RANGE-WIDE

PALLID STURGEON

STOCKING PLAN

ORIGINAL UPPER BASIN STOCKING PLAN 1997
ORIGINAL RANGE-WIDE STOCKING PLAN 2008

FINAL MAY 2019

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RANGE-WIDE
PALLID STURGEON
Stocking Plan

Prepared by FWS R6 Fisheries and Aquatic Conservation

for

Region 6
U.S. Fish and Wildlife Service
Denver, CO

Approved: _____ 7/9/19
Regional Director Date

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EXECUTIVE SUMMARY

Background

The Pallid Sturgeon, *Scaphirhynchus albus,* was listed as endangered in 1990 by the U.S. Fish and Wildlife Service. The primary cause for decline was identified as habitat loss and flow modifications attributed to construction of reservoirs and dams and to dam operations on the Missouri River (USFWS 1990). The Pallid Sturgeon Recovery Plan recognized that recovery actions related to habitat and flows would take decades to achieve (USFWS 1993). To prevent extinction in the interim, it was deemed imperative that extant populations of Pallid Sturgeon be conserved genetically and demographically to allow for restoration of wild, self-sustaining populations as habitat conditions can be managed and improved.

With few wild individuals remaining and recruitment negligible, conservation of extant populations could be supported through development of a Pallid Sturgeon Conservation Propagation and Stocking Program (CPSP) that includes strategies for genetics management, propagation, fish health, stocking and assessment (USFWS 1993, 2014). In years since Pallid Sturgeon was listed, USFWS has worked with State and Federal partners to plan and implement a propagation and stocking program. Early plans to pioneer this program include *the Pallid Sturgeon Propagation and Genetics Plan* (Bollig 1993) and *Stocking/Augmentation Plan Guidelines for the Pallid Sturgeon* (Whitmore 1995). *A Stocking/Augmentation Plan for the Pallid Sturgeon (Scaphirhynchus albus) in Recovery Priority Management Areas 1 & 2 in Montana and North Dakota* was developed in 1997 (USFWS 1997) and the *Pallid Sturgeon Range-wide Propagation Plan* was finalized in 2005 (USFWS 2005) with updates in 2018. The first *Range-wide Pallid Sturgeon Stocking and Augmentation Plan* was finalized in 2008 (USFWS 2008) with an *Upper Basin Genetics Management Plan* completed in 2013 (Heist, 2013). The program has proven successful to date at preventing local extinction of populations in the Missouri and Yellowstone Rivers and for supplementing wild pallid sturgeon.

The purpose of this document is to update and replace the Range-wide Pallid Sturgeon Stocking and Augmentation Plan (USFWS 2008).

Stocking Plan and Goals

In accordance with the Pallid Sturgeon Recovery Plan (USFWS 2014), the primary strategy for recovery of Pallid Sturgeon is to:

1) Conserve the range of genetic and morphological diversity of the species across its historical range;
2) Fully quantify population demographics and status within each management unit;
3) Improve population size and viability within each management unit;
4) Reduce threats having the greatest impact on the species within each management unit;
5) Use artificial propagation to prevent local extirpation within management units where recruitment failure is occurring.

Implied in item 5 is the need to develop a successful propagation and stocking program which increases the survival of hatchery-origin Pallid Sturgeon in the wild. This program serves as a safeguard against future loss and as a way to improve our understanding of life-history, recruitment and habitat needs for Pallid Sturgeon. This stocking plan serves to guide and inform stocking activities as part of the comprehensive CPSP as it is jointly employed by Federal and State partners using a scientifically based, collaborative and adaptive management approach.

As noted in the Pallid Sturgeon Recovery Plan (USFWS 1993, 2014), stocking, and resultant survival of hatchery-origin Pallid Sturgeon is not a substitute for a self-sustaining, genetically and demographically diverse wild population; nor does information learned from stocking necessarily replace ecological insights into and conditions appropriate for that learned from wild-produced populations. Stocking is an important tool for augmenting extant populations in the near-term while habitat and threats are being addressed. As management actions that support Pallid Sturgeon survival in the wild are implemented and it is scientifically documented that wild-produced Pallid Sturgeon are able to recruit and reproduce in the wild, we anticipate less reliance on stocking to the point where stocking will be reduced and ultimately eliminated. Improved understanding of stocked Pallid Sturgeon survival rates, carrying capacity, population viability, and other factors could also lead to reduced or intermittent (versus annual) stocking of Pallid Sturgeon in the future. Flow and physical habitat improvements for Pallid Sturgeon are expected to increase riverine productivity, potentially allowing for increased carrying capacity compared to current flow and habitat regimes. There remains much to be learned about what is necessary for a wild, self-sustaining population beyond simply reproduction in the wild. In the meantime, there is a limited window of time to ensure the protection and support of extant populations such that recovery can be achieved in the future. To date the success of the CPSP has provided a buffer to the extirpation of extant populations; however, the CPSP continues to be a critical, near-term priority action necessary to increase the likelihood of long-term recovery.

The CPSP goals, which guide genetics, propagation, stocking, and population assessment are to:

1) Increase the number of individuals in specific management units where the population is deemed demographically threatened by low numbers **(POPULATION SIZE)**

2) Establish year-classes to support population sustainability in specific geographic management units that do not have a self-sustaining population structure (lack multiple year-classes and/or successful reproduction) **(POPULATION STRUCTURE)**

3) Achieve genetically representative and diverse populations with sufficient effective population sizes (Ne) across the species' range that can maintain self-sustaining, wild-reproducing populations into the future **(GENETIC VIABILITY)**

4) Establish and/or maintain refugia populations within the species' historic range to ensure against future catastrophic loss **(POPULATION RESILIENCE)**

5) Understand and learn about the species' life history, habitat and flow needs, and effectiveness of management actions through strategic stocking **(RESEARCH)**

Adaptive Changes in the Stocking Program

The earliest stocking targets were based on balanced family lot and genetic representation using a conservative number to support the effective population size (Ne) and demographic population goal (USFWS 1997). Basin workgroups, which develop and implement propagation and stocking strategies, have accepted and generally agreed-upon concepts for controlled propagation and stocking (USFWS 2018). However, ecological, physical, genetic and jurisdictional differences result in some geographic variation in strategies for Pallid Sturgeon stocking.

Each year, biologists, scientists and managers convene to share results of ongoing field and lab work and consider changes to the program approaches to increase effectiveness and promote population recovery. Over the past two decades, this information has improved our understanding of propagation, stocking, genetics, life-history, ecology, gear-use and sampling effectiveness within each basin and range-wide. The CPSP program does reflect some local population and habitat differences, as well as jurisdictional differences in how state and local field offices stock and sample; however, guidance for propagation and stocking is standardized through CPSP plans, and these plans are intended to guide all Pallid Sturgeon propagation and stocking efforts.

The level of coordination necessary for the complex network of hatchery managers, field biologists, agency leadership and regional scientists requires significant resources for planning, implementing, tracking and communicating program results. This type of program is necessarily adaptive as newly generated information shapes future program decisions. It is also important to ensure the process and decision-making is clear and articulated as part of a larger network of programs and work within the Missouri and Mississippi rivers. Current success reflects adaptive learning and the extensive resources invested in capacity, funding and operations. However, there remains a need for more clearly articulated decision process and program evaluation.

Stakeholders, scientists and managers need a clear framework for the stocking decision process and criteria that ensure the best available information as well as clearly delineated channels for input and feedback are well-documented, adaptive in nature and provide transparent decision-making. Although the CPSP is inherently adaptive and collaborative, decision process and criteria have not been comprehensively tracked basin-wide or documented as an over-arching CPSP. The CPSP is working to adopt an adaptive management process for decision-making which will include criteria and benchmarks for achieving objectives. When in place, the CPSP adaptive process is intended to be science-based, fully transparent, and should promote trust among managers, stakeholders and the public, creating a better likelihood of continued support and success in achieving program objectives.

Stocking Targets

Long-term stocking program designs and strategies are described in this document along with the current stocking targets. Annual stocking targets are the scientifically or expert derived number and genetic parentage of fish to be stocked annually. These are calculated annually by Basin Workgroups through the guidance and side-boards of this plan and under the guidance and participation of U.S. Fish and Wildlife Service (USFWS) and States to achieve recovery goals.

Stocking targets are based on:

1) Sturgeon survival rates, demographic and genetic information, effective population size, and life-history information reported in both peer-reviewed literature and agency reports/grey literature.

2) Management unit or reach Pallid Sturgeon-specific survival estimates and ecological conditions updated regularly with monitoring information

3) Population modeling that incorporates updated survival estimates and demographic data

4) Expert opinions from those most familiar with Pallid Sturgeon demographics, reproduction, genetics and ecological habitat (i.e. Recovery Team, Basin Workgroups, species experts).

Annual stocking targets are adjusted to reflect changes and new information accordingly. Annual evaluation of these data are imperative to ensure the best available and most up-to-date information is used to calculate stocking targets and to ensure that longer-term stocking strategies can support Pallid Sturgeon survival adequate for long-term persistence. Ultimately the CPSP adaptive management framework will further support annual adjustments to stocking targets. Stocking is not intended to simply add more fish to wild populations; rather, the intent is to eventually support the capacity for fish to survive and reproduce in the wild.

BEST AVAILABLE INFORMATION

At the time of writing, this plan incorporates the best available data and information. As new data are collected and evaluated, changes may be necessary. To ensure timely updates to this stocking plan, a regularly scheduled review of data within the context of this plan will be completed by USFWS and partners. If there is a need to modify this plan based on new or better data, the desired changes and supporting data should be submitted to the USFWS Pallid Sturgeon Recovery Coordinator (contact information below). The Recovery Coordinator will work with the Pallid Sturgeon Recovery Team in coordination with Basin Workgroups to review the information from a range-wide perspective, USFWS Regional leadership throughout the pallid sturgeon range, and submit final recommendations to the USFWS Regional Director for the Mountain-Prairie Region (Region 6) to make a final decision.

This plan is consistent with the objectives and criteria defined in the policy *Controlled Propagation of Species Listed Under the Endangered Species Act* (Controlled Propagation Policy, 65 FR 56916-56922), and objectives are accomplished using the best available information and strategies for propagation and stocking. The Controlled Propagation Policy recommends an analysis of risk. A thorough risk analysis of the CPSP is included in the Pallid Sturgeon Range-wide Stocking and Augmentation Plan (USFWS 2008). That analysis concluded that propagation and stocking are necessary to prevent extinction and do not pose a significant risk to other resources. Please refer to that plan for the reach-by-reach details of that risk analysis. In accordance with the Pallid Sturgeon Recovery Plan (USFWS 2014), the primary goal of a Pallid Sturgeon CPSP is to support efforts to achieve a self-sustaining, wild population of Pallid Sturgeon including representative population structure and genetic viability with population resilience able to withstand catastrophic events and ambient levels of anthropomorphic, ecological and physical change.

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INTRODUCTION

Pallid Sturgeon (*Scaphirhynchus albus*) is one of three species of *Scaphirhynchus* and one of eight species (including one subspecies) of sturgeon belonging to the family Acipenseridae that inhabit North America. In 1990, the Pallid Sturgeon was listed by the U.S. Fish and Wildlife Service (USFWS) as Endangered throughout its range in the Missouri and Mississippi river basins due to declining populations and fragmented habitat (USFWS 1990). Currently Pallid Sturgeon occur in fragmented portions of its historic range (Figure 1).

Following listing, the USFWS completed and approved a recovery plan for the species (USFWS 1993, updated in 2014). This plan describes the species and habitat and provides an analysis of threats and proposed recovery actions that are necessary to down list and ultimately delist the species. For a more complete description of historic and current ecology, life history and habitat use as well as an analysis of threats, please refer to the 2014 Pallid Sturgeon Recovery Plan (USFWS 2014).

RECOVERY PLANNING

Recovery-Priority Management Areas

The 1993 Recovery Plan for Pallid Sturgeon defined six Recovery Priority Management Areas (RPMAs) throughout the historic geographic range of Pallid Sturgeon (Figure 2). For institutional history and because the RPMA designations continue to be used in context of history and local stocking and sampling, the definitions are included here.

1. RPMA 1: Missouri River from the mouth of the Marias River (including 30 River Miles of the Marias River) to the headwaters of Fort Peck Reservoir.
2. RPMA 2: Missouri River from Fort Peck Dam to the headwaters of Lake Sakakawea and the Yellowstone River upstream to Cartersville and major tributaries of the Yellowstone River basin.
3. RPMA 3: Missouri River from 20 miles upstream of the mouth of the Niobrara River to Lewis and Clark Lake (free-flowing reach downstream from Fort Randall Dam and upstream of Gavins Point Dam).
4. RPMA 4: Missouri River below Gavins Point Dam to its confluence with the Mississippi River. RPMA 4 includes major tributaries (Platte, Kansas, Osage Rivers, etc.) to 20 miles upstream of the confluence with the Missouri River.
5. RPMA 5: Mississippi River from its confluence with the Missouri River to the Gulf of Mexico. RPMA 5 includes major tributaries (St. Francis, Arkansas, Yazoo Rivers, etc.) to 20 miles upstream of the confluence with the Missouri River).
6. RPMA 6: Atchafalaya River (an outflow distributary river) from the Mississippi River to the Gulf of Mexico.

