Appendix 2-A

Decision Criteria and Processes for Sacramento River Water Temperature Management

2/18/09 update

Management Goals

Water temperatures in the Sacramento River between Keswick Dam and Bend Bridge will be managed to provide suitable habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. The annual cold water management process will be initiated by Reclamation, in consultation with NOAA's National Marine Fisheries Service (NMFS), by March 15 each year. Reclamation and NMFS will utilize input from the Sacramento River Temperature Task Group (SRTTG) to make management decisions.

Water temperatures will be managed in the mainstem river from April 15 through October 1 to provide maximum protection for winter-run spawning and egg incubation while insuring that cold water reserves will not be depleted to the point that water temperatures out of Shasta Dam can no longer be controlled through manipulations of the temperature control device. As the timing and distribution of spawning, and the coldwater pool available, are variable from year to year, the objective of temperature control from April 15 through October 1 is to protect a minimum of 90 percent of the winter-run population throughout 90 percent of the spawning and rearing period. Additionally, Reclamation shall apply all available authorities to manage cold water reserves to maintain sufficiently cool water temperatures for the protection of spring and fall-run Chinook salmon spawning October 1 through November 30. The criteria prescribed below are intended to apply under most water year conditions, consistent with requirements in this Opinion and the State Water Resources Control Board (SWRCB) Water Right Order No. 90-5.

In any year when the January 15 annual conditions forecast predicts low storage levels and runoff into Shasta Reservoir such that the requirements in this Appendix will be impossible to meet using the full range of Reclamation's authority to reduce or curtail water deliveries and releases, the SRTTG will meet as soon as possible in February to discuss alternative criteria. Reclamation will convene the SRTTG by February 1 and will provide written information for the group's consideration, including the following: (1) Annual forecast showing monthly storage and flow release predictions; (2) CVP water supply report; (3) Recent temp profiles for Shasta, Trinity, and Whiskeytown reservoirs; and (4) Temperature model runs with Jellys Ferry, Balls Ferry and Clear Creek compliance point targets. Reclamation will provide a written report of the SRTTG recommendations for alternative cold water management to NMFS, and NMFS will make the final decision and provide alternative written criteria to Reclamation. Reclamation will submit bi-weekly written reports to NMFS, detailing all water releases and deliveries during the previous period, required temperature measurements, remaining water levels in Shasta reservoir, and the most recent model runs and materials from the SRTTG meetings. Upon receipt of a report, NMFS will determine, with input from the SRTTG, whether the alternative management criteria should be modified and shall so notify Reclamation in writing. This procedure will continue until November 30.

If at any point during the temperature control season of a year in which the February forecast predicted adequate storage levels, it becomes evident that the temperature requirements in the preceding biological opinion are not likely to be met despite the reduction or curtailment of all water deliveries and releases within Reclamation's authority, the process for revising cold water management criteria in a dry year will be followed.

To ensure the accuracy of temperature data, quality assurance/quality control protocols will be followed by Reclamation for stream and reservoir temperature monitoring procedures and equipment. Monitoring equipment will be calibrated regularly throughout the temperature control season. The temperature criterion of 56°F shall be measured as a daily average temperature, not to exceed 56.5°F for more than 3 days running and shall not exceed 57°F for 1 day.

Time periods for temperature management are:

April 15 – May 7	Winter-run Chinook salmon migrate upstream and hold prior to spawning. Temperature concerns are for holding adults and unspawned eggs.
May 8 – July 31	Winter-run Chinook salmon spawning, egg incubation, and early rearing occur between Keswick and Red Bluff Diversion dams. Spawning timing and distribution determined by weekly aerial redd surveys, carcass surveys. Peak timing and distribution is variable. Temperature concerns are for spawning, egg incubation, and early rearing.
August 1 – Sept. 30	Winter-run Chinook salmon egg incubation and early rearing occur. Spring-run spawning and egg incubation may occur in September.
October 1 – Nov. 30	Fall-run and spring-run Chinook salmon spawning, egg incubation, and early rearing occur.

Decision Criteria

<u>April 15 – May 7</u>

In this period, winter-run Chinook salmon migrate upstream and hold prior to spawning. Winter-run spawning typically does not begin until the second week of May, although some spawning may begin during this period. Temperature concerns are primarily for holding adults and unspawned eggs. Temperatures must be maintained at 56°F or lower at compliance locations between Balls Ferry and Bend Bridge beginning on April 15. In the April 15-May 7 pre-spawning period, the cold water pool should be conserved by setting the temperature compliance requirement at Balls Ferry or above. Temperature requirements for upstream migration and holding are less stringent than for spawning and egg incubation. The temperature compliance location shall therefore be set at Balls Ferry in all years, unless predicted storage conditions at Shasta Reservoir are severe. In years of low storage, the procedure for revising these criteria, described above, shall be followed.

May 8 – July 31

Winter-run Chinook salmon spawning, egg incubation, and early rearing occurs in this period between Keswick and Red Bluff Diversion dams. Spawn timing and distribution are determined by weekly aerial redd surveys, and secondarily by carcass surveys. Peak timing and distribution is variable. Water temperature concerns are for spawning, egg incubation, and juvenile rearing. Temperatures must be maintained at 56°F or lower at compliance locations between Balls Ferry and Bend Bridge throughout this period.

By May 1, the SRTTG, with NMFS approval, shall establish the initial 56°F temperature compliance point at Balls Ferry, Jellys Ferry, or Bend Bridge, to start on May 8. Establishment of the initial compliance point will be based on an assessment of the coldwater pool volume available in Shasta Reservoir and the anticipated spawning distribution based on previous year's data. Priority will be given early in this period to provide the maximum spatial protection for winter-run spawning and egg incubation.

At 2-week intervals from May 8 through July 31, the SRTTG shall reassess the location of the temperature compliance point based on:

- Bi-weekly reservoir temperature profiles (documenting the size of the remaining coldwater pool volume),
- Modeled daily water temperatures in the upper river for the remainder of the temperature control season,
- Weekly aerial redd survey data (documenting the distribution of winter-run spawning),
- Carcass survey data (documenting the distribution of carcasses and estimated run size).

If there are expected problems with maintaining the compliance point at the current location throughout the temperature control season, and impacts on winter-run spawning and egg incubation are expected to be low based on real-time survey data, with NMFS approval, the SRTTG may adjust the compliance location upstream. A primary consideration in the decision to move the compliance point during this period shall be to insure the ability to control cold water releases through the end of the temperature control season.

August 1 – Sept. 30

Winter-run Chinook salmon egg incubation and early rearing occurs in this period. Spring-run Chinook salmon spawning and egg incubation may occur in September. Water temperature concerns are for winter-run egg incubation and juvenile rearing, and spring-run Chinook salmon spawning and egg incubation. Temperatures must be maintained at 56°F or lower at compliance locations between Balls Ferry and Bend Bridge throughout this period.

By July 20, the SRTTG shall discuss strategies for temperature control during the August 1 – September 30 period. Location of the temperature compliance point shall be established based on:

- Size of the remaining coldwater pool volume (determined by the end of July temperature profile),
- Modeled daily water temperatures in the upper river for the remainder of the temperature control season.
- Spatial and temporal distribution of Chinook salmon redds.

During this period, data from weekly aerial redd surveys (documenting the distribution of Chinook salmon spawning) will be used to assess temperature impacts on Chinook salmon spawning and egg incubation. In past years, when low numbers of new Chinook salmon redds were observed in the month of September, and cold water pool volume was low, variances have been allowed in temperature compliance, in order to conserve cold water for Chinook salmon spawning in October and November. NMFS shall make the final decision as to location of the temperature compliance point.

<u>October 1 – November 30</u>

Fall-run and spring-run Chinook salmon spawning, egg incubation, and early rearing as well as winter-run Chinook salmon juvenile rearing occur in this period. Temperatures must be maintained at 56 F or lower at compliance locations between Balls Ferry and Bend Bridge from October 1 – 31, and cold water must be managed to provide thermal protections to all Chinook salmon and steelhead life stages as envisioned in the SWRCB Order 90-5. The most restrictive (coldest) water temperature concerns in this period are for fall-run and spring-run Chinook salmon spawning and egg incubation (56°F or lower). By September 25, the SRTTG shall discuss strategies for temperature control during October and November. Temperature management throughout the period will be consistent with SWRCB Order 90-5 and the water quality basin plan. Location and temperature target for the temperature compliance point shall be based on:

- Size of the remaining coldwater pool volume (determined by the end of September temperature profile), and
- Modeled daily water temperatures in the upper river for October and November.

In many years, the remaining coldwater pool volume will be low during October. Based on aerial redd survey data, water temperatures shall be managed to provide maximum benefit to the greatest number of spawners. NMFS shall make the final decision regarding cold water management.

Appendix 2-B

Summary of Proposed Conservation Measures to Offset Operations of the Red Bluff Diversion Dam Provided December 2, 2008, by Tehama-Colusa Canal Authority

Introduction

This appendix includes excerpts from "Proposed Conservation Measures to Offset Operations of the Red Bluff Diversion Dam," a report dated December 2, 2008 which was provided by the Tehama-Colusa Canal Authority to Reclamation. Reclamation provided this report to NMFS for consideration in the development of this RPA. The following tables and study proposals include actions that NMFS has determined to be relevant to partially addressing effects of the proposed action on spring-run Chinook salmon and the Southern DPS of green sturgeon.

Table 1 – *Recommended Conservation Measures for Spring-run Chinook Salmon*

	Status	Implementation Action	Likely Result/ Population Affected (min and max: 2003-2007)	Commitment/ Estimated Cost[1]	Timeline
Impact from RBDD: The range of mortality to spring-run adults varies, but can be estimated somewhere between 75 and 375 fish (0.71 and 3.55%).					
Mill Creek	It is unclear whether Upper and Ward Dams present passage problems during low flows.	Consistent with Draft Recovery Plan Action 2.5.2.1, this report recommends a study to evaluate fish passage at Upper and/or Ward Dams to determine if they meet NMFS' fish passage criteria.	Improved passage for 230 to 1,155 adults to over 40 miles of anadromous habitat.	Reclamation and/or TCCA commit at least $75,000 to complete the study to assess fish passage at the dams.	2010
		If fish passage improvements are recommended for Upper and/or Ward Dams, Reclamation commits to funding or participating in funding the solution.		Reclamation and/or TCCA commit at least $100,000 towards fish passage improvements at each dam.	2011

[1] These cost estimates were provided by TCCA for projects to offset effects of the proposed action. The RPA has reduced adverse impacts from the interim operations of the RBDD to spring-run by allowing unimpeded passage from May 15 until June 15, a critical period for adult spring-run migration. Consequently, fewer projects are needed to offset impacts, and the cost has been reduced from these estimates and commitments, consistent with Action I.3.5.

	Status	Implementation Action	Likely Result/ Population Affected (min and max: 2003-2007)	Commitment/ Estimated Cost[1]	Timeline
Deer Creek	**Stanford-Vina Dam** The Deer Creek Flood Feasibility Study Technical Advisory Committee (TAC) is developing alternatives to address problems associated with the dam.	Consistent with Draft Recovery Plan Action 2.5.65.2, Reclamation proposes a jump-pool enhancement at the existing Stanford-Vina Dam fish ladders. However, if the TAC recommends improvement/replacement of the dam, Reclamation commits to funding or participating in funding the solution.	Improved passage for 161 to 2,235 SR adults to over 25 miles of holding habitat and 30 miles of spawning habitat.	Reclamation and/or TCCA commit at least $100,000 towards improvements to the existing ladders at Stanford-Vina Dam. If the TAC recommends improvement/replacement of the dam, then Reclamation and/or TCCA commits to funding at least $250,000 towards the solution.	2010
	DCID Dam Work is also underway to develop an environmental flow enhancement program.	Consistent with Draft Recovery Plan action 2.5.21.1, Reclamation will consider the recommendation of DWR and DFG (passage improvements, dam replacement, and/or flow augmentation) and fund or participate in funding the solution.	Improved passage for 161 to 2,235 SR adults to over 25 miles of holding habitat and 30 miles of spawning habitat.	Reclamation and/or TCCA commit at least $100,000 in funding the solution to the fish passage problems associated with the dam.	2010
Antelope Creek	**Corridor Assessment** The in-progress Westside Watershed Analysis and the Recovery Plan recognize the physical constraints associated with multiple channels at the mouth of the Antelope Creek.	Consistent with Draft Recovery Plan Action 2.5.11.1, Reclamation proposes a study to assess the physical constraints affecting migration upstream and downstream at the mouth of Antelope Creek	Implementation of a solution would enable an unknown number of juveniles to successfully locate the Sacramento River. Estimated adult population: 3-102, but carrying capacity is unknown.	Reclamation and/or TCCA commit at least $75,000 to complete the study to assess channel constraints on the creek. Reclamation and/or TCCA commit at least $100,000 towards a solution.	2010 2011

	Status	Implementation Action	Likely Result/ Population Affected (min and max: 2003-2007)	Commitment/ Estimated Cost[1]	Timeline
	Paynes Crossing Environmental documentation and design are already funded and underway to address low-flow passage problems at the crossing.	Consistent with Draft Recovery Plan Action 2.5.20.3, Reclamation proposes to improve passage conditions at Paynes Crossing to allow upstream passage during low flows. When a recommendation is made by USFWS and CDFG, Reclamation commits to funding or participating in funding the solution.	Improved passage for 2 to 92 adults to 7 miles of holding and spawning habitat (carrying capacity is unknown due to juvenile outmigration constraints on the creek).	Reclamation and/or TCCA commit at least $500,000 in funding the solution to the fish passage problems associated with the crossing.	2010
	Edwards Dam Environmental documentation and design are already funded and underway to address the faulty screens at this diversion.	Consistent with the Draft Recovery Plan Action 2.5.11.2, Reclamation would implement a solution at this diversion because it does not meet NMFS' fish passage criteria. When a recommendation is made by CDFG, USWFS, and Mr. Edwards, Reclamation commits to funding or participating in funding the solution.	Improved downstream migration for juveniles. Estimated population affected: Downstream migrating juveniles.	Reclamation and/or TCCA commit at least $200,000 towards implementation of the solution.	2010
Battle Creek	Intake 2 at the Coleman Fish Hatchery is currently unscreened. A plan to screen the intake is through the environmental documentation and permitting process.	Reclamation proposes to fund implementation of the project to screen Intake 2 at the Coleman Fish Hatchery.	Screening the intake at the Coleman Fish will improve downstream migration for approximately 467 juveniles.	Reclamation and/or TCCA commit at least $75,000 towards construction for the fish screen.	2009

	Status	Implementation Action	Likely Result/ Population Affected (min and max: 2003-2007)	Commitment/ Estimated Cost[1]	Timeline
Stony Creek	The CHO is not currently used to divert water from the Tehama-Colusa Canal into Stony Creek.	Reclamation proposes to develop operational guidelines for delivering water from the Tehama-Colusa Canal to Stony Creek between October and December.	Improved passage and habitat conditions for 12 miles of anadromous habitat. Estimated population affected: carrying capacity unknown.		2009
Total Cost				$1,575,000	

Note: Table 2 – *Recommended Conservation Measures for Winter-run Chinook Salmon* is not presented in this summary, as similar measures are described in the RPA.

