake reservoirs are generally very similar. Genetic studies have also documented higher genetic diversity downstream from Bonneville Dam and lower diversity in the Upper Columbia and Snake Rivers although there are no distinct lines of demarcation between sturgeon GMUs in the region. The Lower Columbia White Sturgeon population is not included in the mid-Columbia sturgeon GMU and is not a candidate source for hatchery broodstock.

Use of local genetic stock is intended to preserve the native, area-specific characteristics of local populations. It is unclear whether the current genetic composition is representative of the historical type or has been unintentionally altered by historical overexploitation and population fragmentation. However, avoiding further alterations is regarded as a precautionary approach.

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[13] *The effective population size produced by conventional broodstock and wild larval collection must ultimately be assessed at maturation of the hatchery-reared population. While larval collections represent large numbers of parents in each brood year, low family sizes and subsequent natural and artificial mortality prior to maturation will erode diversity at maturation. Conversely, while conventional broodstock represent small numbers of parent in each brood year, larger family sizes increase the likelihood of survival of at least some offspring from each parent until maturation. Further, the cumulative number of parents represented in a conventional broodstock program over the duration of a sturgeon generation will be substantial. The relative effectiveness of each alternative will depend on sample numbers and survival rates. These parameters will be assessed in the proposed program which will be managed adaptively based on empirical results.*

Ideally, sources of sturgeon hatchery production, particularly conventional broodstock, could be secured from subpopulations which would otherwise have a low probability of reproducing naturally. This would reduce hatchery-related impacts on natural production of the healthier subpopulations in the region and help preserve alleles represented in non-reproductive populations. Thus, broodstock or wild larvae from John Day or McNary reservoirs would be preferred over broodstock from Bonneville or The Dalles reservoirs. Hatchery production using John Day or McNary sturgeon actual may provide opportunities for parental contributions which might not otherwise be afforded by normal opportunities for natural production in these systems. However, source preferences must also be balanced with cost efficiencies of broodstock or larvae collection. Fish are typically easier to collect from the larger more-productive populations and attempting to capture significant numbers of fish from the smaller populations can be ineffective or cost-prohibitive.

Strategy 6. Utilize only wild-origin sturgeon for hatchery broodstock.

Only wild fish will be utilized for hatchery broodstock even after significant numbers of hatchery-origin fish reach sexual maturation in future years. Thus, the mean proportion of hatchery broodstock composed of natural-origin adults each year (pNOB) will be equal to one. Use of wild broodstock will reduce multigenerational risks of domestication in the hatchery and maximize the proportionate natural influence (PNI) for any given level of naturally spawning hatchery-origin fish (pHOS).

Strategy 7. Employ best management practices for integration of hatchery sturgeon with the natural genetic and life history diversity of wild sturgeon.

The sturgeon hatchery will be operated as an integrated program where hatchery and wild fish are managed as one gene pool. Integrated programs are intended to artificially increase the demographic size or productivity of a population, while preventing genetic divergence between the hatchery and naturally-spawning components (HSRG 2004, 2009, 2014). Minimizing domestication effects and maintaining (in hatcheries) the adaptive advantages of sturgeon populations allows selective pressures in nature to shape the genetic character of hatchery-origin fish, and benefit long-term natural population fitness (Mobrand et al. 2005). Integrated programs may be most appropriate when: a) conservation is one of the programmatic goals; or b) significant genetic and ecological interactions cannot be avoided.

Sturgeon hatchery integration practices include:

a) Using multiple broodstock and wild larvae to ensure a large effective population size;
b) Employing factorial mating strategies to optimize expression of the existing diversity;
c) Rearing maternal families separately to manage individual contributions;
d) Maintaining low rearing densities to avoid artificial selection and mortality in the hatchery;
e) Avoiding fish size, condition or health differences that might contribute to differential post-release mortality; and
f) Avoiding selective rearing or culling practices.

These practices emulate those developed for conservation aquaculture programs being implemented as part of sturgeon recovery efforts in the Kootenai River (KTOI 2010) and Upper Columbia River (UCWSRI 2013). See Section 8 for more details on implementation of this strategy.

Strategy 8. Limit hatchery impacts on wild sturgeon production by releasing only families with fewer than 10% autopolyploid individuals.

Autopolyploidy is a duplication of chromosomes which reduces long-term reproductive fitness of the offspring of affected individuals. See Section 5.3.3 for further discussion of autopolyploidy. In order to avoid reducing productivity of natural spawning sturgeon, only families with a small incidence of autopolyploidy will be released. Genetic testing will be conducted of family groups before release. Polyploidy can be purposefully created by stressing gametes at key points in the fertilization process. Hence, it is likely that the incidence of autopolyploidy can also be reduced by employing practices that avoid stress. Limits on releases of autoploidy families will be necessary until such time as research identifies causes and effective remedies.

Strategy 9. Design hatchery facilities and employ practices to minimize disease risks which might impair hatchery effectiveness or health of wild sturgeon.

Fish health is a function of both facilities and practices. Healthy fish start with effective facilities and systems – even the most careful health management practices often cannot overcome faulty facility design or inadequate systems. The hatchery design in this plan was specifically developed to optimize fish health based on experience and lessons from other sturgeon hatcheries operating in the region. Related elements include pathogen-free water source, water treatment and distribution systems, separation of spawning, incubation and juvenile rearing components, and space/water/container combinations sufficient to minimize rearing densities.

Fish health management will also be an essential consideration in all aspects of hatchery operation. Operations will be conducted according to a detailed fish health management plan (e.g., BCMA 2003) in order to:

a) prevent the introduction of exotic diseases or disease causing agents;
b) reduce the occurrence of disease in fish held in the culture facility;
c) minimize the spread of disease to stocks within and outside the facility;
d) maintain an environment that promotes the health and productivity of cultured fish and reduces the susceptibility of fish to disease;
e) protect public health and minimize disease risks to cultured and wild fish through judicious use of drugs and chemicals; and
f) provide guidance for fish health management decisions.

Plan elements will address:

a) fish health monitoring, & records,
b) water quality monitoring,

c) broodstock, larval and pre-release pathogen testing,
d) stress management procedures for handling and movement,
e) outbreak investigation and management,
f) disposal of dead fish,
g) bio-security measures including disinfection, and
h) disease treatment protocols.

To minimize WSIV disease risk, hatchery operators will test adult fish for WSIV annually and will not hold or spawn positive fish. Pathogen screening will occur at an existing lab. A separate fish pathology lab will not be developed at the hatchery. Pathology screening of current sturgeon production at Marion Drain is conducted at the USFWS laboratory at Dworshak.

A fish health plan will be specific guidance for handling of disease outbreaks including criteria preventing release. Under certain circumstances, severe outbreaks may require destruction of infected cohorts rather than release.

Strategy 10. Produce hatchery sturgeon at one primary facility and one companion facility.

Experience has demonstrated that the most efficient and cost effective approach to sturgeon aquaculture will be to conduct the majority of the program in a single facility. This will avoid costly duplication of investment in facilities and staff. At the same time, concentrating all activities in one locale also involves some level of risk to production from system problems or disease outbreaks. Different facilities and staff also inevitably provide different opportunities for sturgeon culture and different experimental treatment groups which can be particularly valuable in the implementation of an adaptive sturgeon program. This effect has been highlighted by the Kootenai sturgeon experience where splitting production between U.S. and Canadian facilities as a conservation contingency for disease or system problems was later found to result in very different performance profiles of hatchery fish following release due to size and time of release differences associated with hatchery differences. The efficacy of sharing production among separate facilities will ultimately depend on the relative costs of producing alternative treatments at a single facility versus multiple facilities.

Planning for the hatchery sturgeon program described by this plan involved a review of potential sites and identified the existing Yakama Tribal Sturgeon Hatchery at Marion Drain as the preferred location for sturgeon production. A smaller companion sturgeon facility will also be developed at the South Fork Walla Walla salmon Facility which is operated by the Umatilla Tribe.

Strategy 11. Conduct hatchery supplementation in an experimental framework that includes a strong monitoring and evaluation program, established benchmarks for the evaluation of benefits and risks, and a clear decision structure for future adaptive management.

Extensive research and experience with White Sturgeon throughout the region provides a strong foundation for planning of this hatchery supplementation program in FCRPS impoundments of the lower basin. At the same time, significant uncertainties remain with respect to the relative magnitude of hatchery risks and benefits, and larger processes driving dynamics of wild subpopulations. Monitoring and adaptive management of this program will be essential to future success. Initial stages of this program involve dedicated research and experimental evaluations of critical uncertainties and implementation alternatives including:

- relative effectiveness and efficiency of conventional broodstock and larval collection methods; hatchery contributions to natural populations and fisheries;
- age and size differences in post-release performance of hatchery fish;
- effects of increased sturgeon density on wild fish population dynamics; and
- carrying capacity limitations, and ecological interactions of hatchery sturgeon with other components of the aquatic community.

Future activities of this program will inevitably be refined based on results of these evaluations. See Section 8 of this Master Plan for a detailed monitoring, evaluation and adaptive management details associated with this hatchery program.

Strategy 12. Continue to regulate fisheries for supplemented populations to provide adequate recruitment of sturgeon to broodstock sizes in order to sustain significant natural recruitment wherever possible.

Hatchery goals involve supplementation rather than replacement of natural production. Fishery mitigation values will be optimized by the combination of both natural and hatchery production. Capacity-based fisheries might be produced by hatchery fish alone but in that case it would cost to produce fish might otherwise have obtained for free by maintaining a viable population of wild spawners. The key to protecting wild spawners will be to continue to regulate fisheries to sustain continuing recruitment of sturgeon through the fishery size slot and into the protected adult population. Effective lifetime exploitation rates will continue to be managed consistent with species optimums and past practice (see Section 9 Harvest Plan).

Strategy 13. Implement the sturgeon hatchery mitigation program in conjunction with continuing efforts to protect and restore habitat and environmental conditions suitable for natural recruitment.

Hatchery production of sturgeon is intended to augment rather than replace natural production. Hatchery production of sturgeon is regarded as an interim mitigation measure until such time as other alternatives might be developed. In the long term, FCRPS mitigation responsibilities are expected to be met by a combination of fishery optimization based on monitoring and

assessment, hatchery supplementation, and other habitat and/or passage measures as might be identified by further research and evaluation. It is also recognized that any habitat restoration measures for sturgeon must also balance competing needs for water and legal mandates including power generation, irrigation, and salmon and steelhead recovery.

5.5 PRODUCTION TARGETS

The following production targets are identified for this program based on hatchery implementation strategies described above.

Table 16. Sturgeon production targets of facilities described in the Master Plan.

	Conventional	Wild larvae
Annual releases	Columbia: ≤5,000 (Fall @ age 0+), ≤20,000 (Spring @ age 1), ≤1,500 (Summer @ age 1+) Snake: ≤5,000 (Spring @ age 1)	
Size at release	15-20 g (age 0+), 100-150 g (age 1), 250-350 g (age 1+)[a]	
Broodstock	20 per year	--
Families	50 total (2 x 5♂x5♀) 10 maternal families/ year	(many)
Eggs	≤1,000,000	--
Fry	≤150,000	≤20,000
Fish / ♀ family	Columbia: ≤2,650 Snake: 500	(few)

[a] *A random sample across available programs will be selected for each target size release.*

5.5.1 Release Numbers

Initial release targets are 31,500 juvenile sturgeon per year.[14] Of these, 26,500 are planned for release into John Day Reservoir and 5,000 total are planned for release into the lower Snake River (Ice Harbor, Lower Monumental and Little Goose reservoirs). Preference will be given to juveniles produced from wild-caught larvae to the extent feasible but the balance will come from a conventional wild broodstock program. This production level is expected to provide substantial fishery benefits given a range of likely survival rates following release (see Section 5.6 Expected Outcomes).

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[14] *The scale of net hatchery production is not planned to increase from this number under the program described by this master plan although release numbers may decrease or increase based on the effectiveness of alternative size and time release strategies. For instance, numbers will be reduced based on population monitoring which identifies reservoir rearing capacity for sturgeon or if larger individual size at release produces more cost effective hatchery contributions. Conversely, total release numbers may increase if smaller individual fish sizes prove to be cost effective and risk averse.*

Releases of this magnitude should also provide sufficient statistical sampling power to accurately assess post-release performance and adjust future production relative to program objectives (see Section 8 Monitoring & Evaluation Plan).

These releases are projected to increase sturgeon standing crop (pounds per acre) to levels comparable to current populations in The Dalles and Bonneville reservoirs (see Section 5.6 Expected Outcomes). Thus, this level of production is not expected to trigger significant ecological impacts to the wild sturgeon population or other components of the aquatic community beyond what would occur normally if John Day Reservoir provided for consistent natural recruitment. If undesirable ecological effects are not identified at this level of release, production levels may be revised in the future.

Finally, this production level can be reasonably achieved with a moderately-sized hatchery program. By way of comparison, the Kootenai sturgeon conservation aquaculture program is designed to produce 20,000 – 40,000 juveniles per year (KTOI 2010). Releases from conservation and maintenance sturgeon hatchery programs in the upper mid-Columbia and transboundary upper Columbia are smaller consistent with different objectives of those programs.

5.5.2 Release Size & Time

Production will initially be released at different sizes and times in order to determine the most cost effective approach for continuing application. Substantial time and area differences in survival have been documented among Kootenai hatchery sturgeon. Monitoring of post-release survival of hatchery sturgeon from the CRITFC sturgeon hatchery program will ultimately identify the most effective and efficient time and size of release, and subsequent production will be revised accordingly.

All juvenile sturgeon released will be externally marked by removal of a unique pattern of lateral scutes and tagging of all or a representative subsample by injection of individually-identifiable PIT tags. Tagging and marking will take place once the fish are larger than 1 oz. (30 g) in weight.

A fall release of up to 5,000 age 0+ juveniles into John Day Reservoir will also be evaluated. Release of younger, smaller juveniles would reduce the resources needed to produce a given number of fish and also reduce the period of hatchery residence and related risks of disease or domestication. However, smaller fish may not survive at the same rate as larger fish if fish released in fall are unable to forage effectively and store sufficient energy to survive the winter. However, release of younger, smaller fish might ultimately produce an equivalent or greater net benefit if higher numbers that can be produced compensates for lower survival. Releases of smaller fish might also provide larger genetic diversity and allow for randomizing net survival.

The majority of production (20,000) will be released into John Day Reservoir in spring just prior to one year of age (age 1). Spring releases should hopefully result in high survival as food resources should be abundant during the period where hatchery fish must adjust to foraging in the wild. Spring releases are also efficient from a hatchery production standpoint – it eliminates the need to hold overlapping cohorts of production from successive brood years.

A fall release of up to 1,500 age 1+ juveniles into John Day Reservoir will also be evaluated. Substantially fewer sturgeon can be produced by rearing fish through a second summer in the hatchery as large fish require much more space and water. However, lower numbers of larger fish might ultimately produce a greater net benefit if increased survival compensates for lower numbers.

A spring release of up to 5,000 age 1 juveniles is planned for the three lower Snake River reservoirs where very limited natural recruitment of sturgeon currently occurs.

All releases will include fish from each family so as to provide representative samples of the adult diversity and control for family effects, to the extent possible, relative to the parent population. The same families will be released into John Day and the lower Snake. Source populations for broodstock and wild larvae will ideally come from John Day and McNary reservoirs as described under Hatchery Strategy 5. Bonneville and The Dalles populations may also be utilized as sources of hatchery production depending on success in capturing adults and/or larvae in John Day and McNary.

5.5.3 Broodstock/Family Number

Breeding matrices and protocols have been developed to maximize effective population number and to minimize chances of future inbreeding in the wild (Anders 2004; KTOI 2010). A factorial mating strategy ensures the largest possible combination of mating pairs to maximize genetic and phylogenic diversity from the available broodstock through recombination. In the breeding plan, up to five females and five male sturgeon will be crossed. Each male will fertilize an equal portion of a female's eggs. Offspring from each mating pair form a maternal family in each spawning event, with the two 5x5 spawning events expected to occur two weeks apart during the spawning season. This mating strategy also emulates natural conditions where multiple males reproduce with multiple females. Embryos from each mated pair will be incubated separately until a critical development stage then balanced in number to ensure equal contributions from each mating whereupon they are combined to form maternal families (based on female spawner) that will be reared separately for the same purpose.

Thus, a total of 20 adult broodstock will be utilized per year to form 10 maternal families. Over the approximately 25-year generation time of sturgeon, these numbers translate into an effective broodstock number of 500 fish. An effective population size of 500 adults is equivalent to a minimum genetic population size benchmark believed sufficient to avoid loss of rare alleles and well above a benchmark of 50 spawners where inbreeding risks are believed to be high (Thompson 1991). The actual effective population size of the supplemented population will be larger because significant numbers of wild fish will also be contributing to reproduction.

Over time, the hatchery program can be expected to recapture mature adults that were used as broodstock in preceding years. Preference will be given in hatchery production to the use of adults that were not previously spawned in order to maximize the contribution of unique individuals to the hatchery-origin population. However, adults may be reused where limited

because mating of different individuals will produce different combinations of the available genetic material which may prove to be adaptive. As hatchery fish reach maturity in the wild, some may also be captured during hatchery broodstock collection (if any). Hatchery-origin fish will not be taken into the hatchery system for use as broodstock.

Ripe broodstock will be collected from tailrace spawning sites in the lower mid-Columbia as they aggregate prior to spawning. Because not all broodstock brought to the hatchery can be expected to complete maturation, more ripening adults will need to be brought into the hatchery than will ultimately be utilized for spawning. Female broodstock will be held separately from male broodstock. Once a female fish has been spawned, she is will be returned to the river where she was caught and released. Males will not be returned to the spawning waters of the river until all female fish are spawned to ensure a supply of milt.

The program also identifies the need to collect mature, non-ripe sturgeon for broodstock. Not every mature female sturgeon spawns in every year because the egg maturation cycle typically requires at least two years and one or more resting years may occur between maturation cycles. As a result, annual broodstock collection efforts typically catch significant numbers of developing but unripe females which can be expected to spawn in the following year. Because broodstock collection can be difficult and costly, these developing fish might prove a cost effective source of the next year's broodstock if their maturation cycle continues uninterrupted while fish are held over the next year in the hatchery. The program will evaluate the feasibility of this practice with overwinter holding of adults in ambient water temperatures.

5.5.4 Family Size

Factorial mating protocols of broodstock will produce a total of 50 half-sibling families per year where a family consists of the progeny of one male and one female. Each unique family will contribute approximately 530 juveniles on average for release into John Day Reservoir. Of these, approximately 5 to 18 (1.0 to 3.4%) would be projected to survive to age 25 based on a range survival assumptions know to occur in other recovery areas. A total of 10 maternal families would each contribute approximately 2,650 juveniles for release per year (26 to 90 at age 25). These family sizes should be sufficient to ensure that each parent has a reasonable opportunity to contribute offspring to the next generation but not so many as to result in an excessive contributions from any one family that might contribute disproportionately to the population genetics (i.e. genetic swamping).

Production practices will be managed to meet family size objectives within ±50% target numbers at release. This will require random culling of fish at various points in the production cycle as identified in the hatchery bio program (See Section 6). Culled fish may be sacrificed or utilized for experimentation. Some families will inevitably be slightly larger and some slightly smaller due to differences in fertilization rates and subsequent survival. It will not be necessary to standardize family sizes beyond the ±50% target levels upon release because differences are small in comparison with expected variability in post-release of families and individuals.

5.6 EXPECTED OUTCOMES

5.6.1 Abundance & Harvest (Lower Mid-Columbia River)

Future abundance and harvest of hatchery sturgeon can be projected from release numbers based on expected survival, growth, and exploitation rates. Projections include a range of values based on optimistic and pessimistic survival assumptions. The range in survival assumptions was based on rates documented for other sturgeon hatchery programs in the basin. Pessimistic projections assumed first, second, and subsequent annual survival rates of hatchery fish post-release at 10%, 75%, and 95%, respectively. These rates were based on recent estimates for Kootenai Hatchery sturgeon where Beamesderfer et al. (2014b) reported recent 5-year annual first, second, and subsequent year rates of 11%, 75% and 94%, respectively, for release from the Ft. Steele Hatchery.[15] Optimistic projections assumed first, second, and subsequent annual survival rates of hatchery fish post-release at 30%, 85%, and 95%. These rates were based on recent estimates for transboundary Upper Columbia River Hatchery sturgeon where the UCWSRI (2013) reported hatchery survival rates of 28% for the first 6 months following release and 85% thereafter. Higher or lower survival rates might occur for the lower mid-Columbia sturgeon program depending on hatchery effectiveness and environmental conditions.

In all sturgeon hatchery programs evaluated to date, a large majority of hatchery-origin sturgeon die following release (Ireland et al. 2002b; Justice et al. 2009; UCWSRI 2013; Beamesderfer et al. 2014b). The first year appears to be a period of adjustment where hatchery fish must learn to forage effectively in the wild.[16] First year survival in the Kootenai River was also size related – larger sturgeon in the release groups generally survived better than smaller sturgeon. After one or two years in the wild, survival rates are comparable to those estimated for wild sturgeon populations (Beamesderfer et al. 2014b). This effect is illustrated by Figure 36 which projects a hatchery-origin population of just 63,000 sturgeon under intermediate survival assumptions after 50 years of releases and a cumulative total release of 1.3 million fish.

Uncertainty in survival of hatchery fish following release introduces substantial uncertainty into projections of future abundance (Figure 37). Optimistic survival assumptions project a hatchery-origin population of approximately 100,000 sturgeon after 50 years. Pessimistic survival assumptions project a hatchery-origin population of approximately 30,000 after 50 years. The large differences in projections highlight the importance of post-release monitoring to estimate actual survival.

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[15] *Lower survival rates reported for the Kootenai Tribal Hatchery were not included. Ft. Steele hatchery releases of relatively large age 1juveniles during the spring are expected to be more representative of lower mid-Columbia releases than the smaller age 1+ KTOI Hatchery releases which occur in the fall.*

[16] *The monitoring and evaluation component of this program includes measures to identify causes of high first year mortality following release.*

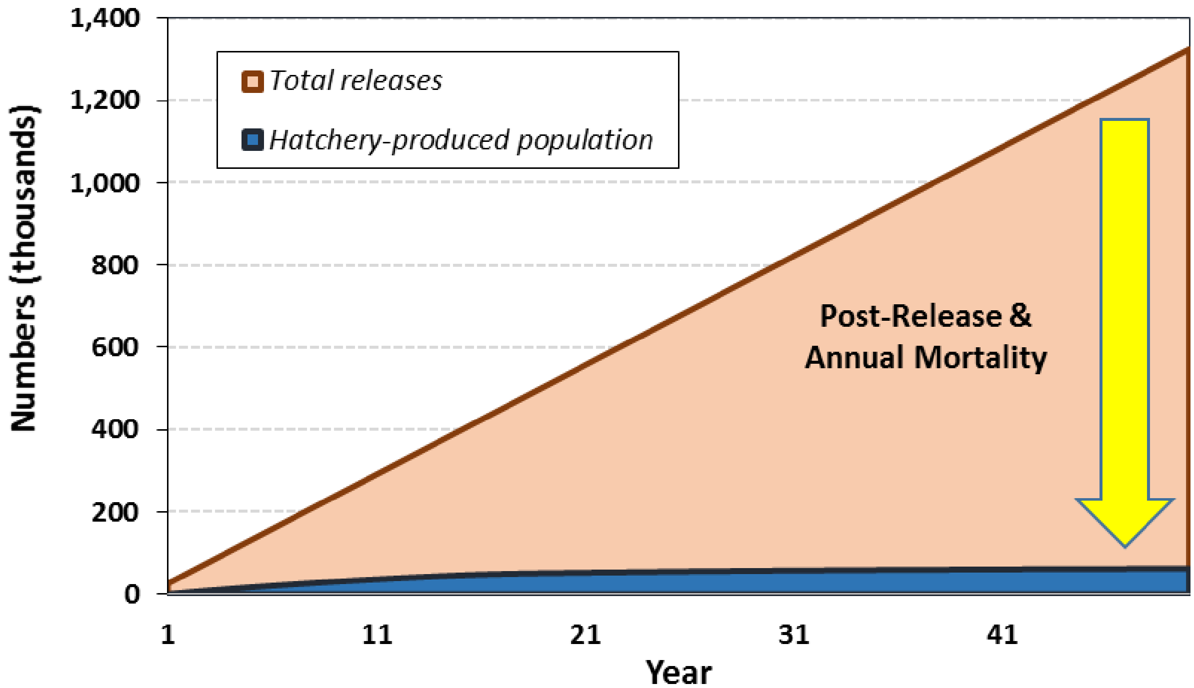

Figure 36. **Projected cumulative number of hatchery sturgeon in John Day Reservoir based on annual releases of 26,500, intermediate survival rate assumptions of 20%, 80% and 95% for year 1, year 2 and subsequent years, and annual exploitation rates of 17% in the harvestable size slot.**

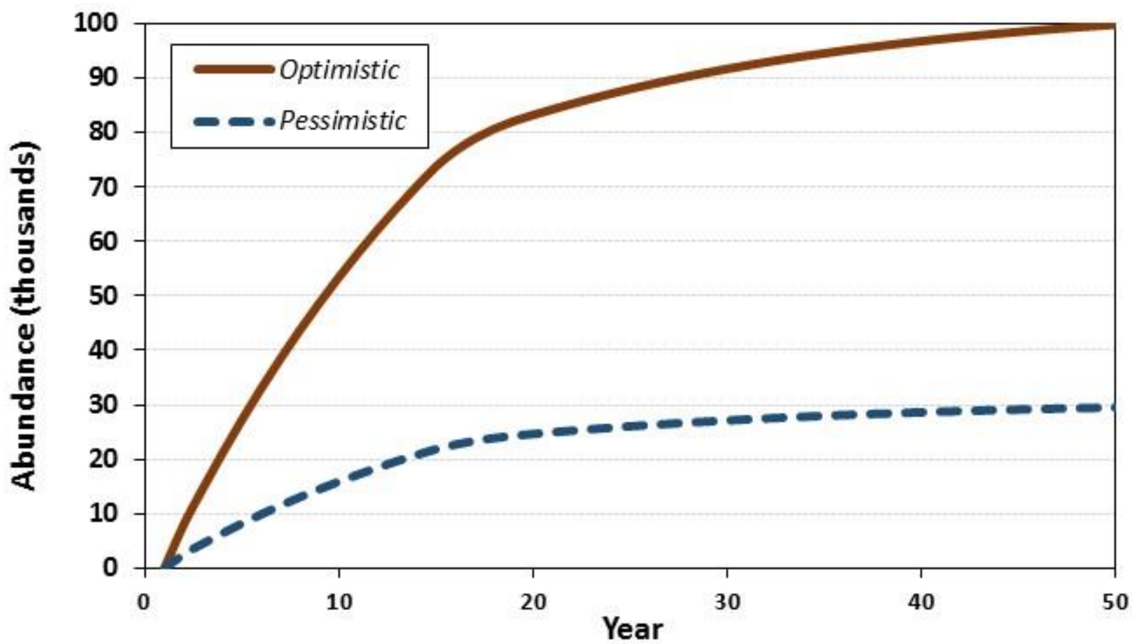

Figure 37. **Projected future abundance of hatchery-origin sturgeon in John Day Reservoir based on optimistic (30%, 85%, and 95%) and pessimistic (10%, 75%, and 95%) assumptions for survival in years 1, 2, and thereafter following release of 1.3 million sturgeon over the 50-year period. Annual exploitation rates of 17% are assumed for fish in the harvestable size slot.**

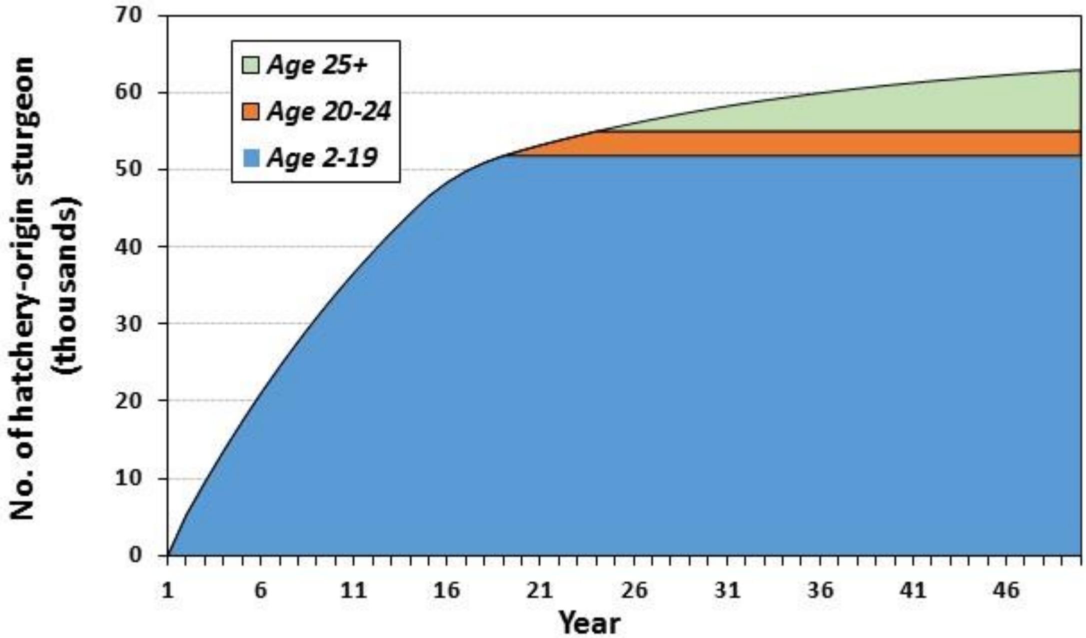

Figure 38. **Age distribution of projected hatchery origin sturgeon population in John Day Reservoir based on intermediate survival rate assumptions of 20%, 80% and 95% for year 1, year 2 and subsequent years, and objective harvest sizes and rates.**

Hatchery numbers gradually build over a long time period as fish progressively fill all age (Figure 38) and size (Figure 39) classes. Numbers eventually stabilize at an equilibrium determined by release numbers and survival rates.

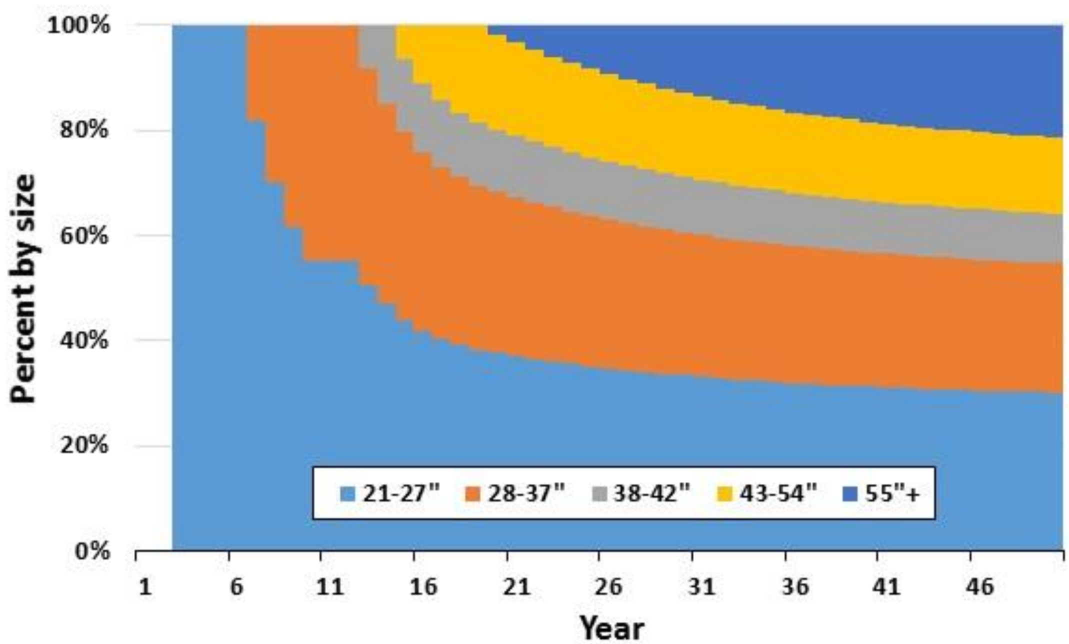

Figure 39. **Size distribution of projected hatchery origin sturgeon population in John Day Reservoir based on intermediate survival rate assumptions of 20%, 80% and 95% for year 1, year 2 and subsequent years, and objective harvest sizes and rates.**

Hatchery-origin sturgeon might ultimately comprise 7-26% of the Zone 6 sturgeon population depending on actual survival rates, if current wild numbers remain stable (Table 17). Hatchery-origin sturgeon would comprise a larger percentage of the John Day population - approximately 40-70%.[17] Proportions would be lower if wild abundance increased over time. Projected sturgeon standing crop (lb/acre) in John Day Reservoir would likely be similar to that of current subpopulations in Bonneville and The Dalles reservoirs. In both cases, fish density (number/acre) in John Day (51,900 acres) would remain substantially below that of Bonneville (20,800 acres) and The Dalles (11,100 acres) reservoirs.

Of course, carrying capacity of John Day Reservoir for sturgeon is unknown. It is particularly unclear whether deep waters in the lower half of this large reservoir will support significant use by sturgeon. Capacity will ultimately be experimentally determined based on monitoring of the distribution of hatchery fish and demographic response to increasing numbers of hatchery fish. Initial release numbers are designed in part to facilitate this evaluation and will inevitably be adjusted in the future based on monitoring results. Thus, long-term population projections, while useful for providing a context for planned production levels, must also be qualified by an expectation of future refinements to the program based on monitoring and evaluation results.

Table 17. Projected future abundance, biomass, and density of hatchery sturgeon in John Day Reservoir relative to current numbers in Bonneville, The Dalles, and John Day reservoirs after 50 years and a cumulative total release of 1.5 million fish.

	Bonneville	The Dalles	John Day		
	Wild	**Wild**	**Wild**	**Hatchery**	**Total**
Abundance[a]	220,000	110,000	40,000	30,000 - 100,000	70,000 - 140,000
Fish / acre	10.6	9.9	0.8	0.6 - 1.9	1.3 - 2.7
Biomass (tons)	900	500	430	760 - 2,580	1,190 - 3,010
lb/acre	87	90	17	29 - 99	46 - 116
Harvest / year[b]	2,200	1,300	1,500	600 - 2,040	2,100 - 3,540

[a] *Includes fork lengths 21 in (53 cm) and above. Assumes few fish will move into downstream reservoirs.*
[b] *Based on current harvest guidelines.*

Hatchery sturgeon are projected to increase annual harvest in John Day Reservoir by about 40-140%, depending on realized survival rates of hatchery fish. Harvest benefits of hatchery production are not realized until fish recruit to the harvestable size slot of 43-54 in (109–137cm) which occurs at approximately age 15 in John Day Reservoir. These estimates are based on an annual exploitation rate of 17% per year which meets the standard of a 60% effective lifetime exploitation rate using the current size slot consistent with sustainability reference points,

[17] *Equivalent to hatchery-origin spawners (pHOS) if hatchery fish spawn effectively.*

growth and natural mortality of sturgeon this population.[18] As with hatchery release numbers, harvest levels will likely be adjusted over time based on stock status, productivity and recruitment of adult sturgeon in this population.

Hatchery sturgeon are also projected to increase total numbers of adult sturgeon in John Day Reservoir by about 75-250%, depending on realized survival rates of hatchery fish. The nature of the spawner-recruitment of sturgeon is unknown. It remains to be seen whether more spawners will result in more recruitment.

5.6.2 Abundance & Harvest (Lower Snake River)

Approximately, 12,000 hatchery-origin sturgeon are projected in the three lower Snake Reservoirs under intermediate survival assumptions after 50 years of releases and a cumulative total release of 250,000 fish (Figure 40). Projected numbers range from 6,000 to 19,000 hatchery-origin sturgeon after 50 years based on pessimistic and optimistic survival assumptions project a hatchery-origin population of approximately (Figure 41). Hatchery numbers gradually build over a long time period as fish progressively fill all age classes before stabilizing at an equilibrium determined by release numbers and survival rates (Figure 42).

Hatchery-origin sturgeon might ultimately comprise 26-55% of the lower Snake River sturgeon population depending on actual survival rates, if current wild numbers remain stable (Table 18). Projected sturgeon standing crop of 31–50 lb/acre (14–23kg) in the lower Snake reservoirs would be about half of peak values observed in lower mid-Columbia Reservoirs.

Fisheries for sturgeon in lower Snake Reservoirs are currently limited to sport fisheries which are closed to sturgeon retention. Hatchery sturgeon are projected to provide the opportunity to harvest 100-340, 43-54 in (109–137 cm) FL sturgeon if the lower Snake populations are opened to sturgeon retention and managed similar to John Day Reservoir. These estimates are based on an annual exploitation rate of 17% per year which meets the standard of a 60% effective lifetime exploitation rate using the current size slot consistent with sustainability reference points, growth and natural mortality of sturgeon this population.

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[18] *See Harvest Plan in Section 9 for further explanation of effective lifetime exploitations rates. Effective lifetime exploitation rates are established consistent with Strategy 10 for ensuring adequate recruitment of broodstock to sustain significant natural production.*

Table 18. Projected future abundance, biomass, and density of hatchery sturgeon in lower Snake River reservoirs relative to current numbers after 50 years and a cumulative total release of 250,000 fish.

	Wild			Hatchery			Total		
	Ice Har.	Lo. Mo.	Lit. Goose						
Abundance[a]	4,800	4,300	6,500	5,600	-	18,800	21,200	-	34,400
Fish / acre	0.6	0.6	0.6	0.2	-	0.8	0.8	-	1.4
Biomass (t)	80	75	130	100	-	340	385	-	625
lb/acre	19	23	26	8	-	27	31	-	50
Harvest / year[b]	0	0	0	110	-	380	110	-	380

[a] *Includes fork lengths 21 inches and above. Assumes few fish will move into downstream reservoirs.*
[b] *Fishery is closed to sturgeon retention.*

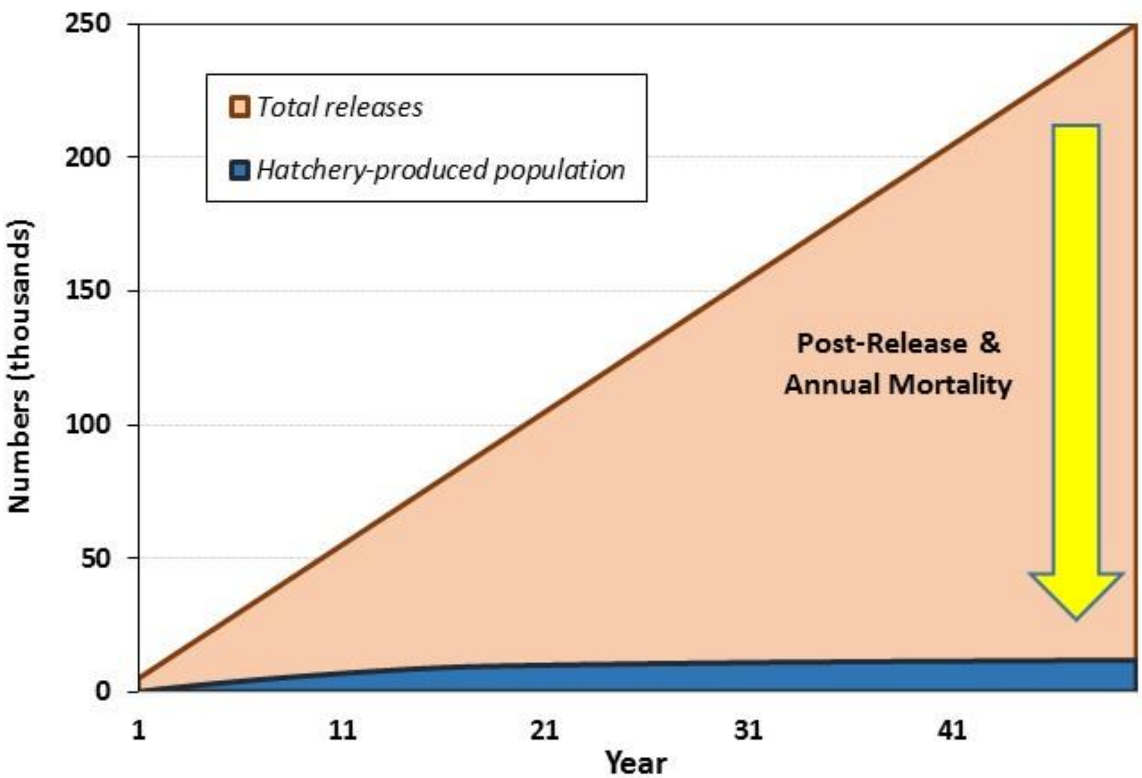


Figure 40. Projected cumulative number of hatchery sturgeon in lower Snake River reservoirs based on annual releases of 5,000, intermediate survival rate assumptions of 20%, 80% and 95% for year 1, year 2 and subsequent years, and annual exploitation rates of 17% in the harvestable size slot.

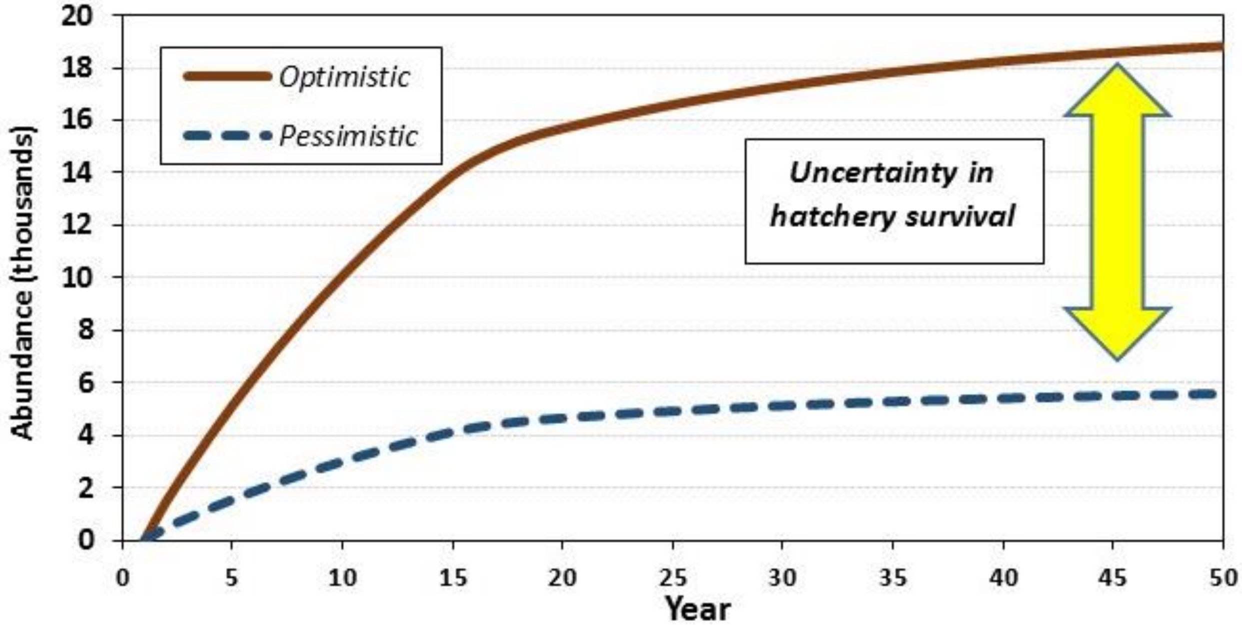


Figure 41. **Projected future abundance of hatchery-origin sturgeon in lower Snake River reservoirs based on optimistic (30%, 85%, and 95%) and pessimistic (10%, 75%, and 95%) assumptions for survival in years 1, 2, and thereafter following release of 250,000 sturgeon over the 50-year period. Annual exploitation rates of 17% are assumed for fish in the harvestable size slot.**

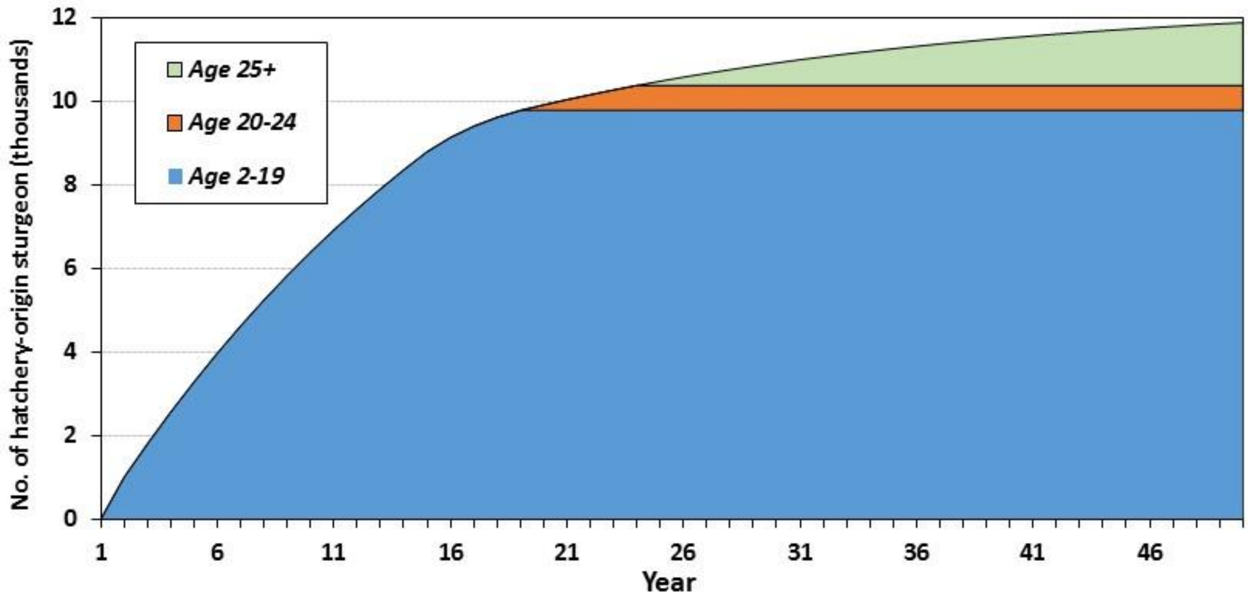


Figure 42. **Age distribution of projected hatchery origin sturgeon population in lower Snake River reservoirs based on intermediate survival rate assumptions of 20%, 80% and 95% for year 1, year 2 and subsequent years.**

5.6.3 Associated By-catch of ESA Species

Increases in sturgeon harvest as a result of the hatchery program are not expected to result in significant catch of listed species. Salmon and steelhead are rarely if ever caught during sturgeon target fisheries. It should also be noted that hatchery supplementation of sturgeon is expected to result in a limited increase in actual fishing effort and exploitation rates. Rather, success rates measured in catch per unit effort are expected to increase due to increased sturgeon abundance in supplemented subpopulations. Impacts of Indian and non-Indian sturgeon fisheries are subject to Section 7 consultations with the NMFS and take limits prescribed in Biological Opinions prepared for US v. Oregon fisheries in the mainstem Columbia River.

Sport fisheries for sturgeon occur primarily from January through June which is largely outside the migration period for salmon and steelhead. Even when salmon and steelhead are abundant, sturgeon fisheries rarely catch these species due to differences in fishing methods. (Sturgeon are caught with bait fished on the bottom, typically in the river thalweg).

Treaty commercial setline seasons target sturgeon during the winter. This fishery is open January 1–31 in all three Zone 6 reservoirs under permanent regulations. This gear does not take salmonids even when they are abundant. Treaty commercial fisheries targeting sturgeon with gillnets also occur in winter, generally beginning on February 1st and end in mid-March, or when the guideline is reached. Some Chinook, coho and steelhead may be present in reservoirs during this period but are very rarely caught because they are too small to be tangled in large mesh (8 – 10 inch stretch) gillnets used for sturgeon. Incidental catches of other species during annual stock assessment sampling with gillnets in December and January is representative of the catch composition in tribal winter gillnet fisheries for sturgeon. In John Day Reservoir in 2013-2013, the catch was 2,247 White Sturgeon, 429 Carp, 202 Channel Catfish, 15 Walleye, seven suckers, two Northern Pikeminnow and one Chinook Salmon (Parker 2015). The large majority of these were released alive.

Sturgeon retention may also be allowed in Tribal gillnet fishing seasons for salmon and steelhead in spring, summer and fall. However, in this case sturgeon harvest is incidental. Sturgeon that are otherwise released may be retained. No additional salmonid take is associated with this increased harvest of sturgeon.

Tribal subsistence seasons are open the entire year and Treaty Indian fishers may continue to take sturgeon for subsistence purposes after commercial seasons have been completed. However, most tribal subsistence harvest of sturgeon typically occurs during commercial sturgeon or salmon fisheries.

5.6.4 Consistency with Hatchery Scientific Review Group Guidance

Much of what we know regarding hatchery risks to natural fish populations comes from our long history of experience with salmon and steelhead hatcheries. CRITFC and its member tribes have expressed concerns about treatment of HSRG recommendations and criteria as specific requirements of hatchery programs. However, for the purposes of this sturgeon hatchery master plan, recommendations and criteria established by the HSRG for salmonid hatcheries are considered useful guidelines for developing a precautionary sturgeon hatchery strategy with allowances for substantial differences in life history between salmonids and sturgeon.

The planned sturgeon hatchery program is consistent with principles, conclusions and criteria developed by the HSRG for regional salmon and steelhead hatcheries (HSRG 2014), to the extent that they are applicable to sturgeon. The following sections relate program goals, objectives, strategies, and measures to HSRG guidance. Additional details may be found in other sections of this master plan.

5.6.4.1 HSRG Principles

Principle 1: Develop clear, specific, quantifiable harvest and conservation goals for natural and hatchery populations within an "All H" context.

The goals of the sturgeon hatchery program are to enhance fisheries for impounded subpopulations consistent with habitat capacity, avoid significant impacts on natural sturgeon populations and the ecosystem, and use hatchery production as an experimental tool for applied research on dynamics and limiting factors of natural sturgeon populations. Quantitative objectives consistent with these goals are identified based on increases in harvest, exploitation rates which protect natural recruitment, limitations on hatchery influence on natural subpopulations consistent with subpopulation status, and sturgeon biomass constraints. The hatchery strategy for harvest mitigation is a response to hydropower impacts on sturgeon productivity and a lack of reasonable habitat-related alternatives in the large river mainstem reservoirs.

Principle 2: Design and operate hatchery programs in a scientifically defensible manner.

Design and operation of the hatchery program is based on a series of twelve strategies identified based on an assessment of ecological, demographic, genetic and uncertainty risks. Strategies include:

1. Release hatchery-reared sturgeon in impounded reaches of the lower mid-Columbia and lower Snake rivers where natural production is not adequate to utilize the existing habitat capacity, with the primary focus on John Day Reservoir.
2. Scale and adjust release numbers to optimize sturgeon production and fishery benefits in target areas while avoiding significant, density-related, intra-specific impacts or inter-specific ecological risk.
3. Hatchery releases will occur annually and all hatchery releases will be marked to facilitate evaluations of hatchery effectiveness.

4. Use a combination of conventional wild broodstock and wild larvae collection for initial production and refine approach based on relative effectiveness and efficiency in achieving program goals.
5. Use sturgeon originating from the mid-Columbia Genetic Management Unit for hatchery production with a preference for sources with a lower probability of successful natural reproduction.
6. Utilize only wild-origin sturgeon for hatchery broodstock.
7. Employ best management practices to integrate hatchery sturgeon with the natural genetic and life history diversity of wild-spawning sturgeon.
8. Design hatchery facilities and employ practices to minimize disease risks which might impair hatchery effectiveness or health of wild sturgeon.
9. Hatchery sturgeon will be produced at one primary facility and possibly one or more companion facilities.
10. Hatchery supplementation will be conducted in an experimental framework that includes a strong monitoring and evaluation program, established benchmarks for the evaluation of benefits and risks, and a clear decision structure for future adaptive management.
11. Fisheries for supplemented populations will continue to be regulated to provide adequate recruitment of sturgeon to broodstock sizes in order to sustain significant natural recruitment wherever possible.
12. Implement the sturgeon hatchery mitigation program in conjunction with continuing efforts to protect and restore habitat and environmental conditions suitable for natural recruitment.

Principle 3: Monitor, evaluate and adaptively manage hatchery programs.

The hatchery plan includes a detailed monitoring and evaluation plan. Program success will be evaluated relative to quantitative objectives identified in the hatchery plan. Monitoring and evaluation elements include hatchery effectiveness, wild stock assessment, fisheries, hatchery optimization research, and other research on critical uncertainties with application to sturgeon restoration, mitigation and management. Results will guide development and implementation of this hatchery program in an adaptive management framework that includes an explicit decision structure for program implementation and course corrections.

5.6.4.2 HSRG Conclusions

Conclusion 1. Identify the purpose of the hatchery program in the context of an "All H Strategy" to meet resource goals over time.

The purpose of the hatchery program is harvest mitigation. The hatchery and harvest strategies are closely aligned. Hatchery benefits substantially outweigh risks which were determined to be relatively low and manageable based on a detailed risk analysis (Table 2). The hatchery strategy

was undertaken in light of substantial uncertainty in the implementation and potential effectiveness of habitat restoration or hydropower management alternatives.

Conclusion 2. For hatchery programs with a harvest purpose, manage broodstock to achieve proper genetic integration with, or segregation from, natural populations.

Sturgeon hatchery production will be managed as an integrated program where the naturally-spawning and hatchery-produced fish are considered components of a single population. The combined natural and hatchery populations will make a greater contribution to harvest than the existing habitat can sustain based on limited natural production. Integration is achieved by use of a combination of conventional wild broodstock and wild larvae collection for production. Only wild-origin sturgeon will be used for hatchery broodstock. All broodstock will come from the native genetic management unit. Best management practices to integrate hatchery sturgeon with the natural genetic and life history diversity of wild-spawning sturgeon will include large effective genetic population sizes of hatchery-origin fish, factorial mating strategies, separate rearing of maternal families, low rearing densities, and non-selective rearing and culling. All hatchery releases will be marked. Hatchery contributions to natural populations will be controlled.

Conclusion 3. The role of a hatchery program in the conservation of naturally spawning populations should be determined by the status of the population.

White Sturgeon are not threatened or endangered with extinction in the lower Columbia and Snake rivers and the hatchery is not a sturgeon conservation measure. However, the program will be managed as such in order to ameliorate risks to natural populations. Release locations and numbers are based on population status consistent with guidelines identified by the HSRG for primary, contributing and stabilizing populations identified in salmon and steelhead recovery plans. Releases of hatchery-reared sturgeon in impounded reaches of the lower Columbia and Snake rivers will occur only where natural production is not adequate to utilize the existing habitat capacity. "Primary" subpopulations where natural production is significant (Bonneville and The Dalles) will not be enhanced. "Contributing" subpopulations where natural production is impaired (John Day) will be enhanced with limits on hatchery influence on wild fish. "Stabilizing" subpopulations where natural production is minimal (Ice Harbor, Lower Monumental, Little Goose), will be enhanced with lesser constraints on hatchery contribution.

Conclusion 4. Promote local adaptation of natural and hatchery populations.

Proper integration or segregation of hatchery programs is the HSRG's recommended means for minimizing the adverse effects of hatcheries on local adaptation of naturally spawning populations. Sturgeon subpopulations are not representative of a locally-adapted metapopulation structure like that of salmon but rather replicate subsamples of a broadly-distributed historical population that has now been fragmented into reservoirs by dam construction. The significance of local adaptation and prospects for its development over time are unknown particularly given the long and overlapping generation time of sturgeon relative to salmon. However, opportunities for local adaptation of sturgeon subpopulations will be provided

by using local broodstock, avoiding transfer of hatchery sturgeon among sturgeon genetic management units, using only wild broodstock for hatchery production (pNOB = 1.0), and development of a wild larval collection as an alternative for conventional wild broodstock collection. Opportunities for local adaptation will be optimized by management of the sturgeon hatchery program to ensure a high proportionate natural influence consistent with standards recommended by the HSRG.

Conclusion 5. Minimize adverse ecological interactions between hatchery- and natural-origin fish.

Adverse ecological interactions highlighted by the HSRG include competition for food and space, predation of hatchery fish upon natural origin fish, and the potential transfer of disease from hatchery- to natural-origin fish. The potential for competition is being limited by scaling and adjusting release numbers to optimize sturgeon production and fishery benefits in target areas. Hatchery fish are being released only in areas where natural recruitment is not sufficient to utilize the available habitat. Release numbers are limited to avoid exceeding sturgeon densities documented in other reservoirs where sturgeon are productive. Population parameters including survival, growth and condition will be monitored to identify any density-related effects should they occur. Intra-specific predation among White Sturgeon is not a significant concern. Sturgeon predation on sturgeon has not been documented even in a hatchery setting where fish are concentrated and fish of disparate sizes are mixed. The adaptive management plan calls for reductions in release numbers should significant negative interactions be identified. Hatchery facilities and practices are designed to minimize disease risks which might impair hatchery effectiveness or health of wild sturgeon. Hatchery capacity is scaled to allow for relatively low density rearing to reduce disease risks. A comprehensive fish health management plan will be implemented including testing, treatment and limitations on spawning or releases of disease-positive fish.

Conclusion 6. Maximize survival of hatchery fish, consistent with conservation goals.

The HSRG recommends survival and reproductive success of hatchery releases must be high relative to those of naturally spawning populations in order to effectively contribute to harvest and/or conservation. This is particularly important for integrated programs to avoid broodstock "mining" from the natural population. It also ensures that the fewest number of hatchery fish will be released to accomplish the desired goal. Relatively high survival of hatchery vs. wild fish is virtually assured in this program where releases are limited to reservoirs where natural production is poor due to habitat or environmental limitations. Broodstock mining is much less of a concern for sturgeon in this case because: 1) wild fish in affected areas have a low probability of successful spawning in most years, 2) a small proportion of the adult population is utilized for broodstock in any one year which leaves the large majority to take advantage of favorable natural spawning conditions when they occur; and 3) the sturgeon are iteroparous and so individual broodstock will have numerous opportunities to spawn naturally during their long lives. The program is also evaluating effects of time and size of release (age 0+ in fall, age 1 in spring, age 1+ in fall) to identify the most effective strategy to optimize survival. Finally, hatchery sturgeon

will be produced at two facilities to increase opportunities to explore effective rearing practices and reduce impacts of problems affecting one facility.

Conclusion 7. Hatchery reforms increase the value of habitat improvements.

The HSRG notes that measures to restore the fitness (and therefore productivity) of naturally spawning salmon and steelhead populations are necessary to realize the benefits from investments in habitat improvements. In the sturgeon situation, fitness has not been degraded by historical hatchery production because sturgeon hatchery contributions to target populations have been negligible. In this case, sturgeon hatchery strategies are specifically designed to avoid detrimental impacts like those that have historically impaired salmon and steelhead production. The sturgeon hatchery mitigation program is being implemented in conjunction with continuing efforts to protect and restore habitat and environmental conditions suitable for natural recruitment to the extent that they are possible.

Conclusion 8. The role of science is to inform policy decisions.

The HSRG has proposed its recommendations as one solution to increase the benefits and reduce the risks associated with operating hatcheries based on experience with salmon and steelhead. The currently available science thus informs policy decisions by evaluating potential biological benefits and risks associated with alternative management actions. The HSRG framework will continue to be adapted and revised as new information becomes available from research that addresses specific questions related to hatchery reform. Sturgeon are not salmon but the sturgeon program was configured to address hatchery reform principles identified by the HSRG. Sturgeon hatchery supplementation will be conducted in an experimental framework that includes a strong monitoring and evaluation program, established benchmarks for the evaluation of benefits and risks, and a clear decision structure for future adaptive management.

Conclusion 9. Harvest reforms can complement hatchery reforms to improve harvest and better achieve conservation objectives.

The HSRG found that harvest reforms, in combination with hatchery reforms, can both increase harvest and help achieve conservation objectives. For example, mark-selective sport and commercial fisheries allow greater catches of hatchery-origin fish while reducing mortality to natural-origin fish needed for escapement and broodstock. Hatchery sturgeon will be marked but benefits of this tool will be limited for sturgeon. Mark-selective fisheries might be considered for the sport fishery but are not a realistic option for treaty tribal commercial and subsistence fisheries for cultural and policy reasons. In addition, sturgeon, are subject to multiple captures for 15 years or so before recruiting to the harvestable size slot – this is a distinct difference from salmon. Large numbers of sublegal sturgeon are typically caught and released for every legal-sized sturgeon retained. External hatchery marking of sturgeon will involve removal of a sequence of lateral scutes (e.g., five successive anterior left lateral scutes). This marking pattern could potentially be replicated by anglers and invite supplemental marking by the public which would degrade the effectiveness of the mark-selective fishery option.

Sturgeon fisheries have been successfully managed in the lower Columbia River for decades with a size slot and annual harvest limits which regulate exploitation rates of fish in the harvestable size slot based on abundance. The lower end of the slot limit allows fish to reach sizes where they provide meaningful yields. The upper end of the slot limit protects mature spawners from harvest in order to sustain natural production. Exploitation rates within the size slot are established to ensure that substantial numbers of sturgeon survive the fishery to recruit to the adult spawner population. A fishery risk of enhancement is that the harvestable population might be maintained by hatchery production even when increased harvest depletes recruitment to the adult spawner population with a corresponding reduction in natural production. In order to avoid this problem, fisheries for enhanced populations will continue to be regulated to provide adequate recruitment of sturgeon to broodstock sizes in order to protect natural recruitment wherever possible. Thus, current exploitation rates within the harvestable size slot will be maintained to avoid overfishing of naturally-produced fish. Total harvest of enhanced populations will increase because combined abundance of harvestable fish will increase with the addition of hatchery fish. Total recruitment of sturgeon to the adult spawning portion of the population will also increase as a result of hatchery enhancement (although the proportionate natural influences will continue to be regulated consistent with outcomes of HSRG criteria).

5.6.4.3 Criteria

The HSRG has recommended a set of standards for managing fitness loss in natural salmon and steelhead populations due to hatchery influence. The proposed sturgeon program achieves the effective outcomes defined by HSRG standards based on natural population status and measured by proportionate natural influence with considerations for differences in salmonid and sturgeon life history.

The HSRG modeled long-term fitness using a quantitative genetic model described by Ford (2002) and implemented in the "All-H Analysis" Model (AHA) (HSRG 2004, 2009, 2014). This model involves the following parameters:

Fw = <u>relative fitness</u> of the wild population (expressed as a proportion of wild phenotypic mean).

PNI = <u>proportionate natural influence</u> of the wild environment on the mean phenotypic values and genetic constitution of the wild population.

pHOS= <u>proportion of hatchery-origin spawners</u> in the wild population.

pNOB= <u>proportion of natural-origin broodstock</u> in the hatchery population.

Mean relative fitness of the wild population declines with decreasing PNI (Figure 43). This functional relationship has been supported by the HSRG with empirical information on the relative reproductive success of hatchery and wild salmon and steelhead (HSRG 2014). PNI in turn is a function of pHOS and pNOB (Figure 44). PNI decreases with increasing pHOS and decreasing pNOB. Different combinations of pHOS and pNOB may produce similar PNI's and similar values of mean relative fitness.

