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M e m o r a n d u m

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Subject: 2018 Sacramento River Sturgeon Spawning Study

Purpose

The purpose of this report is to document findings regarding a pilot study to determine white sturgeon (*Acipenser transmontanus*) spawning locations in the Sacramento River and the associated temporal, spatial, and habitat parameters.

Background

White sturgeon (*Acipenser transmontanus*) populations have been severely reduced due to dams blocking access to much of their historical spawning grounds, diversions which entrain larval and juvenile sturgeon, habitat degradation, a legacy commercial fishery; legal sport harvest and illegal harvest (poaching). White sturgeon is a California state species of concern, and is an important recreational fishery managed by CDFW. Recent white sturgeon population monitoring and population modeling data show a continued downward decline in the number of adult spawners in California (Blackburn et. al., 2018). The Sacramento River system is the primary river system supporting spawning of white sturgeon. The majority of white sturgeon are thought to spawn in the middle Sacramento River between Knights Landing (RK 142) and Colusa (RK 237) between mid-February and mid-May (Schaffter 1997). Southern Distinct Population (sDPS) green sturgeon (*Acipenser medirostris*) are not known to spawn in the Sacramento River downstream of the Glenn-Colusa Irrigation District Diversion Hole at rkm

332.5 (Poytress et. al 2015). However, no sturgeon spawning surveys have been conducted on the middle Sacramento River since the early-1990s.

White sturgeon are aggregate broadcast spawners and typically spawn in deep pools or runs over gravel, cobble or bedrock substrates with swift or complex currents. Eggs are round or nearly so, dark gray in color, with diameters ranging from 3.2 mm to 4.0 mm (Van Eenennaam et al 2006). Upon contact with water, the egg's surface becomes adhesive and they readily stick to bottom substrates upon contact. The use of artificial substrates, such as egg mats, has been shown to be an effective method for documenting sturgeon spawning habitat through the collection of eggs. CDFW conducted a pilot sturgeon spawning survey in the Sacramento River between Knights Landing (river kilometer [rkm 144]) and Boyds Landing (rkm 171) in 2017 but did not collect any sturgeon eggs. Cramer Fish Sciences collected 47 white sturgeon eggs from egg mats deployed near Hamilton Bend (rkm 310) in April 2017.

Methods

CDFW North Central Region staff reviewed the report of findings of Schaffter (1997), Kohlhurst (1976) and bathymetry data to determine potential spawning sites in four reaches of the Sacramento River. The reaches delineated for the survey from upstream to downstream were Colusa, Tisdale, Knights Landing, and Verona. (**Figures 1 through 4**). Site selection for egg mat deployment was based on flow habitat type (e.g., pool, deep run), water depth, and to a lesser extent, substrate composition. Suitable sturgeon spawning habitat typically consists of pools or deep runs with depths ranging from 1.8 to 11.2 meters and flow velocities of ≥ 1.0 meter per second with substrates consisting of gravel, cobble, and boulder (Poytress 2013, Schaffter 1997). Prior to the initial deployment of egg mats, CDFW staff conducted reconnaissance surveys using dual frequency identification sonar (DIDSON) in an attempt to locate sturgeon aggregations and determine substrate composition at potential sampling sites. In total, 13 sites were selected for sampling: six sites in the Colusa reach, two sites in the Tisdale reach, three sites in the Knights Landing reach, and two sites in the Verona reach.