The geographic boundaries of the RPMAs defined in 1993 were based on recent Pallid Sturgeon records and suitable habitat for restoration and recovery of the species. The six discrete RPMAs are considered the least degraded river stretches of the Missouri and Mississippi rivers and those that have the highest habitat diversity.

Figure 1. Geographic range of Pallid Sturgeon and location of major impoundments and water control structures on the Missouri and Mississippi rivers. Bold red lines approximate the current distribution of Pallid Sturgeon and include both natural and hatchery-origin fish (from USFWS 2014).

Although the revised Recovery Plan (USFWS 2014) describes the geographic distribution of Pallid Sturgeon in terms of four contiguous management units (see next section), RPMA descriptions continue to be used to help differentiate within-unit reaches for monitoring activities as well as use of the term in historic context; therefore terminology is retained here.

The 2008 Range-Wide Stocking Plan (USFWS 2008) defined four geographic management units (MU) for Pallid Sturgeon encompassing its historic geographic range in the Missouri, Yellowstone and Mississippi rivers (Figure 4). The purpose of the management units is to define riverine habitats important for Pallid Sturgeon in the context of a five factors. While the management units have defined boundaries, Pallid Sturgeon may be found or use habitats outside those boundaries in tributaries and/or in connected waters such as reservoirs. Those management units were defined primarily from data obtained since publication of the 1993 Recovery Plan and are based on five principal criteria that have recently been adopted in the revised Pallid Sturgeon Recovery Plan (USFWS 2014):

(1) Genetic data for Pallid Sturgeon throughout its range;
(2) Morphological differences among Pallid Sturgeon throughout its range;
(3) Biogeography of other fish species including speciation associated with physiographic provinces; many fish species are documented to separate along these physiographic province boundaries (Wiley and Mayden 1985; Burr and Page 1986; Cross et al. 1986);
(4) Common threats; and
(5) Potential need and ability to implement different management actions across management units to address varying threats within management units.

Designated Management Unit descriptions cross-referenced with RPMA reaches

The following describes the boundaries of GMUs (Figure 2). The description also provides a cross reference of the RPMAs designated in 1993 in context of over-arching MUs.

1. Great Plains Management Unit (GPMU): Great Falls of the Missouri River and the Yellowstone River and major tributaries, Montana to Fort Randall Dam, South Dakota.
   - Includes RPMAs 1 and 2.

2. Central Lowlands Management Unit (CLMU): Missouri River from Fort Randall Dam to the confluence of the Grand River, including the lower Platte and lower Kansas rivers.
   - Includes RPMA 3 and upper part of RPMA 4 from Gavins Point Dam to the mouth of the Grand River.

3. Interior Highlands Management Unit (IHMU): Missouri River from the confluence of the Grand River to the confluence of the Mississippi River, including the Mississippi River from Keokuk, Iowa to the confluence of the Ohio and Mississippi rivers.
   - Includes lower part of RPMA 4 from the Grand River to the confluence of the Mississippi River.

4. Coastal Plain Management Unit (CPMU): Mississippi River from the confluence of the Ohio River downstream to the Gulf of Mexico, including the Atchafalaya River outflow (distributary) system.
   - Includes RPMAs 5 and 6.

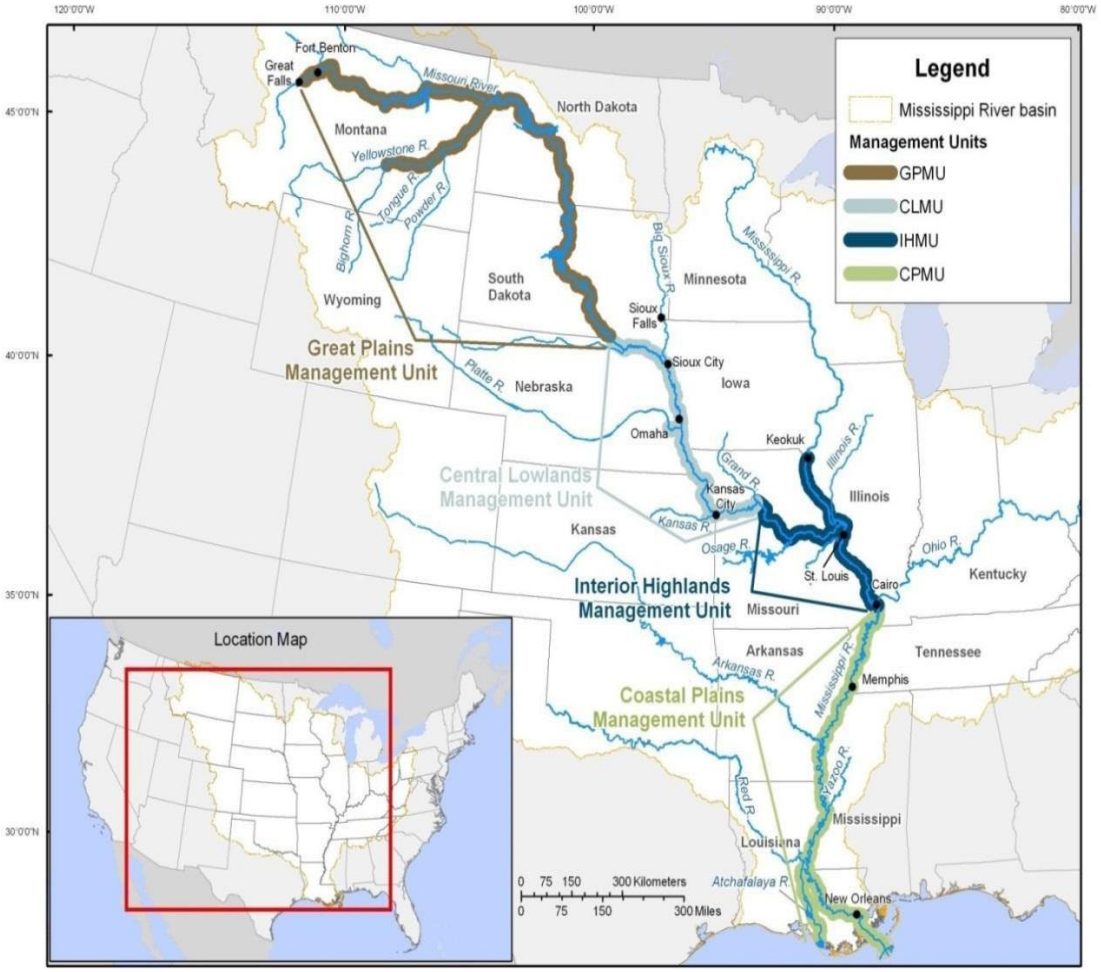


Figure 2. Geographic management units for Pallid Sturgeon in the Missouri and Mississippi river basins: (1) Great Plains Management Unit (GPMU); (2) Central Lowlands Management Unit (CLMU); (3) Interior Highlands Management Unit (IHMU); (4) Coastal Plains Management Unit (CPMU) (from USFWS 2014).

Pallid Sturgeon Recovery Basin Workgroups

Propagation, management, research and monitoring of Pallid Sturgeon are coordinated geographically by three workgroups which act as the recovery implementation arm of the Pallid Sturgeon Recovery Program: the Upper Basin Pallid Sturgeon Workgroup, the Middle Basin Pallid Sturgeon Workgroup, and the Lower Basin Pallid Sturgeon Workgroup

Each workgroup includes key representatives from relevant Federal, State and/or local agencies, universities, non-government organizations and private entities. The geographic

focus of the three workgroups overlap the four Pallid Sturgeon management units and are sometimes colloquially referred to as recovery areas or recovery basins.

Geographic focus of the Upper Basin Workgroup includes the Missouri River and Yellowstone River in Montana, North Dakota and South Dakota (RPMA 1 and 2) upstream of Gavins Point Dam, comprising the GPMU, plus a small portion of CLMU between Randall Dam and Gavins Point Dam (RPMA-3).

The Middle Basin Workgroup focus is on recovery implementation in the Missouri River in South Dakota, Nebraska, Kansas, Iowa, and Missouri from Gavins Point Dam to the confluence of Mississippi River, and the Mississippi River from Keokuk, IA to the confluence with the Ohio River encompassing the CLMU and IHMU (RPMAs 4 and 5).

The Lower Basin Workgroup geographic focus includes the Mississippi River in Kentucky, Missouri, Tennessee, Arkansas, Mississippi, and Louisiana from the confluence of the Ohio River to the Gulf of Mexico, and the Atchafalaya River downstream to the Gulf of Mexico encompassing the CPMU (RPMA 6) (http://www.pallidsturgeon.org/recovery/map/).

The Upper Basin Workgroup (UBWG) was established shortly after the initial listing of Pallid Sturgeon in 1990. Since that time, the UBWG led development of the CPSP in research, planning and implementation (USFWS 2005). The Middle and Lower Basin Workgroups have largely adopted the plans and guidance documents initially developed by the Upper Basin Work Group related to propagation and stocking, although they have also developed basin recovery strategies specific to local ecological and genetic conditions and have contributed substantially to the body of information supporting the CPSP.

CONSERVATION PROPAGATION AND STOCKING PROGRAM PURPOSE AND GOALS

The following excerpt from the Pallid Sturgeon Recovery Plan (2014) directs development and implementation of a CPSP:

4. IMPLEMENT AND EVALUAT[E] A CONSERVATION PROPAGATION AND STOCKING PROGRAM

4.1 Implement a Conservation Propagation and Stocking Program
Current stocking efforts are conducted in accordance with a range-wide stocking plan (USFWS 2008). This plan should be amended if necessary using adaptive management principles as new data become available from Tasks 3.1-3.3 and 4.2.

GPMU, CLMU, IHMU, CPMU

(1) Annually review, update if necessary, and implement range-wide stocking and propagation plans using the most recent information.

(2) Annually review and update the tagging plans with the most recent information.

(a) Improve tagging mechanisms to minimize tag loss/failure in hatchery produced fish.
    (i) Ensure that genetic samples are collected from all fish used in propagation efforts.
    (ii) Continue to evaluate tag placement location for improved PIT tag retention.
    (iii) Ensure that all monitoring crews have appropriate tag reading equipment.
(b) Ensure that all field crews throughout the Missouri and Mississippi River drainages have appropriate equipment to read tags.
(c) Implement tagging plan.

4.2 EVALUATE SUCCESS OF PROPAGATION AND STOCKING PROGRAM
GPMU, CLMU, IHMU, CPMU

(1) Evaluate Pallid Sturgeon supplementation using various age classes of progeny.
    (a) Use data to derive Pallid Sturgeon specific survival rates where stocking occurs.
    (b) Use data to refine stocking strategies:
        (i) Determine optimal stocking numbers,
        (ii) Determine optimal stocking size,
        (iii) Determine optimal stocking time and location.
    (c) Evaluate dispersal of hatchery progeny.
    (d) Evaluate effectiveness of hatchery products within each management unit.
    (e) Determine when stocking is no longer needed.
(2) Ensure that hatchery stocking and propagation records are incorporated into integrated a range-wide species recovery database.

4.3 RESEARCH METHODS TO IMPROVE SPAWNING, CULTURING, REARING, AND STOCKING OF PALLID STURGEON
GPMU, CLMU, IHMU

(1) Continue to refine efficient, effective spawning techniques in the hatcheries and in the field.
(2) Conduct trials to determine spawning requirements of broodstock (e.g., optimal spawning temperature) and methods for maximizing survival and growth of progeny collected from broodstock.
(3) Continue to refine techniques to improve hatchery product quality and survivability.
(4) Continue to refine and improve cryopreservation techniques.
    (a) [E]nsure cryopreservation program is adequately funded to maintain sperm as long as necessary.

In accordance with the Pallid Sturgeon Recovery Plan (USFWS 2014), the primary goal of a Pallid Sturgeon CPSP is to support efforts to achieve self-sustaining, wild populations of Pallid Sturgeon including representative population structure and genetic viability and to retain population resilience that can withstand catastrophic events and ambient levels of anthropomorphic, ecological and physical change.

The current goals of the Conservation Propagation and Stocking Program are to:
1) Increase the number of individuals in specific management units where the population is deemed demographically threatened by low numbers **(POPULATION SIZE)**

2) Establish multiple year-classes in specific management units that do not have a self-sustaining population structure (lack multiple year-classes and/or successful reproduction) **(POPULATION STRUCTURE)**

3) Achieve a genetically diverse and representative effective population size (Ne) across the species' range that can maintain a self-sustaining, wild-reproducing population into the future **(GENETIC VIABILITY)**

4) Establish and/or maintain refugia populations within the species' historic range to provide against future catastrophic loss in any one unit **(POPULATION RESILIENCE)**

5) Understand and learn about life history, habitat and flow needs, and effectiveness of management actions through strategic stocking **(RESEARCH)**

POPULATION GOALS AND TARGETS

Pallid Sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery factor criteria are sufficiently addressed such that a self-sustaining genetically diverse population of 5,000 adult Pallid Sturgeon is realized and maintained within each management unit for 2 generations (20-30 years). In this context, a self-sustaining population is described as a spawning population that results in sufficient recruitment of naturally-produced Pallid Sturgeon into the adult population at levels necessary to maintain a genetically diverse wild adult population in the absence of artificial population augmentation. Additionally, in this context a genetically diverse population is defined as one in which the effective population size (Ne) is sufficient to maintain adaptive genetic variability into the foreseeable future ($N_e \geq 500$), conserve localized adaptions, and preserve rare alleles.