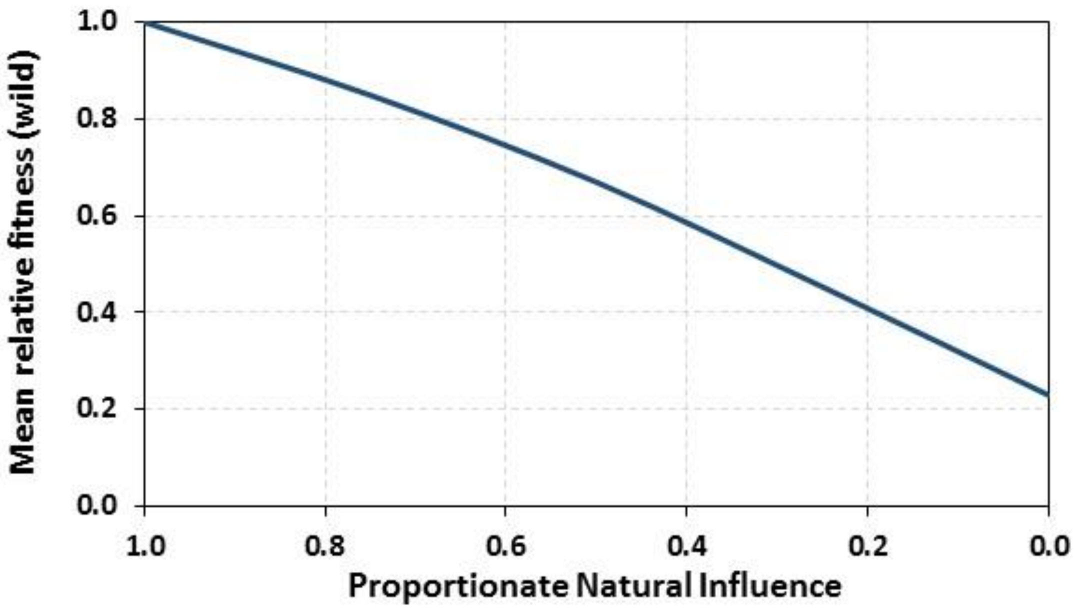


Figure 43. **Relationship between mean relative fitness (Fw) of a wild salmon or steelhead population and proportionate natural influence (PNI) identified by the HSRG as a basis for recommended criteria for hatchery influence (HSRG 2009). Values were estimated as per HSRG (2009) appendix A1 equation 12 and Figure 11 as reflected by values in HSRG (2014) Table 3-2.**

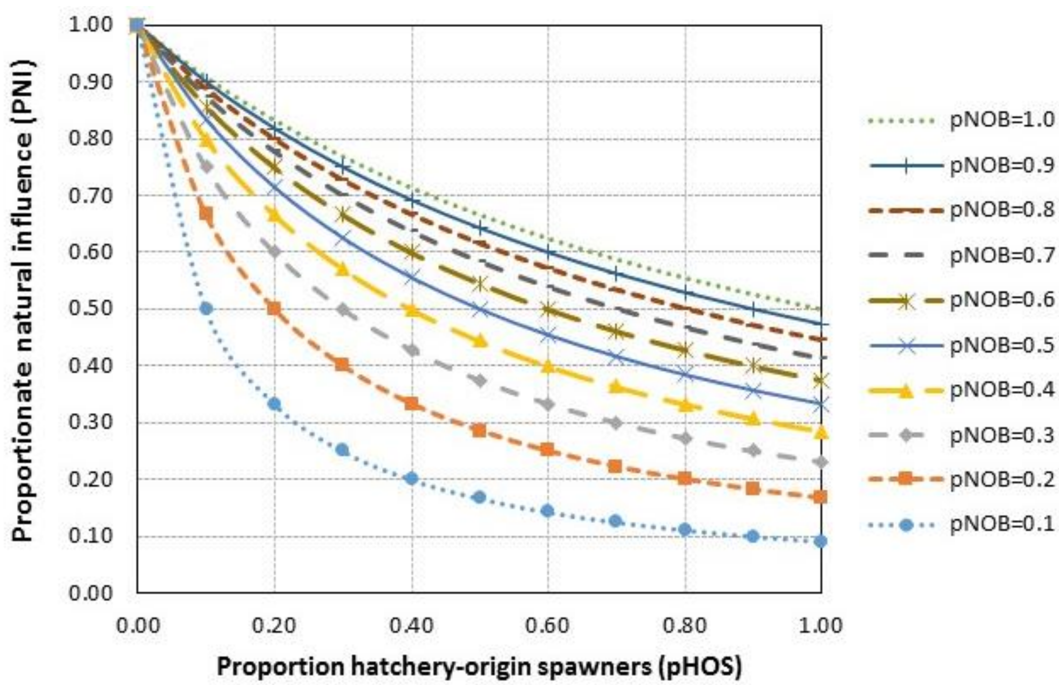


Figure 44. **Proportionate natural influence for wild fish (PNI) as a function of the proportion of naturally spawning fish composed of hatchery adults (pHOS) and the mean proportion of hatchery broodstock composed of natural origin fish (pNOB) where PNI = [pNOB/(pNOB + pHOS)] as described by the HSRG (2009, 2014).**

Based on model relationships and assumptions, the HSRG identified criteria for hatchery influence in relation to population status and priority designations identified in salmon and steelhead recovery plans (Table 19). Criteria were identified for both integrated and segregated populations – only integrated population criteria are applicable to this sturgeon program. Standards for hatchery influence progressively decrease from primary to contributing to stabilizing populations. Criteria were established for PNI, pHOS and pNOB in primary and contributing populations. Specific quantitative criteria were not established for stabilizing populations. Current operating conditions were considered adequate to meet conservation goals for stabilizing populations as long as no further decline in status occurs.

Table 19. HSRG criteria for salmon and steelhead hatchery influence for integrated populations based on population recovery designation (HSRG 2009, 2014).

Population	PNI	pHOS	pNOB	Fitness
Primary	≥ 0.67	< 0.30	≥ 2 pHOS (i.e. 0.60)	0.83
Contributing	≥ 0.50	< 0.30	> pHOS (i.e. 0.30)	0.67
Stabilizing	na	na	na	Na

na = not applicable.

Table 20 shows projected sturgeon numbers from planned releases for HSRG standard metrics. Numbers are based on projections from a range of survivals following release of hatchery fish, reflecting uncertainty in adaptation to natural conditions based on experience in upper Columbia and Kootenai sturgeon hatchery programs. Numbers also reflect risk-based sturgeon hatchery implementation strategies including use of only wild broodstock (pNOB = 1.0).

Table 20. Projected sturgeon population numbers with enhancement based on HSRG standards. Values consistent with HSRG standards are highlighted in green.

	Population	Designation	Releases	PNI	pHOS	pNOB	Fitness
Columbia	Bonneville	Primary	--	1.0	0	0	1.00
	The Dalles	Primary	--	0.95	<5%[a]	1.0	0.99
	John Day	Contributing	26,500	0.6 - 0.7	0.4 - 0.7[b]	1.0	0.76 - 0.85
	McNary	Contributing	--	0.95	<5%[a]	1.0	0.99
	Combined	--	26,500	0.8 - 0.9	0.1 - 0.3	1.0	0.89 - 0.97
Snake	Ice Harbor	Stabilizing	5,000	0.6-0.8	0.3-0.6	1.0	0.80 - 0.89
	L. Monumental	Stabilizing					
	Little Goose	Stabilizing					

[a] *Small numbers of hatchery fish are expected to move into the population from program releases in upstream reservoirs.*

[b] *Outcomes are consistent with the HSRG standard reflected in PNI and corresponding fitness effects even though specific pHOS criteria embedded in the criteria are not met for this population.*

Bonneville Reservoir: No hatchery sturgeon will be released into the Bonneville population where natural recruitment is significant and the carrying capacity of the available habitat may be filled. Straying of hatchery sturgeon from John Day Reservoir past two dams into Bonneville Reservoir is expected to be negligible, so the Bonneville sturgeon population readily meets the HSRG standard for a primary population.

The Dalles Reservoir: No hatchery sturgeon are planned for release into The Dalles population at this time. Small numbers of hatchery fish may be expected to move from John Day Reservoir into The Dalles Reservoir based on wild population movement patterns identified in ongoing mark-recapture studies. Resulting pHOS in The Dalles is not expected to exceed 0.05 which translates into a PNI of 0.95 based on the pNOB of 1.0 in the sturgeon hatchery program. The Dalles numbers readily meet the HSRG standard for a primary population.

John Day Reservoir: Most sturgeon hatchery releases will occur in John Day Reservoir where the pHOS will gradually increase to a projected 0.4 - 0.7 over the next 25 to 50 years as hatchery fish are gradually recruited into the adult population. These pHOS values exceed HSRG criteria for a contributing population (0.30). However, the HSRG PNI standard (≥ 0.5) for a contributing population is readily met with projected values of 0.6 to 0.7 based on the sturgeon hatchery pNOB of 1.0 (Figure 45). In fact, the John Day sturgeon PNI is projected to be similar to that of a primary population. ***Therefore the sturgeon hatchery program produces outcomes in John Day consistent with the HSRG standard reflected in PNI and corresponding fitness effects even though it does not meet specific pHOS criteria embedded in the criteria. This result is due to differences in sturgeon and salmonid life history upon which the HSRG standard is based (Box 2).***

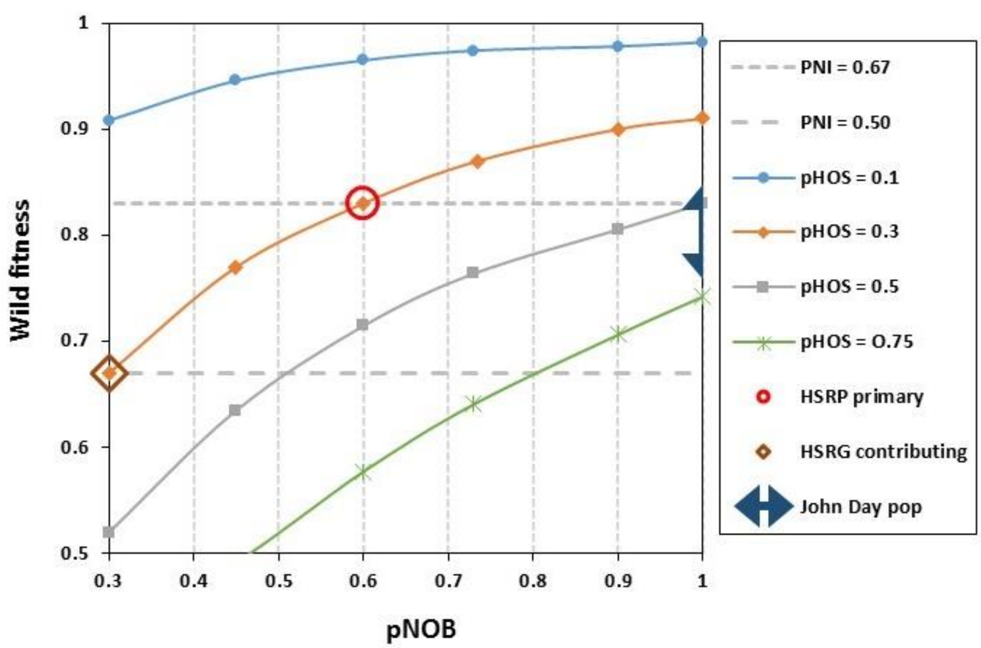


Figure 45. Relationship of wild population fitness to proportion hatchery origin spawners (pHOS) and proportion (pNOB) based on relationships reported in HSRG (2009).

Box 2. Sturgeon vs. salmonid life history differences in application of HSRG hatchery criteria.

Application of HSRG criteria for hatchery influence on wild fitness must consider the substantial differences in salmonid and sturgeon life histories.

HSRG criteria for salmonids assume limitations for pNOB in order to control demographic impacts on natural production from use of natural-origin fish for hatchery broodstock (HSRG 2009, Appendix A1, p. 16). For salmonids, it is not realistic for pNOB to exceed pHOS by one (contributing) or two (primary) times when pHOS is substantially greater than 0.3 in order to achieve a PNI of 0.5 to 0.67 or more. Higher pHOS would require substantial mining of the natural broodstock to support the higher pNOB needed to produce a high PNI. Broodstock mining would substantially reduce spawning escapement of natural-origin fish which would reduce population viability as well as subsequent recruitment needed to produce sufficient returns to support both the natural and hatchery population. Therefore reducing pHOS is a much more effective and efficient method of increasing PNI for salmonids than increasing pNOB (HSRG 2009). Thus, the HSRG identified pHOS and pNOB criteria for salmonid in addition to the overarching PNI criteria.

For sturgeon, the same limitations on pHOS do not apply due to differences in life history from salmonids. Broodstock mining is not a significant concern or a constraint for sturgeon on pNOB and by extension pHOS. pNOB remains an effective and efficient means of maintaining a high PNI for sturgeon at pHOS values greater than 0.3. Where the salmonid hatchery strategy must achieve a high PNI by limiting pHOS, the sturgeon hatchery strategy can achieve a high PNI by maximizing pNOB. The long life span and large size of sturgeon results in high female fecundity which allows for substantial hatchery production from a relatively small number of broodstock in any one year. The large majority of natural spawners remain in the wild to spawn naturally during any given year. Further, because the long-lived and iteroparous sturgeon spawn multiple times over their lifetime, use of wild fish for hatchery broodstock in one year does not preclude their opportunity for genetic contribution to natural production during the rest of their life.

Even though annual broodstock numbers are relatively small, the delayed maturation and resulting long generation time of sturgeon (25 years) allows for a large effective population size of hatchery-origin fish. For instance, 20 broodstock per year for 25 years will produce an effective hatchery-origin population size of 500 fish which meets established rules of thumb for numbers needed to avoid inbreeding depression and loss of genetic diversity.

The essential goal of the HSRG criteria is to maintain a high PNI. Embedded pHOS criteria are a means of getting there given the constraints of salmonid life history. Because the sturgeon life history allows for a very high pNOB (1.0) in the hatchery without substantial viability or production tradeoffs like those seen in salmonids, desired PNI values can be achieved for sturgeon with a substantially higher pHOS than is feasible for salmonids.

McNary Reservoir & Hanford Reach: No hatchery sturgeon are currently planned to be released into the McNary population. Small numbers of hatchery fish may be expected to move from the lower Snake into McNary based on wild population movement patterns identified in ongoing mark-recapture studies. Corresponding pHOS in McNary is not expected to exceed 5% which translates into a PNI of 0.95 based on the pNOB of 1.0. McNary numbers readily meet the HSRG standard for a contributing population. It remains to be seen if significant numbers of hatchery sturgeon released into upper mid-Columbia reservoirs by PUD mitigation programs will move downstream into McNary. PUD sturgeon are being marked and periodic stock assessments in McNary will estimate the incidence of these marked fish.

Combined Lower Mid-Columbia River Reservoirs: Sturgeon values easily meet the most conservative HSRG integrated population standards where the entire lower mid-Columbia sturgeon population is considered to be the aggregate of Bonneville, The Dalles, John Day and McNary populations. Sturgeon subpopulations are basically replicated subsamples from the unimpounded historic population rather than locally-adapted populations within a metapopulation structure as is the case with salmonids. As a result, some might argue that an aggregate analysis is a more appropriate way to view the sturgeon genetic management unit. In an aggregate analysis, pHOS of approximately 0.07 – 0.26 at a pNOB of 1.0 produces a PNI on 0.79 – 0.93 and a relative fitness of 0.89 – 0.97. These values meet the HSRG primary population standard of <0.30 for pHOS, pNOB > 2 pHOS, and PNI > 0.67.

Lower Snake River Reservoirs: Modest numbers of hatchery sturgeon are planned to be released into Ice Harbor, Lower Monumental, and Little Goose. These reservoirs support small populations of sturgeon dominated by large fish due to very low natural recruitment. These sturgeon populations are analogous to stabilizing populations identified for salmonids in ESA recovery plans although they do not represent unique, locally-adapted populations. A substantial portion of these populations may consist of adult fish that pre-date dam construction which is only a couple sturgeon generations removed from the present time. Specific quantitative criteria are not identified by the HSRG for stabilizing populations although existing conditions were recommended to be maintained. Existing conditions for lower Snake River sturgeon populations are characterized by chronic failure of natural recruitment. Fishery enhancement with hatchery sturgeon will result in 30 to 60% of the adult population to be comprised of hatchery-origin fish. However, risks to natural production and the lower mid-Columbia genetic management unit are nominal because natural production is already greatly impaired. As a result, these reservoirs are an ideal location for fishery enhancement.

5.7 Consistency with NPCC Fish and Wildlife Program

5.7.1 Fish & Wildlife Program Scientific Principles[19]

Principle 1. Healthy ecosystems sustain abundant, productive, and diverse plants and animals distributed over a wide area.

White Sturgeon have adapted over eons to thrive in large, diverse, and dynamic rivers like the Columbia and Snake. These fish ranged widely throughout these systems to utilize seasonally diverse and widely-distributed food and habitat resources for feeding, spawning, rearing and maturation. Dam construction has blocked movement and created a series of sturgeon subpopulations in reservoir and river reaches that may no longer provide the full spectrum of habitats necessary for sturgeon to consistently complete their life cycle. Distribution, abundance, productivity and diversity of White Sturgeon has been substantially reduced by loss of the connectivity and function of the healthy, historical riverine ecosystem. The primary purpose of the sturgeon hatchery program is to provide fishery mitigation for these effects. However, program objectives also include protection and conservation of natural populations, production and ecosystems. Hatchery supplementation is expected to increase distribution and abundance throughout the historical range of this species. Supplementation might also increase diversity and productivity of depleted subpopulations by stabilizing abundance and increasing the effective population size of the naturally-spawning population. At the same time, hatchery supplementation of sturgeon will be limited to levels which do not pose substantial risk to other components of the ecosystem in comparison with current numbers and densities of sturgeon observed in more productive sturgeon population of the Columbia River.

Principle 2. Biological diversity allows ecosystems to adapt to environmental changes.

Recognizing that natural disturbance and change are part of every ecosystem, this program focuses on mitigating the effects of unnatural change. The long evolutionary history of sturgeon attests to the adaptive plasticity and potential of the species. The sturgeon hatchery program production and practices are designed specifically to protect and propagate the diversity inherent in impounded subpopulations of White Sturgeon by use of an integrated hatchery-wild production strategy. Related measures include utilizing fish only from the target genetic management unit; using only wild origin fish to avoid domestication; using multiple broodstock and wild larvae to ensure a large effective population size; employing factorial mating strategies to optimize expression of the existing diversity; rearing maternal families separately to manage individual contributions; maintaining low rearing densities to avoid artificial selection and mortality in the hatchery; avoiding fish quality differences that might contribute to differential post-release mortality; and avoiding selective rearing or culling practices. Maintaining a broad

[19] The 2014 Fish and Wildlife Program distilled the eight principles identified in previous programs into six.

spectrum of genotypic and phenotypic diversity will be essential for providing the raw material by which impounded sturgeon can optimize viability and production in these altered systems.

Principle 3. Ecosystem conditions affect the well-being of all species including humans.

Hatchery sturgeon will help maintain significant sturgeon populations and sturgeon fisheries throughout their historical range including lower mid-Columbia and lower Snake impoundments where natural recruitment is limited by the interactions of spawning/incubation habitat availability and water regulation. Sturgeon will be maintained as a significant component of the aquatic ecosystem. Ecological risks were identified in the hatchery risk assessment which is the basis for production strategies and design. Hatchery production levels and release locations are specifically designed to maintain sturgeon population levels within the range of densities documented within the region and to avoid substantial risk to other components of the ecosystem. A robust monitoring and evaluation is identified in order to continue to assess the potential for ecosystem risk.

Principle 4. Cultural and biological diversity is the key to surviving changes.

Physical and biological diversity is the foundation of population and ecosystem function and viability. Preserving genetic diversity and phenotypic variability of sturgeon in an integrated hatchery program can help perpetuate the range of genetic and life history expressions that co-evolved with historical ecological regimes in the lower mid-Columbia and lower Snake rivers in the interim while critical ecosystem-based habitat limitations may be addressed. This hatchery program is part of a comprehensive strategy for sturgeon conservation, restoration and management with a long-term goal of restoring viable sturgeon populations and fisheries in the lower mid-Columbia and lower Snake river reservoirs. Sturgeon fisheries are also a key component of the regional culture that includes tribal and non-tribal fisheries.

Principle 5. Ecosystem management should be adaptive and experimental.

This program includes a robust monitoring and evaluation component that includes metrics related to the sturgeon function and role in the ecosystem. This plan also identifies related test hypotheses and decision points and pathways for implementation in an adaptive framework. An adaptive approach involving testing and evaluation of restoration alternatives is essential for this program due to the substantial uncertainties in sturgeon populations and ecosystem dynamics. Presently, much remains unknown regarding existing habitat and/or flow limitations in the impounded reaches, and the effect of these limitations on sturgeon carrying capacity, spawning success, age-0 survival, and etcetera. This project aims to gain information needed to better understand these limitations and restore significant natural sturgeon populations throughout the impounded lower mid-Columbia and lower Snake rivers.

Principle 6. Ecosystem management can only succeed by considering people.

People, or more specifically people involved in fishing for sturgeon, are central to the mitigation goal of this sturgeon hatchery program. Development of a sturgeon conservation, restoration and mitigation program has involved extensive collaboration among tribal and state partners which will be essential for the long-term success of this effort.

5.7.2 Fish & Wildlife Program Strategies

The 2014 Fish and Wildlife Program identifies a series of strategies for achieving basin wide goals and objectives. Relationships to these strategies must be addressed by the hatchery plan. Strategies include:

A. *<u>Ecosystem Function</u>: Protect and restore natural ecosystem functions, habitats, and biological diversity wherever feasible consistent with biological objectives in the program.*

The sturgeon hatchery program addressed by this master plan addresses a number of related sub-strategies identified by the Council Program.

<u>Habitat</u>: The draft 2014 NPCC Fish and Wildlife Program calls for investigation of site-specific habitat measures for sturgeon such as substrate enhancement and channel restoration as viable alternatives for improving natural recruitment in some areas. The basin-wide sturgeon framework calls for implementing experimental habitat restoration measures to address limiting factors for White Sturgeon where appropriate (Beamesderfer & Anders 2013). However, site-specific habitat measures have not been identified, planned or implemented for lower mid-Columbia or lower Snake sturgeon subpopulations owing to uncertain benefits and the difficulty of implementation in a large mainstem river system (see Section 2.3.5 Habitat Restoration). The sturgeon hatchery is mitigation for FCRPS habitat impacts in the interim until such time as effective measures might be developed.

<u>Strongholds</u>: The strongest sturgeon population in the region is found in the lower Columbia downstream from Bonneville Dam. Upstream from Bonneville Dam, self-sustaining and relatively abundant sturgeon populations are found in Bonneville Reservoir and in the Snake River between Lower Granite and Hells Canyon dams. The lower mid-Columbia is sturgeon hatchery program is designed to avoid impacting these strong populations. Hatchery releases will be concentrated in John Day Reservoir which is three dams removed from the lower Columbia population and two dams removed from the Bonneville Reservoir population. The intervening reservoirs provide a buffer for any hatchery sturgeon who might migrate be entrained downstream. Monitoring of sturgeon in The Dalles and Bonneville Reservoir will quantify any downstream movement and provide a basis for adjustments in hatchery production or practices as appropriate. In the Snake River, no hatchery releases are contemplated by this program upstream from Lower Granite Dam.

<u>Predator control</u>: As top-level predators, the diet of adult sturgeon can include salmon and steelhead and other native fish species such as lamprey. Corresponding predation rates by sturgeon will be managed and controlled by limiting hatchery releases to avoid producing sturgeon densities that substantially exceed those of naturally-produced populations in stronghold populations. Both natural and hatchery sturgeon will benefit from predator control actions on native and non-native predatory fish species, Double-crested Cormorants, and marine mammals such as California and Steller sea lions.

<u>Water Quality</u>: Natural production of sturgeon will benefit from Council efforts to provide flows and habitat conditions of adequate quality and quantity for improved survival of anadromous

and native resident fish populations at and between hydroelectric facilities on the mainstem Columbia/Snake Rivers. The sturgeon hatchery is mitigation for FCRPS habitat impacts.

Climate change: Climate change may impact fish and wildlife populations and mitigation and restoration efforts implemented under the program in the Columbia River Basin (ISAB 2007). Specific effects and corresponding White Sturgeon responses to climate change are currently not well understood (Beamesderfer & Anders 2013). Climate change might potentially impact natural productivity of sturgeon populations through impacts on spring runoff and seasonal temperature patterns. Natural recruitment among impounded populations is positively correlated with spring flow. Hence, reductions in winter snow pack associated with climate change would be expected to reduce the frequency and magnitude of natural recruitment in many areas. Like all cold-blooded creatures, sturgeon reproduction, growth, maturation, and survival is strongly related to water temperature. Changes in temperature patterns associated with climate change can have complex effects. The Council highlights the need to evaluate fish and wildlife investments and their ability to perform in the face of future climate conditions. Sturgeon hatchery production is intended provide mitigation for FCRPS effects on natural sturgeon production. The utility of sturgeon hatchery production is more likely to increase than decrease in a future with climate change. Consequently, investments in sturgeon hatchery production will continue to pay substantial dividends.

Mainstem hydrosystem flow and passage operations: Natural sturgeon production will benefit from continuing efforts to manage dams and reservoir operations to protect and restore ecosystem function and habitat (see Section 2.3.4 Flow Augmentation). However, specific flow measures have not been implemented for lower mid-Columbia or lower Snake sturgeon subpopulations owing to uncertain benefits and the difficulty of implementation in a large mainstem river system.

Similarly, a variety of passage-related activities are currently in some stage of consideration or development but passage improvements are not expected to provide significant improvements in current sturgeon production in the near term (see Section 2.3.2 Passage). The sturgeon hatchery is mitigation for FCRPS habitat impacts in the interim until such time as effective measures might be developed.

Estuary: Sturgeon historically ranged freely between riverine, estuary, and nearshore ocean habitats. The estuary currently supports high levels of sturgeon abundance and productivity during portions of the year including summer when large numbers of fish congregate to take advantage of seasonally abundant food resources. Loss of access to productive estuary and marine habitats has had a substantial impact on impounded sturgeon subpopulations which must rely on local resources which are often limited. In addition, sturgeon populations with continuing access to productive areas downstream from Bonneville Dam can no longer migrate upstream into high energy areas which historically protected spawners from sea lion predation. Because of migration barriers, restoration of ecosystem function will not benefit impounded sturgeon populations but hatchery supplementation will mitigate, at least in some measure, for the loss of access to estuarine resources by impounded sub-populations.

B. **<u>Hatcheries:</u> The Council supports using hatcheries as a tool to help meet the mitigation requirements of the Northwest Power Act. The Council also acknowledges the commitments made by federal, state, and tribal governments in other laws, and in on-going court cases, including U.S. v Oregon.**

The Council identifies three potential strategies for hatchery programs including segregated, integrated and reintroduction. The sturgeon hatchery program addressed by this master plan is an integrated production approach which is designed to contribute harvest opportunities while complementing habitat improvements by providing a demographic boost for native populations well within the sustainable carrying capacity of the habitat which will be determined experimentally by monitoring sturgeon population parameters in response to increasing abundance. This program also addresses specific commitments among federal, state and tribal governments in the Columbia River fish management plan and related agreements under *U.S. v. Oregon*.

Hatchery production practices are designed to match and maintain the genetic and life history diversity of the target subpopulations. Habitat and natural influences will continue to drive the life history fitness of the composite population which includes a number of subpopulations where hatchery influence is absent or minimal. Fish production is projected to fall well within the carrying capacity of the habitat as judged by adjacent populations where natural recruitment is significant. Adverse ecological interactions including density dependence, straying, predation and disease will be minimized by production levels and practices. Impacts will be subject to monitoring. All hatchery fish will be visibly marked in order to evaluate their status and effects. Hatchery-origin fish are expected to reproduce naturally in suitable habitat and conditions. The program's adaptive management plan includes off-ramp for modifying or eliminating hatchery production in the event monitoring and evaluation demonstrates that conditions suitable for significant natural production have been effectively restored.

C. **<u>Other Strategies</u>: Wild fish, anadromous fish in blocked areas, resident fish mitigation, sturgeon, lamprey, and eulachon.**

The sturgeon hatchery program addressed by this master plan addresses a number of related strategies.

<u>Wild fish</u>: Protection of wild sturgeon is an explicit objective of the program. Hatchery implementation strategies include specific direction for actions required to protect wild fish from potentially detrimental impacts of hatchery selection, ecological and/or fishery impacts. Hatchery supplementation will bolster distribution and abundance of unproductive sturgeon populations in focal impoundments which may, in turn, improve productivity and diversity over the long term. Hatchery fish will also provide an experimental tool for applied research on limiting factors, habitat capacity, broodstock limitations, population parameters, and immigration/entrainment in natural populations. This research could well be the key to the identification and implementation of effective habitat restoration measures for sturgeon in the future.

Anadromous fish mitigation in blocked areas: The related council strategy typically focuses on mitigation for anadromous salmon and steelhead in areas upstream from impassable dams. However, because all mainstem dams block movements of all but a small number of sturgeon, this strategy might be considered applicable to sturgeon throughout the basin. In that case, the sturgeon hatchery program will directly mitigate for anadromous sturgeon migration blockage by producing fish for harvest opportunities for this species.

Resident fish mitigation: Sturgeon upstream from Bonneville Dam no longer have access to marine waters and can now be considered a resident species. The hatchery program provides fishery mitigation for sturgeon in place, in kind. This meets the highest priority for resident fish mitigation identified by the Council (weak but recoverable native populations affected by the hydropower system). Hatchery fish will also provide an experimental tool for applied research on factors limiting wild subpopulations which is consistent with mitigation principles that include projects to identify or resolve data gaps.

Sturgeon: A sturgeon hatchery is one of a suite of implementation actions specifically identified as alternatives for increasing abundance and survival of White Sturgeon as well as improving understanding of how development and operation of the FCRPS affect sturgeon. As directed by the Council's sturgeon strategy, this sturgeon mitigation program is being implemented to complement ongoing monitoring, research, habitat actions, dam operations and passage, adaptive management, natural production, collaboration, coordination, and evaluation activities.

As directed by the Council, this sturgeon hatchery is a mitigation strategy to supplement populations where natural recruitment is currently severely limited. The strategy is conservative and responsible in establishing protocols for source populations and numbers of hatchery fish released. Although the program is primarily for fishery mitigation purposes, it has been designed based on sturgeon conservation principles and practices based on knowledge gained from ongoing hatchery efforts in other areas including the Kootenai and upper Columbia rivers. The program is employing experimental hatchery releases and monitoring to assess ecological factors and population productivity limitations. The program is also designed around an experimentally adaptive approach to optimize hatchery production and practices consistent with monitoring natural production and environmental carrying capacity.

D. Adaptive Management: The Council is committed to an adaptive management approach that uses research and monitoring data to understand, at multiple scales, how program projects and measures are performing, and to assess the status of focal species and their habitat.

This sturgeon hatchery program is designed around a "true" or active adaptive management strategy involving a systematic, rigorous approach for learning through designing management

actions as experiments.[20] True adaptive management is an appropriate strategy when uncertainty is high, risks are acceptable or reversible, and answers can be obtained in a reasonable time frame (Marmorek 2011). This involves a structured, iterative process designed to support optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time by learning via experimental management and system monitoring as originally conceived by Holling (1978) and Walters (1986) and reiterated by Ludwig and Walters (2002). Implementation of this strategy involves a robust monitoring and evaluation component involving explicit test hypotheses, quantitative benchmarks, checkpoints and a decision pathway for program adjustments.

E. <u>Public Engagement</u>: On an ongoing basis, the Council will educate and involve Northwest citizens to develop, implement, and improve understanding of the fish and wildlife program and the Council, and to promote successful ecosystem management.

This hatchery plan has been developed following an extensive collaborative planning process to complete a comprehensive strategic plan for sturgeon conservation, restoration and management throughout the basin. The planning process also involved four regional workshops as detailed in section4.8.2. This process involved regional, tribal, state, and Federal management entities. Broader public review of hatchery-related measures identified in this master plan will be completed as part of normal public involvement processes by respective entities as well as the NEPA review that will occur under the 3-step Master Planning process.

5.7.3 Artificial Production Policies

1. The manner and use of artificial production must be considered in the context of the environment in which it will be used.

Artificial production of sturgeon is consistent with current ecological conditions in the lower mid-Columbia and lower Snake. Several impoundments provide significant areas of favorable sturgeon habitat that is not fully seeded by natural recruitment due to spawning habitat limitations. Evaluations of other regional sturgeon hatchery programs have determined that substantial numbers of hatchery sturgeon released as juveniles can readily adapt to natural habitats and are likely to survive and grow to recruit to harvestable and adult sizes. Potential carrying capacity limitations were considered in scaling planned hatchery releases to produce sturgeon densities comparable to those observed in other reservoirs where regular natural recruitment occurs. Reservoir carrying capacity for sturgeon will be determined by monitoring sturgeon population parameters in response to increasing abundance (See Section 8).

[20] "True" adaptive management is contrasted with "pretend" or passive adaptive management which involves implementation of a project, monitoring, and adaptation if problems are evident.

2. ***Artificial production must be implemented within an experimental, adaptive management design that includes an aggressive program to evaluate the risks and benefits and address scientific uncertainties.***

An adaptive management framework will guide development of this White Sturgeon mitigation hatchery program. The adaptive management program described in Section 8.5 will be used to address uncertainties in conservation aquaculture. The program's multifaceted monitoring and evaluation plans are a crucial part of this adaptive management process.

3. ***Hatcheries must be operated in a manner that recognizes that they exist within ecological systems whose behavior is constrained by larger-scale basin, regional and global factors.***

The proposed hatchery program is part of a larger comprehensive strategic effort for sturgeon conservation, restoration and management. This comprehensive effort also includes habitat protection and restoration, natural production, fishery management, and research, monitoring and evaluation. As one piece of the larger effort, hatchery supplementation of sturgeon in the lower mid-Columbia and lower Snake impoundments provides a viable alternative for sturgeon restoration in areas where ecological systems are significantly constrained by larger-scale factors.

4. ***A diversity of life history types and species needs to be maintained in order to sustain a system of populations in the face of environmental variation.***

Sturgeon hatchery objectives specifically call for conducting sturgeon enhancement in a manner which ensures protection and conservation of natural populations, production and ecosystems. The program includes a series of implementation strategies designed to minimize adverse effects on biological diversity based on a detailed risk analysis. Strategies provide direction on release locations, release numbers, marking, source populations, hatchery practices, disease management, and adaptive management. The risk analysis is detailed in Section 5.2. Implementation strategies are described in Section 5.3.

5. ***Naturally selected populations should provide the model for successful artificially reared populations, in regard to population structure, mating protocol, behavior, growth, morphology, nutrient cycling, and other biological characteristics.***

This plan describes an integrated hatchery program designed to preserve and perpetuate locally adaptive genetic, life history, and behavioral traits of endemic White Sturgeon populations. These traits and other biological conditions are explicitly considered in the program design. Although this is primarily a fishery mitigation program, the design emulates a conservation program in order to minimize risks and optimize benefits to the supplemented sturgeon populations. For instance, practices include using only wild origin fish to avoid domestication; using multiple broodstock and wild larvae to ensure a large effective population size; employing factorial mating strategies to optimize expression of the existing diversity; rearing maternal families separately to manage individual contributions; maintaining low rearing densities to avoid artificial selection and mortality in the hatchery; avoiding fish quality differences that might contribute to differential post-release mortality; and avoiding selective rearing or culling practices.

6. ***The entities authorizing or managing an artificial production facility or program should explicitly identify whether the artificial propagation product is intended for the purpose of augmentation, mitigation, restoration, preservation, research, or some combination of those purposes for each population of fish addressed.***

The primary purpose of the hatchery is for fishery mitigation. Objectives also call for ensuring conservation and protection of natural populations, production and ecosystems, and employing hatchery-produced sturgeon as an experimental tool for applied research on limiting factors, habitat capacity, broodstock limitations, population parameters, and immigration/entrainment in natural populations.

7. ***Decisions on the use of the artificial production tool need to be made in the context of deciding on fish and wildlife goals, objectives and strategies at the subbasin and province levels.***

Decisions to artificially produce White Sturgeon in this portion of the Columbia and Snake Rivers were made based on related programmatic guidance by the Columbia River Treaty Tribes, States of Oregon and Washington, Federal parties and the Northwest Power and Conservation Council as detailed in Section 4 of this master plan. For instance, the 2014 NPCC identifies a specific strategy for sturgeon that includes hatcheries (see Section 4.1.2). Fish and Wildlife Program subbasin plans for the mainstem Columbia specifically identify sturgeon as a focal species, include sustainable levels of production and consumptive harvest of sturgeon as objectives, and recognize hatchery production as an appropriate strategy for addressing recruitment failure (see Section 4.1.3) The proposed hatchery program follows specific recommendations for use of sturgeon hatcheries identified by the Columbia Basin White Sturgeon Planning Framework prepared for the NPCC (Beamesderfer & Anders 2013). Agreement and collaboration among tribal and agency co-managers guides the implementation of this program.

8. ***Appropriate risk management needs to be maintained when using the tool of artificial propagation.***

Hatchery supplementation will be conducted in an experimental framework that includes a strong monitoring and evaluation program, established benchmarks for the evaluation of benefits and risks, and a clear decision structure for future adaptive management. Adaptive multidisciplinary research, monitoring, and evaluation efforts for this program will continue to assess the risks of artificial propagation. The results of these efforts will be used to determine any appropriate and reasonable next steps, which may include adjusting the supplementation level or location of releases. This program also recognizes that effects of complex ecological interactions can be difficult or impossible to monitor and employs precautionary hatchery implementation strategies in recognition of related uncertainties. See Section 5.3 for further discussion of risks associated with measurement and process uncertainty.

9. ***Production for harvest is a legitimate management objective of artificial production, but to minimize adverse impacts on natural populations associated with harvest management of artificially produced populations, harvest rates and practices must be dictated by the requirements to sustain naturally spawning populations.***

Implementation strategies explicitly call for fisheries on supplemented populations to continue to be regulated to provide adequate recruitment of sturgeon to broodstock sizes in order to sustain significant natural recruitment wherever possible. Effective exploitation rates will be regulated to optimize fishery yield while also protecting adult populations essential for natural production. Section 1 details corresponding harvest plans and guidelines.

10. ***Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement must be fully addressed.***

All federal and other legal mandates for fish protection, mitigation, and enhancement relevant to this project will be met. Implementing the proposed programs would assist the federal government in fulfilling its Tribal Trust responsibilities and would aid in restoring Tribal ability to exercise Treaty-reserved fishing rights.

6 PRODUCTION DESIGN & REQUIREMENTS

Key components of the sturgeon hatchery facility are identified in Figure 46. This program will collect and hold adult brood stock, spawn ripe adults, incubate embryos, rear larvae and juveniles, and release juvenile sturgeon (Figure 47). The program will also rear and release juveniles from collected wild larvae. Relative numbers of hatchery and wild origin larvae propagated will depend on relative success and cost effectiveness of the respective efforts. Initially, juvenile sturgeon will be released at age 0+ in fall, age 1 in spring and age 1+ in fall in order to evaluate the relative success and cost effectiveness of these alternatives. Future production may be revised based on the results of experimental evaluations of age and time release strategies.

The majority of the production will occur at the Marion Drain facility. Supporting production will occur at the Walla Walla South Fork Hatchery to provide alternative rearing protocols for experimental evaluation, contingency for any unforeseen production issues in the primary facility, and an opportunity to develop additional sturgeon culturist expertise.

Production design and requirements consistent with program goals and objectives were based on plans, operations and experience of other regional White Sturgeon hatcheries including Bonners Ferry and Twin Rivers facilities operated by the Kootenai Tribe of Idaho and the Ft Steele and Nechako facilities operated by the Freshwater Fisheries Society of British Columbia. Production design and requirements are detailed by life stage in section following.

The production strategy is scheduled around the sturgeon life cycle to optimize use of the available water, space and staff (Table 21). The annual cycle begins with capture of mature wild broodstock in May and June. Spawning is distributed among multiple events depending on broodstock availability. Developmental stages progress from these events at identical, parallel pace until juvenile rearing when heating/chilling equalizes growth and normal size distribution between groups.

The process of moving sturgeon biomass between culture containers is based on development (life stage), loading density and treatments. Developmental stages include: egg, hatched un-fed larvae, fed larvae (<1 g), fry (1 g), juveniles (>1 g), fish sizes after grading (1– 50 g), pre-release fish (300 g for 1+ release) and broodstock (holding adults and spawners). As fish progress through development they require different, often larger culture containers with appropriate water flow rates to accommodate and facilitate growth. The driving biological demand of the increased water volume and flow rate is to deliver oxygen and remove metabolic waste (CO_2, total ammonia, waste feed and fecal matter).

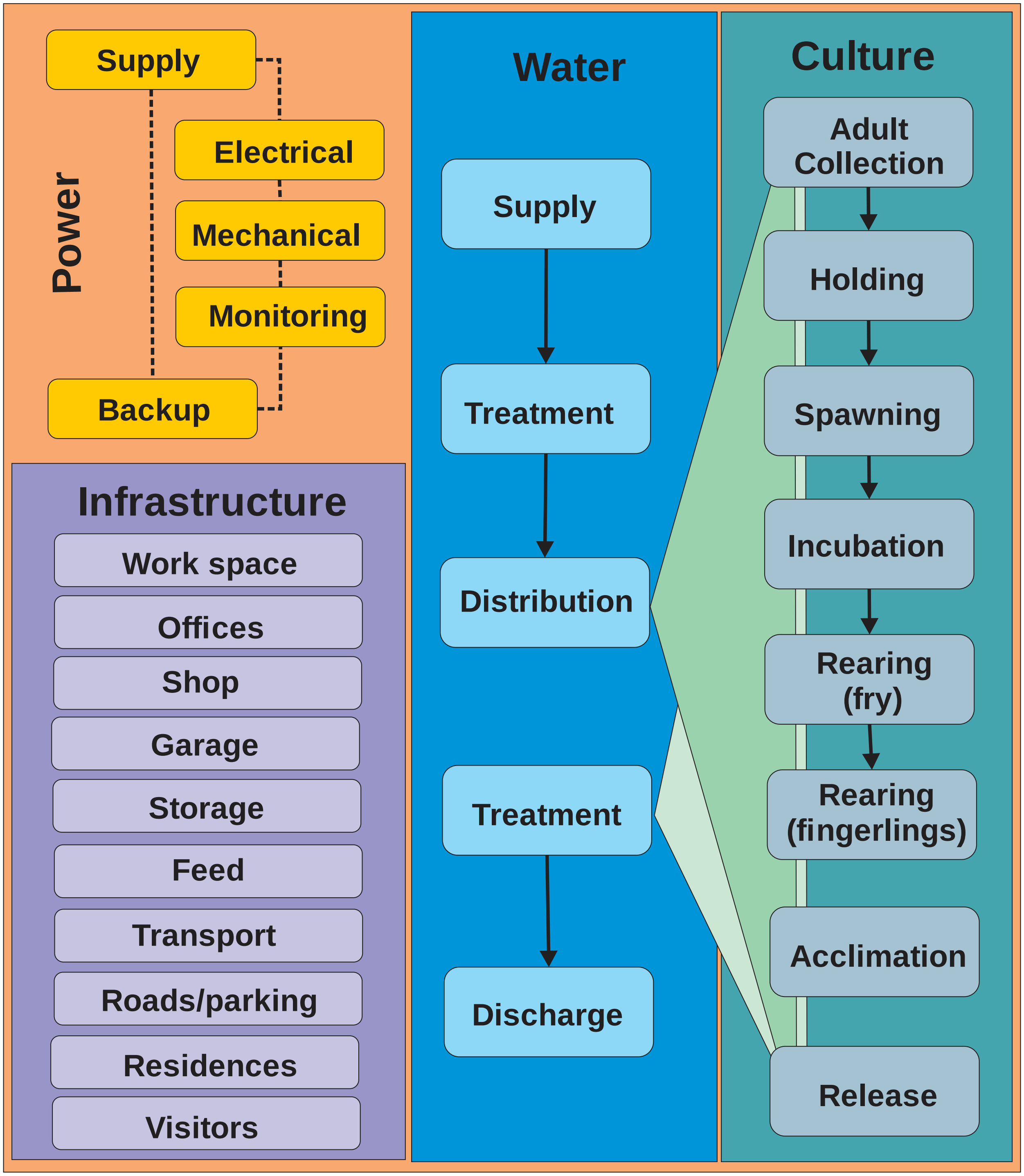


Figure 46. Key hatchery facility components addressed by this plan.

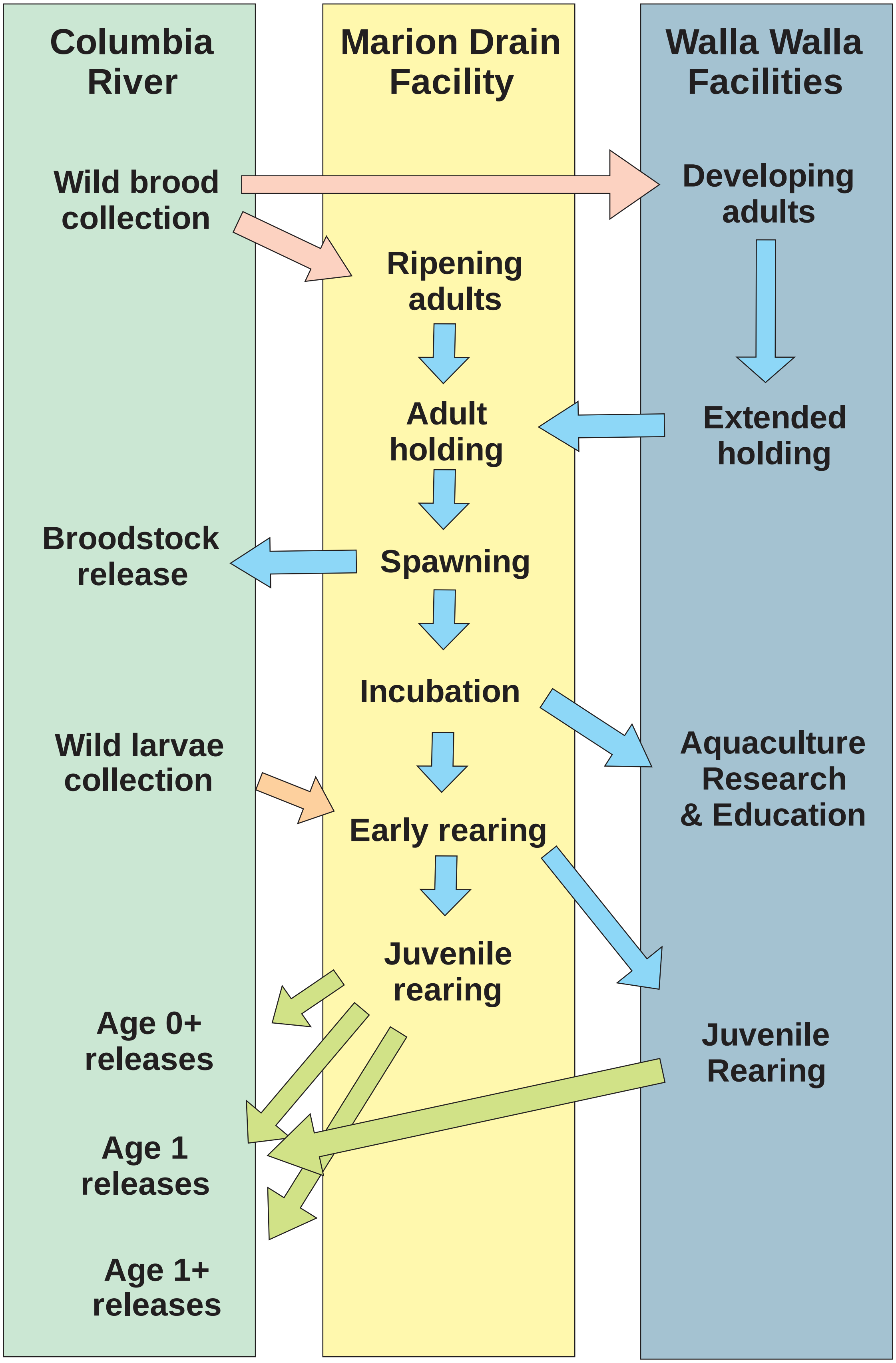
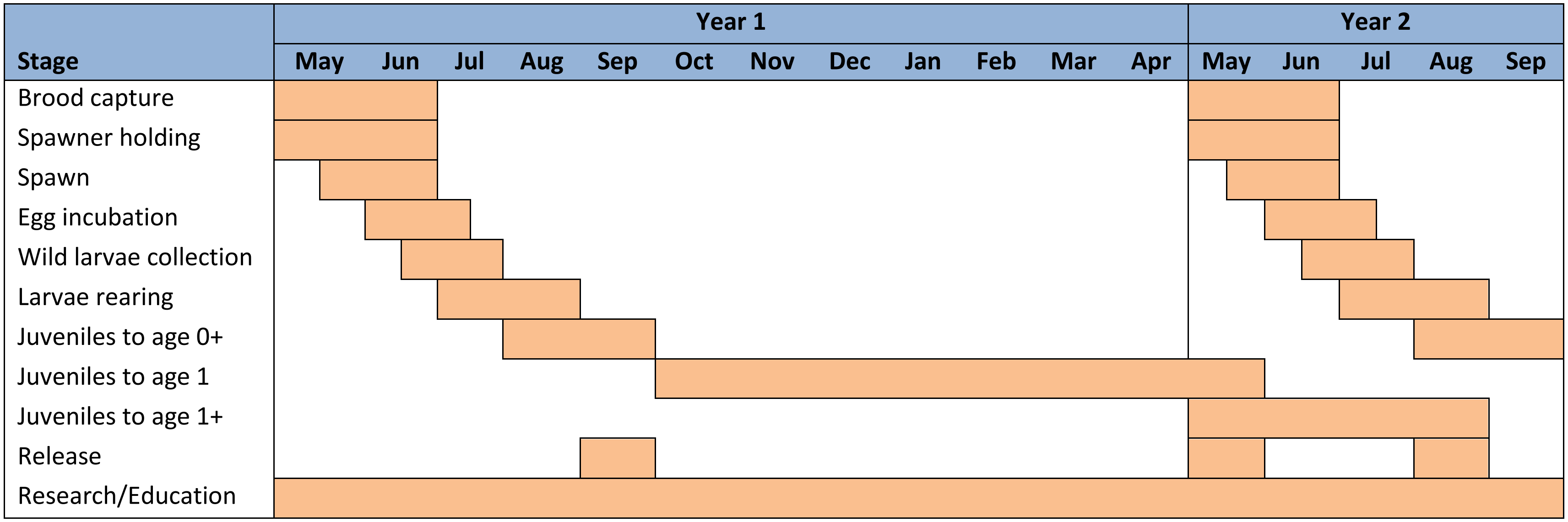


Figure 47. Sturgeon hatchery program production elements.

Table 21. Production schedule overview for one brood year.



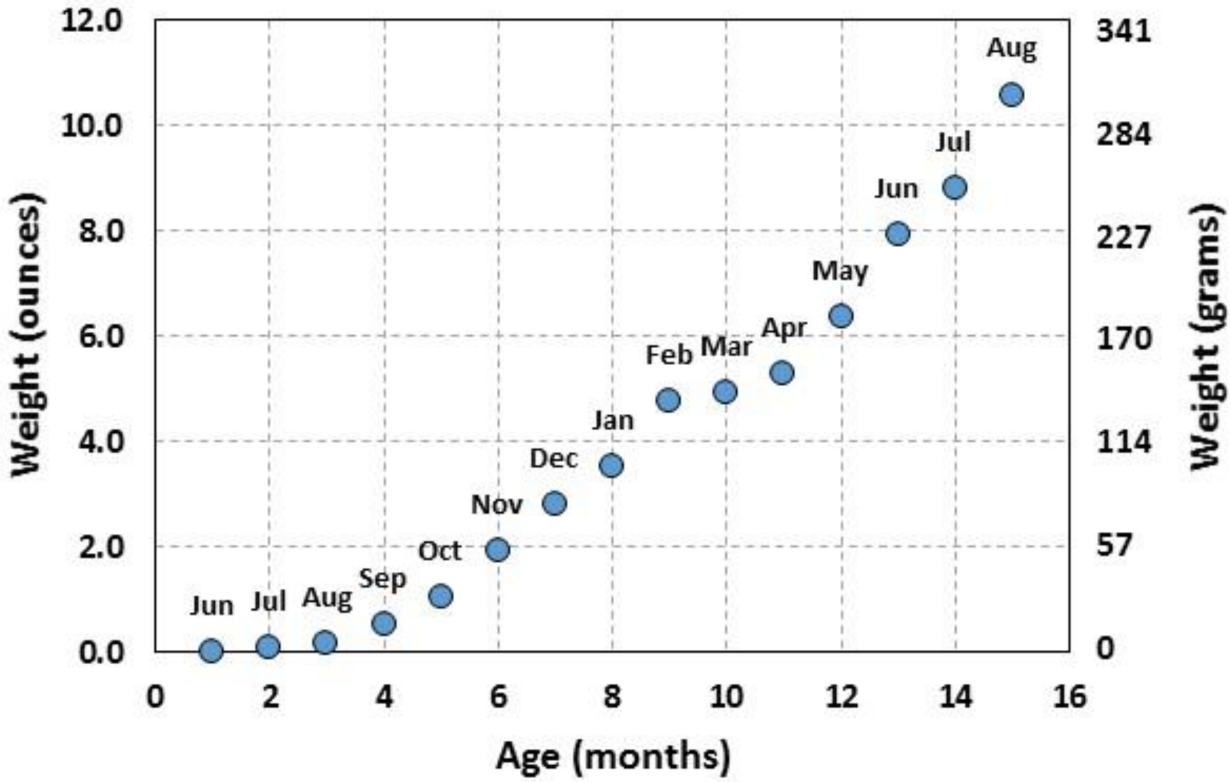


Figure 48. Projected average weight of hatchery-produced sturgeon by age at water temperatures of 57–63°F (14–17°C).

The production schedule and strategy at Marion Drain (Table 22, Table 23) will require the following:

- Predicted peak biomass is around 3,375 kg (7,425 lb) near spring release dates.
- At peak rearing densities in spring, the Marion Drain facility will be operated at 0.1 lb/gal (12 kg/m^3) and 0.6 gal/min/lb (1 L/min/kg).
- Total peak water delivery, including both hatchery-spawned and wild-spawned components of the program, would be in the order of 4,000 L/min (1,100 gal/min).
- Maximum water temperature is 63°F (17°C) and the capacity to mix must be available to achieve temperatures as low as 50°F (10°C) for supply to brood tanks during critical periods or to regulate growth.

The production schedule and strategy at the Walla Walla hatchery will require the following:

- Predicted peak biomass is around 1,485 lb (675 kg) of juvenile sturgeon in spring near spring release dates.
- Total peak water delivery at this time would be in the order of 178 gal/min (675 L/min).
- Water temperature of 61-63°F (16-17°C).

Table 22. Summary of sturgeon program numbers and weight by life history stage and family.

Facility	Life stage	Number (maximum)			Number / Family [a]		Weight	
		Total	Males	Females	Half-Sibling	Maternal	Individual	Total (lb.)
Marion Drain	Spawners	20	10	10	--	--	220 lb. (avg.)	4,400
	Egg take [c]	1,000,000	--		20,000	100,000	--	110
	Eggs @ neurulation [c]	500,000 [b]	--	--	10,000	50,000	--	55
	Fry (unfed)[c]	400,000	--	--	8,000	40,000	--	--
	Fry (fed) [c]	150,000			3,000	15,000	1 g	330
	Juveniles (Sept) [c]	37,250[a]	--	--	745	3,725	15–20 g	1,400
	Age 0+ release (Sept) [c]	5,000	--	--	100	500	15–20 g	200
	Juveniles (Oct) [c]	32,250	--	--	645	3,225	30–70 g	3,500
	Age 1 total (Mar)	21,900	--	--	440	2,190	100–150 g	6,000
	Age 1 release (May) [c]	20,000	--	--	400	2,000	100–150 g	5,500
	Age 1+ release (Aug) [c]	1,500	--	--	30	150	250–350 g	1,000
	Larvae (wild)[d]	20,000	--	--	TBD	TBD	--	--
	Fry & Juveniles (wild)[d]	5,000	--	--	TBD	TBD	100–150 g	1,400
Walla Walla	Fry (fed) [c]	30,000	--	--	600	3,000	1 g	70
	Juveniles (Sept) [bc]	7,500			150	750	20–40 g	500
	Age 1 release (Apr) [c]	5,000	--	--	100	500	100–150 g	1,400

[a] *Number of families: 10 maternal (per female parent), 50 half-sibling (shared male or female parent).*

[b] *post equalization (surplus available for research and education).*

[c] *Progeny of wild broodstock spawned in Marion Drain hatchery.*

[d] *Production from wild-caught larvae.*

Table 23. Minimum container and water requirements consistent with sturgeon hatchery production targets.

	Life stage	Containers: Type	Containers: Size	Containers: No.	Containers: Each (gal)	Temp. (°F)	Inflow (gal/min): each	Inflow (gal/min): total	Inflow (gal/min): /lb.	Loading (maximum): #/cont.	Loading (maximum): lb./cont.	Loading (maximum): lb./gal
Marion Drain	Spawners	Circular	12’ x 4’	12	2,500	50-60	65	800	≥0.9	1 – 2	400	≤0.2
		Circular	20’ x 5’	2	10,000							
	Eggs	Jar	18” x 10”	50	4	50-55	4	200	≥9.0	20,000	2	≤0.6
	Larvae/Fry (unfed)	Circular	6’ x 4’	20	500	54-61	5	100	≥0.6	12,500	28	≤0.1
	Fed fry	Circular	12’ x 4’	20	2,500	57-63	5	100	≥0.6	7,500	16	≤0.1
	Juveniles (age 1)						34	660	≥0.6	1,000	275	≤0.1
	Juveniles (age 1+)	Circular	20’ x 5’	1	10,000	57-63	120	120	≥0.6	1,500	1,000	≤0.1
	Larvae/Fry (wild)	Circular	6’ x 4’	4	500	54-61	1	5	≥0.6	5,000	11	≤0.1
	Juveniles (wild)	Circular	10’ x 4’	8	1,800	57-63	34	166	≥0.6	1,000	170	≤0.1
Walla Walla	Fed fry	Circular	12’ x 4’	2	2,500	61-63	4	8	≥0.6	15,000	33	≤0.1
	Juveniles (age 1)						90	180	≥0.6	2,500	700	≤0.3

6.1 PRODUCTION PRACTICES

6.1.1 Broodstock Collection & Holding

Wild broodstock are captured in spring immediately prior to spawning. Capture occurs ideally in May or June and fish may be transported to the facility. Sturgeon are typically collected by setlines, or angling. Sex and stage of maturity of adult-sized fish (typically 6 ft, 3 m, or larger) are assessed in the field by surgical biopsy (Figure 49). Fish assessed as F3/F4 for females (eggs in a near mature state; Bruch et al. 2001) and M2 or flowing for males (Table 24) are expected to spawn soon in the year of capture and are transported to the hatchery.

Fish are transported in a trailer-mounted tank in river water with air supplementation to maintain sufficient oxygen levels and salt to mitigate stress response. After transport, the fish are transferred to hatchery circular tanks and placed in temperature-matched water. Commercial salt can be added to achieve a 1% solution by brine drip or manual addition of crystals to relieve stress and help heal any abrasions. The salt concentration is maintained for 24 h and eventually flushed by regular flows. Fish are held at elevated flow rates for 48 h to keep oxygen levels high.

Figure 49. Surgical biopsy of potential broodstock fish in the field (*photo courtesy of D. Miller*).

Table 24. Sexual maturity codes used for White Sturgeon (adapted from Bruch et al. 2001 by UCWSRI 2013).

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

Capacity for holding up to 20 mature fish for spawn of the year will be required. The production plan calls for the capture and spawning of 10 female and 10 male sturgeon. An idealized factorial breeding plan calls for up to five female and five male fish to be spawned in each of two spawning events. Because not every ripening fish can be expected to reach full maturity in the hatchery, more than the target number is typically collected. However, not every fish is held for the duration of the season. Capacity requirement calculations also recognize that not all females will be mature at once.

Broodstock are held in circular tanks constructed of fiberglass, fiberglass-reinforced plastic or enamel-coated steel and are served with cool and warm water to induce or hold final maturation. Water supply to tanks holding brood is heated or chilled, depending on the need to advance or maintain reproductive state. Air and oxygen supply are also required.

A total of twenty 12 ft (4 m) tanks and two 20 ft (6m) tanks will provide adequate capacity and flexibility for broodstock holding and spawning activities at the Marion Drain Facility. The 20 ft tanks can hold several maturing males and female fish. Broodstock that are closest to spawning time as assessed by biopsy or flowing milt are placed in 12 ft tanks for final maturation and spawning induction. Female fish often surpass 100 kg (220 lb.) in weight and as such for safety and ease of handling, particularly large individual females may be held separately in 12 ft tanks. As well, if two or more female fish are held in one tank, it becomes difficult to determine which fish has released eggs at ovulation based on observation of eggs on the tank bottom after induction. This can also lead to unnecessary, repeated handling of gravid fish to determine which fish has released eggs. Male fish typically mature at a younger age than female fish and may be smaller and thus, two or three may be kept in a 12 ft tank. Males also tend to mature more synchronously after induction. After the first round of fish are spawned, the remaining fish in the 20 ft are moved to the 12 ft tanks as they are again assessed for maturation progress during their tenancy in the hatchery.

Once a female fish has been spawned, she is monitored for at least 24 h and returned to the same area of the river where she was caught within days of spawning. Male fish are not released until all female fish are spawned to ensure milt supply for later events. Broodstock fish are not fed during their residency.

At capacity, total biomass of adult broodstock would average about 4,400 lb (2,000 kg) assuming individual fish sizes of 165-330 lb (75 -150 kg) each. Maximum total water inflow required would be 400 – 800 gal/min (1,500 – 3,000 L/min) at 54°F (12°C). In common sturgeon culture practice, a 165 lb (75 kg) ripe male will need 13 gal/min (50 L/min) in a 12 ft (4 m) tank. However, maximum flows need to be considered for planning purposes.[21] As spawning proceeds and numbers of adult

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[21] *Broodstock are not active, so at 16°C do not need the 1l/kg normal flow. However, brood tanks would may be used for other fish or greater density at another time, so the plumbing needs to be able to provide flows to accommodate 50 kg/m3 or 50+ L/min/m3.*

fish are reduced, water demands will likewise be reduced. The ability to provide a range of water temperatures is particularly important in the broodstock holding and spawning stage for regulation of maturation.

6.1.2 Spawning & Fertilization

Spawning and fertilization follow standard methods as documented in Conte et al. (1988) and as modified for state-of-the-art. Ripening females are monitored in the hatchery until the late stages of maturation are reached and confirmed by biopsy. Final stages are recognized by the position of the germinal vesicle in relation to the animal pole of the egg where the micropyles are located. Microscopic examination of eggs boiled in Ringer's saline and sliced along the animal/vegetative pole axis is used to determine the migration of the polar vesicle and indicate the fertilization ability of the egg. As required, water temperature in individual tanks can be turned down to arrest further gonad development and allow a more synchronous spawning event with the other female fish to meet the factorial mating design protocol.

Spawning typically occurs in June or July. Female broodstock must be induced to release eggs by hormone injection in the final stages of maturation because captive wild sturgeon rarely ovulate unaided. Ovulation is induced by injection with synthetic luteinizing hormone analogue (LHRHa) at 0.1 mg/kg body weight in two doses (loading dose 10%, resolving dose 90%) given 24 h apart. Significant numbers of eggs are typically released upon ovulation and apparent on the bottom of the spawning tank within 24–48 h of hormone injection.

Eggs are hand-stripped except in rare cases of oviduct blockage where an incision is made to extract the eggs. Hand-stripping has been used in lieu of incision (favored by the sturgeon aquaculture industry to reduce stress and injury) and fish spawned by hand stripping can be released shortly after spawning. Up to 100,000 eggs will be collected from individual female broodstock as numbers permit. Egg number is quantified volumetrically from repeated counts of sub samples. This represents a small portion of the total fecundity. The unspawned eggs may be subsequently absorbed by the sturgeon although if returned to the original location, natural spawning may not be ruled out. A total of 1,000,000 eggs from all female fish will be collected.

Male maturation can be regulated by temperature control; male fish are treated with a single injection of 0.1 mg/kg LHRHa 48-24 hours prior to spawning and are held at elevated temperatures to keep them mature. Eggs are fertilized with sperm collected from ripe males after a sample has been assessed for motility under the microscope. Excess unfertilized eggs and milt can also be shipped to satellite facilities at this time. Eggs from individual females are split volumetrically into separate equal lots and are separately fertilized with milt from different males according to the factorial mating design. Ideally, up to five sub samples of eggs from one female are fertilized with sperm from up to five males and each male will fertilize eggs from up to five females. Families from one female and one male are referred to as full-sibling families. Families from the same female and different males are referred to as maternal families and are described as "half-siblings". Each of two 5x5 spawning events will produce 5 maternal families, 25 half-

sibling families (50 in total). Maternal family identity is maintained through the spawning, fertilization and incubation process.

Fertilized eggs are typically glutinous and will adhere to anything and each other. Therefore, after fertilization, “de-adhesion” with an inert clay material (Fuller’s Earth) is done by coating the egg surface with the fine clay (Fuller’s Earth) to prevent eggs from adhering to one another and surfaces. In the wild, eggs adhere to rocks and in crevices but de-adhesion is necessary in the hatchery to avoid egg clumping, suffocation and mortality during incubation. Spawning occurs in the main area of fish culture and eggs/milt are then transferred to an egg disinfection area adjacent to a separate incubation area. This work space is typically a small laboratory with storage.

Figure 50. Milt collection from male sturgeon (Yakama Sturgeon Hatchery).

Figure 51. Separate lots of sturgeon eggs from half-sibling families following de-adhesion.

6.1.3 Incubation & Early Rearing

Eggs from individual matings are incubated separately in modified MacDonald upwelling jars consistent with standard sturgeon hatchery practices (Figure 52). Transparent acrylic plastic of incubation jars allows direct observation of eggs and flow patterns. Water piped into the jar gently maintains neutral buoyancy of the eggs to prevent clumping and fungal development. Dead eggs (white, discolored or mottled) and egg shells are siphoned daily from the incubators and collection tanks.

Eggs from each half-sibling family are incubated in separate jars. Each maternal family consists of five jars of eggs, one jar from each of males crossed with one female. Each 5x5 spawning matrix will thus require 25 separate jars. Thus, a total of 50 jars (4 gal, 15 L ea.) will be required for the 50 half-sibling families. Normal loading for the jars is up to 0.25 gal (1 L) of fertilized eggs or about 23,000 - 25,000 eggs. Production targets for this program are at least 20,000 green eggs per half-sibling family.

Figure 52. Examples of MacDonald upwelling jars used for sturgeon egg incubation.

Spawning events may be synchronous and it is therefore important that incubation systems of water delivery, jars and tanks be flexible in their construction and location to accommodate changes to routine. For example: normally four or five female fish are induced to spawn on one day, but on occasion, only two of these fish may respond and give eggs within 24 h of LHRHa injection. This means that only 10 jars and two 6 ft (2 m) tanks will be put to use at one time. Water flow to the jars that contain eggs must not be interrupted when more jars come as required in subsequent days. This calls for fine control of water pressure by using valves that keep their flow and adaptability of the system to accommodate change. Also common is that the male fish may be called upon to give milt the next day, or that milt be stored under pure oxygen in air-tight bags in refrigerators.

