PRELIMINARY PROPOSAL FOR FY 2005 FUNDING

Title: Effects of permanent and short-term changes in water levels on survival of white sturgeon eggs and larvae in shallow habitats

Study Code: ADS-04-NEW

This proposal addresses Objective 2 of this study code. The proposal also addresses FWP Measure 10.4A.2—Determine the impacts of the hydrosystem on sturgeon.

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PROJECT SUMMARY

RESEARCH GOAL

Pursuant to Objective 2 of Study Code ADS-04-New, White Sturgeon Passage at Lower Columbia Dams, the goal of this work is to determine if permanent and short-term changes in water surface elevations caused by construction and operation of U.S. Army Corps of Engineers dams in the Columbia River Basin has reduced the survival of white sturgeon *Acipenser transmontanus* eggs and larvae.

STUDY OBJECTIVES

During year 1, we will determine: 1) if white sturgeon eggs and larvae occur in shallow riparian habitats that could be susceptible to short-term water level fluctuations, and 2) if there is a loss of white sturgeon productivity due to long-term reductions of riparian habitat. If eggs and larvae are found in riparian habitats, during year 2 we will conduct laboratory experiments to examine how long eggs can withstand dewatering, if hiding-phase larvae are capable of moving to accommodate changes in water elevations, and if not, factors affecting their survival in non-circulating pools of water.

METHODOLOGY

White sturgeon eggs are large, adhesive, and are readily identified in the field. Thus, we will use visual observation techniques to examine if they are attached to rocks and vegetation in shallow shoreline areas of the Columbia River. We will attempt to collect hiding-phase larvae from rock crevices and other habitat types using slurp guns and feeding larvae with nets. The elevation of the locations of eggs and larvae will be noted and compared to potential water level elevations they may encounter. Laboratory studies will be used to examine egg characteristics and larval behavior and survival.

RELEVANCE

The Reasonable and Prudent Alternative section in the 2000 Biological Opinion (BIOP) lists several measures to avoid jeopardy in Section 9.6. Though mostly intended to improve juvenile and adult salmonid survival, these measures will affect resident fishes including white sturgeon, and the BIOP calls for minimizing negative impacts on, or providing benefits to, resident fish and wildlife.

PROJECT DESCRIPTION

BACKGROUND AND JUSTIFICATION

A better understanding of the distribution of white sturgeon egg incubation sites and larval rearing habitats is needed to assess how construction and operation of U.S. Army Corps of Engineer dams influence spawning and survival of newly spawned eggs and hatched embryos. It is generally accepted that white sturgeon eggs and larvae can be found on the substrate in a variety of habitats downstream from dams (Parsley et al. 1993; McCabe and Tracy 1994). Recently, Coutant (2004) developed a hypothesis that eggs are either deposited in or transported to shallow seasonally-flooded riparian habitat and adhere to rocks and vegetation during incubation. He proposed that newly-hatched yolk-sac larvae remain in these shallow waters, hiding in crevices for protection from predation. As larvae develop and begin feeding, this riparian habitat would theoretically offer plentiful food. When water recedes with decreasing discharge, young juvenile sturgeon would also retreat to deeper channels. This hypothesis is supported by findings from the lower Fraser River where white sturgeon eggs and larvae were found in island complexes and side channels and not in the main channel (Perrin et al. 2003). Past work in the Columbia River primarily investigated the timing and general location of white sturgeon spawning and did not focus specifically on the occurrence of eggs or larvae in riparian habitats.

If white sturgeon eggs and larvae do occur in shallow riparian habitats, construction and operation of the federal hydropower system may affect survival and subsequent recruitment to age-1 in many ways. In shallow areas they could be susceptible to desiccation due to short-term fluctuations in water elevations resulting from daily operations at the dams. These short term fluctuations are known to strand outmigrating anadromous salmonids (Tiffan et al. 2002) during the same time that white sturgeon are known to spawn, incubate, and hatch. The dampening of the seasonal discharge regimes by dams to reduce flooding and increase power generation in winter has also reduced the seasonal water level fluctuations in areas where backwater effects are minimal, and thus reduced the availability of newly inundated riparian habitats. Further, white sturgeon population as a whole may suffer from a loss of productivity because the extensive loss of riparian habitat caused by impoundment and stabilization of water levels within reservoirs. The backwater effects from downstream dams have reduced the range of annual variations in water surface elevations that would have normally have resulted from seasonal changes in river discharge. This alone has caused the primary loss of productive salmonid habitats throughout much of the Columbia River Basin (Dauble et al. 2003). Where shorelines historically retreated and expanded with seasonal changes in river discharge and elevation, they now fluctuate very little. This lack of fluctuation has enabled periphyton to become established on many subsurface rocky areas that may have once been important egg attachment sites for white sturgeon. In addition, the lack of submerged and emergent vegetation typical of seasonally inundated riparian zones in natural rivers also may result in reduced egg attachment sites and larval rearing areas (Coutant 2004).