Given recruitment is either lacking or insufficient in portions of the range, the current strategy for Pallid Sturgeon stocking employed is to use the median number of fish stocked per parent as the baseline target. This is achieved by producing family lots from individuals that have not been previously spawned or are under-represented. This is accomplished through stocking equal numbers of progeny from each cross. Stocking above the median lot size per family lot or single parent over time could negatively impact N_e.

The following numbers will change annually as adjusted for new information. Below provides a snapshot of stocking targets in 2018 using plan guidelines:

GPMU

- Upstream of Fort Peck Reservoir (RPMA-1)
  - Annual release goal: 300 per family of yearlings.
- Fort Peck Dam downstream to Lake Sakakawea and Yellowstone River (RPMA-2)
  - Annual release goal: 400 per family of yearlings.

CLMU and IHMU

- Fort Randall to Gavins Point Dam (RPMA-3)
  - Annual release goal: 30 per family up to 240 yearlings.
- Gavins Point Dam to the Mississippi River confluence (RPMA-4)
  - Annual release goal: 280 per family of yearlings, or yearling equivalents.

STOCKING STRATEGIES TO SUPPORT TARGETS

Background

At the onset of planning for the CPSP, stocking targets included considerations for numbers to be stocked, genetic representation, and balancing family crosses to achieve a sustainable effective population size (N_e) and target demographic population size in each recovery unit through stocking no more than 1000 1-year old fish (USFWS 1995, 1997). The appropriate season and age-at-stocking was determined to be spring age-1 (fish stocked in spring after ~1 year in hatchery) based on requirements that hatchery-origin fish had to have a physical mark or tag in order to differentiate wild and hatchery-origin fish. At the time, a stocking target of 250 fish per family lot was established with as many crosses that could be produced through wild-caught brood stock. Generally, the number of crosses has been a small number because capture of wild adults remained a challenge.

Missouri River sturgeon iridiovirus (MRSIV) had a substantial impact to the GPMU hatchery program from the late 90s until mid to late 2000s. Although some survival occurred in the presence of the MRSIV, two consecutive year-classes of hatchery progeny were euthanized as part of quarantine protocols due to the virus presence. Since the virus was associated with holding the fish in the hatchery for longer periods at higher densities, it was hypothesized that stocking fish at an earlier life-stage could prevent losses due to MRSIV outbreaks. Furthermore, when genetic analyses were determined as a valid individual mark, it was no longer necessary to hold fish (and risk disease outbreak) to a size adequate for a physical tag. At the same time, detection of hatchery-origin fish that had been stocked into the wild remained low. This resulted in a shift to a strategy of stocking all available healthy hatchery-origin Pallid Sturgeon to maximize the opportunity for genetic output until sampling could detect survival in the wild. During the years between 2004 and 2010, any hatchery-origin fish that were assessed as healthy were stocked into the wild (verses culling and euthanizing fish exceeding family lot targets). This included multi-seasonal stocking events of younger life-stages (excess larval and fall fingerlings) in addition to the standard spring fingerlings.

In 2009, population estimates based on increasing numbers of recaptures in the Upper Basin, showed significant numbers of hatchery-origin fish were actually surviving in the wild contrary to earlier hypotheses. The shift was likely due to both increased sampling effectiveness and fish reaching a size that was more vulnerable to sampling gear. During the interim, control of MRSIV in hatcheries prevented virus outbreaks, while state fish health policies better reflected actual risks. Higher survival rates for hatchery-origin fish led to increased population estimates, indicating it was possible to meet population goals using initial, more conservative stocking targets. Managers and biologists also considered potential negative impacts from density dependence (carrying capacity), habitat availability and ecological food-web implications as other possible confounding factors affecting survival and system sustainability (Dutton 2017). Although not conclusive, there was information to suggest adverse effects of stocking fish beyond carrying capacity in some reaches (Steffenson and Mestle 2016; Steffenson et al. 2017). In addition, managers and biologists considered possibility of genetic

swamping as some family lots had better survival in the wild after stocking. In response to these issues, the program shifted back to the more conservative stocking strategy emphasizing Ne and balanced numbers from family lots to better capture the genetic diversity of the population and away from stocking all available progeny. As previously stated, the current strategy for Pallid Sturgeon stocking is to use the median number of fish stocked per parent as the baseline target. This is accomplished through stocking equal numbers of progeny from each cross.

Survival Estimates

In the Upper Basin (RPMAs 1, 2 and 3) initial survival estimates relied on Hadley and Rotella (2009). The current standard for survival estimates in the Upper Basin follows Rotella (2017) which uses a mathematical model for estimating the monthly and annual survival rates of released hatchery-origin Pallid Sturgeon derived from recaptures of PIT-tagged fish. The investigators use the Cormack-Jolly-Seber model in the program MARK (White and Burnham 1999) to estimate survival rates according to the characteristics of the released and recaptured fish (e.g., year class, age, time of release, recapture, fin curl or iridovirus status at time of release, sampling effort, etc.) (Rotella 2009, 2015, 2017).

Steffensen et al (2010, 2016) assessed survival and developed a modeling approach to estimate population size that informs stocking targets and objectives in stocked reaches of the CLMU and IHMU. Annual age-specific survival estimates were derived using a Cormack-Jolly-Seber model within Program MARK. Data included hatchery-origin Pallid Sturgeon (HOPS) stocked (mark) and recapture events from all sampling in the lower Missouri River.

Estimates are used in two ways for stocking:
(a) To better formulate release strategies expected to yield the highest survival probabilities within each management unit/RPMA/reach and
(b) To model projections for the number of hatchery-origin Pallid Sturgeon expected to survive to 15 years of age (sexual maturity) within each management unit/RPMA/reach to improve understanding of population response and program effectiveness.

ANNUAL STOCKING DECISIONS

Size, Condition, Location and Season at Stocking

Current stocking of Pallid Sturgeon emphasizes yearlings. It is desirable to stock HOPS as young as possible to minimize effects from hatchery-selection and to minimize costs of maintaining fish in hatcheries. However, this is balanced with a desire for the fish to be larger at stocking, thereby promoting better survival and ensuring fish can be more precisely tagged at stocking and more accurately identified when they are recaptured.

The rationale for stocking yearling fish (age-1) reflects the practical aspects of stocking at the smallest size that allows for tag retention while promoting greatest chance of survival.
With the more recent emphasis on conservative stocking targets (and away from stocking multiple year-classes of various sizes) hatcheries can meet production targets using primarily yearling fish (age-1).

Another consideration is fish condition at stocking. The CPSP must balance promoting fish condition with promoting natural representation of genetic diversity in phenotype (size or growth). Condition is a concern as fish in bad condition may not survive, but promoting growth or size over natural range of variability can result in hatchery selection and loss of natural genetic variation. In the next two years (2019-2020), under the guidance of the USFWS, the CPSP will assess the best way to develop and implement a fish health and condition index using a family lot health and history assessment to ensure hatchery-origin fish have the best opportunity to thrive in the wild while not promoting hatchery selection. The process needs to include evaluation for feasibility in rearing, methodology, effectiveness in promoting goals for survival and for the over-arching CPSP relative to recovery goals for Pallid Sturgeon.

Stocking locations are determined by basin workgroups. They are based on past results, knowledge about riverine habitat and access for stocking. Total numbers of fish stocked into each management unit may slightly vary yearly as determined by local managers who have a more in-depth understanding of the management unit. If conditions in the unit are deemed unfavorable, inadequate or more favorable for proposed targets, workgroups can request an annual adjustment to reduce or increase median stocking numbers for that unit or reach. These local adjustments will be documented with the rationale that is supported by information, data or well-supported hypotheses. These statements should be included in annual stocking reports and with stocking records.

Stocking Decision Process

Through an adaptive approach, annual stocking targets and the process by which they are determined, will continue to evolve to reflect new information. The typical annual stocking process and decision points include the following:

1. **Annual stocking targets by RPMA/MUs**
2. **Brood stock availability (wild and captive/cryopreserved milt)**
3. **Progeny Produced**
4. **Number of fish requested**
5. **Number of fish stocked**
6. **Data Tracking**
7. **Program Evaluation to inform out-year stocking**
8. **Reporting**

A chain of custody for tracking and documenting stocking decisions and actions are as follows:

- **WHAT: Determination of Annual stocking target**
    - **WHO:** Basin Workgroups
      HOW: Adaptively based on CPSP guidance in light of new information
      WHEN: Final numbers are generally agreed to in late winter but can reflect discussion ongoing throughout the previous year and will use this plan for over-arching guidance
    - **Conditions - criteria**

        - Evaluate new information
            - Sound scientific conclusions
            - Fills or updates information gap
            - Hypotheses evaluated, updated and modified as needed
        - Baseline is median number of fish stocked historically in MU/RPMA
        - Include any research stocking needs (approved plans)
            - Proposals reviewed and approved by Workgroup, FWS, States
            - Project addresses priority info gap or improves understanding
        - Document how targets were derived (show calculations)
        - Document any changes from previous year, unusual requests for upcoming year, or general strategy
    - **Custody – Workgroup Chair** or designee (with support from field and hatchery personnel)

- **WHAT: Number and source of wild broodstock spawned in hatcheries**
    - **WHO:** Pallid Sturgeon Recovery Coordinator with input from Field supervisors, hatchery managers, workgroups and other partners.
      HOW: Based on broodstock/cryo-preserved milt in captivity and the capture of wild fish
      WHEN: Targeted in winter but adjusted with results until sampling conducted
    - **Conditions - Criteria**
        - Available broodstock (wild and captive/cryo) for crosses
            - Captive broodstock (F1) from deceased extant adults that are un- or under-represented as progeny in the wild
            - Extant wild broodstock that are un- or under-represented as progeny in the wild
            - Male broodstock that have not contributed milt to the cryopreserved milt repository
            - Broodstock utilized for research efforts, i.e. fish passage, flow test, spawning habitat, population assessment, etc.
        - Genetic analysis indicating unique crosses
            - Increases genetic diversity
            - New or under-represented parentage
            - Other genetic criteria for crosses
        - Document any changes due to logistics or fish condition/survival etc
        - Document rationale for crosses using genetics, logistics and other information
    - **Custody – Pallid Sturgeon Recovery Coordinator**

- **WHAT: Number of progeny produced** including where fish are produced and reared
    - **WHO:** Hatchery managers, fish health staff and propagation team
      HOW: Evaluation of propagation efforts to reach targets
      WHEN: Late spring to early fall after spawning and early life-stage rearing
    - **Conditions - Criteria**

        - Based on egg, fry and young of year rearing and survival
            - Early life-stage mortality
            - Initiation to feed mortality
        - Reared and culled as necessary to achieve targets
            - Random culling to minimize effects of hatchery production
            - Maintain densities in tanks to prevent expression of MRSIV
        - Follow fish health/condition assessment
            - See Propagation Plan
            - Follow State and Federal aquatic health standards
        - Follow fish disposition plan for excess fish
            - Target requested numbers
            - Equalize family contribution
            - Maintain healthy tank densities
        - Document any hatchery conditions or other relevant information
        - Provide data to integrated database
    - **Custody - Hatchery Manager**

- **WHAT: Determination of (Pre stocking) number of fish requested/tagged** for each GMU/RPMA/reach
    - **WHO:** Local Field Supervisors
      HOW: Baseline target with any adjustments
      WHEN: Late fall or following spring
    - **Conditions and Criteria**
        - Stocking locations determined for successful recruitment
            - Provide criteria [from field supervisors]
        - Tagging and Marking protocols followed and documented
            - Size of fish to be tagged
        - Statement of rationale for any local adjustments to baseline annual targets per reach/GMU
            - Follow guidelines to extent possible
        - Include any research stocking needs (approved plans)
            - Proposals reviewed and approved
            - Addresses information gap or improves understanding
        - Document rationale for any changes to standard procedure
    - **Custody – Local Field Supervisor** with support from Hatchery Manager

- **WHAT: Actual (Post stocking) numbers of fish actually stocked**
    - **WHO:** Field and/or hatchery personnel
      HOW: Numbers of fish released at specific localities
      WHEN: Late fall or following spring
    - **Conditions - Criteria**
        - Based on final release numbers
            - Not to exceed numbers based on targets
        - Include hatchery source, age, season at localities with a GMU/RPMA/reach

            - Supported and documented with data and analyses to extent possible
            - Explain criteria for hatchery origin choice for redundant family lots reared at more than 1 hatchery considering:
                - proximity to stocking location/transportation logistics
                - condition disparity among hatcheries for same lot
                - transportation across state lines/permits and disease
        - Include any research stocking needs (approved plans)
            - Proposals reviewed and approved
            - Addresses information gap or improves understanding
        - Document any unusual circumstances, river or environmental conditions or other at time of stocking
    - **Custody – Stocking Supervisor** (hatchery or field personnel that oversees stocking)

- **Stocking data** recorded, checked and distributed
    - **WHO:** Field and/or hatchery personnel
      HOW: Centralized databases
      WHEN: Summer, late fall or winter
    - **Conditions - Criteria**
        - Use Quality Assurance/Quality Control data protocols on above information and documentation
    - **Custody – Data Supervisor** (field personnel working with hatchery personnel)

- **Program Evaluation** based on effectiveness monitoring
    - **WHO**: Workgroup members led by chair (or designee)

  HOW: Program effectiveness monitoring
  WHEN: Late fall or winter
    - **Conditions – Criteria**
        - Follow Effectiveness monitoring
        - Ensure thorough review of analyses and conclusions
    - **Custody – Workgroup Chair** (or designee)

- **Annual stocking report** distributed to USFWS and States
    - **WHO:** Workgroup chair (or designee)
      HOW: Centralized database
      WHEN: Summer post stocking
    - **Conditions - Criteria**
        - Standardized format
        - brief report completed
        - distributed
    - **Custody - Workgroup Chair** (or designee)

Figure 3. This diagram is the CPSP decision process as part of routine decision-making.