Eggs are ideally incubated at approximately 50°F (10°C). Water may be heated or chilled to this temperature depending on source. At this temperature, eggs begin hatching approximately 10 days after fertilization and the hatch is complete at approximately 14 days post-fertilization. Flow to an incubation jar is 2–3 gal/min (8–12 L/min) for eight days until neurulation, 4 gal/min (15 L/min) for two days during neurulation, and 2–3 gal/min 8–12 L/min) until hatching occurs in 12–14 d. Just before and during neurulation, eggs require a higher flow rate to prevent fungal infections (gentle rolling prevents this); eggs at other developmental stages seem not to require this high flow and develop better at the lower flow rates (Conte et al. 1988).

Until neurulation the eggs are not to be disturbed akin to a salmon egg to the ‘eyed’ stage. At neurulation the egg numbers in each jar are balanced for equal paternal contribution according

to the volume of eggs and the neurulation rate (based on live/dead egg sub samples) to numbers that add up to approximately 50,000 eggs per maternal family (10,000 eggs per jar) to produce between 400,000–500,000 unfed larvae total per maternal family. Excess neurulated eggs may be transferred to other facilities at this point if desired.

Incubation jars are positioned in or just above larval rearing containers so that outflow water from the jars flow over a lip, and directly into a 6' circular tank. As eggs hatch, the emerged larvae tend to move vertically and into the water flow that carries them over the spout of the jar and directly into the fry collection tank below. When all the egg shells and other biologic materials are shed completely and the tanks cleaned out, 1–1.5 in (3–4 cm) bioballs are introduced to the tank bottom as larvae refugia. The bioballs remain until first feeding at which time regular tank cleaning begins. These bioballs help the fry maintain their position and save the energy of the yolk for growth and not movement for orientation (larvae are photophobic).

All five half-sibling jars from one maternal mating, each containing the fertilized eggs of a one female by one male cross, are held in two of the 6 ft (2 m) tanks. Thus, ten maternal families will require a minimum of twenty 6 ft circular tanks. Two tanks for each maternal family provide operational flexibility should more fish become mature ahead of schedule; over-ripe females are opportunity wasted.

Upon hatch, target survival to first feeding is 50% on experienced average and survival to fully-feeding fry is projected to result in 250,000 or more fry. Fish are fed with artificial diet. Experience has shown that fish started with natural diets are more difficult to transfer to an artificial diet later. Effective practices for first feeding have been subject to significant experimentation in sturgeon aquaculture but additional work is needed. It may be possible to increase survival rates using natural or live food but the tradeoff comes in lower growth and survival later when fish must be transitioned to artificial feed. It is not cost-effective or practical to support significant hatchery production entirely with natural diets. On the other hand, relatively high mortality of hatchery sturgeon has been documented in other areas when fish must adapt to a natural diet. It is unknown whether the neuroplasticity to handle live feeds after release might be improved by initial feeding of a live diet to fry in the hatchery. The proposed program includes a research component to address questions such as this.

Each 6'circular tank (maternal family) has water inflow from up to five jars, each with up to 4 gal/min (15 L/min) at peak flows for a maximum of 20 gal/min (75 L/min). The total maximum water draw for incubation for a single spawning event for five maternal families is 200 gal/min (375 L/min). Once hatching is complete, water flows into 6 ft tanks may be reduced to approximately 5 gal/min (20 L/min) and regulated by a vertical directional spray bar. The vertical spray bar allows optimal flow without introducing too much current velocity by redirection of the water. This flow rate will meet a larval rearing standard of 0.5 gal/min/lb (0.75 L/min per kg) of biomass. Under this scenario, total flows of approximately 100 gal/min (400 L/min) will be required in total during larval rearing.

6.1.4 Wild-caught Larvae

Program production targets also call for culture of up to 20,000 wild-caught yolk-sac or first-feeding larvae.[22] Wild larvae are held in 6 ft tanks under similar conditions to the hatchery-spawned fish. Four 6 ft (2 m) circular tanks and four 9 ft and 10 ft (3 m) circular tanks will be required for wild-caught juveniles. Fish are transferred into the larger tanks as they grow. Wild-caught larvae will be reared at the Marion Drain Hatchery where an existing building is being rededicated to this portion of the production.

Survival rates of wild-caught fish are typically much lower than those of hatchery-produced juveniles due to stress associated with capture and handling. Also, larvae are often at different developmental stages and as such have different requirements (food, flow, etc.) and are reared communally. This 'batch' rearing does not compensate for fish of the same age and losses may be higher. Survival rates of 20-35% were reported by the upper Columbia program during the first two years of this program. However, it is likely that survival rates will be improved with experience. Propagation of wild-caught larvae is an experimental component of the CRITFC program and will be managed adaptively over time as is being done in other programs.

Wild caught larvae will be isolated from the conventional broodstock production for biosecurity purposes. An outbreak of White Sturgeon *Iridiovirus spp.* in the Upper Columbia program in autumn of 2013 highlights fish health risks associated with this production strategy.

6.1.5 Juvenile Rearing

Up to 150,000 feeding fry from up to 10 maternal families may be transferred as families to 12' tanks in the rearing portion of the Marion Drain facility when fish are approximately 1 g (0.04 oz.) in size. Enumeration occurs at this time. A portion of the production will be transferred to the Walla Walla South Fork Hatchery at this time for grow out and release in the lower Snake River. Seed stocks for juvenile production at the Walla Walla facility may also be supplied from downsizing (density reduction) practices of the Marion Drain facility in June. Optimal size for transport and delivery to Walla Walla is the 1 g size because the fish are robust and feeding well at this stage. As tank space is not limiting at the receiving hatchery, the number of fish received will be influenced by the level of supply for maternal family input at Marion Drain. A target of 30,000 1 g fry is reasonable because fish are well established and starting to grow well. The fish are also easily loaded into bags with oxygen overlay and placed over ice (insulated from direct contact with towels) in coolers. At this size, the fish have not developed sharp scutes of a size that will damage cohorts or the plastic bags.

The maternal family may be downsized at this time and surplus fish are selected randomly. Excess fish may be transferred to other facilities for experimental uses, commercial aquaculture or sacrificed. Recipients of any excess fish will not allow them to be released in the Columbia basin.

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[22] *Number is contingent on ability to cost-effectively collect that many from the wild.*

These reductions are conducted without bias to minimize hatchery influences although obvious culls (deformed or inordinately small fish) will be removed from both groups.

At Marion Drain, the same 12 ft (4 m) tanks utilized for broodstock holding will be used for juvenile after tanks have been cleaned and disinfected following repatriation of adult fish to the river. At the fish culturist discretion, a portion of the fish may also be kept in the 6' tanks to reduce rearing densities and provide a safeguard in the event of fish health issues. At Walla Walla, juveniles will be reared in 16 ft (5 m) circular tanks (which fill into the existing space).

Figure 53. Juvenile sturgeon rearing in a circular tank at Ft. Steele Trout and Sturgeon hatchery in British Columbia *(photo by R. Beamesderfer).*

Fish are grown at Marion Drain in the 12 ft (4 m) tanks until fall when 5,000 age 0+ fish will be tagged and released into John Day Reservoir. Following this release, final random culling occurs of the remaining fish to equalize maternal family groups. Numbers are reduced to 150% of target release numbers to assure a buffer for project numbers. By the time fish pass the 15-30 g (1.5oz) stage in August - September, experience shows that mortalities are almost nil except for culling. Thus, family size release targets of 2,000 age 1 fish in spring will require fall numbers of about 3,000 per family in fall. An additional 2,250 fall fish will be required to produce 1,500 age 1+ fish for release in the following fall. These fish are randomly selected from each family without regard to size. At rearing temperatures of 63°F (17°C) sizes will average up to 30 g (1 oz.). Extra fish would be available for transfer to another facility and otherwise would be sacrificed. The Yakama sturgeon hatchery program is expected to transfer these fish to another part of the facility for grow-out and commercial sale.

After family balancing, production at Marion Drain can utilize all available 12 ft (4 m) and 20 ft (6 m) tanks to optimize rearing densities. As required by size distribution, larger and small fish from a family may be transferred or graded into separate tanks for growth management which will increase total flows accordingly as all tanks would be in use. Water temperature may be managed to regulate growth as required to bring the slow-growing portions of each family to size.

After fish reach 30 g (1 oz.) and before release, fish are PIT tagged. Briefly, fish are transferred from tanks in small numbers, anaesthetized, weighed and measured, and PIT tagged in the anterior dorsal musculature on the left side. A tag retention check and sample weight/length sampling is done prior to release on 10% of the population and fish are monitored prior to release. Feeding is stopped three days prior to release. Loading, transport and release of fish to the project area is by transport trailer and conducted to standard hatchery practices. After release of the juvenile fish the tanks are cleaned, disinfected and prepared for the arrival of broodstock fish when they are captured in June.

After the first year of spawning, one 20 ft (6 m) tank at Marion Drain will hold up to 1,500 age 1+ fish for release in August at approximately 300 g (0.7 lb.). These fish will remain in this tank throughout grow out until release.

6.2 BIOLOGICAL PROGRAM

The biological program defines the process flow of fish movements, growth, water flows and predicted growth pattern. Table 25 and Table 26 outlines the biological program identified to meet fish production requirements at the Marion Drain facility. Table 27 outlines the biological program identified to meet fish production requirements at the Walla Walla facility. Programs are consistent with a ± 35-50% design level.

Maximum rearing density for sturgeon is 0.3 lb/gal (35 kg/m^3). Minimum water flow requirements are approximately 0.6 gal/min/lb (1 L/min/kg). This flow rate gives a two-hour turnover time for the water in a 12 ft (2,500 gal, 9,500 L) tank and should obviate the need for supplemental oxygenation of the water. This program will typically use substantially lower rearing densities in order to optimize survival and growth. At peak rearing densities in spring, the Marion Drain facility will be operated at 0.1 lb/gal (12 kg/m^3) and 0.6 gal/min/lb (1 L/min/kg). Total peak water delivery at this time, including both hatchery-spawned and wild-spawned components of the program, would be in the order of 1,100 gal/min (4,000 L/min) (Figure 54). At peak rearing densities in spring, the Walla Walla facility will be operated at 0.3 lb/gal (34 kg/m^3) and 0.6 gal/min/lb (1 L/min/kg). Total peak water delivery at this time would be in the order of 178 gal/min (675 L/min) (Figure 55).

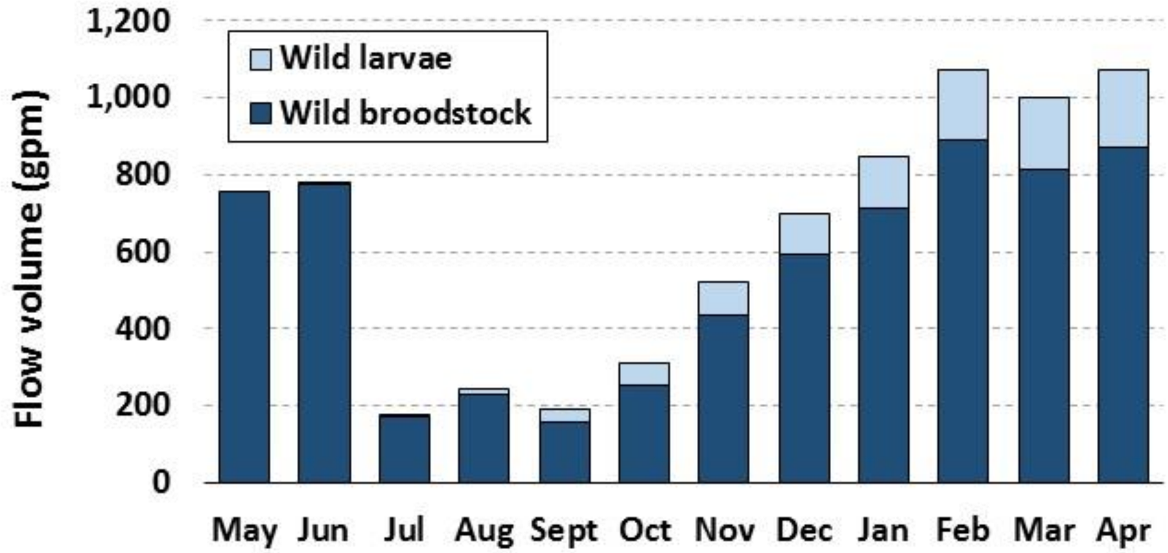

Figure 54. Flow requirements for Marion Drain sturgeon production.

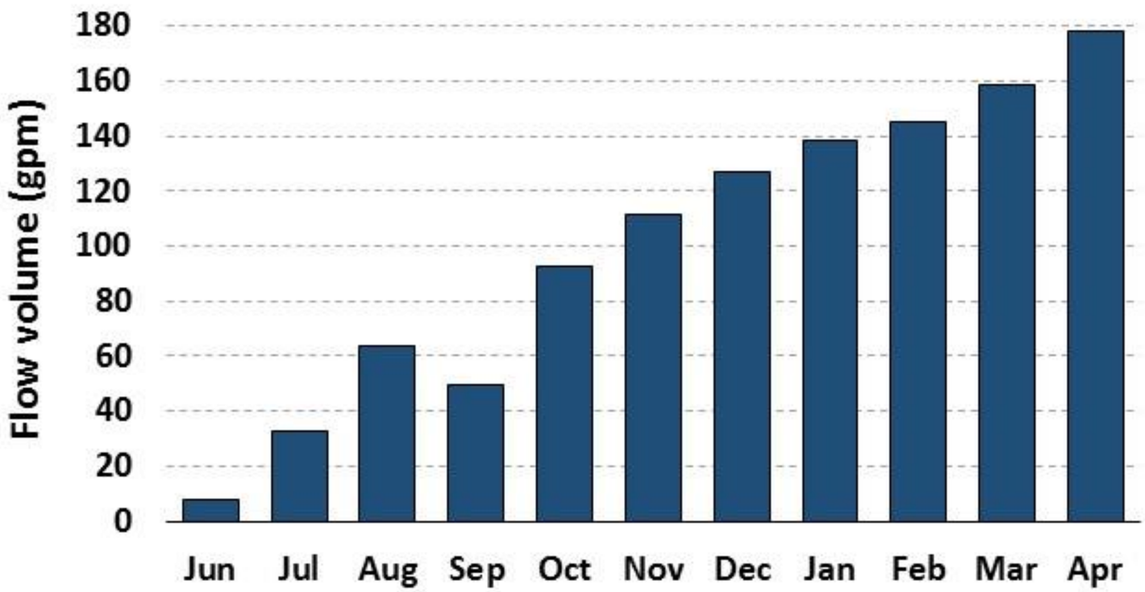

Figure 55. Flow requirements for Walla Walla sturgeon production.

Table 25. Biological program for the Marion Drain sturgeon facility (wild broodstock production).

	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Stage	Eggs	Eggs										
		Larvae	Larvae									
			Fed fry	Fed fry								
					Juv	Juv	Juv	Juv	Juv	Juv	Juv	Juv
	Yearling	Yearling	Yearling	Yearling								
	Adult	Adult										
Count												
Eggs	250,000	500,000										
Larvae		200,000	400,000									
Fry			150,000	85,000								
Juvenile					40,000	32,000	30,000	28,000	27,000	25,000	22,000	22,000
Yearling	1,500	1,500	1,500	1,500								
Adult 12'												
Adult 20'	20	20										
Container	Jar	Jar	Jar									
		6'	6'	6'								
	12'	12'		12'	12'	12'	12'	12'	12'	12'	12'	12'
	20'	20'	20'	20'								
# Containers												
Jar	50	50	50									
6'	10	20	20	10								
12'			10	20	20	20	20	20	20	20	20	20
12' Adult	10	10										
20' Adult	1	1										
20' Yearling	1	1	1	1								
Volume (m3)												
6'		40	40	40								
12'	100	100		200	200	200	200	200	200	200	200	200
20'	80	80	40	40								
Fish Size (each)												
Fry (g)			0.5	1								
Juvenile (g)				5	15	30	55	80	100	135	140	150
Yearling (g)	180	225	250	300								

	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Adult (kg)	100	100										
Biomass (kg)												
6'			275	85								
12' juvenile				425	600	960	1650	2240	2700	3375	3080	3300
12' Adult	1000	1000										
20' Adult	1000	1000										
20' Yearling	270	337	375	450								
	2,270	2,337	650	960	600	960	1,650	2,240	2,700	3,375	3,080	3,300
Loading (kg/m3)												
6'		0.0	6.9	2.1								
12'				2.1	3.0	4.8	8.3	11.2	13.5	16.9	15.4	16.5
12' Adult	10.0	10.0										
20'Adult	12.5	12.5										
20' Yearling	3.4	4.2	9.4	11.3								
Water flow (L/min)												
Jars	600	600										
6'			275									
12'				425	600	960	1,650	2,240	2,700	3,375	3,080	3,300
12' Adult	1,000	1,000										
20' Adult	1,000	1,000										
20' Yearling	270	337	375	450								
	2,870	2,937	650	875	600	960	1,650	2,240	2,700	3,375	3,080	3,300
Feed rate (%BW/d)												
Fry			11	9								
Juvenile				6.5	6.5	6	5	3.5	2	1.7	1.3	1
Yearling	0.8	0.8	0.8	0.8								
Feed use (kg/d)												
Fry			30	8								
Juvenile				28	39	58	83	78	54	57	40	33
Yearling	22	27	30	36								
Month	670	835	1,868	2,210	1,209	1,786	2,558	2,430	1,674	1,779	1,241	1,023

Table 26. Biological program for the Marion Drain sturgeon facility (wild larvae production).

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Wild larvae		20000										
Fry			10000									
Juveniles				9000	8000	7000	6000	5000	5000	5000	5000	5000
Size (g)		0.05	1	5	15	30	55	80	100	135	140	150
Biomass (kg)		1	10	45	120	210	330	400	500	675	700	750
Tanks (size)		6'	6'	6'	10'	10'	10'	10'	10'	10'	10'	10'
Tanks (number)		4	4	4	8	8	8	8	8	8	8	8
Volume (m3)		8	8	8	56	56	56	56	56	56	56	56
Loading (kg/m3)		0.125	1	6	2	4	6	7	9	12	13	13
Water flow (L/min)		1	10	45	120	210	330	400	500	675	700	750
Feed use (kg/month)		3	34	126	242	391	512	434	310	356	282	233

Table 27. Biological program for the Walla Walla sturgeon facility.

Column1	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Stage	Fry	Fry	Fry	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Release
Count											
Fry/Juvenile	30,000	25,000	20,000	7,500	7,000	6,500	6,000	5,500	5,000	5,000	5,000
Container	12'	12'	12'	12'	12'	12'	12'	12'	12'	12'	12'
No. Containers	2	2	2	2	2	2	2	2	2	2	2
Total Volume (m^3)	20	20	20	20	20	20	20	20	20	20	20
Fish Size											
Juvenile (g)	1	5	12	25	50	65	80	95	110	120	135
Biomass (kg)											
Per 12' Tank	15	63	120	94	175	211	240	261	275	300	338
Total Biomass kg	30	125	240	188	350	423	480	523	550	600	675
Loading (kg/m3)	2	6	12	9	18	21	24	26	28	30	34
Water flow (l/min)	30	125	240	188	350	423	480	523	550	600	675
Feed rate (%BW/d)											
Fry/Juvenile		7.0	3.4	2.7	2.1	1.7	1.7	1.3	1.3	1.3	1.0
Feed use (kg/d)											
Fry/Juvenile		8.8	8.2	5.0	7.3	7.0	8.0	6.8	7.2	7.8	6.8
Month		271	254	155	227	217	247	211	222	242	209

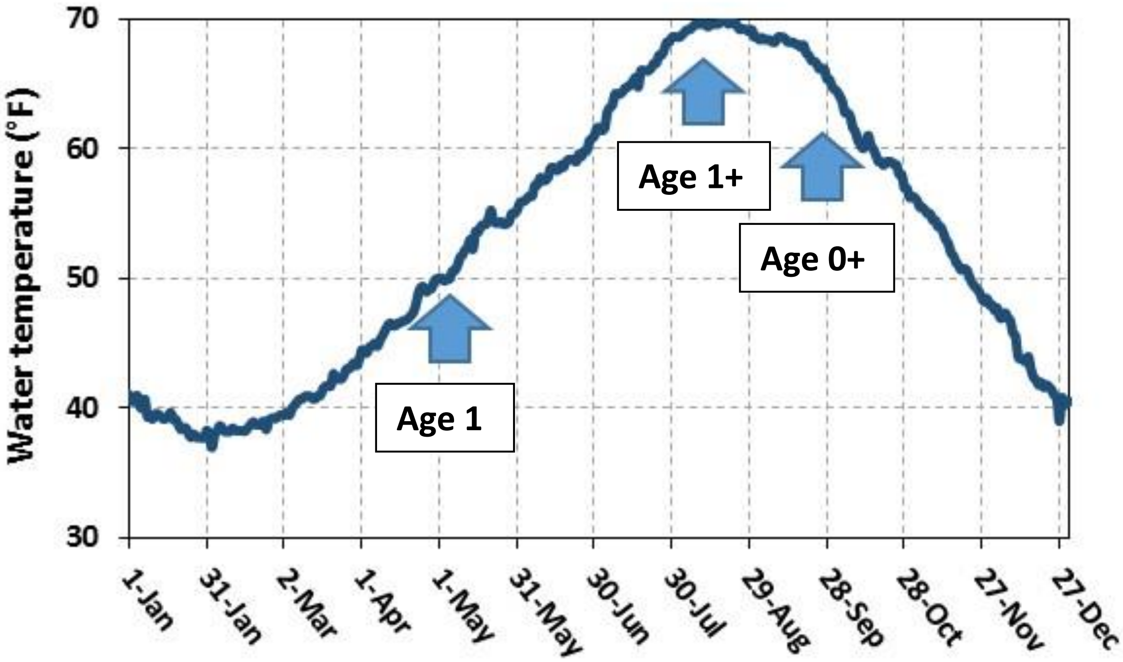

Figure 56. Release timing in relation to 2005-2014 average Columbia River water temperature (as measured at McNary Dam).

6.3 RELATED ACTIVITIES

6.3.1 Transport

Fish transport occurs on three occasions: 1) broodstock in, 2) broodstock out, and 3) juvenile sturgeon for release or to other facilities. In the former two cases, the broodstock are moved from and to the capture area by dual axle (two ton) trailer fitted with a 500 gal (2 m^3) volume tank filled with water and fish towed behind a truck suitable for the purpose. Access to the holding tanks must be as smooth as possible for the fish to minimize abrasion and duress. In the ideal scenario, the fish is moved to and from the tank using a tube net or tarpaulin stretcher and lifted by hand for a minimal time out of the water. Stress can cause an inhibition of spawning and physical trauma may result from mishandling. Optimal tank access from the trailer is a minimal distance with minimal lift. In the latter scenario, juvenile fish for release will be crowded passively in the holding tank, netted, and transferred to the trailer tank for transport to the river. All fish transport involves vehicles and trailers containing water and fish. Approaches to the hatchery need to take incline into consideration when water is in the trailer tank. As well, adequate space for vehicle and trailer maneuverability need be taken into account.

Transport to the release site is by using the transport trailer filled with hatchery water and loaded by the method described above. Salt may be added for longer trips to ameliorate any stress effects of transport. Fish are released to the river using gravity from an 8 inch valve fitted with a plastic flexi-hose that is submersed in the river. Temperatures are matched as close as possible by pumping river water into the tank over a time span that matches temp at no more than 2°C per hour. For boat mid-river releases of small batches, fish are crowded in the tank and

transferred to an on-board holding tank filled with aerated water. For release, fish are, netted enumerated by weight in the net suspended on a scale (or volumetric method) and released overboard.

For larval fish captured in the river, larvae are removed from the cod end of the funnel net, or from an instream collection box using a jar filled with water to minimize trauma or a small mesh dip net. Larvae must typically be separated from volumes of other material collected by nets. These larvae are placed in a bucket containing aerated water and covered. When collection is complete, the larvae are transferred to the facility and the process reversed. Fish for the release process are identical to cultured fish releases.

6.3.2 Fish Movements

The process flow of fish movements is from smaller to progressively larger containments as different life stages are attained and fish grow. This involves separating for density and security, culling, grading, marking and reducing densities. Within the facility, fish movements from container to container need to be of minimal duration to minimize stress and time out of the water to minimize other fish health impacts. Wherever possible, fish movements described above need to be along the shortest route to and from rearing containers or work stations (grading, marking, etc.).

Pathways for fish movement need to be logical and free from impediments; there are human and fish safety considerations while transferring fish from container to container. Overhead areas need to be of sufficient height to accommodate net handles, brush handles and the like when caring for fish, especially when using large diameter tanks. Passageways between tanks will facilitate the use of wheeled trolleys, containers, small tanks, tables and dollies both by clearance and surface and conform to worker safety guidelines. A common problem in some hatchery design is piping that is placed on floor surfaces that impedes wheeled carts and poses a tripping hazard. To alleviate this, supply lines and pipes are best trenched and covered. Covers must be removable to allow access and cleaning; they must also be made with non-slip surfaces, able to withstand considerable weight and have drainage to prevent water pooling. These routes must not have tripping hazards or prone to be slippery. Hoses, hose bibs and other water delivery systems need to be well marked and in defined, compact locations so as not to be tripping hazards or impede handling procedures. If trenches are used to deliver service to the tanks, appropriate grating to support heavy traffic will be needed.

6.3.3 Food & Feeding

Feed requirements for juvenile rearing at target rearing temperatures will be approximately 11% of body weight per day for fry, gradually decreasing to about 1.3% at age 1. Fish are fed according to standard procedure based on size, development and separation of fast and slow responders (growth rate). In a general sense, fish to 1 g are fed *ad libitum* and to excess and the feed ratio thereafter follows Conte et al. (1988) for life stages. Auto feeders will also be used for juveniles

6.3.4 Grading, Culling, Marking & Tagging

First-feeding White Sturgeon grow in a bimodal distribution in juvenile stages, the causes of which are not fully understood. However, if the larger and smaller fish are separated and given appropriate feed sizes and types, the smaller fish will exhibit compensatory growth and gain weight to match their cohorts. This separation is known as grading.

Month old sturgeon fry and two and three month old juveniles are graded by hand using visual cues for size discrimination. Fish are netted from the original tank and separated by size into different tanks. Once the tank of origin is emptied and the fish placed in new culture containers, the trough is removed, cleaned and repositioned at the next set of tanks.

This procedure is facilitated by layout including two spare tanks in the general arrangement of four tanks per group; one tank to grade small fish into and one for large fish. Therefore, after an initial grade when the fish are graded out of one 6 ft tank, there are two open tanks for staff to grade fish. These additional tanks can help reduce fish stress by removing one handling event and speeding up the process. As space becomes limiting, the 12 ft (4 m) tanks are brought on line with empty tanks for grading. The grading of juvenile sturgeon can continue every two to four weeks or as needed.

Culling begins when juvenile sturgeon have reached a plateau in survival (all fish are feeding and growing). Fish are removed from within a maternal family to keep biomass at a desired level. The objective is random depopulation to optimize density-dependent hatchery selection without compromising genetic diversity. Malformed or exceedingly small fish are also removed. This practice reduces loading densities in tanks and also removes possible disease vectors by removal of weak fish. The practice of culling is very similar to grading except that it is random in nature and is normally done at the same time. One instance when culling is a separate event is in preparation for marking and tagging where the final number of release fish is achieved. In all instances, a materials set up is very similar or identical to grading. Again, an extra set of tanks increases ease and efficiency of the process and addresses fish health and welfare concerns. To obviate hatchery selection pressures it is advised that this and all grading be done without bias for any physical or behavioral attributes.

Prior to the release of juvenile sturgeon to receiving waters, fish must be marked and PIT tagged when fish are greater than 20-30 g in weight. The marking of fish involves a procedure similar to grading and may be done in conjunction with the final cull. Fish are removed from the tank, placed in an anesthetic bath and scutes are removed from the lateral array and the fish injected with an intramuscular PIT tag. Scute are removed in a pattern that denotes hatchery origin. Fish are transferred to an adjacent tank to recover from tagging.

6.3.5 Mortality Disposal

There are three types of mortality classifications for sturgeon and all are treated ultimately in the same fashion. Sturgeon die from natural causes (dropout – defects - or trauma), disease and through culling. The severity and number of the mortalities are incremental with natural causes, disease and culling. Records of mortalities are kept on each tank to identify disease outbreaks.

For biosecurity reasons when dealing with mortalities, the physical plant design needs to accommodate an area where a freezer can be installed that is away from operations and feed storage. This limits the risk of pathogen spread and preserves biosecurity. Sturgeon mortalities are placed in plastic bags and then in waterproof (wheeled) containers and placed in the mortality freezer. Disposal of the frozen mortalities occurs on an as needed basis and in a manner that conforms to local regulations. Mortalities for disposal must not pass back through production or feed storage areas, thus, provision need be made for a bio secure area that has access to the outside disposal method and internal wheeled access. The area also needs to be cleaned and disinfected in addition to having drainage to a wastewater system.

6.4 SYSTEMS AND PROCESSES

6.4.1 Water In

The most common type of water supply system for aquaculture is flow through supply where water is pumped or gravity fed to a culture system, flows into culture containers and is discharged from the facility. This is also known as a single pass system. A second type of water supply system is water re-use, where water from source enters the culture system and a proportion of the water re-enters the system and in doing so, decreases the inflow and outflow volumes of water. Re-use systems can 'make up' a percentage of the total water flow and are usually in the order to 50 – 85%. Water flow in this type of system is usually captured from the outflow stream and redirected to the culture containers by means of pumps or gravity. The third type of water supply system is recirculation water supply, or recirculation aquaculture systems (RAS). In this system water from source origin is recycled continuously and is treated to maintain water quality.

Flow-through systems from surface water may pass through settling ponds to remove large particulates before the culture containers. In circumstances where pumps are required such as when using a well or bore hole, the water must be de-gassed and oxygenated using an aeration tower (packed columns) or low-head oxygenators. The water then flows into the culture containers and then to discharge. In re-use systems, water is normally captured from the waste stream and moved to an aeration unit that removes CO_2 and increases O_2 before re-entering the culture container. In this dual-drain and side-box system, 60% of the water is collected from the side drain and 40% from the bottom drain. The bottom drain contains most of the heavier solids and sediments. Solids removal may or may not be included in the returning water treatment for the side drain as it contains relatively low particulates. Make-up water inflow and outflow volumes are reduced compared to flow through and reduces raw water demands. In RAS, inflow water is essentially limited to initial system charging and compensation for evaporation and waste removal. Likewise, wastewater discharge is nominal. All culture water is treated for five essential factors: 1) CO_2 removal, 2) O_2 supplementation, 3) solids removal, 4) ammonia reduction and 5) protein fractionation (removal).

Table 28. Water supply criteria for sturgeon (FFSBC 2012).

Parameter	Recommended value
Alkalinity	100-400 mg/L as $CaCO_3$
Ammonium (NH_4^+-N)	Max. 0.05 mg/L at pH 7.0
Ammonia (NH_3-N)	<0.01 mg/L as N
Biological oxygen demand	<4 mg/l
Dissolved oxygen	>90%
Hardness	2-5 dH/50-400 mg/L as $CaCO_3$
pH	6.5-8.0
Nitrite (NO_2-N)	<0.1 mg/L
Nitrate (NO_3-N)	Max. 2 mg/L
Carbon Dioxide (CO_2)	Max. 10 mg/L
Salinity (as required)	0-0.5 ppt for fry, 0-3 ppt for juveniles, 3 ppt for broodstock

Water supply needs to be clean, free of sediment, free of pathogens and contain normal levels of dissolved gasses. Most commonly, sturgeon hatchery surface water is settled and filtered to remove sediments and suspended solids, treated with UV and/or ozone to remove pathogens and de-gassed to equilibrate dissolved oxygen and nitrogen gasses. If well water is used as the source, and the quality of the water assured, settling may not be indicated and only UV treatment used. River water poses the highest risk to biosecurity as there are pathogens in all waters that have resident fish populations; full treatment of river water is recommended. It is true that 'natural' fish are exposed to pathogens and immunity or pathogen tolerance is attained. However, in a culture situation the introduction of pathogens in such close quarters can lead to rapid transmission of disease and cause epidemic losses. The natural and fish culture situations differ considerably with regard to pathogen exposure. Mixes of well and river water must follow the treatment for river water.

If an exposure to endemic pathogens is deemed to be important in sturgeon culture, a process of 'polishing' can be done to limit the incoming pathogen load. In this process a 'side loop' of water delivery can be treated with UV irradiation to decrease the pathogen load entering the facility. In addition to permitting the passage of some pathogens, irradiation will allow dead pathogens to enter the culture water which may aid in immune development. Water quality profiles for water sources need to be determined prior to construction irrespective of the source on an annual basis. This analysis will include metals, total ammonia nitrogen (TAN), polycyclic aromatic hydrocarbons (PAHs), polychlorinated hydrocarbons (PCHs), total dissolved solids (TDS), and bacterial load; these parameters follow those required for salmonid hatcheries.

Ongoing water quality testing for common parameters must be continued for source waters and tank inflow water. This becomes a matter of standard operations. Water quality monitoring for culture conditions is a daily routine.

Inflow water may be treated with UV or ozone to decrease pathogen load. Wild-caught fish carry pathogens into the hatchery as do personnel and other species of fish unaffected by some

diseases that are virulent to sturgeon. This aspect of biosecurity pertains to the movement of equipment, materials, other animals (rodents, birds, mink etc.) and staff, but also to the use of untreated river water and the entry of adult fish into the hatchery. In the former, even water used for cleaning should be potable, meaning passing through a chlorination plant or the same water treatment as water used in fish culture. In the latter, there is no treatment for water carried in on broodstock fish, however, transport trailer water is bleached (and neutralized) before discharge outside the perimeter of the facility or to sewer drains.

The complexity of water quality manipulation increases as inflow and discharge decreases. Likewise, environmental control of water quality increases with increasing reuse to RAS. The advantages of RAS are controlling the rearing environment, reduction of pumping costs and reduced operating costs and flexibility of locating the facility; it can be anywhere. The disadvantage of RAS is the high initial capital and operating cost.

RAS systems have gained wide acceptance in conservation aquaculture and in commercial operations. Sturgeon RAS facilities have been in continuous operation for the last 20 years in the private sturgeon aquaculture industry in California and British Columbia and once the initial cost is amortized, operational costs may be modest relative to flow-through systems where water is pumped from wells. The idea that RAS is suitable for conservation aquaculture is gaining ground although acceptance has been slow. The topic is presented here to highlight alternative culture methods that may have suitability to the current need.

6.4.2 Air & Oxygen Supply

Oxygen levels are normally kept at 85% of saturation in outflow water. Requirements to ensure inflow water is at or near saturation, include aeration towers or supplemental oxygen supply such as a pressure packed column (in the case of a RAS system) or low head oxygenation. In all considerations, emergency oxygen supply will need to be in place such as oxygen diffuser bars that are tank side or in a common area.

For well water or pumped water, degassing and aeration of inflow water is essential. Supplemental oxygen can be employed if saturation is not achieved by aeration, or the use of Low Head Oxygenators can be used prior to the header tank. Carbon dioxide levels need to be held below 10 mg/l in all culture water and should be no more than 1mg/l in inflow water. The anticipated pH range for sturgeon culture should be 7.1 – 8.4 and alkalinity as $CaCO_3$ in the order of 80 – 400 mg/l. An alkalinity doser can be employed for inflow or header tanks water to achieve optimal alkalinity (normally a concern if using a biofilter in RAS).

With adequate de-gassing and aeration of incoming water, supplemental aeration or oxygenation should not be required during regular rearing cycles. However, supplemental or emergency aeration and oxygenation are essential under certain circumstances such as peak loading, males expressing milt in a tank, interrupted water flow, malfunctioning feeder or feed delivery, accidental standpipe removal,. Each tank will need to be fitted with an air line, valve, and oxygen monitoring system. In the absence of an oxygen monitoring system, some culturists keep an air stone bubbling to ensure gas removal and saturation and provide extra current and mixing.

Emergency oxygen supply with the capability to extend service to all tanks in an emergency should be plumbed in and included in the hatchery design. Additional uses for air and oxygen are ancillary to primary fish culture purposes, but useful around the hatchery. These purposes are for cleaning, drying, inflating various objects at odd times. It is helpful to have additional airlines in laboratory areas, work benches and near cleaning sinks for use as a sterile, non-liquid cleaning method.

6.4.3 Temperature Controls

In addition to the above treatment, culture water will be heated (and subsequently de-gassed again) or chilled for control of spawning and growth rate. The optimal temperature range for sturgeon culture is between 50–67°F (10–17°C) (Conte et al. 1988). Water must be made available at that range on demand. The level of heated water supply will be set by further consideration of needs and will have to be engineered. As a rule of thumb, all 12 ft (4 m) tanks require a temperature controlled water supply for female conditioning. The capacity of controlling water temperature has a proven utility at the current Marion Drain facilities (among others) and is recommended here.

6.4.4 Water Out

There are two sources of discharged water from the sturgeon hatchery: 1) tank effluent and 2) drain (gray) water. Tank effluent can contain unused feed, fecal matter and contain other metabolic wastes. These are all of biological origin and can be dealt with as with regular salmon hatchery water such as sedimentation, filtration or green zone settling ponds. However, hatchery sturgeon are under intensive culture and are a wild strain of fish, not a domestic variety. Therefore, cultured sturgeon will succumb to infection from ubiquitous sources such as *Saprolegnia spp.* fungi, *Flavobacter spp., Vibrio spp*. and others. Treatment may require the use of antifungal or antibiotic agents that ultimately end up in the effluent water. Water discharge capability must meet local, state and federal requirements for discharge into receiving waters (NPDES). NPDES permitting is usually set by feed use levels, but other parameters may have to be considered in the permitting process.

6.4.5 Power & Electrical Systems

Power and electrical systems are a critical component of an effective hatchery program. This includes a ready and consistent supply of power as well as back-up systems for any periodic interruptions that may occur.

The electrical systems will be designed to provide adequate power, lighting, heating, ventilation and air conditioning (HVAC), and control for the occupancy and use of the hatchery will be consistent with standard engineering practices and will comply with the latest national codes, Washington Codes, construction codes, and life safety codes. A list of general codes and industry standards to be used in design and construction are as follows:

- American National Standards Institute (ANSI);
- American Society for Testing and Materials (ASTM);
- Insulated Cable Engineers Association;

- Illuminating Engineering Society;
- Institute of Electrical and Electronics Engineers;
- International Building Code;
- National Electric Code (NEC), Latest Addition;
- National Electrical Manufacturers Association;
- National Fire Protection Association;
- Underwriters' Laboratories; and
- Occupational Safety and Health Administration Regulations.

Stand-by power is provided by redundant, spark-ignited, propane fired engine generators. The generator is housed in sound attenuated, weatherproof, lockable enclosures and mounted on a pad adjacent to the Control Building. The generator includes a battery for starting the engine, block heater, fuel vaporizer and transfer switch.

Interior wiring will be in electrical metallic tubing (EMT) and flexible metallic tubing, except in hazardous areas where rigid galvanized steel conduits will be used. Exterior wiring will be in rigid galvanized steel conduits with threaded couplings or liquid tight flexible metal conduit. For underground electric utilities, the conduit will be concrete encased, schedule 40 PVC.

The lighting systems must be designed to meet Washington efficiency requirements and will meet light level recommendations of the Illuminating Engineering Society Handbook. All luminaires will have UL listing. Interior lighting will be LED. Minimal exterior lighting will be provided. Switchable floodlighting will be provided to facilitate nighttime maintenance or service for areas such as the heat exchangers. Luminaire Schedules will show the light fixture symbols and unique identification numbers, type (fluorescent, LED, etc.), description and features, manufacturers, catalog numbers, number and type of lamps, and mounting position.

6.5 RELATED FACILITIES

6.5.1 Laboratory

Every fish culture facility needs lab facility support for preparation of clean materials for sending out for analysis, such as water or tissue samples and for the preparation of dirty materials such as necropsy. The facility is best located within or close enough to the culture facility to make it practical, but secure enough so as not to cause cross contamination of naïve fish. Laboratory equipment requires clean dry space in an enclosable area free from dust, airborne mist and cross draft. Therefore, a lab in an enclosed room is recommended and ideal. A chemical storage cabinet is located in the lab; here NDIPES-regulated materials are stored and other chemicals related to fish culture such as disinfectants. There are a number of special qualities for a lab that depend on the planned use such as types of sinks, fume hoods, cabinets, refrigerators, freezers, etc.

6.5.2 Feed Storage

Feed storage should be in a pest and rodent-free secure area adjacent to fish growing operations. This area is preferably in an enclosed, temperature-controlled and sealed room or building. The area must be dry and cool and also contain a refrigerator and freezer for feed and feed additives.

The area needs full electrical service with weight balances (floor and bench) and also have a chemical storage cabinet capable of storing prescribed medications. Feed storage near the culture area is required to minimize handling; this is good to maintain the integrity of the feed and respects staff safety. Adequate floor space for feed movement within the storage area is required to obviate large storage of feed that may form a safety hazard. The feed storage area is best located near truck access. Although the feed demands of planned production is not large, multiple handling of feed bags increases the fines content of the feed which when introduced to the feeder can solidify and turn rancid in addition to house pathogens if not temperature controlled; fish feed is rich in fats, oils and protein that are a perfect medium for fungal and bacterial growth if not stored properly. As well, feed fines in the water can promote degradation of water quality. Space also promotes feed rotation and inventory control.

6.5.3 Refrigeration & Freezers

Electrical and splash free areas need to be included in construction for refrigerator and freezer space. In addition to the feed storage freezer, there is an additional need for a mortality freezer (as described above) and another freezer for general purpose storage. For refrigeration, one refrigerator is needed in the laboratory, one in the feed area and another general purpose refrigerator located a safe location somewhere in the hatchery area. GFI circuitry is required on all refrigerator and freezer outlets as directed by general building codes and engineering principles.

6.5.4 Disinfection & Cleaning Stations

Biosecurity procedures require an area to clean, disinfect and dry (heated space preferred) used equipment. This area must be big enough and accessible enough so that portable troughs, carts, trolleys, nets and other equipment can be scrubbed using hot water and soap, sprayed with disinfectant and left to dry. Floor drains capable of accepting used soap and disinfectant are required. Commercial-scale (kitchen) sinks of aluminum construction with hot and cold water, and goose-neck spray nozzles are ideal in this situation.

6.5.5 Supporting Facilities & Equipment

These include workshop for repairing and fabricating equipment, garages for vehicles, equipment storage and crew support facilities. Storage area is essential to any hatchery. This area must be away from the fish culture area for contamination and safety reasons. The area requires shelving and dry storage for seasonal or occasional equipment, stores and supplies and for old or disused materials (i.e. bone yard). Proper lighting and a dry area are essential for storage areas. Crew support facilities include a locker room, bathrooms and on-call quarters.

7 CONCEPTUAL FACILITY DESIGN

7.1 PREFERRED SITES

The target stocking levels demand large water volumes and tank space. Rather than one central facility for production, this program is proposing to develop several complementary locations and rearing sites for sturgeon production contingent on funding and costs. Multiple facilities, where cost effective, will capitalize on existing opportunities, provide a combination of production, research, education and training benefits, limit risks of concentrating production at one site, and provide for a shared involvement in the sturgeon propagation effort.

Yakama Nation Marion Drain Sturgeon Hatchery – The Columbia River Inter-Tribal Fish Commission has recommended that new facilities be developed at this existing hatchery site to house the majority of the sturgeon aquaculture activities. The essential elements to support this are: central location, ample water supply of high quality, optimal building siting and regulatory permitting, economies of scale with existing programs, and sturgeon culture expertise including high qualified personnel (HQP). From this location, existing HQP can receive, spawn, incubate and grow sturgeon proficiently. Because of the vertically integrated nature of the growing cycle (adult, egg, larvae, fry, and juvenile) at the site, the Marion Drain facility would also provide fish to other facilities consistent with production targets.

Walla Walla South Fork Hatchery – A companion facility will be operated at the Walla Walla South Fork Salmon Hatchery operated by the Confederated Tribes of the Umatilla Indian Reservation. This facility will rear juvenile fish transferred from the Marion Drain Facility after incubation and hatching.[23] Current plans call for expansion of the existing adult holding and spawning facility into a full production hatchery for incubation, spawning and rearing of spring Chinook salmon to augment numbers available for harvest and re-establish a naturally spawning population in the subbasin.

In addition, complementary research operations may be developed at a third location, the Walla Walla Community College Water and Environment Center. This location which is jointly operated by the CTUIR, does not lend itself to a full-fledged production hatchery but provides an excellent and cost-effective opportunity for supporting activities. It is expected that the Tribes will also utilize this facility for education and outreach purposes under existing Tribal programs.

[23] *Initial considerations for the companion facility focused on Ringold Hatchery, Bonneville Hatchery's captive brood facility, and a McNary Dam site. Subsequently, new information on the South Fork Walla Walla salmon hatchery developed in Master Planning for expansion of that facility identified additional space and water for cost-effective rearing of juvenile sturgeon.*

7.2 SITE EVALUATION PROCESS

Hatchery sites were selected based on a review of existing hatchery facilities or sites in the region that could potentially be used to collect, hold, rear and/or release White Sturgeon produced through this mitigation hatchery master plan (Figure 57). Potential sites were identified because of their proximity to Zone 6 fisheries of the Columbia River, the Hanford Reach, and the lower Snake River, as well as the ceded areas of each of the Columbia River treaty tribes. Only a few of the locations were determined to be suitable for juvenile rearing, education and outreach, and complete hatchery operations (i.e. broodstock holding and spawning, incubation and early rearing, and juvenile rearing and preparation for release). See Appendix 13.1 for an inventory of existing hatchery facilities with more detail on the purpose, production, facilities and water resources of each facility or site.

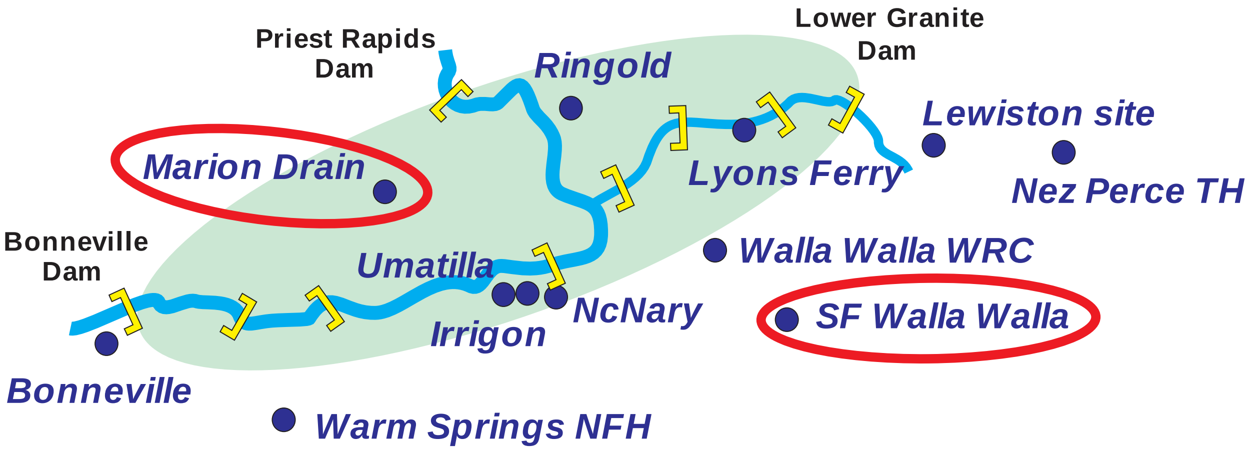

Figure 57. Locations of potential sturgeon hatchery sites considered in proximity to the focal mitigation area (highlighted).

The hatchery facilities or sites that were considered for White Sturgeon produced through this master plan were:

1. Bonneville Hatchery: This hatchery is located in Oregon downstream from Bonneville Dam. A building, water and space is projected to be available following the completion of a Snake River salmon and steelhead captive broodstock rearing program around 2016.
2. Irrigon Hatchery: Irrigon Hatchery, operated by ODFW, is located along the Columbia River above John Day Dam, 3 miles west of Irrigon. The site covers 33 acres and is owned by the USFWS. This facility serves as an egg incubation and rearing facility for summer steelhead destined for the Grande Ronde and Imnaha river systems. It also rears fall Chinook from eyed eggs to subyearling size, as well as legal-sized rainbow trout for northeast Oregon.
3. Lewiston Site: This undeveloped site in Lewiston, Idaho sits next to the Snake River levy. No hatchery facilities currently exist on the site; however, it offers an existing well and pump house with high quality, high-volume water.

4. Lyons Ferry Hatchery: Lyons Ferry Hatchery, operated by WDFW, is located at RM 59 (RKM 95) on the Snake River adjacent to the reservoir pool behind Lower Monumental Dam. The hatchery was constructed under the Lower Snake River Compensation Plan and rears Snake River fall Chinook, Tucannon River spring Chinook (in collaboration with Tucannon FH), four stocks of steelhead, and two stocks of rainbow trout.
5. Marion Drain, Yakama Sturgeon Hatchery: Marion Drain is located on approximately 15 acres (6 ha) in the Yakima River basin adjacent to Marian Drain near Toppenish Washington. The Yakama Nation operates the facility for sturgeon production as an experimental program. Current capacity is approximately 20,000 yearlings per year, in addition to fish held for longer periods for commercial production.
6. McNary Dam: This undeveloped site adjacent to McNary Dam presents the opportunity to utilize Columbia River water which would allow the hatchery to hold adults and rear juveniles under ambient conditions. The CTUIR is contemplating the development of a multi-species aquaculture facility which might also include lamprey and mussels.
7. Nez Perce Tribal Hatchery Complex: The Cherrylane Hatchery, operated by the Nez Perce Tribe, sits on a flat bench along the south bank of the Clearwater River about 32 km (20 miles) east of Lewiston and adjacent to Highway 12. The hatchery is designed to accommodate the incubation and rearing of 1.4 million fall Chinook and 625,000 spring Chinook salmon. Another 200,000 spring Chinook smolts are produced for acclimation. The facility also holds adult Pacific Lamprey that are collected and transported from fish ladders at John Day and The Dalles Dams.
8. Ringold Springs Hatchery: Ringold Springs Hatchery is located on the Hanford Reach, 17 miles west of Mesa, WA near Columbia River mile 352. The hatchery is operated as part of the WDFW's Priest Rapids Hatchery Complex, which also includes the Meseberg, Naches and Columbia Basin hatcheries. It produces fall Chinook, spring Chinook and summer steelhead.
9. Umatilla Hatchery: Umatilla Hatchery sits adjacent to the Columbia River, 3.5 miles west of Irrigon, Oregon. The 23 acre (9 ha) site is owned by the US Army Corps of Engineers. Satellite facilities include: Three-Mile Dam facility on the Umatilla River for adult broodstock trapping and holding, Minthorn and South Fork Walla Walla for adult holding, and Pendleton, Minthorn, Thornhollow, and Imeques facilities for juvenile acclimation. ODFW operates the main facility and the CTUIR operate the satellite facilities. The facilities produce fall Chinook, spring Chinook and summer steelhead.
10. Walla Walla Community College Water and Environment Center: The Center is located on campus at the Walla Walla Community College. No production currently takes place at the Center, which includes an aquatic research and propagation laboratory, specimen/biology laboratory, water quality laboratory, hydrology laboratory, classrooms and office space.
11. Walla Walla South Fork Hatchery: The hatchery is located east of Milton-Freewater, Oregon, at approximately RM 7 (RKM 11) on the South Fork Walla Walla River. The CTUIR

operate the facility, which is part of the Northeast Oregon Hatchery Program under the NPCC Fish and Wildlife Program. The facility collects and spawns adult spring Chinook but a master plan completed by the CTUIR (2013) calls for expansion to a full production facility including incubation and rearing.

12. Warm Springs National Fish Hatchery: This facility is located at RM 10 (RKM 16) on the Warm Springs River, on reservation lands leased from the CTWSR. The Warm Springs River is a tributary of the Deschutes River. The hatchery produces spring Chinook.

Each facility or site poses different opportunities and constraints that could affect its use for this hatchery program. Currently, only one of the hatchery facilities, the Yakama Nation's Marion Drain hatchery, produces sturgeon. The other eight existing facilities produce spring Chinook, Fall Chinook, and/or steelhead. Factors that could affect an existing facility's desirability for sturgeon production include available water supplies, location, and facility characteristics. Table 29 shows the opportunities and constrains associated with each of the potential hatchery facilities or sites.

Table 29. Summary of opportunities and constraints associated with each potential hatchery facility or site.

Site	Opportunities	Constraints
Bonneville	• Existing facilities are available following the completion of the captive brood rearing program. • Facility available in FY 2015.	• Space and water not adequate to support full sturgeon production program.
Irrigon	• Potential availability of space, staff, and support facilities provide cost-effective option. • Site is in close proximity to potential sturgeon capture and release sites.	• The facility is currently operating at capacity and limited by water supply. • Well water might provide sustained growth over winter, but would need to be heated.
Lewiston	• Provides high-volume well water with quality and temperature suitable for year-round rearing. • Potential joint venture with city provides opportunity for information/education outreach.	• Requires development of new facility; potentially demanding significant resources. • Significant travel distance to adult collection and juvenile release sites.
Lyons Ferry	• Potential availability of space, staff, and support facilities provide cost-effective option. • Site is in close proximity to potential sturgeon capture and release sites.	• Facility is currently operating at capacity and is limited by water supply. • Well water might provide an opportunity to sustain growth over the winter period.

Site	Opportunities	Constraints
Marion Drain	• Only operational sturgeon facility in the mid-Columbia region. • Staff has demonstrated expertise in sturgeon culture and propagation. • Potential availability of space, staff, and support facilities provide cost-effective option. • Significant space is available for expansion.	• Facility will require significant upgrades for long-term production. • Water may be limited and subject to future higher priority uses for tribal salmon programs. Lack of suitable surface water is also a concern. • Moderate travel distance to some potential broodstock collection and release sites.
McNary Dam	• Land and water are potentially available due to changes in smolt collection and transportation. • Use of river water would allow adult holding and juvenile rearing under ambient conditions. • Close proximity to planned sturgeon collection and release areas.	• Would require substantial facility development. • Lack of existing hatchery infrastructure and staff would require dedicated resources
Nez Perce	• Potential availability of space, staff, and support facilities provide cost-effective option. • Tribal operation and tribal authority.	• Facility is currently operating at capacity and is limited by water supply. • Surface water temperatures typically colder than ideal for rearing. Well water may help sustain winter growth. • Significant travel distance to adult collection and juvenile release sites.
Ringold	• Potential availability of land, staff, and support facilities provide cost-effective option. • Site close to potential sturgeon capture/release sites. • Facility has unused space and water. Well and possibly surface water is suitable for sturgeon rearing. • Potential expansion at site for fall Chinook rearing might provide some cost saving/sharing.	• Additional facilities would be required for sturgeon production.
Umatilla	• Potential availability of space, staff, and support facilities provide cost-effective option. • Site close to potential sturgeon capture/release sites. • Well water might provide an opportunity to sustain growth over the winter period.	• Facility operating at capacity with limited water supply. • Well water source provides would require heating to maintain suitable rearing temperatures.

Site	Opportunities	Constraints
WWCC Center	• Facility provides opportunity for educational outreach, training in sturgeon culture, and culture research. • Facilities are best suited to egg incubation and limited juvenile rearing.	• Space and facilities not likely sufficient for complete production program, including adult holding/spawning • Significant travel distance to adult collection and juvenile release sites.
Walla Walla	• Space and water will be available with expansion of existing facility for year-round spring Chinook salmon production. • Potential availability of space, staff, and support facilities provide cost-effective option. • Domestic well water source provides temperatures suitable for juvenile sturgeon rearing. • Tribal operations and authority.	• Currently a seasonally operated facility with limited staff and support availability. • Surface water temperatures typically colder than ideal for rearing. • Significant travel distance to adult collection and juvenile release sites.
Warm Springs	• Potential availability of space, staff, and support facilities provide cost-effective option. • Effective history of cooperation with the CTWSR.	• Facility is currently operating at capacity. • Surface-water temperatures not ideal for year-round sturgeon production and could require some heating. • • Remote location increases costs and operation difficulties.

Table 30 ranks the relative suitability of each site for sturgeon production based on water, facilities, power, and staff.[24] Water was evaluated based on quantity and quality relative to production design and requirements identified in Section 6. Water quality concerns superseded all other considerations (e.g., water too cold for sturgeon production). Facilities were assessed based on the availability of existing infrastructure that could be utilized for sturgeon production, supporting infrastructure, and/or space for development of dedicated sturgeon production facilities. Power supply was assessed based on availability and reliability. Staffing was assessed based on current the availability of trained professional staff at the site, staff size, and experience with sturgeon.

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[24] *Ratings and rankings were revised from the review draft of this plan based on new information regarding the Walla Walla Hatchery identified in plans for expansion of that facility.*

Table 30. Evaluation of alternative site suitability for sturgeon production.[1]

	Water		Infrastructure			Power	Staff/Expertise		Grade Point avg.	Rank
Site	Quantity	Quality	Production	Support	Space	supply	Existing	Sturgeon		
Marion Drain	B	A	B	B	A	A	B	A	3.50	1
Walla Walla South Fork[3]	B	B	B	A	A	A	B	C	3.25	2
Bonneville Hatchery	B	A	B	A	C	A	A	C	3.25	2
Ringold	B	B	C	A	A	B	A	B	3.25	2
Irrigon	B	C	C	A	B	A	A	C	3.00	5
Lyons Ferry	C	B	C	A	B	A	A	C	3.00	5
Umatilla	C	B	C	A	B	A	A	C	3.00	5
McNary Dam	A	B	C	C	A	A	C	C	2.88	8
Nez Perce	C	C	C	A	B	A	A	C	2.88	8
Lewiston	A	B	C	C	A	B	C	C	2.75	10
WWCC Center	D	B	C	B	C	B	A	C	2.50	11
Warm Springs	C	D	C	A	A	A	A	C	1.00[2]	12

[1] *A = high suitability, B = suitable for designated use with moderate development and/or adaptation, C = limited potential or extensive development required, D = not suitable.*

[2] *Water quality limitations supersede other considerations.*

[3] *Infrastructure and staff evaluated based on plans for expansion of existing adult collection and holding to full salmon production facility.*

7.3 PRIMARY PRODUCTION SITE – MARION DRAIN STURGEON HATCHERY

The Yakama Nation (YN) Sturgeon Facility at Marion Drain (Marion Drain) is located on 60 acres (24 ha) south of Toppenish Washington. The facility is adjacent to the Marion Drain irrigation and drainage channel for the Yakama River floodplain and surrounding area (Figure 58). Agricultural fields surround the sides not bordered by the Drain and there is a keypad entryway to the facility. An 8 ft (2.5 m) chain link fence topped with barbed wire surrounds the facility.

Figure 58. Yakama Nation Sturgeon Facility at Marion Drain.

A sturgeon hatchery has been under development by the YN at Marion Drain since 2009 when the first holding facilities were constructed. Facilities and systems have been progressively improved in the interim. Sturgeon were originally obtained from various sources, including the Pelfry sturgeon hatchery operating downstream from Bonneville Dam and mid-Columbia hatchery research by CRITFC and the U.S. Fish and Wildlife Service (Kappenman & Parker 2004). The program successfully spawned captive broodstock beginning in 2007. Wild broodstock were spawned beginning in 2010.

The program is currently involved with spawning wild broodstock and rearing 6,500 juveniles to age 1 for release in Grant County Public Utility District reservoirs to meet mitigation requirements of their operating license. The program is also spawning and providing fertilized eggs for transfer to other facilities for Chelan and Douglas County PUDs. In addition, the facility is holding approximately 10,000 one to twenty-five year-old sturgeon ranging from 1–200 lb (0.5–90 kg) in size for an assessment of the potential for commercial production and sales of meat and caviar.

7.3.1 Program Elements

It has been proposed that there be three program components for the Marion Drain facility:

Broodstock Holding & Spawning

- Hold up to 20 adult sturgeon (4,400 lb, 2,000 kg maximum) in spawning condition from capture to final maturation, evaluation and spawning until returned to the river.
- Use well water for final maturation and induction of early spawning with capacity to temper water and preserve males for additional spawning use.
- Provide 12 ft (4 m) tanks to allow separation of males and females in spawning condition and for ease of handling.

Incubation

- Incubate up to 5 individual paired matings per spawning event to neurulation and hatching for 10 maternal families (two times 5♀ x 5♂ factorial mating design).
- Incubate up to 1,000,000 fertilized eggs.
- Hatch up to 400,000 unfed fry.
- Feed up to 150,000 fed fry and pond out to 12 ft (4 m) tanks.
- Provide capacity to incubate up to 20,000 wild-caught yolk-sac fry or first-feeding fry.

Juvenile Rearing

- Produce 5,000 age 0+ juveniles for release in fall, approximate size range 15-20 gm (0.5 – 1.0 oz).
- Produce 20,000 age 1 juveniles for release in the spring of the following year; approximate size range 100-150 gm (3.5–5.0 oz).
- Produce an additional 1,500 yearling juveniles for release in the following autumn; approximate size 250-350 gm (9–12 oz).
- Water supply is well water of 57–61°F (14-16°C) with capability to chill water as required.
- Seed stock may be supplied from the Marion Drain facility to a companion facility; approximate size at delivery 1 g (0.04 oz) in the spring and 15–20 g (0.5–0.7 oz) in the autumn during routine biomass downsizing.

7.3.2 Water & Power Supply

The site currently has two shallow production wells and one deep back-up well. The two production wells each produce upwards of 600 gal/min (2,300 L/min) and tap into the same aquifer. These wells are 160 ft (50 m) deep and cost around $125,000 each to install. Constant 14°C (57°F) water is supplied from two shallow wells at a total capacity of 1,200 gal/min (4,800 L/min). The deep well for backup and is considered a surplus well due to water regulation and aquifer management. This well can produce upwards of 600 gal/min (2,300 L/min) and taps into a separate aquifer. Water from this well is high in iron content and is anoxic.

Well water passes through gas balancing columns prior to use for rearing sturgeon. Water from shallow wells is pumped to a 4m high aeration tower and passes through a 6 ft (2 m) diameter column of 1 in (2.5 cm) bio rings for passive aeration. All aeration towers are passive; there are

no blowers and air enters through a port in the top. Culture tank outflow O2 is 7mg/l. Tank inflow water is at saturation levels of 9.8mg/l. Air blowers are used for in-tank aeration.

Marion Drain Hatchery meets water quality requirements for sturgeon production after gas balancing treatment (Table 31). The well water at Marion Drain has a pH range of 8.1-8.3, which is slightly higher than the recommended range for sturgeon rearing of 6.5-8.0. Sturgeon rearing is currently taking place at Marion Drain and the pH difference does not appear to be detrimental. Fertilization and growth rates at Marion Drain appear to be similar to that of other sturgeon hatcheries in the region.

Table 31. Marion Drain hatchery water quality.

Parameter	Recommended Value	Marion Drain Sample Value
Alkalinity	100-400 mg/L as $CaCO_3$	197 mg/L as $CaCO_3$
Ammonium (NH_{4+}-N)	Max. 0.05 mg/L	
Ammonia (NH_3-N)	< 0.01 mg/L as N	
BOD	< 4	
Dissolved Oxygen	> 90%	9.63 mg/L
Hardness	2-5 dH/50-400 mg/L as $CaCO_3$	107 mg/L as $CaCO_3$
pH	6.5 – 8.0	**8.1 - 8.3**
Nitrite (NO_2-N)	< 0.1 mg/L	None Detectable
Nitrate (NO_3-N)	Max. 10 mg/L	2.6 mg/L
Carbon Dioxide (CO_2)	Max. 10 mg/L	Not Measured
Salinity	0 – 0.5 ppt for fry 0 – 3 ppt for juveniles 3 ppt for broodstock	Not Measured

The current production at Marion Drain utilizes the full 1,200 gal/min (4,500 L/min) available from the two existing production wells. Assuming that the current production will remain and that water requirements for new White Sturgeon production will be in addition to current demand, additional wells or recirculating systems will be needed to accommodate the water demand of the new White Sturgeon program. An additional 600 gal/min (2,300 L/min) well has previously been investigated and is believed to be feasible.[25] Along with an additional well, a separate degassing and piping system would be required to increase the available rearing water supply. The site also has the potential to support a second new well if necessary (for total of 4 production wells). In addition, the site is located next to the Marion Drain which provides access to surface water and the possibility of tapping shallow subsurface water through an infiltration gallery which could provide a source of naturally-fluctuating temperatures.

[25] *A test well will be completed in the near term in conjunction with this planning process.*

There are currently two water delivery lines to the existing buildings that are interconnected as backup so that either well or tower can service the tanks from the two aeration towers. The wells can be isolated or shared in event of a shut down. The lines are also connected to two chiller units that have the capacity to deliver an excess of chilled water, if required. The 10°C water is tempered in large tanks to keep constant water supply volumes through the chillers; capacity is 100 gal/min (400 L/min) at 50°F (10°C). Water is recirculated to the chillers to keep the pumps operating below maximum levels.

The conceptual plan proposes using a water delivery arrangement similar to the existing system for new production facility at Marion Drain. Water use permits allow for two additional wells to be drilled and there appears to be ample space to ensure that the new wells do not draw down on the local aquifer or that the additional infrastructure does no impinge on current operations.[26] Water capacity for two new wells will be in excess of 950 gal/min (3,750 L/min) to meet peak water use demands. Water treatments of aeration and degassing will be required.

Water systems will include to capacity to temper water as required for the different life stages. The main production component of the sturgeon mitigation facility will require heat pumps/chilling units and tempering tanks to manipulate temperatures for broodstock management and for acclimation of released fish. This chilled water may also be used to cool incubation water as recent work has demonstrated that incubation temperatures of 50–55°F (10–13°C) increase growth and survival of larvae.