Table 3 – *Recommended Conservation Measures for Green Sturgeon*

	Description	Rationale	Commitment/ Estimated Cost	Timeline
Impact from RBDD: Impacts to green sturgeon are difficult to quantify due to a lack of information.				
Genetic Evaluation of Green Sturgeon Effective Spawning Population	Reclamation would direct a genetic study to evaluate effective spawner abundance above and below RBDD, and conduct comparisons with general census estimates to allow correlations between seasonal habitat conditions and reproductive success.	The lack of information describing the number of annual spawning adults, as well as the total population size of the Southern DPS of green sturgeon, was acknowledged as a source of uncertainty in making status evaluations for ESA recommendations (BRT 2005). Effective conservation of green sturgeon will require better information on their spawning success under various habitat conditions.		3-5 years
Telemetric Studies of Movements of Adult Green Sturgeon Including the Effects of RBDD	Reclamation would direct a telemetric study to monitor green sturgeon movement throughout the Sacramento River with special emphasis in the immediate vicinity of RBDD. Specific objectives would include intensive evaluation of green sturgeon behavior at RBDD, monitoring of behavioral and migrational patterns throughout the river and location of additional aggregation sites.	Previous and ongoing telemetric studies have provided important information on green sturgeon migrational and behavioral patterns in the Sacramento River. There is a need to continue these studies to fill in missing information on how these fish react to the RBDD, where they aggregate before, during and after spawning.		

Characteriza-tion of Green Sturgeon Spawning Grounds	Reclamation would direct a study involving the tagging of 10 wild adult green sturgeon during their upstream migration in the months of March through May. Analysis of the tracking data will provide information regarding ideal spawning conditions.	The habitat requirements for green sturgeon are poorly known; however there are indications that cold, clean water is required for spawning. Spawning aggregations of green sturgeon have been identified at certain stretches along the upper Sacramento River during tracking and telemetry studies carried out by researchers at UC Davis. However, little is known about the micro-habitat conditions which determine whether a particular site is a good spawning area or not, other than depth (areas of approximately homogenous 5 m depth appear to be preferred) and possible current complexity.	3-5 years
Juvenile Green Sturgeon Movements and Identification of Critical Rearing Habitat	Reclamation would direct a study to determine the rearing habitat of juvenile green sturgeon within the river, delta, and bay. Ultrasonic telemetry will be used to record their movements and periods of residence within different regions, some of which are natural and other are altered by the construction of levees and disposal of dredging materials.	The tagging and tracking of juveniles will reveal the habitat preferences of juveniles within the river, delta, and bay. The placement of monitors at reaches with levees and water diversions will provide data to determine their effect on the rate of movement and residence times of juveniles. The placement of monitors at dredge disposal and non-dredge disposal sites will provide information about its impact on the behavior of juvenile green sturgeon within the delta and bay.	3-5 years
Spawning of Wild Caught Green Sturgeon and Rearing of Juveniles for use in Telemetry Studies	Reclamation would direct a study involving capture and tagging of a maximum of 2 ripe females and 4 ripe males, for spawning induction.	Tracking data would provide information on post-spawning survival and spawning periodicity, of both females and males. The green sturgeon would also provide valuable data, regarding egg size, fecundity, fertility and quality of eggs and larvae.	3-5 years

Develop Screen Criteria	Reclamation would direct a series of laboratory experiments to determine the swimming performance and behavior of young green sturgeon (*Acipenser medirostris*) and white sturgeon (*A. transmontanus*), including effects of positive barriers (screens), passive barriers (louvers), and behavioral deterrent devices (near-field vibrations and strobe-light flashes).	Very little is known concerning the swimming performance and behavior of green and white sturgeon larvae and juveniles, especially near fish-protection screens and louvers. Field-based, population-monitoring studies typically provide uneven results for water and fisheries management efforts, due to the variable influences of river stage and hydraulics and the life-stage-dependent swimming performance and behavior aspects of the resident and migratory fishes. A laboratory-based study will provide the baseline information to evaluate and calibrate field study results relevant to native sturgeons' interactions with fish screens and louvers.	5 years
RBDD Gate Configuration Management Team	Reclamation will prepare two operating scenarios each year by May 1. Based on projected releases from Keswick Dam, Reclamation will estimate gate configurations under a 12-inch minimum opening and an 18-inch opening.	Possible points of discussion for the Management Team may include whether the proposed operation will enhance or deter use of the existing fish ladders and the relative impacts to spring-run versus green sturgeon. Upon selection of one of the scenarios, resource agencies may review actual conditions after May 15 to determine if a change is necessary. The current gate configuration at RBDD is 12-inches and it is based on the known girth of large green sturgeon. Raising the gate configuration to 18-inches would benefit green sturgeon because it would allow the species more room beneath the dam gates to migrate past the dam. This would improve passage for an unknown number of green sturgeon.	2009

PROPOSAL TO

Tehama-Colusa Canal Authority

Studies of green sturgeon as conservation measures to offset operations of Red Bluff Diversion Dam[2]

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[2] The following study proposals (tasks 1-5) were updated on May 12, 2009.

Background

Life History

Green sturgeon (*Acipenser medirostris*) have been recorded from the coastal waters of Mexico, the United States, and Canada. In North America, the green sturgeon's range in the ocean extends from the Bering Sea to Ensenada, Mexico. This range includes the entire coast of California. They have been found in rivers from British Columbia south to the Sacramento River in California. There is no evidence of the species spawning in Canada and Alaska, although they are caught in the Fraser and Skeena Rivers (Houston, 1988). They are found in the Columbia River (Moyle, 2002) and Willapa Bay in Washington (Langeness, pers. commun) and coastal rivers in Oregon (Emmet *et al.*, 1991). Within California, they have been recorded in the Sacramento/San Joaquin watershed, Eel, Klamath, and Trinity Rivers (Moyle, 2002). Their abundance increases gradually north of Point Conception.

Sturgeons, with their large size, subterminal and barbeled mouths, lines of bony plates on the sides, and shark-like tail, are among the most distinctive of freshwater fishes. Three species of sturgeon species were originally described, and this species was named *medirostris* or "middle snout" because the length of its snout was greater than one congeneric and less than another (Ayers, 1857). Green sturgeon have a dorsal row of 8-11 bony plates (scutes), lateral rows of 23-30 scutes, and two bottom rows of 7-10 scutes. The dorsal fin has 33-36 rays, and the anal fin, 22-28. This species is similar in appearance to the white sturgeon (*Acipenser transmontanus*), with which it co-occurs, except that its barbels are usually closer to the mouth than to the tip of the long snout. In addition, there is one large scute behind the dorsal fin, as well as one behind the anal fin, which are both lacking in white sturgeon. Body color is olive-green, with an olivaceous stripe on each side and scutes that are paler than the body. The common name, green sturgeon, is apt due to its distinctly green hue.

The ecology and life history of green sturgeon have received comparatively little study because of the species' low abundance and low commercial and sport-fishing value. Adults migrate up the Klamath and Sacramento Rivers between late February and late July (Moyle, 2002). Their spawning period is from March to July, with a peak from mid-April to mid-June (Emmett *et al.*, 1991). The males and females spawn in deep, slow moving pools. The females lay thousands of large eggs, which are adhesive and settle into the spaces between the cobbles in the bottom of the river. The eggs hatch in seven days, and the larvae have a large yolk sack, swim near the bottom, and begin feeding after 10-15 days. Larvae hatched in the laboratory avoid light, indicating that they hide during the day and forage at night. The larva becomes a fully developed juvenile with a length of 74 mm FL at an age of 45 days (Deng, 2002). Juveniles captured at the Red Bluff diversion dam in the upper Sacramento River had grown to an average FL of 29 mm FL. This rate of growth is consistent with rapid growth of 300 mm in one year, and 600 mm within two to three years of juveniles in the Klamath River (Nakamoto *et al.*, 1995). Juveniles inhabit the estuary from 2-4 years, when they migrate to the ocean (Allen *et al.*, 2009).

Green sturgeon travel extensively in the ocean, moving principally over the continental shelf prior to returning to fresh water to spawn (Moyle, 2002). Thirteen of 15 sturgeon tagged in the Sacramento River were captured to the north in estuarine and coastal waters (California Fish and Game, 2002). A northern migration is further supported by the prevalence of green sturgeon during the summer in the Columbia River estuary, Willapa Bay, and Grays Harbor (Adams *et al.*, 2002). Furthermore, green sturgeon with individually coded ultrasonic tags affixed to them in San Pablo Bay have been detected by tag-detecting electronic monitors situated in river systems in Oregon and Washington (Kelly, unpub. data). Individuals tagged in Willapa Bay, and identified by four monitors placed to record the estuarine entry and departure, resided in the estuary during most of the summer, yet exhibited rapid and frequent movements between other estuaries along the coast of North America (Moser and Lindley, 2007). Five subadult (101-106 cm TL) and one adult (153 cm TL), carrying with ultrasonic tags, were tracked by boat for 2-16 h per day over periods ranging from 1-12 days (Kelly *et al.*, 2007). The four subadult fish remained within San Pablo Bay for the duration of their tracks; one moved well into Suisun Bay. The adult fish exited the bay and ocean within six hours of its release near Tiburon, California. Green sturgeon carrying individually coded ultrasonic tags were detected by an array of automated, tag-detecting receivers in the Sacramento River (Heublein *et al.*, 2008). They exhibited four movement patterns: 1) a spring migration upstream to a spawning location, 2) a spring migration downstream to the ocean, 3) summer residence in deep, low velocity pools within the river, and 4) and a fall migration downstream to the ocean in response to rain events.

Red Bluff Diversion Dam

The Red Bluff Diversion Dam (RBDD), which was completed in 1964, provides irrigation to the Tehama-Colusa Irrigation District. This seasonally operated water diversion is at river kilometer (Rkm) 391 on the mainstem of the Sacramento River. Gates on the dam are lowered to impede water flow from 15 May to 14 September of each year. There are only two opportunities for fish to pass the dam during closure: a fish ladder and a narrow gap ($\leq$ 0.5 m) between the flood gates and the river bottom. No green sturgeon have been observed swimming up the fish ladders. Furthermore, the high velocities, created as water moves through the narrow passage between the gates and the bottom block the upriver movement of green sturgeon during the spring spawning migration (Brown, 2007; Israel *et al.* 2009). Acoustically-tagged green sturgeon have been detected and eggs have been collected upstream of RBDD (Thomas et al.; William Poytress, pers. commun.), and aggregations of green sturgeon have been observed below the RBDD once the gates are lowered (Kurt Brown, pers. commun.;Robert Chase, pers. commun.). However, green sturgeon have been captured with gonads in a post-spawn condition 60 km downstream of the RBDD in a reach adjacent to the Glen Colusa Irrigation District pumping facility (Matt Manuel, pers.commun.). Thus, RBDD appears to divide the spawning and holding habitats for adult green sturgeon and rearing habitats for larvae and juveniles. This observation is consistent with two possibilities. Firstly, green sturgeon move upstream of the dam prior to the dam closure, spawn, and then pass under the dam on the way downstream. Secondly, green sturgeon spawn in pools below the dam and then migrate down river. Evidence exists that sturgeon perform both of the above-mentioned behavioral patterns. Understanding the individual and population level effects of the operation of RBDD and flow management for green sturgeon in the upper Sacramento River is necessary for assessing the risks to Southern DPS green sturgeon.

Telemetric studies have provided insight into the relationship between the RBDD and upstream migrating green sturgeon (Hublein et al., 2008; Thomas, *et al.* 2008, *Israel et al.*, 2009). Coded ultrasonic beacons were implanted within the peritoneum of adult green sturgeon captured in San Pablo Bay, California in spring 2004-2006. Their movement upstream was recorded by series of automated monitors deployed at intervals along the length of the Sacramento River both below and above the RBDD. Two distinct migratory patterns were observed for 15 individuals detected by the monitors. Firstly, six individuals moved upstream, potentially spawned, remained over the summer, and then traveled downstream immediately after the first rain event during the fall. Secondly, nine sturgeon moved upstream, potentially spawned, but departed during the summer and early fall before the first rain event. The upstream migration of tagged green sturgeon arriving at the RBDD after May 15 was blocked due to its closure. However, five green sturgeon passed under the gates of the RBDD on a downstream migration. Ten dead green sturgeon were recovered within a kilometer of the Red Bluff Diversion Dam during the spring of 2007. One observed to have the linear imprint on its dorsum indicative of it being trapped by a gate from the Dam.(Klimley, pers. commun). It is likely that the others were also injured/killed when they were trapped in the 30-cm space under the gates during their downstream migration. The gates on the RBDD were raised from 30 to a minimum of 45 cm to provide additional space between the gates and the bottom upon observing this loss of life. Three of five green sturgeon, carrying coded ultrasonic beacons, that made the upstream migration during spring 2007 were not trapped by the dam, and moved past it when the gates were open wider (UC Davis Biotelemetry Laboratory, unpublished data). In 2008, an additional ten green sturgeon were tagged and three previously tagged sturgeon returned to the river upstream of Knights Landing. One of the previously tagged sturgeon ascended above Red Bluff Diversion Dam on March 1 and remained upstream of the RBDD site until late December. The remaining sturgeon showed similar outmigration patterns as previously observed (Heublein *et al.*, 2008) with some leaving in the early summer and others in the late fall following flow increases. Of those which left the river early in June 2008, including one previously tagged sturgeon (Vogel 2005), there is some evidence to suggest that small summer flow increases may be correlated with these downstream movements.