White sturgeon are an important recreational, commercial, and cultural resource inhabiting reservoirs and river reaches influenced by Army Corps of Engineers projects. Objective 2 of Study Code ADS-04-NEW, *White Sturgeon Passage at Lower Columbia River Dams,* states that the Army Corps of Engineers should "evaluate how different operations effect survival, passage, and spawning success of sturgeon in the vicinity of dams". White sturgeon populations vary considerably in abundance and age structure throughout the Columbia River Basin (Beamesderfer et al. 1995). The abundance and density of fish is greatest in the unimpounded river downstream from Bonneville Dam and this area supports one of the largest and most productive sturgeon populations in the world (DeVore et al. 1995). Conversely, the white sturgeon population from the Kootenai River in northern Idaho has been listed as endangered since 1994. Populations in the Snake River downstream from Hells Canyon Dam appear to be persisting but at a lower abundance than prior to impoundment.

Prior to Coutant's (2004) promotion of the riparian habitat hypothesis, the variations in population status among areas had been attributed to a number of factors. In particular, construction and operation of hydroelectric dams on the Columbia and Snake rivers has directly affected white sturgeon populations in several ways. For example, fish cannot migrate up and down the river as they historically did (North et al. 1993), and areas of spawning habitat have been reduced (Parsley and Beckman 1994). Variations in population characteristics have also been attributed to differences in exploitation rates and recruitment success, access to marine food resources, and suitability of hydrologic conditions and available habitats (Beamesderfer et al. 1995; DeVore et al. 1995). The riparian habitat hypothesis presents several research gaps that need to be addressed before the hypothesis can be accepted. This proposal seeks to begin filling those data gaps.

OBJECTIVES AND METHODOLOGY

The riparian habitat hypothesis hinges on one truth – that white sturgeon eggs and larvae are found in shallow habitats. Thus, this proposal will first address that question. If white sturgeon eggs and larvae are indeed found in shallow habitats, this proposal then outlines a plan of study to ascertain risk to white sturgeon from desiccation and to begin to assess potential losses to population productivity caused by construction and operation of the federal hydroelectric power system.

The first of the three objectives listed below would be addressed through field studies conducted in 2005. The second and third objectives would be addressed only if white sturgeon eggs and larvae are found in riparian habitats where they could be susceptible to desiccation.

Objective 1. Determine if white sturgeon eggs and larvae occur in seasonally inundated riparian habitats or if they occur only in permanently submerged areas.

Rationale

Currently there is debate over the type of habitat where white sturgeon eggs and larvae can be found in the Columbia River simply because past objectives for sampling these life stages did not require sampling in seasonally inundated riparian habitats. Accurate information concerning the importance of these habitats is critical in assessing how construction and operation of U.S. Army Corps of Engineer dams affect survival of early life stages of sturgeon. It is generally accepted that white sturgeon eggs and larvae can be found near the riverbed substrate in a variety of water depths (Parsley et al. 1993; McCabe and Tracy 1994). Coutant (2004) recently developed a hypothesis that eggs are transported to shallow seasonally-flooded riparian habitat for incubation, and resulting larvae also develop in these areas. If this is the case, eggs and larvae could be susceptible to desiccation during short-term water fluctuations. Also, long-term losses of flooded riparian habitat due to dampened seasonal flow regimes may have resulted in a reduction of rearing habitat for young sturgeon from historically levels, thus contributing to decreased recruitment success in many areas of the Columbia River Basin.

Task 1.1 Sample flooded riparian habitats to detect the presence of white sturgeon eggs and larvae.

Because the unimpounded Columbia River downstream from Bonneville Dam supports one of the largest and most productive sturgeon populations in the world (DeVore et al. 1995), we will focus on this area to increase our chances of finding eggs and larvae. White sturgeon spawn in the lower Columbia River at water temperatures of 10-18 ^{o}C, with most spawning at 14^{o}C, which commonly occurs in June (Parsley et al. 1993). Spring water temperatures will be monitored to determine when sampling starts.

Activity 1.1.1

White sturgeon eggs are large, adhesive, and easily identified. Thus, we will use visual observation techniques to search for them in shallow (< 1m deep) water. Maps of areas downstream from Bonneville Dam will be examined and lateral and longitudinal sampling transects will be planned to coincide with expected water surface elevations. Since white sturgeon eggs hatch in about a week at 16 ^{o}C (Deng et al. 2002), sampling will occur weekly. Along each transect, the numbers of eggs encountered and the substrate types they are adhered to will be recorded. Riverbed elevations along each transect will be measured or obtained from existing bathymetry to ascertain susceptibility of white sturgeon eggs and larvae to desiccation.