A pollution abatement treatment system will be constructed adjacent to the existing effluent treatment pond.

The current power supply is 600 A, 3-phase, and 480v power. During initial evaluation it appeared that the current power system would have enough excess capacity to support the new facilities. The existing 600 kW back-up diesel powered generator with an automatic transfer switch will supply essential systems in the case of total power loss.

[26] *The Yakama Nation has its own Water Code program which issues the permits for wells on tribal property including the Marion Drain site. Permitting goes through the YN rather than the state.*

7.3.3 Facility Description

Over five acres are available for new hatchery building located in the middle of the site. Access to the site is by gravel road with little to no slope. The existing facility includes a hatchery building used for spawning, incubation and rearing; three pole-barn style covered rearing areas (currently used for potential commercial grow-out production), and three mobile home style buildings used for an office, storage, and crew quarters. Production containers include a variety of circular tanks.

Hatchery Building

The conceptual design (± 35-50% level) for a new production building needed to support the program objectives is described in Figure 59 through Figure 63. The hatchery building will be of clear-span, steel clad construction with an envelope of at least 210 x 81 ft (64 x 25 m). The interior of the building includes distinct areas separated by walls for different life stages to accommodate biological and biosecurity demands.

One room will house twenty 6 ft (2 m) tanks for use in incubation and early rearing. A second room will house two 20 ft (6 m) tanks, and twenty 12 ft (4 m) tanks for use in broodstock holding, spawning, and juvenile rearing. Adult holding will be accommodated in the juvenile rearing area and will be cleaned and disinfected after spawning events are complete and before the tanks are used for juvenile rearing. This configuration provides flexibility in the designs to accommodate changes to the plan and expansion. Total rearing volume is 80,000 gal (300 m^3).

The building also includes areas for ancillary services to support fish culture and controlled access to culture areas. These include separate rooms for mechanical/electrical controls, feed storage, food preparation, egg fertilization, equipment storage, office space, and a crew locker room.

Tanks are arranged in groups to facilitate grading and tank-to-tank transfer. Space is provided to access each tank with mobile equipment used in normal routine such as feeding and specific practices such as grading. This arrangement helps prevent damage to the tank sides when using wheeled equipment such as a cart, dolly or pallet jack. It is also a common practice to have a large access route between the larger tanks and the smaller tanks. A large passage way of 10–15 ft (3–5 m) permits the passage of machinery and equipment along the hatchery route. Furthermore, this space is also valuable for the temporary set up of troughs for use in the grading and marking of juveniles. The passageway needs be fitted with water access and be drained. Larger tanks need additional care in terms of maintenance and this care requires larger tools such as longer handled nets and brushes than those used in the smaller tanks. Consequently, space between larger tanks needs to accommodate these activities. Likewise, as the larger tanks will be used to hold fish of up to 200 lb (90 kg) or more, it is important that operators have enough room to carry fish safely without risk to staff or fish. Overhead gantry rails for transporting large fish in stretchers will be needed to facilitate moving fish in spawning condition from tank to tank as required. Space must also be provided for benches or tables for equipment, trolleys for equipment or fish and general movement in and around the tanks. Clean up water hoses are vital for this area as surfaces must be cleaned after handling fish and moving equipment.

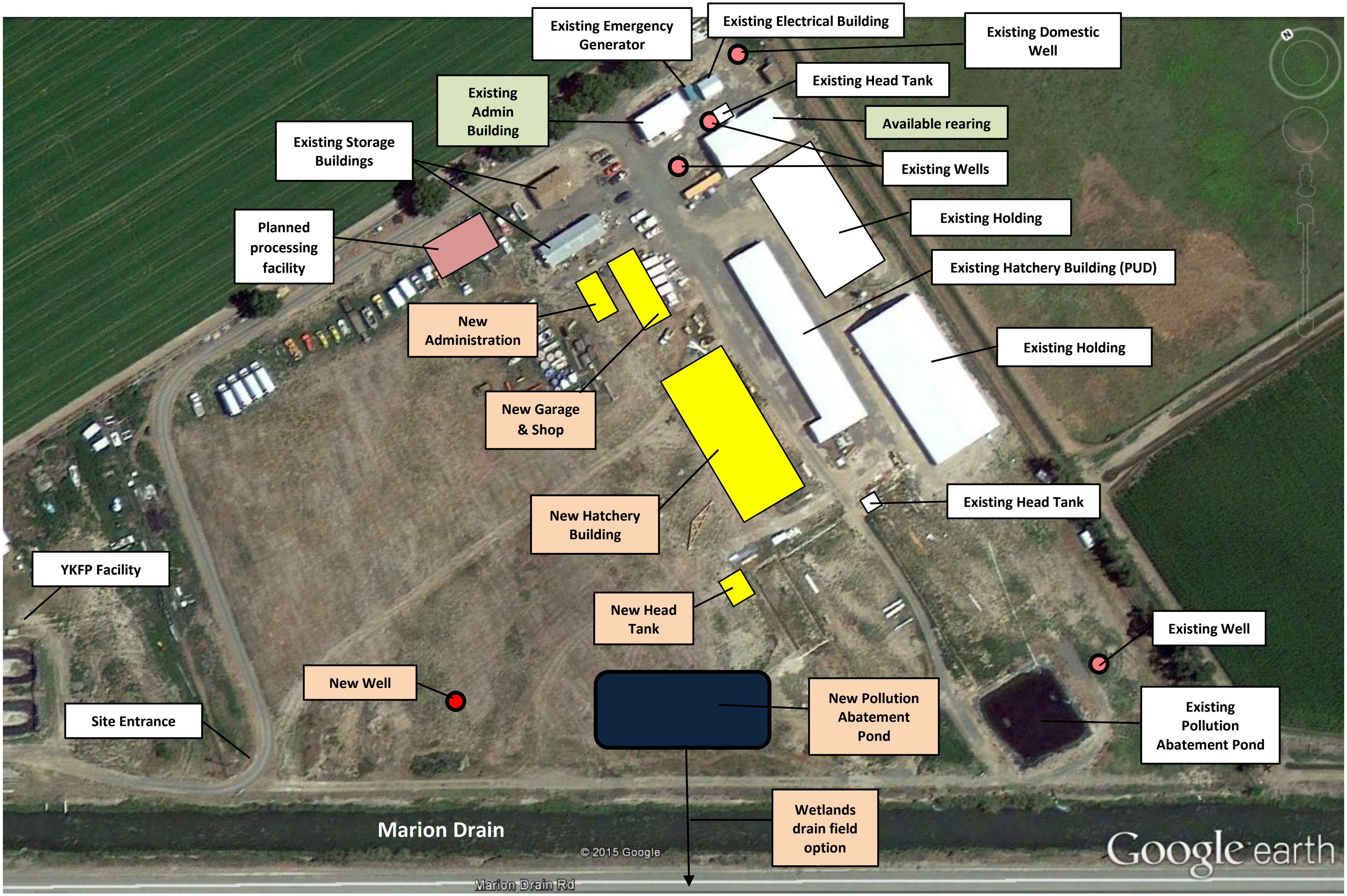

Figure 59. Proposed general arrangement for Marion Drain conservation fish culture facilities.

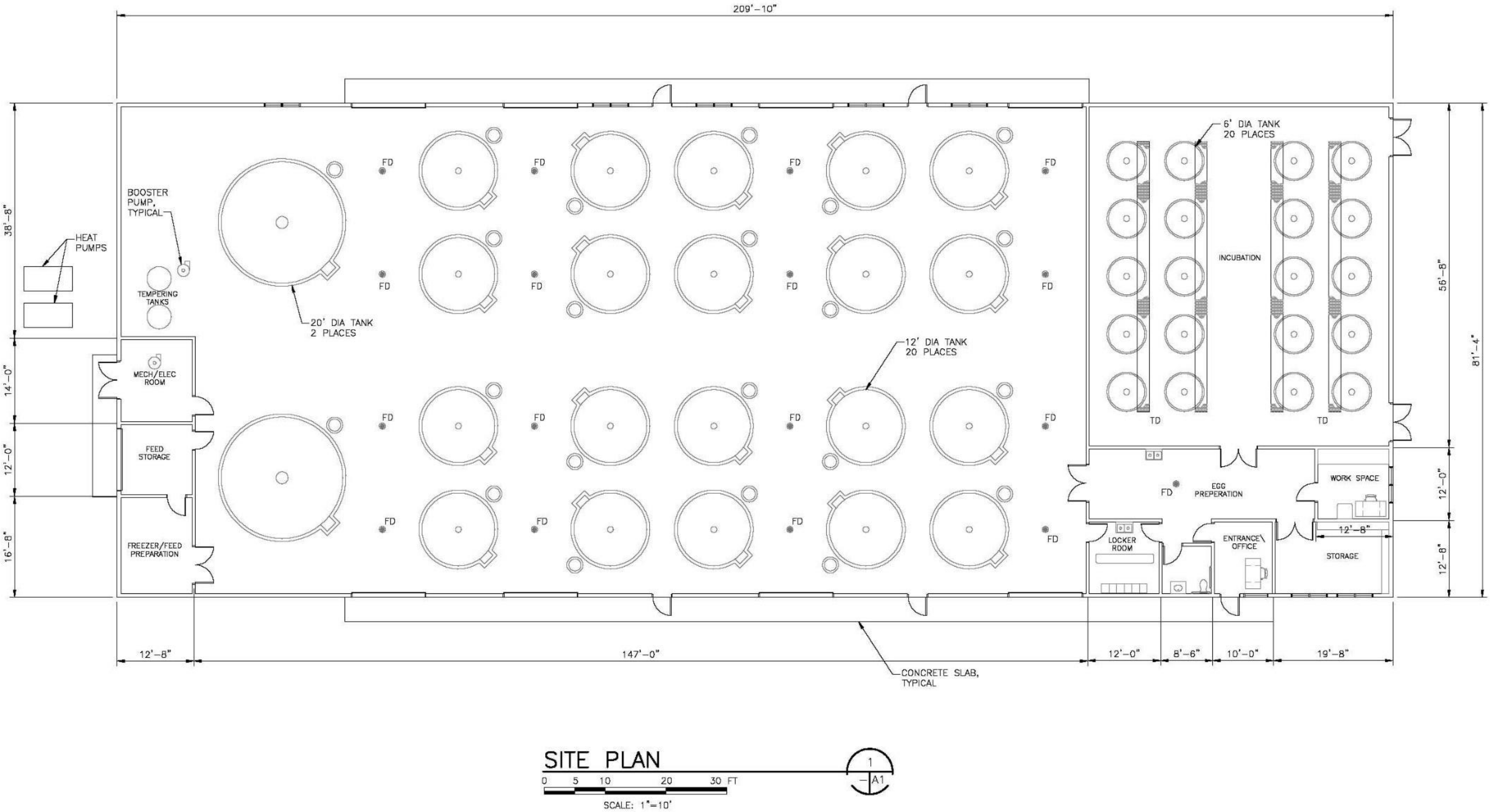

Figure 60. Conceptual design for the proposed sturgeon production facility at Marion Drain hatchery.

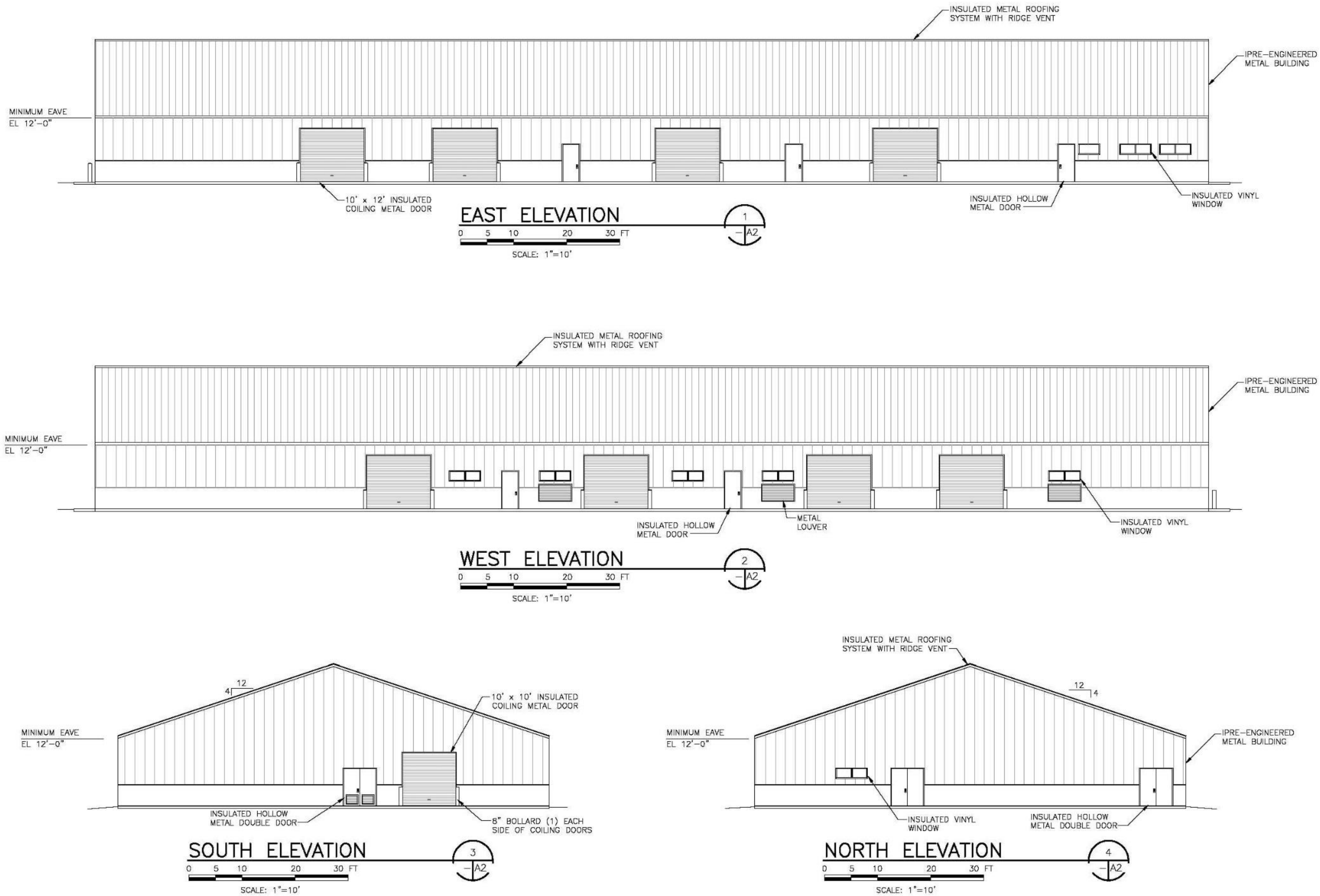

Figure 61. Building description for the proposed sturgeon production facility at Marion Drain hatchery.

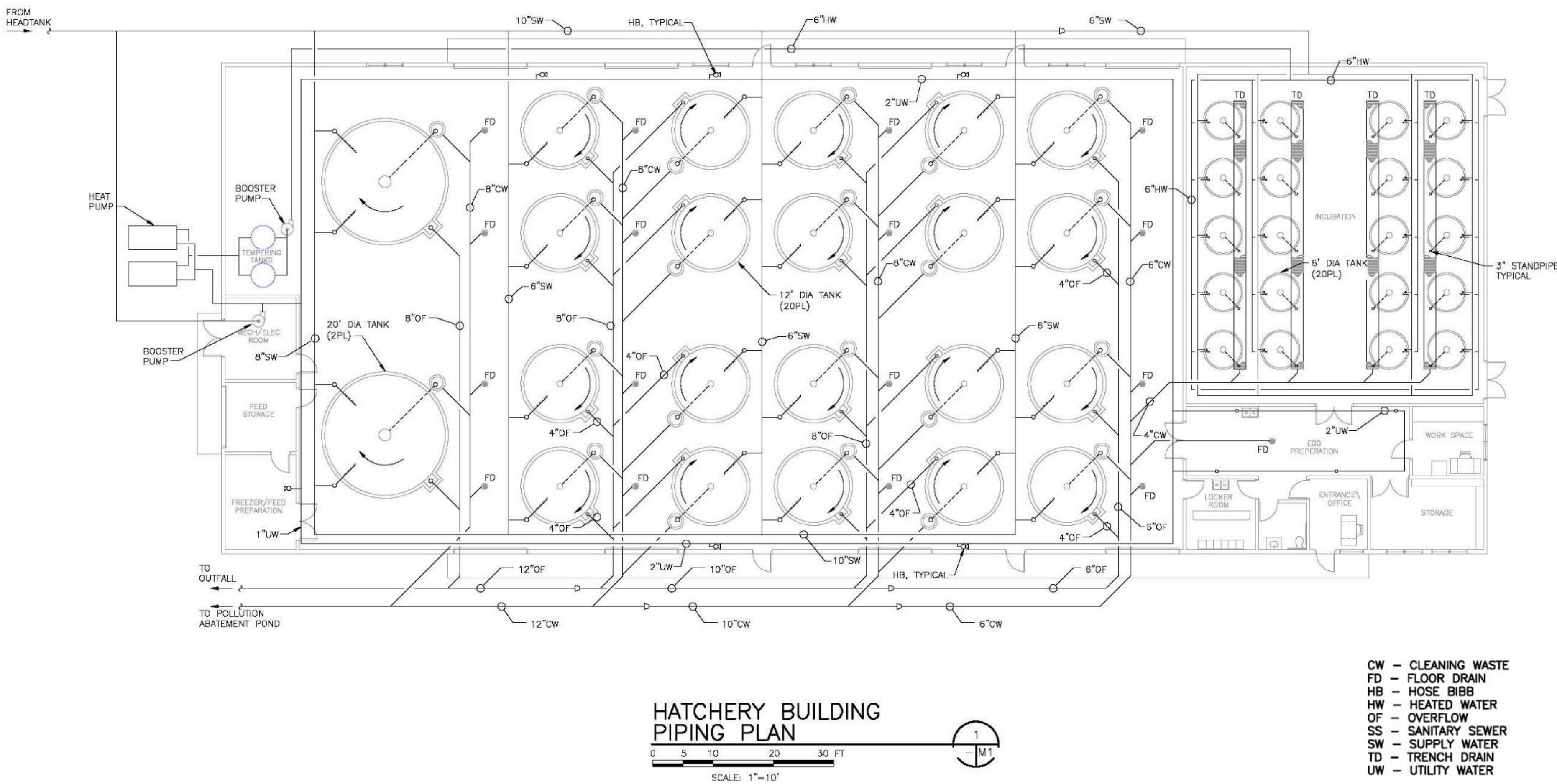

Figure 62. Conceptual hatchery building piping plan for the proposed sturgeon production facility at Marion Drain hatchery.

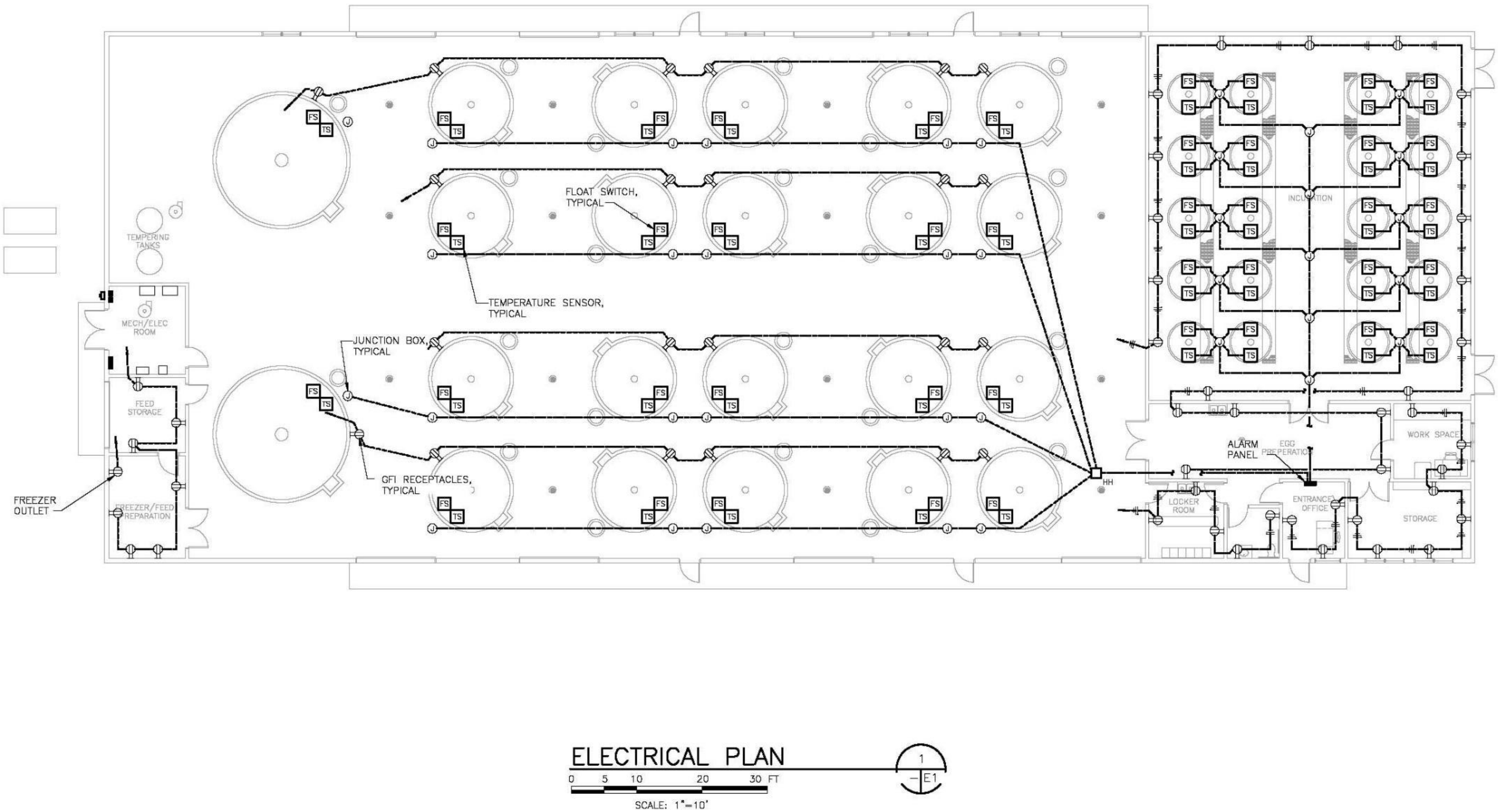

Figure 63. Conceptual design for the electrical plan at the proposed sturgeon production facility at Marion Drain hatchery.

Wild Rearing Building

The conceptual hatchery plan calls for rededication of a pre-existing portion of the Marion Drain facility for wild larval rearing. Wild larvae will be reared in a separate building from the rest of the proposed production in order to provide biosecurity. This space includes a covered building with circular tanks and plumbing. The building is 47 x 80 x 10 ft (14 x 25 x 3 m) and currently holds approximately twelve 6 ft (2 m), five 9 ft (2.7 m), and six 10 ft (3 m) circular tanks. The building will need to be replumbed, the drain rerouted, and concrete poured for the floor. This portion of the facility was previously developed by the YN with tribal funds and grants. The availability of this space was one of the reasons that the Marion Drain site is identified as the preferred option for this program.

Design elements include:

- Building:
  - Building dimensions
  - Door sizes and locations
  - Window sizes and locations
  - Ventilation systems
  - Assume no major site improvements outside of the building are needed to accommodate the interior changes.
  - Assume some minor grading and a 50 x 25 ft (15 x 8 m) gravel surface parking area.
- Tanks
  - Number, size, and existing layout
  - Water inlet conditions and fixtures/facilities
  - Water drain conditions and fixtures/facilities
- Process water supply piping
  - Single pass
  - No new chiller facilities or equipment is needed
  - Main distribution piping layout, with location and dimensions for primary feeders and distribution lines
  - Control valve inventory (number of each size and type)
  - Provide supply standpipes throughout building
  - Form drain sumps, standpipes, and trench drains to accommodate tank layout.
- Drain systems
  - Primary goal is to reconfigure the tank locations and associated supply and drain piping.
  - Main drain piping layout, with location and dimensions for primary feeders and distribution lines
  - Size and slope
  - Drain exit point, and final terminus of drain

        - Drain control devices
        - Slope properly to drain
    - Yard water – pressurized system
        - High pressure yard hydrants installed at 6 (six) locations throughout the building for spray down, cleaning, and fish culture needs
        - existing domestic well has a pressure tank that operates between 50 - 60 psi
    - Flooring
        - Assume cast-in-space (CIP) floor over compacted subgrade
        - 6 in (15 cm) thick concrete, 47 x 80 ft (14 x 24 m) area, or 3,760 ft^2 (350 m^2) of concrete floor
        - Plan for possible future flexibility with use of trenches, grating panels, and allow for reconfiguration of piping in the future
        - Purpose of concrete floor is to ease cleaning, provide a safe work surface, and aid in disease control
    - Septic and Potable water
        - Assume existing potable water and septic system with the building is ok without any upgrades
    - Lighting & HVAC
        - Assume existing HVAC and lighting is adequate for new use with minor maintenance allowance. Allow minor allowance for electrical system maintenance and minor upgrades
    - Ventilation

Pollution Abatement & Waste Water

The conceptual design includes construction of a new concrete pollution abatement pond. The two cell clarifier is a two chambered concrete settling pond for fish and feed waste. In this arrangement you can dry out one site for cleaning while leaving the other in operation. With the addition of this program the site production will be over the 20,000 lb (900 kg) threshold and over the 5,000 lb (2,300 kg) feed/month limits requiring waste treatment. Waste water will be discharged into Marion Drain or piped across the drain and county road to discharge into the adjacent wetland.

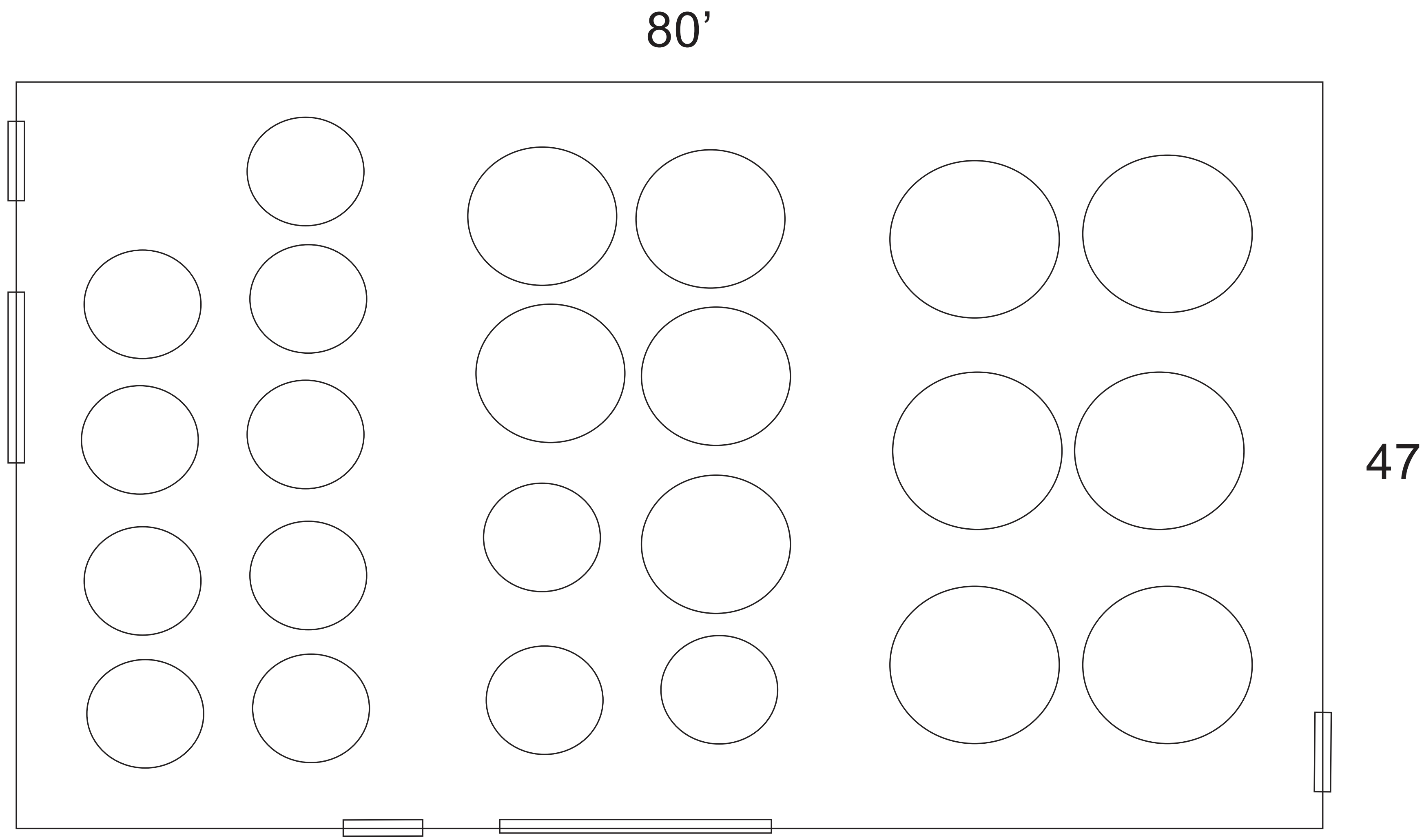

Figure 64. Conceptual design for wild rearing building (conversion of existing building).

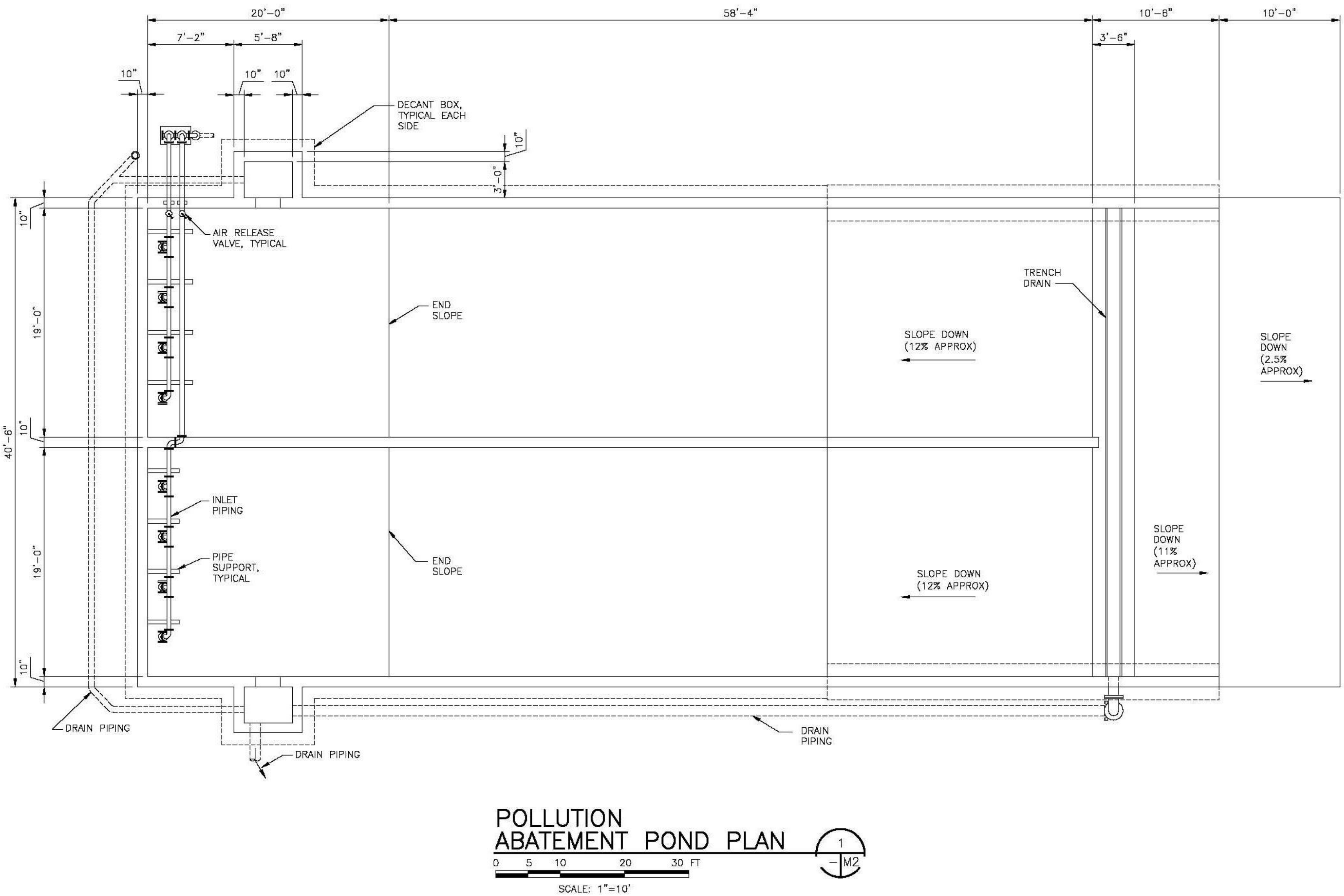

Figure 65. Conceptual design for the pollution abatement pond at the proposed sturgeon production facility at Marion Drain hatchery.

Garage/Workshop

A garage/workshop building will be constructed to support the new hatchery facility. Thus building will also house feed storage. The dimensions shown in Figure 66 identify an approximately 3,720 ft^2 (345 m^2) building for space planning. However, cost estimation for this building uses a 4,000 ft^2 (370 m^2) building to provide an allowance for HVAC and unforeseen items at this preliminary phase. The space plan and layout may be revised in the final design.

The current plan for this facility is an insulated prefabricated steel building with metal roofing, metal siding, insulation, and unfinished interior walls. This type of construction is typically the most economical for garage/shop/warehouse space that does not to be finished out on the inside. An alternate approach would be to consider a conventional light framed wood building with slab on grade floor, stick framed walls, and a trussed roof to be consistent with the administration building.

Design elements include:

- In-wall unit HVAC system for office and shop.
- Infrared or forced air heat/fan units for inside garage bays
- Running water for shop, utility sink, and small restroom in shop area.
- Minor site grading, gravel parking areas similar to wild rearing building.
- Potable water available on-site is adequate for new building
- Piping to building
- Tool and equipment allowance
- Rooms and furnishings
- Furnishing allowance for shop and storage area

Based on these assumptions, we estimate a building cost of $40/$ft^2$. This would include structural design, fabrication, delivery, and assembly of the steel building, as well as the design and construction of the building foundation. Typically the steel building fabricator does the building engineering and a local in-state engineer does the foundation design.

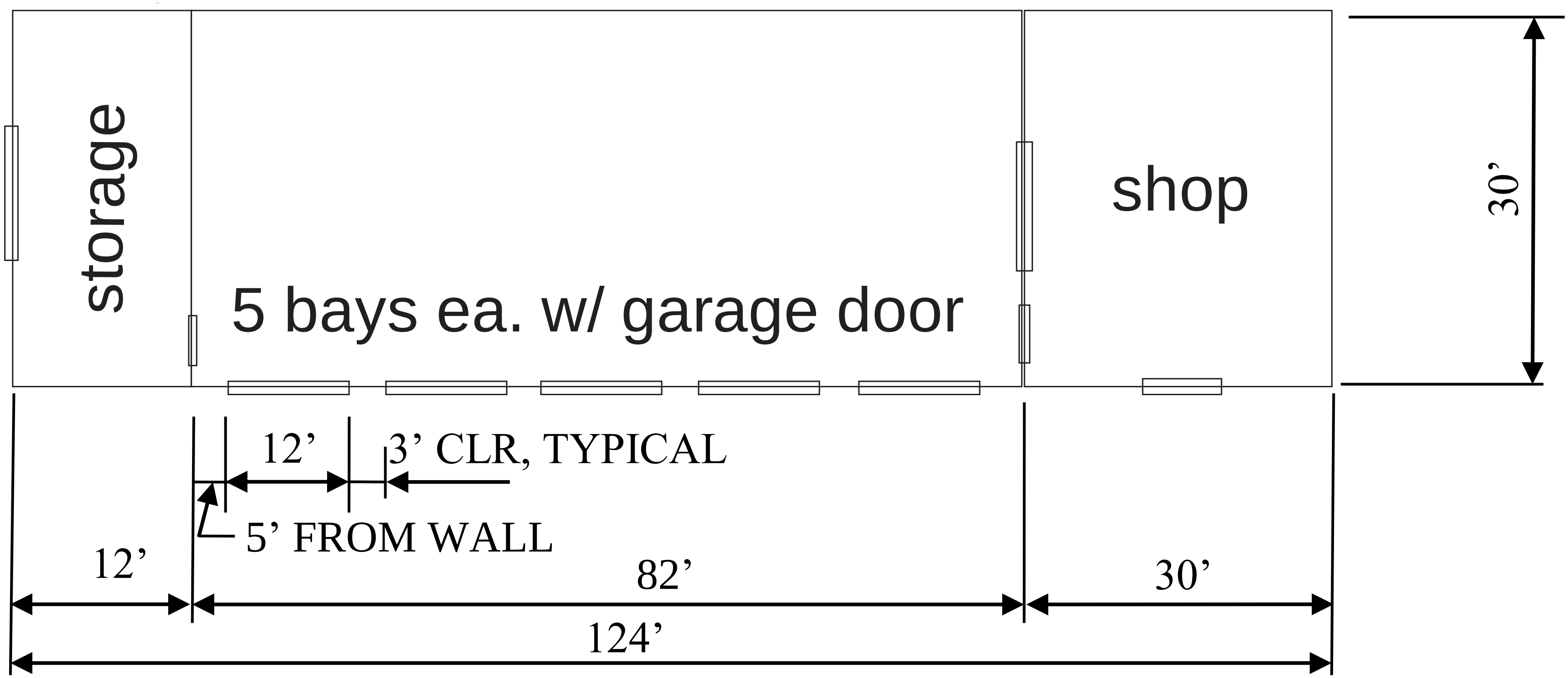

Figure 66. Conceptual design for garage and shop.

Office/Administration

Building style will be similar to the pre-engineered metal building planned for the hatchery building. This plan identifies a conventional light framed wood building with slab on grade floor, stick framed walls, and a trussed roof. This type of construction is typically easier to finish out on the inside with plumbing, insulation, wiring, drywall, etc., and can be more aesthetically appealing on the outside.

The dimensions shown in Figure 67 identify an approximately 1,200 ft^2 (110 m^2) building for general space planning. However, cost estimation for this building uses a 1,500 ft^2 (140 m^2) building to provide an allowance for HVAC needs, storage closets, and potentially built-in shelving or industrial grade shelving units. The space plan and layout may be revised in the final design to fit with the site, parking and vehicle circulation, address means of egress and Americans with Disabilities Act (ADA) codes, determine energy loads (electrical and HVAC), and provide the necessary space and efficiency with the building design. The building style and cost may be more amenable to a narrower and longer facility, or a stepped roof to save costs.

Design elements include:

- Eight-foot high ceiling, with typical light framed wood construction and insulation (includes all fixtures and built-in furnishings, lighting, etc.).
    - Sheet-rock walls in all but wet areas.
    - Cement board walls in restrooms.
    - Industrial grade finishes and lighting.
- Central HVAC system (need to define HVAC room or closet).
- Piping of potable water available on-site to the new building.
- Plumbing for restrooms
- New septic system
- Minor site grading, assume gravel parking areas.
- Rooms and furnishings
    - Furnishing allowance for offices and meeting room.
    - Stainless steel tables and lab equipment for utility work space
    - Storage units

We estimate the cost at \$100/ft^2 for a conventional light framed wood building, inclusive of all cost from excavation through finishes. This cost estimate would not include utility hook ups such as a septic system, sewer connection, and potable water well.

Crew Quarters

Existing space in a manufactured home that is currently used for administration and crew quarters, will be rededicated for use solely as crew quarters.

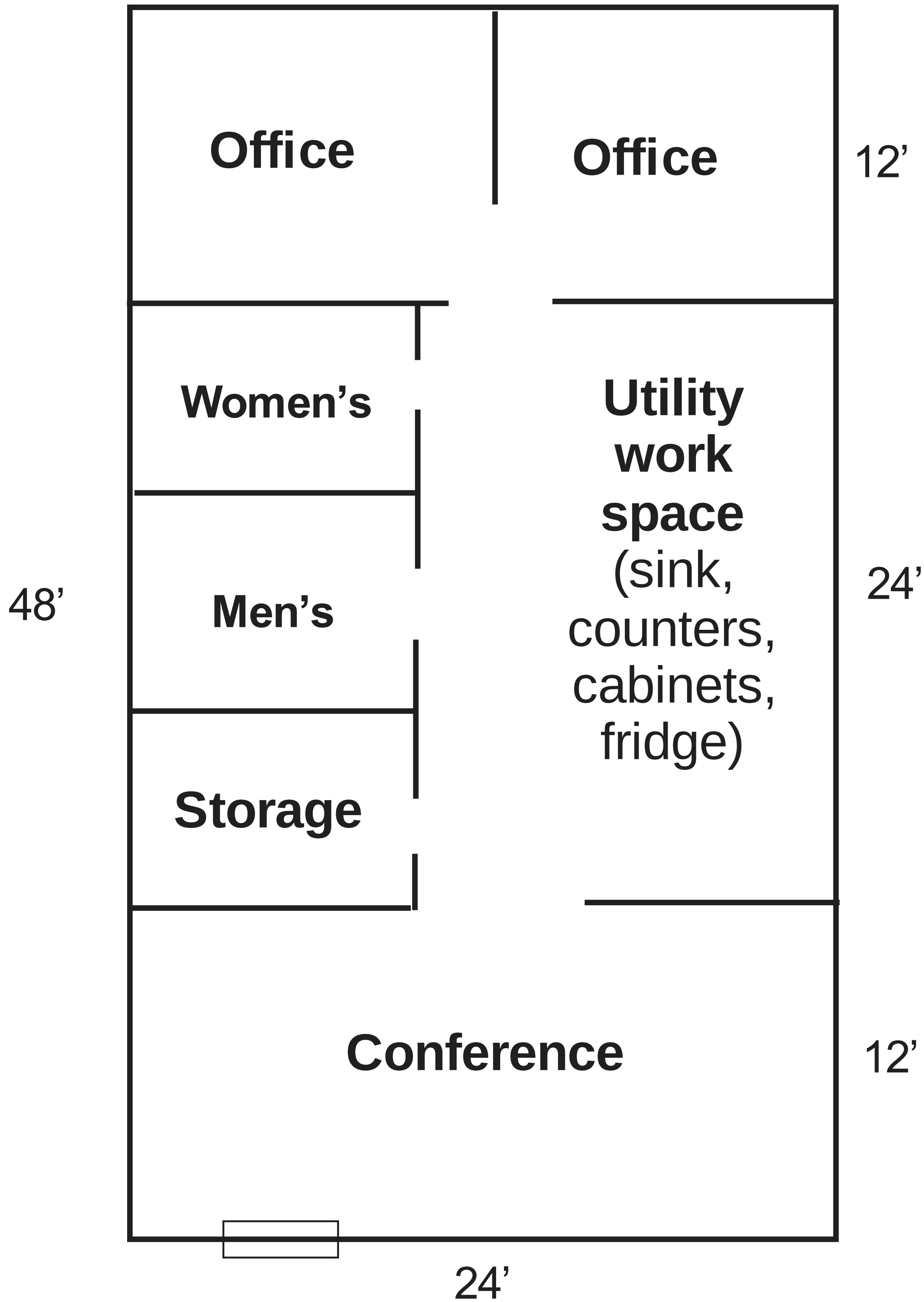

Figure 67. Conceptual design for office.

Adjacent Yakima/Klickitat Fisheries Project Hatchery

The Yakima/Klickitat Fisheries Project (YKFP) of the Yakama Nation currently operates a small hatchery facility adjacent to the sturgeon hatchery at Marion Drain (Yakama Nation 2010, 2012; Sampson et al. 2013; Fiander & Blodgett 2014). The YKFP facility has two large lined ponds, six raceways, an incubation room, an egg isolation trailer, water chiller, two pole buildings (used to hold fish hauling trucks, sensitive equipment, pumps and generators), a mechanical building, caretaker's house, and the YKFP maintenance shop.

The YKFP facility is currently operated for summer Chinook production (200 to 500 thousand smolts per year). Adults are collected and spawned at Wells Hatchery in October. Green eggs are transferred to Marion Drain where they are hatched and reared. Pre-smolts are trucked to Nelson Springs and Roza Dam acclimation raceways for final acclimation and release. Small numbers may also be acclimated and released directly from Marion Drain. In addition, trout may be transferred in and grown at the YKFP site prior to release for a put and take fishery. YKFP production utilizes water from two wells from September through March for egg incubation and fry rearing. Surface water from Marion Drain is used year round.

The YKFP salmon and trout hatchery and YN sturgeon hatchery facilities at Marion Drain are operated as independent programs with coordination occurring through the YN fisheries program. Separate space is identified for each program and the available space is more than adequate for the combined facilities. Each facility is operated with separate water systems. Wells for each facility are widely separated so as not to cause overlapping cones of influence and combined use of well water is consistent with requirements and permitting by the YN hydrological program.

The YN has committed to use of the Marion Drain site as a primary production facility for sturgeon. Any further consideration of expansion of production for other fish species will be contingent on the established requirements of the sturgeon production program.

7.4 COMPANION FACILITY – WALLA WALLA SOUTH FORK HATCHERY

7.4.1 Program Elements

- Produce 5,000 yearling juveniles for spring release. Alternatively a fall release at age 0+ can be considered based on water availability for winter and early spring rearing
- Water supply is well water of 57–61°F (14–16°C) with the capability to mix warmer surface water during summer months.
- Seed stock is to be supplied from the Yakama Nation Marion Drain facility from their breeding program; approximate size at delivery 1 g in the spring and 30–70 g in the autumn.
- Options for use of well and surface water optimize available thermal profiles that would benefit fish culture operations.

7.4.2 Water & Power Supply

Water supply to the South Fork hatchery includes surface water and groundwater. Surface water supplied from the South Fork Walla Walla River is the primary water source for the South Fork facility. The surface water right is for 20.15 cfs. Raw water treatment for the proposed facility includes drum screens for particle filtration followed by ultraviolet disinfection.

Two groundwater aquifers underlie the South Fork facility. The site currently has a shallow well that draws water from a depth of approximately 180 ft (55 m). The existing well currently provides 100 gal/min (380 L/min) of artesian flow. The original well report from 1997 suggested that if the well was pumped it may produce over double that amount. Water from the well is treated and used for domestic purposes on the property and the adult salmon spawning facility. The well water on site is high in hydrogen sulfide and other ions making it unsuitable for rearing without treatment (BPA 2014). The existing salmon facility does not hold a groundwater permit and is limited to no more than 15,000 gal/d (57,000 L/d). The currently proposed upgrades to the South Fork facility for salmon rearing estimate that hatchery operations will require about 1,000 gal/d and each residence on site will use about 500 gallon per day. If it were determined that additional groundwater was necessary to meet salmon production demands, a groundwater right would be applied for and additional pump testing would be required.

Juvenile rearing will utilize well water which provides temperatures of 57–61°F (14–16°C) throughout the year in order to optimize growth. Water quantity demands for juvenile rearing are relatively small due to the limited volume of sturgeon production in the companion facility. Total inflow requirements at seasonal peaks in biomass are 90 gal/min if juveniles are released in fall and 100 gal/min (380 L/min) if juveniles are held for spring release. Water treatment of well water will be required for aeration and to remove hydrogen sulfide.

The South Fork Facility currently has a ready and consistent power supply as well emergency generator building to supply power to critical hatchery infrastructure in the event of an interruption.

7.4.3 Facility Description

The existing South Fork facility was constructed in 1996 on 13 acres (5 ha) at RM 5.2 (RKM 8) of the South Fork of the Walla Walla River (Figure 68). The BPA-owned facility has a spawning building, holding ponds for adult fish, a screened surface water intake, a pump house, pollution abatement pond, chemical storage building, emergency generator building, a water (ozone) treatment building, a potable water well, and two residences. The South Fork facility is currently used only for spring Chinook holding and spawning. Once spawned, eggs are transported to the Umatilla hatchery for incubation and rearing. In addition to spring Chinook spawning, the South Fork facility is used for lamprey as port of the Umatilla hatchery program.

Proposed improvements at the Walla Walla Hatchery will add the capacity to produce 500,000 spring Chinook Salmon smolts (CTUIR 2013). Improvements include upgrades to the existing adult holding and spawning facility and new smolt production facilities. New facilities include a 20,100 ft^2 (1,870 m^2) hatchery and administrative building, a 16,450 ft^2 (1,530 m^2) “grow-out” building, a water treatment system, and a 3,200 ft^2 (300 m^2) shop building. The “grow-out” building will contain 10 circular rearing tanks, each approximately 25 ft (8 m) in diameter, to provide rearing for 500,000 spring Chinook Salmon smolts. The rearing facility would require a maximum surface water withdrawal of 12.8 cfs (BPA 2014).

When the facility is expanded to full production of Spring Chinook, the building currently used for ozone treatment will be converted to sturgeon rearing use. Juvenile sturgeon rearing will require two 16 x 5 ft (5 x 1.5 m) circular tanks (6,000 gal, 22,700 L capacity each). The building space of 30 x 50 ft (9 x 15 m) will provide room for juvenile rearing as well as fish handling and biosecurity requirements (Figure 69).

Figure 68. **Existing facilities at Walla Walla South Fork Hatchery facility plan (BPA et al. 2014).**

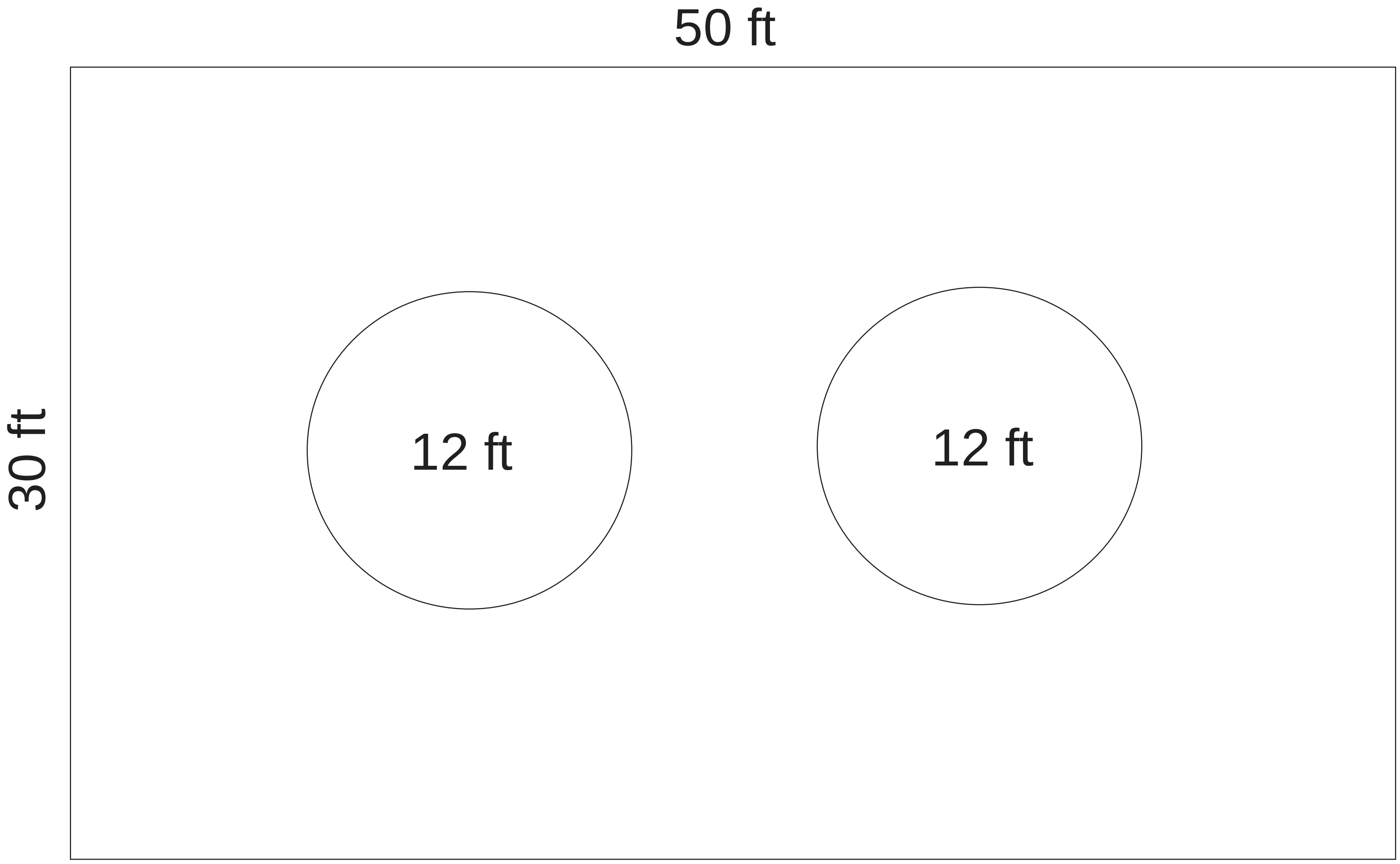

Figure 69. Sturgeon rearing building configuration at Walla Walla South Fork Hatchery.

7.5 WATER & ENVIRONMENTAL CENTER (WEC) WALLA WALLA COMMUNITY COLLEGE

The Water and Environmental Center (WEC) at the Walla Walla Community College is located in Walla Walla, WA. The WEC is approximately 128 mi (206 km) or 2.5 hours driving time from the Yakama Nation sturgeon hatchery at Marion Drain and approximately 80 mi (129 km) or 1.5 hours driving time from McNary Dam.

7.5.1 Program Elements

A variety of companion incubation and rearing options were initially considered for the WEC but further investigation found that the available space and water would not support significant production. The facility does present an excellent opportunity for dedicated experimental research in a controlled setting as well as education and outreach in support the broader sturgeon hatchery program. Studies addressing unknowns in incubation, early life history and juvenile rearing of White Sturgeon cannot be assessed under production circumstances, yet are essential for future improvements in conservation aquaculture. Example research projects that can be implemented at this facility are detailed in Section 8.3.6. The WEC is ideally suited to help elucidate answers to these key culture points through experimentation at their aquatic facility. Research equipment and animals for various projects will be available with qualified staff to oversee the work. The work could be carried out as dedicated research or part of an academic curriculum for practical training.

7.5.2 Water Supply

The WEC aquatic facility is currently using a limited amount of dechlorinated water that charges a recirculation facility of small capacity. The amount of water available suits the current level of research and investigation and can be expanded to accommodate additional projects with low water uses.

Additional production would require development of additional water sources. Construction of a new deep well is being explored with potential completion in 2017. It was estimated that this well would deliver 50 gal/min (190 L/min) of 52-55°F (11 – 13°C) water. This water would be subject to degassing and aeration before use. It is unknown if metal chelation would need to be completed before use. The temperature of the well water is ideally suited for incubation and first-feeding studies. However, if this water was to be used for fish culture, it would be difficult to attain the 50–60 g target for fall release. Heated water would be required. Warm water is also potentially available from the College’s steam heating plant although the supply may not be adequate for use in fish culture and extensive treatment might be required.

7.5.3 Facilities

The WEC does not have developed areas for fish culture outside of the aquatic laboratory facility room. Additional fish rearing space and support systems (water delivery, drains, etc.) would need to be constructed for significant production. Ancillary equipment and capacity such as feed, equipment and outerwear storage would be required.

8 MONITORING & EVALUATION PLAN

The CRITFC sturgeon hatchery program will be implemented in an experimental framework that includes a strong monitoring and evaluation program, established benchmarks for the evaluation of benefits and risks, and a clear decision structure for future adaptive management. An adaptive, experimental framework is required because of substantial uncertainties in effectiveness and effects of sturgeon hatcheries. Unlike salmon hatcheries which have a long track record of experience, sturgeon hatcheries are relatively new and performance has proven to be quite case-specific.

The CRITFC sturgeon hatchery monitoring and evaluation effort will be closely integrated with other sturgeon monitoring activities in the lower Mid-Columbia and lower Snake Rivers. Many activities serve multiple implementation, monitoring, research and evaluation objectives for hatchery implementation and effectiveness, wild stock assessment, fishery management or other conservation or restoration purposes. For instance, wild broodstock collection also provides mark-recapture information for stock assessment, individual maturation data for assessments of adult recruitment, and genetic samples for stock-structure.

8.1 KEY UNCERTAINTIES

Feasibility of Wild Larvae Collection

Rearing of wild-caught larvae may ultimately prove to be a more desirable and effective production strategy than conventional broodstock collection. Wild larvae potentially represent a broader spectrum of the natural diversity. However, efforts to employ this method in upper Columbia sturgeon conservation programs have identified significant problems with mortality in the hatchery while getting wild larvae onto feed and fish health apparently related to capture and handling stress. The upper Columbia program has demonstrated the feasibility of collecting sufficient wild larvae to meet limited production targets of conservation programs. It remains to be determined whether sufficient numbers of wild larvae can be cost-effectively captured in the much-larger lower mid-Columbia systems to meet the more-ambitious mitigation production objectives.

Optimum Rearing Methods

Effective methods for spawning of wild adults, incubation, and rearing have become well established over the last 20 years but room for improvement still exists. Current methods have demonstrated the capability to produce substantial numbers of juveniles for release. Sturgeon hatchery methods continue to evolve and improvements in systems and practices are expected to continue to improve efficiency and effectiveness of this technology.

Optimum Release Strategy

Hatchery effectiveness will ultimately be evaluated based on the quantity and quality of fish produced. Production will be evaluated based on the ability of the hatchery to raise fish and the ability of the hatchery fish to adapt to conditions in the wild. Effective hatchery strategies

invariably involve tradeoffs between numbers and size of release. Large numbers of fish can be released at relatively small sizes. However, smaller sturgeon are not expected to survive as well as fish reared for longer periods to reach larger sizes. Larger, older sturgeon typically survive better than smaller sturgeon following release. However, space and water constraints generally limit the numbers of large fish that can be reared. Holding fish to larger size is more costly because fish must continue to cared-for and fed. The potential for undesirable artificial selection is increased by extended holding time in the hatchery and culling required to reduce numbers consistent with hatchery capacity.

Hatchery Contributions

While large numbers of juvenile sturgeon can be produced and released from the hatchery, experience in other areas has shown that the large majority of these fish do not survive beyond their first year in the wild. Once individual fish adapt to conditions in the wild, annual mortality is low but many fish appear to have difficulty during in the first year following release. Survival has varied from area to area, and from year-to-year, apparently in response to habitat, environmental and ecological conditions. The long term effectiveness of the program in meeting mitigation goals for sturgeon will depend in large part on the survival rates realized by hatchery sturgeon in the lower Columbia and Snake river impoundments.

Sturgeon Carrying Capacity

The rearing capacity of lower Columbia and Snake river impoundments for sturgeon is unknown. Density-related population processes are very poorly understood among sturgeon. We don't know how recruitment is related to spawner abundance or how increasing sturgeon density might affect condition, growth or survival of hatchery or wild fish. The habitat and ecological capacity of the system must inevitably limit sturgeon at some point but where or how that limitation is manifested, remains to be determined. Sturgeon carrying capacity will likely vary by life stage and over time, as the biological community responds to current and future habitat conditions, nutrient availability, and seasonal environmental variability.

Hatchery Genetic Effects

The hatchery program has been specifically designed to minimize the potential for detrimental genetic effects of hatchery production practices. The effectiveness of this strategy remains to be determined based on monitoring of genetic characteristics of hatchery fish at various points in the production process relative to that of wild subpopulations.

Ecological Interactions

Sturgeon are likely a significant component in the river and reservoir aquatic ecosystem but the dynamics of these systems and the role and effects of sturgeon are poorly understood.

Alternatives for Improving Natural Recruitment

Poor or inconsistent natural recruitment currently limits production in many or most impounded subpopulations. While natural recruitment has been generally correlated with river discharge during spring and effects are area-specific, the mechanism(s) of recruitment failure are poorly

understood. Effective remedies for improving natural production remain to be determined through ongoing research efforts conducted outside the scope of specific hatchery-related monitoring, research, and evaluation activities by complementary sturgeon projects under the NPCC Fish and Wildlife program.

8.2 MR&E OBJECTIVES

The following objectives identify the full suite of hatchery-related and other monitoring, research and evaluation activities.

1. **Monitor and evaluate effectiveness and efficiency of collection of wild broodstock and larvae for use in hatchery production.**
2. **Monitor and evaluate operational effectiveness of the hatchery based on water quantity and quality, fish production, genetic representation, and fish health.**
3. **Monitor and evaluate post-release performance and effects of hatchery-origin sturgeon.**
4. **Continue to monitor and evaluate status and trends of wild sturgeon populations.**
5. **Monitor and evaluate fishery contributions and management effectiveness for hatchery-origin sturgeon.**
6. **Identify operational alternatives that enhance the efficiency and quality of sturgeon hatchery production.**
7. **Conduct research to address critical uncertainties with application to sturgeon restoration, mitigation and management.**

8.3 MR&E WORK PLAN & METHODOLOGY

The following sections identify tasks, hypotheses, metrics and approaches for addressing each monitoring, research and evaluation objective. Reference values are also identified for related metrics – these reference values are not objectives per se but rather representative or baseline values consistent with production targets and planning assumptions. Many different combinations of values may ultimately be consistent with program objectives identified in Section 5.2 of this plan. Reference values function as triggers for assessing incremental progress in each objective area toward overarching program objectives.

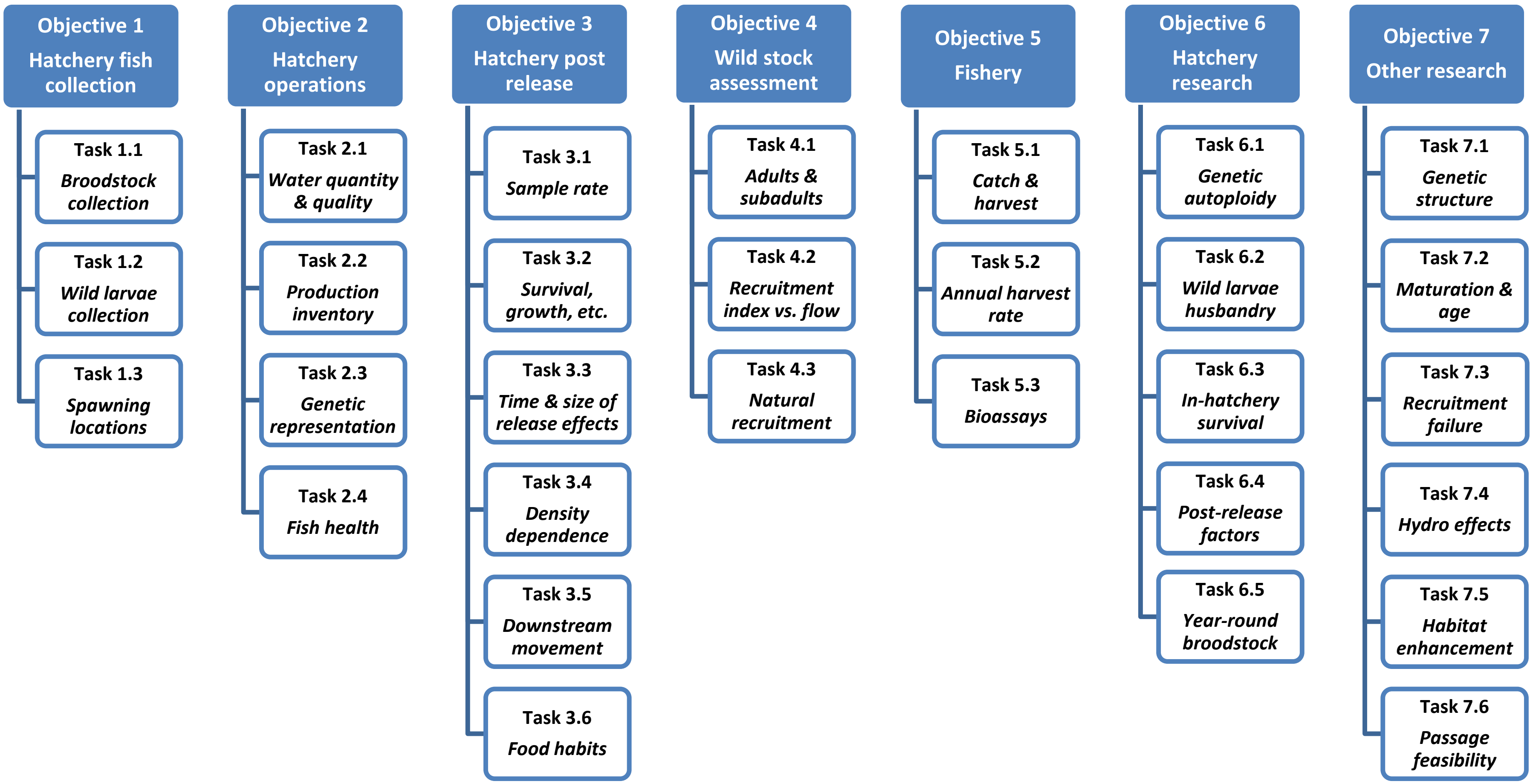

Figure 70. Monitoring and evaluation objectives and tasks for lower mid-Columbia white sturgeon, including hatchery program elements.

8.3.1 Hatchery Effectiveness – Broodstock & Larval Collection

MR&E Objective 1.	**Monitor and evaluate effectiveness and efficiency of collection of wild broodstock and wild larvae for use in hatchery production.**

Task 1.1. Collect sufficient wild broodstock collection to meet hatchery production targets.