Egg mats were constructed by securing a furnace filter insert to a 76 × 107 × 5-cm rectangular steel frame; the mats were rigged with a 9.5-mm diameter braided polypropylene rope attachment bridle, 9.5-mm diameter buoy line of sufficient length, and a 25-cm diameter inflatable buoy to mark the egg mat location and facilitate retrieval. Once a sampling site was selected, the mat was deployed by gradually lowering it to the river bottom from the stern of the boat while holding the boat stationary in the current. When the egg mat reached the river bottom, the buoy and remaining buoy line were deployed and observed for several minutes to insure the egg mat remained in place. Deployment date and time, GPS coordinates; and water depth and temperature were recorded at each sampling site. GPS coordinates, river depth and water temperature were recorded with a Humminbird® multi-function depth-finder. Flow velocity was either measured at 0.3 m from the bottom, 0.6 m from the surface, or estimated to the nearest 0.3 meter per second by observing floating debris; and substrate composition was determined from either DIDSON or recreational grade sonar imagery taken at the sampling sites. River discharge in cubic feet per second (cfs) was recorded from the CDEC Sacramento River gage at

Wilkins Slough for the Knights Landing and Verona reaches the CDEC Sacramento River gage at Colusa for the Tisdale and Colusa reaches (CDEC 2018). One egg mat was deployed per site except for the most upstream Knights Landing site (KL-1) and the Verona sites (VER1, VER-2), where two egg mats were deployed per site.

Egg mats were retrieved every three to seven days over the duration of the sampling period. Once the egg mats were hauled on board, two crew members conducted a thorough visual inspection for sturgeon eggs attached to furnace filter material and mat frame. Both sides of each mat were checked, and any vegetation such as cocklebur seeds (*Xanthium strumarium*) and small woody debris were removed from the mats prior to re-deployment.

Figure 1. Colusa Reach Sites, 2018 Sacramento River Sturgeon Spawning Survey.

Figure 2. Colusa Reach Sites, 2018 Sacramento River Sturgeon Spawning Survey.

Figure 3. Tisdale Reach Sites, 2018 Sacramento River Sturgeon Spawning Survey.

Figure 4. Knights Landing Reach Sites, 2018 Sacramento River Sturgeon Spawning Survey.

Figure 5. Verona Reach Sites, 2018 Sacramento River Sturgeon Spawning Survey.

Results

Total sampling time (days) ranged from seven days in the Verona reach to 42 days in the Knights Landing reach. Sampling was discontinued in the Knights Landing reach on 20 March 2018 so that the egg mats could be used for deployment in the Colusa reach. Egg mats were temporarily removed from sampling sites in the Verona and Colusa reaches prior to a forecasted rapid increase in flows from 6,899 cfs to over 45,000 cfs on 8 April 2018. There was concern that the high flow event would result in egg mat loss due to drifting large woody debris entangling the mat buoy lines or mobilized bed loads burying the egg mats. Egg mats were not replaced in the Verona reach due to heavy angling pressure. Egg mats were redeployed in the Colusa reach on 17 April 2018 when flows receded to 8,873 cfs. Location, deployment and retrieval dates, and total sampling days for Sacramento River sturgeon spawning sampling sites are presented in **Table 1.**

Sacramento River flows during the study period ranged from a low of 4,007 cfs on 23 February 2018 to high of 45, 821 cfs on 8 April 2018 at Butte City (reference flow site for Colusa and Tisdale reaches) and from a low of 2,416 cfs on 18 February 2018 to high of 24,946 cfs on 9 April 2018 at Wilkins Slough (reference flow site for Knights Landing and Verona reaches) **(Figures 6 and 7**). Water temperatures over the duration of the survey period ranged from 8.8° C on 27 February 2018 in the Knights Landing reach to 18.9° C on 27 April 2018 in the Colusa reach, which is within the water temperature range documented during spawning events for both sturgeon species (Poytress et. al. 2015, Jackson et. al. 2015, Shaffter 1997). Habitat parameters such as depth and current velocity at sites selected for egg mat deployment were consistent with white sturgeon spawning habitat parameters reported by Poytress et.al. 2015 and Shaffter (1997). Sampling site characteristics including initial site depth, temperature range, current velocity range, and dominant substrate are presented in **Table 2**. Substrate composition at the majority of sampling sites consisted mainly of sand and fines, rather than larger substrate classes such as coarse gravel, cobble, and boulder, which are substrates typically associated with sturgeon spawning habitat (Poytress et. al. 2015, Shaffter 1997, Parsley and Beckman 1994). However, in 1973, Kohlhurst (1976) documented white sturgeon spawning just upstream of the mouth of the Feather River at river kilometer (rkm) 129, where bottom substrate consists of fine to medium sands. White sturgeon spawning in the San Joaquin River was documented in reaches where sand is the dominant substrate (Jackson et. al 2012).