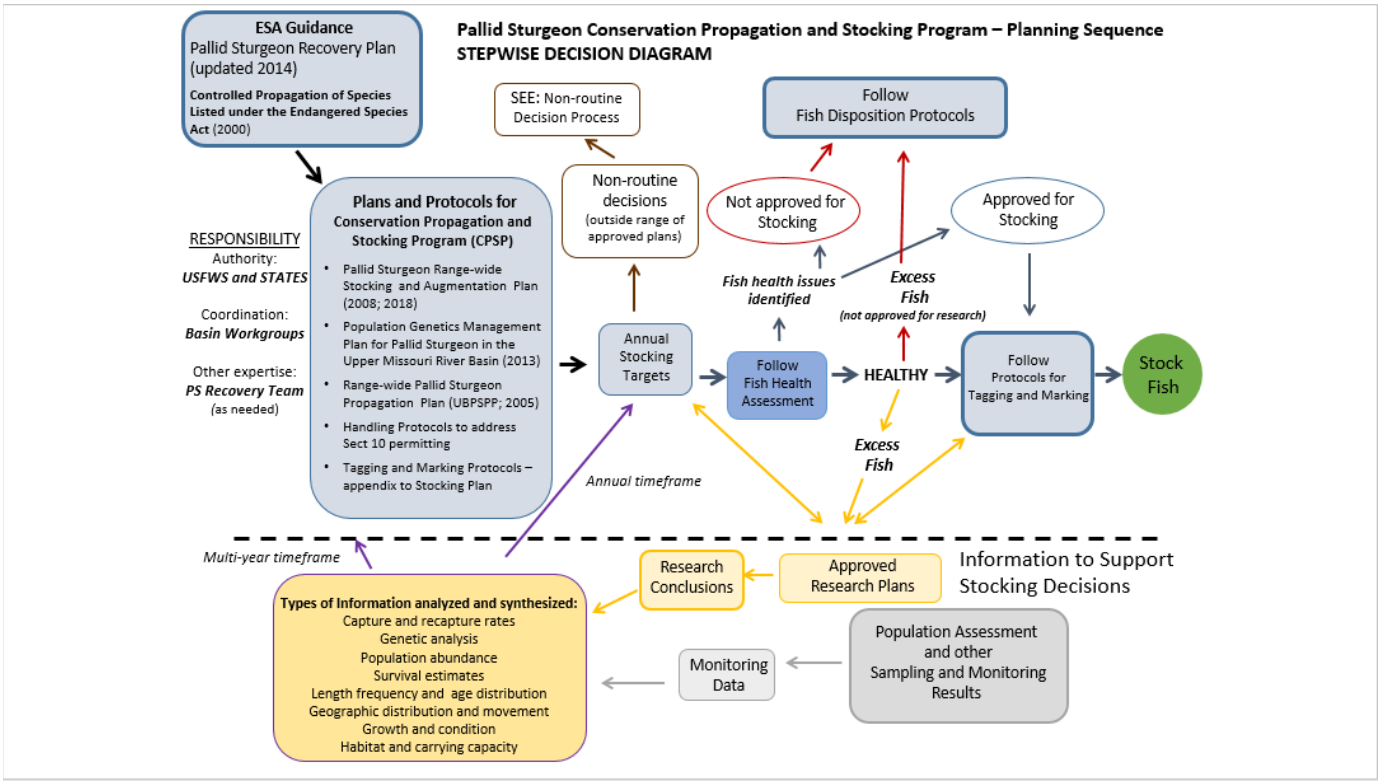
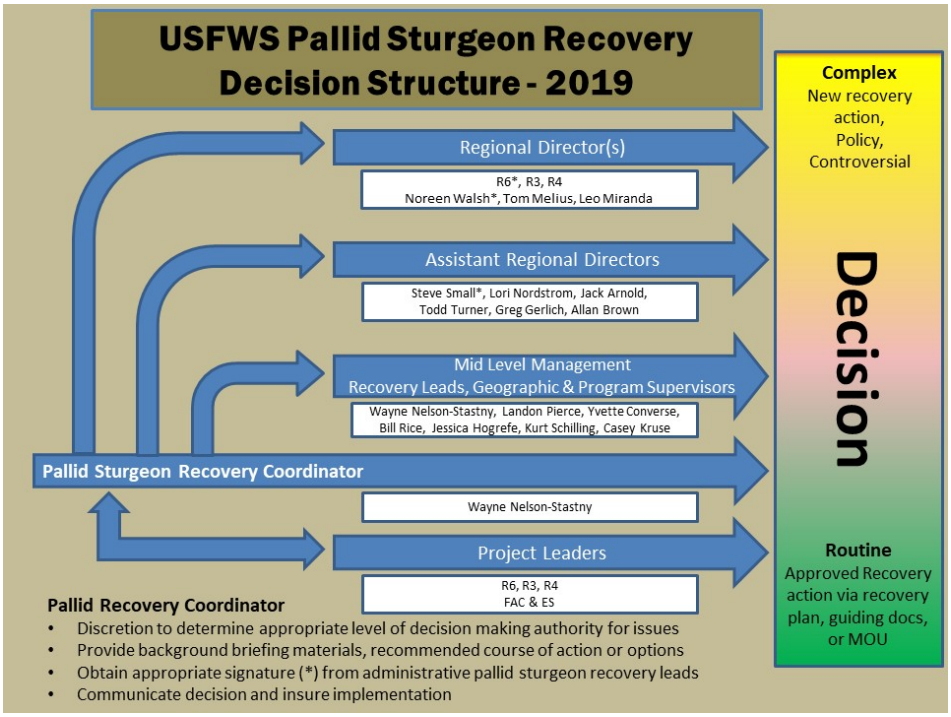


Figure 4. This diagram is the process followed for non-routine decisions that are outside the scope of CPSP planning documents and guidance, or are controversial or contentious.



STANDARDIZATION OF HEALTH AND CONDITION ASSESSMENT, DATABASE(S)/REPORTING AND ANNUAL REVIEW AT ALL PALLID PROPAGATION FACILITIES

In the past year the USFWS began adopting and will continue to implement steps laid out in the following: "Institutionalize standardized health and condition assessments and database, review and reporting for all Pallid Sturgeon propagation facilities" (addendum of memo and response attached).

DATA, REPORTING AND EVALUATION

Database and Reporting

A standardized database of all information pertaining to stocking is currently maintained by the USFWS Missouri River Fish and Wildlife Conservation Office (FWCO) in Bismarck, ND. Those data include the brood stock source, stocking date, location of stocking, number of fish stocked, size and average weight of fish prior to stocking, method of marking and tag numbers. Stocking information is provided to RPMA managers and State hatchery chiefs in addition to the Missouri River Fish and Wildlife Conservation Office in Bismarck, ND generally within 5 days of stocking. Development of standardized forms and reporting is necessary and will facilitate timely transfer and use of information in an adaptive way.

Standardized annual (or regularly scheduled) assessment and program evaluation are necessary to gauge progress toward benchmarks and program effectiveness. Information and data will standardized, compiled and summarized across MUs/RPMAs (as practical but ultimately into a single report) to inform range-wide decisions. Although some information is relevant locally and analysis is directed to some extent based on local results, the overall objective of stocking is to improve the status of Pallid Sturgeon throughout its range.

The comprehensive CPSP will include a simple, clearly defined, objective-oriented, hypothesis-driven program evaluation which will be piloted in the upcoming season and further developed with implemented in the subsequent year (2019-2020). Huenemann (2018) compiles spawning and stocking records for the Middle Basin (CLMU and IHMU) in a non-tabular, narrative form. This provides an example of an annual reporting format that can be used across and among reaches for stocking. However, a more comprehensive annual (or regularly scheduled) assessment and report of the range-wide stocking are needed to better document CPSP actions and inform future CPSP activity and changes to the program.

Designing and Evaluating Program Effectiveness

The CPSP evaluation is an integral part of the process to determine annual stocking targets and program effectiveness and, on some level, has been conducted since the onset of stocking. However, a range-wide formalized and standardized evaluation of the CPSP that allows for hypothesis-based testing of CPSP objectives has not been implemented. Much of the data for this is available and current basin reporting can continue, but a standardized CPSP evaluation will be developed and implemented in the next year and will consider using a framework that includes:

1. Program objectives and benchmarks where feasible and practical
2. Assumptions
3. Testable hypotheses with criteria
4. Data requirements
5. Decision process tracking
6. Results
7. Conclusions
8. Recommendations for changes or modifications related to assumptions and hypotheses
9. Reporting and information dissemination

Program objectives, assumptions and hypotheses should consider including the following:

1. Pallid Sturgeon recovery actions that require activities related to stocking hatchery-origin fish will have detailed evaluation criteria explicitly linked to management objectives and deliverables pertaining to stocking. This includes recovery actions and related hypotheses that rely on stocking from the MRRP and other project area impacts being evaluated.
2. Benchmarks of stocking success based on recaptures, survival and population projections will be the basis for future stocking targets.
3. Standardized assessment of hatchery-orgin and wild fish including survival/recruitment, growth and condition will be used to assess the success of stocking and may be related to the following variables:
    a. Size/age at stocking
    b. Fish health/condition
    c. Stocking location
    d. Parentage or genetic representation
    e. Hatchery of origin or rearing conditions
    f. Tagging effectiveness

In addition, the decision-tracking process described earlier will be included as part of annual reporting. This reporting format, process and supporting data and records will be developed and implemented to the extent possible over the next year (2019-2020). Records will be maintained by the Data Supervisor in the Missouri River Fish and Wildlife Conservation Office in Bismarck ND or a delegate as determined by the USFWS Ecological Services and Fish and Aquatic Conservation Program Recovery Lead(s). Analysis and report completion will be overseen by USFWS Fish and Aquatic Conservation Program who retains primary responsibilities for the CPSP. This will be done in conjunction with USFWS Recovery Leads and in coordination with workgroups.

The following are examples of information for which data are available and could be analyzed as part of program evaluation and reporting. An adaptive management framework including hypotheses and evaluation will be developed and tiered from Pallid Sturgeon recovery planning as well as the over-arching CPSP:

1. Hatchery-origin family survival rates.
2. Effect of stocking size on survival rates.
3. Effect of release location on survival rates.
4. Effect of HRPS hatchery of origin on survival rates.
5. Effect of health/condition on survival if applicable
6. Hatchery-origin abundance within each RPMA.
7. Hatchery-origin length-at-age, growth rates and condition.
8. Movement patterns at various life stages.
9. Family lot identity, history and health.

GENETIC INFORMATION RELEVANT TO STOCKING

Current genetic analyses indicate that Pallid Sturgeon population structure may best be described as genetically distinct groups: 1) upper Missouri stock (GPMU), 2) lower Missouri/middle Mississippi River (CLMU/IHMU) stocks, and 3) lower Mississippi River (CPMU) which comprises a substantial number of hybrids. Schrey and Heist (2007) examined microsatellite allele frequencies in Pallid Sturgeon from the upper Missouri, lower Missouri and middle Mississippi rivers and found significant allele frequency differences between the upper Missouri and lower Missouri/middle Mississippi rivers but no significant differences between the lower Missouri and middle Mississippi rivers. Since that study, genetic techniques have been refined considerably including the use of larger numbers of specimens and loci, more accurate genotyping technology, better discrimination between Pallid Sturgeon and hybrid/backcross fish and identification and removal of unmarked hatchery offspring from databases used to determine stock structure.