The hatchery implementation strategy initially involves a combination of conventional broodstock and wild larvae collection. Wild larvae are potentially a more desirable source of hatchery production due to genetic considerations. However, collection, disease and survival issues with larvae collection will need to be resolved. In the meantime, wild broodstock will provide an effective and well-established source of hatchery production. The program will concurrently develop wild larvae collection and husbandry methods, while using wild broodstock as necessary to maintain production objectives.

Hypothesis

Hypothesis 1.1.1. Wild broodstock collection is sufficient to meet hatchery production targets of 10 ripe males and 10 ripe females per year.

Metrics

Task	Metric	Reference value
1.1. Broodstock collection	Number by sex & maturation stage	Ripe: 20 / year (10 ♂, 10 ♀)
	Collection effort (sample hours)	To be determined
	Catch per effort	
	Mortality (if any)	
	Collection locations / habitat	

Approach

Wild broodstock are captured in May and June prior to spawning. Collection efforts will focus on John Day Reservoir but may also involve adjacent reservoirs. Broodstock collection efforts will be coordinated between this program and similar efforts conducted for upper mid-Columbia Public Utility District sturgeon mitigation efforts. Sturgeon are typically collected by setlines, or angling. Sex and stage of maturity of adult-sized fish (typically 6 feet or larger) are assessed in the field by surgical biopsy. Fish assessed as F3/F4 for females (eggs in a near mature state; Bruch et al. 2001) and M2 or flowing for males (Table 24) are expected to spawn soon in the year of capture and are transported to the hatchery. Fishing typically continues until broodstock targets are met or ripe sturgeon are no longer available as all have spawned.

Fishing effort is recorded by gear as hours fished and number of sampling days required to meet production targets. Catch per effort is number of mature fish caught per hour of gear effort. Any mortalities during capture or handling are noted. Biological data is collected and all fish are tagged according to normal wild stock assessment sampling protocols and data from broodstock collection is incorporated into the stock assessment analysis.

Task 1.2. Evaluate the feasibility of collecting sufficient numbers of wild larvae in a reasonably cost-effective manner to meet hatchery production targets.

Future applications of adult broodstock and wild larvae methods will be based on the relative effectiveness and efficiency of each alternative in achieving program objectives. Monitoring and evaluation will be key to that determination. Identifying times and areas where substantial numbers of wild larvae may be collected will be a particular challenge. This method has proven effective in the upper Columbia for meeting conservation objectives but fishery mitigation objectives require substantially more fish than a strict-conservation program. In addition, collection of larvae has been easier in the upper Columbia where localized spawning sites have been identified than in the much larger lower mid-Columbia where specific spawning locations have not been identified. Both broodstock and larval collection efforts will be closely monitored in order to optimize effectiveness and efficiency over time. Effectiveness will be evaluated relative to numerical objectives based on genetic considerations. Efficiency will be evaluated based of effort and catch rates of setline and gillnet sampling for adults. Sampling times and areas will be modified over time based on results.

Hypothesis

Hypothesis 1.2.1. Sufficient numbers of wild larvae can be collected in a cost-effective manner to support hatchery production targets of 20,000 per year.

Metrics

Attribute	Metric	Reference value
1.2. Larval collection	Number larvae collected	20,000
	Collection effort (sample hours & days)	To be determined
	Catch per effort	
	Mortality (if any)	

Approach

Wild larvae will be collected downstream from spawning sites in dam tailraces with modified plankton nets using techniques pioneered in the Upper Columbia River (Howell & McLellan 2013a, 2013b). Nets consist of a single D-frame 0.8 m wide x 0.6 m tall to which a tapered plankton net (≈3.4 m long) made up of 1.6 mm knotless nylon delta-mesh is attached. The cod end is connected via PVC pipe to a 6.5 gallon collection bucket via a PVC pipe that was connected to the lid. This allowed for easy removal of the collection buckets in order to examine the catch. Buckets contain circular openings fitted with 750 micron Nitex mesh allowing water to flow through and a mechanical flow meter to provide velocity measurements for estimating water volume sampled.

Nets will initially be fished on sites peripheral to the thalweg at various distances downstream from the dam in order to identify effective fishing sites. Nets may be anchored in place or to the boat. Stations will be fished during day and night. Nets will be checked periodically. Effort will be concentrated at times and areas of the greatest catch per unit effort. Cost-effectiveness will be evaluated based on the relative number of sampling days required to collect wild broodstock.

Task 1.3. Utilize telemetry of ripe adults to improve effectiveness and efficiency of adult broodstock and wild larvae collection by identifying concentrations of ripe adults and specific spawning sites.

Sampling efficiency and effectiveness for both adults and larvae might be substantially improved by identifying times and areas where sturgeon spawning is concentrated. While it is generally known that sturgeon spawn during spring in dam tailraces, specific spawning and staging areas are unclear. Trial and error sampling with setlines, gillnets, and angling has met variable success and the ability to catch target numbers of ripe males and females varies considerably from year to year and area to area. Pilot larval collection efforts have been initiated in lower mid-Columbia reservoirs but have not yet proven particularly successful. Small numbers of embryos or larvae have been captured but nowhere near the numbers needed.

Hypothesis

Hypothesis 1.3.1. Effectiveness and efficiency of adult broodstock and wild larvae collection can be improved using telemetry including hydro acoustics to identify concentrations of ripe adults and specific spawning sites.

Hypothesis 1.3.2. Hydro acoustics can substantially improve the effectiveness and efficiency of broodstock and larvae collection efforts by helping to localize sturgeon spawning concentrations in dam tailraces.

Metrics

Attribute	Metric	Reference value
1.3. Adult telemetry	Number tagged	To be determined
	Number ripe by year	
	Tailrace location by week in spring	

Approach

Tracking of ripe sturgeon with acoustic tags and tag detection arrays has proven very effective for monitoring spawning behavior and identifying areas of fish concentration in the upper Columbia and Kootenai (Ross et al. 2015). Tagging can occur for nominal cost during normal adult broodstock collection efforts. Fixed acoustic detection arrays have the ability to collect large amounts of detailed spatial data without substantial effort – they merely require periodic downloading and processing of data. At the same time, adult telemetry can also address other key research questions regarding spawning behavior, including the effects of flow and dam operations on spawning activity. While it is known that natural recruitment is related to tailrace morphology and river discharge, the mechanism for recruitment failure is unknown. A better understanding of spawning behavior, site selection, and effects of environmental factors has the potential to inform our understanding of recruitment mechanisms and alternative for remediation.

8.3.2 Hatchery Effectiveness – Operational Monitoring

MR&E Objective 2.	Monitor and evaluate operational effectiveness of the hatchery based on water quantity and quality, fish production, genetic representation, and fish health.

Task 2.1. Monitor water quantity and quality in the hatchery relative to objective levels consistent with fish production and health objectives for each sturgeon life stage.

Water quantity and quality monitoring includes flow rates, temperature, dissolved oxygen, nutrients, and chemistry of the inflow, discharge and key points in the system. The quantity and quality of incoming and circulating water is obviously critical to fish health and performance. Effluent must also be monitored for consistency with relevant regulatory standards. Water quantity and quality are managed through effective systems, operations, and practices.

Hypothesis

Hypothesis 2.1.1. Water quantity and quality in the hatchery are sufficient to meet fish production and health objectives for each sturgeon life stage.

Metrics

Attribute	Metric	Reference value
Water quantity & quality	Inflow	See Section 6.4 Table 28
	Temperature	
	Dissolved oxygen	
	Chemistry	

Approach

Water monitoring systems will be built into key points throughout the hatchery.

Task 2.2. Inventory fish production by stage relative to program objectives.

Fish production monitoring includes estimates of numbers, survival, growth, and feed conversion rates by life stage. Fish production targets of this program are identified in Section 5.5 of this plan. Section 5.6 identifies projected fish numbers and weight by life history stage and family consistent with production targets. Hatchery systems and operations are designed to manage fish numbers by life stage in order to meet production targets.

Hypothesis

Hypothesis 2.2.1. Fish production by stage is consistent with program release objectives for numbers and size.

Metrics

Attribute	Metric	Reference value
Fish Production	Maturation success	See Table 22
	Families produced	
	Egg take (total & per family)	
	Numbers by life stage (total & per family)	
	Weight by life stage	
	Fertilization/Survival by life stage	
	Growth rate by life stage	
	Feeding rate by life stage	1.3-11% body wt. / day
	Food conversion rate (%)	To be established
	Mark retention (pre-release) (%)	>95%

Approach

Inventory monitoring documents the hatchery population at key stages to track progress relative to planning values. These inventories are the basis for managing fish numbers and sizes at various stages by managing water temperature, feeding, and containers or by transferring, releasing, or culling portions of the production.

Task 2.3. Assess genetic representation of fish production for consistency with diversity objectives of the program.

Genetic representation is monitored based on parental contribution by family, haplotype frequencies, and the incidence of autoploidy. The aim is to include a diverse sample of the wild subpopulation and avoid inadvertent selection or other undesirable genetic effects.

Hypothesis

Hypothesis 2.3.1. Broodstock number targets of 10 males and 10 females are achieved annually.

Hypothesis 2.3.2. Genetic haplotype frequencies in hatchery-origin spawners are similar to those of the wild subpopulation where they are released.

Hypothesis 2.3.3. The incidence of genetic autoploidy is 10% or less in 100% of hatchery sturgeon families.

Hypothesis 2.3.4. Parentage analysis of hatchery broodstock will provide an effective basis for identifying effective future contributions of individuals among hatchery-origin fish recaptured in future sampling.

Metrics

Attribute	Metric	Reference value
Genetic representation	Parental contribution by family	♂ 10% ea., ♀ 10% ea.
	Haplotype frequencies (% by type)	To be established
	Autoploidy (incidence)	<10% in 100% of families

Approach

Production will be subsampled a key stages including post-fertilization and pre-release for genetic monitoring. Genetic analysis is as described in Matala (2013, 2014, and 2015). Genetic samples will also be collected from recaptured fish and cross-referenced with individual PIT tag numbers for the parentage analysis.

Task 2.4. Monitor fish health and test prior to release.

Fish health monitoring includes pathogen testing of broodstock and larvae brought into the facility and of hatchery juveniles prior to release, tracking of mortality rates, and additional testing as required. Sturgeon hatchery operations include systems and protocols for monitoring and minimizing pathogen introduction and transmission in hatchery and wild subpopulations. Maintaining optimal rearing conditions will reduce or prevent stress-related disease outbreaks in the facility. Fish health will also be assessed based on fish growth and condition in normal production monitoring.

Hypothesis

Hypothesis 2.4.1. Fish production is not significantly impacted by poor health or disease.

Metrics

Attribute	Metric	Reference value
Fish Health	Pathogen screening (broodstock, wild larvae)	Standard protocol
	Prerelease testing (juveniles)	
	Mortality events (frequency and magnitude)	Negligible occurrence

Approach

Standard disease testing protocols will be applied in tests of all broodstock, samples of wild larvae, samples of juveniles prior to release, and samples of in-hatchery mortalities. Ideally samples will be collected during random in-hatchery culling. Numbers of mortalities will also be recorded daily during normal hatchery record keeping.

8.3.3 Hatchery Effectiveness – Post Release Monitoring

MR&E Objective 3.	**Monitor and evaluate post-release performance and effects of hatchery-origin sturgeon.**

Task 3.1. Evaluate collection efficiency of hatchery-reared sturgeon in post-release sampling relative to sampling effort and desired precision of population parameter estimates.

Post-release performance of hatchery-reared sturgeon in John Day Reservoir will be evaluated based on monitoring of population parameters including survival, abundance, growth, and condition. Population data will provide a basis for evaluation of a number of key questions or hypotheses. The initial hatchery strategy involves release of fish at various ages, sizes and season. Relative survival of fish from these release groups will be evaluated to identify optimum strategies for future production – optimum strategies will involve tradeoffs between hatchery capacity to produce fish of a given size and subsequent survival of those fish. Monitoring of sturgeon released into Snake River reservoirs will be based on periodic stock assessments expected to be conducted at approximately five year intervals.

Hypothesis

Hypothesis 3.1.1. Sufficient numbers of hatchery-reared sturgeon can be cost-effectively recaptured following release to estimate population parameters with reasonable precision.

Metrics

Attribute	Metric	Reference value
3.1 Population	Annual recapture rate (John Day Reservoir)	≥ 5%
	Periodic recapture rate (Lower Snake River)	≥ 2%

Approach

Juvenile sturgeon (hatchery and wild) will be sampled annually in John Day Reservoir using similar methods to the recruitment index sampling conducted annually at standardized sites in lower mid-Columbia impoundments (e.g., Cox 2015). Recruitment indexing has demonstrated that 2 inch (5.1 cm) mesh stretch-measure multifilament nylon mesh gillnets fished overnight during fall are very effective in capturing juvenile sturgeon 8-24 inches (20-60 cm) in length with little harm and very limited bycatch or mortality of salmonid species. Sampling effort with gillnets will be increased from current index sampling to increase sample sizes with sites distributed throughout portions of the reservoir and habitats used by juvenile sturgeon in order to provide a representative sample of the population. Samples of sturgeon larger than 20 inches (50 cm) will be also be provided by ongoing stock-assessment sampling conducted by the tribes and states using setlines and large-mesh (8 inch, 20 cm) gillnets.

Task 3.2. Estimate survival, growth, condition and maturation of hatchery-reared sturgeon following release.

Another critical question is whether or when population parameters respond to increasing fish density – this is the habitat rearing capacity question. Population parameters will be related to fish abundance over time as the hatchery-origin population increases. Density-related responses might be expected to occur in survival, growth and/or condition factor.

Hypothesis

Hypothesis 3.2.1. Substantial numbers of hatchery-reared sturgeon survive, grow and mature following release.

Hypothesis 3.2.2. Recapture rate, survival rate, growth rate, condition factor, and emigration rate of hatchery and wild juveniles is the same.

Metrics

Attribute	Metric	Reference value
Population	1st- year survival	≥ 20%
	2nd- survival	≥ 80%
	3+ year survival	≥ 95%
	Abundance	Significant Increasing trend
	Growth rate	2-3 in. / year
	Condition factor (relative weight)	≥ 100%
	Emigration to adjacent reservoirs	≤ 5% in aggregate

Approach

Early post-release abundance, survival, and growth of hatchery juveniles will be estimated based on annual mark-recapture sampling. All juvenile sturgeon released from the hatchery will be individually tagged (PIT tags) and secondarily- marked by removal of specified scutes to designate hatchery fish. All untagged wild juveniles will be PIT tagged for identification upon recapture.

Annual abundance and survival of juvenile hatchery sturgeon following release will be estimated with multiple mark-recapture estimators (e.g., Cormack-Jolly-Seber models) using maximum likelihood statistical methods similar to those employed for Kootenai hatchery sturgeon (Ireland et al. 2002b; Justice et al. 2009; Paragamian et al. 2005; Beamesderfer et al. 2014). In these analyses, sample rates of approximately 5% per year have been estimated to provide reasonable estimates of precision (Beamesderfer & Justice 2008). Growth and condition will be determined from individual measurements at recapture. Condition factor will be estimated for individual fish based on length and weight measurements using a relative weight index (Beamesderfer 1993).

Stock assessment of the John Day Reservoir which is the primary focus of hatchery releases is expected to shift from a three-year cycle to an annual cycle to optimize sampling power of mark-recapture estimates over the long term (Box 3). Abundance is currently estimated using a closed, multiple mark recapture model (modified Schnabel) based on multiple sample periods within a year. The refinement would involve moving to use of an open, multiple mark-recapture model (Cormack-Jolly-Seber). A multiple mark-recapture design capitalizes on sturgeon longevity which

allows individual fish to be recaptured multiple times over their life. Each successful encounter provides information on survival and growth which is not captured in a simple closed model sampling design. This modification will be most-effectively applied by changing the sampling schedule to include all three reservoirs in each year rather than a single reservoir per year. Similar designs have been employed with great effectiveness to other sturgeon stock assessments including the Kootenai (Paragamian et al. 2005; Beamesderfer et al. 2014a) and upper Columbia (Irvine et al. 2007).

Box 3. Application of an open multiple-mark recapture sampling design to Columbia River sturgeon population assessments.

Advantages of an open, multiple mark-recapture model (Cormack-Jolly-Seber):

1. Explicit quantitative estimates (and precision) of annual capture probability, recruitment and mortality parameters. These values are key to identifying key productivity limitations that determine abundance and population dynamics, identifying limiting factors, and projecting future trends.
2. Consistency. Estimators that incorporate multiple years of data build on previous years to successively estimate the same population parameters based on an every-growing number of recapture histories. As a result, these estimators should be much less prone to jumping around from sample year to sample year than estimates based solely on closed population estimators based on single year data
3. Accuracy: The multi-year time frame allows for much better mixing and representative sampling of tags which in turn should reduce biases due to violations of representative mark/recapture sampling assumptions in single-year closed population models.
4. Precision: Precision is increased over the long term by use of all the information contained in recaptures of tags from previous years. Current estimates based only on marking and recapture within one year but recaptures include many more fish from past years than the sample year.

Analysis of statistical precision of survival estimates: Effects of sample rate and annual survival rate on the precision of annual survival estimates derived from mark-recapture monitoring of hatchery sturgeon are shown in Figure 71. This example is based on a simple Cormack-Jolly-Seber (CJS) mark-recapture model formulation. Actual survival estimates are based on a more complicated variation on this model but the simple example illustrates the nature of the relationships[27]. More accurate estimates of sampling precision consistent with the specific mark-recapture model formulation would require a much more involved analysis which is not warranted given uncertainty in the expected survival values.

[27] *The model form used will involve 1) cohort-specific survival rate in each year and 2) age-related capture probabilities. The simple model used in this precision analysis estimated 1) annual survival rates for an aggregate sample of all fish at large in any year and 2) a single capture probability for all fish.*

For the purposes of this analysis, sampling precision was represented in terms of the 95% confidence interval on estimated annual survival rate. Thus, a value of 10% on the y-axis of Figure 71 represents upper and lower confidence interval bounds of plus-or-minus an absolute 10% survival about the estimated value. For an estimated annual survival rate of 70%, the corresponding confidence bounds are 60% (e.g., 70%-10%) and 80% (e.g., 70%+10%). These are approximate intervals based on a simple normal approximation using the estimator variance, hence, are intended to represent the pattern of effects (another simplification of this analysis in the interest of time).

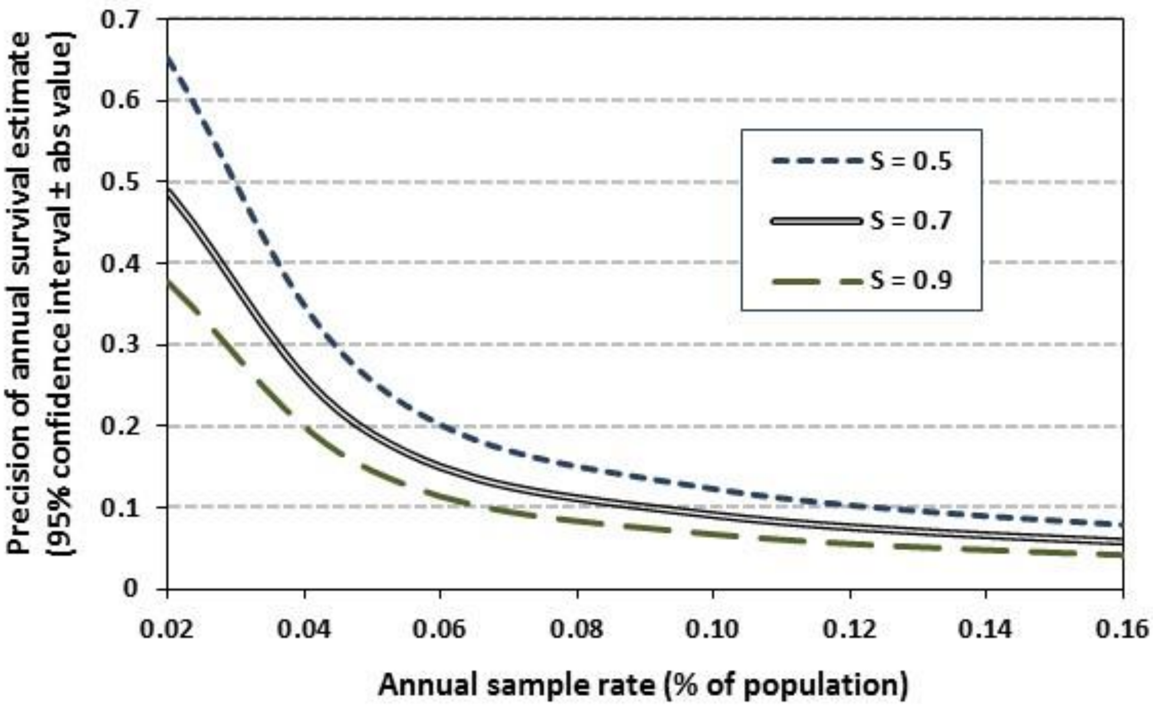

Figure 71. Example statistical analysis of the effects of annual release number and sampling rate on 95% confidence intervals for survival estimated using a simple Cormack-Jolly-Seber mark-recapture model (6-year sampling interval). Estimates are based on a range of annual survival rates.

The precision of survival estimates is related to the number of recaptures in the mark-recapture sample. Anything that increases the number of recaptures will increase precision. Thus, greater sample rates, release numbers, post-release survival, and the number of sample years all contribute to more precise estimates.

Precision increases with increasing sampling rate. Sample rate is the proportion of the population caught per year. Higher sampling rates increase numbers of fish examined for marks, marks at large in future years, and subsequent recaptures. Precision is quite sensitive to increased sample rates at low sampling levels but higher sampling levels provide marginally smaller improvements in precision. Beyond a sampling rate of about 5-10%, very large increases in sampling effort are generally required to produce substantial improvements in precision. The example analysis suggests that it will be difficult to reduce the precision of survival rate estimates of hatchery fish

much below an absolute value of ±5–10% within the first few years following release with any reasonable sampling level. As a point of reference, age-specific monitoring sample rates for hatchery sturgeon in the upper Columbia have averaged 2-7% and sampling precision on survival estimates has averaged about 20-30% (Golder Associates 2007). Year-specific monitoring sample rates for hatchery sturgeon in the Kootenai River typically range from 4-9% and sampling precision on survival estimates has averaged about 10-30% (Beamesderfer et al. 2014b).

Average survival rates of fish also affect the estimate precision because more fish are available for recapture and multiple recapture. Thus, it is easier to get a more precise estimate of a higher survival rate than a lower one, given the same sampling effort. Estimate precision also increases with the number of years of sampling at any given rate. Each subsequent year of sampling provides additional information on survival in all previous years as more and more fish from each cohort are recaptured and also subject to multiple recaptures. Thus, additional sampling years are a useful alternative to an increased annual sampling rate for increasing estimate precision and current estimates will continue to improve with continuing monitoring efforts.

Analysis of the statistical precision of condition factor estimates: Estimates of condition factor based on relative weight provide a relatively powerful indicator of potential differences in hatchery vs. wild sturgeon or changes in response to increasing abundance (Figure 72).

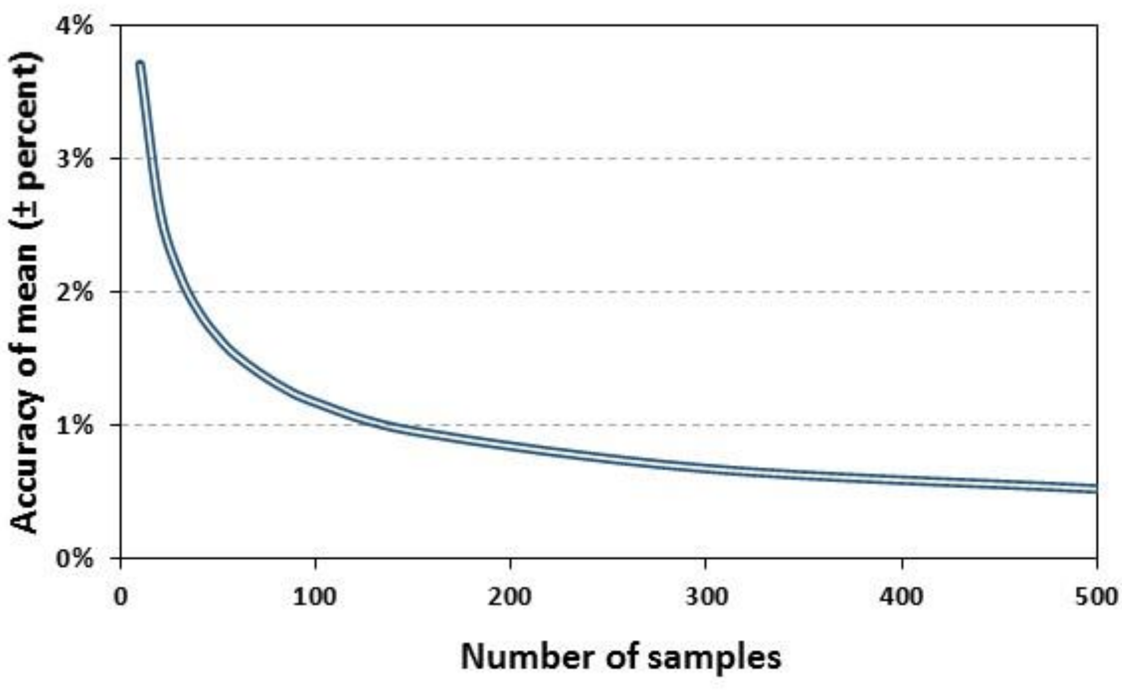

Figure 72. Example statistical analysis of the effects of sample size on 95% confidence intervals for condition factor estimated based on a relative weight index.

Hatchery v. Wild Characteristics - A key assumption in any inferences from hatchery to wild fish is that hatchery fish are representative of wild fish. This is obviously not the case in the first year following release as hatchery survival is typically poor during an adjustment period to natural conditions. After a period of acclimation to natural conditions, it may be more reasonable to assume that hatchery and wild fish behave similarly but this will need to be empirically evaluated as part of the MR&E program. The assumption can be tested to some degree based on a comparison of survival rates, growth rates, condition factor, recapture rates and distribution of hatchery and wild juveniles. The monitoring and evaluation plan includes a substantial increase in monitoring effort for juvenile sturgeon from current levels. This sampling is expected to provide substantial new information on wild juveniles as well as hatchery juveniles.

Task 3.3. Evaluate effects of age, size and season of release on survival of hatchery-reared sturgeon and use to identify optimal production strategies.

Kootenai sturgeon hatchery assessments have demonstrated that post-release performance of juveniles is heavily influenced by size and season of release. The CRITFC program will test releases of different sizes and season to identify optimum strategies for meeting hatchery objectives.

Hypothesis

Hypothesis 3.3.1. Condition, growth, survival of hatchery-reared sturgeon is independent of age, size and season of release.

Hypothesis 3.3.2. Condition, growth and survival following release is similar for fish spawned from wild broodstock in the hatchery and collected as wild-spawned larvae and reared in the hatchery.

Metrics

Attribute	Metric	Reference value
Population	1^{st}- year survival	≥ 20%
	2^{nd}- survival	≥ 80%
	3+ year survival	≥ 95%
	Abundance	Significant Increasing trend
	Growth rate	2-3 in. / year
	Condition factor (relative weight)	≥ 100%
	Emigration to adjacent reservoirs	≤ 5% in aggregate

Approach

Methods are as in tasks 3.1 and 3.2. Evaluations will compare release size and season treatments (fall age 0+, spring age 1, and fall age 1+).

Task 3.4. Evaluate survival, growth, and condition of hatchery sturgeon relative to increasing abundance to identify limitations of the reservoir rearing capacity.

<u>*Hypothesis*</u>

Hypothesis 3.4.1. Survival, growth, and condition of hatchery sturgeon does not decrease with increasing abundance at planned release levels (such that the reservoir rearing capacity for sturgeon is not exceeded).

<u>*Metrics*</u>

Attribute	Metric	Reference value
Population	Annual recapture rate	≥ 5%
	1st- year survival	≥ 20%
	2nd- survival	≥ 80%
	3+ year survival	≥ 95%
	Abundance	Significant Increasing trend
	Growth rate	2-3 in. / year
	Condition factor (relative weight)	≥ 100%
	Emigration to adjacent reservoirs	≤ 5% in aggregate

<u>*Approach*</u>

Reservoir carrying capacity for sturgeon will be empirically determined by monitoring changes in survival, growth and condition of hatchery and wild juvenile and subadult sturgeon in response to increasing density produced by hatchery releases over time. The test hypothesis is that annual estimates of size-specific survival, growth and condition are not significantly correlated with sturgeon abundance (i.e. population correlation coefficient = 0).

Our ability to identify fine-scale survival differences is limited. However, estimates of condition factor from length and weight measurements of all sturgeon captured and estimates of growth increments for recaptured fish are expected to provide much more sensitive indicators of differences and effects.

Sampling effort will be scaled to produce annual recapture rates of at least 5%. Statistical power analyses suggest that a 5% sample rate can provide 95% confidence intervals on the order of ±15 to 25% depending on the absolute value of annual survival (Figure 71). Annual recapture probabilities of 4-9% for juvenile Kootenai sturgeon produced 95% confidence intervals on estimates of annual survival of approximately ±10 to 40% (Beamesderfer et al. 2014).

Based on projected abundance of approximately 30,000 hatchery juveniles (age 1-10, length 10-36 in, 25–91 cm), a 5% sample rate is estimated to provide annual samples of 1,000 or more individuals after the first few years of releases. This sample size is expected to provide very precise estimates of individual attributes such as relative weight (Figure 72).

Increased assessments of juvenile sturgeon will be initiated immediately upon release of hatchery fish so that the first few years of sampling represent a relatively-unaffected baseline condition. Data on juvenile sturgeon from juvenile index sampling prior to hatchery releases will

also be analyzed to represent the unsupplemented baseline condition although limited sample sizes may require pooling of annual samples for growth and condition estimates, and mark-recapture sample sizes are too small to estimate survival rates of wild juveniles from previous sampling. Data from index sampling of juveniles in Bonneville and The Dalles Reservoirs will also be analyzed for a comparison with unsupplemented populations. Limited sample size caveats of index sampling apply.

Ideally, an expanded juvenile sampling program would be implemented concurrently in Bonneville and The Dalles reservoirs to provide an unsupplemented control for comparison with the supplemented John Day population (to the extent that all populations are representative of common effects including trends in climate and flow). However, funding resources for monitoring and evaluation are finite and prioritized for sampling of the supplemented population. Thus, the evaluation of sturgeon density effects does not follow a strict before-after control-impact (BACI) design.

A staircase design attempts to control for time-treatment interactions by initiating treatments sequentially in separate experimental units (Walters et al. 1988; McAllister & Peterman 1992). Monitoring would take place before the initiation of treatments to detect time trends and variability in properties to be measured that might be unique to each experimental unit. However, this design is precluded by a limited number of reservoirs that might serve as experimental units and a desire to limit hatchery influence among the more-productive reservoir populations.

Instead, this evaluation employs a quasi-experimental before-after design (ISRP 2005). This design involves evaluation of management actions intended to improve conditions at selected sites rather than random assignment of experimental treatments to representative units. The evaluation is specific to the area of concern and the suite of actions taken. Measurements are taken over an extended period of project implementation with the objective of asking if there is are real differences over time in relation to project actions. Based on the nature of the differences, we might infer that changes resulted from actions because cause and effect relationships between the quasi-treatments cannot be conclusively demonstrated in this design due to the lack of formal experimental treatment controls (ISRP 2005). However, the fundamental goal of this project is to achieve desired conditions – not to statistically demonstrate and quantify cause-effect relationships. ISRP (2005) noted that corroborative results of quasi-experimental monitoring studies over time and space can provide compelling evidence for the actual effect of an action. It was also reported that this may be the most useful type of study design for determining effectiveness of management actions in large systems. Inferences of causal relations may not be justified by the study design in complex systems even in carefully replicated observational studies because many uncontrolled factors can still influence results.

Task 3.5. Estimate downstream passage/entrainment of hatchery-reared fish and relative influence on source and downstream populations.

Movements will be evaluated based on recaptures of hatchery fish in adjacent reservoirs during the ongoing stock-assessment program. Substantial numbers of hatchery fish previously released into upper mid-Columbia Reservoirs were subsequently observed in downstream areas one or more dams below release sites. It is unknown whether fish movement was volitional or involuntary. It is also unknown whether similar movements will occur in the larger, less-riverine lower mid-Columbia reservoirs.

Hypothesis

Hypothesis 3.5.1. Downstream passage/entrainment of hatchery-reared fish does not significantly affect abundance and survival in source and downstream populations.

Metrics

Attribute	Metric	Reference value
Population	Annual recapture rate	≥ 5%
	1^{st}- year survival	≥ 20%
	2^{nd}- survival	≥ 80%
	3+ year survival	≥ 95%
	Abundance	Significant Increasing trend
	Growth rate	2-3 in. / year
	Condition factor (relative weight)	≥ 100%
	Emigration to adjacent reservoirs	≤ 5% in aggregate

Approach

Recapture information in other reservoirs, including the lower Snake where hatchery fish are released and The Dalles and Bonneville where hatchery fish might migrate, will be provided by ongoing juvenile indexing and stock assessment work. Indexing occurs annually in lower mid-Columbia reservoirs. Stock assessment currently occurs at three year intervals in lower mid-Columbia reservoirs. Stock assessment has occurred periodically in lower Snake River reservoirs.

Task 3.6. Evaluate food items and diet of hatchery sturgeon following release for changes over time which might be indicative of ecological effects of increasing sturgeon density.

The potential significance of ecological interactions of hatchery sturgeon with the reservoir aquatic community will be evaluated with food habit studies of hatchery sturgeon. Diet and food web interactions of impounded White Sturgeon are only generally understood.

Hypothesis

Hypothesis 3.6.1. Hatchery sturgeon utilize a wide variety of food items and diet does not change over time as sturgeon densities increase (such that sturgeon numbers are substantially altering aquatic communities and productivity).

Metrics

Attribute	Metric	Reference value
Food habitats	Diet composition by species	% by number

Approach

Samples of hatchery fish will be sacrificed for food habit studies. These samples may or may not be representative of wild fish but the primary concern of this analysis will be the impact of hatchery fish. Sampling will be stratified by fish size, season, and area of reservoir to control for potential confounding effects. Fish will be collected with the same small mesh gillnets used for post-release assessment of hatchery fish. Area strata will include the dam tailrace, upper reservoir downstream from the immediate vicinity of the dam, and lower-middle portion of the reservoir. Seasonal strata will include spring, summer and fall. Sampling will be focused at sites representative of sturgeon occurrence in each area strata. Target sample sizes will be 10 to 30 per strata per year. Food habitats will be evaluated for different sizes of sturgeon to identify where interactions occur. Along with sturgeon abundance estimates, this information will be used to estimate the magnitude of effect and also allow for bioenergetics analysis of trophic demand. Food habitats will also be compared over time to determine if diet composition changes in response to increasing sturgeon densities.

8.3.4 Wild Stock Assessment

MR&E Objective 4.	Continue to monitor and evaluate status and trends of wild sturgeon populations.

As part of ongoing sturgeon mitigation and management efforts, annual stock assessments are conducted in Zone 6 reservoirs to estimate wild subpopulation status and trends based on abundance, size composition, growth and condition factor. Annual year class strength is currently indexed based on catch-per-effort indices in small mesh gillnet sampling of each reservoir during the fall of each year. Ongoing wild stock assessments will provide a basis for evaluation of hatchery sturgeon as they reach larger sizes. Hatchery-origin sturgeon are also expected to enhance wild subpopulation assessments. For instance, natural recruitment can be estimated based on hatchery abundance from relative proportions of wild and hatchery fish in juvenile sampling. Hatchery fish will also provide known-age fish for aging validation studies.

Task 4.1. Monitor status and trends of subadult and adult sturgeon in Zone 6 reservoirs based on annual estimates of abundance, size composition, survival and recruitment from setline sampling and mark-recapture analysis.

Hypothesis

Hypothesis 4.1.1. Status and trends of subadult and adult sturgeon are effectively estimated with reasonable precision based on mark-recapture sampling and models.

Metrics

Attribute	Metric	Reference value
Population parameters	Catch numbers	Not applicable
	Recapture numbers	
	Abundance	
	Size distribution	
	Growth rate	
	Condition factor (relative weight)	
	Emigration to adjacent reservoirs	
	Relative year class strength	
	Annual capture probability	
	Annual survival rates	
	Annual recruitment numbers (by size class)	

Approach

Stock assessment protocols are detailed in annual project reports (Beamesderfer et al. 1995; North et al. 1995, 1996, 1998, 1999; Rien et al. 1997; DeVore et al. 1998, 1999; Burner et al. 2000; Kern et al. 2001, 2002, 2003, 2004, 2005, 2006; Chapman & Hughes 2007; Weaver et al. 2007; Storch et al. 2009; Chapman & Jones 2010, 2011; Chapman et al. 2012; Farr et al. 2013; Farr & Jones 2014; Cox & Schade 2014; Cox 2015).

In summary, each reservoir is assessed on a three-year rotating cycle. Sampling is conducted with setlines and large mesh gillnets to which sturgeon are recruited at approximately 25 to 40 inches. Sets are distributed throughout the reservoir in an attempt to collect a random sample. Two or more passes are made for each reservoir and used as mark-recapture periods for the purposes of population estimation. Biological information is collected on each sturgeon caught, all sturgeon are tagged with individually-numbered PIT tags, and all fish are scanned to identify recaptures. Abundance was historically estimated with Schnabel multiple mark-recapture estimators from data collected in a given year. Confidence (95%) in population estimates is typically 20-30%. The feasibility of using Cormack-Jolly-Seber multiple mark recapture models and maximum likelihood estimators is currently being examined. Individual data on length and weight is used to estimate growth and condition. Size composition and growth information is the basis for projections of near-term recruitment of sturgeon into fishery size slots. These estimates are the basis for development of annual harvest guidelines.

Task 4.2. Evaluate relationships between relative year class strength and river discharge based on juvenile sampling and catch-per-effort indices.

<u>*Hypothesis*</u>

Hypothesis 4.2.1. Relative year class strength is effectively estimated based on juvenile sampling and catch-per-effort indices, and is related to river discharge and dam operations during spring spawning and incubation periods.

<u>*Metrics*</u>

Attribute	Metric	Reference value
Population parameters	Catch numbers	Not applicable
	Recapture numbers	
	Abundance	
	Size distribution	
	Growth rate	
	Condition factor (relative weight)	
	Emigration to adjacent reservoirs	
	Relative year class strength	
	Annual capture probability	
	Annual survival rates	
	Annual recruitment numbers (by size class)	

<u>*Approach*</u>

Annual sturgeon recruitment in lower mid-Columbia impoundments is indexed with based on catches of age 0+ fish in standardized gillnet sets during fall. The annual recruitment index of age 0+ fish is based on the percentage of samples where one or more young-of-the-year sturgeon are caught – this index has more robust statistical properties than simple catch per effort when catch rates are low (Counihan et al. 1999). Effort and sampling locations are standardized among years. Additional detail on sampling and analysis methods may be found in annual project reports (Kern et al. 2001, 2002, 2003, 2004, 2005, 2006; Chapman & Hughes 2007; Weaver et al. 2007;

Storch et al. 2009; Chapman & Jones 2010, 2011; Chapman et al. 2012; Farr et al. 2013; Farr & Jones 2014; Cox & Schade 2014; Cox 2015).

Task 4.3. Estimate natural recruitment based on marked-unmarked ratios and recaptures of marked hatchery fish in reservoirs where hatchery fish are released.

<u>*Hypothesis*</u>

Hypothesis 4.3.1. Natural recruitment can be effectively estimated based on marked-unmarked ratios and recaptures of marked hatchery fish in reservoirs where hatchery fish are released.

<u>*Metrics*</u>

Attribute	Metric	Reference value
Population parameters	Catch numbers	Not applicable
	Recapture numbers	
	Abundance	
	Size distribution	
	Growth rate	
	Condition factor (relative weight)	
	Emigration to adjacent reservoirs	
	Relative year class strength	
	Annual capture probability	
	Annual survival rates	
	Annual recruitment numbers (by size class)	

<u>*Approach*</u>

Sampling methods are as described in Task 3.4.

8.3.5 Fishery Monitoring

MR&E Objective 5.	**Monitor and evaluate fishery contributions and management effectiveness for hatchery-origin sturgeon.**

An extensive sturgeon harvest monitoring program is conducted for treaty Indian commercial and subsistence, and non-Indian sport fisheries between Bonneville and McNary dams. This information is used to monitor sturgeon harvest over the course of the year and provides near term information needed to manage these quota-based fisheries. Additional information on the fishery monitoring effort may be found in Section 9.5.

Task 5.1. Evaluate contributions of hatchery supplementation to harvest in Columbia River Treaty commercial and non-Indian recreational fisheries based on catch sampling for marked hatchery-origin fish.

Hypothesis

Hypothesis 5.1.1. Hatchery supplementation will Increase harvest of White Sturgeon in commercial, subsistence and recreational fisheries for impounded lower Columbia River subpopulations by 100% or more within one sturgeon generation (25 years).

Metrics

Attribute	Metric	Reference value
Fishery	Catch (by fishery)	100% improvement
	Harvest (by fishery)	100% improvement
	Proportion hatchery marks (by fishery)	≥ 50%

Approach

The ongoing fishery monitoring effort will provide information on contributions of hatchery fish at such time as these fish recruit to fishery size slots. Contributions will be estimated from harvest information based on marked hatchery fish.

Harvest in commercial fisheries is estimated from fish tickets which are reported from fish buyers for all sturgeon purchased. Biological data including lengths, weights, marks, and tags, is also collected from subsamples of the commercial catch at the fish buying stations. Subsistence harvest is estimated based on a survey program of treaty tribal fishers. Both commercial and subsistence fisheries are surveyed by the Yakama Nation fisheries program.

Sport fishery harvest is also monitored in Zone 6 reservoirs during sturgeon retention seasons with a roving angler survey. This survey estimates angler effort from index counts and angler catch rates from angler interviews. Biological data is also collected from the catch of interviewed angler including lengths, weights, marks, and tags. Numbers of released fish are also recorded from the subsample of total anglers that are interviewed. Sport fisheries upstream from McNary Dam are not monitored in season – catches are estimated post season from catch record cards.

Biological data from fishery samples is incorporated into stock assessments, which are conducted in each reservoir every three years.

Quantitative objectives for fishery enhancement are to increase harvest of White Sturgeon in commercial, subsistence and recreational fisheries for impounded lower Columbia River subpopulations by 100% or more within one sturgeon generation (25 years) consistent with constraints of existing habitat capacity. Because all hatchery fish are marked and PIT tagged, harvest of hatchery and wild fish may be estimated separately for the purposes of this evaluation. Harvest from wild-only populations is also being monitored. This assessment is consistent with a BACI design since treated and untreated subpopulations are monitored and a long time series of information will be available for each both before and after hatchery supplementation. However, recruitment is variable in different reservoirs such that unsupplemented subpopulations may not be representative of supplemented subpopulations which are chosen specifically because they are recruitment limited. Environmentally-driven recruitment patterns may also not be comparable before and after supplementation. All of these variables will be taken into account in assessment of whether the hatchery supplementation has meet harvest doubling goals relative to what would have occurred in the absence of supplementation.

Task 5.2. Evaluate annual harvest rates of populations relative to effective lifetime exploitation rates which ensure recruitment of adults to maintain adequate adult populations and significant natural production when environmental conditions are favorable.

Section 9.6 of this plan for a description of the biological basis of sturgeon exploitation rate benchmarks.

Hypothesis

Hypothesis 5.2.1. Supplemented populations can be harvested at rates that continue to ensure recruitment of adults adequate to provide significant natural recruitment when suitable conditions occur (equivalent to effective lifetime exploitation rates of 60% and annual exploitation rate in John Day River of 16% of fish in the harvestable size slot).

Metrics

Attribute	Metric	Reference value
Fishery	Annual exploitation rate (John Day)	≤ 16%
	Effective lifetime exploitation rate	≤ 60%

Approach

Exploitation rates will be estimated from total harvest determined by fishery assessments and abundance of sturgeon in the harvestable size slot as estimated with mark-recapture methods in ongoing sturgeon stock assessments.

Task 5.3. Perform assays on fish within the current harvestable sizes to ascertain their contaminant levels.

Contaminant levels in sturgeon flesh will be bio assayed and evaluated for suitability for human consumption relative to established health criteria.

Hypothesis

Hypothesis 5.3.1. Contaminant levels in harvestable sizes of sturgeon from lower Columbia River impoundments are at values suitable for human consumption.

Metrics & Approach

Standard methods

8.3.6 Hatchery-Optimization Research

MR&E Objective 6.	**Identify operational alternatives that enhance the efficiency and quality of sturgeon hatchery production.**

While effective sturgeon aquaculture methods have been established, sturgeon hatcheries are still relatively new compared to salmon hatcheries. Room for improvement still exists. Operational effectiveness can be improved by dedicated research on key questions and practices. A progressive sturgeon hatchery program will include a significant research component. The Water & Environmental Center operated by the Confederated Tribes of the Umatilla Indian Reservation in cooperation with the Walla Walla Community College is identified in this plan as a primary research facility for the sturgeon hatchery program. Additional research and experimentation will also occur at primary and supporting hatchery facilities.

The list below identified examples of questions which may be included in the related research effort. Additional questions will inevitably be identified as the program is implemented.

Task 6.1. Determine if genetic autoploidy is significant in production and if so, whether it can be reduced with alternative spawning and fertilization practices.

Hypothesis 6.1.1. The incidence of genetic autoploidy can be reduced with alternative spawning and fertilization practices.

Task 6.2. Determine if health and survival of wild-origin larvae can be substantially improved in the hatchery from current low levels.

Hypothesis 6.2.1. Health and survival of wild-origin larvae can be substantially improved in the hatchery from current low levels.

Task 6.3. Determine if and how stage-specific growth and survival can be improved in the hatchery.

Hypothesis 6.3.1. Early life history survival can be substantially improved by use of algal, live, moist and/or dry feed introduction at the first feeding.

Hypothesis 6.3.2. *Early life history survival is related to the availability of essential fatty acids in the diet.*

Hypothesis 6.3.3. *Early life history survival is affected by temperature at fish feeding.*

Hypothesis 6.3.4. *Stage-specific growth and survival is related to food type and related conversion efficiency.*

Hypothesis 6.3.5. *Stage-specific growth and survival is related to flow rates in containers.*

Hypothesis 6.3.6. *Stage-specific growth and survival is related to light intensity.*

Hypothesis 6.3.7. *Stage-specific growth and survival is related to flow rates in containers.*

Hypothesis 6.3.8. *Stage-specific growth and survival is related to time of feed introduction (night, day, crepuscular).*

Hypothesis 6.3.9. *Stage-specific growth and survival can be improved by use of substrate in the rearing environment.*

Task 6.4. Hold wild broodstock collected in developing condition one-year prior to spawning to determine if extended holding can significantly reduce effort and costs of broodstock collection.

Hypothesis 6.4.1. *Maturing adults can be successfully held in the hatchery for one year to reduce costs of broodstock collection.*

Hypothesis 6.4.2. *Extended holding of wild broodstock collected in developing condition (stage F3) one-year prior to spawning can significantly reduce effort and costs of broodstock collection.*

Task 6.5. Determine causes and feasibility of improving poor first year survival of hatchery fish following release.

Hypothesis 6.5.1. *Year-1 survival of hatchery fish following release can be improved by exposing juveniles to a mixture of natural and artificial foods for several months prior to release.*

Hypothesis 6.5.2. *Distribution and habitat preferences of hatchery juveniles in reservoirs as determined with Juvenile Salmon Acoustic Tags (JSAT), can help identify rearing and release strategies conducive to improving first year survival following release.*

Metrics & Approach

To be determined

8.3.7 Other Research

MR&E Objective 7.	Conduct research to address critical uncertainties with application to sturgeon restoration, mitigation and management.

Hatchery-related monitoring, research, and evaluations will be conducted as part of a comprehensive restoration, mitigation and management effort for impounded White Sturgeon subpopulations. By way of context, this section identified other related research that is underway or in consideration for implementation. These subjects include research needs identified in the Columbia Basin White Sturgeon Planning Framework (Beamesderfer & Anders 2013) that are particularly pertinent to the lower mid-Columbia Region. Related tasks and qualitative hypotheses are identified below. Details on metrics and approach will be established by project implementers.

Task 7.1. Identify the genetic population structure among impounded and unimpounded White Sturgeon subpopulations throughout the region.

Hypothesis 7.1.1. The genetic population structure varies among impounded and unimpounded White Sturgeon subpopulations throughout the region. [28]

Task 7.2. Resolve uncertainties in sturgeon life history regarding maturation and age

Hypothesis 7.2.1. Effectiveness of sturgeon restoration, mitigation and management efforts can be improved by a better understanding of sturgeon life history including maturation and accurate aging methodologies.

Task 7.3. Identify mechanisms of recruitment failure among impounded populations in order to provide insights into effective alternatives for remediation.

Hypothesis 7.3.1. Research on mechanisms of recruitment failure among impounded populations will provide insights into effective alternatives for remediation.

Task 7.4. Evaluate the feasibility of improving natural recruitment of selected White Sturgeon subpopulations by dam flow management and dam operations.

Hypothesis 7.4.1. Natural recruitment of selected White Sturgeon subpopulation can be improved by management of dam flows and operations.

Task 7.5. Evaluate the feasibility of improving natural recruitment of selected White Sturgeon subpopulation by habitat restoration actions such as substrate enhancement.

Hypothesis 7.5.1. Natural recruitment of selected White Sturgeon subpopulation can be improved by habitat restoration actions such as substrate enhancement.

[28] *Ongoing efforts.*

Task 7.6. Evaluate the feasibility of improving sturgeon productivity in the unimpounded lower Columbia and in impounded subpopulations by improvements in adult and/or juvenile passage opportunities.

Hypothesis 7.6.1. Sturgeon productivity in the unimpounded lower Columbia and in impounded subpopulations would benefit by improvements in adult and/or juvenile passage opportunities.

<u>*Metrics & Approach*</u>

To be determined

8.4 IMPLEMENTATION SCHEDULE

The sturgeon hatchery monitoring, research and evaluation program will occur in three phases – each building on the results of the previous.

Phase I – Experimental Implementation

Phase I includes the initial start-up of this program and extends for approximately the five years. Phase I is expected to questions regarding the feasibility of wild larvae collection and rearing, and the efficacy of extended holding of developing adults for use as broodstock. Subsequent production strategies will be determined based on experimental evaluation of these alternatives. Phase I will also include critical evaluations of operational effectiveness as well as dedicated research on operational alternatives with the potential to enhance the efficiency and quality of sturgeon hatchery production. Finally, initial monitoring results of post-release performance during Phase I will provide preliminary assessments of the relative effectiveness of alternative size/age release strategies and potential future contributions of hatchery fish to impounded subpopulations. This phase will inevitably involve refinements to hatchery facilities, systems and practices based on initial experiences.

Phase II – Program Optimization

Phase II extends approximately 10 years from year 5 through 15. During this phase, many outstanding questions regarding operation effectiveness, optimum production alternatives, and post-release performance of hatchery fish should be resolved. Operational monitoring will continue for the duration of the program but the need for dedicated research should be reduced as the most proximate questions are addressed. By the end of phase II, hatchery fish should begin to recruit to harvestable sizes such that fishery contributions can begin to be assessed.

Phase III – Program Maturity

By year 16, the program will have a point where facilities, systems and practices have become well established based on past experience. Monitoring will continue but should be streamlined by this point on key indicators.

Table 32. Implementation schedule (20-year) for sturgeon hatchery monitoring, research and evaluation. (Dark and light colors indicate more and less-intensive monitoring efforts).

Objective	Phase I					Phase II										Phase III				
Year:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Brood v. larvae																				
2. Operations																				
3. Post-release																				
4. Wild status																				
5. Fishery																				
6. Hat. research																				
7. Other research																				

8.5 Adaptive Management & Decision Framework

Adaptive management is a structured, iterative process of optimal decision making in the face of uncertainty, with an aim to reduce uncertainty over time through system monitoring. In this way, decision making simultaneously maximizes one or more resource objectives and, either passively or actively, accrues information needed to improve future management. The challenge in using an adaptive management approach lies in finding the correct balance between gaining knowledge to improve management in the future and achieving the best short-term outcome based on current knowledge (Stankey & Allan 2009).

The sturgeon hatchery program described in this Master Plan will supports a "true" or active adaptive management strategy involving a systematic, rigorous approach for learning through designing management actions as experiments. True adaptive management is an appropriate strategy when uncertainty is high, risks are acceptable or reversible, and answers can be obtained in a reasonable time frame (Marmorek 2011). Far from "trial and error", this involves a structured, iterative process designed to support optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time by learning via experimental management and system monitoring as originally conceived by Holling (1978) and Walters (1986) and reiterated by Ludwig and Walters (2002).

Many questions fundamental to successful protection, mitigation and management of impounded White Sturgeon can be most effectively answered through an experimental approach which involves controlled testing of hypotheses in an adaptive management framework. For instance, the most robust assessment of reservoir carrying capacity will be through monitoring of post-release responses to increasing density. Hatchery priorities, strategies and production targets will change over time based on temporal risk patterns, actions needed to address immediate risks, and action designed to anticipate future risks.

The sturgeon hatchery program will be subject to ongoing evaluations overseen by the Columbia River Treaty Tribes, as well as Washington and Oregon fishery co-managers. It is expected that program objectives and activities will continue to be refined throughout their duration based on monitoring, research and evaluation findings.

Program termination or large substantive changes in program objectives and activities will be driven by monitoring and evaluation of system responses. Substantial modification or termination will be considered when and if:

- Natural production of impounded sturgeon is restored to levels consistent with the available sturgeon habitat.
- Hatchery sturgeon production produces unacceptable negative impacts on wild sturgeon production or key components of the aquatic ecosystem.
- Mitigation objectives cannot be substantively achieved, programs cannot be reasonably adapted to achieve objectives, or adaptations prove cost-prohibitive relative to program objectives.

The decision structure for adaptive management of the hatchery program is described in Figure 73. Associated hypotheses and benchmarks were described in the monitoring and evaluation chapter.

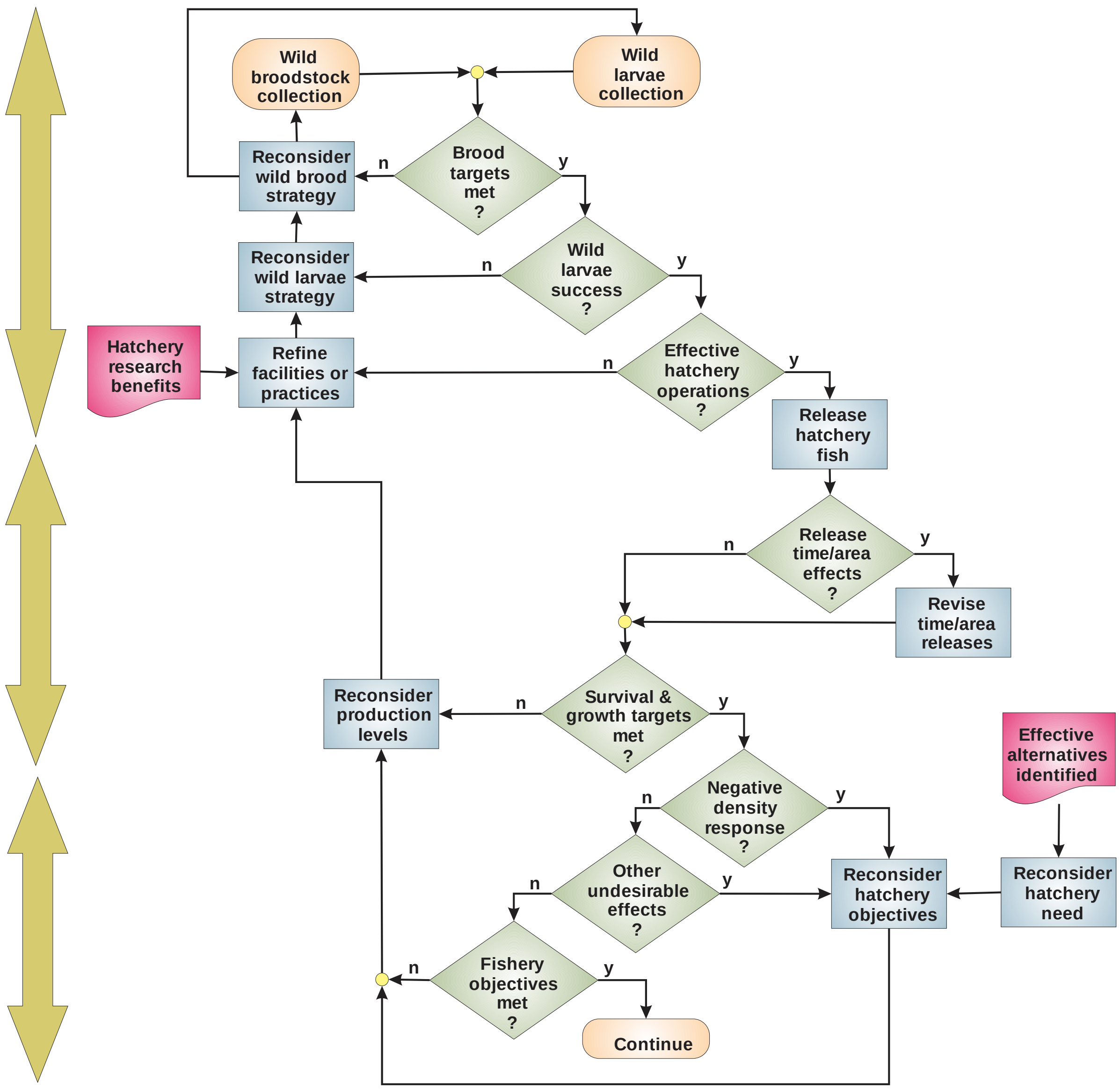

Figure 73. Decision framework for adaptive management of sturgeon hatchery program.

9 HARVEST PLAN

Fisheries for impounded sturgeon populations between Bonneville and McNary dams are very closely managed in order to optimize the benefits consistent with the limited productivity of these populations. Fishery mitigation for this reduced productivity is a primary goal of the sturgeon hatchery program. The long term success of this program will require an effective harvest plan.

Hatchery-produced sturgeon will be managed in an integrated manner with wild sturgeon in existing fisheries under the current management structure. Exploitation rates will continue to be limited by wild subpopulation objectives and will not be increased in response to hatchery supplementation. However, hatchery fish will increase numbers of sturgeon available for harvest in existing fisheries from the subject populations, so more total harvest will be available for equivalent exploitation rates (see section 5.6 on page 122). Increased numbers of harvestable sturgeon will allow for larger catch allowances and longer fishing seasons. Fisheries will be stabilized from year-to-year as large fluctuations due to variable natural year class strength are avoided. Augmenting weak subpopulations will also distribute fisheries more evenly among areas, with corresponding access, allocation, and anti-crowding benefits.

9.1 FISHERY DESCRIPTION

White Sturgeon are harvested between Bonneville and McNary Dam by treaty-Indian commercial and subsistence fisheries and by non-Indian recreational fisheries. This fishery area is commonly referred to as "Zone 6." (Zones 1 through 5 are commercial fishing areas downstream from Bonneville Dam). Recreational sturgeon harvest occurs in McNary Reservoir. Recreational sturgeon fishing in the lower Snake River between Ice Harbor and Lower Granite dams is limited to catch and release. Treaty Indian commercial and subsistence fishing is mainly conducted with three types of gear: hook-and-line, setlines, and gillnets, although a few sturgeon are also taken in hoop nets fished from platform scaffolds. Non-Indian recreational fishing is restricted to hook-and-line gear.

9.2 MANAGEMENT PROCESS

Sturgeon fisheries in the Columbia River between Bonneville and McNary dams are jointly managed by the Columbia River Treaty tribes (CRTT: Nez Perce, Umatilla, Warm Springs, and Yakama) and the States of Washington and Oregon under the continuing Federal Court jurisdiction of *U.S. v Oregon*. In 1987, the Sturgeon Management Task Force (SMTF) was formed under *U.S. v Oregon* in response to concerns over increasing catches in non-Indian recreational and treaty Indian commercial and subsistence fisheries and declining sturgeon abundance. The SMTF consists of representatives from Oregon, Washington, and each of the four CRTT. This body annually reviews stock status and develops harvest management recommendations.

Sturgeon fisheries in the Columbia River upstream from McNary Dam are managed by the States of Washington and Oregon. Fisheries in the lower Snake River downstream from Lower Granite

Dam are managed by Washington. The CRTT do not at the present time open sturgeon fisheries above McNary Dam.

9.3 MANAGEMENT GOALS

Sturgeon fisheries in lower Columbia River impoundments are managed for two goals:

1. Maintain a significant and stable population of wild adults in order to sustain meaningful levels of natural spawning and recruitment.
2. Optimize fishery value and quality consistent with harvest sharing agreements among the Treaty Indian and non-Indian fisheries.

9.4 FISHERY REGULATION

Sturgeon commercial, subsistence and sport fisheries in the lower mid-Columbia and lower Snake Rivers are managed with a combination of size limits, annual harvest guidelines, seasons, sanctuaries and bag limits (WDFW 2014). These regulations are described below. A description of sturgeon fisheries in other areas of the Basin may be found in Beamesderfer and Anders (2013).

9.4.1 Size Limits

Sturgeon fisheries are managed with size slot limits which allow harvest over only a limited range of sizes (Figure 74). Slot limits have been in place for Columbia River sturgeon since 1950 and have been instrumental in rebuilding populations depleted by historical overfishing. The upper size limit protects the adult population from harvest in order to sustain natural reproduction and recruitment in areas and years where conditions are favorable. The lower size limit allows fish to reach desirable sizes for harvest, as total yield and yield per fish are much higher when fish are allowed to reach three to four feet in length before harvest.

The current slot limit is 43–54 in (109–137 cm) FL in the Columbia River from The Dalles Dam to Priest Rapids Dam (The Dalles, John Day and McNary reservoirs). The lower Snake (Ice Harbor, Lower Monumental, and Little Goose Reservoirs) was also managed for a 43–54 in (109–137 cm) FL slot limit until the fishery was permanently closed to sturgeon retention effective July 1, 2015. The slot limit is 38–54 in (96–137 cm) in Bonneville Reservoir. The smaller minimum size currently in Bonneville Reservoir is an acknowledgement of lower growth rates of fish in that population than of fish in the other reservoirs, although the Effective Lifetime Exploitation Rate (ELER) analysis suggests that the wider slot limit would require lower exploitation rates in order to meet spawner reference point objectives (See Section 9.6).

Sturgeon slot limits have been modified over the years in an attempt to balance harvest rates with increasing fishing effort as sturgeon fishing has grown in popularity since the 1970s (ODFW & WDFW 2014). A slot limit of 36–72 in (91–183 cm) TL (~33–66 in, 84–168 cm FL) was in place for the sport fishery from 1958 until 1989. A slot limit of 48–72 in TL 122–183 cm (~44–66 in, 112–168 cm FL) was in place for the commercial fishery from 1950 until 1993. Both sport and commercial size ranges have been reduced at several points in the interim.

9.4.2 Annual Harvest Guidelines

Commercial and recreational fisheries are managed in accordance with annual catch guidelines established by State and Tribal Fishery Managers for Bonneville, The Dalles and John Day reservoirs (Table 33). Management using reservoir-specific quotas has occurred since 1994. Guidelines are established based on population-specific abundance of harvestable-sized sturgeon, target exploitation rates, and harvest sharing agreements between the States and Tribes. Pool-specific guidelines are updated every three years based on new stock assessment data (one population is surveyed each year). Abundance changes in response to variable annual recruitment patterns and changes in harvest. Guidelines may increase years after a series of good production years and decrease years after poor production years.

The current harvest allocation is approximately 60% treaty and 40% recreational in aggregate for Zone 6. Reservoir-specific guidelines are shaped in response to fishery objectives. The recreational fishery is allowed a greater share of the catch in Bonneville Pool, while the treaty Indian fishery is allowed a greater share of the catch in The Dalles and John Day pools. Subsistence catch by CRTT fishers is relatively minor and not included in harvest guidelines.

Harvest guidelines are not in effect in McNary Pool, nor were they in the lower Snake River prior to closure to retention upstream from Ice Harbor Dam. Only recreational sturgeon fisheries occur in these areas. Because Treaty sturgeon fisheries do not currently occur upstream of McNary Dam, this area is not considered in SMTF harvest sharing agreements.

9.4.3 Seasons

Retention of sturgeon in Treaty commercial and non-Indian sport fisheries is limited to portions of the year when reservoir and fishery-specific guidelines have not yet been met. Treaty commercial gillnet fisheries may occur throughout the year. These fisheries generally target salmon with season dates depending on salmon abundance. Sturgeon retention may be allowed during commercial gillnet seasons when fish are available on the harvest guideline. The sturgeon harvest guideline is not typically sufficient to allow for incidental harvest of sturgeon in all salmon seasons. For instance, sturgeon sales have not been allowed in fall Treaty gillnet fisheries since 1991. One of the primary benefits of the sturgeon hatchery mitigation program is expected to be increased opportunity to harvest sturgeon during salmon seasons.

Much of the Treaty commercial sturgeon harvest occurs during the winter season after the annual harvest guideline is renewed on January 1. Winter gillnet seasons historically targeted steelhead but in recent decades have shifted to sturgeon due to poor prices for steelhead and higher prices for sturgeon. Treaty winter gillnet seasons generally begin on February 1st and end in mid-March, or when the guideline is reached, whichever comes first. Treaty setline seasons target sturgeon during the winter. This fishery is open January 1–31 in all three Zone 6 reservoirs under permanent regulations. After the guideline has been achieved, sturgeon sales are prohibited. Subsistence seasons are open the entire year and Treaty Indian fishers may continue to take sturgeon for subsistence purposes after commercial seasons have been completed.