Shipboard tracking during spring of 2008 indicated that adults may move extensively between deep pools, in which they may spawn (Thomas *et al.*, 2008). Depth- and temperature-sensing transmitters were implanted within the peritoneum of two individuals to describe their upstream and downstream movements by following them with a boat, while recording their GPS coordinates, depth and surrounding water temperatures. One male green sturgeon was tagged in a pool near the confluence of the mainstem with Antelope Creek and tracked as it moved back and forth between this and another pool 10 km downtream on the mainstem near the confluence of Deer Creek. When in the pool at Antelope Creek, the sturgeon periodically made circular movements between the head and tail of the pool, and green sturgeon eggs were recovered from egg mats placed at the tail of the pool. The presence of RBDD on the mainstem with its gates down might prevent green sturgeon from making a similar ‘ping-pong’ pattern of movement between spawning sites above and below the dam.

The prevalence of larvae passing RBDD has declined drastically in the past two years, during which only 13 and 3 post larval sturgeon were recovered in the rotary screw traps operated at the dam during spring 2007 and 2008, respectively (William Poytress, pers.

commun.). It is unknown if this is due to reduced spawner abundance, changes in habitat, or decreasing survival during the egg and larval stages. Based on captures in rotary screw traps operated by the USFWS and DFG, the species is thought to reside in the river during its first year of life, slowly moving downriver during this period. The species is known to become tolerant of saline conditions at approximately 30 cm, a length attained in the wild at about age 1+, which correlates with the collection of larger juvenile fish (20-100 cm TL) at delta fish salvage facilities and captured in the delta (Radtke 1966). Juveniles are then thought to reside in the estuary for 1-4 years before initiating their first oceanic out-migration.

Currently, the Bureau of Reclamation (BOR) has funded two years of cooperative research among BOR, USFWS, and two of the U.C. Davis PIs (Israel and Klimley) including tasks on (1) egg and juvenile field sampling, index development, and genetic assessment, (2) adult migration and behavior assessment around RBDD, (3) identification of green sturgeon habitat and distribution methods, and (4) reporting and development of information. We anticipated continuing these tasks, and have included tasks to continue genetic, adult behavior around RBDD, and reporting to the description of suggested studies. Public Policy Consulting has provided us with a document, which describes a number of candidate studies that would be of interest to the Tehama-Colusa Canal Authority (TCCA) and National Marine Fisheries Service (NMFS). These suggested studies include (1) developing a reliable population estimate of green sturgeon within the Sacramento River, (2) relating the presence of spawning adults to particular reaches of the river based on flow characteristics and physical properties such as temperature, turbidity, and dissolved oxygen, 3) relating the presence of rearing juveniles to particular reaches of the river based on flow characteristics and physical properties such as temperature, turbidity, and dissolved oxygen, (4) developing a capture and propagation program for the Southern DPS, and (5) describing the response of post larval and juvenile green sturgeon to screens and other equipment used to protect sturgeon during times of diversion using pumps.

Task 1a

Genetic Evaluation of Green Sturgeon (*Acipenser medirostris*) in the Sacramento River, California

Israel, J.A. (PI) and B.P. May

Background

Recovery and sustainability of green sturgeon will in part depend upon retention and maintenance of genetic diversity and understanding how it is related to the population's demographics. Green sturgeon demonstrate type III survivorship (high fecundity and heavy mortality in early life stages), thus genetic diversity may be lost disproportionately to estimated adult census size because of the high variance in spawning success and/or early life history stage survival in a heterogeneous environment. Green sturgeon collected during sampling for various studies can be used to evaluate gene flow between DPSs, estimate the number of breeding green sturgeon, and assess demographic processes influencing the green sturgeon population in the river. The relatedness between juvenile green sturgeon collected at Red Bluff Diversion Dam between 2002 and 2007 have been evaluated to estimate the number of adults spawners contributing to a group of samples (Israel and May in prep). Estimates of breeding green sturgeon above RBDD during this five year period ranged from 10-54 individuals depending on the year and calculation method (Israel and May, in prep). With increased research into estimating the abundance of sturgeon in the river, we will be able to examine the relationship between the estimated adult census size sturgeon (N) and the genetically effective population size of adult sturgeon (N_b). These population parameters can together yield insight into the demography and dynamics of the Southern green sturgeon DPS and how water and conservation management may influence the population.

Using a genetic approach to population estimation in collaboration with other ongoing census estimation studies (Klimley *et al.*, US ACE 2009-2011 study), we will examine whether eggs, larvae, and juveniles produced are the product of "match-mismatch" recruitment (Hedgecock, 1994), and which stages may prove most influential for successful early life stage survival. By considering the N_b/N ratio, in light of genetic and ecological data about eggs, larvae, and breeding adults, the variance in reproductive success among individuals can inform managers about how extrinsic mechanisms (i.e. habitat fragmentation of spawning habitats), variance in productivity among habitats, and/or habitat-induced early mortality influences the dynamics of the Sacramento River green sturgeon population. This information will be critical to recovery efforts focused on actions for restoring spawning habitats and propagating fishes for increasing population growth rate.

Goals and Objective

1. Genetic-based estimates of spawner abundance above and below Red Bluff Diversion Dam derived from kinship reconstruction.

2. Integration of genetic and census estimates of green sturgeon population size to assess effective population to census size ratio.
3. Evaluation of correlation between seasonal flow characteristics between estimated number of breeding fishes and estimated census number of fishes to consider hypotheses surrounding variance in reproductive success.

Methods

Eggs, larval, and juvenile green sturgeon will be primarily collected by USFWS during their studies on these life history stages between April and July as part of the ongoing cooperative study. Between July and October, genetic analyses at the Genomic Variation Laboratory will estimate the abundance of spawning adults based on the genotypes of these sampled eggs, larvae, and juveniles. Based on the tested methods of kinship reconstruction (Israel 2007), analyses will use the Hardy (2003) kinship estimator and Eggert and Chessel accumulation functions to evaluate the maximum number of breeding fishes.

Individual genotypes will be iterated in multiple formats. First, individual genotypes will be added temporally to evaluate the outmigration patterns of samples from breeding pairs. Second, individual genotypes will be added spatially to a dataset with potential adult samples to assess locality of adult spawning and resulting offspring from possible parental genotypes. Finally, individual genotypes will be added randomly to determine the accumulation of new genotypes and describe the equation for the accumulation curve and its asymptote, which represents the genetically effective number of spawners (N_b). The estimate censuse number of adults will be calculated as part of an ACE-funded study currently being initiated in the Biotelemetry Laboratory for the next three years. Environmental parameter including seasonal, monthly, and daily mean flows and seasonal, monthly, and daily mean temperatures in the upper Sacramento River will be explored to evaluate possible correlation with population demographics.

We expect this study to occur over a three month period. The first half of the time will be used for DNA extractions, genotyping, and data gathering. The second half of the period will be used for data analysis. This will occur for an additional three year period, and relies upon US Fish and Wildlife Service cooperation for collecting eggs and larvae.

Task 1b

Telemetric studies of Movements of Adult Green Sturgeon Including the Effects of the Red Bluff Diversion Dam

Klimley, A.P. (PI), J.A. Israel, M. Thomas, and A. Hearn

Background

In 2008, scientists from the UC Davis Biotelemetry Laboratory undertook multiple telemetric studies of movements of adult green sturgeon in the upper Sacramento River (i.e. above GCID). These investigations included fine scale movement analysis using the California Fish Tracking Consortium acoustic receiver array (Israel et al. 2009) as well as intensive multi-day continuous tracks of adult green sturgeon in the upper Sacramento River. We found that by tagging adults in the river during the spring we could gain insight into riverscape movements which included spawning, aggregation, and interhabitat transit. While continuous tracks are rather common place in oceanic environments, they had not previously been undertaken in such a large dynamic body of water such as the upper Sacramento River. Additionally, our ability to cooperatively capture green sturgeon in the spring (Poytress et al. 2009), then detect tagged green sturgeon where eggs were collected both constituted methodological advances.

Several key findings resulted from the last year's studies (Israel et al. 2009, Thomas *et al*., 2008): 1) green sturgeon exhibited "Ping Pong" movements between aggregate sites located at the confluence of Antelope Creek and near the confluence of Deer Creek, 2) an additional aggregate site was located on the mainstem near the confluence of Deer Creek, 3) adult sturgeon ascended above Red Bluff Diversion Dam as early as mid-April and remained upstream into the early winter, and 4) multiple green sturgeon made numerous visits to RBDD from Antelope following gate closure. Such behavioral findings have been critical in understanding the mechanisms by which green sturgeon locate and perhaps form spawning pairs. Furthermore, the additional understanding of these behavioral mechanisms has imparted further concern for the separation of the population above and below RBDD.

Continued river tagging of green sturgeon will provide additional information for multiple purposes. Having fish tagged in the river will guarantee information about spawning migration and habitat movements of adults in the upper Sacramento River. These observations of movements are to be integrated with egg and larval occurrence information (Poytress *et al.*, 2009) to provide information concerning inter-habitat movement. This will enable us to evaluate whether movement influences estimates of adult abundance (see Klimley study plan funded by ACE in 2009-2011). Furthermore, this tracking of sturgeon around RBDD will provide insights into how sturgeon movements are influenced by flow management. The findings of this study may provide necessary information for refining critical habitat requirements. Additionally, these behavioral components may be used as inputs for future population viability models, which could be useful in a species recovery plan.

Goals and Objectives

1. Evaluate how individual green sturgeon orient to the gates at the RBDD using VPS system in conjunction with the Science and Technology program-funded investigation planned by Richard Corwin and Robert Chase of the BOR.
2. Continue tracking of additional green sturgeon to validate the behavioral patterns observed in 2008.
3. Locate additional aggregation sites both below and above RBDD and provide additional site references for future egg and larval monitoring programs.
4. Provide fine scale movement information and potentially develop a correction index to be utilized with the green sturgeon density distribution abundance estimate study (Klimley study plan funded by ACE in 2009-2011)
5. Determine inter-annual variability in spawning and post spawn holding site variability.

Methods

We will tag ten wild adult green sturgeon during their upstream migration above the RBDD after the gates are closed on the 1th of June until the pumps are installed permanently. The fork-length and weight of each individual will be recorded and a genetic sample collected. We will additionally determine sex and reproductive condition by collecting a gonad sample during the implantation of the acoustic transmitter. We will work closely with Richard Corwin and Robert Chase in setting up the high spatial resolution VPS system upstream of the RBDD. The accuracy of its positioning ability will be evaluated by placing transmitters at fixed locations within the triangular array, in particular near the gates of the dam. These fish will be tracked by the array after 15 June when the gates are closed, and the river depth increases so that the transmitter on the sturgeon can be detected by at least three buoys in the array – a precondition for providing an accurate position determination. We will assist the BOR investigators in the analysis of the fine-scale movements of green sturgeon near the dam in order to ensure that the gate height permits the downstream migration of the sturgeon.

We will tag adult female green sturgeon with a Vemco V-16 continuous acoustic transmitter. Each transmitter contains a pressure sensor and temperature sensor, which transmits precise respective measurements at the sturgeon's exact location. Tags are surgically implanted into the peritoneal cavity using a 3-4 cm incision, which is then closed by 3-4 individual sutures. In addition, each individual will also carry a similar Vemco V-16 coded transmitter that will be detected by the acoustic monitor array during periods when the animal is not being tracked by boat. The continuous transmitters will allow animals to be manually tracked through the riverscape by boat over a 4-5 day duration, 24 hours per day, utilizing a Vemco VR-100 receiver. Concurrent with the track environmental measurement (Depth, pH, DO, Salinity and Turbidity) will be collected using a specialized multiprobe linked with a secondary GPS unit and echo sounder used to develop bathymetric maps associated with the sturgeons movements. Flow velocity measurements will also be manually taken every hour using a Marsh McBirney Flow meter. Coded tags will provide details on the migration of each individual, and these annual data will be integrated with data from previous years (i.e. Israel *et al.*, 2009) to increase sample sizes for examining the influence of RBDD on movements and habitat fragmentation, as well as consideration of possible flow and temperature mechanisms behind movement patterns. Additionally, the periodicity of spawning can be estimated when tagged fish return in future years.

We expect this study to occur over a four month period (2 months of shipboard tracking, 2 months data analysis). This will occur for an additional three year period as there is evidence to suggest inter-annual shifts in spawning aggregate locations.

Task 2

Characterization of Green Sturgeon Spawning Grounds

Klimley, A.P. (PI), M. Thomas, and A. Hearn

Introduction

Spawning aggregations of green sturgeon have been identified at certain stretches along the upper Sacramento River during tracking and telemetry studies carried out by researchers at UC Davis. However, little is known about the micro-habitat conditions which determine whether a particular site is a good spawning area or not, other than depth (areas of approximately homogenous 5 m depth appear to be preferred) and possible current complexity. Currently, vast sections of the river have been listed as critical, and yet spawning is only known to occur at a few specific locations within these sections. What makes an appropriate spawning ground? Do sturgeon require a particular sediment type and/or current regime? How do they utilize the available appropriate habitat during their spawning activities? Do they display competitive behavior?

Methods

We propose to tag 10 wild adult green sturgeon during their upstream migration earlier during the season from March through May at a known spawning site. The fish will likely be collected at the pool near Antelope Creek, known to be a site of reproduction based on the capture of ripe females and the collection of eggs on mats situated at the base of the pool. The fork-length and weight of each individual will be recorded and a genetic tissue sample collected. We will additionally determine sex and reproductive condition by collecting a gonad sample during the implantation of the acoustic transmitter. Each individual will be fitted internally with a V16 coded tag with a pressure sensor. Total surgery time should not exceed five minutes. A further 5 receivers will be deployed at the following: a known spawning aggregation site (likely to be the pool near Antelope Creek), an adjacent, apparently suitable spawning site, but where spawning has not been observed (control site), and three nearby potential spawning sites (determined by depth and riverbed homogeneity). Thus, passage through or residence at any of these sites will be detected by the receivers. Finally, two satellite communicating monitors will be deployed one above the Red Bluff Diversion Dam and one below to determine whether any sturgeon move upstream or downstream past the dam in real time. This information will be provided to biologists both at UC Davis and the Bureau of Reclamation for management purposes.