Identification of unmarked hatchery fish included in prior analyses was done by reconstructing the genotypes of hatchery parents for which fin clips were unavailable using genotypes of known offspring or by genotyping sperm. Current analyses (Heist unpublished) confirm significant allele frequency differences between the GPMU and CLMU ($FST = 0.019$, $P < 0.001$), and between the GPMU and IHMU ($FST = 0.015$, $p < 0.001$) but not between the CLMU and lower IHMU ($FST < 0.001$, $p = 0.82$). Thus, microsatellite allele frequencies of remnant wild Pallid Sturgeon from the GPMU are significantly different from those in either the CLMU or lower IHMU. Current genetic analyses of the lower Mississippi River confirm the conclusion of Allendorf et al. (2001) that the lower Mississippi River comprises a substantial number of hybrids with too few genetically pure Pallid Sturgeon collected for meaningful analyses of stock structure.

Since 2007, USFWS has prohibited the stocking of Pallid Sturgeon across management units with the exception of the Fort Randall reach of the CLMU that is stocked with GPMU fish to increase population resiliency (USFWS 2008). Some stocked fish have managed to move across units, primarily downstream. Pallid Sturgeon from the GPMU stock should not be stocked into the CLMU/ IHMU and fish from the CLMU/IHMU stock should not be stocked above Fort Randall Dam (there remains a need to clarify stocking guidance in the RPMA 3 section of CLMU). Current genetic analyses do not indicate genetic distinctiveness of CLMU and IHMU,

consistent with tag/recapture and telemetry data that indicate considerable fish movement between the CLMU and IHMU. Thus, the CLMU and IHMU can be considered a single genetic unit. However, hybridization between shovelnose sturgeon and pallid sturgeon increases at the CLMU and IHMU boundary and continues to increase further downstream into the IHMU and CPMU..

Effective population size (Ne) indicates the rate at which populations become inbred due to a small number of successful breeders from each generation because of few spawners and/or a large variance in reproductive success among spawners. If a large fraction of individuals in the population are offspring of a small number of breeders, genetic variation will be lost, and there may be a loss of evolutionary fitness due to inbreeding depression. The minimum Ne necessary for a healthy population is uncertain. Franklin (1980) suggested a one-time Ne of 50 followed by a long term Ne of 500 as an appropriate conservation goal. Effective population size is generally less than the number of individuals in a population (census size or Nc), and sometimes orders of magnitude less, but averages taken among many species are on the order of Ne ≈ 1/10 Nc (Frankham 1995; Palstra and Ruzzante 2008).

The current revised Pallid Sturgeon Recovery Plan (USFWS 2014) considers these factors when recommending a "self-sustaining genetically diverse population of 5,000 adult Pallid Sturgeon… within each management unit for 2 generations" as a criterion for down listing from endangered to threatened. Effective population size can be estimated using known number of breeders and their offspring (Saltzgiver et al. 2012) or by measuring linkage disequilibrium within populations (Waples and Do 2010). Both measures indicate the Ne of the generation that produced the current generation of spawners but not the Ne of the current generation of spawners. Thus, while Ne estimates based on HOPS can indicate whether hatchery practices are successful in maintaining genetic variation in the absence of natural recruitment, evaluation of recovery goals should be based only on Ne estimates from wild-spawned fish resulting from natural recruitment.

In recent decades, reproduction in the upper Missouri River basin has been exclusively the result of hatchery spawning of wild-caught adults, so population-based Ne estimates reflect hatchery contribution (Rotella 2015). In the lower Missouri and middle Mississippi rivers there is limited natural recruitment, although most individuals are HOPS. In addition, variability in reproductive success in HOPS has been noted to range widely among individual spawning adults, either due to variance at time of reproduction (e.g. number of viable eggs produced, sperm motility, or survival of fertilized eggs), differences in hatchery success, mortality at early life stages or in post-stocking survival or recapture. Therefore, accurate estimates of Ne for Pallid Sturgeon are based on overlapping generations and a mix of hatchery and wild reproducing groups contributing to the overall population.

The current Ne estimates for both the upper and lower Missouri River do not account for variations in survival from hatcheries or in the wild, for different family lots of HOPs. Thus, given the challenges with estimating Ne for Pallid Sturgeon, another approach to evaluating the number of individuals successfully contributing offspring to the population would be to monitor

the representation of HOPS families post-stocking. Each hatchery-origin family is individually marked, either with physical tags or through genetic marks (genetic parentage analysis). The survival and distribution of HOPS individuals can be tracked spatially, from points of stocking, and temporally to evaluate individual family survival through various life stages. Actions to address under representation or over representation of family lots can will be ultimately be considered to increase the Ne for pallid sturgeon.

Reproductive contribution can also be monitored, such that individual parental reproductive contribution to the overall population can be managed when possible. In populations with a limited number of spawning individuals, inbreeding and consequent negative impacts on fitness are primary concerns. Pallid Sturgeon have limited natural reproduction in the wild, and the population is currently enhanced by hatchery reproduction of wild and captive individuals. Inbreeding is managed in hatchery crosses through use of genetic data to identify spawning pairs to avoid relatedness between individual parents. One goal of maintaining a large Ne in the CPSP is to prevent inbreeding by reducing the likelihood that stocked fish that spawn in the wild are related.

Outbreeding depression may occur when individuals from genetically different populations reproduce and the genetic difference results in decreased fitness of the resulting offspring. In the case of Pallid Sturgeon, it is assumed outbreeding depression would be a concern if spawning individuals from the GPMU with CLMU/ IHMU stocks (genetic analysis indicates CLMU and IHMU should be treated as one management unit), or with individuals from the CPMU in the Mississippi River. At this time, this is not a significant concern but should remain a consideration.

A captive brood stock is maintained at Gavins Point National Fish Hatchery, representing a portion of the majority of families created over time from adults captured in the wild and spawned at one of the participating hatcheries from the upper basin (USFWS 2014). A small portion of the captive brood stock is now reproductively viable, and resulting offspring have been used for research and restoration stocking. The captive brood stock serves as a backup brood source for production when wild adults not previously spawned are no longer available for brood stock in the wild, to balance reproductive contribution of hatchery-origin fish captured in the wild, or in case of catastrophic loss and local extirpation/extinction. Genetic data is used to evaluate individual reproductive contribution within the captive brood stock and to prevent inbreeding between spawning pairs. Similar captive brood stock efforts are not in place for the middle and lower basins.

Current data indicate that hybridization between Pallid Sturgeon and Shovelnose Sturgeon is rare in the upper Missouri River, increases in the Interior Highlands Management Unit, (including the portion of this unit that encompasses the lower Missouri River), and pervasive in the Mississippi River (Schrey et al. 2011). Pallid Sturgeon and Shovelnose Sturgeon hybrids have been detected in the Mississippi River since at least the 1970s (Carlson et al. 1985). Several studies have attempted to develop morphological (Wills et al. 2002) or genetic (Schrey et al. 2011; Tranah et al. 2004) means of classifying the two species and their hybrids. While

there are no unbiased estimates of the frequencies of occurrence of Pallid, Shovelnose, and hybrid sturgeon, genetic identification of 984 field-identified "Pallid Sturgeon" in one data set indicate that hybrids make up 0% of field-identified "Pallid Sturgeon" from the GPMU, <10% in the CLMU, >50% in the IHMU, and >98% in the CPMU (Heist, unpublished). These data are potentially biased in that researchers working in different MU's maybe differ in the likelihood to field identify a hybrid as a Pallid Sturgeon. However, it appears that pure Pallid Sturgeon out-number hybrids in the GPMU and CLMU while hybrids outnumber pure Pallid Sturgeon in the IHMU and CPMU.

Successful hatchery spawning of hybrids (at the time thought to be pure Pallid Sturgeon) with stocking of their viable offspring indicate that hybrids are fertile, while genetic assignments of wild-caught fish to hybrid categories beyond F1 generation indicate that multiple backcross generations are present. The currently-available suite of molecular markers does not provide sufficient resolution to determine the fraction of an individual sturgeon's genome that is derived from each species nor to determine whether hybridization is recent and anthropogenic or ancient and natural.

STOCKING HISTORY

Two Decades of Propagation and Stocking

Early in Pallid Sturgeon recovery planning, it was acknowledged that successful propagation and stocking of Pallid Sturgeon was necessary to avoid extirpation in the absence of natural reproduction and recruitment (USFWS 1993). Hatchery release or stocking strategies were designed to mimic natural evolutionary and ecological process while promoting the survival of remaining wild fish (USFWS 1993, 1995, 1997, 2002). When listed, genetic information on Pallid Sturgeon was sparse, and better information was needed to understand similarities with Shovelnose sturgeon as well as evolutionary history and relationships among Pallid Sturgeon populations throughout its range. Managers also needed more specific life history and ecological information about Pallid Sturgeon life history and ecology.

Information learned from early propagation and stocking efforts served as the basis for current recovery planning and has been foundational to development of a comprehensive CPSP. With more being learned about Pallid Sturgeon life history, fish sampling and stocking effectiveness, the CPSP has evolved into a complex, strategic program. This scientifically-based program includes genetics, propagation, health, stocking protocols and strategies that are executed among a diverse network of Federal and State partners. The CPSP has allowed managers and scientists to learn about early life-history stages of Pallid Sturgeon that were previously unknown or a challenge to detect due to extremely low numbers in the wild in certain geographies.

By supplementing the population as well as adding different life-stages of hatchery-origin fish to certain reaches of river observed under and correlated with specific flow, habitat and hydrologic conditions, Pallid Sturgeon have become better understood, and management and recovery actions will be more effectively designed and implemented. This fills critical information gaps and informs recovery and other ESA functions such as Section 7 consultations

and Section 10 permitting and informs State, Federal and private entities about potential impacts of river management. This kind of information was either unavailable or inconclusive before the CPSP was in place due to paucity of fish in the wild. Now, after more than 20 years of strategic stocking and augmentation, this valuable information is being used to inform future management actions.

The ultimate goal of the CPSP is for HOPS to reproduce in the wild. Estimates vary from 7-20 years for stocked, HOPS to reach maturity in the wild, and managers and scientists who monitor and study the fish are starting to see indications that stocked fish are spawning in the wild, while successful natural reproduction and natural recruitment from HOPS is yet to be documented. Yet, this is encouraging progress towards the ultimate goal of the Pallid Sturgeon recovery program and ensures the success of the CPSP be considered in the context of the broader goal for a wild, self-sustaining population.

A Stocking History Timeline

1992-1996

Hatchery propagation of Pallid Sturgeon began in 1992 when wild-caught broodstock from the Mississippi River (3 females, 4 males) was spawned successfully at Blind Pony SFH (Krentz et al. 2005; Huenemann 2018). This was the first captive spawning of Pallid Sturgeon and was done using knowledge gained from the spawning of numerous Scaphirhynchus species (Huenemann 2018). The progeny of those matings were stocked in the lower Missouri and middle Mississippi rivers (Missouri, Illinois). Recent reconstruction of genotypes of the parents of these captured fish based on genotypes of offspring, suggest these parents were likely hybrids. (E. Heist, personal communication). Follow-up attempts to capture or spawn wild Pallid Sturgeon in 1993-1996 were unsuccessful. These years experienced high river flows in the Missouri River which impeded broodstock collection.

1997-2004

A successful spawn of a limited number of wild Pallid Sturgeon occurred in 1997 at Gavins Point NFH and Blind Pony SFH. The fish spawned at Gavins Point NFH were collected at the confluence of the Yellowstone and Missouri rivers (GPMU-RPMA-2). Meanwhile, the fish spawned at Blind Pony SFH had been collected from the Mississippi River (IHMU-RPMA-5). Efforts to collect broodstock from the lower Mississippi rivers for stocking in the Middle Basin were discontinued in 1998.

Wild-caught Pallid Sturgeon from RPMA-2 were successfully spawned at Gavins Point NFH in 1998 and 1999, but progeny in 1998 were lost due to siltation after a portion of the fish had been distributed off-station for research. Pallid Sturgeon from RPMA-1 or RPMA-2 were also successfully spawned at Garrison Dam NFH in 1998-2004, except when the facility was quarantined for a virus in 2001.

The Natchitoches NFH (Lower Basin) successfully spawned sturgeon from the Atchafalaya River in 1998 and subsequently in 2004 for stocking in RPMA-6. In 2004, the Lower Basin Workgroup reviewed adult collection records from the Mississippi and Atchafalaya rivers and concluded that Pallid Sturgeon were naturally reproducing in the Lower Basin. As a result, the hatchery propagation and stocking program for Pallid Sturgeon in the Lower Basin (CPMU) was suspended and, to date, has not resumed.

The captive GPMU broodstock currently maintained at Gavins Point NFH (see below) was initiated from matings of wild-caught adults in 1997-1999 and 2001-2003 (USFWS 2005). From 1997-2004, approximately 62,000 hatchery-origin Pallid Sturgeon, progeny of adults collected in RPMA-1 and RPMA-2 (GPMU) in the upper Basin, had been stocked in CLMU-RPMA-4 in the Middle Basin (Huenemann 2018).