Table 33. Recent annual sturgeon harvest guidelines in sport and commercial sturgeon fisheries between Bonneville and McNary Dam.

Year	Bonneville			The Dalles			John Day			Combined			Comm.
	Sport	Comm.	Total	Sport	Comm.	Total	Sport	Comm.	Total	Sport	Comm.	Total	%
1999	1,520	1,300	2,820	800	1,200	2,000	560	1,160	1,720	2,880	3,660	6,540	56%
2000	1,520	1,300	2,820	800	1,200	2,000	560	1,160	1,720	2,880	3,660	6,540	56%
2001	1,520	1,300	2,820	700	1,100	1,800	560	1,160	1,720	2,780	3,560	6,340	56%
2002	1,520	1,300	2,820	700	1,100	1,800	165	335	500	2,385	2,735	5,120	53%
2003	1,700	1,200	2,900	400	900	1,300	165	335	500	2,265	2,435	4,700	52%
2004	700	400	1,100	400	900	1,300	165	335	500	1,265	1,635	2,900	56%
2005	700	400	1,100	400	900	1,300	165	335	500	1,265	1,635	2,900	56%
2006	700	400	1,100	100	550	650	165	335	500	965	1,285	2,250	57%
2007	700	400	1,100	100	550	650	165	335	500	965	1,285	2,250	57%
2008	700	400	1,100	100	550	650	165	335	500	965	1,285	2,250	57%
2009	700	400	1,100	300	1,000	1,300	165	335	500	1,165	1,735	2,900	60%
2010	1,400	1,400	2,800	300	1,000	1,300	165	335	500	1,865	2,735	4,600	59%
2011	2,000	2,000	4,000	300	1,000	1,300	500	1,000	1,500	2,800	4,000	6,800	59%
2012	2,000	2,000	4,000	300	1,000	1,300	500	1,000	1,500	2,800	4,000	6,800	59%
2013	1,100	1,100	2,200	300	1,000	1,300	500	1,000	1,500	1,900	3,100	5,000	62%
2014	1,100	1,100	2,200	300	1,000	1,300	500	1,000	1,500	1,900	3,100	5,000	62%
2015	1,100	1,100	2,200	300	1,000	1,300	500	1,000	1,500	1,900	3,100	5,000	62%

Table 34. Zone 6 recreational fishery retention seasons, 2003-2013 (ODFW & WDFW 2014).

Year	Bonneville	The Dalles	John Day
2004	Jan 1 – Jun 25	Jan 1 – Jun 27	Jan 1 – Jul 11
2005	Jan 1 – Jun 10	Jan 1 – Jun 24	Jan 1 – Jul 10
2006	Jan 1 – Jul 23	Jan 1 – Apr 7	Jan 1 – Jun 30
2007	Jan 1 – Jul 29	Jan 1 – Mar 28	Jan 1 – Jun 10
2008	Jan 1 – Jul 11	Jan 1 – Mar 14	Jan 1 – Mar 25
2009	Jan 1 – Jun 5	Jan 1 – Apr 18	Jan 1 – Apr 12
2010	Jan 1 – Feb 20	Jan 1 – May 5	Jan 1 – Feb 28
2011	Jan 1 – Feb 18, Jun 30-Jul 2, Jul 7-8	Jan 1 – Jul 29	Jan 1 – Apr 9
2012	Jan 1 – Feb 17, Jun 15-16, Jun 22-23	Jan 1 – Nov 3	Jan 1 – May 20
2013	Jan 1 – Feb 10, Jun 14-15, Jun 21	Jan 1 – Nov 11	Jan 1 – Jun 28
2014	Jan 1-Feb 17, Feb 24-Mar 9, Jun 13-14, Jun 20-21, Jul 11-12, Jul 18-19	Jan 1 – Jul 31	Jan 1 – Jun 13

Sport fishery retention seasons in Zone 6 reservoirs reopen January 1 when the guidelines renew and extend until guidelines are reached. Retention season dates vary among reservoirs and years depending on angler effort and success (Table 34). Seasons may be broken up with closure windows in order to provide opportunity across the year. In recent years, retention periods in Bonneville Reservoir have been distributed from January until July. Catch-and-release recreational fishing is allowed once recreational quotas are reached.

Historically, the McNary Reservoir recreational sturgeon fishery was open for retention year round, but season restrictions have recently been implemented. Retention of White Sturgeon is allowed in recreational fisheries from McNary Dam upstream to Priest Rapids (Columbia River) from February through July. This season was adopted in 2010. Prior to 2010, sturgeon retention was allowed year-round.

Sturgeon retention was historically is allowed year-round for lower Snake River recreational fisheries in which retention is allowed. In 2010, the sturgeon retention season was limited to February 1 through July 31. WDFW permanently closed the Snake River upstream from Ice Harbor Dam to sturgeon retention effective July 1, 2015.

Declining recruitment in the wild sturgeon population downstream from Bonneville Dam has led to closure to sport and commercial fisheries to retention beginning in 2014. With this closure, harvest opportunity is now limited to the impounded populations.

9.4.4 Sanctuaries

Sturgeon are also protected from harvest with seasonal fishery closures of designated areas. Sturgeon sport fishing is prohibited to protect spawning sturgeon from May 1 through July 31 in areas immediately downstream from The Dalles, John Day, McNary, Priest Rapids, and Ice Harbor Dams. Sanctuary closures around dams and tributaries are also in place for Treaty Indian commercial and subsistence fisheries.

9.4.5 Bag Limits

Sport fishery regulations for sturgeon include daily and annual bag limits. Limits have been periodically reduced over the years from historically liberal levels. The daily bag limit of one sturgeon per day has been in place since 1996. A three fish daily bag limit was established in 1951 and reduced to two fish in 1986. An annual bag limit of five sturgeon per year was in place from 2004-2012. In 2013, the annual bag limit was reduced to two fish per year. Annual bag limits were first adopted in 1986 in Oregon (30 sturgeon per year) and 1989 in Washington (15 sturgeon per year). Annual limits of 10 were established by both states in 1994. Oregon and Washington also require sport anglers to purchase a harvest tag (catch record card) to fish for sturgeon. Legal-size sturgeon must immediately upon removal from the water, be recorded on the harvest tag along with the location of harvest. Catch record cards have been required in Oregon since 1986 and Washington since 1989. Only retained sturgeon are recorded. Released sturgeon are not recorded and past experience with salmon has shown that data for released fish on catch record cards is of limited utility. Catch record cards are collected from anglers after the end of each year.

9.5 FISHERY MONITORING

The monitoring and evaluation strategy is designed to support the fishery strategy and does so quite effectively. Sturgeon abundance and size composition is estimated based on periodic stock assessments. Stock assessments involve mark-recapture sampling of sturgeon captured with gillnets and setlines. These efforts produce estimates of size-specific abundance which are used to assess population status and adjust harvest guidelines. Stock assessments also provide data on recruitment, growth and condition integral to the management strategy. Annual harvest guidelines are established based on abundance and objective exploitation rates.

An extensive sturgeon harvest monitoring program is conducted for treaty Indian and non-Indian fisheries between Bonneville and McNary dams. Harvest is estimated in season and used as a basis for real time management decisions relative to harvest guidelines. Harvest in commercial fisheries is estimated from fish tickets which are reported from fish buyers for all fish purchased. Biological data including lengths, weights, marks, and tags, is also collected from subsamples of the commercial catch at the fish buying stations. Subsistence harvest is estimated based on a survey program of treaty tribal fishers. This survey is conducted by the Yakama Nation fisheries program.

Sport fishery harvest is also monitored in Zone 6 reservoirs during sturgeon retention seasons with a roving angler survey. This survey estimates angler effort from index counts and angler catch rates from angler interviews. Biological data is also collected from the catch of interviewed angler including lengths, weights, marks, and tags. Numbers of released fish are also recorded from the subsample of total anglers that are interviewed. Sport fisheries upstream from McNary Dam are not monitored in season – catches are estimated post season from catch record cards.

Biological data from fishery samples are incorporated into stock assessments conducted in each reservoir every three years. Fishery monitoring provides limited biological data on maturation or reproductive investment sex-differences in life history of sturgeon. However, years of research

and stock assessment have provided a general understanding of these features. More detailed information of this nature is not essential for effective fishery implementation where harvest is concentrated on subadult sturgeon. The circumstance is similar to salmon where harvest occurs prior to spawning and management is not sex-based. Sex-specific information may be much more important in adult sturgeon fisheries in other areas where the potential for sex-selective exploitation is significant.

Annual estimates of exploitation rate are based on total harvest divided abundance of sturgeon in the harvestable size slot derived from mark-recapture estimates.

9.6 BIOLOGICAL BASIS OF MANAGEMENT

Management goals for sustainability and fishery optimization of impounded lower Columbia River sturgeon populations are met with a combination of size slot limits and annual harvest guidelines. Size slot limits protect the adult spawning stock from exploitation and help optimize yield by allowing fish to grow to large sizes before harvest. Harvest guidelines regulate annual exploitation based on abundance to ensure that numbers of sturgeon recruiting through the fishery to adulthood are sufficient to maintain the naturally-spawning population.

Size limits and harvest guidelines work in concert to meet the management goals. That is to say that specific exploitation rate objectives are conditional on size limits and vice versa. Objectives are implemented through the fishery regulatory structure that also includes closed seasons, daily and annual bag limits, no-fishing sanctuaries, etc. These rates are considered appropriate for the impounded lower Columbia sturgeon subpopulations where natural recruitment is sufficient to produce a substantial sturgeon population.

9.6.1 Harvestable Size Slot

The harvestable size slot limit has been an essential element of Columbia River sturgeon management for 65 years. This strategy is designed to protect mature adult sturgeon from harvest in order to maintain a pool of spawners and sustain consistently high levels of natural recruitment.

Maturation of White Sturgeon typically occurs between 39-60 in (100-150 cm) FL in males and 47-71 in (120-180 cm) FL in females (Bajkov 1949; Scott & Crossman 1973; Galbreath 1985; Conte et al. 1988; Webb & Kappenman 2013). Median sizes of female maturation in lower Columbia River reservoirs were reported to range from 63-76 in (160-194 cm) FL (Welch & Beamesderfer 1993).

The size slot historically allowed harvest of fish 36-72 in (91–183 cm) TL (32-65 in, 82–165 FL). The size slot was subsequently narrowed in order to control exploitation rates and prolong seasons in response to growth in popularity and angler effort in the sturgeon fishery over the years. Current slot lengths are 38-54 in (96–137 cm) FL in Bonneville Reservoir and 43-54 in (109–137 cm) FL in The Dalles, John Day and McNary reservoirs (Figure 74).

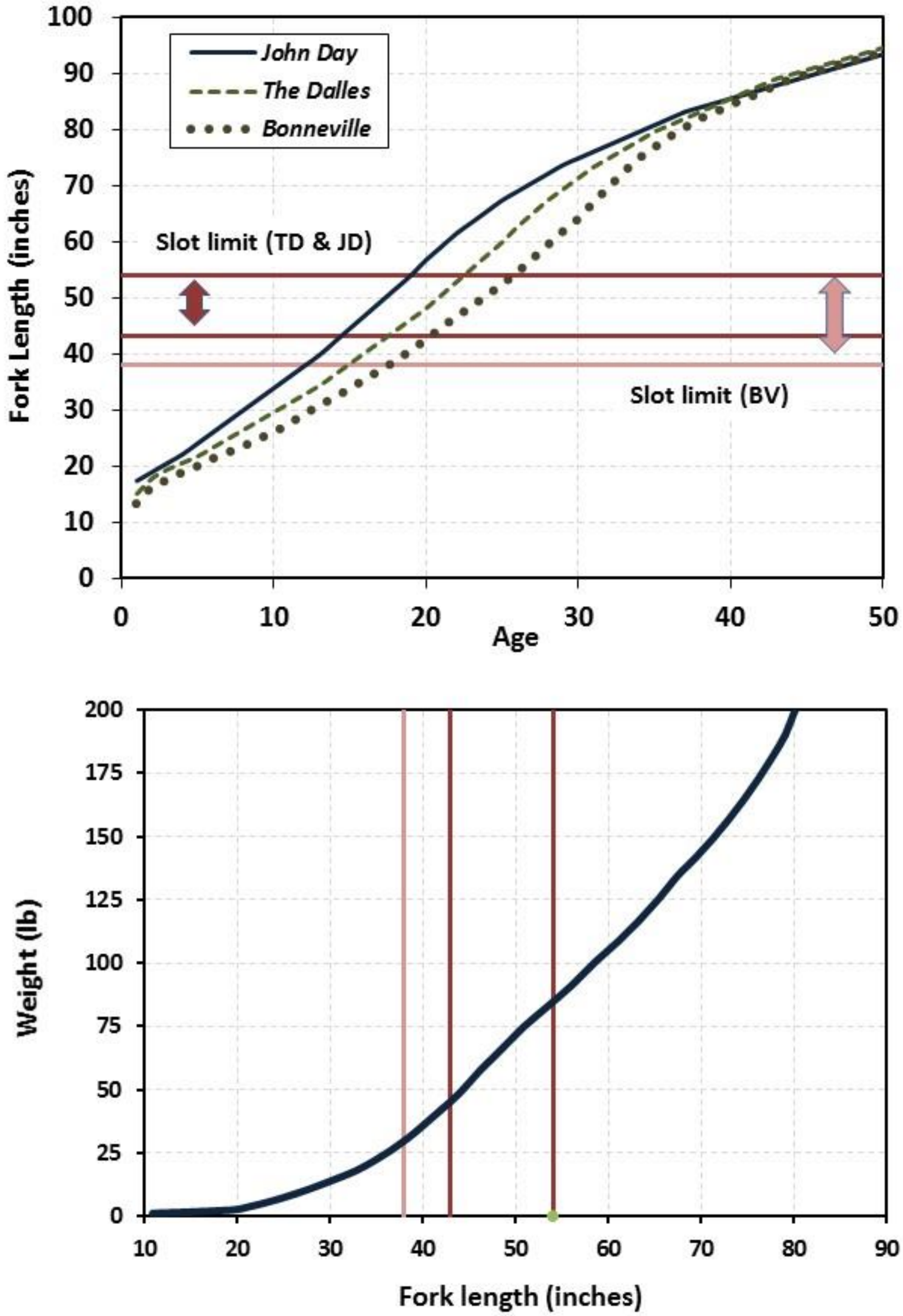

Figure 74. Average values in Bonneville, The Dalles and John Day reservoirs for length at age and weight at length (combined average of all three areas) of impounded sturgeon populations.

The sustainability of the size-based harvest strategy is clearly demonstrated by rebuilding of a large and productive sturgeon populations in the lower Columbia over several decades following its implementation in 1950. Sturgeon populations had previously collapsed due to commercial overfishing in the late 1800s and apparently languished at low levels until adults were protected by the size slot. Size protections allowed abundance in the lower river to rebuild to over one million fish by the 1980s. This population produced harvests averaging almost 50,000 sturgeon per year from 1980 through 2000. Substantial sturgeon subpopulations were also restored in lower Columbia impoundments although numbers were lower due to inconsistent juvenile recruitment.

9.6.2 Sustainable Recruitment

The key to the sustainability of any fishery strategy is to establish harvest limits that protect the adult stock from overfishing to the point of recruitment limitation. Recruitment objectives are ideally based on productivity or stock-recruitment relationships. For instance, salmon recruitment objectives are often based on stock-recruitment relationships around spawning escapements which produce maximum sustained yield of healthy stocks or around probabilities of risky low spawning escapements for weak, threatened or endangered stocks. However, stock-recruitment relationships have not been described for any Columbia River White Sturgeon population (or any other sturgeon population or species for that matter).

This plan identifies sustainability objective values for Columbia River sturgeon based on biological reference points (BRPs) identified in the scientific literature for other long-lived species including marine groundfish and tuna where stock-recruitment relationships are also unknown (Smith et al. 1993; Mace 1994). BRPs are stock-specific, production-based benchmarks which provide a means of quantitatively measuring the effect of fishing on the stock and determining the level of stock maintenance (Smith et al. 1993; Mace 1994; Gabriel & Mace 1999; Hennen 2015). Sturgeon BRPs are intended to ensure that survival of sturgeon through the fishery size slot is sufficient to maintain a significant adult spawning population. Application of BRPs to Columbia River sturgeon formalizes expression of current sturgeon fishery sustainability objectives which have been developed over the years.

The BRP for sturgeon recruitment is defined in this plan as the stock biomass that produces 40% of the maximum spawning potential ($B_{40\%}$). Maximum spawning potential in this case is defined relative to that of the unexploited biomass. In this application, the biomass value is equivalent to biomass per recruit. This parameter is proportional to net survival through the fishery. A related BRP, $F_{40\%}$ is the fishing mortality rate which produces 40% of the maximum spawning potential. Reference F values of 20-50% (e.g., those which produce 20-50% of the unexploited biomass) are variously employed for other fish species. In situations where data is limited, including long-lived species and those with little stock-recruitment information, a 40% value is often used as it provides a precautionary standard in the face of uncertainty.

9.6.3 Sustainable Exploitation Rates

The plan identifies sustainable exploitation rates as those that produce a spawning biomass equivalent to 40% of the unexploited biomass.[29] In an equilibrium situation, spawning biomass as a percentage of the unexploited level is equal to one minus the effective lifetime exploitation rate (ELER) which is defined as the percentage of fish of a cohort recruiting to a fishery that are harvested over the life of their exposure to the fishery. Thus a spawning biomass equivalent to 40% of the unexploited value is produced by an effective lifetime exploitation rate (ELER) of 60%.

Corresponding annual exploitation rates depend on the number of years sturgeon are vulnerable to fishing in the size slot which is a function of the width of the slot and fish growth rate (Box 4, Figure 75, Table 36, Table 37). For instance, target annual exploitation rates in most reservoirs are 16% of the sturgeon available in the 43 to 53 inch harvestable size slot (based on 5 years of vulnerability on average). Over the five years, this annual rate produces an effective lifetime exploitation rate (ELER) of 60% (Table 35). The target annual exploitation in Bonneville Reservoir would be 11% because the wider slot limit and slower growth subjects sturgeon to the fishery for 8 years rather than 5.

Table 35. Sustainable exploitation rate objectives identified by this plan for impounded lower Columbia and Snake river sturgeon subpopulations.

Subpopulation	Harvestable size slot (inches)	Years in slot	Annual exploitation rate	Effective lifetime exploitation rate	Spawner biomass (% of unexploited)
Bonneville	38 – 54	8	≤11%	≤60%	≥40%
The Dalles	43 – 54	5	≤16%	≤60%	≥40%
John Day	43 – 54	5	≤16%	≤60%	≥40%
McNary	43 – 54	<5	≤16%	≤60%	≥40%
Ice Harbor	43 – 54	--[a]	--[a]	--[a]	--[a]
Lower Monumental	43 – 54	--[a]	--[a]	--[a]	--[a]
Little Goose	43 – 54	--[a]	--[a]	--[a]	--[a]

[a] *Not estimated due to closure of the fishery to sturgeon retention for these small unproductive populations.*

Appropriate biological reference points obviously vary with stock productivity and the same $B_{40\%}$ rates applied to subpopulations with significant recruitment would severely overfish less-productive populations which may already be stock-limited. Lower Snake River subpopulations where natural recruitment rates are very low and inconsistent cannot be expected to sustain similar levels of exploitation. No exploitation currently occurs in Snake River reservoirs.

Objective values for annual exploitation rate identified in this plan based on a $B_{40\%}$ reference point are consistent with management practice for lower Columbia River sturgeon developed over the years. The harvest rates identified in this hatchery plan to produce spawning biomass

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[29] *Biomass and abundance of spawners are effectively interchangeable in this application where mature fish are unexploited.*

equivalent to 40% of the unexploited value (60% effective lifetime exploitation rate and $B_{40\%}$ biological reference point) are generally similar in order of magnitude to rates identified by ODFW based on population viability modeling. Plan rates of 11%, 16%, and 16% for Bonneville, The Dalles and John Day reservoirs, respectively, are slightly less than ODFW values.

Annual exploitation rates based on effective lifetime exploitation rates and a 40% spawning biomass reference point are ultimately a much more conceptually intuitive and parsimonious framework for sturgeon fishery management than rates inferred from complex population modeling exercises. The ELER rates transparently represent the uncertainties underlying complex population dynamics models in a context that can more readily be explained to management policy makers. The method explicitly recognizes the importance of protecting a significant and stable population of wild adults in order to sustain meaningful levels of natural spawning and recruitment where the nature of the stock-recruitment relations is unknown (particularly for impounded subpopulations).

Box 4. Definition of Effective Lifetime Exploitation Rate (ELER).

ELER is a direct and transparent expression of fishery impact describing net fishery exploitation rate for an age cohort over the period of its exposure to sizes of fish subject to harvest. It is a function of annual exploitation rate (E) and the number of years of fishery vulnerability (n):

$$ELER = 1 - [(1 - E)^n]$$

ELER can be directly related to biological reference points for recruitment including relative biomass (B_x) or egg production per recruit (EPR_x) expressed relative to X% of unexploited value.

$$B_x = 1 - ELER_x$$
$$EPR_x = 1 - ELER_x$$

These parameters are a measure of the effect of fishing on broodstock recruitment which is the essential feature of a sustainable sturgeon management strategy. For instance, a 60% ELER means that the fishery reduces survival of sturgeon through the fishery window such that broodstock recruitment is 40% of what would have occurred in the absence of fishing.

ELER is independent of assumptions regarding other population parameters such as natural mortality, reproduction, etc. for which data are lacking or estimates are highly uncertain.

ELER is dependent on the average number of years of vulnerability to the fishery, which is a function of fishery size limits and annual growth rates.

ELER can be calculated for an equilibrium population but also for specific cohorts recruiting over time, thus providing a very useful index of fishery-related trends in broodstock recruitment even where size limits or growth rates vary over time.

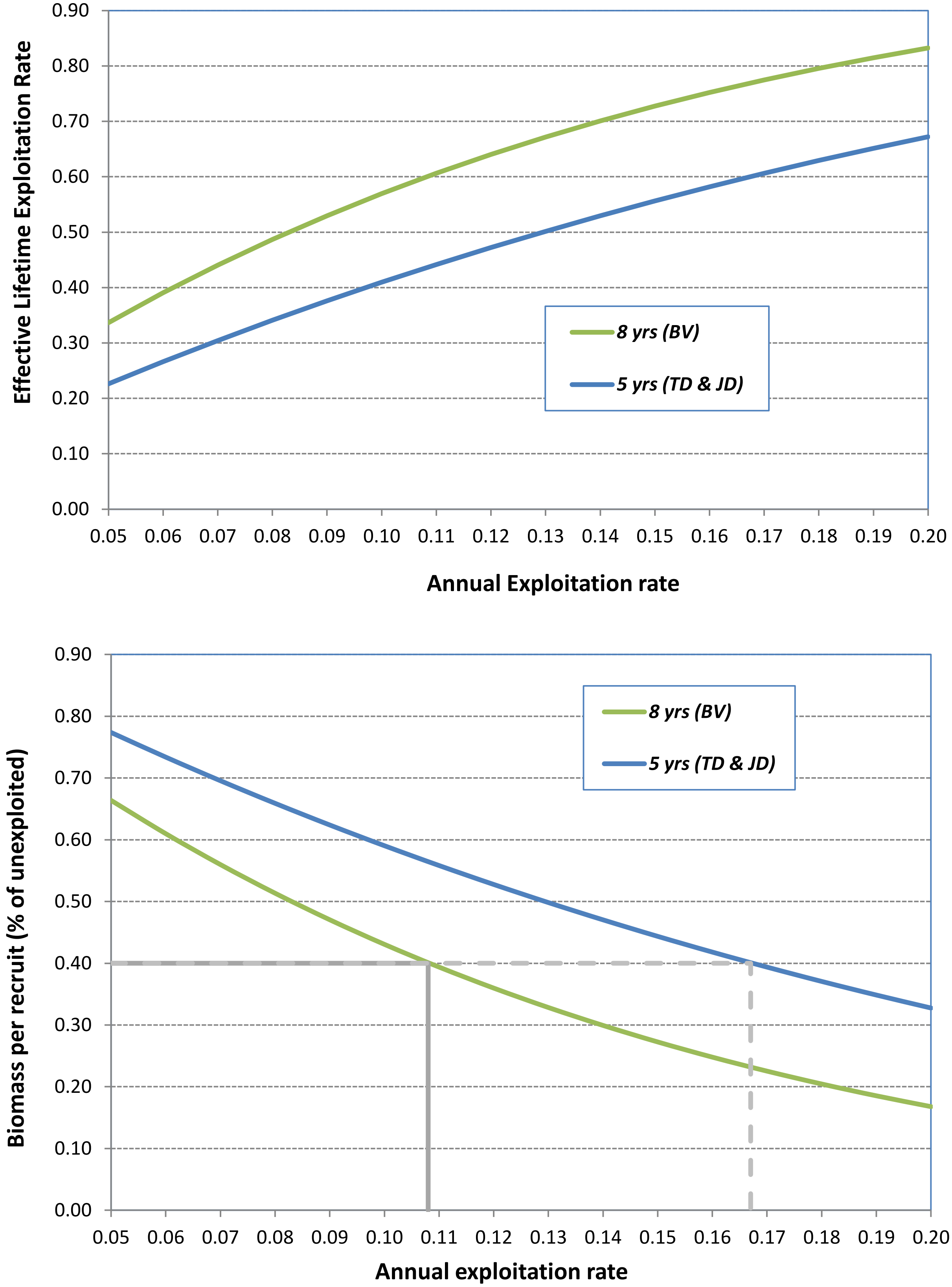

Figure 75. Relationships between annual exploitation rate, years of vulnerability to fishing, effective lifetime exploitation rate and biomass per recruit.

Table 36. Effective lifetime exploitation rate based on annual exploitation rate and years of vulnerability. Values that produce 40% of the unexploited level are highlighted.

Annual rate	Years in slot						
	5	6	7	8	9	10	11
0.05	0.226	0.265	0.302	0.337	0.370	0.401	0.431
0.06	0.266	0.310	0.352	0.390	0.427	0.461	0.494
0.07	0.304	0.353	0.398	0.440	0.480	0.516	0.550
0.08	0.341	0.394	0.442	0.487	0.528	0.566	0.600
0.09	0.376	0.432	0.483	0.530	0.572	0.611	0.646
0.10	0.410	0.469	0.522	0.570	0.613	0.651	0.686
0.11	0.442	0.503	0.558	0.606	0.650	0.688	0.722
0.12	0.472	0.536	0.591	0.640	0.684	0.721	0.755
0.13	0.502	0.566	0.623	0.672	0.714	0.752	0.784
0.14	0.530	0.595	0.652	0.701	0.743	0.779	0.810
0.15	0.556	0.623	0.679	0.728	0.768	0.803	0.833
0.16	0.582	0.649	0.705	0.752	0.792	0.825	0.853
0.17	0.606	0.673	0.729	0.775	0.813	0.845	0.871
0.18	0.629	0.696	0.751	0.796	0.832	0.863	0.887
0.19	0.651	0.718	0.771	0.815	0.850	0.878	0.902
0.20	0.672	0.738	0.790	0.832	0.866	0.893	0.914

Table 37. Adult biomass per recruit (survival through fishery in % of unexploited value). Values that produce 40% of the unexploited level are highlighted.

Annual rate	Years in slot						
	5	6	7	8	9	10	11
0.05	0.774	0.735	0.698	0.663	0.630	0.599	0.569
0.06	0.734	0.690	0.648	0.610	0.573	0.539	0.506
0.07	0.696	0.647	0.602	0.560	0.520	0.484	0.450
0.08	0.659	0.606	0.558	0.513	0.472	0.434	0.400
0.09	0.624	0.568	0.517	0.470	0.428	0.389	0.354
0.10	0.590	0.531	0.478	0.430	0.387	0.349	0.314
0.11	0.558	0.497	0.442	0.394	0.350	0.312	0.278
0.12	0.528	0.464	0.409	0.360	0.316	0.279	0.245
0.13	0.498	0.434	0.377	0.328	0.286	0.248	0.216
0.14	0.470	0.405	0.348	0.299	0.257	0.221	0.190
0.15	0.444	0.377	0.321	0.272	0.232	0.197	0.167
0.16	0.418	0.351	0.295	0.248	0.208	0.175	0.147
0.17	0.394	0.327	0.271	0.225	0.187	0.155	0.129
0.18	0.371	0.304	0.249	0.204	0.168	0.137	0.113
0.19	0.349	0.282	0.229	0.185	0.150	0.122	0.098
0.20	0.328	0.262	0.210	0.168	0.134	0.107	0.086

9.6.4 Size at Harvest vs. Exploitation Rate

Sustainability may be achieved by a variety of size-based strategies. The example in Figure 76 below shows how sustainable levels of adult abundance (as indexed by a spawning B_{40} biological reference point) are affected by annual exploitation rate and fish sizes subject to harvest. The more sizes (and ages) subject to the fishery, the lower the annual exploitation rate must be to maintain a given level of adult recruitment. A B_{40} objective value is produced by an annual rate of 16% for a 43-54 in (109–137 cm) FL size slot, 6% for a 32-65 in (81–165 cm) FL slot, and 3% on fish >60 in (152 cm: mature adults).

This example provide clear justification, in terms of conservation rebuilding, for a targeted fishery on mostly immature subadult sturgeon. Harvesting a certain proportion of fish before they reach their prime spawning years is every bit as sustainable a fishery strategy as harvesting a certain proportion of mature adult sturgeon.

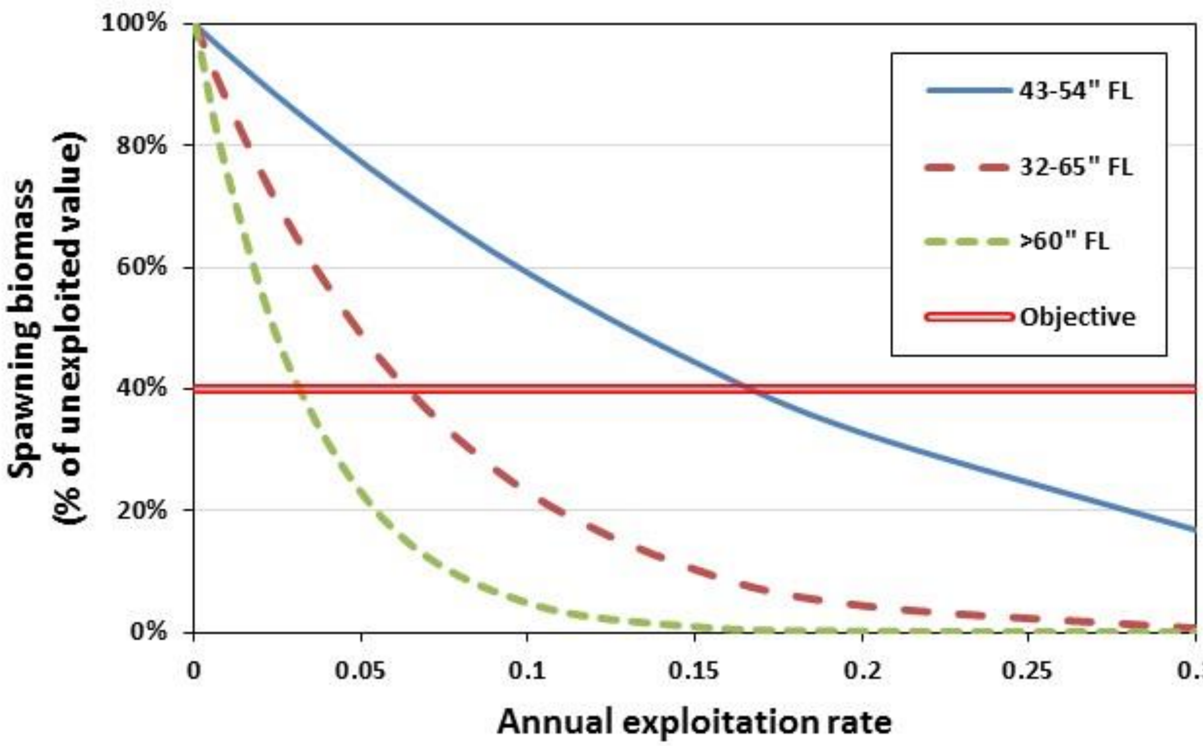

Figure 76. Effects of annual exploitation rate and fishery size regulation on spawning stock size of John Day Reservoir Sturgeon expressed as a percentage of the unexploited biomass at population equilibrium. In this example, sustainability is assumed to occur at a biological reference point equivalent to ≥40% of the unexploited biomass. Annual exploitation rate is harvest as a percent of abundance in the harvestable size range.

9.6.5 Optimum Sustained Yield

Optimum sustained yield (OSY) for this fishery is defined in terms of economic and social qualities in addition to simple yield. OSY is produced for impounded sturgeon populations by harvesting fish at sizes and rates that optimize fishery values within the constraints imposed by the recruitment reference points. Minimum and maximum sizes in the current slot limit balances maximum yield values in the commercial fishery and maximum catch values in the sport fishery while providing fish of size deemed to be desirable for retention by anglers.

Minimum size was selected to allow fish to reach large sizes prior to harvest. Sturgeon yield is generally maximized by allowing fish to grow to large sizes before harvest. Delaying harvest of fish with low natural mortality rates like sturgeon substantially increases fishery yield by weight. The low natural mortality rate of sturgeon and growth to large size makes it beneficial to restrict harvest on small fish to let them grow to more desirable sizes. Maximizing yield per recruit is particularly important in the commercial fishery where value is proportional to weight of landed catch.

Maximum size limits ensure that large numbers of sturgeon are available for harvest. Harvest number is greater when fish are harvested at smaller sizes even at a cost in terms of net yield. A lower maximum size limit increases harvest in terms as numbers as more fish may be caught before succumbing to natural mortality. Sport fishery benefits are optimized by maximizing number rather than weight of fish harvested. Size is also an issue in the sport fishery but less so than the commercial fishery. Fish smaller than the current slot limits are not desirable for harvest due to their low yield by weight.

Yield per recruit

Yield-per-recruit (Y/R) curves highlight the tradeoffs between fishing rates and the total harvest by weight of a cohort of sturgeon over their lifetime. Equilibrium values of Y/R for different fishing mortality rates are a function of growth rate and natural mortality. Yield-per-recruit is generally maximized at low values of fishing mortality for large, long-lived, low mortality fishes like sturgeon. Low fishing rates allow sturgeon to grow to larger, more-valuable sizes before harvest. High fishing rates result in growth overfishing where fish that would have reached larger sizes are cropped at a smaller size.

Figure 77 describes the effect of exploitation rate and size regulation on yield per recruit. These relationships show how best to maximize yield by weight of any given cohort of fish across their lifespan (independent of effects on recruitment to broodstock). The red circles show the exploitation rates for each size regulation consistent with the need to maintain sustainable levels of broodstock abundance ($B_{40\%}$). Note that the exploitation rates producing maximum yield per recruit are often greater than the rates needed to sustain recruitment. A sustainable long term fishing strategy prioritizes management for sustainable recruitment over maximum yield per recruit. Thus the circles represent objective fishing levels and corresponding yields. Curves show that the large majority of the potential yield from a cohort of sturgeon is obtained from exploitation rates of 3-16% range (depending on size regulation). Greater exploitation rates do

not produce substantially higher yields from a cohort of sturgeon and risk recruitment overfishing which will reduce future abundance, harvest and yield.

Maximum sustainable yields of sturgeon are produced by exploiting fish at larger minimum sizes (Figure 77). Yield per recruit under a 60 in (152 cm) minimum size regulation is twice that produced by either the 32-65 (81–165 cm) or the 43-54 in (109–137 cm) size slot regulation. However, yields would be distributed among few fishers – many would be excluded from realizing a harvest in most years.

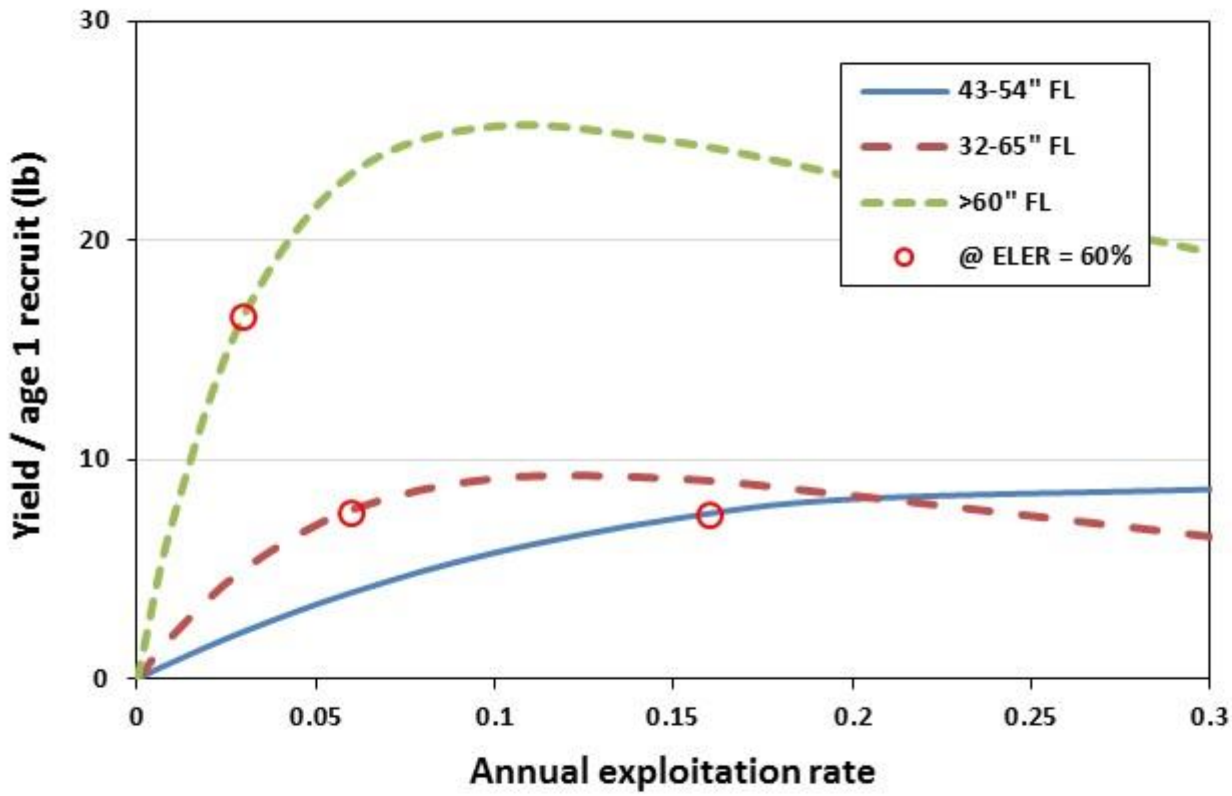

Figure 77. Effects of annual exploitation rate and fishery size regulation on yield per age one recruit. Circles show size-specific catches that occur at annual harvest rates and sizes at the B_{40} reference point where harvest is believed to be sustainable.

Catch per recruit

Optimum yields also consider fish numbers as well as size. Fewer large fish can be harvested from a cohort than small fish for an equivalent impact on recruitment to adults. Thus, postponing harvest to larger sizes will reduce the opportunity for individual fishers to share in the harvest, particularly in the sport fishery where a large number of anglers participate and the majority are unsuccessful.

Figure 78 shows the harvest numbers associated with the B_{40} exploitation rates for different size regulations. Number of fish harvested with a 43-54 in (109–137 cm) regulation is twice that in the 60 in (152 cm) minimum regulation. Under the slot limit, many more sport anglers are able to harvest fish in any given year and the commercial harvest is more evenly distributed among treaty fishers. Even higher sustainable catches might be produced by the 32-65" size slot. However, both the 32-65 in (81–165 cm) and >60 in (152 cm) regulation require much lower exploitation rates within the harvestable size slot which would produce much shorter retention seasons.

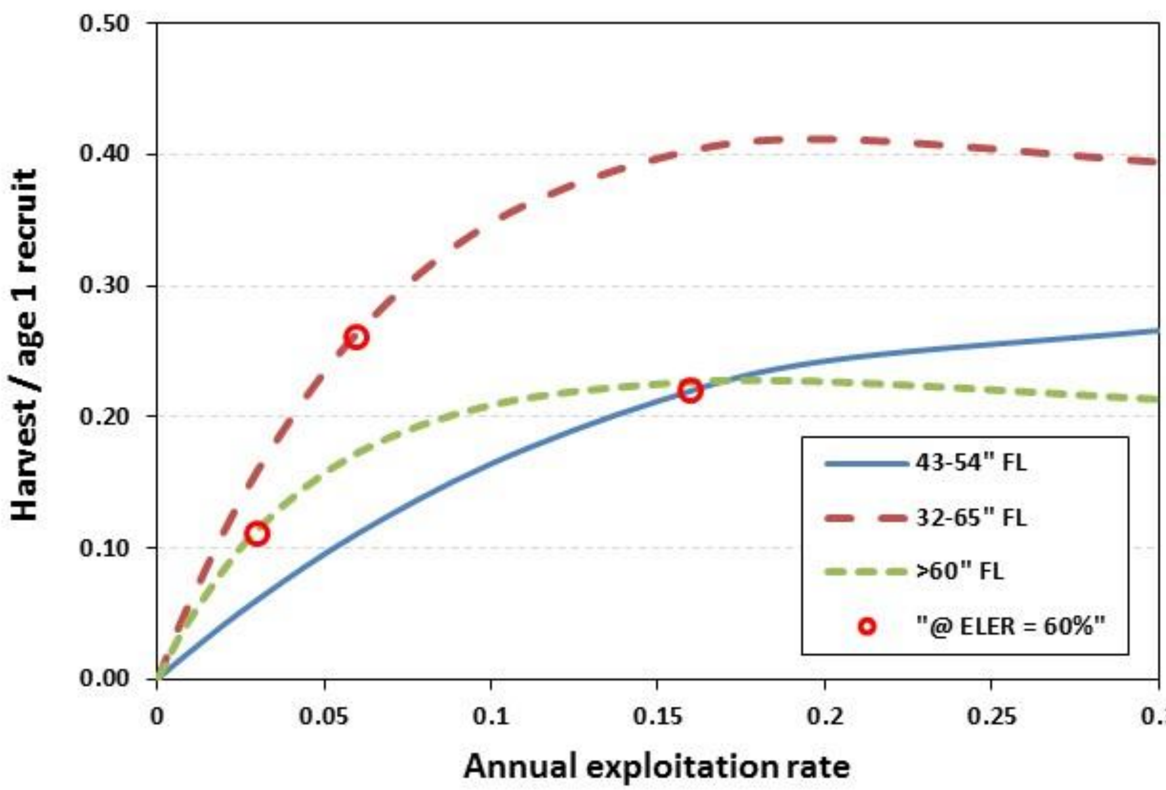

Figure 78. Effects of annual exploitation rate and fishery size regulation on catch per age one recruit. Circles show size-specific catches that occur at annual harvest rates and sizes at the B40 reference point where harvest is believed to be sustainable.

Subadult v. Adult Harvest Strategy

The subadult size slot strategy provides distinct advantages over an adult harvest fishery strategy by spreading the harvest more broadly among anglers, allowing for longer retention seasons, and reducing risk of short-term overharvest of adult spawners. The quality of this sturgeon fishery involves the opportunity to catch and retain fish throughout a broad area of the river over an extended season. Individual treaty tribal fishers fish at dedicated sites and extending sturgeon harvest opportunity throughout the available fishing area is essential for this fishery. Sport fishing opportunity involves both large fishing areas and extended fishing seasons for sturgeon retention. These considerations factor into selection of the width of the harvestable size slot. Wider slots require lower annual exploitation rates which effectively require smaller fishing areas and shorter retention seasons to achieve. Narrower slots allow for larger fishing areas and longer retention seasons by allowing greater annual exploitation rates within the harvestable size slot.

A large-fish only harvest strategy produces a much lower-quality fishery than the size slot strategy where measured in terms of numbers of fish harvested, harvest sharing among participants, and opportunity to harvest sturgeon over a broad areas and extended time period. Harvest would be distributed among few fishers in short seasons subject to abrupt closure on limited notice in a derby-style fishery which concentrates and crowds effort into areas with limited access. The fishery might even have to be regulated by limited entry or a tag draw format.

Focusing harvest on larger sturgeon increases risk of recruitment overfishing because of the compounding effect of small differences in harvest rates. Limiting harvest of adults using the slot limit is a good risk spreading strategy for a long live species like sturgeon. It ensures that harvest mortality is 0% for fish that have escaped the fishery and reached spawning age. Thus, a large pool of mature spawners is protected from fishery impacts.

The practicalities of implementing a concentrated mature-fish only sturgeon fishery in the Columbia River are very low because the fishery is widely distributed, access sites are many, and fishing occurs over an extended seasons. The two places where this strategy has been implemented with apparent success are for Paddlefish in Montana and North Dakota (Scarnecchia et al. 2007; 2008; 2011; 2014), and Lake Sturgeon in Lake Winnebago Wisconsin (Bruch 1999). These areas present special circumstances that are not available in the lower Columbia and Snake. The paddlefish fishery is a snag fishery on prespawning adults staging in dam tailraces. The Winnebago fishery is a spear fishery conducted in the shallow lake during winter through the holes in the ice.

The current fishery strategy has been in place for decades, has been effective in conserving and improving sturgeon populations and is widely understood and embraced by the fishing community which recognizes the critical importance of protecting fish that have reached spawning size. A concentrated adult target fishery is completely contrary to the long established standard, and also poses unnecessary risk to stock sustainability. The maximum size limit has also been instrumental in enforcement efforts for sturgeon protection – there is no question of illegality in cases of possession of a spawning size sturgeon. There is no interest in altering the fishery to focus on harvest of mature fish.

9.6.6 Historical Management Context

Lower Columbia River sturgeon populations and fisheries recovered very slowly following stock collapse from commercial overfishing during the late 1800s. Significant improvement did not occur until after a maximum size limit of 6 feet was adopted for commercial and sport fisheries in 1950 to protect mature adults from continuing harvest. For the next 40 years, sturgeon sport fisheries were effectively managed with a combination of size limits (36–72 in, 91–183 cm TL), daily bag limits, and annual bag limits. Commercial fisheries were regulated with size limits (48–72 in, 122–183 cm TL) and gear restrictions generally in conjunction with salmon seasons.

By the 1970s, increasing sturgeon numbers coupled with declining opportunity in Columbia River salmon fisheries, led to rapid growth in lower Columbia River sturgeon fisheries above and below Bonneville Dam. By the mid-1980s, it was clear that ever-increasing harvest levels could not be sustained. Beginning in the late 1980s, substantial changes in management were implemented in order to reduce catches to levels believed to be sustainable (ODFW & WDFW 2014). Significant changes included: 1) increasing the minimum size limit in recreational fisheries; 2) reducing the maximum size limit in all fisheries; (3) reducing daily and annual catch limits for recreational fisheries; and (4) adopting annual catch guidelines for commercial fisheries.

From 1986-1990, annual exploitation rates of sturgeon within harvestable size slot averaged 29% per year in the unimpounded lower Columbia River, peaking at 38% of 40-72 inch TL fish in 1989-1991 (DeVore et al. 1995). Model analyses by Rieman and Beamesderfer (1990) suggested that maximum yields of a generalized White Sturgeon population were produced at exploitation rates of 2-20% depending on assumptions regarding the productivity of the stock-recruitment function. A model of the unimpounded lower Columbia population developed by DeVore et al. (1995)subsequently estimated that maximum sustained yield would be produced by an 18% exploitation rate on the 36–72 in TL (82–166cm FL) size slot under an assumption of constant recruitment.[30] Fishery managers used this modeling as the basis for identifying an objective annual exploitation rate of 15% rate for the sturgeon population downstream from Bonneville Dam (Brad James, WDFW, personal communication 08/14/15).

Throughout the 1990s, fishery managers implemented a series of annual and daily bag limit, and commercial fishery restrictions in trying to achieve the 15% rate (WDFW & ODFW 1991; Tracy 1991). The size slot in Bonneville Pool and below Bonneville was reduced three times between 1989 and 1997, first to 40–72 in (102–183 cm) TL in 1989, then to 42–66 in (107–168 cm) TL in 1994, then to 42–60 in (107–152 cm) TL in 1997 as part of the effort to reduce harvest impacts. Also by 1997, the daily limit was 1 fish and the annual limit was 10 fish (down from 30 fish in the 1980's). These measures were temporarily effective but soon outstripped by continued growth

[30] *The constant recruitment assumption means that maximum yield was effectively determined based growth and survival rates as the exploitation rate of the specified harvest slot that maximized harvest in terms of weight. The rate avoided growth overfishing but included no specific elements to protect spawner abundance.*

in angler effort for sturgeon culminating with over 200,000 angler trips per year from 1997-2000 (WDFW & ODFW 2002). As a result, annual harvest guidelines were developed for lower Columbia River sturgeon fisheries beginning in 1997. Fisheries were regulated with a combination of time, area, bag and gear restrictions in order to limit harvest to these levels.

The first harvest guideline of 67,300 sturgeon in 1997 was based on estimated sturgeon abundance and a 15% annual exploitation rate on 36-72 inch TL fish (DeVore et al. 1999). However, the rate was recalculated for the 42–60 in (107–152 cm) TL size slot that was also adopted in 1997. The corresponding annual rate was 22.5%.[31] Essentially, modeling predicted the legal-size population was to increase to a 3-year average of 298,700 fish, with 22.5% equaling a 67,300 fish annual guideline. From 1998 through 2011, annual harvest guidelines were established based on stock assessments of sturgeon abundance and management measures were implemented accordingly. Guidelines were not based explicitly on a specific exploitation rate object but were regularly reduced over time from the 1997 guideline in response to a declining trend in sturgeon abundance.

In 2011, Oregon completed a new cycle of population modeling which determined that an exploitation rate of 16% would allow the population to rebuild from current low levels (ODFW 2012). This analysis was based on a stochastic population viability analysis which included assumptions for stock-recruitment relationships (proportional to adult abundance) and demographic risks of small population sizes (quasi extinction thresholds). Analyses also incorporated increased mortality associated with sea lion predation. The 2012 fishery was managed for a 16% exploitation rate but the 2013 fishery was managed for a lower rate according to direction from the Oregon and Washington Fish and Wildlife Commissions for more conservative management. In 2014, harvest of lower Columbia River sturgeon was prohibited.

An analysis of population and harvest data shows that observed annual exploitation rates often exceeded the 22.5% reference value in every year from 1997 until 2010 (Figure 79), primarily due to overly optimistic projections of recruitment to harvestable size and future sturgeon abundance. Rates also exceeded the 16% annual exploitation rate identified as optimum by ODFW (2012) and the same rate estimated by the ELER method to produce a spawning biomass equivalent to 40% of the unexploited level where lower Columbia River sturgeon growth is such that they are in the harvestable size slot for five years on average. As a result cohorts entering the harvestable size slot were typically harvested at ELER rates of 70% (Figure 79).

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[31] *Much of this is attributable to the population monitoring strategy, which has since been altered. Throughout most of this timeframe, a mark-recapture technique was used that required a recapture period of about 18-months for each annual estimate. Accordingly, population estimates were not available until at least six months after an annual fishery concluded. This placed increased reliance upon projection models.*

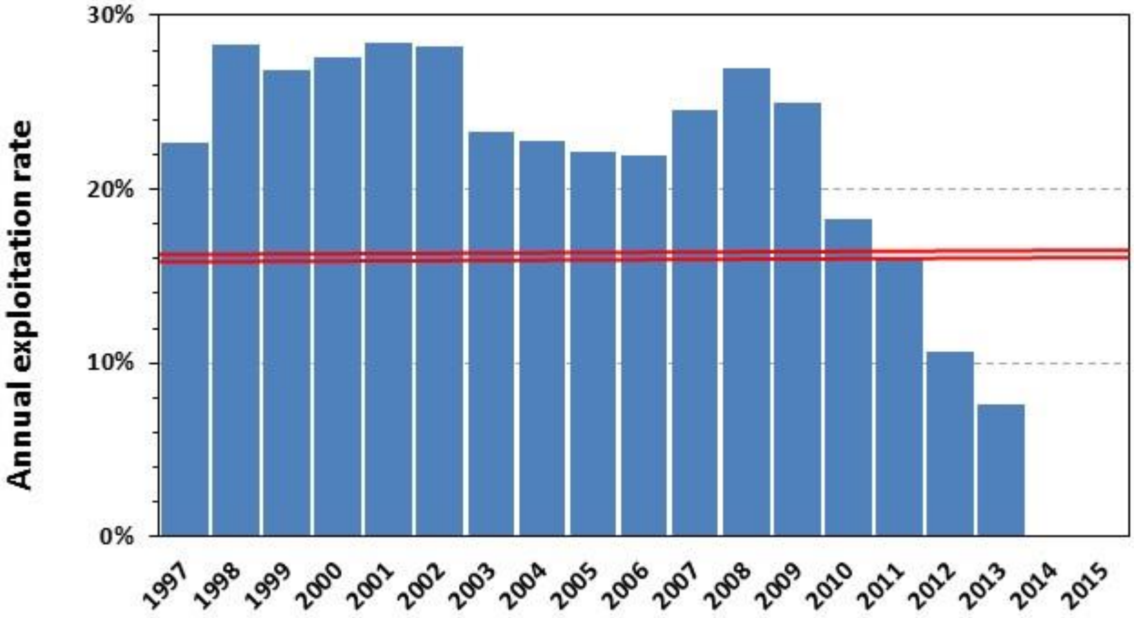

Figure 79. Annual fishery exploitation rates of White Sturgeon in harvestable size slots the 38 – 54 inch fork length harvestable size slot in lower Columbia River based on data reported in WDFW & ODFW 2014. The reference line represents the annual exploitation rate producing a spawning biomass equivalent to 40% of the unexploited level.

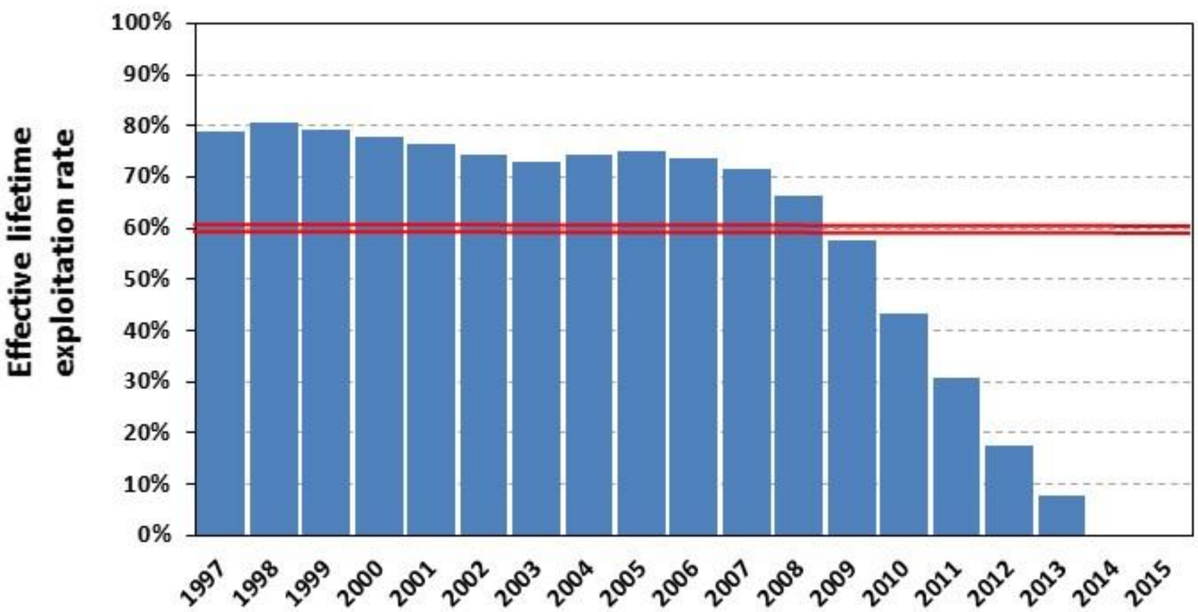

Figure 80. Effective lifetime exploitation rates of White Sturgeon cohorts recruiting to the fishery in the specified year based on annual exploitation rate and years of vulnerability in the harvestable size slot in lower Columbia River based on data reported in WDFW & ODFW 2014. The reference line represents the annual exploitation rate producing a spawning biomass equivalent to 40% of the unexploited level.

Sturgeon fisheries in lower Columbia River reservoirs have been based on pool-specific harvest guidelines since 1991 (WDFW & ODFW 2014). Guidelines were initially linked to the same 15% annual harvest rate of the 36–72 in (91–183 cm) TL identified by DeVore et al. (1995) for the unimpounded sturgeon population. Because Bonneville Reservoir is the most productive pool in terms of recruitment, it was managed for the same 15% (or size slot equivalent) identified for the population downstream from Bonneville (DeVore et al 1997). The Dalles and John Day pools were managed for a 10% (or size slot equivalent) rate because of their lower sturgeon productivity. In reality, connections between the guidelines and baseline target exploitation rates became blurred in negotiations over sport and Tribal commercial harvest guidelines. Decisions tended to be based more on updated abundance estimates and previous harvest levels. Size slot limits in the reservoirs were also reduced several times from 1988 through 1997 in an attempt to limit harvest.

Within the last few years, staff recommendations and decisions on setting Zone 6 annual harvest guidelines have refocused on sustainable exploitation rates influenced by recent ODFW population modeling. For Bonneville Pool, the rate established in 2013 was 15% of the 38–54 in (96–137 cm) FL population (SMTF 2013). For The Dalles Pool, the rate established in 2015 was 24% of the 43-54 in (109–137 cm) FL population. For John Day Pool, which is the least productive of the three pools, the rate established in 2014 was 18% of the 43–54 in (109–137 cm) FL population.

Historical annual exploitation rates of reservoir sturgeon populations varied based on management agreements but were generally greater than target levels in Bonneville and The Dalles reservoirs (Figure 81) until the last few years when exploitation rate management predominated. As a result, effective lifetime exploitation rates of 60-90% produce spawner biomass of 10-40% of unexploited values (Figure 82).

9.6.7 Hatchery Sturgeon Fishery Strategy

An essential strategy of the sturgeon hatchery program is to continue to regulate fisheries for supplemented populations to provide adequate recruitment of wild and hatchery sturgeon to broodstock sizes in order to sustain significant natural recruitment wherever possible. Exploitation rate objectives based on wild fish will be maintained in enhanced Columbia River sturgeon subpopulations. Rates will not be increased relative to current levels in reservoirs where hatchery fish are released. This is a conservative enhancement strategy intended to ensure that historical levels of wild broodstock and natural recruitment are maintained and not depleted as a consequence of hatchery enhancement.

Fishery value and quality will be substantially improved by increased numbers of fish available for harvest as a result of hatchery production. <u>Total harvest from enhanced populations will increase because total numbers of sturgeon available in the harvestable size slot will increase.</u> Total broodstock numbers are also expected to increase as hatchery-origin sturgeon escape the fishery because harvest will be limited to the same 60% ELER as wild-origin sturgeon.

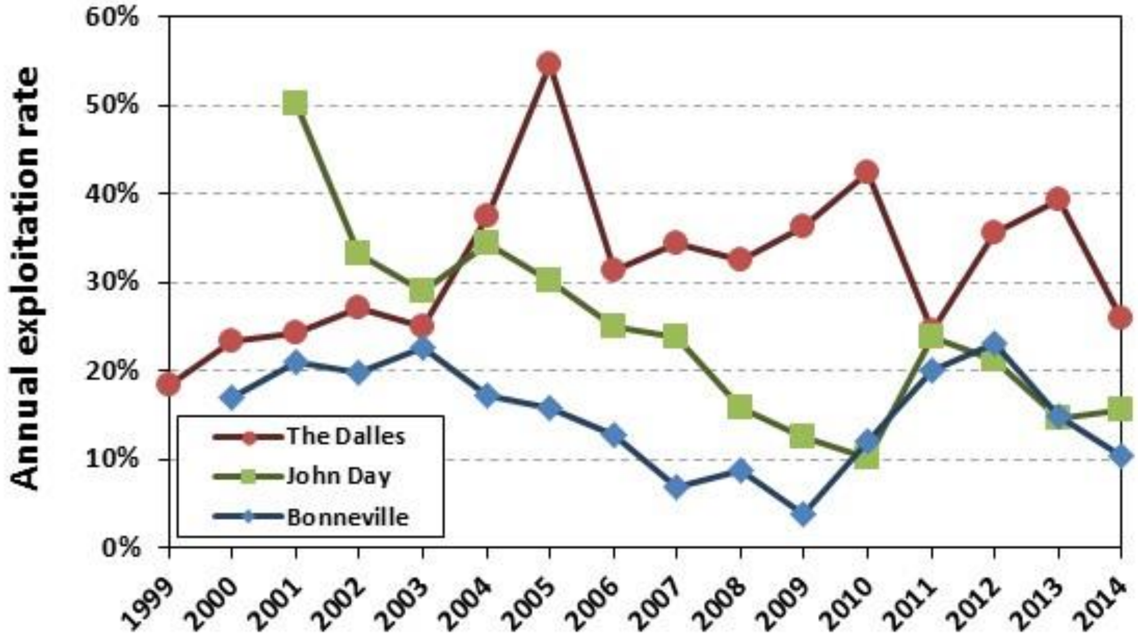

Figure 81. **Annual fishery exploitation rates of White Sturgeon in harvestable size slots in lower Columbia River reservoirs.**

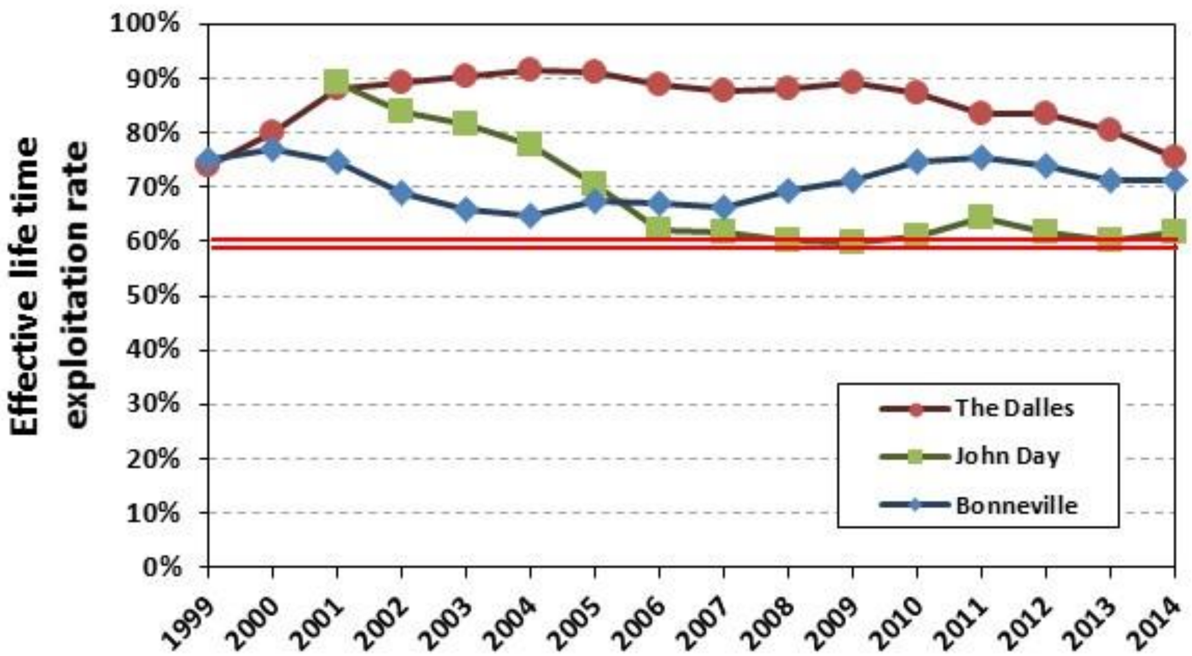

Figure 82. **Effective lifetime exploitation rates of White Sturgeon cohorts recruiting to the fishery in the specified year based on annual exploitation rate and years of vulnerability in the harvestable size slot in lower Columbia River reservoirs. The reference line represents the annual exploitation rate producing a spawning biomass equivalent to 40% of the unexploited level.**

9.6.8 Feasibility of Mark-Selective Sport Fisheries

Mark selective fisheries are commonly utilized in sport and some commercial fisheries to focus harvest on hatchery-origin fish. The primary purposes include increasing harvest rates of hatchery fish to utilize harvestable surpluses and reduce the contribution of hatchery fish to natural spawning. Mark-selective fisheries are not an option for tribal subsistence or commercial fisheries by policy for technical and cultural reasons (Nez Perce, Umatilla, Warm Springs and Yakama Tribes 2014):

> *In the case of Columbia River salmon (including steelhead), mark selective fisheries are any fisheries that allow the retention of fish with a clipped adipose fin (hatchery fish) and require the release of unclipped fish (generally wild fish). Mark selective fisheries result in differentially higher harvest impacts on clipped fish. Mark selective fisheries became a popular harvest management tool after the listing of salmon populations for protection under the Endangered Species Act and the mass fin clipping of hatchery fish. The costs of implementing and monitoring mark selective fisheries are considerable. For example, a mass-marking trailer costs around $1 million. Yet the benefits to wild populations remain unknown.*
>
> *Proponents of mark selective fisheries claim that by maintaining low harvest impacts on wild stocks and removing additional hatchery fish that may stray and spawn in the wild, conservation benefits accrue to wild populations. While mark selective fisheries may reduce harvest impacts on wild populations, the benefits to wild stocks have not actually been quantified. In fact, no agency is evaluating the assumed benefits and fisheries managers have not agreed on an evaluation framework.*
>
> *The tribes believe that implementation of mark selective fisheries has allowed non-treaty fisheries the opportunity to access a larger share of hatchery fish while maintaining the same allowable impacts on wild fish as would occur without mark selective fisheries.*

This hatchery master plan describes an integrated sturgeon hatchery program designed to minimize divergence between hatchery and wild sturgeon and to maintain significant sturgeon subpopulations free from hatchery influence. However, the states might consider implementing for mark-selective non-Indian sport fisheries for sturgeon in areas where hatchery fish are released.