Schedule: June-July 2005

Activity 1.1.2

Coutant (2004) hypothesized that white sturgeon yolk-sac larvae move to riparian crevices, interstitial spaces, vegetation, or other cover, while feeding larvae must leave these protective areas to forage for food. We will use slurp guns and nets to sample for yolk-sac larvae and foraging larvae in shallow (< 1m deep) water. Various net types will first be tested in riparian habitats to determine the optimal sampling method. Areas to be sampled will be mapped by substrate type and presence of riparian vegetation, and sampling for larvae would occur in a stratified random manner. Collected fish will be placed in a bucket, identified and counted, and returned to the river.

Schedule: May-August 2005

Activity 1.1.3

If white sturgeon egg and larvae are found in seasonally flooded riparian habitats, the depths and elevations at which they are found will be compared to the range of possible water surface elevation fluctuations to determine if desiccation is a possibility. Existing 2-dimensional hydraulic models of the Bonneville tailrace combined with known ramping rates can be used to ascertain risk of desiccation to eggs and larvae.

Schedule: September-December 2005

Objective 2. Conduct laboratory studies to determine the ability of white sturgeon eggs to withstand dewatering.

Rationale. It is possible that white sturgeon eggs can survive periods of dewatering that would occur due to daily water level fluctuations caused by dam operations. Other species of fish have been found to have eggs resistant to exposure to air, but these species often are adapted to tidal conditions (Marliave 1981; Taylor 1999). For example, 69% of pacific herring *Clupea pallasi* eggs survived two 8-hr periods of exposure to air daily (Jones 1972). Survival to exposure during dewatering is also strongly affected by air temperature, vegetative cover, and other factors.

Task 2.1. Obtain newly-spawned white sturgeon eggs from hatcheries. In the laboratory, expose them to air for various periods to mimic daily water level fluctuations and monitor survival. Conduct trials at air and water temperatures and conditions (sun, shade, protective vegetation) they would encounter in the wild as determined during Objective 1.
Schedule: June-July 2006.

Objective 3. Examine if hiding-phase larvae are capable of moving to accommodate changes in water elevations. If not, examine their survival in non-circulating pools of water.

Rationale. Coutant (2004) hypothesized that white sturgeon yolk-sac larvae move to riparian crevices for protection. If these areas are dewatered, it is unknown if larvae would attempt to leave the crevice or remain. If they remain there are two possibilities—a small pool might form where they could survive, or the crevice would drain and the larvae would desiccate.

Task 3.1. The design of this experiment would be based on information collected during Objective 1. White sturgeon yolk-sac larvae or eggs would be obtained from hatcheries. Rocks would be arranged in tanks mimicking conditions larvae inhabit as observed during Objective 1. Larvae would be placed in the tanks and allowed to acclimate. Water levels would be lowered at the rate and to levels that occur below Bonneville Dam. The behavior and survival of larvae in crevices would be observed.

Schedule: June-July 2006.

Task 3.2. If white sturgeon larvae are observed stranded in non-circulating pools of water during Objective 1, conditions they are exposed to will be monitored (i.e., temperature, dissolved oxygen levels). These conditions will be mimicked in the laboratory and survival of larvae will be monitored.
Schedule: June-August 2006.

FACILITIES AND EQUIPMENT

The Columbia River Research Laboratory, a field station of the U.S. Geological Survey's Western Fisheries Research Center, is located in Cook, Washington, along the Columbia River. The facility is approximately 60 miles east of Portland, Oregon and is located on the grounds of the U.S. Fish and Wildlife Service's Willard National Fish Hatchery. The laboratory has wetlab and drylab facilities, office space, and a mechanical shop. The electrical system is connected to backup generators for emergency use during power outages. The laboratory has a fleet of approximately 30 vessels ranging in length from 18 to 30 feet in length that are capable of performing limnological and fish sampling tasks. The office has exceptional computational capabilities and a T-1 line connecting to the Internet. Staff use a variety of graphical and analytical software, and geographic information systems including Arc/Info and ArcView to facilitate data summarizations and presentations.

IMPACTS

The proposed activities will be coordinated with ongoing projects funded by the U.S. Corps of Engineers, the Bonneville Power Administration, and others. We will minimally impact young white sturgeon by visually examining eggs and returning larvae to the river.

COLLABORATIVE ARRANGEMENTS AND SUBCONTRACTS

For some tasks, the USGS contracts with Johnson Controls International (JCI) for biological technician support. All JCI contractors conduct field work under the technical direction of USGS personnel.

LIST OF KEY PERSONNEL AND PROJECT DUTIES

Personnel	Roles
Michael J. Parsley	Project Leader; project administration, reporting, analysis
Dena M. Gadomski	Principal Investigator; data maintenance, analysis, reporting
Eric Kofoot	Project Technician; field data collection, data summarization

TECHNOLOGY TRANSFER

The project leader will ensure that information and analyses from this work are available to resource managers via presentations at professional meetings, workshops, and when otherwise requested. Technical findings may be published in peer-reviewed journals. The USGS's Columbia River Research Laboratory produces metadata records in compliance with National Biological Information Infrastructure standards.

REFERENCES

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