At the known spawning aggregation site, we intend to deploy a radio-positioning system (VRAP), consisting of three moored hydrophones which allow horizontal and vertical positioning in real time of tagged individuals within the area. This system will provide continuous positions over a period of one week. Two Acoustic Doppler Current Profiler (ADCP) units will be used in collaboration with researchers from United States Department of Fish and Wildlife at both the study site and the control in order to create a cross channel vertical profile of current and temperature. Point samples of current velocity, dissolved oxygen, turbidity, and temperature will be taken at a matrix of positions, separated by ten meter intervals, at one meter depth intervals from the surface to the bottom throughout the study period using the UC Davis hydrolab. At the end of the spawning season, we will collect sediment samples from the river bed at the nodes of the matrix of positions using a grab sampler.

Results

Analysis of the VR2 data will show the relative use of the five sites (study site, control site and three potential spawning grounds) by tagged fish, and whether fish pass through or remain for extended periods. Analysis of the VRAP data will provide insight into the spawning behavior of the sturgeon, interactions between individuals will show whether competition or dominance occur. In combination with the ADCP data, we will show whether sturgeon display preference for particular current regimes, and whether these are stable throughout the spawning season. Sediment analysis will show whether bottom substrate is a key variable in determining whether or not a site is appropriate for spawning.

Chronology

We expect this study to run for approximately six months (1 month of preparatory work, 3 months of fieldwork, and 2 months analysis and write-up) during the first year. During the second year, we expect to repeat the procedure at the study site, and to carry out similar procedures at other sites where spawning aggregations have been identified, either by the VR2 receivers used in this study, or during field research of other, related studies. This will provide insight into inter-annual and inter-site variability, and allow us to design a generalized model of ideal spawning habitat, which will be used in the third year to predict other potential sites both in the Sacramento and other rivers such as the Feather.

The results of this research will provide key input to refining critical habitats, and may also aid in future conservation efforts such as in re-introduction to other areas, or habitat enhancement. In terms of future research directions, knowing critical spawning grounds may be of great assistance in understanding juvenile ecology – another critical aspect in the conservation and management of the species.

Task 3

Juvenile Green Sturgeon Movements and Identification of Critical Rearing Habitat

Klimley, A.P. (PI), M. Thomas, and A. Hearn

Background

Little is known about the distribution of juvenile green sturgeon in the Sacramento/San Joaquin watershed. Herring fishers within the bay also occasionally capture juveniles of the same size, often in spawning areas because they are believed to feed on the eggs released by the herring. There is a greater need to determine the distribution of juveniles than sub-adults and adults as the movements of six green sturgeon have been described from shipboard tracking in San Francisco Bay (Kelly *et al*. 2007). Based on captures in rotary screw traps operated by the USFWS and DFG, the species is thought to reside in the river during its first year of life, slowly moving downriver during this period. The species is known to become tolerant of saline conditions at approximately 30 cm, a length attained in the wild at about age 1+, which correlates with the collection of larger juvenile fish (20-100 cm TL) at lower-river fish salvage facilities and netted in the delta (Radtke 1966). Juveniles are then thought to reside in the estuary for 1-4 years before initiating their first oceanic out-migration.

Objective

The objective of this study will be to determine the rearing habitat of juvenile green sturgeon within the river, delta, and bay. Ultrasonic telemetry used to record their movements and periods of residence within different regions, some of which are natural and other are altered by the construction of levees and disposal of dredging materials.

Methods

The movements of juvenile green sturgeon and their distribution in the watershed relative to environmental and anthropogenic factors will be determined specifically using two techniques: 1) placing coded tags on them and detecting them with automated, tag detecting monitors distributed in the environment and by implanting coded ultrasonic beacons, and 2) affixing to them depth-sensing transmitters and following them within a boat while periodically recording their position. We will use both techniques to characterize the rearing habitat of juvenile green sturgeon.

Automated Monitoring. Firstly, coded beacons (Fig. 1) will be placed in the peritoneum of juveniles and these will be detected with automated, tag-detecting monitors (Fig. 2) deployed throughout the mainstem of the river, delta, and estuary of the Sacramento/San Joaquin watershed. There are nearly 150 tag-detecting monitors distributed within the watershed (Fig. 3).

Fig. 1. RECODE beacon.

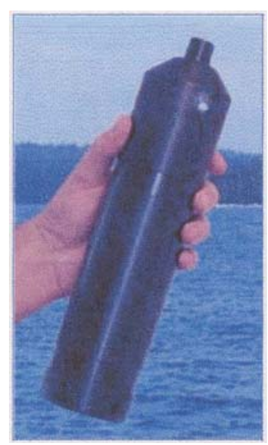

Fig. 2. VR02 monitor

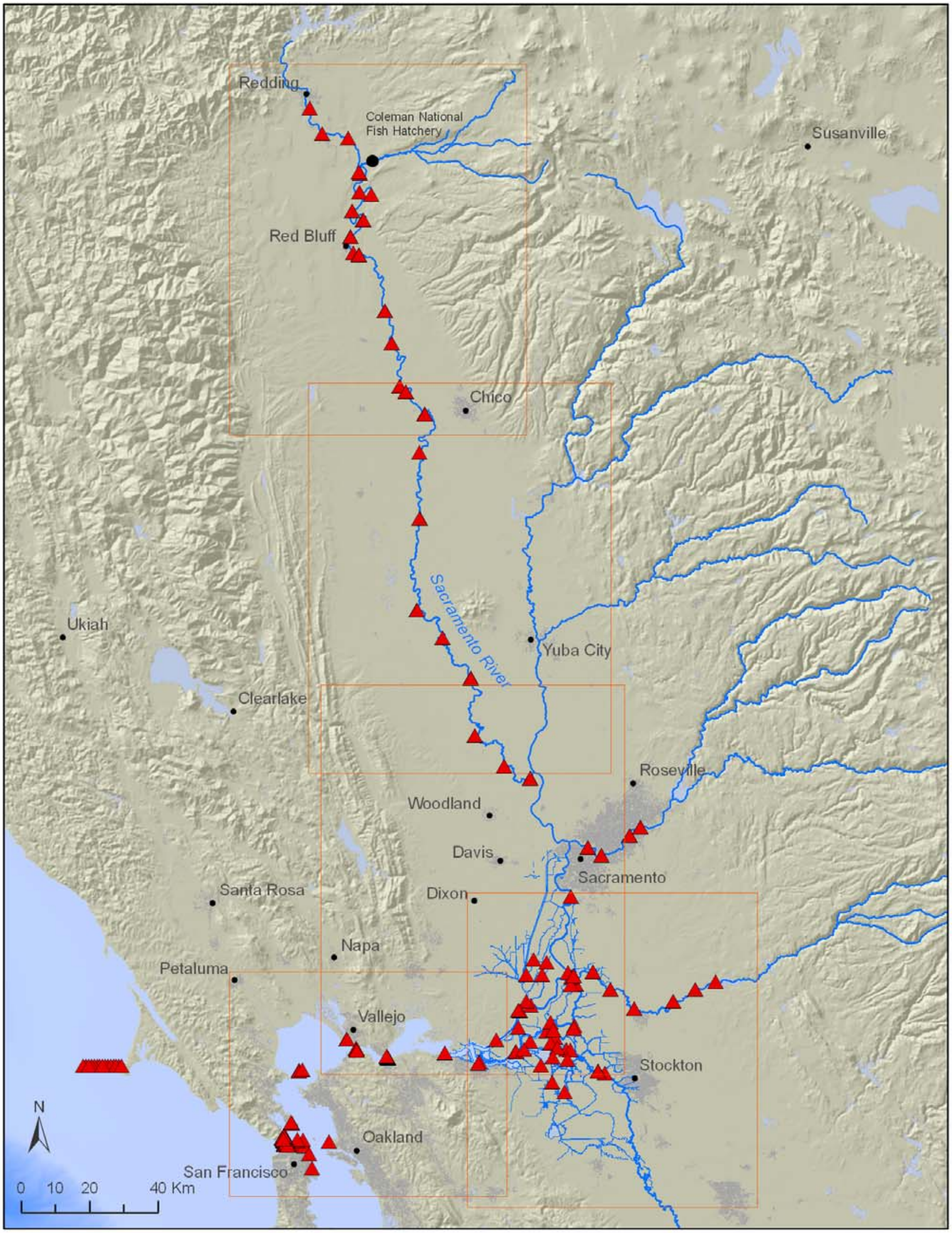

Fig. 3. Locations of automated, tag-detecting monitors capable of detecting juvenile green sturgeon carrying coded ultrasonic beacons.

The challenge for a coded tagging study of juveniles is acquiring individuals for tagging. There are two sources of juveniles. One source is multiple rotary screw traps operated by the U.S. Fish and Wildlife Service immediately downstream of the Red Bluff Diversion Dam (RBDD). Biologists under the supervision of William Poytress have in the past captured post-larval green sturgeon at a rate of 200-300 individuals per year (Fig. 4). Although these post-larvae are less than 2 cm in TL, a size too small for tag implantation, they could be raised to a size appropriate for tag implantation. Richard Corwin and Robert Chase of the Bureau of Reclamation (BOR) can raise post-larvae, captured by the rotary screw traps, in large circular rearing tanks, housed in the laboratory located adjacent to the RBDD operated by the BOR. Post-larval green sturgeon are also captured at the rotary screw trap operated at the Glen Colusa Irrigation District, and these post-larvae will be placed in a large 120 quart cooler equipped with aeration and transported to the RBDD rearing facilities for rearing. Winter and spring of 2006-07 were very dry, and relatively few post-larvae were captured, but we attempted to raise two post-larvae to a larger size. They were successfully raised to sizes > 40 cm TL. Due to the paucity of individuals captured by the traps, these two individuals have been tagged, released into the delta and tracked by boat for a period of four days.

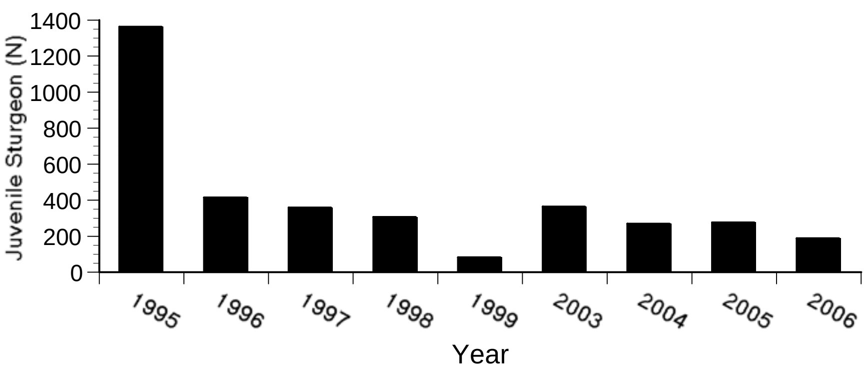

Fig. 4. The number of juvenile green sturgeon captured at the RBDD rotary screw traps from 1995-2006 in mainstream of Sacramento River below RBDD (data from USF&W).

We will capture juvenile green sturgeon in two locations in the Sacramento River watershed. First, small juveniles caught in the rotary screw traps at Red Bluff Diversion Dam (RBDD) and larger juveniles caught at the traps at Glen Colusa Irrigation District (GCID) will be transferred to holding tanks adjacent to the RBDD in a laboratory facility operated by the Bureau of Reclamation. It may be feasible to obtain a sample of 100 fish because from 200 to 400 juveniles have caught by the USF&W over a period of four years from 2003-2006, when the traps were deployed in the mainstream of the Sacramento River immediately downstream of the RBDD. Yet the reduced number of postlarvae captured during the last two years, roughly a dozen during 2007 and only three during 2008 may necessitate our capturing two males and two females, transporting them to the Center for Aquatic Biology and Aquaculture (CABA) at UC Davis, inducing them to spawn artificially, and then returning them to the mainsteam of the river at Antelope Creek. The eggs would be incubated until they hatch, and the larvae grown out using artificial feeds at CABA (see Task 4). The artificial spawning of adults would produce many progeny and enable us to tag as many as 70 juvenile green sturgeon per year. Individuals captured during spring of 2009 would reach as size sufficient to tag during spring of 2010 at the end of Year 1 of the proposed contract. They would be tagged with coded beacons as well as a similar number of individuals during Years 2 and 3 of the study. These individuals would be released either within the mainstem of the river or the delta to identify their residence times in different habitats within the watershed.

Table I. Juvenile green sturgeon captured at the Delta pumping station during 2006 (data from IEP report, see internet web site, ftp://ftp.delta.dfg.ca.gov).

No.	Date	Time (hrs)	Total Length (cm)	No.	Date	Time (hrs)	Total Length (cm)
1	28 Dec 06	1700	54.0	21	27 July 06	0200	16.5
2	29 Dec 06	0600	32.0	22	27 July 06	0600	19.5
3	03 Oct 06	0200	26.0	23	28 July 06	0600	21.0
4	04 Oct 06	0200	28.0	24	31 July 06	0600	17.7
5	05 Oct 06	0200	36.5	25	31 July 06	0600	15.3
6	05 Oct 06	0400	12.5	26	01 Aug 06	0600	15.5
7	18 Oct 06	2200	30.5	27	02 Aug 06	2359	18.7
8	01 Nov 06	1800	35.0	28	07 Sept 06	1200	26.5
9	04 Nov 06	0200	24.5	29	09 Sept 06	1000	23.0
10	04 Nov 06	0200	36.0	30	16 Sept 06	1000	10.0
11	20 Nov 06	1000	30.1	31	17 July 05	0900	50.6
12	21 Nov 06	2200	27.0	32	11 Dec 01	0900	40.0
13	21 Nov 06	2359	25.5	33	21 Dec 01	0300	48.6
14	22 Nov 06	2359	28.0	34	27 Dec 01	0900	4.2
15	01 Dec 06	2000	32.0	35	15 Oct 01	1400	33.5
16	11 July 06	0900	49.8	36	10 Dec 01	1400	37.5
17	19 Sept 06	0700	28.0	37	02 Mar 01	0300	31.0
18	19 Sept 06	0700	30.0	38	21 Feb 00	0900	28.4
19	19 July 06	0200	15.0	39	21 Feb 00	1500	28.6
20	26 July 06	8888	19.0				

An alternative source of juveniles is the pumping facilities within the Delta. They range in size from 4.2-54.0 cm long. Twenty individuals were captured from October to December 2006 in the pumping facilities (Table I). Biologists at UC Davis have an agreement with both state and federal biologists to place individuals captured in water in a large, 120 quart cooler for either tagging with coded ultrasonic beacons or transportation the Center for Aquatic and Aquaculture (CABA) located at UC Davis, where they will be raised to a sufficient size to implant beacons as part of The Directed Action funded by CDFG.