No sturgeon eggs were collected during the 2018 Sacramento River sturgeon spawning study. No sturgeon aggregations were observed during DIDSON surveys conducted for site substrate evaluation. However, white sturgeon were observed breaching in the Colusa and Tisdale study reaches during egg several mat deployment and retrieval efforts. No other fish eggs were observed on the egg mats. Several lamprey microphthalmia were collected from egg mats deployed in the Knights Landing reach. Debris loads (e.g., vegetation, fine substrate) on egg mats ranged from light to heavy. Although heavy debris loads, particularly cocklebur seeds, made for more time-consuming mat inspections, detection of any sturgeon eggs attached to the mats or seeds would still have been possible.

Table 1. Location, deployment and retrieval dates, and total sampling days for Sacramento River sturgeon spawning sampling sites, 6 February through 12 May 2018.

Site	Latitude	Longitude	River Kilometer[1]	Deployment Dates	Retrieval Dates	Total Days
COL-1	39.29682	-122.01502	246.9	3/29, 4/03, 4/17, 4/20, 4/24, 4/27, 5/01, 5/03, 5/08, 5/11	4/3, 4/17, 4/20, 4/24, 4/27, 5/1, 5/3, 5/8, 5/11	27
COL-2	39.29819	-122.01585	246.7	3/29, 4/03, 4/17, 4/20, 4/24, 4/27, 5/01, 5/03, 5/08, 5/11	4/3, 4/17, 4/20, 4/24, 4/27, 5/1, 5/3, 5/8, 5/11	27
COL-3	39.22715	-122.00805	242.5	3/29, 4/03, 4/17, 4/20, 4/24, 4/27, 5/01, 5/03, 5/08, 5/11	4/3, 4/17, 4/20, 4/24, 4/27, 5/1, 5/3, 5/8, 5/11	27
COL-4	39.2664	-122.01403	234.6	3/29, 4/03, 4/17, 4/20, 4/24, 4/27, 5/01, 5/03, 5/08, 5/11	4/3, 4/17, 4/20, 4/24, 4/27, 5/1, 5/3, 5/8, 5/11	27
COL-5	39.20537	-121.98321	230.3	3/29, 4/03, 4/17, 4/20, 4/24, 4/27, 5/01, 5/03, 5/08, 5/11	4/3, 4/17, 4/20, 4/24, 4/27, 5/1, 5/3, 5/8, 5/11	27
COL-6	39.19743	-121.94576	224.6	3/29, 4/3, 4/17, 4/20, 4/24, 4/27, 5/01, 5/03, 5/08, 5/11	4/3, 4/17, 4/20, 4/24, 4/27, 5/1, 5/3, 5/8, 5/11	27
TIS-1	39° 05.779	-121°53.746	206.6	2/06, 2/09, 2/13, 2/16, 2/20, 2/23, 2/27, 3/02, 3/09	2/09, 2/13, 2/16, 2/20, 2/23, 2/27, 3/02, 3/09	28
TIS-2	39° 01.900	-121°49.689	194	2/06, 2/09, 2/13, 2/16, 2/20, 2/23, 2/27, 3/02, 3/09	2/09, 2/13, 2/16, 2/20, 2/23, 2/27, 3/02, 3/09, 3/13	28
KL-1	38° 57.167	-121°50.337	181.8	2/06, 2/13, 2/20, 2/23, 2/27, 3/02, 3/06, 3/13	2/13, 2/20, 2/23, 2/27, 3/02, 3/06, 3/13, 3/20	42
KL-2	38° 57.167	-121°50.337	171.2	2/06, 2/13, 2/20, 2/23, 2/27, 3/02, 3/06, 3/13	2/13, 2/20, 2/23, 2/27, 3/02, 3/06, 3/13, 3/20	42
KL-3	38° 54.362	-121°47.447	157.3	2/06, 2/13, 2/20, 2/23, 2/27, 3/02, 3/06, 3/13	2/13, 2/20, 2/23, 2/27, 3/02, 3/06, 3/13, 3/20	42
VER-1	38.77829	-121.629919	132.7	3/30	4/06	7
VER-2	38.77829	-121.629919	131.8	3/30	4/06	7