Practical problems of effective marking would need to be resolved for effective implementation. Where hatchery salmon are being readily identified by removal of the adipose fin, no similar structure has been identified for sturgeon. Removal of fins or barbels is believed to result in significant mortality of sturgeon (Rien et al. 1994). Hatchery fish will be externally marked for stock assessment purposes by removal of a unique pattern of lateral scutes. Scute marking has long been practiced and is generally effective for distinguishing marked cohorts and identifying recaptures of fish that have lost external or internal tags. However, there is no way to prevent or enforce anglers from undertaking their own marking of sublegal sturgeon catch which may be significant and accrue over time.

If mark-selective sport fisheries are implemented, effects on sturgeon harvest allocation agreements between Columbia River Treaty Tribes and the states of Washington and Oregon will need to be addressed.

Currently, total harvest numbers are scaled to abundance in order to limit exploitation rates and sustain significant recruitment of sturgeon through the fishery size slot into the spawning adult population. Total harvest is apportioned between Treaty Tribal and non-Indian fisheries according to sharing agreements negotiated through *US v. Oregon*.

With implementation of mark-selective sport fisheries for sturgeon, exploitation rates on wild-spawned sturgeon might be reduced with no corresponding reduction in total harvest. Thus, recruitment rates of wild-spawned sturgeon to the adult spawner population might be increased. Alternatively, total fishery harvests of sturgeon might be increased with equivalent impacts on wild sturgeon exploitation associated with increased catch and release in sport fisheries selecting for hatchery fish. Sharing formulae for future sturgeon harvests that include hatchery-origin fish will be subject to policy-level agreements among *US v. Oregon* parties.

Table 38 illustrates harvest allocation and hatchery contribution effects of alternative fishery scenarios involving potential implementation of mark selective sport fisheries. Numbers are based on a hypothetical population that produces a sustainable harvest of 1,000 sturgeon per year prior to hatchery supplementation. Hatchery supplementation is assumed to double sturgeon abundance and calculations are based on an annual exploitation rate of sturgeon in the harvestable size slot of 17% similar to that identified for the John Day population. These numbers are for illustration purposes only and do not suppose any policy decisions which are the purview of the management agencies.

Table 38. Examples of fishery scenarios involving potential implementation of mark-selective sport fisheries for hatchery-supplemented sturgeon subpopulations in lower Columbia River impoundments.

Scenario	Harvest			Harvest shares		Wild mortality[a]		Hatchery[b]
	Total	Sport	Tribal	Sport	Tribal	Number	Rate	%
1	1,000	500	500	50%	50%	1000	0.17	0%
2	2,000	1,000	1,000	50%	50%	1000	0.17	50%
3	2,000	1,000	1,000	50%	50%	550	0.09	45%
4A	6,400	5,400	1,000	84%	16%	769	0.13	0%
4B	4,000	3,000	1,000	75%	25%	650	0.11	31%
5	3,600	1,800	1,800	50%	50%	990	0.17	39%

[a] *Includes catch and release or illegal mortality of wild fish in mark-selective sport fisheries equivalent to 5% of catch.*

[b] *At recruitment into the protected adult size range. Equivalent to pHOS at population equilibrium.*

Scenario 1 represents a baseline situation where no hatchery fish are present and harvest is equally allocated between sport and Tribal fisheries.

Scenario 2 describes a hatchery-supplemented population, no mark-selective fishery for hatchery fish, and equal harvest sharing. In this case, total harvest doubles but fishery impact rates on the wild subpopulation component remains at 17%. Because hatchery and wild fish are exploited at the same rate, the proportion of hatchery-origin spawners in adult population will be 50%.

Scenario 3 shows the effect of a mark-selective sport fishery when equal harvest shares are maintained and wild fish saved by the mark-selective fishery are passed into the spawning size classes. In this case, total harvest is the same as scenario 2 (2,000). 50:50 sharing of the harvest is maintained. The Tribal fishery harvests 500 wild and 500 hatchery fish. All 1,000 of the sport harvest is hatchery fish. Catch and release of wild fish in the sport fishery would also result in a mortality of 50 fish if the associated mortality rate was 5% of the fish caught and released. This is a harvest-neutral scenario relative to Scenario 2 but it reduces the fishery impact rate on wild fish by almost half and reduces pHOS from 50% to 45%.

Scenario 4a represents a mark-selective fishery allocation where between fisheries is based on wild fish impacts rather than total harvest. This scenario is unacceptable to the Treaty Tribes and is presented for illustration purposes only. It highlights the shortcomings of harvest allocation based in impacts rather than fish caught In this case, tribal harvest of 1,000 would produce an 8.5% exploitation rate. However, because the sport fishery takes only hatchery fish, sport harvest could theoretically harvest all the hatchery fish while still limiting total wild impacts to just 13%. Corresponding pHOS would be reduced to zero. In this scenario harvest shares become extremely unbalanced with the sport fishery taking 84% and the Tribal fishery taking only 16%. Of, course it is not practical to expect even a mark-selective sport fishery to harvest every hatchery sturgeon.

Scenario 4b is similar to 4a except it assumes that an unconstrained mark-selective sport fishery can catch half of the hatchery population. Harvest shares are again grossly unbalanced (75:25). Wild impact rates are reduced from 17-11% and pHOS from 50% to 31%.

Scenario 5 illustrates what might happen if a mark-selective sport fishery were implement and equal harvest sharing was maintained but total fishery impact rate was maintained at 17%. This is equivalent to taking the wild fish impacts saved by going mark-selective in the sport fishery and allowing them to be caught in the tribal fishery. In this case, total harvest of both fisheries increases from 2,000 in the non-selective scenario 2 to 3,600. Tribal and sport harvests increase from 1,000 each to 1,800 each. The sport harvest is comprised entirely of hatchery fish while the Tribal harvest is split between wild and hatchery fish. But because total harvest of hatchery fish is increased, pHOS can be reduced from 50% to 39%.

Previous analyses of hatchery contributions to natural populations in this plan have suggested that pHOS is much less a constraint to limiting hatchery effects for a supplemented sturgeon than is the case for salmon (see Section 5.7.3). However, this exercise shows that implementation of mark-selective sport fisheries for sturgeon in hatchery-supplemented subpopulations may be a useful tool for increasing harvest and reducing pHOS if hatchery effects are a significant concern.

10 ENVIRONMENTAL COMPLIANCE

An Environmental Impact Statement (EIS) will be completed during Step II of the Master Planning following approval of this Step I plan by the NPCC. EIS preparation will be directed by BPA. This section presents an overview of environmental compliance steps to be undertaken during Step 2 of the program. Consistency with various legal mandates is addressed.

10.1 NATIONAL ENVIRONMENTAL POLICY ACT

The EIS for the proposed hatchery program will address Federal review requirements under the National Environmental Policy Act (NEPA). This act requires federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions.

An EIS is a detailed analysis that serves to insure that the policies and goals defined in NEPA are infused into the ongoing programs and actions of the federal agency. EISs are generally prepared for projects that the proposing agency views as having significant prospective environmental impacts. The EIS should provide a discussion of significant environmental impacts and reasonable alternatives (including a No Action alternative) which would avoid or minimize adverse impacts or enhance the quality of the human environment. EPA reviews and comments on EISs prepared by other federal agencies, maintains a national filing system for all EISs, and assures that its own actions comply with NEPA. Draft and final EIS's are also subject to public comment periods.

Under some circumstances, an Environmental Assessment (EA) might be prepared to address NEPA requirements. When the significance of impacts of a project proposal are uncertain, an EA is prepared to assist in making this determination. If it is found that significant impacts will result, the preparation of an environmental impact statement (EIS) should commence immediately. If a finding of no significant impact (FONSI) is upheld in the EA review process, then no EIS may be required.

An EIS will be prepared for the proposed program in order to ensure a comprehensive assessment of the potential for impacts.

10.2 ENDANGERED SPECIES

The Endangered Species Act of 1973, as amended (Federal Register Vol. 64, No. 56, March 24, 1999) requires that federal agencies ensure that actions they authorize, fund or conduct are not likely to jeopardize the continued existence of any ESA proposed or listed species or their designated critical habitat. The only White Sturgeon listed under the ESA occurs in the Kootenai River – they were listed "endangered" on 1994 (59 Federal Register 45989). Listed salmon and steelhead and designated critical habitat occur in the project area. These include Upper Columbia River spring-run Chinook Salmon, Snake River spring/summer-run Chinook Salmon, Snake River fall-run Chinook Salmon, Upper Columbia River steelhead, Snake River Basin steelhead, Middle Columbia River steelhead, Snake River sockeye, and Bull Trout.

10.2.1 Biological Opinion

Section 7 of the Endangered Species Act (ESA) of 1973 (as amended) directs federal departments and agencies to ensure that actions authorized, funded, and/or conducted by them are not likely to jeopardize the continued existence of any federally proposed or listed species, or result in destruction or adverse modification of critical habitat for such species. Section 7(c) of the ESA requires that federal agencies contact the USFWS and/or the National Marine Fisheries Service (NMFS) (the Services) before beginning any construction activity to determine if federally listed threatened and endangered species or designated critical habitat may be present in the vicinity of a proposed project. A Biological Evaluation/Assessment (BE/BA) must be prepared if actions by a federal agency or permits issued by a federal agency will result in construction (i.e. actual action on the ground) and if the Services determine that threatened and endangered species may occur in the vicinity of a proposed project. The Services use this document as the basis of a Biological Opinion that will outline criteria to ensure the project does not further jeopardize an endangered species.

10.2.2 Recovery Plan

Recovery Plans have been completed for listed salmon, steelhead and Bull Trout.

10.3 CLEAN WATER ACT

Consistency will be demonstrated with Section 401 of the Federal Water Pollution Control Act (Clean Water Act). The authority to review the programs for consistency with Section 401 is the responsibility of the Idaho Department of Environmental Quality.

10.4 NATIONAL HISTORIC PRESERVATION ACT

Funding these projects is considered an undertaking within Section 106 of the National Historic Preservation Act of 1966, as amended (P.L.89-665, 16 U.S.C. 470). Section 106 requires that every federal agency take into account how each of its undertakings could affect historic properties. Historic properties are districts, sites, structures and traditional cultural places that are eligible for inclusion on the National Register of Historic Places. BPA will be responsible for ensuring that all necessary steps are taken to evaluate potential effects on listed properties.

10.5 STATE APPROVALS

Developing the proposed aquaculture facilities will require various regulatory approvals from State agencies. It is expected that the CRITFC and BPA would lead this effort which will be based on environmental and engineering analyzes of potential project construction and operational effects. Permitting requirements will be verified during Step 2 planning and approvals sought during Step 3.

11 COST ESTIMATES & ASSUMPTION

11.1 COST OVERVIEW

Total cost of completing hatchery planning, construction and outfitting based on conceptual plans is estimated to be $8.4 million. This amount is within the ±35 to 50% range specified for a Step I plan. Refinements to the hatchery plan and budget will be necessary during subsequent planning steps in order to reduce capital budget costs to the approximately $6 million available.

Table 39. Summary of estimated expenditures to complete hatchery planning, design, and construction.

Program Area	Budget		
	Planning	Capital	Total
Planning & Design Step II	$ 250,000	--	$250,000
Environmental Compliance Step II	$ 200,000	--	$200,000
Step III Design	--	$700,000	$700,000
Construction	--	$6,793,322	$6,793,322
Capital Equipment	--	$500,000	$500,000
Land purchases, leases, easement	--	--	$0
Total	$ 450,000	$7,993,322	$8,443,322

Annual operation and monitoring costs range from $622,000 to $1,169,000 over a ten-year period.

Table 40. Summary of annual operation and monitoring costs (in thousands of dollars).

	Year										
Item	1	2	3	4	5	6	7	8	9	10	Total
O&M	402	422	443	465	489	513	539	566	594	624	5,056
M&E	220	231	443	465	488	448	471	494	519	545	4,324
Total	**622**	**653**	**886**	**930**	**977**	**962**	**1,010**	**1,060**	**1,113**	**1,169**	**9,381**

11.2 FACILITY PLANNING & DESIGN

Facility planning and design costs occur in three steps under the NPCC hatchery planning process:

Step	Design Phase	Variance Expected
1	Conceptual	± 35 to 50%
2	Progress Review / Preliminary	± 25 to 35%
3	Detailed/Final	± 10 to 15%

Step I conceptual planning will be completed with this Master Plan.

Step 2 planning costs are estimated to be $250,000 or less. Planning costs of this step in other recent hatchery master plans ranged from $450,000 for the Shoshone-Bannock Crystal Springs Salmonid Hatchery to $1.6 million for the Kootenai Twin River Sturgeon Hatchery. However, costs identified in the feasibility study for the Spokane Tribal Sturgeon Hatchery were $160,000 – these costs are much lower because the plan involve expansion of an existing facility.

Environmental compliance costs for Step 2 of the planning process are in addition to hatchery planning and design costs. Preliminary estimated of cost is $200,000 including a contingency assumption of +20% based on an assumption that the environmental compliance process will involve an Environmental Impact Statement. Planning costs of this step in other recent hatchery master plans ranged from $400,000 for the Shoshone-Bannock Crystal Springs Salmonid Hatchery to $180,000 for the Kootenai Twin River Sturgeon Hatchery. Expected environmental compliance costs were much less for the Spokane Tribal Hatchery ($67,000 to $102,000) because the plan involved expansion of an existing facility.

Planning costs through Step 3 are estimated to be $500,000 or less including a contingency assumption of +30%. Planning costs of this step in other recent hatchery master plans ranged from $480,000 for the Shoshone-Bannock Crystal Springs Salmonid Hatchery[32] to $1.4 million for the Kootenai Twin River Sturgeon Hatchery.[33]

[32] *Crystal Spring Hatchery is currently in Step 2.*

[33] *Step 3 and hatchery construction has been completed.*

11.3 CONSTRUCTION COSTS

The preliminary estimate of construction costs for the Marion Drain Sturgeon Hatchery and the Walla Walla companion facility as described in the conceptual design is $6.793 million (Table 41, Table 42).

Table 41. Opinion of probable construction costs based on Marion Drain conceptual sturgeon facility.

Item	Cost
Mobilization	$316,868
General Conditions	$452,668
Site work	$122,850
Hatchery Building	$2,580,830
Head tank 20' x 25'	$270,000
Pollution abatement pond	$340,000
Lift Station	$30,000
Yard piping	$80,000
Outfall structure	$24,500
Instrumentation & Alarm	$130,000
Electrical	$70,000
Well	$200,000
Office	$221,500
Garage/Shop	$257,000
Wild rearing building upgrade	$100,000
Walla Walla	$300,000
Total Construction Cost	**$5,496,216**
Contingency (20%)	$1,099,243
Total with contingency	**$6,595,459**
Escalation (3%)	$197,864
Total with Escalation	**$6,793,322**

Table 42. Budget detail for preliminary estimates of Marion Drain construction costs.

ITEM	QUANTITY	UNIT[1]	COST	AMOUNT	TOTAL
MOBILIZATION (7%)	**1**	**LS**	**316,868**	**316,868**	**316,868**
GENERAL CONDITIONS (10%)	**1**	**LS**	**452,668**	**452,668**	**452,668**
SITEWORK					**122,850**
DEMOLITION (MISC)	1	LS	7,500	7,500	
EROSION CONTROL (Silt Fence)	300	LF	5	1,500	
DEWATERING	1	LS	2,000	2,000	
CLEAR & GRUB	1	AC	5,000	5,000	
EXCAVATION (MISC)	25	CY	20	500	
BACKFILL (MISC)	25	CY	20	500	
STRUCTURAL BACK FILL (MISC)	500	CY	25	12,500	
GRADING	1,600	SY	0.25	400	
SITE CLEAN-UP	1	LS	2,000	2,000	

ITEM	QUANTITY	UNIT[1]	COST	AMOUNT	TOTAL
STORMWATER	1	LS	5,000	5,000	
WATER WELL	1	LS	50,000	50,000	
GRAVEL ACCESS ROADS AND PARKING (14,400 sf)					
BASE COURSE, 6"	267	CY	75	20,025	
FINISH COURSE, 2"	91	CY	75	6,825	
BOLLARD, 8"	14	EA	650	9,100	
HATCHERY BUILDING					**2,580,830**
PRE-ENGINEERED METAL BUILDING	17,068	SF	80	1,365,440	
EXCAVATION	860	CY	20	17,200	
NATIVE BACKFILL	430	CY	20	8,600	
IMPORTED BACKFILL	170	CY	75	12,750	
CONCRETE FOUNDATIONS					
CONCRETE GRADE BEAM	36	CY	900	32,400	
CONCRETE FOOTING	40	CY	450	18,000	
CONCRETE PIERS	6	CY	1,200	7,200	
CONCRETE SLAB	316	CY	450	142,200	
EXTERIOR CONCRETE WALKS & SLABS	39	CY	450	17,550	
INTERIOR WALLS	315	LF	150	47,250	
FREEZER	1	LS	30,000	30,000	
HVAC	17,068	SF	5	85,340	
PROCESS EQUIPMENT					
BOOSTER PUMP	2	EA	10,000	20,000	
FIBERGLASS TEMPERING TANKS	2	EA	3,500	7,000	
HEAT PUMPS	2	LS	12,500	25,000	
PROCESS PIPING					
CLEANING WASTE PIPING					
CW PIPING - 10"	60	LF	70	4,200	
CW PIPING - 8"	185	LF	55	10,175	
CW PIPING - 6"	375	LF	45	16,875	
CW PIPING - 4"	125	LF	40	5,000	
4" FLOOR DRAINS	18	LF	250	4,500	
HEATED WATER PIPING					
HW PIPING - 6"	425	LF	45	19,125	
OVER FLOW PIPING					
OVER FLOW - 10"	95	LF	70	6,650	
OVER FLOW - 8"	125	LF	55	6,875	
OVER FLOW - 6"	125	LF	45	5,625	
OVER FLOW - 4"	315	LF	40	12,600	
SANITARY SEWER PIPING - 4#	140	LF	40	5,600	
SUPPLY WATER PIPING					
SW PIPING - 10"	190	LF	70	13,300	
SW PIPING - 8"	95	LF	55	5,225	
SW PIPING - 6"	440	LF	45	19,800	
SW PIPING - 4"	440	LF	40	17,600	
UTILITY WATER PIPING - 2"	690	LF	35	24,150	
TRENCH DRAINS	176	LF	100	17,600	
FIBERGLASS CIRCULAR TANKS, 20' DIA.	2	EA	32,000	64,000	
FIBERGLASS CIRCULAR TANKS, 12' DIA.	20	EA	16,000	320,000	
FIBERGLASS CIRCULAR TANKS, 6' DIA.	20	EA	3,500	70,000	

ITEM	QUANTITY	UNIT[1]	COST	AMOUNT	TOTAL
INTERIOR FINISH	1,920	SF	50	96,000	
HEAD TANK, 20' X 25'					**270,000**
STRUCTURE	500	SF	350	175,000	
EQUIPMENT	1	LS	75,000	75,000	
PIPING	1	LS	20,000	20,000	
POLLUTION ABATEMENT POND	**1**	**LS**	**340,000**	**340,000**	**340,000**
LIFT STATION	**1**	**LS**	**30,000**	**30,000**	**30,000**
YARD PIPING					**80,000**
12" OF PIPING	600	LF	80	48,000	
12" CW PIPING	400	LF	80	32,000	
OUTFALL STRUCTURE					**24,500**
DEWATERING	1	LS	2,000	2,000	
EARTHWORK	1	LS	1,000	1,000	
RIP RAP	1	LS	1,500	1,500	
STRUCTURE	1	LS	20,000	20,000	
INSTRUMENTATION & ALARM	**1**	**LS**	**130,000**	**130,000**	**130,000**
SUPPORTING FACILITIES					**878,500**
Office	1,500	SF		221,500	
Garage/Shop	4,000	SF		257,000	
Wild rearing building upgrade				100,000	
Walla Walla				300,000	
ELECTRICAL					**70,000**
SERVICE	1	LS	50,000	50,000	
YARD LIGHTING	1	EA	20,000	20,000	
WELL	1	EA	200,000	200,000	200,000
TOTAL CONSTRUCTION COST					**$5,496,216**
CONTINGENCY (20%)					**1,099,243**
TOTAL WITH CONTINGENCY					**$6,595,459**
ESCALATION (3%)					**$197,864**
TOTAL WITH ESCALATION					**$6,793,322**

Units: CY = cubic yards, EA = each, LF = linear feet, LS = lump sum, SF = square feet, SY = square yard.

General Conditions include items such as contractor bonding, insurance, and are the contract terms/rules and regulations on how to perform the work. Items within this typically include preparation of schedules, payment schedules, how to deal with disagreements, and general paperwork associated with construction submittals, etc. Includes a set of guidelines that define many of the rights, responsibilities, and limitations of authority of the owner and contractor, and include the general procedures governing the performance of the work.

Mobilization is a fund to allow the contractor to set up a field office such as renting and installing construction site trailers, temporary power, phones, bathroom facilities, pre-order materials, and set up to get the job going. Can also include "demobilization", which involves taking down everything at the end.

Table 43. Budget detail for preliminary estimates of Walla Walla construction costs.

ITEM	QUANTITY	UNIT	COST	AMOUNT	TOTAL
Total	**1**	**LS**	**300,000**	**300,000**	**$300,000**

Itemized costs to be determined

11.4 OPERATIONS AND MAINTENANCE

Operations and maintenance budgets range from $402,000 in year one to $624,000 in year ten assuming an annual inflation rate of 5%. Substantial economies of scale are achieved by siting this program at an existing sturgeon hatchery – this is particularly true for personnel costs which are shared among several programs. Note that costs for wild broodstock and larval collection are included in the monitoring and evaluation budget. Personnel time for operational monitoring in the hatchery are included in the O&M budget.

Table 44. Operation and maintenance budget projections (thousands of dollars).

	Year										
Item	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Personnel	200	210	221	232	243	255	268	281	295	310	2,516
Repairs & Maintenance	20	21	22	23	24	26	27	28	30	31	252
Equipment & supplies	20	21	22	23	24	26	27	28	30	31	252
Fish feed	40	42	44	46	49	51	54	56	59	62	503
Vehicles & fuel	10	11	11	12	12	13	13	14	15	16	126
Utilities & phone	40	42	44	46	49	51	54	56	59	62	503
Service contracts	5	5	6	6	6	6	7	7	7	8	63
Indirect (@20%)	67	70	74	78	81	86	90	94	99	104	843
Total	**402**	**422**	**443**	**465**	**489**	**513**	**539**	**566**	**594**	**624**	**5,056**

11.5 FISH COLLECTION, MONITORING & EVALUATION

Fish collection, monitoring and evaluation budgets range from $220,000 in year one to $545,000 in year ten based on phases of the monitoring plan and assuming an annual inflation rate of 5% (Table 45). This includes the costs of adult brood and larval collection (item 1 in Table 45). The hatchery monitoring effort will be closely integrated with sturgeon monitoring and evaluation activities conducted under the ongoing project #1986-50.

Table 45. Preliminary hatchery monitoring and evaluation budget projections (thousands of dollars).

Objective	Phase I					Phase II					
Year:	1	2	3	4	5	6	7	8	9	10	Total
1. Brood & larvae	170.0	178.5	187.4	196.8	206.6	153.2	160.8	168.9	177.3	186.2	1,785.6
2. Operations[a]	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]
3. Post-release[b]			200.0	210.0	220.5	231.5	243.1	255.3	268.0	281.4	1,909.8
4. Wild status[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]
5. Fishery[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]	--[c]
6. Hat. research	50.0	52.5	55.1	57.9	60.8	63.8	67.0	70.4	73.9	77.6	628.89
7. Other research	Not available										
Totals	220.0	231.0	442.6	464.7	487.9	448.5	470.9	494.5	519.2	545.1	4,324.3

[a] *Hatchery operational monitoring costs included with staff costs of operations and maintenance budget.*

[b] *Post-release monitoring of hatchery juveniles expected to be included in the next phase of the sturgeon monitoring project 1986-50 (contingent on co-manager agreement).*

[c] *Wild status and fishery monitoring addressed under separate budget by ongoing sturgeon monitoring project 1986-50.*

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13 APPENDICES

13.1 Inventory of Potential Hatchery Sites for Sturgeon Production

This report includes a preliminary survey of existing and potential hatchery facilities that might be considered for use in sturgeon production. This survey was undertaken to inform Tribal policy makers of potential options in the event that an emerging consensus of the need for sturgeon supplementation is reached by fishery co-managers.

Potential facilities were identified by canvassing tribal fish managers. The effort was generally focused on alternatives in proximity to fishery Zone 6 of the Columbia River, the Hanford Reach, and the lower Snake River. Particular effort was made to include options in the ceded areas of each of the Columbia River treaty tribes. The list may or may not be all inclusive but is the first step in developing a more through list for consideration in Step I of the formal Master Planning process mandated by the Northwest Power and Conservation Council. This exercise initially focused on existing facilities but does not preclude the development of an entirely new facility, if determined to be appropriate by the Council and fishery co-managers.

A total of eleven facilities or sites were examined for this review.[34] This report briefly summarizes the purpose, production, facilities and water resources of each facility or site. Opportunities and constraints of each are briefly identified as a first step to a more comprehensive assessment in the hatchery master planning process.

Existing hatchery facilities in the region are configured with few exceptions for the production of spring Chinook, Fall Chinook, and steelhead. The only hatchery in the region currently producing sturgeon is the Marion Drain facility developed initially by the YIN as an experimental program.

Figure 83. Locations of selected hatcheries and facilities in proximity to the lower Mid-Columbia River (Bonneville Dam to Priest Rapids Dam) and lower Snake River (Ice Harbor Dam to Lower Granite Dam) sturgeon management areas (highlighted).

[34] A McNary Dam site was added in 2013 following discussions with the CTUIR staff.

Table 46. Partial list of potential hatcheries and facilities (in alphabetical order) in proximity to the lower Mid-Columbia and lower Snake River sturgeon management areas.

Facility/Site	Drainage	Operator	Focal species			
			Fall Chinook	Spring Chinook	Summer Steelhead	Other
Bonneville	Columbia River mainstem	Oregon	--	X	X	--
Irrigon	Columbia River mainstem	Oregon	X	X	X	trout
Lewiston site	Clearwater	None	--	--	--	--
Lyons Ferry	Snake	Washington	X	X	X	trout
McNary Dam	Columbia River mainstem	None	--	--	--	--
NPT Hatchery (Cherrylane)	Clearwater	NPT	X	X	--	Lamprey
Ringold	Columbia River mainstem	Washington	X	X	X	Warmwater
SF Walla Walla	Walla Walla	CTUIR	--	X	--	Lamprey
Umatilla	Columbia River mainstem	Oregon	X	X	X	--
Warm Springs NFH	Deschutes	U.S. Fish and Wildlife & CTWSR	--	X	--	--
Water Resources Center	Walla Walla	Community College & CTUIR	--	--	--	--
Yakama Sturgeon Hatchery	Yakama - Marion Drain	YIN	--	--	--	Sturgeon

13.1.1 Irrigon Hatchery

Location

Irrigon Hatchery is located along the Columbia River above John Day Dam 3 miles west of Irrigon and 279.4 miles upstream from the mouth of the Columbia River (ODFW 2011a; USFWS 2011a). The area of the site is 33 acres, owned by the USFWS.

Operators

Oregon Department of Fish and Wildlife

Purpose

Irrigon Hatchery began operation in 1984 as part of the Lower Snake River Compensation Program (LSRCP)—a program to mitigate for spring Chinook and summer steelhead losses caused by the four federal dams constructed on the lower Snake River (ODFW 2011a; USFWS 2011a). This facility serves as an egg incubation and rearing facility for summer steelhead destined for the Grande Ronde and Imnaha river systems. Fall Chinook are also reared from eyed eggs to subyearling size from fish spawned at Lyons Ferry. In addition, Irrigon is also used as a rearing site for legal-sized rainbow trout destined for northeast Oregon waters.

Figure 84. Irrigon Hatchery operated by the Oregon Department of Fish and Wildlife on the Columbia River.

Production

Summer steelhead: 1.015 million smolts from 1.4 million eyed eggs hatched and reared to age 1 for transfer to Imnaha and Wallowa acclimation sites.

Fall Chinook: 1.2 million subyearlings reared from eyed eggs transferred from Lyons Ferry and subsequently released in the Grande Ronde and Snake rivers.

Spring Chinook: Up to 250,000 fry from Lookingglass Hatchery and reared from April through September for transfer back to Lookingglass for spring release.

Trout: various sizes for release in various water bodies throughout northeast Oregon.

Facilities

Production facilities include 68 6 ft. circular tanks, 32 100 ft by 20 foot raceways, and 288 vertical incubator units (24 stacks of 12 trays). There are no satellite facilities associated with this hatchery.

Water

The hatchery water supply is provided from two wells that can deliver a total of approximately 21,000 gal/min. Water rights and design capacity is about 25,000 gal/min. The 21,000 gal/min is available year round with actual low water use occurring in June when only 9,600 gal/min is needed. Water flows from an upper series of raceways and is re-used in the lower series prior to discharge.

Opportunities

- The potential availability of space, staff, and support facilities provide a much more cost-effective option than developing a stand-alone sturgeon facility.
- The site is in close proximity to potential sturgeon capture and release sites.

Constraints

- This facility is currently operating at capacity and is limited by water supply.
- Well water might provide an opportunity to sustain growth over the winter period but would need to be passively or actively heated during a portion of the year to support significant sturgeon production.

13.1.2 Lewiston site

Location

Undeveloped site in Lewiston, Idaho next to the Snake River levy.

Operators

No existing hatchery

Purpose

Location was previously the site of a vegetable processing facility which used a large volume of water from an on-site well. The water source is the reason for consideration of a site like this.

Production

None

Facilities

Existing well and pump housed in a small building.

Figure 85. Location of potential hatchery site in Lewiston, Idaho.

Water

High volume, high quality well water.

Opportunities

- High volume existing well water source of good quality and temperatures suitable for year-round sturgeon rearing.
- Potential joint development plans by the city provide excellent opportunity for information and educational outreach.

Constraints

- Would involve development of a facility from the ground up. This would provide the flexibility to tailor facilities to the specific needs of a sturgeon program but construction and operation would involve dedication of significant resources, potentially more than the capital amount available for the project.
- Significant travel distance to adult collection and juvenile release sites in the lower Snake and lower mid-Columbia.

Figure 86. Potential "pea plant" hatchery site in Lewiston, Idaho.

13.1.3 Lyons Ferry Hatchery

Location

Lyons Ferry FH is located at RM 59 of the Snake River adjacent to the reservoir pool behind Lower Monumental Dam (USFWS 2011b; WDFW 2010).

Operators

Washington Department of Fish and Wildlife

Purpose

The hatchery was constructed under the LSRCP Program to offset fish losses caused by the construction and operation of four hydropower dams on the lower Snake River (USFWS 2011). The hatchery was completed and became operational in 1984.

Production

The hatchery rears Snake River fall Chinook, Tucannon River spring Chinook (in collaboration with Tucannon FH), four stocks of steelhead, and two stocks of rainbow trout.

Figure 87. Lyons Ferry Hatchery operated by the Washington Department of Fish and Wildlife on the Snake River.

Fall Chinook: Approximately 420,000 eyed eggs are transferred to the Irrigon FH (Oregon Department of Fish and Wildlife) for hatching, rearing, and release of subyearling smolts into the lower Grande Ronde River. Approximately 3.0 M eyed eggs are retained on station for hatching and rearing. These fish are released at Lyons Ferry FH (200,000 subyearlings + 450,000 yearlings), Captain Johns AF (500,000 subyearlings + 150,000 yearlings + direct release of 200,000 subyearlings), Big Canyon AF (500,000 subyearlings + 150,000 yearlings), and Pittsburg Landing (400,000 subyearlings + 150,000 yearlings). Approximately 200,000 and 400,000 eyed eggs are transferred to the Oxbow FH (Idaho Department of Fish and Game) and Umatilla FH (Oregon Department of Fish and Wildlife), respectively, for hatching, rearing, and release of subyearling smolts into the Hells Canyon reach of the Snake River. Summer Steelhead: The program releases 60,000 yearling smolts on-station at Lyons Ferry FH, 100,000 yearling smolts into the Tucannon River (direct release), 85,000 yearling smolts into the Touchet River (acclimated release from the Dayton Pond AF), and 100,000 yearling smolts into the Walla Walla River (direct release). The total release objective of the program is 345,000 smolts.

Facilities

Rearing facilities include 233 raceways, 4 adult ponds and one small lake. Four satellite acclimation facilities are associated with the hatchery: Captain Johns Acclimation Facility (AF) at RM 164 of the Snake River between Asotin, Washington and the mouth of the Grand Ronde River (fall Chinook release site); Pittsburg Landing AF at RM 215 of the Snake River, approximately 31 miles downstream from Hells Canyon Dam (fall Chinook release site); Big Canyon AF at RM 35 of the Clearwater River (fall Chinook release site); Cottonwood Creek AF at RM 29 of the Grande Ronde River at Cottonwood Creek (steelhead release and adult broodstock collection site); and Dayton Pond AF at RM 53 of the Touchet River within the Walla Walla River watershed (steelhead release and adult broodstock collection site).

Water

The principle water source for rearing fish at Lyons Ferry FH is well water which is pumped from an underground aquifer. Water is supplied to LFH from the Marmes pump station, which has emergency power backup generation. The Marmes pump (wells) facility has three 300 horsepower (HP) pumps, four 200 HP 5 pumps and one 75 HP pump. The well water right for LFH is 53,200 gallons per minute (gal/min), or 118.5 cubic feet per second (cfs) of flow, and water temperature is a constant 52°F.

Opportunities

- The potential availability of space, staff, and support facilities provide a much more cost-effective option than developing a stand-alone sturgeon facility.
- The site is in close proximity to potential sturgeon capture and release sites.

Constraints

- This facility is currently operating at capacity and is limited by water supply.
- Well water might provide an opportunity to sustain growth over the winter period.

13.1.4 Nez Perce Tribal Hatchery Complex

Location

The Cherrylane hatchery site is on a flat bench on the south bank of the Clearwater River about 32 km (20 miles) east of Lewiston and adjacent to Highway 12.

Operators

Nez Perce Tribe

Purpose

NPTHC is a supplementation program that produces and releases spring, fall, and early-fall stocks of Chinook salmon to help restore self-sustaining and naturally-reproducing populations in the Clearwater River basin. The hatchery will help preserve the genetic integrity of these fish populations and, in the long term, establish harvest opportunities for tribal and non-tribal anglers.

Production

The hatchery is designed to accommodate the incubation and rearing of 1.4 million fall Chinook and 625,000 Spring Chinook salmon. Another 200,000 spring Chinook smolts are produced for acclimation. Releases are made on-site and at acclimation sites located throughout the Clearwater Basin.

The facility also holds adult Pacific Lamprey that are collected and transported from fish ladders at John Day and The Dalles Dams until release during the following spring to spawn naturally.

Figure 88. Nez Perce Tribal Hatchery on Idaho's Clearwater River.

Facilities

Facilities include the central hatchery at Cherry Lane and a number of satellite or acclimation sites throughout the Clearwater basin. The main facility includes a hatchery building, water treatment facilities, rearing containers, effluent ponds, an operations and shop building, and staff residences would be built on the site. The hatchery building accommodates the spawning shelter, incubation room and early rearing area. The spawning shelter is roofed, with open sides and has receiving, fertilization and disinfection equipment. The operations and shop building includes an office, day room, washrooms, feed storage, chemical storage, laboratory, vehicle and tool storage, and shop work areas. Resident personnel would provide around-the-clock security to the hatchery grounds.

Rearing containers, raceways, and ponds are used to rear spring and fall Chinook. Natures-type raceways were built for rearing fall Chinook but lined earthen ponds have proven to be a more effective alternative for this purpose. Temporary facilities will be adapted for lamprey holding in the future.

The facility includes extensive state-of-the-art computerized monitoring and control systems.

Water

The facility utilizes both well and surface water. Current capacities are approximately 500 gal/min (well) and 3,000 gal/min (surface). Well water temperatures range from the high 50s to low 60s. Surface water temperatures vary seasonally from near 32 to the upper 60s. Current production utilizes all available water.

Opportunities

- The potential availability of space, staff, and support facilities provide a much more cost-effective option than developing a stand-alone sturgeon facility.
- Tribal operation and tribal authority.

Constraints

- This facility is currently operating at capacity and is limited by water supply.
- Surface water temperatures are typically colder than ideal for sturgeon rearing although well water might provide an opportunity to sustain growth over the winter period.
- Travel distance to adult collection and juvenile release sites in the lower Snake and lower mid-Columbia is significant.

13.1.5 Ringold Springs Hatchery

Location

The hatchery is located on the Hanford Reach 17 miles west of Mesa, WA at approximately Columbia River Mile 352 (WDFW 2008).

Operators

Washington Department of Fish and Wildlife

Purpose

The facility began operation in 1962 as part of the Columbia River Fisheries Development Program, a program to mitigate for fishery losses due to hydroelectric development in the Columbia River basin. Ringold hatchery is operated as part of the WDFW's Priest Rapids Hatchery Complex, which also includes the Meseberg, Naches and Columbia Basin hatcheries. Priest Rapids Hatchery was designed as a mitigation facility for Fall Chinook after Priest Rapids and Wanapum Dams were constructed, and is funded by the Grant County Public Utility District and by Army Corp of Engineers for the John Day portion of the fish.

Production

Fall Chinook: Fish are transferred from Bonneville Hatchery and acclimated for 30 to 45 days prior to release from Ringold Springs (approximately 3 million sub-yearlings per year. Plans are currently underway for a substantial expansion.

Summer Steelhead: Currently, a maximum of 180,000 (average 171,000) 4-5 fish/lb yearling smolts are released annually after ~6 months of acclimation in a 5-acre pond fed with water from Ringold Spring.

Figure 89. Ringold Hatchery operated by the Washington Department of Fish and Wildlife near the Columbia River north of Richland WA.

Figure 90. Outdoor circular tanks at Ringold Hatchery.

Spring Chinook: This program currently releases up to 500,000 yearling spring Chinook salmon smolts, funded by the CTUIR as a way to reestablish a source of adults for harvest and reintroduction strategies. Spring Chinook production has been started and stopped several times over the years based on availability of funds. No adult spawning or incubation is currently possible at this facility, due to high water temperatures, making it dependent on other hatcheries for egg take and early rearing (currently Little White salmon NFH).

Others: This facility is also utilized to produce warmwater and cool water gamefish.

Facilities

The hatchery is site is approximately 500 acres and includes a wide variety of tanks, raceways, and ponds. The spring Chinook facilities include a 9-acre earthen rearing pond and 14 vinyl raceways. Summer steelhead rearing facilities consist of a 4.8-acre earthen pond.

Water

The facility water supply consists of a gravity-flow, spring supply of approximately 27,000 gal/min. Limited amounts of surface water are also available from the Columbia River with a water right application pending.

Opportunities

- The potential availability of space, staff, and support facilities provide a much more cost-effective option than developing a stand-alone sturgeon facility.
- The site is in close proximity to potential sturgeon capture and release sites.
- This facility has unused space and water including well and surface water suitable for sturgeon rearing.
- Recent communication from the COE regarding the expansion of Ringold for fall Chinook rearing might also provide some unique cost saving/cost sharing if the proposed sturgeon facility were located here.

Constraints

- Additional facilities would be required for sturgeon production.

13.1.6 McNary Dam site

Location

Undeveloped site adjacent to McNary Dam.

Operators

No existing hatchery. Dam is operated by the U.S. Army Corps of Engineers.

Purpose

This site presents the opportunity to utilize Columbia River water which would allow the hatchery to hold adults and rear juveniles under ambient conditions. The CTUIR is contemplating the development of a multi-species aquaculture facility which might also include lamprey and mussels.

Production

None. The site was used for temporary sturgeon spawning and rearing facilities during the 1990s as part of CRITFC's exploratory sturgeon aquaculture efforts.

Facilities

Extensive infrastructure is available at the site, including water withdrawals used for operation of the fish collection systems.

Figure 91. Location of potential hatchery site at McNary Dam, Oregon.

Water

High volume surface water from river withdrawal.

Opportunities

- Close proximity to abundant sources of power and river water.
- Use of river water would allow adult holding and juvenile rearing under ambient conditions.
- Undeveloped space exists on existing USACE property.
- Site is in close proximity to planned sturgeon collection and release areas.

Constraints

- Would involve development of a facility from the ground up. This would provide the flexibility to tailor facilities to the specific needs of a sturgeon program but construction and operation would involve dedication of significant resources, potentially more than the capital amount available for the project.
- Lack of existing hatchery infrastructure and staff would require dedicated resources (in contrast to developing sturgeon production capabilities at an existing hatchery where infrastructure and staff can be shared).
- Availability of site and interest by the USACE has not been determined.

13.1.7 Umatilla Hatchery

Location

Umatilla Hatchery is located adjacent to the Columbia River, 3.5 miles west of Irrigon, Oregon (ODFW 2011a, 2011c). The site area is 23 acres, owned by the US Army Corps of Engineers. Satellite facilities include Three-Mile Dam facility on the Umatilla River for adult broodstock trapping and holding, Minthorn and South Fork Walla Walla for adult holding, and Pendleton, Minthorn, Thornhollow, and Imeques facilities for juvenile acclimation. Operation began in 1991.

Operators

Oregon Department of Fish and Wildlife (central facility) and the Umatilla Tribe (satellite facilities).

Purpose

The Umatilla Hatchery was authorized under the Northwest Power Planning Council's (NPPC) Fish and Wildlife Program. The NPPC authorized hatchery construction to produce up to 290,000 pounds of salmon and steelhead for release in the Umatilla River. Hatchery funding is provided by the Bonneville Power Administration.

Figure 92. Umatilla Hatchery operated by the Oregon Department of Fish and Wildlife on the Columbia River near Irrigon.

Production

Fall Chinook: 600,000 subyearlings for Umatilla River release.

Spring Chinook: 810,000 smolts for acclimated release into the Umatilla River.

Summer steelhead: 150,000 smolts for acclimated release into the Umatilla River.

Facilities

Production facilities include 10 91 ft by 19 ft Oregon ponds, 24 91 ft by 9 ft Michigan ponds, 8 Canadian troughs, and 552 vertical incubator units.

Water

Water is supplied to the hatchery from four remote wells and one Rainey well capable of pumping 5,500 gal/min.

Opportunities

- The potential availability of space, staff, and support facilities provide a much more cost-effective option than developing a stand-alone sturgeon facility.
- The site is in close proximity to potential sturgeon capture and release sites.
- Well water might provide an opportunity to sustain growth over the winter period.

Constraints

- This facility is currently operating at capacity and is limited by water supply.
- Well water source would require passive or active heating to provide suitable sturgeon rearing temperatures during a portion of the year.

Figure 93. Hatchery rearing ponds.

13.1.8 Walla Walla Community College Water and Environment Center

Location

On campus at the Walla Walla Community College

Operators

The Center, operated by the college, provides offices for CTUIR monitoring and evaluation projects as well as Habitat Program staff.

Purpose

The William A. Grant Water & Environmental Center (WEC) opened in 2007 to foster conservation, management, and enhancement of the Walla Walla Watershed.

Production

None

Facilities

The center was expanded in 2011 to include an aquatic research and propagation laboratory, specimen/biology laboratory, water quality laboratory, hydrology laboratory, classrooms and office space.

Water

Well, surface and city water are available.

Opportunities

- The facility provides an excellent opportunity for educational outreach regarding sturgeon restoration efforts, training in sturgeon culture, and sturgeon culture research.
- Facilities are best suited to egg incubation and limited juvenile rearing.

Constraints

- Space and facilities are not likely to be sufficient to support a comprehensive sturgeon production program (particularly the adult holding and spawning).
- Travel distance to adult collection and juvenile release sites in the lower Snake and lower mid-Columbia is significant.

Figure 94. Walla Walla Community College Water and Environment Center.

13.1.9 Walla Walla South Fork Hatchery

Location

The hatchery is located east of Milton-Freewater, Oregon, at approximately RM 5.2 South Fork Walla Walla River (CTUIR 2008, 2013).

Operators

Confederated Tribes of the Umatilla Indian Reservation

Purpose

This hatchery was developed to facilitate reintroduction of spring Chinook Salmon into the Walla Walla River. This facility is part of the Northeast Oregon Hatchery Program (NEOH) under the Northwest Power and Conservation Council Fish and Wildlife Program. The facility was authorized as a Umatilla Hatchery satellite facility under the NPPC Fish and Wildlife Program and began operation in 1997. It currently serves as the adult holding and spawning site for the spring Chinook component of the Umatilla Hatchery Program as well as the holding facility for the Walla Walla spring Chinook adult outplanting program. A Master Planning process is underway to upgrade the facility to provide year-round rearing for spring Chinook salmon smolts.

Production

Spring Chinook: planned annual production of 500,000 yearling for release into the South Fork Walla Walla River.

Figure 95. South Fork Walla Walla Hatchery facility operated by the CTUIR.

Facilities

The facility includes a water intake system with automatic screen cleaning, pump station having a pumping capacity of 8,700 gal/min, ozone water treatment system, settling pond, five adult holding ponds (each 90 by 10 by 6 foot effective water depth), mechanical fish crowder, standby generator, chemical storage and spawning buildings and two homes for night-watch personnel. The spawning building includes a fish lift, electroshock anesthesia system, sorting and spawning facilities, wet and dry storage rooms, walk-in cooler/freezer, restroom, and office space. Currently, no incubation, rearing, or release facilities are available for the Walla Walla spring Chinook hatchery program although current plans call for expansion of the facility to provide these functions.

Water

Water is provided from the South Fork Walla Walla River. Temperature varies seasonally from near 32°F to approximately 65°F. Two groundwater aquifers underlie the South Fork facility. The site currently has a shallow well that draws water from a depth of approximately 180 feet. Water supply is well water of 57–61°F (14–16°C) with the capability to mix warmer surface water during summer months.

Opportunities

- Space and water are potentially available.
- Tribal operations and authority.

Constraints

- This is a seasonally-operated facility with limited availability of staff and support.
- Surface water temperatures are typically much colder than ideal for sturgeon rearing although well water might provide an opportunity to sustain growth over the winter period.
- Travel distance to adult collection and juvenile release sites in the lower Snake and lower mid-Columbia is significant.

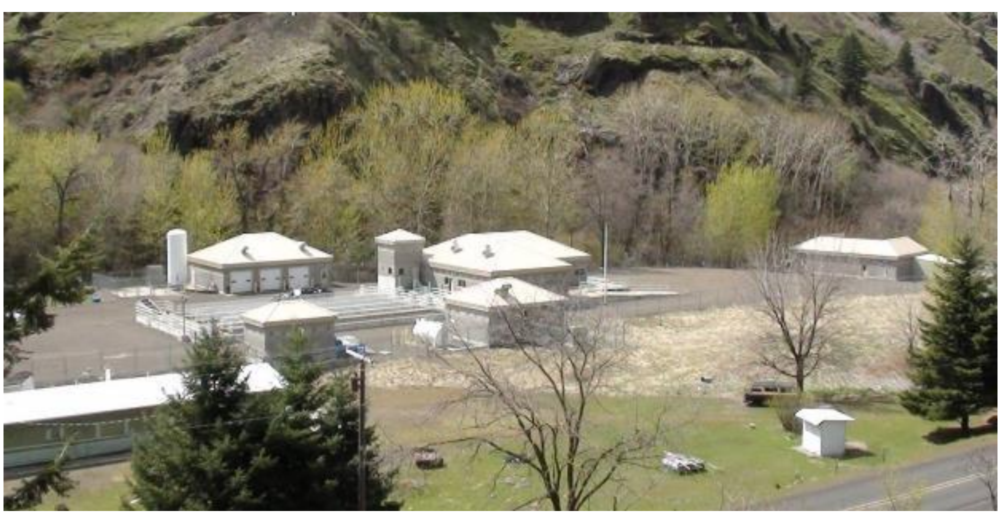

Figure 96. South Fork Walla Walla Hatchery facility.

13.1.10 Warm Springs National Fish Hatchery

Location

Warm Springs National Fish Hatchery is located at RM 10 of the Warm Springs River, on reservation lands leased from the CTWSR (USFWS 2007). The Warm Springs River enters the Deschutes River at RM 84, which in turn enters the Columbia River at RM 204.

Operators

The hatchery is managed by the U.S. Fish & Wildlife Service in cooperation with the Confederated Tribes. The Confederated Tribes have sole management responsibility for fishery resources on the Reservation.

Purpose

Established in 1966, the hatchery began operation in 1978 to provide harvest opportunities for hatchery spring Chinook salmon while protecting wild fish populations in the subbasin.

Production

The annual production goal for spring Chinook is up to 750,000 marked smolts. Annual releases are typically less.

Figure 97. Warm Springs National Fish Hatchery operated by the U. S. Fish and Wildlife Service.

Facilities

All fish passing upstream are blocked by a barrier dam and are directed to a fish ladder at Warm Springs NFH. Fish that are not passed upstream are directed into a catch pond (28ft x 8ft, with a water depth of 3ft). Two oval shaped ponds, each 50ft x 26ft with approximately a 6ft water depth are used to hold broodstock until spawning. Incubation facilities consist of 16 stacks of 15 Heath incubator trays. Rearing facilities at Warm Springs NFH consist of 20 rectangular Burrows ponds measuring 75ft x 16ft with a water depth of 1.7ft, and 20 modified rectangular Burrows ponds measuring 75ft x 8ft with a water depth of 1.7ft.

Water

The water source for the hatchery is the Warm Springs River with temperatures ranging seasonally from 32 to 72°F. Water is heated and chilled at different times of the year to provide suitable temperatures for spring Chinook production. The intake structure and pumps are located at the hatchery site just upstream of the barrier dam.

Opportunities

- The potential availability of space, staff, and support facilities provide a much more cost-effective option than developing a stand-alone sturgeon facility.
- Effective history of cooperation with the CTWSR.

Constraints

- This facility is currently operating at capacity.
- Surface water temperatures are not ideal for year-round sturgeon production and would typically require costly heating during a portion of the year.
- Remote location increases costs and difficulties of operation.

Figure 98. Warm Springs National Fish Hatchery facility.

13.1.11 Yakama Sturgeon Hatchery - Marion Drain

Location

The facility is located on approximately 15 acres In the Yakima River basin adjacent to Marian Drain near Toppenish Washington.

Operators

Yakama Indian Nation

Purpose

The long-term goal of the Yakama Sturgeon Management Project described in this narrative is to facilitate restoration of viable populations and fisheries for White Sturgeon in mid-Columbia River reservoirs. Initial goals involve development of critical expertise and refinement of sturgeon culture methodology. The program is also producing juvenile sturgeon for release into mid-Columbia River reservoirs as hydro mitigation according to FERC license agreements with the Public Utility Districts. Long term plans call for the exploration of commercial production for human consumption.

Production

Current capacity is approximately 20,000 yearlings per year in addition to fish held for longer periods for commercial production.

Figure 99. The temporary juvenile rearing facility at the Yakama Sturgeon Hatchery.

Facilities

Facilities include a covered incubation shed, approximately 20 circular tanks ranging in size from 6' to 15' in diameter, and one small lined pond. Office and storage space is available on site. The current power supply is 600 amp of which approximately 25% is currently in use. Backup power is provided by a 600kw generator.

Water

Water primarily comes from two wells. The first well drilled to 320 ft produces approximately 500 gal/min at a temperature of 60°F. The second well drilled to 185 ft produces approximately 600 gal/min at a temperature of 56°F. A third 185 ft well is planned and expected to produce an additional 600 gal/min. Surface water is also available from Marion Drain adjacent to the hatchery site at temperatures ranging from the high 30's in winter to the low 70's F in summer. Two heat pumps will provide the capacity of a 60 gal/min output with a 12°F change from ambient water temperature (e.g., 60°F increased to 72°F or decreased to 48°F).

Opportunities

- This is the only operational sturgeon facility in the mid-Columbia region.
- Staff has demonstrated expertise in sturgeon culture and propagation.
- The potential availability of space, staff, and support facilities provide a much more cost-effective option than developing a new facility from scratch.
- Significant space is available for expansion.

Constraints

- This is an experimental/developmental facility. Significant upgrades will be required to provide a facility suitable for long term production.
- Water resources at the site may be limited and subject to future higher priority uses for tribal salmon restoration hatchery programs. Lack of suitable surface water is also a concern.
- Travel distance to some potential broodstock collection and release sites is moderate.

13.2 HATCHERY GENETIC MANAGEMENT PLAN

As per ISRP (1999). The purpose of this hatchery and genetic management plan (HGMP) template is to provide a single source of hatchery information for comprehensive planning by federal, state, and tribal managers, and for permitting needs under the Endangered Species Act (ESA).

13.2.1 SECTION 1. GENERAL PROGRAM DESCRIPTION

1.1) Name of Program

Columbia River Inter-Tribal Fish Commission White Sturgeon Hatchery Program

1.2) Population (or stock) and species

White Sturgeon *Acipenser transmontanus*

1.3) Responsible organization and individual:

Name (and title):	Blaine Parker, Sturgeon Program Lead
Organization:	Columbia River Inter-Tribal Fish Commission
Address:	700 NE Multnomah St., Suite 1200, Portland OR 97232
Telephone:	(503) 238-0667
Email:	parb@critfc.org

Other organizations involved, and extent of involvement in the program:

1.4) Location(s) of hatchery and associated facilities:

The primary facility is planned for construction at the Yakama Nation Sturgeon Hatchery at Marion Drain, Washington (Yakima River Subbasin, WRIA 37). A companion facility for rearing juvenile fish transferred from the Marion Drain Facility after incubation and hatching will be located at the Walla Walla South Fork Salmon Hatchery. Complementary research operations may be developed at the Walla Walla Community College Water and Environment Center (WEC).

1.5) Type of program:

Integrated Harvest.

1.6) Purpose (Goal) of program:

The goal of this program is to utilize hatchery production to help mitigate impacts of development and operation of the Federal Columbia River Power System on sturgeon population productivity and fishery opportunities in lower mid-Columbia River and lower Snake River reservoirs.

1.7) Specific performance objective(s) of program

1. Release hatchery-reared sturgeon in impounded reaches of the lower Columbia and Snake rivers where natural production is not adequate to utilize the existing habitat capacity, with a primary focus on John Day Reservoir.
2. Scale and adjust release numbers to optimize sturgeon production and fishery benefits in target areas while avoiding significant, density-related, intra-specific impacts or inter-specific ecological risk.

3. Hatchery releases will occur annually and all hatchery releases will be tagged to facilitate evaluations of hatchery effectiveness.
4. Use a combination of conventional wild broodstock and wild larvae collection for initial production and refine approach based on relative effectiveness and efficiency in achieving program goals.
5. Use sturgeon originating from the mid-Columbia Genetic Management Unit for hatchery production with a preference for sources with a lower probability of successful natural reproduction.
6. Utilize only wild-origin sturgeon for hatchery broodstock
7. Employ best management practices to integrate hatchery sturgeon with the natural genetic and life history diversity of wild-spawning sturgeon.
8. Design hatchery facilities and employ practices to minimize disease risks which might impair hatchery effectiveness or health of wild sturgeon.
9. Hatchery sturgeon will be produced at one primary facility and possibly one or more companion facilities.
10. Hatchery supplementation will be conducted in an experimental framework that includes a strong monitoring and evaluation program, established benchmarks for the evaluation of benefits and risks, and a clear decision structure for future adaptive management.
11. Fisheries for supplemented populations will continue to be regulated to provide adequate recruitment of sturgeon to broodstock sizes in order to sustain significant natural recruitment wherever possible.
12. Implement the sturgeon hatchery mitigation program in conjunction with continuing efforts to protect and restore habitat and environmental conditions suitable for natural recruitment.

The following production targets (Table 47) are identified for this program based on the hatchery objectives described above.

Table 47. White Sturgeon Hatchery Program production targets.

	Conventional	Wild larvae
Annual releases	Columbia: ≤5,000 (Fall @ age 0+), ≤20,000 (Spring @ age 1), ≤1,500 (Summer @ age 1+) Snake: ≤5,000 (Spring @ age 1)	
Size at release	15-20 g (age 0+), 100-150 g (age 1), 250-300 g (age 1+)	
Broodstock	20 per year	--
Families	50 total (2 x 5♂x5♀) 10 maternal / year	(many)
Eggs	≤1,000,000	--
Fry	≤150,000	≤20,000
Fish / ♀ family	Columbia: ≤2,650 Snake: 500	(few)

This production is projected to increase total abundance of sturgeon (all sizes) in Zone 6 (Bonneville to McNary dams) by 30,000 to 100,000 depending on post-release survival of hatchery-origin sturgeon. Hatchery-origin sturgeon might ultimately comprise 7-26 percent of the Zone 6 sturgeon population depending on actual survival rates, if current wild numbers remain stable. Projected sturgeon standing crop (lb/acre) in John Day Reservoir would approach that of current populations in Bonneville and The Dalles reservoirs. Hatchery sturgeon are projected to increase annual harvest in John Day Reservoir by about 40-140 percent.

Production is projected to increase total abundance of sturgeon (all sizes) in the three lower Snake Reservoirs by 6,000 to 19,000 depending on post-release survival of hatchery-origin sturgeon. Hatchery-origin sturgeon might ultimately comprise 26-55 percent of the lower Snake sturgeon population depending on actual survival rates, if current wild numbers remain stable. Hatchery sturgeon are projected to provide the opportunity to harvest 100-340, 43-54 inch sturgeon if the lower Snake populations are opened to sturgeon retention and managed similar to John Day Reservoir.

1.8) List of Performance Indicators

Table 48. List of Performance Indicators for the White Sturgeon Hatchery Program.

Activity	Attribute	Metric	Reference value
Broodstock and Larval Collection	Broodstock collection	Number by sex & maturation stage	Ripe: 20 / year (10 ♂, 10 ♀) Maturing: up to 20 / year (10 ♂, 10 ♀)
		Collection effort (sample hours)	To be determined
		Catch per effort	
		Mortality (if any)	
	Larval collection	Number by stage	20,000
		Collection effort (sample hours)	To be determined
		Catch per effort	
		Mortality (if any)	
	Adult telemetry	Number tagged	To be determined
		Number ripe by year	
		Tailrace location by week in spring	
Operations	Water quantity & quality	Inflow	See Section 3 (Water Source)
		Temperature	
		Dissolved oxygen	
		Chemistry	
	Fish Production	Maturation success	See Table 22
		Families produced	
		Egg take (total & per family)	
		Numbers by life stage (total & per family)	
		Weight by life stage	
		Fertilization/Survival by life stage	
		Growth rate by life stage	
		Feeding rate by life stage	1.3-11% body wt. / day
		Food conversion rate (%)	To be established
		Mark retention (pre-release) (%)	>95%
	Genetic representation	Parental contribution by family	♂ 10% ea., ♀ 10% ea.
		Haplotype frequencies (% by type)	To be established
		Autoploidy (incidence)	<5%

Activity	Attribute	Metric	Reference value
	Fish Health	Pathogen screening (broodstock, wild larvae)	Standard protocol
		Prerelease testing (juveniles)	
		Mortality events (frequency & magnitude)	Negligible occurrence
Post-Release Monitoring	Population	Annual recapture rate	≥ 5%
		1^{st}- year survival	≥ 20%
		2^{nd}- survival	≥ 80%
		3+ year survival	≥ 95%
		Abundance	Significant Increasing trend
		Growth rate	2-3 in. / year
		Condition factor (relative weight)	≥ 100%
		Emigration to adjacent reservoirs	≤ 5% in aggregate
	Food habitats	Diet composition by species	Not applicable
Wild Stock Assessment	Population parameters	Catch numbers	Not applicable
		Recapture numbers	
		Abundance	
		Size distribution	
		Growth rate	
		Condition factor (relative weight)	
		Emigration to adjacent reservoirs	
		Relative year class strength	
		Annual capture probability	
		Annual survival rates	
		Annual recruitment numbers	
Fishery Monitoring	Fishery	Catch (by fishery)	Relative to pre-hatchery baseline
		Harvest (by fishery)	
		Proportion hatchery marks (by fishery)	
		Size composition (by fishery)	

1.9) Expected size of program

Initial annual release targets are 26,500 juvenile surgeon per year into the John Day Reservoir and 5,000 juvenile sturgeon per year into the lower Snake River (Ice Harbor, Lower Monumental and Little Goose reservoirs) resulting in a total release of 31,500 juvenile sturgeon annually.

1.10) Date program started or is expected to start:

The White Sturgeon Hatchery Program is anticipated to start in 2018.

1.11) Expected duration of program:

The expected duration of the program is 50 years.

1.12) Watersheds targeted by program:

The area targeted by the program is the mainstem Columbia River from Bonneville Dam (45°38′39″N 121°56′26″W) to McNary Dam (45°55′47″N 119°17′46″W) and the lower Snake River from Ice Harbor Dam (46°14′59″N 118°52′47″W) to Lower Granite Dam (46°39′38″N 117°25′41″W). The primary hatchery facilities are planned to occur at the Yakama Nation Sturgeon Hatchery at Marion Drain in the Yakima Subbasin (WRIA 37, 46°20′03″N 120°28′21″W). The Marion Drain facility is adjacent to the Marion Drain irrigation and drainage channel in the Yakama River basin; well water would be used for water supply to the hatchery. The South Fork Walla Walla facility is located at 45°15′32″N 118°13′15″W.

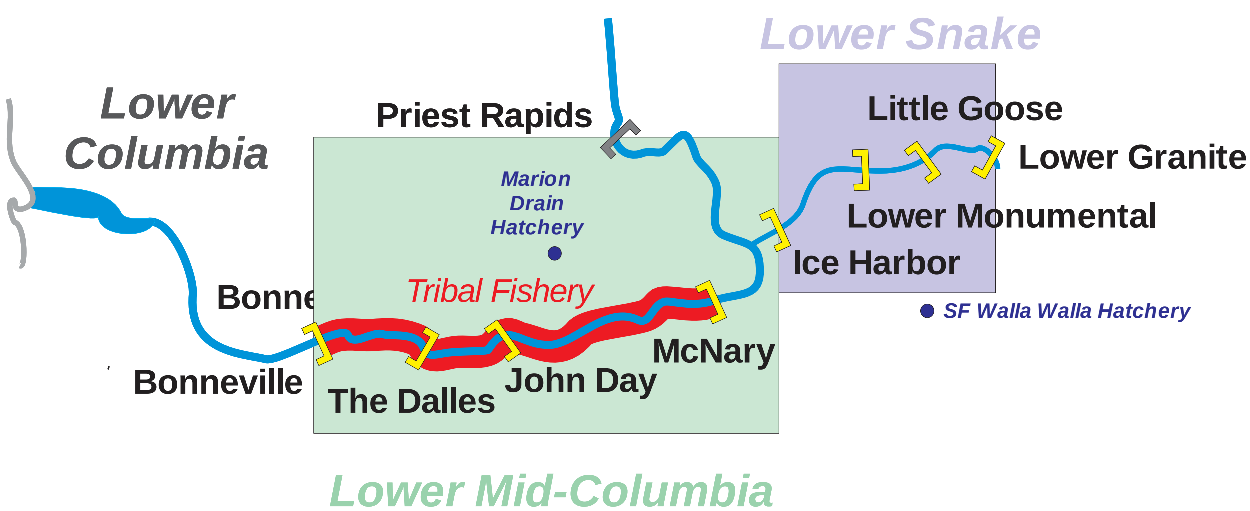

Figure 100. Lower Columbia and lower Snake sturgeon subpopulation areas considered in this plan.

13.2.2 SECTION 2. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

2.1) Related Agreements & Guidance

A number of related regional planning efforts provide guidance that direct or influence management and mitigation activities for lower mid-Columbia and lower Snake River White Sturgeon. These include:

- Northwest Power & Conservation Council (NPPC),
- Columbia River Treaty Tribes,
- State of Oregon,
- State of Washington, and
- U.S. v Oregon/Columbia River Fish Management Plan.

The NPPC follows a three-step review process to evaluate projects requesting funding for implementation. As part of this process, a White Sturgeon Hatchery Master Plan was prepared (CRITFC 2015). The NPPC also provides guidance within overarching Fish and Wildlife Program planning documents (NPPC 2014). The NPPC Fish and Wildlife Program has adopted subbasin plans in 2004-05 and 2010-11 which provide more specific direction for each of the three subbasins affected by this hatchery program.

In 2007-2008, BPA and other federal agencies agreed to implementation of commitments for the Columbia River basin as part of the consultation resulting in the 2008 Biological Opinion for the Federal Columbia River Power System (FCRPS BiOp), and in the Columbia Basin Fish Accords (Accords) executed with several Indian Tribes and states. The White Sturgeon Hatchery Master Plan was included in projects funded under these Accords.