Two models of coded ultrasonic tags, a model with a life of a year on the smaller juveniles (12-25 cm TL) and a model of a life of three years on larger juveniles (26-50 cm TL), would be placed on juveniles held in captivity. Studies are currently being carried out at UC Davis to determine the minimum size juvenile, into which a transmitter can be inserted into the peritoneum and without reducing its capacity to swim rapidly as well as not to increase the oxygen consumption during normal swimming. The distribution of the juveniles would be determined by the array of automated tag-detecting monitors deployed throughout the river, delta, and bay.

Shipboard Tracking. Individual green sturgeon, carrying pressure and temperature sensing transmitters, will be released at experimental sites. Four tagged fish will be followed by a two person tracking team each year aboard a small boat equipped with a portable receiver and hydrophone. Tracking will be carried out continuously for 24 hours of the day for a period of five days for each of eight fish. There will be two teams of trackers, and they will each track for 12-hour shifts, and will stay at a hotel near the tracking site when not tracking. The geographical coordinates of the fish will be determined automatically by the receiver and paired with the depths and temperatures from the ultrasonic tags. Water will be pumped into a shipboard tank, where a Hydrolab probe will measure water conductivity, salinity, pH, temperature, and concentration of dissolved oxygen, while software will pair these measurements with depths of the fish and those recorded by a fathometer. At hourly intervals the Hydrolab will be lowered throughout the water column to measure these physical properties at increasing depths.

Results

The tagging and tracking of juveniles, both by an array of tag-detecting monitors and by a team of trackers, will reveal the habitat preferences of juveniles within the river, delta, and bay. The placement of monitors at reaches with levees and water diversions will enable us to determine their effect on the rate of movement and residence times of juveniles. The placement of monitors at dredge disposal and non-dredge disposal sites will provide information about its impact on the behavior of juvenile green sturgeon within the delta and bay.

Task 4

Spawning of Wild Caught Sacramento River Green Sturgeon and Rearing of Juveniles for use in Telemetry Studies[3]

Doroshov, S (P.I.), A.P. Klimley, and J. Van Eenennaam

Objectives

We propose in collaboration with the Biotelemetry Laboratory a maximum of 2 ripe females and 4 ripe males will be captured for spawning induction, each spring. The additional female and 2 males maybe needed if the first attempted spawning is not successful. Considering the amount of time and funds allocated to prepare for one spawning each spring, a 2nd spawning trial during the season, would add little additional cost. These fish would be part of the total requested number of adults to be telemetry tagged by the Klimley Lab, as they would be implanted with tags after spawning. If induced ovulation and egg collection is successful this would be the first documented case of a post-cesarean section green sturgeon tagged and released. The tracking data would provide information on post-spawning survival and spawning periodicity, of both females and males. In addition to providing juveniles for telemetry tagging, the spawning of wild caught southern distinct population green sturgeon would provide valuable data, regarding egg size, fecundity, fertility and quality of eggs and larvae. With the potential further decline in Sacramento River water flow and changes in water quality, a conservation-oriented hatchery, based on information collected in this project, may become, in the future, the only option for mitigation of these and other impacts on the green sturgeon population.

Methods

Broodstock captured from the Sacramento River will be transported to the UC Davis, Putah Creek Aquaculture Facility in a sturgeon transport trailer and then held in 1 or 2 twelve foot diameter circular tanks that will be semi-recirculating with an in-line chiller to maintain appropriate water temperatures for spawning induction.

Spawning induction procedures, egg incubation and larval rearing techniques for green sturgeon have already been established (Van Eenennaam, *et al.*, 2001; 2004; 2005; 2006; 2008). Briefly, to determine female maturity, eggs will be sampled with a 5mm ID Teflon tubing through a small abdominal incision. Eggs will be bisected to measure egg polarization index (PI, relative distance of the germinal vesicle from the animal pole (Van Eenennaam, *et al*. 2006) which is a measure of a female's readiness to spawn. Males will be selected based on the presence of large white testis when sampled. The spawning induction of female green sturgeon will be a priming injection of 1 µg/kg GnRHa, followed by a second injection of 19 µg/kg (12 h later), and for males, a single injection of 10 µg/kg. Ovulation is expected 12-16 hours after the

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[3] Either a Section 10 permit will be required from NMFS or a collecting permit from CDFG to collect the adults and spawn them. We are currently communicated with Jeff McLain and David Woodbury about the necessity of spawning wild adults and setting up a program of artificial propagation for the green sturgeon.

resolving injection. Ovulated eggs would be collected (see Cesarean Surgery procedures below) not later than 1.5 h after ovulation, briefly rinsed in freshwater, and fertilized with milt diluted 1:200 for at least 4 min, or until the eggs start to adhere to the sides of the fertilization container. Fertilized eggs would be silted for 1 h and incubated in upwelling incubators. Optimally, all these procedures should be performed within the temperature range of 12 to 16^{o}C.

Cesarean Surgery: When ovulated eggs have been released by the female (the tank is checked for eggs every hour beginning at 10 hours post-2nd injection) the female is removed from the holding tank by tube-net and placed into an anesthetic bath (MS-222@50 ppm) until equilibrium is lost and gill ventilation is every 2-3 seconds. The female is removed from the anesthetic bath by carefully placing her into a hooded stretcher placed in the tank. The stretcher is lifted, water drained and moved to sawhorse supports. The gills of the female are then irrigated with fresh oxygenated water containing 25 ppm MS-222, which is exchanged with fresh water every 10 minutes, to ensure the fish does not stop ventilating its gills. Using a 100 qt cooler, small submersible water pump, and 1" diameter tygon tubing, we use this small recirculation system to keep the female under a moderate state of anesthesia, during which the female is still ventilating her gills, but is calm.

Due to the fact that sturgeon have internal mullerian ducts and cannot be easily hand-stripped like salmonids, the most efficient way to remove eggs is by caesarian section. After anesthetizing the female, the incision area is gently swapped with 10% iodine and an 8-10 cm long incision is made in the abdomen using a # 10 scalpel blade and a Brown Adson tissue forceps. The location of the incision is slightly lateral to the mid-line to contain about 1.2 cm thick of muscle and 4-6 ventral scutes anterior from the pelvic fin. All surgical tools, and egg collection equipment are sterilized and aseptic conditions maintained. Eggs are removed using plastic spoons with no sharp edges. After egg collection (takes about 15 minutes) and insertion of the telemetry tag, the incision is closed by two sets of sutures (takes about 15 minutes) for added strength, to ensure the peritoneum will be closed, and to help with apposition and rapid healing. The first is an internal suture used to bring the peritoneum and bottom half of the muscle together and the second is an external suture for the top part of the muscle and skin. The internal suture is made using single interrupted stitches with the PDS II absorbable violet monofilament suture #0, with a swaged-on CT-2 taper needle. The external stitches will use the same suture material except a larger swaged-on CP-1 cutting needle is needed to cut through the tough sturgeon skin. The external sutures used are a special tension suture pattern called the "far-near-near-far" pattern. The advantage of this suture is that it apposes the skin edges and provides a degree of tension, which is important for the large sturgeon females when they become more active as they are healing. The female is placed into a recovery tank and observed continually until she is swimming normally. The female will be released at the point of capture after 3-4 days observation. The amount of days the individual fish are held in captivity, before and after spawning, needs to be kept at a minimum. Wild-caught green sturgeon refuse to feed in captivity, and the cesarean incision healing would certainly be impaired in non-feeding fish, leading to suffering and mortality.

The UCD system for embryo incubation is already constructed but requires two small submersible chillers to maintain water temperatures during egg incubation Larval rearing would require a minimum of 6-4' diameter tanks, for the critical weaning period, after yolk adsorption.

And as the larvae grow, larger tanks will be used for grow-out until individuals are large enough for telemetry tagging.

The larvae at UCD will be cared for by Doroshov and Klimley's labs. Systems for larval rearing of sturgeon are already available at UCD. The sites at UCD are supplied with well water and growth would be much faster than fish grown out at the Bureau site using river water.

Task 5

Larval and Juvenile Green and White Sturgeon Swimming Performance and Behavior: Responses to Fish-protection Screens and Louvers.

J.J. Cech, Jr. (PI) and D.E. Cocherell

Introduction

Very little is known concerning the swimming performance and behavior of green and white sturgeon larvae and juveniles, especially near fish-protection screens and louvers. Field-based, population-monitoring studies typically provide uneven results for water and fisheries management efforts, due to the variable influences of river stage and hydraulics and the life-stage-dependent swimming performance and behavior aspects of the resident and migratory fishes. A laboratory-based study will provide the baseline information to evaluate and calibrate field study results relevant to our native sturgeons' interactions with fish screens and louvers. It also specifically relates to one of the key questions on water operations and environmental issues that have been raised repeatedly at recent Science Program workshops and reviews: "What are the population-level effects of large and small water diversions throughout the Bay-Delta system on anadromous sturgeons' different life stages?" Identifying and providing for efficient fish protection (including screening), especially for diversions with the greatest fish-entrainment potential, will further ensure that agricultural water diversions do not impair improvements to fishery production resulting from river-habitat restoration. From the Final rule on Green Sturgeon (Federal Register / Vol. 71, No. 67 / Friday, April 7, 2006 / Rules and Regulations):

"The threat of screened and unscreened agricultural, municipal, and industrial water diversions in the Sacramento River and Delta to green sturgeon is largely unknown as juvenile sturgeon are often not identified and current CDFG and NMFS screen criteria do not address sturgeon. Based on the temporal occurrence of juvenile green sturgeon and the high density of water diversion structures along rearing and migration routes, we find the potential threat of these diversions to be serious and in need of study."

Methods and Results

We propose a series of laboratory experiments to determine the swimming performance and behavior of young green sturgeon (*Acipenser medirostris*) and white sturgeon (*A. transmontanus*), including effects of positive barriers (screens), passive barriers (louvers), and behavioral deterrent devices (near-field vibrations and strobe-light flashes).

1. Determine the age, mass, and length of post-hatch larval sturgeon, regarding positive rheotactic behaviors. These behaviors, indicating the detection and response to water currents, help prevent downstream movements of these small fish in their riverine rearing areas. Furthermore, these behaviors may help determine the ages and sizes at which they start to show avoidance behaviors. These age and size-related data are key in understanding and modeling of resistance to entraining velocities at water diversions.

2. Conduct critical swimming velocities tests, in a Brett-style, recirculating-flow chamber, on green and white sturgeon, starting at the age of first positive rheotactic behaviors to 6 months old, under night and day photophases. These data will be valuable in determining escapement swimming velocities in entraining flow fields. Knowing if Sacramento River sturgeons swimming abilities increase linearly with age or if they only start increasing at specific ages will be key. Within these tests we can determine the station-holding capabilities of sturgeon. Station-holding can be described as the fish's volitional choice to avoid passive movements, via staying at a location. Station-holding is germane to our proposal in predicting age and sizes of fish are capable of avoid entraining facilities.

3. Perform tests in our laboratory flumes with positive barriers (screens) and passive barriers (louvers). We propose to test various flow conditions (low, medium, to high velocities based on critical swimming experiments results) to observe screen contact rates and passage rate through louvers (under night and day photophases). We will observe if contacting the screen has short and long term effects on the fish, via post-test health assessments and growth experiments (contact versus non-contact treatments) respectively. This will elucidate the damage type and severity fish suffer from diversion structures interactions. In addition, we propose to investigate if screen vibrations or photo-deterrents affect sturgeon screen contacts and passage rates. In addition we propose to test behavioral deterrent devices, such as near-field vibrations at the screens and strobe-light flashes over the screens.

4. We propose to conduct, also, several of the previous experiments with exercise-conditioned fish versus non-conditioned fish. Exercised fish are those kept in a constant flow fields, coaxing the fish to be active. In the river fish may have higher activity levels than they would in large aquaria (*i.e.*, laboratory holding tanks). These experiments will help identify if hatchery fish can benefit from exercise conditioning.

Hypothesis 1. The probability of entrainment loss within the zone of influence depends on: species (green vs. white sturgeon), swimming performance, behavior (*e.g.*, response to flow and other stimuli), exposure duration, and environmental conditions (*e.g.*, day vs. night).

Hypothesis 2. Fish that are exercise-conditioned, vs. non-exercise-conditioned fish, gain a performance advantage, when encountering the zone of influence of a water diversion, with a consequent lower probability of entrainment-related damage.

We propose to focus on these factors and experiments because of their relevance in developing initial criteria to prioritize screened diversions for future fish protection. If white sturgeons perform significantly similar to endangered green sturgeons, it could be justified to use white sturgeon as surrogates in future swimming performance experiments.

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APPENDIX 2-C: YOLO BYPASS ACTIONS

Yolo Bypass Interagency Working Group

California Department of Fish and Game

California Department of Water Resources

National Marine Fisheries Service

US Fish and Wildlife Service

June 2006

Yolo Bypass Conceptual Aquatic Restoration Opportunities:

The following describes potential northern Yolo Bypass (above Little Holland Tract) aquatic restoration opportunities. The CALFED Ecosystem Restoration Program Implementing Agencies (CDFG, USFWS, NMFS) in cooperation with the DWR, are evaluating the feasibility of implementing the following opportunities. These opportunities were developed through consultations with participating agencies of the Yolo Bypass Interagency Working Group (YBIWG). The YBIWG acknowledges key issues, interests, and concerns raised during previous discussions with stakeholders and evaluates potential restoration opportunities with these issues in mind.

The primary goal of the YBIWG is to improve conditions for native fish species (particularly State and federal Threatened and Endangered fish species and species of special concern) in the Yolo Bypass, thereby enhancing populations and recovery efforts while minimizing land management impact.

This document focuses, at a conceptual level, on the sequential development of potential restoration opportunities in the northern Yolo Bypass. The set of potential restoration opportunities is provided to foster discussion among public entities and stakeholders interested in the northern Yolo Bypass.

The YBIWG has identified the following potential restoration opportunities for further evaluation:

- **Putah Creek** – Lower Putah Creek stream realignment and floodplain restoration for fish passage improvement and multi-species habitat development on existing public lands.
- **Lisbon Weir** – Improve agriculture and habitat water control structure for fish and wildlife benefits.
- **Additional multi-species habitat development** – Identify areas of opportunity within the Yolo Bypass Wildlife Area, or other appropriate areas that could provide for controlled localized seasonal inundation on more frequent intervals.
- **Tule Canal Connectivity** – Identify passage impediments. Evaluate the feasibility of improving fish passage or removing fish passage impediments.
- **Multi-species fish passage structure**– Evaluate the feasibility of constructing a multi-species fish passage structure at the Fremont Weir.