Table 2. Site depth, water temperature range, current velocity range, and dominant substrate for Sacramento River sturgeon spawning sampling sites, 6 February through 12 May 2018.

Site	Initial Depth or Depth Range (m)	Temperature Range (°C)	Current Velocity Range (mps)	Dominant Substrate
COL-1	5.2	12.2 - 18.9	0.3 - 1.1	Gravel
COL-2	6.1	12.2 - 18.9	0.3 - 1.1	Gravel
COL-3	7.3	12.2 - 18.9	0.3 - 1.1	Gravel
COL-4	5.2	12.2 - 18.9	0.2 - 1.1	Sand
COL-5	6.1	12.2 - 18.9	0.2 - 1.1	Sand
COL-6	7.0	12.2 - 18.9	0.2 - 1.1	Sand
TIS-1	7.0 - 8.0	10.0 - 13.2	0.7 - 0.9	Sand
TIS-2	4.3 - 7.6	10.0 - 13.2	0.5 - 0.9	Sand
KL-1	4.9 - 9.8	8.8 - 14.3	1.0 - 1.1	Sand
KL-2	4.6 – 9.5	8.8 - 14.3	1.0 - 1.1	Sand
KL-3	5.2 to 9.5	8.8 - 14.3	1.0 - 1.1	Sand
VER-1	12.2	14.7	1.0 - 1.1	Sand
VER-2	7.0	14.7	1.0 - 1.1	Sand