2005-2017

In 2005, the Pallid Sturgeon Recovery Team expressed concerns about stocking fish from the Upper Basin in the Middle Basin because new information indicated that Pallid Sturgeon from the upper portions of the Missouri River (RPMA-1 and RPMA-2) were genetically distinct from Pallid Sturgeon in the lower Missouri and Mississippi rivers. However, a reliable source of broodstock from the lower Missouri River (downstream of Gavins Point Dam) had not yet been identified. As a result, the Recovery Team approved continued use of Upper Basin fish for stocking in the CLMU-RPMA-4 until a reliable source of broodstock from the lower Missouri River could be established. At that time, the Upper and Middle Basin Workgroups agreed to the partitioning of hatchery responsibilities: (1) Garrison Dam NFH and Miles City SFH would rear fish for stocking in the Upper Basin; (2) Neosho NFH and Blind Pony SFH would rear fish for stocking in the Middle Basin; and (3) Gavins Point NFH would rear fish for stocking in both Basins.

Adult Pallid Sturgeon from the Upper Basin (GPMU-RPMA 1&2) have been successfully spawned every year since 2005 at either Garrison Dam NFH or Miles City SFH. The progeny of those spawnings are currently released in the GPMU and the RPMA 3/Fort Randall reach. From 2005-2007, a portion of the GPMU progeny were released into the lower Missouri River (CLMU or IHMU) (Huenemann 2018).

Adult broodstock for the Middle Basin stocking program have been collected from the lower Missouri River and successfully spawned at Gavins Point NFH, Blind Pony SFH, and/or Neosho NFH for stocking in the CLMU and the Missouri River portion of the IHMU from 2007 through 2018 (Huenemann 2018). Therefore, no fish have been stocked across management units since 2007 except for into RPMA 3.

FIELD OPERATION AND HATCHERIES

The following hatcheries currently are or have been involved with the propagation of Pallid Sturgeon in support of recovery efforts for the species:

- USFWS R6 Garrison Dam NFH, Riverdale, North Dakota
- USFWS R6 Gavins Point NFH, Yankton, South Dakota
- USFWS R3 Neosho NFH, Neosho, Missouri
- USFWS R6 Bozeman Fish Technology Center, Bozeman, Montana
- MTFWP Miles City SFH, Miles City, Montana
- MDC Blind Pony SFH, Sweet Springs, Missouri

The following field offices are currently providing assistance with stocking and sampling of Pallid Sturgeon in support of recovery efforts:

- Montana Fish Wildlife and Parks Regions 4,6 and 7
- USGS Fort Peck Field Office of the Columbia Science Center
- USFWS R6 Missouri Fish and Wildlife Conservation Office, Bismarck, ND
- USFWS R6 Great Plains Fish and Wildlife Conservation Office, Pierre and Yankton, SD
- USFWS R3 Columbia Fish and Wildlife Conservation Office, Columbia, MO
- USFWS R3 Carterville Fish and Wildlife Conservation Office, Carterville, IL
- USFWS R4 Lower Mississippi River Fish and Wildlife Conservation Office, Vicksburg, MS
- North Dakota Game and Fish Department
- USFWS Fish Health Centers (R3 & R6)
- USFWS Fish Technology Centers (R3, 5 & 6)
- Nebraska Game and Parks Commission
- Missouri Department of Conservation
- U.S. Army Corps of Engineers (Vicksburg, Kansas City, Omaha)

Garrison Dam NFH, Bozeman Fish Technology Center and Miles City SFH currently, or have in past, propagated and reared Pallid Sturgeon to stock primarily in the upper Missouri River (GPMU). Neosho NFH and Blind Pony SFH currently, or have in the past, propagated and reared Pallid Sturgeon for stocking in the lower Missouri River (CLMU and IHMU). Gavins Point NFH has dual responsibility for spawning and rearing Pallid Sturgeon for stocking in both regions of the Missouri River and for maintaining GPMU captive broodstock and holding CLMU brood stock not yet in spawning condition.

Currently, stocking of HOPS is restricted to the Missouri River and Yellowstone River; no stocking occurs in the Mississippi River. After a brief period of experimental propagation and stocking at low numbers from 1997-2004, the lower IHMU and CPMU stocking program was suspended. Local managers considered populations in that reach to be self-sustaining, naturally reproducing and recruiting in the wild. More recent information indicates a significant proportion of fish were genetically introgressed from hybrid Shovelnose-Pallid Sturgeon ancestry (Heist et al. 2013). This information needs to be considered as part of a range-wide genetics assessment of Pallid and Shovelnose Sturgeon to understand the implications for propagation and stocking and in general pallid sturgeon recovery. Therefore, the CPMU and lower reaches of the IHMU do not currently have a Pallid Sturgeon propagation or stocking program.

Hatchery Security

Gavins Point NFH, Neosho NFH, and Garrison Dam NFH are considered secure facilities with up-to-date biosecurity measures in place (Jeffrey Powell, USFWS, Manager, Gavins Point NFH, pers. comm.; March 15, 2018). All three facilities are locked with alarm systems, back-up generators, and redundant (back-up) ultraviolet (UV) light disinfection and filtration systems of the water supplies.

Gavins Point NFH has redundant UV disinfection (300,000 micro-watt seconds) and filtration (17 and 21 microns) of the water supplies. The hatchery has three residents on site and a structured call system for responding to alarms. Gavins Point NFH maintains the GPMU captive broodstock and retains wild-caught adults on station until they have spawned. This hatchery has two water supplies available to those fish at all times. This redundant system maintains the water supply to Pallid Sturgeon even if the hatchery loses its supply of well water and an alarm system fails.

Neosho NFH is located within the city limits of Neosho, Missouri. All buildings are locked, and vehicle access is closed using locked gates after business hours. Local fire and police have access to the property. Neosho NFH maintains wild-caught broodstock on station. The hatchery building (aka the old Sturgeon building) has three water supplies: well, spring, and pond water. The building contains a 50 micron filtration system capable of handling up to 250 gallons per minute, and a UV disinfection unit with 744,000 micro-watt seconds intensity.

Garrison Dam NFH is equipped with redundant UV disinfection units that treat 300 gallons-per-minute (gpm) of water with UV intensities in excess of 230,000 microwatt seconds (at the end of bulb life) and filtration down to 40 microns. If one of the systems is down for maintenance, the other system is available. In the event both filtration systems are down, Garrison Dam NFH has UV disinfection and filtration in the Sturgeon building to treat the water. In the unlikely event that the water supply from the Garrison Dam penstock is disrupted, a third water supply line from a lined 3-acre pond is available. Additional disease preventive measures include segregation of Pallid Sturgeon from other species and disinfection of water lines, tanks and equipment after yearling Pallid Sturgeon are released prior to the arrival of new broodstock. The hatchery has three residences on station to provide security and quick response to emergencies and alarms. In the event of a problem after hours, a Sensaphone automatically dials preprogrammed phone numbers until the staff acknowledges the alarm.

Miles City State Fish Hatchery (MT FWP) is a locked facility with an alarm system. Two full-time employees live on-site that alternate call schedules to respond to alarms from low-water or power failures. A backup generator that is tested weekly is in-place to provide power to hatchery circulating pumps in the event of a power outage. Three separate water supplies are available; Yellowstone River, Tongue River, and well water. The Yellowstone River pump station has a rotating chain screen that prevents debris and fish from entering pump intake. There are two variable frequency drive pumps that can regulate flow to the hatchery and offer redundancy. An alarm system is in-place to notify personnel of river-pump failure. The Tongue River station has a single turbine pump used as a backup to the Yellowstone River station.

Water from both stations is pumped into two large holding reservoirs above hatchery elevation. Holding supply can be gravity fed for days or weeks depending on demand. Groundwater pumped from the well feeds directly into facility and bypasses both reservoirs.

Two drum filters are used to filter the water supply. The primary filter screen size is 37 microns and the secondary is 21 microns. Miles City State Fish Hatchery is equipped with two 860 GPM redundant UV disinfection units rated at 30,000 microwatt seconds (at the end of bulb life). Additional disease preventive measures include segregation of Pallid Sturgeon from other species and disinfection of water lines, tanks, and equipment after yearling Pallid Sturgeon are released.

Other fish hatcheries that have been involved in the CPSP also have systems in place to ensure security of water systems and fish protection and to prevent catastrophic loss of fish. Specific information can be requested from the Hatchery Managers at those facilities.

FISH HEALTH

The Range-wide Pallid Sturgeon Propagation Plan (2018) has a more complete description of fish health related issues for the CPSP. The following is information relevant to stocking activities.

Aquatic animal health is an essential component of any artificial propagation and stocking program. The US Fish and Wildlife Service (USFWS) Aquatic Animal Health Policy (713 FW 1-5) serves as the basis for efforts to contain, control, and minimize the impacts of aquatic animal pathogens and diseases on Service-managed or Service-contracted properties. Additionally, each state has different requirements and regulations regarding issuance of an importation permit to stock HRPS. Certain circumstances, such as the presence of viral pathogens that commonly infect sturgeon species (e.g. adenovirus, acipenserid herpesvirus-1 and -2 and iridovirus (ex. Missouri River Sturgeon Iridovirus [MRSIV]), viral hemorrhagic septicemia virus (VHSV), ranavirus, certain confirmed clinical diseases (bacterial, viral or parasitic), novel pathogens or pathogens of unknown pathogenicity, or the presence of recognized aquatic nuisance species may impact importation permitting for stocking or movements.

The USFWS recognizes a list of regulated pathogens of nationwide concern. These pathogens have the potential to produce severe epizootics of clinical disease but are also known to exist in a carrier state. They include viral, bacterial, and parasitic agents, and all generally have both a screening and confirmatory test available. Three pathogens of notable importance to Pallid Sturgeon are MRSIV, ranavirus and VHSV.

MRSIV is of special concern for USFWS Region's 3 and 6. The virus causes mortality in HRPS under certain rearing conditions and its effect on free-ranging sturgeon populations is unknown. Even though the virus is detected in free-ranging populations, hatchery amplification of pathogens is a significant concern for stocking programs and recovery efforts. MRSIV was first detected in Shovelnose Sturgeon at the Gavins Point NFH in 1999. Since 1999, iridovirus

outbreaks have occurred at Gavins Point NFH, Garrison Dam NFH, Neosho NFH, Blind Pony SFH, Miles City SFH, and the Bozeman FTC. In a hatchery environment, the iridovirus outbreaks can cause high initial mortality, are generally most severe for young of the year fish, and surviving Pallid Sturgeon may continue to carry the virus after the initial outbreak. This virus can cause significant mortality at recommended sturgeon propagation temperatures. Iridovirus identified in the Upper Missouri River Basin can infect both Shovelnose and Pallid Sturgeon and can be transmitted between these species. This virus is distinctly different from the White Sturgeon iridovirus (WSIV). The Range-wide Pallid Sturgeon Propagation Committee recommends sturgeon experiencing a MRSIV epizootic not be stocked. However, stocking iridovirus-positive fish that have recovered from a MRSIV outbreak is acceptable subject to the approval of State and Federal resource management agencies whose regulations and policies vary widely from state to state. Currently USFWS guidelines require that entities responsible for border water areas must support the stocking proposal before they are implemented. Improvements in hatchery specific culture and husbandry practices continue to reduce iridovirus outbreaks.

Ranaviruses can infect amphibians, fish and reptiles, and can cause mass mortality in juvenile hatchery-reared sturgeon. A ranavirus (frog virus 3-FV3) was first detected in juvenile Pallid Sturgeon reared at the Blind Pony SFH in Missouri during a significant mortality event, and resulted in approximately 95% cumulative mortality at water temperatures ranging from 16-26 degrees Celsius Ranavirus-induced mortality appears to be most severe as water temperatures rise. Given their high virulence and ability to infect between taxonomic classes, care must be taken to not spread ranaviruses through stocking or fish movements.

Viral Hemorrhagic Septicemia Virus (VHSV) has caused large-scale mortality in salmonid aquaculture operations in Europe and in a wide variety of freshwater species in the Great Lakes Region of North America. VHSV has a wide range of potential carrier species, and therefore it is critical to continue monitoring Pallid Sturgeon for VHSV. VHSV is a reportable pathogen that requires notification to the United States Department of Agriculture – Animal and Plant Health Inspection Service, appropriate Canadian Agencies and International Organization for Animal Health. The disease is caused by a rhabdovirus and can cause large-scale mortalities of valuable adult fish. It is also listed as an emergency disease by the Great Lakes Fishery Commission - Great Lakes Model Fish Health Program.

Fish Health Testing

Prior to release, the health of HOPS will be evaluated using the most current valid tests. Each facility will be required to undergo a pre-release health evaluation prior to each proposed stocking event. The evaluation will include an internal and external examination to detect observable signs of disease and collection of tissue samples for pathogen testing. Sample numbers will be based on numbers suggested in the most recent edition of the American Fisheries Society-Fish Health Section Bluebook inspection manual, sampled from cultural units representing one year class of Pallid Sturgeon, and preferably 4 weeks prior to stocking. Fish health testing will comply with protocols and procedures identified in the April 18, 2018 memo and March 15, 2019 response (Appendix A)

or specific information about fish health testing of pathogens in pre-stocking Pallid Sturgeon, refer to *the Range-wide Pallid Sturgeon Propagation Plan* (2018).

All suggested stocking rates and calculations in this document assume that HOPS are deemed healthy by a pre-release fish health assessment, per regulations stipulated in Chapter 713 of the USFWS Fish Health Manual, before stocking and that all applicable Federal and State agency permits are obtained. This can include State and Federal efforts, inspections or permits ensuring prevention of spread of Aquatic Invasive Species from hatchery source waters.