Biological monitoring will be implemented as necessary and may be used to guide future actions and adaptive management.

Multi-species restoration opportunities discussed here are presented in a sequential order of completion. For the full value of the proposed restoration opportunities in the Yolo Bypass to be realized, the following ordered scheme should occur.

Step 1 - Putah Creek

Evaluate and develop a plan for the realignment and restoration of lower Putah Creek. The area proposed for restoration is within existing public lands. The realignment has the potential to create 130 to 300 acres of shallow water habitat. Benefits would include improved salmonid immigration and emigration to and from Putah Creek, an increase in avian (shorebird and waterfowl) habitat, increased aquatic and riparian habitat for other native species, as well as a significant enhancement to existing fish habitat in and around Putah Creek.

Goals:

- Improve passage, rearing, and emigration of adult and juvenile salmon and steelhead in Putah Creek.
- Provide diverse aquatic and riparian habitats for shorebirds, ground nesting birds, waterfowl, plants, invertebrates, plankton, and spawning and rearing of native fish species.

Step 2 – Lisbon Weir

Modify or replace Lisbon Weir to provide better fisheries management opportunities in Putah Creek and the Toe Drain, while improving the reliability of agricultural diversions and reducing maintenance requirements. A conceptual example of the synergistic benefits of these proposed restoration actions is the idea that improving Lisbon Weir's reliability for agricultural diversions could increase flexibility in water distribution, thereby allowing for greater attraction flows to be released down the realigned Putah Creek.

Goals:

- Improve irrigation water distribution system to benefit fish and wildlife.
- Improve likelihood of adult fall-run Chinook immigration to Putah Creek
- Reduce delay and possible stranding of adult steelhead, Chinook salmon and sturgeon, when passable conditions to the Sacramento River exist.

Step 3 – Additional multi-species habitat development

Expand existing shallow water habitat for various species including juvenile native fish. Additional multi-species habitat could be developed through the excavation of a low shelf along a limited portion of the Toe Drain and through small scale setback levees, or by other unidentified means. Restoration opportunities for the development of additional seasonal shallow water habitat, where opportunities exist, may occur on:

Undeveloped lands within the Yolo Bypass Wildlife Area.

1. Other undeveloped public lands within the Yolo Bypass.
2. Private lands where cooperative agreements between the implementing agencies and the landowners provides mutual benefits.

Goals:

- Increase rearing habitat available to juvenile steelhead, Chinook salmon, and splittail.
- Increase shallow water habitat availability for multiple species (fish, wildlife, plankton, and others).

Step 4 – Tule Canal Connectivity

Identify areas of stranding adjacent to the Fremont Weir. Evaluate the feasibility of improving connectivity between the Fremont Weir, the Fremont Weir scour ponds, and the Toe Drain to reduce stranding of adult and juvenile fish. Identify seasonal road crossings and agricultural impoundments in the northern Yolo Bypass that impact wetted habitat connectivity, immigration, and emigration of fish species utilizing the Yolo

Bypass. Develop conceptual approaches for the modification of crossings and impoundments.

Goals:

- Reduce delay and stranding of adult steelhead, Chinook salmon, and sturgeon immigrating within the Yolo Bypass
- Reduce delay and overall losses of juvenile Chinook salmon and steelhead emigrating within the Yolo Bypass.

Step 5 – Multi-species fish passage

Evaluate the feasibility and appropriateness of providing fish passage improvements in and along the Fremont Weir. Appropriate operational constraints would guide plan development and would ensure:

1. Continued maintenance of flood conveyance capacity.
2. No substantial changes in timing, volume, and/or duration flow.
3. Minimal disturbance to existing land use and agricultural practices.

Restoration opportunities may include the addition of a new, controlled multi-species fish passage structure at the eastern edge of the Fremont Weir. Additionally, restoration opportunities may include improvements along the existing weir face and apron to facilitate sturgeon passage along the length of Fremont Weir without introducing any additional flows. Conceptual designs for this option could include rock ramps that would provide a gradual slope up the face of the weir. In addition to the installation of new fish passage structures, the existing fish ladder will be analyzed to determine if modifications could allow for a greater range of fish species passage.

Goals:

- When present in the northern Yolo Bypass, improve immigration and emigration (reduce delay and stranding) of adult and juvenile fish (steelhead, Chinook salmon, and sturgeon).

The YBIWG identified potential restoration opportunities with consideration given to the elimination or minimization of potential negative impacts to the following areas of concern:

- Flood control
- Agricultural operations
- State and federal wildlife area infrastructure investments
- Public and private waterfowl management operations
- Wildlife management operations
- Water quality

- Educational activities
- Recreation
- Vector control
- Welfare of selected fish species at various life stages.

The intent of the YBIWG is to keep all users and interest whole. Conceptual restoration opportunities were developed to be implemented with minimal impact to Yolo Bypass users. Restoration opportunities that significantly changed the timing and/or duration of flow, or that resulted in substantial new regulation of the Yolo Bypass, were eliminated from further consideration.

APPENDIX 2-D – SUMMARY OF AMERICAN RIVER FLOW MANAGEMENT STANDARD

SUMMARY OF THE FLOW MANAGEMENT STANDARD PROGRAM

FOR THE LOWER AMERICAN RIVER

1.0 FLOW MANAGEMENT STANDARD DESCRIPTION

The Flow Management Standard (FMS) for the Lower American River includes provisions for: (1) minimum flow and water temperature requirements; (2) the lower American River Group (ARG) to play a consultative role in operational decisions; and (3) monitoring and evaluation to ascertain the biological and ecological status of the river, and to provide input into the river management process.

1.1 MINIMUM FLOW REQUIREMENTS

The Minimum Flow Requirements prescribe the minimum flows to be released from Nimbus Dam, and are the cornerstone of the FMS. The Minimum Flow Requirements do not preclude Reclamation from making higher releases at Nimbus Dam, and can vary throughout the year in response to the hydrology of the Sacramento and American river basins.

Minimum Release Requirements

The Minimum Release Requirements (MRR) range from 800 to 2,000 cfs based on a sequence of seasonal indices and adjustments. The minimum Nimbus Dam release requirement is determined by applying the appropriate water availability index (Index Flow). Three water availability indices (i.e., Four Reservoir Index (FRI), Sacramento River Index (SRI), and the Impaired Folsom Inflow Index (IFII)) are applied during different times of the year, which provides adaptive flexibility in response to changing hydrological and operational conditions.

During some months, Prescriptive Adjustments may be applied to the Index Flow, resulting in the MRR. If there is no Prescriptive Adjustment, the MRR is equal to the Index Flow.

Discretionary Adjustments for water conservation or fish protection may be applied during the period extending from June through October. If Discretionary Adjustments are applied, then the resultant flows are referred to as the Adjusted Minimum Release Requirement (Adjusted MRR).

The MRR and Adjusted MRR may be suspended in the event of extremely dry conditions, represented by "conference years" or "off-ramp criteria". Conference years are defined when the projected March through November unimpaired inflow into Folsom Reservoir is less than 400,000 acre-feet. Off-ramp criteria are triggered if forecasted Folsom Reservoir storage at any time during the next twelve months is less than 200,000 acre-feet.

Water availability indices, Index Flows, Prescriptive Adjustments, MRRs, Discretionary Adjustments, and Adjusted MRRs are presented in **Table 1**.

Table 1. Flow Management Standard Indices and Flow Requirements

<table>
<tr><th>Month</th><th>Index</th><th>Index Flows (cfs)</th><th>Prescriptive Adjustments</th><th>Minimum Release Requirements (cfs)</th><th>Discretionary Adjustments</th><th>Adjusted Minimum Release Requirements (cfs)</th></tr>
<tr><td>October</td><td>FRI</td><td>800-1,500</td><td>NA</td><td>800-1,500</td><td>Fish Protection Adjustment</td><td>1,250- 1,499</td></tr>
<tr><td>November</td><td>FRI</td><td>800-2,000</td><td>Spawning Flow Progression</td><td>800-2,000</td><td>NA</td><td></td></tr>
<tr><td>December</td><td>FRI</td><td>800-2,000</td><td>NA</td><td>800-2,000</td><td>NA</td><td></td></tr>
<tr><td rowspan="3">January</td><td>SRI
If Above Normal or Wet Year (SRI ≥ 15.7 MAF) then release 1,750 cfs</td><td>1,750</td><td rowspan="2">December End-of-Month Storage Adjustment

When End-Of-December Storage is < 300 TAF, then January MRR is 85% of December MRR</td><td rowspan="3">800-1,750</td><td>NA</td><td></td></tr>
<tr><td>SRI
If Dry or Below Normal Year (10.2 < SRI < 15.7 MAF) then maintain December MRR up to 1,750 cfs</td><td>800-1,750</td><td>NA</td><td></td></tr>
<tr><td>SRI
If Critical Year (SRI < 10.2 MAF) then reduce MRR</td><td>85% of December MRR, but not less than 800</td><td>NA</td><td>NA</td><td></td></tr>
<tr><td rowspan="3">February</td><td>SRI
If Above Normal or Wet Year (SRI ≥ 15.7 MAF) then release 1,750 cfs</td><td>1,750</td><td rowspan="2">January End-of-Month Storage Adjustment

When End-Of-January Storage is < 350 TAF, then February MRR is 85% of January MRR</td><td rowspan="3">800-1,750</td><td>NA</td><td></td></tr>
<tr><td>SRI
If Dry or Below Normal Year (10.2 < SRI < 15.7 MAF) then maintain January MRR up to 1,750 cfs</td><td>800-1,750</td><td>NA</td><td></td></tr>
<tr><td>SRI
If Critical Year (SRI < 10.2 MAF) then reduce MRR</td><td>85% of January MRR, but not less than 800</td><td>NA</td><td>NA</td><td></td></tr>
<tr><td>March through May</td><td>IFII</td><td>800-1,750</td><td>May End-of-Month Storage Adjustment

When Calculated End-Of-May storage is < 700 TAF,
then IFII Index Flow or February MRR, whichever is less</td><td>800-1,750</td><td>NA</td><td></td></tr>
<tr><td>June though Labor Day</td><td>IFII</td><td>800-1,750</td><td>September End-of-Month Storage Adjustment

When Calculated End-Of-September storage is < 300 TAF, then IFII Index Flow or Calculated Storage-Based Flow, whichever is less</td><td>800-1,750</td><td>Water Conservation or Fish Protection Adjustment</td><td>1,500-1,749</td></tr>
<tr><td>Post-Labor Day through September 30</td><td>IFII</td><td>June through Labor Day MRR, but not more than</td><td>NA</td><td>800-1,500</td><td>Fish Protection Adjustment</td><td>1,250-1,499</td></tr>
</table>

Table 1. Flow Management Standard Indices and Flow Requirements

Month	Index	Index Flows (cfs)	Prescriptive Adjustments	Minimum Release Requirements (cfs)	Discretionary Adjustments	Adjusted Minimum Release Requirements (cfs)
		1,500				

Water Availability Indices and Other Definitions

Four Reservoir Index

The FRI is an index of the end-of-September combined carryover storage in Folsom, French Meadows, Hell Hole, and Union Valley reservoirs and is used to calculate the Index Flow for October through December.

Sacramento River Index

The SRI is an index of forecasted water year runoff for the Sacramento River Basin, and is used to calculate the Index Flow for the months of January and February.

Impaired Folsom Inflow Index

The IFII is an index of the forecasted volume of flow into Folsom Reservoir from May through September, and is used to calculate the Index Flow from March through September.

Index Flows

Index Flows are the initial flows (nominal flows) identified by application of the various water availability indices, and are subject to Prescriptive and Discretionary Adjustments, which result in Minimum Release Requirements (defined below). Year-round water availability indices and corresponding Index Flows are presented in **Figure 2**. The October 1 through December 31 Index Flows range between 800 and 2,000 cfs. The January 1 through Labor Day Index Flows range between 800 and 1,750 cfs. The post-Labor Day through September 30 Index Flows range between 800 and 1,500 cfs.

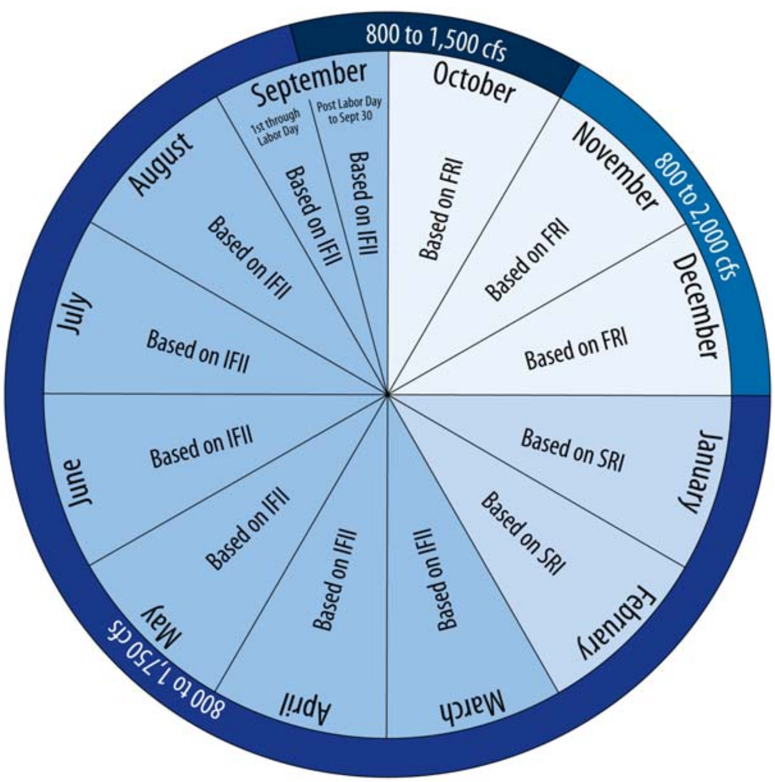

Figure 2. Index Flow Requirements

Prescriptive Adjustments

The FMS includes five Prescriptive (non-discretionary) Adjustments to the Index Flows in consideration of Folsom Reservoir storage and water conservation.