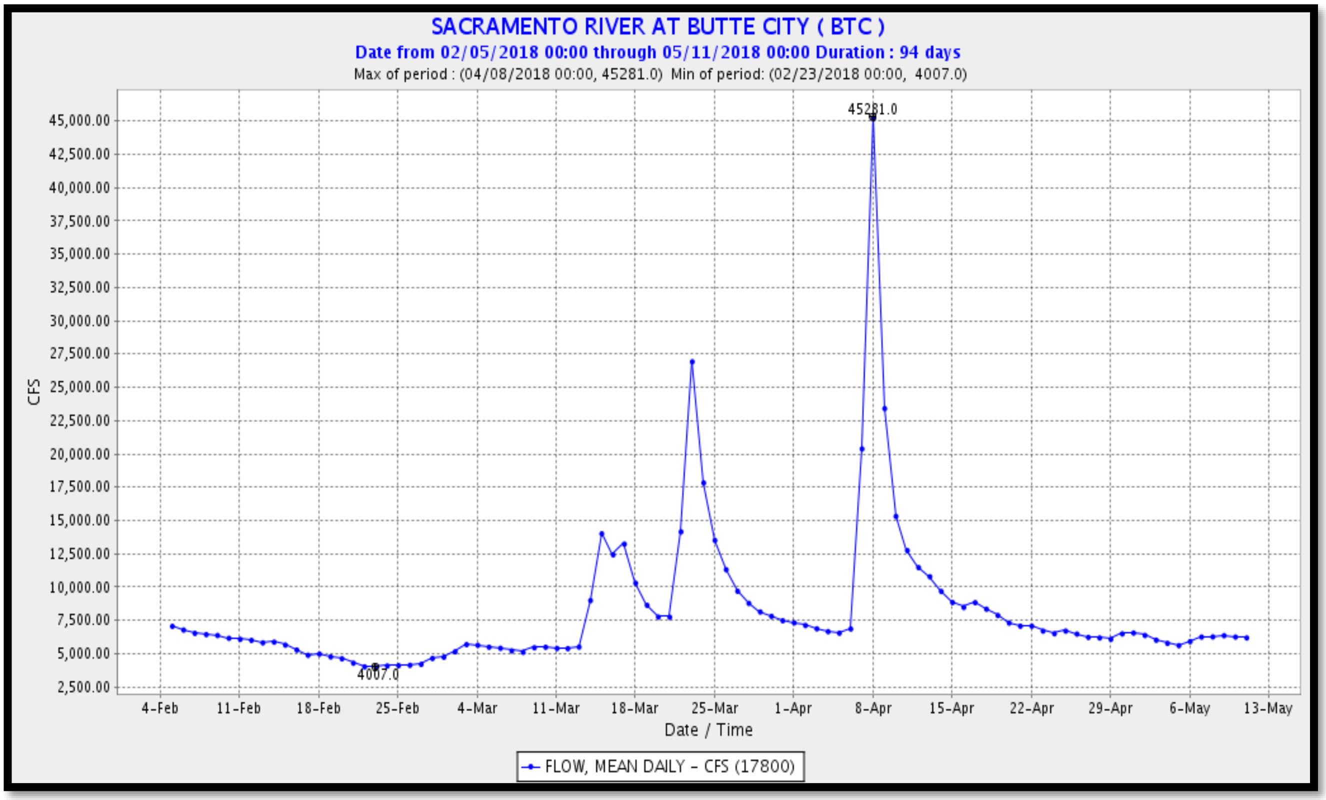

Figure 6. Sacramento River flows at Butte City, 5 February through 11 May 2018.