FISH MARKING AND TAGGING

In accordance with permitting conditions under ESA, all Pallid Sturgeon must be handled according to the guidelines described in the *Range-wide Pallid Sturgeon Procedures and Protocols for Handling Pallid Sturgeon* (USFWS 2019)

Within these guidelines, a fish marking and tagging system has been developed that ensures positive identification of each fish and its origin. This system is necessary to effectively track stocking actions and monitor the success and effectiveness of the CPSP. Tagging schemes are developed within the respective Pallid Sturgeon workgroups and communally understood and agreed upon. Coordinated marking efforts among these workgroups are essential in areas that may allow stocked fish to out-migrate into waters overseen by another workgroup and thus these tagging and marking schemes are standardized to the extent necessary to prevent tag confusion throughout the range and still allow for local strategies.

For specific information on tagging and marking protocols and strategies, refer to *USFWS Range-wide Pallid Sturgeon Tagging and Marking Plan* (USFWS 2019).

The USFWS has developed DNA-based protocols that can be used to identify HOPS upon recapture as long as DNA samples have been collected from the parental stock. These DNA methods reduce the need to physically mark or tag each fish prior to release and allow for stocking of life-stages too small in size to sustain physical tags. These methods (DeHaan et al. 2005) were developed by the genetics staff at the USFWS Conservation Genetics Laboratory at Abernathy Fish Technology Center in Longview, WA, in collaboration with researchers at the University of California-Davis, Southern Illinois University, and the University of Alabama.

Parental-based genotyping (aka genetic tagging) is used for all HOPS released into the Missouri River (DeHaan et al. 2008; Heist et al. 2013). All spawned adults are genotyped at a suite of DNA markers (microsatellites and/or SNPs) and recorded in a DNA database maintained in duplicate at the USFWS Northeast Fish Technology Center, the Warm Springs Fish Technology Center and Southern Illinois University. The DNA genotype of any Pallid Sturgeon retrieved from the Missouri River or elsewhere can be compared to all possible parents and parental crosses in the database to determine whether the captured fish is of hatchery-origin, and if so, the specific family from which it originated.

All stocked pallid sturgeon receive at least 1 mark. Fish <70 only receive a genetic mark, while fish >70 mm receive a secondary mark. Passive Integrated Transponder (PIT) tags will be used as a rule if and when size appropriate, as they provide a long-term individual identification of a fish. When PIT tags are not appropriate, such as in young-of-year fish that are too small (e.g. <140mm), a marking system using a combination of identifiers such as CWT and sub-cutaneous latex polymer injections (elastomer) on the rostrum will identify fish to broodstock source and will provide family and year-class information. Elastomer color can also be used to designate stocking year and location on the rostrum. When fry stocking occurs, those fish are already marked genetically (William Ardren, USFWS, personal communication, DeHaan et al. 2005). While these genetic tags have proven useful in identifying hatchery-origin fish that were released and subsequently were collected with failed physical marks, or released as fry, the cost associated with reading genetic tags can be high and needs to be incorporated into the cost of stocking and population assessment. Scute removal is also an effective mark to discern year class. All tagging will be conducted in accordance with basin workgroup tagging plans prior to transport for stocking to evaluate short-term tag loss, and allow for re-tagging if necessary, and culling of mortalities at time of stocking.

SUMMARY

In general, the CPSP for Pallid Sturgeon has been successful on many levels. After more than twenty years, the program has developed an impressive body of information on propagation and stocking and applied it to Pallid Sturgeon recovery. This information led to an extensive network of collaborative and coordinated planning. Operations and funding that support Pallid Sturgeon propagation and stocking as well as flow and habitat assessment occurs in some reaches. USFWS, States, ACOE, US Geological Survey, Bureau of Reclamation and other partners are active in all aspects of Pallid Sturgeon recovery including the CPSP and are invested in the outcomes. The program will continue to adapt and improve to respond to new information, opportunities and the evolution of many diverse agency programs. The CPSP needs continual evaluation, more standardized and formalized program evaluation and clearly articulated decision-tracking that is reported annually. In addition, there remains a need for improved coordination across MUs/Basins and Workgroups to best inform recovery actions and understand the status of Pallid Sturgeon range-wide. The USFWS is working to establish a clear management approach for the CPSP that is complementary to and integrated with other programs (e.g. MRRP) but focused first on Pallid Sturgeon Recovery.

Although significant accomplishments, successes and findings have provided hope that wild populations will be able to sustain themselves in the future. It is clear the CPSP will be necessary for years (or decades) to come. Until then, the CPSP plans should be updated every five years with new information, to reflect new technology, and changing ecological and societal conditions to continue to support Pallid Sturgeon recovery.

Overall Conclusions

1. Hatchery propagation of Pallid Sturgeon is preventing extirpation of Pallid Sturgeon within management units where stocking is deemed necessary and is an integral part of the Pallid Sturgeon recovery efforts at this time.

2. Propagation and stocking of hatchery-origin Pallid Sturgeon is adding to genetic diversity and supporting effective population size among natural and hatchery-origin Pallid Sturgeon within each management unit where stocking is occurring. All aspects of broodstock management and spawning are and should continue to be guided by the genetic principles and protocols as described in the Population Genetics Management Plan (Heist et al. 2013).

3. Continued support for genetic analyses is necessary to the ongoing success of the CPSP. Genetics analyses are critical to identify wild-caught broodstock sources to be used for propagation and to determine the origin of fish captured through sampling (hatchery v. wild). Without genetic analyses, it would be difficult to ascertain the CPSP effectiveness as well as effectiveness of management actions on wild fish recruitment.

4. Program Evaluation for the CPSP should be standardized and formalized on a range-wide basis as described herein. In the past year the USFWS began adopting and will continue to implement steps laid out in the following: “Institutionalize standardized health and condition assessments and database, review and reporting for all Pallid Sturgeon propagation facilities”

(addendum of memo and response attached). Recommendations should be incorporated into out-year CPSP action to ensure an adaptive approach to propagation and stocking and the best outcomes of the program.

5. The need for a range-wide genetic status assessment and summary for Pallid Sturgeon should be considered. Such an assessment will provide an updated and over-arching perspective on genetics for the species to help inform MU or RPMA/reach specific management in light of range-wide demographic and genetic circumstances. Current molecular markers are insufficient for fine-scale resolution of pure species, hybrids and backcrosses. The need and strategy for developing higher resolution markers could be another outcome of the development of a range-wide genetics plan. Such a plan would also provide the foundational information to better understand the status and implications of Pallid-Shovelnose sturgeon hybridization, thereby informing future recovery and management options to address hybridization issues where they occur.

6. A list of priority research needs and information gaps should be maintained as part of Pallid Sturgeon recovery efforts and to help direct programs like the CPSP. The list of research needs and information gaps will be prioritized and evaluated through a, yet to be developed,

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Appendix A.
Condition Memo and Response

April 17, 2018

U.S. Fish and Wildlife Service (USFWS) Region 3 and 6, Fish and Aquatic Conservation Program (FAC) and Ecological Services (ES) Pallid Propagation Decision Document

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Action:
· Decision to resume pallid sturgeon propagation at Neosho National Fish Hatchery (NFH) in 2018
· Institutionalization of standardized: health assessments, condition index, database/reporting and annual review at all pallid propagation facilities.

Decision:
This decision document outlines the background, actions taken, and process of restarting yearling pallid sturgeon propagation activities at Neosho NFH and also includes added processes to ensure standardization of quality, consistency and assessment at all pallid sturgeon propagation facilities. The USFWS FAC and ES Programs support restarting the propagation program at Neosho NFH. This decision was made following a review by internal and external scientific experts, implementation of actions recommended by these experts to address fin curl, testing the effectiveness of these actions, and a final review by the group of technical experts. Additional processes are articulated in this document and planned for implementation at all pallid propagation facilities to manage any future issues that may arise.

Decision:
Resume pallid sturgeon propagation at Neosho NFH in 2018

Background:
Neosho NFH performed two critical roles in the recovery of pallid sturgeon in the Middle Missouri River Basin. Neosho NFH served as a spawning facility for pallid sturgeon and produced pallid sturgeon juveniles for conservation stocking. Some problems with pallid sturgeon propagation were identified by the hatchery through the Middle Basin Pallid Sturgeon

Workgroup (MBW) in 2014. Problems included the consistency in which Neosho NFH was able to obtain viable eggs from captured pallid sturgeon, and with the development of fin curl by juveniles reared on well water.

The MBW and the U.S. Army Corps of Engineers (COE) requested that a hatchery Technical Review Team be assembled and conduct a review of the Neosho NFH to identify possible remedies for these spawning and fin curl issues. The Neosho NFH underwent a review on February 24th and 25th 2016, funded by the COE. The Technical Review Team was comprised of ten members with expertise in pallid sturgeon health, spawning and propagation. Team members were employees of the USFWS, the Missouri Department of Conservation, and Montana Fish, Wildlife, and Parks and a private facilitator.

A final report is attached, (File: Neosho NFH report.pdf), to this decision and summarizes the observations and recommendations developed during the Technical Review Team on-site inspection of Neosho NFH. The report lists 14 recommendations for improving Neosho NFH's pallid sturgeon program. These recommendations were offered to the MBW, USFWS, and the COE for their review and consideration. In the interim, Neosho NFH discontinued production of juvenile pallid sturgeon but remained as a holding and spawning facility for wild collected adults.

Actions taken to support the decision to resume propagation of yearlings at Neosho NFH:

Fin Curl:

· Fin curl at Neosho NFH was recognized prior to the hatchery review when in 2014, fish that were initially reared at Blind Pony State Fish Hatchery were brought to Neosho NFH for grow out and began to develop fin curl when they were put in well water. In 2015, formal testing of the problem began using progeny from the captive brood at Gavins Point NFH. Fish were tested in 2015, 2016, and 2017. Fin curl was consistently observed in well water reared fish in all years. In 2016, it was discovered that passing spring water through outdoor ponds prevented fin curl from developing or allowed curled fins to regenerate to normal. It is not fully understood why this worked, but similar success using the same process was noted in lake sturgeon being reared at Genoa NFH.

· No stocking of fin curl fish. If fin curl develops in any fish within a family lot prior to stocking, then that family lot will not be released.

Review Team Recommendations:

· All actions recommended by the Review Team were completed with the exception of the conversion from rectangular tanks to circular tanks for both yearling propagation and adult brood holding. Neosho will upgrade to circular tanks as funding allows. A full accounting of the actions taken for each of the 14 recommendations made by the Technical Review team is attached to further support this decision (File: Neosho NFH review recommendations and responses.docx).

Institutionalization of standardized; health assessments, condition indicies, database/reporting and annual review at all pallid propagation facilities.

Fish Health Assessments prior to stocking in 2019:

· USFWS R3 and R6 fish health experts will standardize health assessments between the regions at pallid propagation facilities, i.e. sampling frequency, numbers of fish sampled, pathogen testing, etc.

· Each USFWS Regions fish health expert will be responsible for implementing the standardized health assessment at pallid propagation facilities within their respective Region.

Fish Condition Index prior to stocking in 2019

· The Range-Wide Pallid Sturgeon Propagation Committee (RWPSPC) will develop a Fish Condition Index for approval by USFWS leadership by the Fall of 2018.

· A team from R3 and R6 working together to establish a uniform baseline and methodology will assess fish condition with the approved Fish Condition Index at all pallid propagation facilities prior to stocking in 2019.

· Fish Condition Index criteria will be utilized as part of a longer term adaptive approach to better understanding meaningful indicies as related to performance of stocked fish in the wild.

Standardized Database/Reporting

· The RWPSPC will develop a standardized template for reporting on propagation activities, from brood fish arrival to stocking, for approval by USFWS leadership. The standardized database and reporting template will be approved and implemented prior to 2019.

Annual Review:

· The RWPSPC will develop adaptive management decision trees, (if – then) to provide clarity and transparency to pallid propagation activities for approval by USFWS leadership. The AM decision tree will be in place prior to January 2019.

· An annual review of pallid propagation activities will be hosted by the Pallid Recovery Lead(s)/RWPSPC prior to the beginning of broodstock collection in 2019.

Memo Response

March 15, 2019

U.S. Fish and Wildlife Service (USFWS) Region 3 and 6, Fish and Aquatic Conservation Program (FAC) and Ecological Services (ES) Pallid Propagation Decision: Direction and Response

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William Rice, R6 FAC Geographic Supervisor (Previous Acting)

Action:
· Documentation of response from Region 3 and 6 FAC to April 17, 2018 Decision Document
· Description of measures and timeline for standardized health and condition assessments, and database, review and reporting from for facilities engaged in Pallid Sturgeon Conservation Propagation and Stocking Program

Purpose:
The purpose of this memorandum is to document the response from US Fish and Wildlife Service Region 3 and 6 Fish and Aquatic Conservation Program (FAC) to the April 17, 2018 memorandum from US Fish and Wildlife Service regarding the condition and health of captive-reared and stocked Pallid Sturgeon (PS). Specifically, this document describes the measures to be implemented and timeline for all facilities engaged in PS Conservation Propagation and Stocking Program (CPSP). These measures are intended to ensure USFWS is adequately considering and addressing health and condition of captive-reared PS that are stocked into the wild. A copy of the April 17 memo is attached to this document.