- Chinook Salmon Spawning Flow Progression Adjustment
- December End-of-Month Storage Adjustment
- January End-of-Month Storage Adjustment
- May End-of-Month Storage Adjustment
- September End-of-Month Storage Adjustment

When Prescriptive Adjustments are applicable, the MRR is equal to the value that results from applying the given adjustment to the Index Flow. When Prescriptive Adjustments are not applicable, the MRR is equal to the Index Flow.

Discretionary Adjustments

Two types of discretionary adjustments are possible: (1) water conservation; and (2) fish protection. A water conservation Discretionary Adjustment may be implemented in consideration of Folsom Reservoir storage, but will not be permitted if it would be likely to cause or exacerbate harmful water temperature-related impacts to rearing juvenile steelhead or spawning fall-run Chinook salmon. Fish protection includes conservation of remaining cold water reserves, taking into account effects of the Discretionary Adjustment on in-river water temperature and habitat.

Overview of the Coldwater Pool Management Model and the Automated Temperature Selection Procedure

Coldwater Pool Management Model

Flexibility to meet the Flow Management Standard (FMS) water temperature objectives may be promoted by using the Coldwater Pool Management Model (CPMM) in the development and updating of the Annual Water Temperature Management Plan. The CPMM may be used to select the most beneficial seasonal target temperature objectives for the lower American River during a given year. Selection of seasonal water temperatures is:

- ❑ Characterized by the rate and duration with which available cold water will be released from Folsom Reservoir to control water temperatures
- ❑ Based on the biological benefit expected from controlling lower American River water temperatures
- ❑ Limited by the amount of cold water available in Folsom Reservoir.

The CPMM requires:

- Initial reservoir conditions (i.e., profiles of water temperature, total dissolved solids, and suspended solids)
- Hydrologic time series data of projected North and South Forks of the American River inflow to Folsom Reservoir
- Reservoir evaporation and river heat gain
- Meteorological data
- Folsom Reservoir operation data (Folsom Dam releases and Folsom Pumping Plant diversion)

Automated Temperature Selection Procedure

The Folsom Reservoir and lower American River water temperature models are utilized in an iterative manner referred to as the Automated Temperature Selection Procedure (ATSP). The ATSP operates the reservoir and river water temperature models with the objective of achieving monthly target water temperatures in the lower American River at Watt Avenue, and is designed to aid in the planning and achievement of general management objectives for the lower American River.

Seasonal Priorities/Automated Temperature Selection Procedure Schedules

The ATSP involves the use of multiple target water temperature schedules for the lower American River at Watt Avenue. The "schedule" approach was developed with the purpose of balancing the seasonal use of Folsom Reservoir's coldwater availability, which varies from year to year. The prioritization order of the target temperature schedules for the FMS reflects the desire to protect juvenile steelhead over-summer rearing while balancing the needs of fall-run Chinook salmon spawning, given the constraints of coldwater pool availability at Folsom Reservoir.

A schedule of water temperatures, for May through November, is specified as the preferred schedule of monthly water temperature targets. Because Folsom Reservoir water temperatures are not isothermal during the May through November period, ATSP water temperature targets are achieved through choice of reservoir level from which releases are drawn. If the preferred schedule cannot be achieved with the available release level choices, the procedure cycles to a second, slightly less preferred schedule of water temperatures. If the second schedule cannot be met, the procedure continues through a series of schedules, arranged by declining preference, until a schedule of targets is met for that year.

Table 1 presents the ATSP schedule developed with the purpose of balancing the seasonal use of Folsom Reservoir's coldwater availability prioritized to protect juvenile steelhead over-summer rearing while balancing the needs of fall-run Chinook salmon spawning. If desirable, an alternative schedule could be developed. Schedule #1 has the most beneficial application of coldwater for conditions when sufficient coldwater is available for Folsom Reservoir releases during the May though November period. Schedule #78 has the least desirable application for fisheries benefits relative to other schedules, but may be the only achievable schedule during years of extremely limited coldwater pool availability in Folsom Reservoir. The monthly May through November targets are varied incrementally, to reduce and shift the amount of coldwater released during the summer months, to achieve the balanced management objectives for steelhead and fall-run Chinook salmon. In Table 1, the cells highlighted in yellow indicate changes in water temperature targets for a given month and schedule, as compared to the previous schedule.

There are no water temperature targets for the months of December through April. During these months of the year, Folsom Reservoir is typically well-mixed and the water column is nearly isothermal with depth. For this reason and because ambient air temperatures are sufficient to maintain suitable water temperatures for steelhead and fall-run Chinook salmon in the lower American River, water temperature targets are not identified for the December through April period.

Table 1. Automated Temperature Selection Procedure Schedules.

Schedule	Lower American River Water Temperature Targets at Watt Avenue (°F)						
	May	Jun	Jul	Aug	Sep	Oct	Nov
1	63	63	63	63	63	56	56
2	63	63	63	63	63	57	56
3	63	63	63	63	63	58	56
4	63	63	63	63	63	59	56
5	63	63	63	63	63	60	56
6	63	63	63	63	63	60	57
7	63	63	63	63	63	60	58
8	63	63	64	63	63	60	58
9	63	63	64	64	63	60	58
10	63	63	64	64	64	60	58
11	63	64	64	64	64	60	58
12	64	64	64	64	64	60	58
13	64	64	65	64	64	60	58
14	64	64	65	65	64	60	58
15	64	64	65	65	65	60	58
16	64	65	65	65	65	60	58
17	65	65	65	65	65	60	58
18	65	65	65	65	65	61	58

Schedule	Lower American River Water Temperature Targets at Watt Avenue (°F)						
	May	Jun	Jul	Aug	Sep	Oct	Nov
19	65	65	65	65	65	62	58
20	65	65	65	65	65	63	58
21	65	65	65	65	65	64	58
22	65	65	65	65	65	65	58
23	65	65	65	65	65	65	59
24	65	65	66	65	65	65	59
25	65	65	66	66	65	65	59
26	65	65	66	66	66	65	59
27	65	66	66	66	66	65	59
28	66	66	66	66	66	65	59
29	66	66	67	66	66	65	59
30	66	66	67	67	66	65	59
31	66	66	67	67	67	65	59
32	66	67	67	67	67	65	59
33	67	67	67	67	67	65	59
34	67	67	68	67	67	65	59
35	67	67	68	68	67	65	59
36	67	67	68	68	68	65	59
37	67	68	68	68	68	65	59
38	68	68	68	68	68	65	59
39	68	68	68	68	68	66	59
40	68	68	68	68	68	67	59
41	68	68	68	68	68	68	59
42	68	68	69	68	68	68	59

Schedule	Lower American River Water Temperature Targets at Watt Avenue (°F)						
	May	Jun	Jul	Aug	Sep	Oct	Nov
43	68	68	69	69	68	68	59
44	68	68	69	69	69	68	59
45	68	69	69	69	69	68	59
46	69	69	69	69	69	68	59
47	69	69	69	69	69	69	59
48	69	69	69	69	69	69	60
49	69	69	70	69	69	69	60
50	69	69	70	70	69	69	60
51	69	69	70	70	70	69	60
52	69	70	70	70	70	69	60
53	70	70	70	70	70	69	60
54	70	70	70	70	70	70	60
55	70	70	70	70	70	70	61
56	70	70	71	70	70	70	61
57	70	70	71	71	70	70	61
58	70	70	71	71	71	70	61
59	70	71	71	71	71	70	61
60	71	71	71	71	71	70	61
61	71	71	71	71	71	71	61
62	71	71	71	71	71	71	62
63	71	71	72	71	71	71	62
64	71	71	72	72	71	71	62
65	71	71	72	72	72	71	62
66	71	72	72	72	72	71	62

Schedule	Lower American River Water Temperature Targets at Watt Avenue (°F)						
	May	Jun	Jul	Aug	Sep	Oct	Nov
67	72	72	72	72	72	71	62
68	72	72	72	72	72	72	62
69	72	72	72	72	72	72	63
70	72	72	72	72	72	72	64
71	72	72	72	72	72	72	65
72	72	72	72	72	72	72	66
73	72	72	72	72	72	72	67
74	72	72	72	72	72	72	68
75	72	72	72	72	72	72	69
76	72	72	72	72	72	72	70
77	72	72	72	72	72	72	71
78	72	72	72	72	72	72	72

APPENDIX 2-E

STANISLAUS RIVER MINIMUM FLOWS FOR FISH NEEDS

Introduction:

The following tables indicate the specific minimum flows needed to achieve the minimum flow schedule as specified in Action III.1.3. The flow is based on releases measured at Goodwin Dam.

Stanislaus River Minimum Fish Flow Schedule
Water Year Type: Critically Dry

OCT	CFS	NOV	CFS	DEC	CFS	JAN	CFS	FEB	CFS	MAR	CFS
1	200	1	200	1	200	1	200	1	200	1	200
2	200	2	200	2	200	2	200	2	200	2	200
3	200	3	200	3	200	3	400	3	200	3	200
4	200	4	200	4	200	4	400	4	200	4	200
5	200	5	200	5	200	5	200	5	400	5	200
6	200	6	200	6	200	6	200	6	400	6	200
7	200	7	200	7	200	7	200	7	200	7	200
8	200	8	200	8	200	8	200	8	200	8	200
9	200	9	200	9	200	9	200	9	200	9	200
10	200	10	200	10	200	10	200	10	200	10	200
11	200	11	200	11	200	11	200	11	200	11	200
12	200	12	200	12	200	12	200	12	200	12	200
13	200	13	200	13	200	13	200	13	200	13	200
14	200	14	200	14	200	14	200	14	200	14	200
15	500	15	200	15	200	15	200	15	200	15	200
16	750	16	200	16	200	16	200	16	200	16	200
17	1000	17	200	17	200	17	200	17	200	17	200
18	1250	18	200	18	200	18	200	18	200	18	200
19	1250	19	200	19	200	19	200	19	200	19	200
20	1250	20	200	20	200	20	200	20	200	20	200
21	1250	21	200	21	200	21	200	21	200	21	200
22	1250	22	200	22	200	22	200	22	200	22	200
23	1250	23	200	23	200	23	200	23	200	23	200
24	1250	24	200	24	200	24	200	24	200	24	200
25	1250	25	200	25	200	25	200	25	200	25	200
26	1000	26	200	26	200	26	200	26	200	26	200
27	750	27	200	27	200	27	200	27	200	27	200
28	500	28	200	28	200	28	200	28	200	28	200
29	200	29	200	29	200	29	200			29	200
30	200	30	200	30	200	30	200			30	200
31	200			31	200	31	200			31	200

APR	CFS	MAY	CFS	JUN	CFS	JUL	CFS	AUG	CFS	SEP	CFS
1	200	1	725	1	150	1	150	1	150	1	150
2	200	2	725	2	150	2	150	2	150	2	150
3	200	3	725	3	150	3	150	3	150	3	150
4	200	4	725	4	150	4	150	4	150	4	150
5	200	5	725	5	150	5	150	5	150	5	150
6	200	6	725	6	150	6	150	6	150	6	150
7	200	7	725	7	150	7	150	7	150	7	150
8	200	8	725	8	150	8	150	8	150	8	150
9	200	9	725	9	150	9	150	9	150	9	150
10	200	10	725	10	150	10	150	10	150	10	150
11	200	11	725	11	150	11	150	11	150	11	150
12	200	12	725	12	150	12	150	12	150	12	150
13	200	13	550	13	150	13	150	13	150	13	150
14	200	14	450	14	150	14	150	14	150	14	150
15	350	15	300	15	150	15	150	15	150	15	150
16	500	16	150	16	150	16	150	16	150	16	150
17	725	17	150	17	150	17	150	17	150	17	150
18	725	18	150	18	150	18	150	18	150	18	150
19	725	19	150	19	150	19	150	19	150	19	150
20	725	20	150	20	150	20	150	20	150	20	150
21	725	21	150	21	150	21	150	21	150	21	150
22	725	22	150	22	150	22	150	22	150	22	150
23	725	23	150	23	150	23	150	23	150	23	150
24	725	24	150	24	150	24	150	24	150	24	150
25	725	25	150	25	150	25	150	25	150	25	150
26	725	26	150	26	150	26	150	26	150	26	150
27	725	27	150	27	150	27	150	27	150	27	150
28	725	28	150	28	150	28	150	28	150	28	150
29	725	29	150	29	150	29	150	29	150	29	150
30	725	30	150	30	150	30	150	30	150	30	150
		31	150			31	150	31	150		

Table 1of 5

Stanislaus River Minimum Fish Flow Schedule
Water Year Type: Dry

OCT	CFS	NOV	CFS	DEC	CFS	JAN	CFS	FEB	CFS	MAR	CFS
1	200	1	200	1	200	1	200	1	200	1	200
2	200	2	200	2	200	2	200	2	200	2	200
3	200	3	200	3	200	3	400	3	200	3	200
4	200	4	200	4	200	4	400	4	200	4	200
5	200	5	200	5	200	5	400	5	400	5	200
6	200	6	200	6	200	6	200	6	400	6	200
7	200	7	200	7	200	7	200	7	400	7	200
8	200	8	200	8	200	8	200	8	200	8	200
9	200	9	200	9	200	9	200	9	200	9	200
10	200	10	200	10	200	10	200	10	200	10	200
11	200	11	200	11	200	11	200	11	200	11	200
12	200	12	200	12	200	12	200	12	200	12	200
13	200	13	200	13	200	13	200	13	200	13	200
14	200	14	200	14	200	14	200	14	200	14	200
15	500	15	200	15	200	15	200	15	200	15	200
16	750	16	200	16	200	16	200	16	200	16	200
17	1000	17	200	17	200	17	200	17	200	17	200
18	1250	18	200	18	200	18	200	18	200	18	200
19	1250	19	200	19	200	19	200	19	200	19	200
20	1250	20	200	20	200	20	200	20	200	20	200
21	1500	21	200	21	200	21	200	21	200	21	200
22	1500	22	200	22	200	22	200	22	200	22	200
23	1500	23	200	23	200	23	200	23	200	23	200
24	1250	24	200	24	200	24	200	24	200	24	200
25	1250	25	200	25	200	25	200	25	200	25	200
26	1250	26	200	26	200	26	200	26	200	26	200
27	1000	27	200	27	200	27	200	27	200	27	200
28	750	28	200	28	200	28	200	28	200	28	200
29	500	29	200	29	200	29	200			29	200
30	200	30	200	30	200	30	200			30	200
31	200			31	200	31	200			31	200