In addition to the Accords, which include collaboration with several Indian Tribes, the White Sturgeon Hatchery Program directly addresses objectives identified in Wy-Kan-Ush-Mi Wa-Kish-Wit (The Spirit of the Salmon), the Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs and Yakama Tribes. Wy-Kan-Ush-Mi Wa-Kish-Wit provides a framework to restore Columbia River salmon, White Sturgeon, and Pacific Lamprey (CRITFC 1995, 2014).

The Oregon Department of Fish and Wildlife (ODFW) identified White Sturgeon as a conservation priority based on their ecological, economical, and social importance. The species is not formally designated as sensitive on the state list but has been identified as a “data gap” species (ODFW 2011b). In 2011, ODFW released a conservation plan for the lower Columbia River sturgeon population (ODFW 2011b). Oregon is currently engaged in a State Conservation planning effort for impounded sturgeon populations from Bonneville Dam upstream to the Washington border in McNary Reservoir.

Oregon has formally adopted a fish hatchery management policy by administrative rule (635-007-0542) to provide general fish culture and facility guidelines and measures to maintain genetic resources of native fish populations spawned or reared in captivity (ODFW 2011b). This policy

directs that hatchery programs shall be managed to provide optimum fishery and conservation benefits while removing as many random mortality effects as possible without having any other influence on the natural life or experience of native fish and their habitats.

ODFW shares responsibility for managing White Sturgeon populations in the first three impoundments upstream of Bonneville Dam (the Zone 6 fishing area) with the Washington Department of Fish and Wildlife (WDFW) and the Columbia River Treaty Tribes through the *U.S. v. Oregon* Management Agreement.

Washington manages White Sturgeon as a species on its Priority Habitats and Species List. WDFW's Fish and Wildlife Commission has proposed a policy for hatchery and fishery reform. This policy was developed for salmon and steelhead but might also inform consideration of sturgeon hatcheries. Guidelines direct WDFW to work with the tribes in implementing hatchery reform and selective fisheries including acting in a manner that is consistent with *U.S. v. Washington* and the Columbia River Fish Management Agreement (CRFMP).

The purpose of the CRFMP is to provide a framework within which the U.S. v Oregon Parties may exercise their sovereign powers in a coordinated and systematic manner in order to protect, rebuild, and enhance upper Columbia River fish runs while providing harvests for both treaty Indian and non-Indian fisheries. Parties to the *U.S. v Oregon* include four Columbia River Tribes (Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, and Confederated Tribes and Bands of the Yakama Nation), and the states of Oregon and Washington. These Parties co-manage the fisheries via the CRFMP. Specific to sturgeon, "the intent of the Parties is to manage sturgeon populations in the Zone 6 fishing area to provide long term sustainable harvest opportunities for Indian and non-treaty fisheries. The Parties established a joint Sturgeon Management Task Force (SMTF) in 1986. The SMTF meets regularly to review sturgeon management issues and establish harvest guidelines for the upcoming year.

The sturgeon hatchery project is being implemented as a complementary element of a comprehensive program for conservation, restoration, mitigation and management of lower Columbia White Sturgeon. Related Projects include White Sturgeon Project 1986-605-000, CRITFC Master Planning Project 2007-155-00, White Sturgeon Genetics Project 2008-504-00, and the Yakama Nation Sturgeon Project 2008-455-00.

2.2) Status of natural populations in target area.

Sturgeon populations trapped between the different mainstem Columbia and Snake River dams complete their life cycle in the fragmented river segments. Today, most impounded populations are recruitment-limited due to a lack of suitable spawning habitat or flow conditions suitable to produce significant recruitment in the available habitat (Parsley & Beckman 1994; Counihan et al. 1999; Parsley & Kappenman 2000; NPCC 2004).

Population status of each impounded White Sturgeon subpopulation in the lower mid-Columbia and lower Snake management units has been monitored periodically since 1987. Bonneville

Reservoir supports the largest sturgeon subpopulation in the impounded management area, recent 10-year average abundance estimate a population of 220,000 fish greater than 21 inches Fork Length (FL). Abundance estimates for The Dalles and John Day Reservoirs are 110,000 and 40,000 fish, respectively. Abundance estimates for lower mid-Columbia management units generally increased in the 1990s and 2000s followed by a recent decline that is expected to continue over the next decade as the effects of poor recruitment from 2000-2005 are observed.

Subpopulations in lower Snake River reservoirs are assessed less frequently because they are not currently the focus of significant fisheries. The three lower Snake River reservoirs, Ice Harbor, Lower Monumental, and Little Goose, support small populations of approximately 4,800, 3,700 and 6,500 sturgeon respectively, based on stock assessments in 1996-1997.

2.2.1) Geographic and temporal spawning distribution.

Natural spawning by impounded sturgeon populations in the lower mid-Columbia and lower Snake River occurs in the moderate to fast currents in dam tailraces during the spring and early summer (April through July).

2.2.2) Annual spawning abundance

Abundance of adult sturgeon is estimated to range from under 100 in some lower Snake River reservoirs to one to two thousand in each of the Bonneville, The Dalles and John Day reservoirs. Estimates are uncertain due to difficulties in capturing large sturgeon.

2.2.3) Status and Productivity

Bonneville Reservoir supports the largest sturgeon subpopulation in the impounded management area due to consistent levels of natural recruitment under a wide range of spring flow conditions. Bonneville Reservoir is not a good candidate for hatchery supplementation because natural recruitment is consistent and the existing population may well be fully utilizing the available habitat.

The Dalles Reservoir supports a substantial sturgeon subpopulation despite being the smallest of the reservoirs in the management area. Natural recruitment is more variable than in Bonneville Reservoir but more consistent than in John Day Reservoir and points upstream. Sturgeon typically recruit to the harvestable size range at about 18 years of age in The Dalles Reservoir and are vulnerable to the fishery in the current harvestable size slot for an average of 5 years.

John Day Reservoir's sturgeon subpopulation is substantially smaller than those of Bonneville and The Dalles, despite its larger size. Natural recruitment is much more sporadic in John Day. Growth and condition in John Day is above average for the lower Columbia River basin.

The three lower Snake River reservoirs, Ice Harbor, Lower Monumental, and Little Goose, support small populations of approximately 4,800, 3,700 and 6,500 sturgeon respectively, based on stock assessments in 1996-1997 (Ward 1998). Standing crop (23 lb/acre) was substantially less than in Bonneville and The Dalles reservoirs but greater than in John Day and McNary/Hanford. Natural recruitment is generally poor and occurs infrequently. Recruitment problems are characterized

by the relative lack of juvenile fish and a skewed age structure with proportionally more, older individuals.

2.2.4) Annual proportions of hatchery and natural fish on natural spawning grounds

Hatchery sturgeon will comprise an increasing percentage of adult fish on natural spawning grounds over the duration of this program. Hatchery-origin sturgeon might ultimately comprise 7-26% of the lower mid-Columbia (Zone 6) sturgeon population and 26-55% of the lower Snake River population depending on actual survival rates, if current wild numbers remain stable.

2.3) Relationship to harvest objectives

Fisheries for sturgeon in lower Columbia River impoundments are managed for two objectives. The first objective is to maintain a significant and stable population of wild adults in order to sustain meaningful levels of natural spawning and recruitment. The secondary objective is to optimize fishery value and quality consistent with harvest sharing agreements among the Treaty Indian and non-Indian fisheries.

Legal harvest of White Sturgeon has been regulated, in part, on the use of size slot limits since the early 1950s. The current harvestable size slot is 38 to 54 inches FL in Bonneville Reservoir and 43 to 54 inches FL in The Dalles and John Day reservoirs. Within Bonneville Reservoir, sturgeon harvest ranged from 908 to 4,852 fish during 1999-2013 from combined sport, commercial and subsistence fisheries. Sturgeon harvest ranged from 605 to 2,279 fish within The Dalles Reservoir, and from 467 to 1,946 fish within John Day Reservoir. Fisheries for sturgeon in lower Snake Reservoirs are currently limited to sport fisheries which are closed to sturgeon retention.

Stock sustainability objectives will be met with recruitment-related biological reference points (BRPs) that ensure survival of sturgeon through the fishery size slot is sufficient to maintain a significant adult spawning population. Yield objectives are achieved by harvesting fish at sizes which optimize value within the constraints imposed by the recruitment reference points.

2.4) Relationship to habitat protection and recovery strategies.

Most impounded populations are recruitment-limited due to a lack of suitable spawning habitat or flow conditions suitable to produce significant recruitment in the available habitat (Parsley & Beckman 1994; Counihan et al. 1999; Parsley & Kappenman 2000; NPCC 2004). White Sturgeon spawn in spring and early summer in high velocity habitats (> 1 m/s) which are generally limited to dam tailraces (Parsley et al. 1993; Perrin et al. 2003). Flows during the spawning period are highly correlated with recruitment of Age-0 White Sturgeon in lower mid-Columbia populations (Parsley & Beckman 1994; Mallette 2008-2014). Research has identified flow conditions that produce significant sturgeon recruitment in most dam tailraces. Significant year classes in Bonneville, The Dalles, and John Day reservoirs require spring discharge averaging at least 225, 250 and 350 kcfs, respectively (Parsley et al. 1993; Parsley & Beckman 1994).

The draft 2014 NPCC Fish and Wildlife Program calls for operation of the FCRPS to provide flow consistent with the needs of productive sturgeon populations, including increased spring and summer flows and spill where feasible. Flow measures are being implemented for the endangered Kootenai sturgeon. However, no flow measures have been implemented to date or

are planned for the specific benefit of impounded sturgeon populations in the mid-Columbia and lower Snake rivers (Beamesderfer & Anders 2013). Sturgeon spawning needs compete with other needs for water including power generation, irrigation, and measures for the benefit of ESA-listed salmon and steelhead.

The basin-wide sturgeon framework calls for implementing experimental habitat restoration measures to address limiting factors for White Sturgeon where appropriate (Beamesderfer & Anders 2013). The draft 2014 NPCC Fish and Wildlife Program calls for investigation of site-specific habitat measures for sturgeon such as substrate enhancement and channel restoration as viable alternatives for improving natural recruitment in some areas.

2.5) Ecological interactions

At least 51 species of fish from 14 families have been identified in the lower mid-Columbia River mainstem (NPCC 2004). Thirty of these species are native, including at least five anadromous fish species. Most of the fish species observed in the reservoirs remain in the impounded reaches throughout their life cycle naturally or, like White Sturgeon, because they are largely constrained within the barriers presented by the dams.

The lower mid-Columbia and lower Snake rivers serve as a migratory corridor and rearing area for salmon and steelhead traveling between the Pacific Ocean and tributary spawning and rearing grounds. Abundance of anadromous species including salmon, steelhead and lamprey has been substantially reduced following dam construction although large numbers of non-native anadromous American shad utilize the reservoirs for spawning and rearing.

Substantial changes in aquatic ecosystem and associated food webs have accompanied impoundment (ISAB 2011). Before reservoir inundation, the dominant resident species included sturgeon, whitefish, trout, and cool water non-game species such as Northern Pikeminnow, sculpin, shiners, chubs, and suckers. Today, impoundments have also favored increased abundance of non-native fishes including largemouth and smallmouth bass, several catfish species, carp, crappie, perch, and Walleye. Impacts on sturgeon from changes in the resident fish community are poorly understood, but predation and competition have likely increased on some areas. Resident fish also likely compete with sturgeon for food and over-wintering habitat.

Prior to impoundment and flow regulation, the riverine system productivity was dominated by periphyton and detrital pathways. The benthic invertebrate community was dominated by lotic taxa and White Sturgeon were likely a top predator due to their varied diet. Productivity has now shifted to more of a lentic system founded on phytoplankton production favoring native and non-native species adapted to lake conditions (ISAB 2011).

13.2.3 SECTION 3. WATER SOURCE

Water supply criteria for sturgeon are provided in Table 49. The water supply needs to be clean, free of sediment and pathogens, and contain normal levels of dissolved gasses. Most commonly, sturgeon hatchery surface water is settled and filtered to remove sediments and suspended solids, treated with UV and/or ozone to remove pathogens and de-gassed to equilibrate dissolved

oxygen and nitrogen. If well water is used as the source, and the quality of the water assured, settling may not be necessary and only UV treatment used.

Table 49. Water supply criteria for sturgeon (FFSBC 2012).

Parameter	Recommended value
Alkalinity	100-400 mf/L as $CaCO_3$
Ammonium (NH_{4+}-N)	Max. 0.05 mg/L
Ammonia (NH_3-N)	<0.01 mg/L as N
Biological oxygen demand	<4
Dissolved oxygen	>90%
Hardness	2-5 dH/50-400 mg/L as $CaCO_3$
pH	6.5-8.0
Nitrite (NO_2-N)	<0.1 mg/L
Nitrate (NO_3-N)	Max. 10 mg/L
Carbon Dioxide (CO_2)	Max. 10 mg/L
Salinity	0-0.5 ppt for fry, 0-3 ppt for juveniles, 3 ppt for broodstock

The primary White Sturgeon hatchery facility will be at the Yakama Nation Sturgeon Hatchery, Marion Drain, in the Yakima River watershed. The proposed water supply system for the White Sturgeon hatchery facility is a single pass water supply.

The Marion Drain site currently has two shallow production wells and one deep back-up well. The two production wells both produce upwards of 600 gal/min and tap into the same aquifer. These wells are 160' deep and cost around $125K each to install. Constant 14°C water is supplied from two shallow wells at a total capacity of 1,200 gal/min (4,800 L/min). The deep well for backup and is considered a surplus well due to water regulation and aquifer management. This well can produce upwards of 600 gal/min and taps into a separate aquifer. Water from this well is high in iron content and anoxic.

Well water passes through gas balancing columns prior to use for rearing sturgeon. Water from shallow wells is pumped to a 4m high aeration tower and passes through a 6 ft diameter packed column of 1" bio rings for passive aeration. All aeration towers are passive; there are no blowers and air enters through a port in the top. Culture tank outflow oxygen level is 7 mg/L. Tank inflow water is at saturation levels of 9.8 mg/L. Air blowers are used for in-tank aeration.

Marion Drain Hatchery meets most water quality requirements for sturgeon production after gas balancing treatment. The well water at Marion Drain has a pH range of 8.1-8.3, which is slightly outside of the recommend range for sturgeon rearing of 6.5-8.0. Sturgeon rearing is currently taking place at Marion Drain and the pH difference does not appear to be detrimental.

Table 50. Marion Drain hatchery water quality.

Parameter	Recommended Value	Marion Drain Sample Value
Alkalinity	100-400 mg/L as $CaCO_3$	197 mg/L as $CaCO_3$
Ammonium (NH_{4+}-N)	Max. 0.05 mg/L	
Ammonia (NH_3-N)	< 0.01 mg/L as N	
BOD	< 4	
Dissolved Oxygen	> 90%	9.63 mg/L
Hardness	2-5 dH/50-400 mg/L as $CaCO_3$	107 mg/L as $CaCO_3$
pH	6.5 – 8.0	**8.1 - 8.3**
Nitrite (NO_2-N)	< 0.1 mg/L	None Detectable
Nitrate (NO_3-N)	Max. 10 mg/L	2.6 mg/L
Carbon Dioxide (CO_2)	Max. 10 mg/L	Not Measured
Salinity	0 – 0.5 ppt for fry 0 – 3 ppt for juveniles 3 ppt for broodstock	Not Measured

The current production at Marion Drain utilizes the full 1,200 gal/min available from the two existing production wells. Assuming that the current production will remain and that water requirements for new White Sturgeon production will be in addition to current demand, additional wells or recirculating systems will be needed to accommodate the water demand of the new White Sturgeon program. Along with an additional well, a separate degassing and piping system would be required to increase the available rearing water supply. The site also has the potential to support a second new well if necessary (for total of 4 production wells). In addition, the site is located next to the Marion Drain which provides access to surface water and the possibility of tapping shallow subsurface water through an infiltration gallery which could provide a source of naturally-fluctuating temperatures.

After completion of the primary sturgeon hatchery facility at Marion Drain, a companion facility will be developed at the Walla Walla South Fork Hatchery. The companion facility is intended to provide rearing facilities for producing 5,000 yearling juveniles. Water supply to the South Fork hatchery can come from surface water or groundwater or a combination of both. Surface water supplied from the South Fork Walla Walla River is the primary water source for Chinook Salmon production at the facility. Juvenile sturgeon rearing will utilize well water which provides temperatures of 16-17°C throughout the year in order to optimize growth. Two groundwater aquifers underlie the South Fork facility. The existing well currently provides 100 gal/min of artesian flow. Total inflow requirements for the companion facility at seasonal peaks in biomass are 100 gal/min for juveniles. The original well report from 1997 suggested that if the well was pumped it may produce over double that amount. If it were determined that additional groundwater was necessary to meet project demands a groundwater right would be applied for and additional pump testing would be required. Water quantity demands for juvenile rearing are relatively small due to the limited volume of sturgeon production in the companion facility.

Treatment of well water similar to the Marion Drain facility will be required for aeration and to remove hydrogen sulfide.

The complementary research operations is located at the Walla Walla Community College Water and Environment Center (WEC). The WEC aquatic facility is currently using a limited amount of dechlorinated water that charges a recirculation facility of small capacity. The amount of water available suits the current level of research and investigation and can be expanded to accommodate additional projects with low water uses. Additional production would require development of additional water sources. Construction of a new deep well is being explored with potential completion in 2017. It was estimated that this well would deliver 50 gal/min of 52-55°F (11–13°C) water. This water would be subject to degassing and aeration before use. It is unknown if metal chelation would need to be completed before use. The cool temperature of the well water is not ideal for fish culture but is suitable for incubation and first-feeding studies.

13.2.4 SECTION 4. FACILITIES

The primary hatchery facility is proposed as an addition to facilities already present at the Marion Drain site. A sturgeon hatchery has been under development by the Yakama Nation at Marion Drain since 2009 when the first holding facilities were constructed. The existing facility includes a hatchery building used for spawning, incubation and rearing; three pole-barn style covered rearing areas (currently used for potential commercial grow-out production), and three mobile home style buildings used for an office, storage, and crew quarters. Production containers include a variety of circular tanks.

At the current stage of the planning process for the new facilities considered under this HGMP, only conceptual facility designs (±35-50% level) have been developed. Over five acres are available for a new hatchery building located in the middle of the site.

The hatchery building will be of clear-span, steel clad construction with an envelope of at least 210 ft. by 81 ft. The interior of the building includes distinct areas separated by walls for different life stages to accommodate biological and biosecurity demands. The building also includes areas for ancillary services to support fish culture and controlled access to culture areas. These include separate rooms for mechanical/electrical controls, feed storage, food preparation, egg fertilization, equipment storage, office space, and a crew locker room.

One room will house twelve 6’ tanks for use in incubation and early rearing. A second room will house two 20’ tanks, and twelve 12’ tanks for use in broodstock holding, spawning, and juvenile rearing. This configuration provides flexibility in the designs to accommodate changes to the plan and expansion. Total rearing volume is 56,000 gal. (212 m^3).

Tanks are arranged in groups to facilitate grading and tank to tank transfer. Working space is provided for access to each tank with mobile equipment used in the processes of normal routines such as feeding and specific practices such as grading. A large passage way of 10-15 ft. permits the passage of machinery and equipment along the hatchery route. Furthermore, this space is also valuable for the temporary set up of troughs for use in the grading and marking of juveniles.

The larger tanks will be used to house fish of up to 200 lb. or more, it is important that operators have enough room to carry fish safely without risk to staff or fish. Overhead gantry rails for transporting large fish in stretchers will be required to facilitate moving fish in spawning condition from tank to tank as required. Clean up water hoses are vital for this area as surfaces must be cleaned after handling fish and moving equipment.

The conceptual hatchery plan calls for rededication of a pre-existing portion of the Marion Drain facility for wild larval sturgeon rearing. Wild larvae will be reared in a separate building from the rest of the proposed production in order to provide biosecurity. This space includes a covered building with circular tanks and plumbing. The building is 47 x 80 x 10 ft and currently holds approximately twelve 6', five 9', and six 10' circular tanks. The building will need to be replumbed, the drain rerouted, and concrete poured for the floor. The availability of this space was one of the reasons that the Marion Drain site is identified as the preferred option for this program. Additional infrastructure will be required at the hatchery including a garage, workshop, vehicle storage, equipment storage, and laboratory space.

For the Walla Wall South Fork Hatchery companion facility, a building currently used for ozone treatment will be converted to sturgeon rearing use when the facility is expanded to full production of Spring Chinook. Juvenile sturgeon rearing will require two 16' x 5' circular tanks (6,000 gal. capacity each) to produce 5,000 yearling juveniles for spring release. The building space of 30' x 50' will provide room for juvenile rearing as well as fish handling and biosecurity requirements. The South Fork Facility currently has a ready and consistent power supply as well emergency generator building to supply power to critical hatchery infrastructure in the event of an interruption.

For complementary research operations at the WEC, the existing aquatic laboratory facility room would be used in support of the broader sturgeon hatchery program. Additional fish rearing space and support systems (water delivery, drains, etc.) would need to be constructed for significant production. Ancillary equipment and capacity such as feed, equipment and outerwear storage would be required.

4.1) Broodstock collection and transport

Broodstock will be captured from wild subpopulations in the lower mid-Columbia River prior to spawning. Ripening fish expected to spawn in the year of capture are transported to the hatchery. Capture ideally occurs in May or June and fish may be held as late as August. Broodstock are moved from and to the capture area by dual axle (two ton) trailer fitted with a 1.5 – 2m^3 (4 – 6 ft) volume tank filled with water and fish towed behind a truck suitable for the purpose. Supplemental air is provided to maintain sufficient oxygen levels and salt to mitigate stress response. After transport, the fish are transferred to hatchery circular tanks and placed in temperature-matched water. Commercial salt can be added to achieve a 1% solution by brine drip or manual addition of crystals to relieve stress and help heal any abrasions. The salt concentration is maintained for 24 hours and eventually flushed by regular flows. Fish are held at elevated flow rates for 48 hours to keep oxygen levels high.

For larval sturgeon captured in the river, larvae are removed from the cod end of the funnel net, or from an instream collection box using a jar filled with water or a small mesh dip net to minimize trauma. Larvae must typically be separated from volumes of other material collected by nets. These larvae are placed in a bucket containing aerated water and covered. When collection is complete, the larvae are transferred to the facility and the process reversed.

4.2) Broodstock holding and spawning facilities

The production plan calls for the capture and spawning of 10 female and 10 male sturgeon. Capacity for holding up to 20 mature fish (4,400 lb) will be required.

Broodstock are held in 12' and 20' circular tanks constructed of fiberglass, fiberglass-reinforced plastic or enamel-coated steel. Water supply to tanks holding brood is heated or chilled, depending on the need to advance or maintain reproductive state. Air and oxygen supply are also required.

Two 20' (7 m) tanks have a capacity of 2 x 40 m^3 and 2,000 kg at 25kg/m^3. This loading density is lower than those seen in commercial operations to account for holding wild stock. The two tanks can hold up to 2,000kg or about 20 adult, maturing fish. Peak flow requirements of 1,400 – 2,000 L/min (370 – 528 gal/min) will be required. Tank types are dual drain Cornell-type, external standpipe, fiberglass or other material, and 5-6' deep. These tanks should be located away from larval and juvenile rearing areas to maintain a biosecurity barrier.

4.3) Incubation facilities

Eggs are incubated in modified MacDonald upwelling jars. Dead eggs (white, discolored or mottled) and egg shells are siphoned daily from the incubators and fry collection tanks. Eggs from each half-sibling family are incubated in separate jars. Each maternal family consists of five jars of eggs, one jar from each of males crossed with one female. Each 5x5 spawning matrix will thus require 25 separate jars. Thus, a total of 50 jars will be required for the 50 half-sibling families. Normal loading for the jars is up to 1 L of fertilized eggs or about 23,000 - 25,000 eggs. Production objectives for this program are at least 20,000 eggs per half-sibling family.

Each 6'circular tank (maternal family) has water inflow from five jars, each with up to 15 L/min (4 gal/min) at peak flows for a total of 75 L/min. The total maximum water draw for incubation for a single spawning event for five maternal families is 375 L/min (100 gal/min). Once hatching is complete, water flows into 6' tanks may be reduced to approximately 20 L/min (5 gal/min) and regulated by a directional spray bar. This flow rate will meet a larval rearing standard of 0.75 L/min (0.2 gal/min) per kg of biomass. Under this scenario, total flows of approximately 750 L/min (200 gal/min) will be required in total during larval rearing.

4.4) Rearing facilities

Feeding fry are transferred as families to 12' tanks in the rearing portion of the facility when fish are approximately 1 g (0.04 oz.) in size. Transfer of juveniles occurs after tanks have been cleaned and disinfected following return of adult fish to the river. Fish are grown to size in the 12' tanks until fall when final random culling is done to equalize maternal family groups. As required by

size distribution, fish from a family may be transferred or graded into paired for growth management which will increase total flows accordingly as all tanks would be in use. Water temperature may be tempered to control growth as required to bring the slow-growing portions of each family to size. In general, a 12' tank will hold 425 kg (925 lbs) at a maximum density of 35kg/m^3 (0.30lbs/gal). Corresponding water flow per tank would be up to 100 L/min (26 gal/min) depending on the fish size and density. This flow rate gives a two hour turnover time for the water and should obviate the need for supplemental oxygenation of the water. Total peak water delivery at this time would be in the order of 1,200 L/min (317 gal/min).

4.5) Acclimation/release facilities

Separate acclimation facilities are not proposed for the White Sturgeon hatchery program. Temperatures within holding tanks for juvenile sturgeon scheduled for release may be manipulated to acclimate fish to temperatures anticipated at the release site. Juvenile fish for release will be crowded passively in the holding tank, netted, and transferred to the trailer tank for transport to the river. Transport to the release site is by using the transport trailer filled with hatchery water. Salt may be added for longer trips to ameliorate any stress effects of transport. Fish are released to the river using gravity from an 8 inch valve fitted with a plastic flexi-hose that is submersed in the river. Temperatures are matched as close as possible by pumping river water into the tank over a time span that matches temp at no more than 2°C per hour. For boat mid-river releases of small batches, fish are crowded in the tank and transferred to an on-board holding tank filled with aerated water. For release, fish are, netted enumerated by weight in the net suspended on a scale (or volumetric method) and released overboard.

13.2.5 SECTION 5. ORIGIN AND IDENTITY OF BROOD STOCK

5.1) Source

See Section 4.1

5.2) Supporting information

5.2.1) History

Because sturgeon can live to 100 years or more, current status and problems reflect current limitations and lingering effects of historical impacts and activities. Intensive commercial fisheries developed in the mid to late 1800s for sturgeon and salmon with the advent of a fish canning industry (Craig & Hacker 1940; Galbreath 1985). The sturgeon population and fishery collapsed during the 1890s as unregulated harvest mined out the adult population. Gear and minimum size regulations were enacted for the commercial fishery in the early 1900s.

Basic research on sturgeon biology by Alexander Bajkov of the Oregon Fish Commission during the 1940s led to protection of spawning adults with a 6-foot maximum size limit for harvest in 1950 (Bajkov 1951; ODFW & WDFW 2002). A minimum size limit of 30 inches was adopted in 1959 and changed to 36 inch in 1958. The 36-72 inch slot limit remained in place until 1986.

Sturgeon harvest in sport, commercial and treaty tribal fisheries gradually increased from 1970 until the 1980s as the population expanded following broodstock protection and anglers

increasingly turned to sturgeon as salmon fisheries declined. By 1987, harvest peaked at almost 90,000 sturgeon after which a series of more conservative regulations were adopted to maintain sustainable harvest levels. Harvests of about 50,000 sturgeon per year were maintained until the early 2000s.

Downstream from Bonneville Dam, harvest levels were steadily reduced beginning around 2003 in response to a decline in natural recruitment beginning in the 1990s. The lower Columbia sturgeon fishery was finally closed effective January 1, 2014 in an attempt to stabilize the current population. The decline in sturgeon abundance in the unimpounded river coincided with a growing influx of sea lions. Predation by sea lions has substantially increased mortality of adult and subadult sturgeon, particularly in sturgeon spawning areas in the Bonneville Dam tailrace. Sea lion predation may also be disrupting normal spawning behavior of sturgeon.

5.2.2) Annual size

A total of 20 adult broodstock will be utilized each year. Over the approximately 25-year generation time of sturgeon, these numbers translate into an effective broodstock number of 500 fish.

5.2.3) Past and proposed level of natural fish in broodstock.

The Sturgeon Hatchery Program is new; consequently, no past performance is available. The program calls to primarily collect mature, ripening sturgeon for broodstock.

5.2.4) Genetic or ecological differences

The program plans to use wild fish for broodstock and breeding matrices and protocols to maximize effective population number and to minimize chances of future inbreeding in the wild. Consequently, no genetic or ecological differences are anticipated between hatchery origin and wild sturgeon.

5.2.5) Reasons for choosing

There are no special traits or characteristics for which the broodstock was selected. White Sturgeon genetic studies have consistently documented small genetic differences in the Columbia Basin with decreasing diversity with distance upstream (Bartley et al. 1985, Brannon et al. 1987, Brown et al. 1992, Setter and Brannon 1992, McKay et al. 2002, Anders & Powell 2002, Rodzen et al. 2004, Drauch Schreier et al. 2011, 2012, 2013; Matala 2013, 2014, 2015). This weak genetic differentiation among sturgeon samples from the lower, middle, and upper Columbia River is consistent with the lack of historically significant migration barriers to sturgeon in the Columbia River between the ocean and Canada, and the wide-ranging life history pattern of this species. Small genetic differences between lower Columbia, mid-Columbia, and upper Columbia samples did not represent enough genetic distance to base a strong argument for consideration as separate stocks. Participants in a 2010 Lower Columbia and Snake River Sturgeon Workshop delineated five genetic management units (GMUs) for White Sturgeon in the Columbia River basin based on their expert opinion and the available information on genetic population structure (Beamesderfer et al. 2011). All sturgeon subpopulations in the lower-mid Columbia and lower

Snake River management areas addressed by this hatchery master plan occur in the mid-Columbia genetic management unit.

5.3) Unknowns

There are no uncertainties regarding the choice of broodstock or location of their collection.

13.2.6 SECTION 6. BROODSTOCK COLLECTION

6.1) Prioritized goals

Objectives 4, 5, and 6 listed in Section 1.7 pertain to broodstock collection and utilization. Objective 6, to achieve an integration of hatchery sturgeon with the natural genetic and life history diversity of wild-spawning sturgeon has the highest priority. Objectives 4 and 5 support this objective.

6.2) Supporting information

6.2.1) Proposed number of each sex.

A total of 20 adult broodstock will be utilized each year. In the breeding plan, up to five females and five male sturgeon will be ideally spawned in each of two spawning events.

6.2.2) Life-history stage to be collected (e.g., eggs, adults, etc.)

Wild adult and larval sturgeon are proposed for collection under the hatchery program. Only adults will be used for broodstock.

6.2.3) Collection or sampling design

Broodstock will be captured from wild lower mid-Columbia River subpopulations in the spring prior to spawning. Sturgeon are typically collected by setlines, angling or large-mesh gillnet. Sex and stage of maturity of adult-sized fish (typically 6 feet or larger) are assessed in the field by surgical biopsy. Ripening fish expected to spawn in the year of capture are transported to the hatchery.

6.2.4) Identity

Not applicable.

6.2.5) Holding

A total of twelve 12’ tanks and two 20’ tanks will provide sufficient capacity and flexibility for broodstock holding and spawning activities. Broodstock that are closest to spawning time are placed in 12’ tanks for final maturation and spawning induction. Females often surpass 100 kg in weight. For safety and ease of handling, large females may be held separately in 12’ tanks. Males are typically smaller than female fish and two or three may be kept in a 12’ tank. All females are held separately during final maturation to aid in the recognition of ovulation and egg release after induction. After the first round of fish are spawned, the remaining fish in the 20’ tanks are moved to the 12’ tanks.

Once a female fish has been spawned, she is returned to the river where she was caught. Spawned females are monitored for at least 24 h and returned to the river at the earliest

convenience. The program will evaluate the feasibility of overwintering adult females expected to spawn the following spring in ambient water temperatures. Males are not released until all female fish are spawned. Broodstock fish are not fed during their residency.

6.2.6) Disposition of carcasses

Most broodstock will be returned live to their capture location following spawning. If broodstock mortality occurs, carcasses will be disposed of by landfill.

6.3) Unknowns

There is some uncertainty regarding the numbers of fish to be collected each year for broodstock, which will depend upon the number and maturation schedule of brood stock collected previously. Annual broodstock collection efforts typically catch significant numbers of ripening females which can be expected to spawn in the following year. Not every mature female sturgeon spawns in every year because the egg maturation cycle typically requires at least two years and one or more resting years may occur between maturation cycles. The program will evaluate the feasibility of overwintering adult females expected to spawn the following spring in ambient water temperatures.

13.2.7 SECTION 7. MATING

There is no ESU-wide hatchery plan for White Sturgeon. Breeding matrices and protocols have been developed to maximize effective population number and to minimize chances of future inbreeding in the wild (Kincaid 1993; Anders 2004; KTOI 2004). A factorial mating strategy ensures the largest possible expression of genetic and phylogenic diversity from the available broodstock through recombination. In the breeding plan, up to five female and five male sturgeon will be ideally spawned in each of two spawning events. The five male and female spawners form a maternal family in each spawning event, with separate events expected to occur two weeks apart during the spawning season. This mating strategy also emulates natural conditions where multiple males reproduce with each female. Embryos from each mated pair will be incubated separately to ensure equal contributions and maternal families will be reared separately for the same purpose.

7.1) Selection method

Not every mature female sturgeon will be ready to spawn they year they are collected as broodstock because the egg maturation cycle typically requires at least two years and one or more resting years may occur between maturation cycles. Selection of specific fish for spawning from those collected as broodstock will be dependent somewhat on the order that fish ripen. Otherwise, there are no specific selection criteria.

7.2) Males

This section is not applicable to sturgeon.

7.3) Fertilization

Spawning and fertilization follow standard methods documented by Conte et al. (1988). Ripening females are monitored in the hatchery until the late stages of maturation are reached. Eggs are

periodically collected from the vent and examined for stage of development. Final stages are recognized by the position of the egg nucleus or germinal vesicle in microscopic examination. Water temperature in individual tanks can be turned down to arrest further gonad development and allow a more synchronous spawning event with the other female fish to meet the factorial mating protocol.

Spawning typically occurs in May or June. Female broodstock must be induced to release eggs by hormone injection in the final stages of maturation because captive sturgeon rarely ovulate spontaneously. Ovulation is induced by injection with synthetic lutenizing hormone LHRHa at 0.1 mg/kg body weight in two doses. Significant numbers of eggs are typically released upon ovulation and apparent on the bottom of the spawning tank within 48 hrs of hormone injection. Egg stage is confirmed by microscopic examination.

Eggs are hand-stripped except in rare cases of oviduct blockage. Hand-stripping has been used in lieu of caesarian section favored by the sturgeon aquaculture industry to reduce stress and injury. Fish spawned by hand stripping can be released shortly after spawning, whereas fish spawned by caesarian section may take several weeks for the sutured incision to heal before they can be returned to the river. Up to 100,000 eggs will be collected from individual female broodstock where possible. Egg number is quantified volumetrically. This represents a small portion of the total fecundity. The unspawned eggs are subsequently absorbed by the sturgeon. Up to 1,000,000 eggs will be collected in total.

Eggs are fertilized with sperm collected from ripe males. Male maturation can be regulated by temperature control. Sperm motility is verified before fertilization. Excess unfertilized eggs and milt can also be shipped to satellite facilities at this time. Eggs from individual females are split into separate lots and are separately fertilized with milt from different males according to the factorial mating design. Ideally, eggs from one female are fertilized with sperm from up to five males. Families from one female and one male are referred to as full-sibling families. Families from the same female and different males are referred to as half-sibling families. Each of two 5x5 spawning events will produce 25 half-sibling families (50 in total). Family identity is maintained through the spawning, fertilization and incubation process.

After fertilization, eggs are stirred with an inert clay material (Fuller's Earth) to remove stickiness. In the wild, eggs adhere to rocks and in crevices but de-adhesion is necessary in the hatchery to avoid egg clumping, and mortality during incubation. Spawning occurs in the main area of fish culture and eggs/milt are then transferred to an egg preparation area adjacent to a separate incubation area. This work space is typically a small laboratory with storage.

7.4) Cryopreserved gametes

Cryopreserved gametes will not be used for the White Sturgeon Hatchery Program.

7.5) Unknowns

The hatchery program has been specifically designed to avoid the potential for detrimental genetic effects of hatchery production practices. The effectiveness of this strategy remains to be

determined based on monitoring of genetic characteristics of hatchery fish at various points in the production process relative to that of wild subpopulations.

13.2.8 SECTION 8. REARING AND INCUBATION

8.1) Number of eggs taken and survival objective to ponding

Up to 1,000,000 eggs will be collected in total on an annual basis (Table 51). Approximately 50,000 eggs per maternal family are planned to produce a total of between 400,000 – 500,000 unfed larvae. Upon hatch, target survival to first feeding is 50% and survival to fully-feeding fry is projected to result in 150,000 or more fry of which 75,000 will be needed for target production.

8.2) Loading density

Sturgeon eggs are relatively small (3-40 mm) and have short incubation periods of about 12-14 days until hatch. Normal loading for MacDonald upwelling jars is up to 1 L of fertilized eggs or about 23,000 - 25,000 eggs. Production objectives for this program are at least 20,000 eggs per half-sibling family.

8.3) Influent and effluent gas concentration

Water supply criteria are outlined in Table 52. Oxygen levels are normally kept at 85% of saturation in outflow water. Requirements to ensure inflow water is at or near saturation, include aeration towers or supplemental oxygen supply such as a pressure packed column or low head oxygenation. In all considerations, emergency oxygen supply will need to be in place such as oxygen diffuser bars that are tank side or in a common area.

For well water or pumped water, degassing and aeration of inflow water is essential. Supplemental oxygen can be employed if saturation is not achieved by aeration, or the use of Low Head Oxygenators can be used prior to the header tank. Carbon dioxide levels need to be held below 10 mg/l in all culture water and should be no more than 1mg/l in inflow water. The anticipated pH range for sturgeon culture should be 7.1 – 8.4 and alkalinity as $CaCO_3$ in the order of 80 – 400mg/l. An alkalinity doser can be employed for inflow or header tanks water to achieve optimal alkalinity (normally a concern if using a biofilter in RAS).

With adequate de-gassing and aeration of incoming water, supplemental aeration or oxygenation should not be required during regular rearing cycles. However, under certain circumstances such as peak loading, males expressing milt in a tank, interrupted water flow, malfunctioning feeder or feed delivery, accidental standpipe removal, supplemental or emergency aeration and oxygenation are essential. Each tank should be fitted with an air line, valve, and oxygen monitoring system. Emergency oxygen supply with the capability to extend service to all tanks in an emergency should be plumbed in and included in the hatchery design.

Table 51. Sturgeon program numbers and weight by life history stage and family.

	Number (maximum)			Number / Family[a]		Weight	
Life stage	Total	Males	Females	Half-Sibling	Maternal	Individual	Total (lb)
Spawners	20	10	10	--	--	220 lb (avg)	4,400
Developing adults	20	10	10	--	--	220 lb (avg)	4,400
Egg take[c]	1,000,000	--		20,000	100,000	--	110
Eggs @ neurelation[c]	500,000[b]	--	--	10,000	50,000	--	55
Fry (unfed)[c]	400,000	--	--	8,000	40,000	--	--
Fry (fed)[c]	150,000[b]			3,000	15,000	0.04 oz	150
Juveniles (Sept)[bc]	37,250[a]	--	--	745	3,725	1-1.5 oz	2,500
Age 0+ release (Sept)[c]	5,000	--	--	100	500	1-1.5 oz	700
Juveniles (Oct)[c]	32,250	--	--	645	3,225	1-3 oz	1,600
Age 1 release (Apr)[c]	20,000	--	--	400	2,000	4-5 oz	5,500
Age 1+ release (Sep)[c]	1,500	--	--	30	150	9-12 oz	1,000
Larvae (wild)[d]	20,000	--	--	TBD	TBD	--	--
Fry & Juveniles (wild)[d]	10,000	--	--	TBD	TBD	4-5 oz	1,375

[a] *Number of families: 10 maternal (same female parent), 50 half-sibling (same male and female parents).*

[b] *post equalization (surplus available for research and education).*

[c] *Progeny of wild broodstock spawned in the hatchery.*

[d] *Production from wild-caught larvae.*

Table 52. Water supply criteria for sturgeon (FFSBC 2012).

Parameter	Recommended value
Alkalinity	100-400 mg/L as $CaCO_3$
Ammonium (NH_{4+}-N)	Max. 0.05 mg/L at pH 7.0
Ammonia (NH_3-N)	<0.01 mg/L as N
Biological oxygen demand	<4 mg/l
Dissolved oxygen	>90%
Hardness	2-5 dH/50-400 mg/L as $CaCO_3$
pH	6.5-8.0
Nitrite (NO_2-N)	<0.1 mg/L
Nitrate (NO_3-N)	Max. 10 mg/L
Carbon Dioxide (CO_2)	Max. 10 mg/L
Salinity (as required)	0-0.5 ppt for fry, 0-3 ppt for juveniles, 3 ppt for broodstock

8.4) Ponding

Ponding occurs when fish are approximately 1 g (0.04 oz.) in size and is expected to require one to two months. At this time fish are transferred from the 6' circular larval rearing tanks to 12' tanks. Downsizing of the maternal family may occur at this time. Surplus fish are selected randomly. Excess fish may be transferred to other facilities or sacrificed.

8.5) Fish Health monitoring

Diseases observed in sturgeon hatchery programs include the natural array of pathogens common to those seen in a salmonid hatchery including myxobacteriosis, columnaris, costia and external fungus. Treatments for these are generally similar to those used for salmonids. In addition, the White Sturgeon Iridovirus (WSIV) is endemic to White Sturgeon including the Columbia River population.

Fish health management will also be an essential consideration in all aspects of hatchery operation. Operations will be conducted according to a detailed fish health management plan (e.g., BCMA 2003) in order to:

g) prevent the introduction of exotic diseases or disease causing agents;
h) reduce the occurrence of disease in fish held in the culture facility;
i) minimize the spread of disease to stocks within and outside the facility;
j) maintain an environment that promotes the health and productivity of cultured fish and reduces the susceptibility of fish to disease;
k) protect public health and minimize disease risks to cultured and wild fish through judicious use of drugs and chemicals; and
l) provide guidance for fish health management decisions.

Plan elements will address:

i) fish health monitoring, & records,

j) water quality monitoring,
k) broodstock, larval and pre-release pathogen testing,
l) stress management procedures for handling and movement,
m) outbreak investigation and management,
n) management of dead fish,
o) bio-security measures including disinfection, and
p) disease treatment protocols.

To minimize WSIV disease risk, hatchery operators will test adult fish for WSIV annually and will not hold or spawn positive fish. A fish health plan will be specific guidance for handling of disease outbreaks including criteria preventing release. Under certain circumstances, severe outbreaks may require destruction of infected cohorts rather than release.

8.6) Number of fish ponded and survival objective to release

Up to 75,000 feeding fry from up to 10 maternal families are transferred as families to 12' tanks in the rearing portion of the facility. In addition, up to up to 20,000 wild-caught yolk-sac or first-feeding larvae will be reared. Wild larvae are held in 6' tanks under similar conditions to the hatchery-spawned fish. Four 6' circular tanks and four 12' circular tanks will be required for wild-caught juveniles.

Survival rates of wild-caught larvae are typically much lower than those of hatchery-produced juveniles due to stress associated with capture and handling. Survival rates of 20-35 percent were reported by the upper Columbia program during the first two years of this program. Propagation of wild-caught larvae is an experimental component of the CRITFC program and will be managed adaptively over time.

Isolation capability either within the building or in a separate structure will be required for biosecurity purposes. An outbreak of White Sturgeon Iridiovirus in the upper Columbia program in autumn of 2013 highlights fish health risks associated with this production strategy.

8.7) Density and loading.

The same twelve, 12' tanks utilized for broodstock holding can be used for juvenile rearing. Transfer of juveniles occurs after tanks have been cleaned and disinfected following return of adult fish to the river. At the fish culturist discretion, a portion of the fish may also be kept in the 6' tanks to act as a safeguard population.

Fish are grown to size in the 12' tanks until fall (about two months following ponding) when final random culling is done to equalize maternal family groups. Numbers are reduced to 150 percent of target release numbers. By the time fish pass the 15-30 g (1.5 oz) stage in August - September, mortalities are anticipated to be almost nil except for culling. Thus, family size release objectives of 1,500 fish in spring will require about 2,250 per family during the fall. These fish are randomly selected from each family without regard to size. At rearing temperatures of 14-17°C (57-63°F)

sizes will average 30-70 g. Extra fish would be available for fall release or transfer to another facility and otherwise would be sacrificed.[35]

Tank fish loading and water flow rates are described in Section 4.4.

8.9) Length, weight, and condition factor.

Sturgeon juveniles at the beginning of the rearing period are approximately 1 g (0.04 oz.) in weight and are reared to 30 to 70 g by the early fall.

8.10) Growth rate, energy reserves

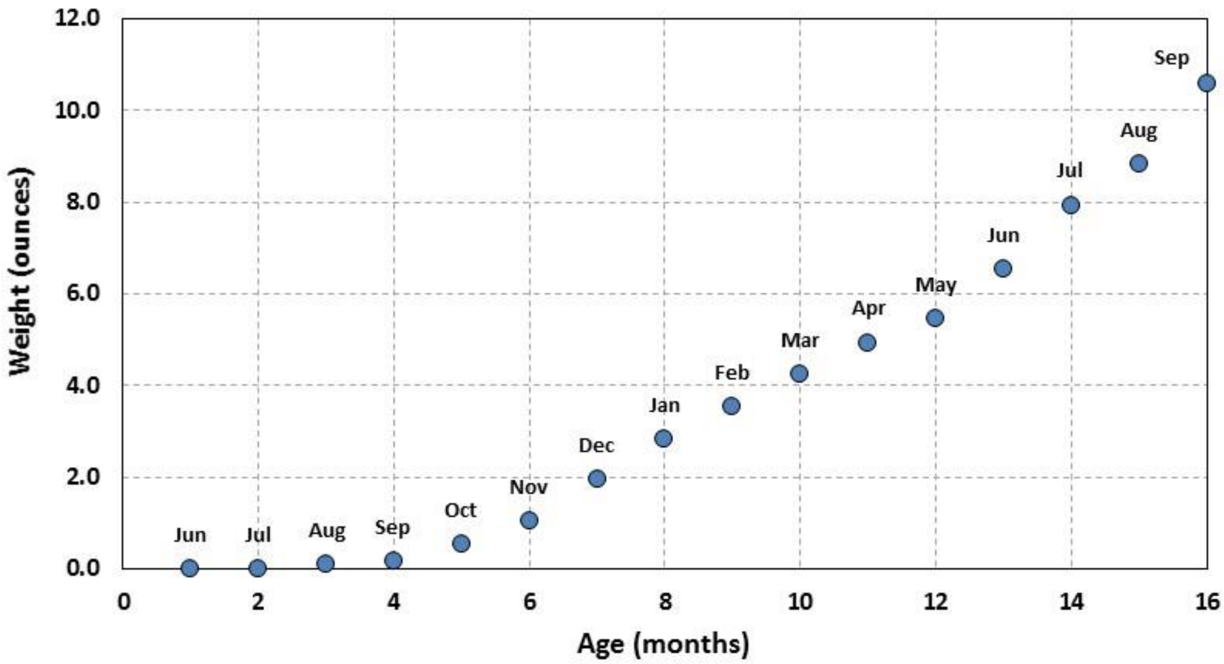

Figure 101. Projected average weight of hatchery-produced sturgeon by age at water temperatures of 14-17°C (57-63°F).

8.11) Food type and amount fed, and estimates of feed conversion efficiency.

Feeding rates of fry, juveniles and adults are 11.0, 0.8, and 0.3% of body weight per day. Fish are fed with an artificial diet. Conversion efficiency varies with fish size.

8.13) Smolt development indices, if applicable

Not applicable.

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[35] *The production plan calls for release of 5,000 age 0+ fish in John Day Reservoir during fall for evaluation of effects of size and time of release on survival. These fish may be produced at a single facility or a supplemental facility whose construction will be contingent on funding available after the primary facility is completed.*

8.14) Use of "natural" rearing methods.

“Natural” rearing methods have not been developed for hatchery sturgeon.

8.15) Unknowns

Effective methods for spawning, incubation, and rearing have become well established over the last 20 years but room for improvement still exists. Rearing of wild-caught larvae may ultimately prove to be a more desirable and effective production strategy than conventional broodstock collection. Wild larvae potentially allow all spawners to participate in natural production in years of favorable environmental conditions and represent a broader spectrum of the natural diversity. However, efforts to employ this method in upper Columbia sturgeon conservation programs have identified significant problems with mortality in the hatchery while getting wild larvae onto feed, and fish health apparently related to capture and handling stress. It remains to be determined whether sufficient numbers of wild larvae can be cost-effectively captured in lower mid-Columbia systems to meet production targets.

13.2.9 SECTION 9. RELEASE

9.1) Life history stage, size, and age at release.

Production of 31,500 juvenile sturgeon will initially be released at different sizes and times in order to determine the most cost effective approach for continuing application. The majority of production (20,000 fish) in the lower mid-Columbia Reservoirs will be released in spring at just under one year of age, weighing approximately 125 g. A fall release of age 0+ juveniles (5,000), weighing approximately 20 g, and a fall release of age 1+ juveniles (1,500), weighing approximately 300 g will also be evaluated. A spring release of up to 5,000 age 1 juveniles will occur in the three lower Snake River reservoirs.

9.2) Life history stage, size and age of natural fish of same species in release area at time of release.

Currently, sturgeon live their entire life cycle in John Day, The Dalles, Bonneville, and lower Snake reservoirs. Consequently all life history stages, sizes, and ages of wild sturgeon may be present in the release area at the time of release.

9.3) Dates of release and release protocols.

Release of juvenile sturgeon will be forced. Specific dates for release of juveniles will be managed adaptively.

9.4) Location(s) or release.

Releases will initially occur in John Day Reservoir which includes a large area of underutilized sturgeon habitat that historically supported a much larger sturgeon population and the lower Snake Reservoirs. The McNary reservoir/Hanford Reach in the Columbia is a candidate for future hatchery supplementation of sturgeon based on poor natural recruitment and current low population densities. Releases of hatchery sturgeon in this reach will be considered at such time as mitigation and fishery needs are satisfied in Zone 6 reservoirs.

9.5) Acclimation procedures.

The water temperature in rearing tanks will be adjusted to be similar to the anticipated ambient water temperature at the release locations.

9.6) Number of fish released

Initial release objectives are 31,500 juvenile White Sturgeon per year.

9.7) Marks used to identify hatchery fish.

All hatchery juvenile sturgeon will receive an external mark by removal of a unique pattern of lateral scutes. In addition, all or a representative subsample of releases will receive a passive integrated transponder (PIT) tag. Adult sturgeon used for broodstock will receive a PIT tag prior to release.

9.8) Unknowns

Hatchery effectiveness will ultimately be evaluated based on the quantity and quality of fish produced. Effective hatchery strategies invariably involve tradeoffs between numbers and size of release. Larger, older sturgeon typically survive better than smaller sturgeon following release. However, space, cost, and water constraints generally limit the numbers of large fish that can be reared.

While large numbers of juvenile sturgeon can be produced and released from the hatchery, experience in other areas has shown that the large majority of these fish do not survive beyond their first year in the wild. The rearing capacity of lower Columbia and Snake river impoundments for sturgeon is unknown.

13.2.10 SECTION 10. MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

As part of the monitoring, research, and evaluation (MR&E) plan for the sturgeon hatchery program, eight key uncertainties have been identified:

1) Feasibility of Wild Larvae Collection
2) Optimum Rearing Methods for Juveniles
3) Optimum Release Strategy
4) Hatchery Contributions to the Population and Fisheries
5) Sturgeon Carrying Capacity
6) Hatchery Genetic Effects
7) Ecological Interactions
8) Alternatives for Improving Natural Recruitment

The first two key uncertainties (1 and 2) were discussed in Section 8.15 and Uncertainties 3, 4 and 5 were discussed in section 9.8. Uncertainty 6 was discussed in Section 7.5. Uncertainties 7 and 8 are described below.

Ecological Interactions

Sturgeon are likely a significant component in the river and reservoir aquatic ecosystem but the dynamics of these systems and the role and effects of sturgeon are poorly understood.

Alternatives for Improving Natural Recruitment

Poor or inconsistent natural recruitment currently limits production in many or most impounded subpopulations. While natural recruitment has been generally correlated with river discharge during spring and effects are area-specific, the mechanism(s) of recruitment failure are poorly understood. Effective remedies for improving natural production remain to be determined through ongoing research efforts conducted outside the scope of specific hatchery-related monitoring, research, and evaluation activities by complementary sturgeon projects under the NPCC Fish and Wildlife program.

A list of performance indicators and reference values for the sturgeon hatchery program is provided in Section 1.8. The following sections provide MR&E information related to broodstock and larval collection, operations, and post-release of sturgeon juveniles. In addition, information related to fish marking, genetic data, and survival and fecundity is provided.

10.1) Hatchery Effectiveness – Broodstock & Larval Collection

MR&E Objective 1 is to monitor and evaluate effectiveness and efficiency of collection of wild broodstock and larvae for use in hatchery production. The hatchery implementation strategy initially involves a combination of conventional broodstock and wild larvae collection. Wild larvae are potentially a more desirable source of hatchery production due to genetic considerations. However, collection, disease and survival issues with larvae collection will need to be resolved. In the meantime, wild broodstock will provide an effective and well-established source of hatchery production. The program will concurrently develop wild larvae collection and husbandry methods.

Future applications of adult broodstock and wild larvae methods will be based on the relative effectiveness and efficiency of each alternative in achieving program objectives. Monitoring and evaluation will be key to that determination. Identifying times and areas where substantial numbers of wild larvae may be collected will be a particular challenge. This method has proven effective in the upper Columbia for meeting conservation objectives but fishery mitigation objectives require substantially more fish than a strict-conservation program.

Both broodstock and larval collection efforts will be closely monitored in order to optimize effectiveness and efficiency over time. Effectiveness will be evaluated relative to numerical objectives based on genetic considerations. Efficiency will be evaluated based of effort and catch rates of setline and gillnet sampling for adults.

10.2) Hatchery Effectiveness – Operational Monitoring

MR&E Objective 2 is to monitor and evaluate operational effectiveness of the hatchery based on water quantity and quality, fish production, genetic representation, and fish health. Water

quantity and quality monitoring includes flow rates, temperature, dissolved oxygen, nutrients, and chemistry of the inflow, discharge and key points in the system.

Fish production monitoring includes estimates of numbers, survival, growth, and feed conversion rates by life stage. Fish production targets of this program are identified in Section 8 of the master plan and Table 22. Hatchery systems and operations are designed to manage fish numbers by life stage in order to meet production targets. Production monitoring inventories the hatchery population at key stages to track progress relative to planning values. These inventories are the basis for managing fish numbers and sizes at various stages by managing water temperature, feeding, and containers or by transferring, releasing, or culling portions of the production.

Genetic representation is monitored based on parental contribution by family, haplotype frequencies, and the incidence of autoploidy. The aim is to ensure that the program includes a diverse sample of the wild subpopulation and avoids inadvertent selection or other undesirable genetic effects. Production will be subsampled a key stages including post-fertilization and pre-release.

Fish health monitoring includes pathogen testing of broodstock and larvae brought into the facility and of hatchery juveniles prior to release, tracking of mortality rates, and additional testing as required. Sturgeon hatchery operations include systems and protocols for monitoring and minimizing pathogen introduction and transmission in hatchery and wild subpopulations. Maintaining optimal rearing conditions will reduce or prevent stress-related disease outbreaks in the facility. Fish health will also be assessed based on fish growth and condition in normal production monitoring.

10.3) Hatchery Effectiveness – Post Release Monitoring

MR&E Objective 3 is to monitor and evaluate post-release performance and effects of hatchery-origin sturgeon. Post-release performance of hatchery-reared sturgeon in John Day Reservoir will be evaluated based on monitoring of population parameters including survival, abundance, growth, and condition. All hatchery juvenile sturgeon will receive an external mark by removal of a unique pattern of lateral scutes. In addition, all or a representative subsample of releases will receive a passive integrated transponder (PIT) tag.

Juvenile sturgeon will be recaptured annually with small mesh gillnets similar to those currently employed in wild year-class strength assessments. Dedicated gillnet sampling will provide information on fish up to approximately 25 inches in length (ages 1 to 6).[36] Larger fish will be sampled with ongoing stock assessment efforts using setlines and large-mesh gillnets.

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[36] *Small mesh gillnetting is currently conducted in ongoing stock assessments to index year class strength. This sampling effort will be substantially increased in John Day Reservoir to assess hatchery fish performance. This change will be accommodated by reducing Treaty Tribal stock assessment*

Population parameters will be estimated based on multiple mark-recapture models. Population data will provide a basis for evaluation of a number of key questions or hypotheses. The initial hatchery strategy involves release of fish at various ages, sizes and season. Relative survival of fish from these release groups will be evaluated to identify optimum strategies for future production – optimum strategies will involve tradeoffs between hatchery capacity to produce fish of a given size and subsequent survival of those fish.

Another critical question is whether or when population parameters respond to increasing fish density – this is the habitat rearing capacity question. Population parameters will be related to fish abundance over time as the hatchery-origin population increases. Density-related responses might be expected to occur in survival, growth or condition factor.

10.4) Hatchery-Optimization Research

MR&E Objective 6 is to identify operational alternatives that enhance the efficiency and quality of sturgeon hatchery production. Operational effectiveness can be improved by dedicated research into various practices. The Water & Environmental Center (WEC) operated by the Confederated Tribes of the Umatilla Indian Reservation in cooperation with the Walla Walla Community College is identified in this plan as a primary research facility for the sturgeon hatchery program. Additional research and experimentation will also occur at primary and supporting hatchery facilities.

10.5) Marking

All hatchery juvenile sturgeon will receive an external mark by removal of a unique pattern of lateral scutes. In addition, all or a representative subsample of releases will receive a passive integrated transponder (PIT) tag.

Wild sturgeon populations from The Dalles, John Day, and Bonneville reservoirs are sampled once every three years. Fish are marked with PIT tags and abundance is currently estimated with mark-recapture methods.

10.6) Genetic data

Genetic representation is monitored based on parental contribution by family, haplotype frequencies, and the incidence of spontaneous autoploidy, which is an increase in genome size. The aim is to ensure that the program includes a diverse sample of the wild subpopulation and avoids inadvertent selection or other undesirable genetic effects. Production will be subsampled a key stages including post-fertilization and pre-release. Reference values for parental contribution within each family are 10 percent from each male and 10 percent from each female

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efforts for wild sturgeon in Bonneville and The Dalles Reservoir. Wild sturgeon population assessments will continue in all three Zone 6 reservoirs based on setline sampling programs conducted by Oregon and Washington. Effects of reduced sampling effort with large mesh gillnets on parameter estimate precision will be addressed by refinements in the wild population experimental design to capitalize on multiple mark-recapture data.

used in each family group. The reference value for autoploidy is less than 5 percent incidence. Haplotype frequency objectives have yet to be established.

10.7) Survival and fecundity

The Sturgeon Hatchery Program is new; consequently, no past performance is available. The egg take from individual females will be small (less than 10%) compared to total fecundity. The target number of juveniles by life stage is provided in Table 22. These objectives will be reached by combination of mortality and culling. Overall target survival to release, (5000 age 0, 25000 age 1, 1500 age 1+) is 2.65%. This includes mortality due to culling. Following release, the reference values for annual survival rates range from at least 20 percent to at least 95 percent (Table 53).

Table 53. Metrics and reference values for monitoring and evaluating post-release performance of hatchery fish.

Attribute	Metric	Reference value
Population	Annual recapture rate	≥ 5%
	1^{st}- year survival	≥ 20%
	2^{nd}- survival	≥ 80%
	3+ year survival	≥ 95%
	Abundance	Significant Increasing trend
	Growth rate	2-3 in. / year
	Condition factor (relative weight)	≥ 100%
	Emigration to adjacent reservoirs	≤ 5% in aggregate

13.2.11 SECTION 11. RESEARCH

Three areas of research will be ongoing in association with the HGMP. These include wild stock assessment, fishery monitoring, and other research. A list of performance metrics and reference values are provided in Section 1.8.

11.1) Objective or purpose

The objective of wild stock assessment is to monitor and evaluate status and trends of wild sturgeon populations.

The objective of fishery monitoring is to evaluate fishery contributions and management effectiveness for hatchery-origin sturgeon.

The objective of other research is to address critical uncertainties with application to sturgeon restoration, mitigation and management.

11.2) Cooperating and funding agencies

This is a cooperative program involving the four Columbia River Treaty Tribes with assistance by the Columbia River Inter-Tribal Fish Commission.

11.3) Principle investigator or project supervisor and staff

Columbia River Inter-Tribal Fish Commission: Blaine Parker
Yakama Nation: Donella Miller

11.4) Status of stock, particularly the group affected by project

Sturgeon in The Dalles, John Day, Bonneville and lower Snake River reservoirs are not listed under ESA. Other information regarding their status is provided in Section 2.2.

11.5) Techniques: include capture methods, drugs, samples collected, tags applied

Wild Stock Assessment

As part of ongoing sturgeon mitigation and management efforts, annual stock assessments are conducted in Zone 6 reservoirs to estimate wild subpopulation status and trends based on abundance, size composition, growth and condition factor. Sampling is conducted with setlines and large mesh gillnets to which sturgeon are recruited at approximately 25 to 40 inches. Each reservoir is sampled once every three years. Fish are marked with PIT tags and abundance is currently estimated with mark-recapture methods. Individual data on length and weight is used to estimate growth and condition. Size composition and growth information is the basis for projections of near-term recruitment of sturgeon into fishery size slots. These estimates are the basis for development of annual harvest guidelines.

Fishery Monitoring

An extensive sturgeon harvest monitoring program is conducted for treaty Indian and non-Indian fisheries between Bonneville and McNary dams. This information is used to monitor sturgeon harvest over the course of the year and provides near term information needed to manage these quota-based fisheries.

Harvest in commercial fisheries is estimated from fish tickets which are reported from fish buyers for all fish purchased. Biological data including lengths, weights and tags, are also collected from subsamples of the commercial catch at the fish buying stations.

Subsistent harvest is estimated based on a survey program of treaty tribal fishers. This survey is conducted by the Yakama Nation fisheries program.

Sport fishery harvest is monitored in Zone 6 reservoirs during sturgeon retention seasons with a roving angler survey. This survey estimates angler effort from index counts and angler catch rates from angler interviews. Biological data is also collected from the catch of interviewed angler. Sport fisheries upstream from McNary Dam are not monitored in-season – catches are estimated post season from catch record cards.

Biological data from fishery samples is incorporated into stock assessments, which are conducted in each reservoir every three years. Stock assessments involve mark-recapture sampling of sturgeon captured with gillnets and setlines. These efforts produce estimates of size-specific abundance which are used to assess population status and adjust harvest guidelines.

Other Research

Hatchery-related monitoring, research, and evaluations will be conducted as part of a comprehensive restoration, mitigation and management effort for impounded White Sturgeon subpopulations. Research needs identified in the Columbia Basin White Sturgeon Planning

Framework (Beamesderfer & Anders 2015) that are particularly pertinent to the lower mid-Columbia Region includes:

- Identify the genetic population structure among impounded and unimpounded White Sturgeon subpopulations throughout the region.
- Resolve uncertainties in sturgeon life history regarding maturation and age
- Identify mechanisms of recruitment failure among impounded populations in order to provide insights into effective alternatives for remediation.
- Evaluate the feasibility of improving natural recruitment of selected White Sturgeon subpopulations by dam flow management and dam operations.
- Evaluate the feasibility of improving natural recruitment of selected White Sturgeon subpopulation by habitat restoration actions such as substrate enhancement.
- Evaluate the feasibility of improving sturgeon productivity in the unimpounded lower Columbia and in impounded subpopulations by improvements in adult and/or juvenile passage opportunities.

13.2.12 SECTION 12. ATTACHMENTS AND CITATIONS

See Sturgeon Hatchery Master Plan

13.3 ABBREVIATIONS AND ACRONYMS

BCMA	British Columbia Ministry of Agriculture
BiOp	2000 Federal Columbia River System Biological Opinion
BPA	Bonneville Power Administration
CRFMP	Columbia River Fishery Management Plan
CRITFC	Columbia River Inter-Tribal Fish Commission
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CTWSRO	Confederated Tribes of the Warm Springs Reservation of Oregon
EA	Environmental Assessment
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
GMU	Genetic Management Unit
HGMP	Hatchery and Genetic Management Plan
HSRG	Hatchery Scientific Review Group
IDFG	Idaho Fish and Game
IPC	Idaho Power Company
ISAB	Independent Scientific Advisory Board
ISRP	Independent Scientific Review Panel
KTOI	Kootenai Tribes of Idaho
NEPA	National Environmental Policy Act
NPCC	Northwest Power and Conservation Council
NPT	Nez Perce Tribe
NTU	Nephelometric turbidity units
PUD	Public Utility District
ODFW	Oregon Department of Fish and Wildlife
ONFCP	Oregon Native Fish Conservation Policy
PAH	Polycyclic aromatic hydrocarbons
PCH	Polychlorinated hydrocarbons
SMTF	Sturgeon Management Task Force
TAN	Total ammonia nitrogen
TDS	Total dissolved solids (TDS),
TMDL	Total maximum daily load
UCWSRI	Upper Columbia River White Sturgeon Recovery Plan
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
YN	Yakama Indian Nation