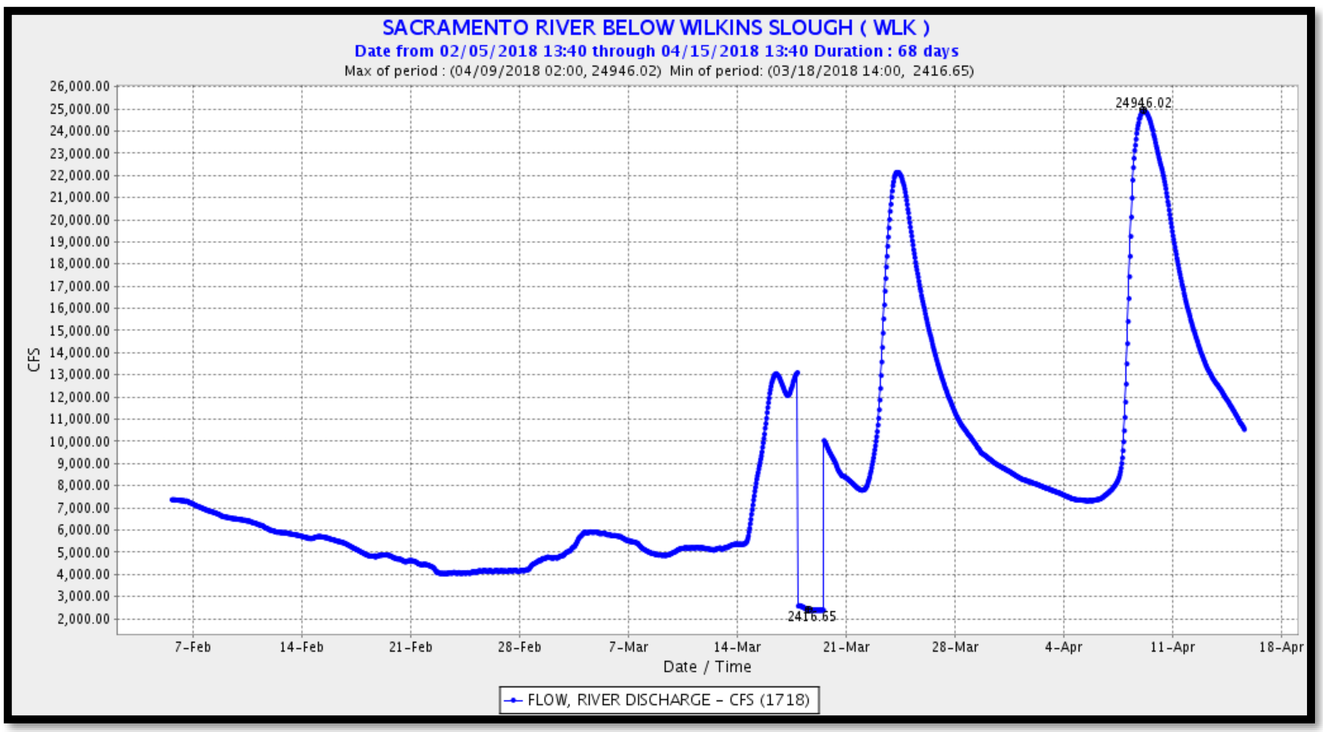

Figure 7. Sacramento River flows at Wilkins Slough 5 February through 6 April 2018.

Discussion

The 2018 Sacramento River sturgeon spawning survey was the second consecutive year that CDFW conducted a sturgeon spawning survey in the Sacramento River. Although the 2018 survey was expanded from the one-reach pilot study focused on the Knights Landing reach to four reaches (Colusa, Tisdale, Knights Landing, and Verona), no sturgeon eggs were collected and therefore sturgeon spawning events could not be documented within the four study reaches. In the Colusa reach, sites COL-1 and COL-2 were in the same location where white sturgeon eggs were collected by Shaffter in 1991 and 1992. Similarly, the two sites in the Verona reach were in the vicinity of where Kohlhorst (1976) collected white sturgeon larvae in 1973. Both sturgeon species are known to initiate spawning in response to increases in flow (Shaffter 1997), (Heublein et. al. 2009), (Poytress et. al. 2015). Shaffter (1997) determined that white sturgeon spawning in the Sacramento River occurred one to three days after maximum flow during 1991 and 1992 flow increases. Three distinct flow increase events occurred over the duration of the 2018 survey which had the potential to trigger sturgeon spawning events (**Figures 6 and 7**). Of these, egg mats were deployed in the Knights Landing reach through first flow increase beginning 14 March. However, temporal gaps during sampling occurred around the second and third flow increases and early stages of the receding hydrograph during which sturgeon spawning events may have occurred. Egg mats were removed from the Knights Landing reach sites on 20 March 2018 for deployment in the Colusa reach. The second flow increase event peaked on 24 March 2018. The timing of egg mat deployment and retrieval dates around these flow increases was such that the sampling events were likely optimized to detect sturgeon spawning at the sampling sites through the collection of eggs. White sturgeon spawning in the Sacramento River may occur as early as mid-February and as late as mid-May (Schaffter 1997), (Kohlhorst 1976). Therefore, it is possible that white sturgeon spawning occurred in some study reaches prior to study initiation; or spawning events occurred after termination of sampling in other reaches.

Recommendations

More intensive reconnaissance surveys for sturgeon aggregations should be considered beginning in mid to late-January to determine timing of egg mat deployments. DIDSON surveys used to detect sturgeon aggregations were of limited success. Deployment of the DIDSON camera via the hand-held, pole mount was difficult as swift currents made it difficult to hold and pan the camera over potential holding areas. One option to overcome this obstacle is to deploy a DIDSON camera via a boat-mounted platform to stabilize the camera while evaluating swift water riverine habitat. Another option is to use a side-scan sonar fish-finder. The use of side-scan sonar units has also been shown to be an effective method for identifying sturgeon holding near the bottom of large rivers and estuaries. One CDFW Anadromous Fisheries vessel is now equipped with a recreational-grade side-scan sonar unit that is capable of marking sturgeon in holding or spawning habitat and also to some extent determining bottom substrate composition (e.g., differences between sand and coarse gravel or cobble). Future sturgeon spawning surveys will likely rely on the use of the side-scan sonar unit to conduct reconnaissance surveys.

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