APR	CFS	MAY	CFS	JUN	CFS	JUL	CFS	AUG	CFS	SEP	CFS
1	200	1	1000	1	200	1	200	1	200	1	200
2	200	2	1000	2	200	2	200	2	200	2	200
3	200	3	1000	3	200	3	200	3	200	3	200
4	200	4	1000	4	200	4	200	4	200	4	200
5	200	5	1000	5	200	5	200	5	200	5	200
6	200	6	1000	6	200	6	200	6	200	6	200
7	200	7	1000	7	200	7	200	7	200	7	200
8	350	8	1000	8	200	8	200	8	200	8	200
9	500	9	1000	9	200	9	200	9	200	9	200
10	750	10	1000	10	200	10	200	10	200	10	200
11	1000	11	1000	11	200	11	200	11	200	11	200
12	1000	12	1000	12	200	12	200	12	200	12	200
13	1000	13	1000	13	200	13	200	13	200	13	200
14	1000	14	1000	14	200	14	200	14	200	14	200
15	1000	15	1000	15	200	15	200	15	200	15	200
16	1000	16	800	16	200	16	200	16	200	16	200
17	1000	17	600	17	200	17	200	17	200	17	200
18	1000	18	450	18	200	18	200	18	200	18	200
19	1000	19	300	19	200	19	200	19	200	19	200
20	1000	20	200	20	200	20	200	20	200	20	200
21	1000	21	200	21	200	21	200	21	200	21	200
22	1000	22	200	22	200	22	200	22	200	22	200
23	1000	23	200	23	200	23	200	23	200	23	200
24	1000	24	200	24	200	24	200	24	200	24	200
25	1000	25	200	25	200	25	200	25	200	25	200
26	1000	26	200	26	200	26	200	26	200	26	200
27	1000	27	200	27	200	27	200	27	200	27	200
28	1000	28	200	28	200	28	200	28	200	28	200
29	1000	29	200	29	200	29	200	29	200	29	200
30	1000	30	200	30	200	30	200	30	200	30	200
		31	200			31	200	31	200		

Table 2 of 5

Stanislaus River Minimum Fish Flow Schedule
Water Year Type: Below Normal

OCT	CFS	NOV	CFS	DEC	CFS	JAN	CFS	FEB	CFS	MAR	CFS
1	250	1	200	1	200	1	200	1	200	1	200
2	250	2	200	2	200	2	200	2	200	2	200
3	250	3	200	3	200	3	400	3	200	3	200
4	250	4	200	4	200	4	400	4	200	4	200
5	250	5	200	5	200	5	400	5	400	5	200
6	250	6	200	6	200	6	400	6	400	6	200
7	250	7	200	7	200	7	200	7	400	7	200
8	250	8	200	8	200	8	200	8	400	8	200
9	250	9	200	9	200	9	200	9	200	9	200
10	250	10	200	10	200	10	200	10	200	10	200
11	250	11	200	11	200	11	200	11	200	11	200
12	250	12	200	12	200	12	200	12	200	12	200
13	250	13	200	13	200	13	200	13	200	13	200
14	250	14	200	14	200	14	200	14	200	14	200
15	500	15	200	15	200	15	200	15	200	15	200
16	750	16	200	16	200	16	200	16	200	16	200
17	1000	17	200	17	200	17	200	17	200	17	200
18	1250	18	200	18	200	18	200	18	200	18	200
19	1500	19	200	19	200	19	200	19	200	19	200
20	1500	20	200	20	200	20	200	20	200	20	200
21	1500	21	200	21	200	21	200	21	200	21	200
22	1500	22	200	22	200	22	200	22	200	22	200
23	1500	23	200	23	200	23	200	23	200	23	200
24	1500	24	200	24	200	24	200	24	200	24	200
25	1500	25	200	25	200	25	200	25	200	25	200
26	1500	26	200	26	200	26	200	26	200	26	200
27	1500	27	200	27	200	27	200	27	200	27	200
28	1250	28	200	28	200	28	200	28	200	28	200
29	1000	29	200	29	200	29	200			29	200
30	750	30	200	30	200	30	200			30	200
31	500			31	200	31	200			31	200

APR	CFS	MAY	CFS	JUN	CFS	JUL	CFS	AUG	CFS	SEP	CFS
1	400	1	1500	1	900	1	250	1	250	1	250
2	750	2	1500	2	600	2	250	2	250	2	250
3	1000	3	1500	3	600	3	250	3	250	3	250
4	1250	4	1500	4	600	4	250	4	250	4	250
5	1500	5	1500	5	600	5	250	5	250	5	250
6	1700	6	1500	6	600	6	250	6	250	6	250
7	2000	7	1500	7	450	7	250	7	250	7	250
8	2000	8	1500	8	450	8	250	8	250	8	250
9	2000	9	1500	9	450	9	250	9	250	9	250
10	2000	10	1500	10	450	10	250	10	250	10	250
11	1500	11	1500	11	300	11	250	11	250	11	250
12	1500	12	1500	12	300	12	250	12	250	12	250
13	1500	13	1500	13	300	13	250	13	250	13	250
14	1500	14	1250	14	300	14	250	14	250	14	250
15	1500	15	1250	15	250	15	250	15	250	15	250
16	1500	16	1250	16	250	16	250	16	250	16	250
17	1500	17	1250	17	250	17	250	17	250	17	250
18	1500	18	1250	18	250	18	250	18	250	18	250
19	2000	19	1250	19	250	19	250	19	250	19	250
20	2000	20	1000	20	250	20	250	20	250	20	250
21	2000	21	1000	21	250	21	250	21	250	21	250
22	2000	22	1000	22	250	22	250	22	250	22	250
23	1500	23	1000	23	250	23	250	23	250	23	250
24	1500	24	1000	24	250	24	250	24	250	24	250
25	1500	25	1000	25	250	25	250	25	250	25	250
26	1500	26	1000	26	250	26	250	26	250	26	250
27	1500	27	900	27	250	27	250	27	250	27	250
28	1500	28	900	28	250	28	250	28	250	28	250
29	1500	29	900	29	250	29	250	29	250	29	250
30	1500	30	900	30	250	30	250	30	250	30	250
		31	900			31	250	31	250		

Table 3 of 5

Stanislaus River Minimum Fish Flow Schedule
Water Year Type: Above Normal

OCT	CFS	NOV	CFS	DEC	CFS	JAN	CFS	FEB	CFS	MAR	CFS
1	300	1	200	1	200	1	200	1	200	1	200
2	300	2	200	2	200	2	200	2	200	2	350
3	300	3	200	3	200	3	400	3	200	3	700
4	300	4	200	4	200	4	400	4	200	4	1200
5	300	5	200	5	200	5	400	5	400	5	1800
6	300	6	200	6	200	6	400	6	400	6	2300
7	300	7	200	7	200	7	400	7	400	7	3000
8	300	8	200	8	200	8	200	8	400	8	3000
9	300	9	200	9	200	9	200	9	400	9	3000
10	300	10	200	10	200	10	200	10	200	10	3000
11	300	11	200	11	200	11	200	11	200	11	3000
12	300	12	200	12	200	12	200	12	200	12	3000
13	300	13	200	13	200	13	200	13	200	13	1200
14	300	14	200	14	200	14	200	14	200	14	800
15	500	15	200	15	200	15	200	15	200	15	800
16	750	16	200	16	200	16	200	16	200	16	800
17	1000	17	200	17	200	17	200	17	200	17	800
18	1250	18	200	18	200	18	200	18	200	18	800
19	1500	19	200	19	200	19	200	19	200	19	800
20	1500	20	200	20	200	20	200	20	200	20	800
21	1500	21	200	21	200	21	200	21	200	21	800
22	1500	22	200	22	200	22	200	22	200	22	800
23	1500	23	200	23	200	23	200	23	200	23	800
24	1500	24	200	24	200	24	200	24	200	24	800
25	1500	25	200	25	200	25	200	25	200	25	800
26	1500	26	200	26	200	26	200	26	200	26	800
27	1500	27	200	27	200	27	200	27	200	27	1200
28	1250	28	200	28	200	28	200	28	200	28	1500
29	1000	29	200	29	200	29	200			29	2300
30	750	30	200	30	200	30	200			30	3000
31	500			31	200	31	200			31	3000

APR	CFS	MAY	CFS	JUN	CFS	JUL	CFS	AUG	CFS	SEP	CFS
1	3000	1	3000	1	1200	1	300	1	300	1	300
2	3000	2	3000	2	1200	2	300	2	300	2	300
3	3000	3	3000	3	1200	3	300	3	300	3	300
4	3000	4	3000	4	1200	4	300	4	300	4	300
5	2300	5	2300	5	1200	5	300	5	300	5	300
6	1500	6	1500	6	1200	6	300	6	300	6	300
7	1200	7	1500	7	1200	7	300	7	300	7	300
8	800	8	1500	8	1200	8	300	8	300	8	300
9	800	9	1500	9	1000	9	300	9	300	9	300
10	800	10	1500	10	1000	10	300	10	300	10	300
11	800	11	1500	11	1000	11	300	11	300	11	300
12	800	12	1500	12	1000	12	300	12	300	12	300
13	800	13	1500	13	1000	13	300	13	300	13	300
14	800	14	1500	14	1000	14	300	14	300	14	300
15	800	15	1200	15	1000	15	300	15	300	15	300
16	800	16	1200	16	1000	16	300	16	300	16	300
17	800	17	1200	17	1000	17	300	17	300	17	300
18	800	18	1200	18	1000	18	300	18	300	18	300
19	800	19	1200	19	1000	19	300	19	300	19	300
20	800	20	1200	20	1000	20	300	20	300	20	300
21	800	21	1200	21	1000	21	300	21	300	21	300
22	800	22	1200	22	1000	22	300	22	300	22	300
23	800	23	1200	23	1000	23	300	23	300	23	300
24	800	24	1200	24	750	24	300	24	300	24	300
25	800	25	1200	25	750	25	300	25	300	25	300
26	800	26	1200	26	500	26	300	26	300	26	300
27	1500	27	1200	27	500	27	300	27	300	27	300
28	2300	28	1200	28	500	28	300	28	300	28	300
29	3000	29	1200	29	300	29	300	29	300	29	300
30	3000	30	1200	30	300	30	300	30	300	30	300
		31	1200			31	300	31	300		

Table 4 of 5

Stanislaus River Minimum Fish Flow Schedule
Water Year Type: Wet

OCT	CFS	NOV	CFS	DEC	CFS	JAN	CFS	FEB	CFS	MAR	CFS
1	400	1	300	1	300	1	300	1	300	1	600
2	400	2	300	2	300	2	300	2	300	2	1200
3	400	3	300	3	300	3	600	3	300	3	2400
4	400	4	300	4	300	4	600	4	300	4	5000
5	400	5	300	5	300	5	600	5	600	5	5000
6	400	6	300	6	300	6	600	6	600	6	5000
7	400	7	300	7	300	7	600	7	600	7	5000
8	400	8	300	8	300	8	600	8	600	8	4500
9	400	9	300	9	300	9	300	9	600	9	2400
10	400	10	300	10	300	10	300	10	600	10	1200
11	400	11	300	11	300	11	300	11	300	11	800
12	400	12	300	12	300	12	300	12	300	12	800
13	400	13	300	13	300	13	300	13	300	13	800
14	400	14	300	14	300	14	300	14	300	14	800
15	500	15	300	15	300	15	300	15	300	15	800
16	750	16	300	16	300	16	300	16	300	16	800
17	1000	17	300	17	300	17	300	17	300	17	800
18	1250	18	300	18	300	18	300	18	300	18	800
19	1500	19	300	19	300	19	300	19	300	19	800
20	1500	20	300	20	300	20	300	20	300	20	1200
21	1500	21	300	21	300	21	300	21	300	21	1200
22	1500	22	300	22	300	22	300	22	300	22	1200
23	1500	23	300	23	300	23	300	23	300	23	1200
24	1500	24	300	24	300	24	300	24	300	24	1200
25	1500	25	300	25	300	25	300	25	300	25	800
26	1500	26	300	26	300	26	300	26	300	26	800
27	1500	27	300	27	300	27	300	27	300	27	800
28	1250	28	300	28	300	28	300	28	300	28	800
29	1000	29	300	29	300	29	300			29	800
30	750	30	300	30	300	30	300			30	800
31	500			31	300	31	300			31	800

APR	CFS	MAY	CFS	JUN	CFS	JUL	CFS	AUG	CFS	SEP	CFS
1	800	1	4800	1	1200	1	800	1	400	1	400
2	800	2	4800	2	1200	2	500	2	400	2	400
3	1200	3	4500	3	1200	3	500	3	400	3	400
4	2400	4	4500	4	1200	4	500	4	400	4	400
5	5000	5	4500	5	1200	5	500	5	400	5	400
6	5000	6	2400	6	1200	6	500	6	400	6	400
7	5000	7	1200	7	1200	7	400	7	400	7	400
8	4500	8	800	8	1200	8	400	8	400	8	400
9	3500	9	800	9	1200	9	400	9	400	9	400
10	2400	10	800	10	1200	10	400	10	400	10	400
11	1200	11	800	11	1200	11	400	11	400	11	400
12	800	12	800	12	1200	12	400	12	400	12	400
13	800	13	800	13	1200	13	400	13	400	13	400
14	800	14	800	14	1200	14	400	14	400	14	400
15	800	15	800	15	1200	15	400	15	400	15	400
16	800	16	800	16	1200	16	400	16	400	16	400
17	800	17	800	17	1200	17	400	17	400	17	400
18	800	18	1500	18	1200	18	400	18	400	18	400
19	800	19	1500	19	1000	19	400	19	400	19	400
20	800	20	1500	20	1000	20	400	20	400	20	400
21	800	21	2500	21	1000	21	400	21	400	21	400
22	800	22	2500	22	1000	22	400	22	400	22	400
23	800	23	2500	23	1000	23	400	23	400	23	400
24	800	24	2500	24	1000	24	400	24	400	24	400
25	800	25	2500	25	1000	25	400	25	400	25	400
26	800	26	1500	26	1000	26	400	26	400	26	400
27	800	27	1500	27	1000	27	400	27	400	27	400
28	800	28	1500	28	800	28	400	28	400	28	400
29	1200	29	1500	29	800	29	400	29	400	29	400
30	2400	30	1500	30	800	30	400	30	400	30	400
		31	1500			31	400	31	400		

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