Direction and Response:
The following includes direction described in the April 17 memo and the FAC response proposed and recommended by the Range-wide Pallid Sturgeon Propagation Committee (Propagation Committee). The Propagation Committee includes expertise in PS reproductive physiology, captive propagation (including hatchery managers) and stocking. These responses have been reviewed and accepted by both Region 3 and Region 6 FAC Programs.

The information herein will also be included in the 2018 revision of the Range-wide Pallid Sturgeon Propagation Plan and relevant aspects are also referenced in the 2018 Range-wide Pallid Sturgeon Stocking Plan. Both plans are guidance for propagation and stocking activities under the umbrella of the Pallid Sturgeon Conservation Propagation and Stocking Program.

Memo Action Item: Institutionalize standardized health and condition assessments and database, review and reporting for all Pallid Sturgeon propagation facilities.

1. Direction:
Fish Health Assessments prior to stocking in 2019:
· USFWS R3 and R6 fish health experts will standardize health assessments between the regions at pallid propagation facilities, i.e. sampling frequency, numbers of fish sampled, pathogen testing, etc.
· Each USFWS Region's fish health expert will be responsible for implementing the standardized health assessment at pallid propagation facilities within their respective Region.

1. Response:
Existing Actions/Protocols:
The Bozeman and La Crosse Fish Health Centers are the Federal facilities with staff responsible for fish health assessments and diagnostics. These programs have used standardized health assessments for all PS propagation facilities since program inception. A standard health assessment checklist is included herein and described in the Range-wide Pallid Sturgeon Propagation Plan. All health assessments are publically available at https://www.fws.gov/policy/713fw1.html. National protocols for fish health and stocking are also available from either USFWS Bozeman Fish Health Center or Midwest Fishery Science Center. In addition, State fish health guidelines and protocols are locally implemented as needed.

Fish health assessment and certification of captive-reared PS family lots have been a standard practice of PS propagation for the past decade and have followed Federal and State protocols with minor variations to address species-specific or localized fish health issues.

Added Actions/Protocols:
· As per this memorandum, the responsible USFWS R3 and R6 fish health experts (currently Lacey Hopper, USFWS Bozeman Fish Health Center and Ken Phillips, USFWS La Crosse Fish Health Center) have reviewed and standardized health assessment applications
· Fish health experts will continue to implement a standard health assessment and certification process that will be the same at all facilities rearing PS.

Summary:
The PS Range-wide Propagation Plan describes use of fish health information for stocking decisions. It is clear that fish with compromised health should not be stocked. In the event that there is a recommendation or reason to consider stocking PS of questionable health (e.g. unique genetic parentage), the review and ultimate decision for such stocking should follow the decision process for 'non-routine decisions' (see CPSP Preamble of Roles and Responsibilities).

Timeline: Implementation will continue with the 2018 year class

2. Direction:
Fish Condition Index prior to stocking in 2019

· The Range-Wide Pallid Sturgeon Propagation Committee (RWPSPC) will develop a Fish Condition Index for approval by USFWS leadership by the Fall of 2018.

· A team (individuals from both R3 and R6), working together to establish a uniform baseline and methodology, will assess fish condition with the approved Fish Condition Index at all pallid propagation facilities prior to stocking in 2019.

· Fish Condition Index criteria will be utilized as part of a longer term adaptive approach to better understanding meaningful indices as related to performance of stocked fish in the wild.

2. Response:
After deliberation regarding pros and cons of use of a standardized 'fish condition index', the Propagation Committee is recommending use of a 'Family Lot History and Health Assessment' (see page 6 template). Information is collected on length and weight, the conventional metrics used to evaluate condition. This data has not been analyzed for purposes of identifying an index but can be used as additional information to assess success of year-class survival. The data included in the assessment allows for evaluation of survival response under the natural range of wild phenotypes (i.e. stocking of fish that could be shorter and lighter but that retain greater range of natural characteristics) to be represented in stocked family lots and is not intended to suggest cause and effect.

The purpose of a captive propagation program for endangered fish is to maintain, to the extent possible, the natural and wild characters of the species represented through available genetic material to promote survival of that species into the future. There are inherent risks of captive propagation related to hatchery selection. The PS CPSP has been designed and adaptively managed over the past two decades to minimize hatchery selection to the extent possible. The strategies employed represent a compromise between breeding for post-stocking survival and conserving the natural range of variation in phenotypes of stocked fish.

The Range-Wide Pallid Sturgeon Propagation Committee has developed the Pallid Sturgeon Family Lot History and Health Assessment to provide for standardization and evaluation of fish condition as represented by health and vigor without inadvertently promoting hatchery selection.

The development and use of performance metrics will continue to be considered and assessed as part of the CPSP evaluation. Development and application of performance and condition metrics will be considered and assessed through development of a programmatic data integration, evaluation and reporting process for the CPSP that includes principles for adaptive management and research assumptions and hypotheses related to CPSP objectives and outcomes.

After continued assessment of the CPSP objectives and outcomes, the Service will consider if metrics may play a role in program evaluation. Some possible considerations that relate to condition may include:

- Effects of current and water velocity in rearing tanks to promote swimming abilities and improve the adaptive performance of their central nervous systems (Kozlov, Nikonorov and Vivitskaya, 1989; Nikonorov and Vitvitskaya, 1993); (The increase in swimming velocity of fry at elevated illumination should be noted.)
- Effects of background sound (avoiding sharp sound variations); (Excessive oxygen consumption is associated with shrill noise during the dark period (Bilio, 2007)).
- Effectiveness of training for post-stocking survival in a natural environment, including development of adequate responses; (may include predators avoidance, and acclimation to natural environmental or physical conditions (sudden changes in current , wave action, light, high salinity in coastal areas, etc.)
- Conditioning to naturally available food (i.e. live food), especially at the onset of exogenous feeding to increase the level of thyroid hormones in the tissue due to inclusion of the hormonal "pool" of the live food (Boyko, Grigoryan and Chikhachev, 1993; Boyko and Grigoryan, 2002; Boyko, 2008);

Timeline: Implementation will begin with the 2018 year class, additional pilot assessments will begin in 2019 with the 2018 year class.

3. Direction:
Standardized Database/Reporting

- The RWPSPC will develop a standardized template for reporting on propagation activities, from brood fish arrival to stocking, for approval by USFWS leadership. The standardized database and reporting template will be approved and implemented prior to 2019.

See Response to #4

Timeline: Development and pilot implementation will commence in January 2019. Further development will occur throughout 2019 with finalization in 2020.

4. Direction:
Annual Review:

- The RWPSPC will develop adaptive management decision trees, (if – then) to provide clarity and transparency to pallid propagation activities for approval by USFWS leadership. The AM decision tree will be in place prior to January 2019.

- An annual review of pallid propagation activities will be hosted by the Pallid Recovery Lead(s)/RWPSPC prior to the beginning of broodstock collection in 2019.

3&4. Response:
The PS Family Lot History and Health Assessment includes a standardized template for reporting on propagation activities, from brood fish arrival through to stocking. The standardized database and reporting template will be used to record data as part of a long-term adaptive approach to better understand conditions related to survival of stocked fish in the wild. These data will be integrated with data from other aspects of the CPSP. The template is included at the end of this document.

Currently the CPSP is initiating and developing a data integration, evaluation and reporting process for the over-arching CPSP that would include adaptive management principles related to the assumptions and hypotheses of CPSP objectives and outcomes. The CPSP data integration, evaluation and reporting program will be developed by a small team representing basin workgroup members, field and facility personnel and other agency and PS expertise as needed. A pilot review will be implemented and further developed throughout 2019 (with adoption of pilot principles) and implementation of a finalized process will be initiated in 2019-20. The following language excerpted from the CPSP provides a framework for an integrated CPSP database.

Evaluating Program Effectiveness
Although CPSP evaluation is an integral part of the process to determine annual stocking targets and program effectiveness and has been conducted since the onset of stocking, a range-wide formalized and standardized evaluation of the CPSP that allows for hypotheses-based testing of CPSP objectives has not been implemented. Much of the data for this is available. A standardized CPSP Evaluation will be developed and implemented in the next year (2019-2020) and will use a framework including:

1. Program objectives and benchmarks where feasible and practical
2. Assumptions
3. Testable hypotheses with criteria
4. Data requirements
5. Decision process tracking
6. Results
7. Conclusions
8. Recommendations for changes or modifications related to assumptions and hypotheses
9. Reporting timelines

Considerations to be included in a CPSP Evaluation Design
Program Objectives, Assumptions and Hypotheses should consider the following:

1. Pallid Sturgeon recovery actions that require activities related to stocking hatchery-origin fish with detailed evaluation criteria explicitly linked to management objectives and deliverables pertaining to stocking. This includes recovery actions and related hypotheses that rely on stocking from the MRRP and other project area impacts being evaluated.
2. Benchmarks of stocking success based on recaptures, survival and population projections should be the basis for out-year stocking targets.

3. Standardized assessment of recaptures and wild fish including survival/recruitment, growth, condition and movement should be used to assess the success of stocking related to the following variables:

a. Size/age at stocking
b. Fish health/condition
c. Stocking location
d. Parentage or genetic representation
e. Hatchery of origin or rearing conditions
f. Tagging effectiveness

The following are examples of information that is available and should be analyzed and included as part of program review, evaluation and reporting. An adaptive framework including hypotheses will be developed and tiered from Pallid Sturgeon recovery planning as well as the over-arching CPSP:

1. Hatchery-origin year class survival rates.
2. Effect of stocking size on year class survival rates.
3. Effect of release location on year class survival rates.
4. Effect of HRPS hatchery of origin on year class survival rates.
5. Effect of health/condition on year class survival if applicable
6. Hatchery-origin abundance within each RPMA.
7. Hatchery-origin length-at-age, growth rates and condition.
8. Movement patterns at various life stages.
9. Family lot identity

Citations

Chebanov, M.S.; Galich, E.V. Sturgeon hatchery manual. FAO Fisheries and Aquaculture Technical Paper. No 558. Ankara, FAO. 2011, 303 p.

(Memo Response continued)

Pallid Sturgeon Family Lot History and Health Assessment

A Pallid Sturgeon family lot history and health assessment database will be utilized to house data from each facility producing Pallid Sturgeon for release into the wild. The database will have the following data for each spawning year and family lot.

PS FAMILY LOT HISTORY AND HEALTH ASSESSMENT - TEMPLATE
Broodstock Data:
· Origin (hatchery, hybrid, or wild)
· Management Area
· PIT Tag
· Iridovirus Status
· Transmitter Present (yes/no)
· Sex
· Reproductive Status
· Oocyte PI with dates
· Capture Date
· Broodstock Weight and Length (at capture, at assessment(s), at release)
· Fate of Fish (returned to river, mortality; reason for mortality)

Spawning Data:
· Spawn Date
· Spawn Temperature
· Polypodium (yes/no)
· Ovulatory Latency (time from priming injection)
· Time of First Milt Collection
· Total Number of Eggs at Ovulation (calculated volumetrically; meniscus)
· Milt Motility (percent dilution, percent motile at activation, percent motile at 1 minute, density of sperm (low=clear in color, less than 25% of field of view contains sperm; medium=white in color and thin, 25-75% of field of view contains sperm; high=white in color and thick, >75% of field of view contains sperm),

Temperature Profile of Facility:

pH of Facility:

Embryo Quality (data as percentage):
· Neurulation
· Hatch

Larval Quality (data as percentage):
· Survival at 1 Week (make a note in the comments to describe if/when the early mortality peak occurred)
· Survival at Initiation to Feed

Total Weight of Sample by Family Lot (data expressed in grams; 2 months, 4 months, 6 months, at stocking):

Number of Fish in Sample (2 months, 4 months, 6 months, at stocking):

Growth Rate (expressed as a percentage increase from previous sample; 4 months, 6 months, at stocking):

Condition Factor (at release; quartile 1, 2, 3):

Health Certification Prior to Release: (scaled evaluation for fin curl and presence of external lesions; sample number based on an assumed pathogen prevalence level (APPL) in the population of 5%; testing dependent on Regional Fish Health Center Director's suggested pathogen list and/or state requirements)*:
Minimum health testing and reporting will include the following:
· MRSIV
· Ranavirus
· VHSV
· Fin Curl
· Lesions with prevalence and severity of the specific pathogens or conditions noted

Number of Stocked Fish by Family: Location and Date

Comments about Transportation to Stocking Location (e.g. water temperature differences between hatchery and river):

Comments about Family Lot (e.g. lethargic, internal/external abnormalities, protozoans/parasites, etc…):

*Pallid sturgeon are regularly tested for MRSIV, Ranavirus, and VHSV in both the upper and middle basins of the Missouri River by standardized methods. Fin curl and lesions are reported using standardized scaled evaluations in both the upper and middle basins.

Timeline: Development and pilot implementation will commence in January 2019. Further development will occur throughout 2019 with finalization in 2020.