State of California
Department of Fish and Wildlife

Memorandum

Date: **July 25 2022**

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Subject: 2022 Sacramento River Sturgeon Spawning Study

Purpose

The purpose of this report is to document findings regarding the 2022 sturgeon spawning survey 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 fish 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 at river kilometer (rkm) 142 and Colusa at rkm 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 at rkm 332.5 (Poytress et. al 2015). 2021 is the fourth consecutive year that a sturgeon spawning survey was conducted on the middle Sacramento River.

White sturgeon are aggregate broadcast spawners and typically spawn in deep pools or runs over sand, 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. 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. The 2018 spawning survey included four Sacramento River reaches: Colusa, Tisdale, Knights Landing, and Verona. No sturgeon eggs were collected during the study, although white sturgeon were observed breaching within the study reaches during several site visits (CDFW 2018). The 2019 spawning survey included two sites in the Knights Landing reach and three sites in the Colusa reach. No sturgeon eggs were collected during the 2019 spawning survey. The 2020 spawning survey included four sites in the Knights Landing reach. The Colusa or Tisdale reaches were not sampled due to logistical issues resulting from Covid-19 work restrictions. No sturgeon eggs were collected during the 2020 survey.

Methods

CDFW North Central Region staff reviewed the report of findings of Schaffter (1997) and Kohlhurst (1976), and bathymetry data to determine potential spawning sites in two reaches of the Sacramento River. 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 either dual frequency identification sonar (DIDSON) or Humminbird® multi-function depth-finder to locate sturgeon aggregations and determine substrate composition at potential sampling sites.

***Tisdale Reach*.** Three sites were selected for egg mat sampling within the Knights Landing reach in 2022, TIS-1 at rkm 203.1, TIS-2 at rkm 200.0, and TIS-3 at rkm 189.7. (**Figure 1**). Sampling was initiated 18 March and terminated 10 May for a period of 53 days.

***Colusa Reach**.* Three sites were selected for egg mat sampling within the Colusa reach in 2022, COL-3 at rkm 244.3, COL-2 at rkm 247.6 and COL-1 at rkm 250.8 (**Figure 2**). Sampling was initiated 29 March and terminated 10 May for a period of 42 days.

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 ensure the egg mat remained in place. Deployment date and time, GPS coordinates or waypoints; 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. Surface flow velocity estimated to the nearest 0.3 meter per second by observing floating debris; and substrate composition was determined from sonar imagery at the sampling sites. River discharge in cubic feet per second (cfs) was recorded from the Sacramento River gage at Colusa for the Tisdale Reach and at the Butte City gage for the Colusa Reach (California Data Exchange Center 2022). Three or four egg mats were initially deployed at each site, however; several egg mats were lost over the duration of the survey due to burial by a mobile bedload of sand or entanglement on large woody debris and were not replaced.

Egg mats were retrieved every three to seven days over the duration of the sampling period, except for a 10-day interval for TIS-1 and TIS-2 between 5 April and 15 April due to vessel motor issues. Retrieval was conducted by using a boat hook or gaff to secure the buoy line and then by slowly hauling the egg mat to the surface to avoid dislodging any attached sturgeon eggs. Once the egg mats were hauled on board, two crew members conducted a thorough visual inspection for sturgeon eggs attached to the furnace filter material and mat frame. Both sides of each mat were checked, and debris such as sticks, leaves, and cocklebur seeds were removed from the mats prior to re-deployment. Any sturgeon eggs found on the mats were enumerated and placed in Whirl-Pak® plastic bags containing 70 percent ethanol labelled with the site code, date collected, and number of eggs vouchered. Observations of other fish species eggs or aquatic organisms were also recorded.

A dissecting microscope at 20-30x power was used to determine species-level identification of any eggs collected using the *Dichotomous Key to Fish Eggs of the Sacramento-San Joaquin River Delta* (Reyes 2011), and embryonic development of sturgeon eggs was determined based on the work of Wang *et. al*. (1985) and Colombo *et. al*. (2007). Egg diameters were measured to the nearest 0.01 mm using a digital caliper. Average water temperature between deployment and retrieval dates was used to calculate degree hours over 10° C, which is the minimum reported temperature for sturgeon egg mitosis (Shelton et. al. 1997). Degree hours were then used to calculate an approximate spawning date and time.

Results

***Tisdale Reach**.* Twenty-five white sturgeon eggs were collected from egg mats deployed in the Tisdale Reach during the 2022 survey season. Twenty-one eggs were collected on 22 April at site TIS-3 from a mat deployed 19 April at a depth of 13 feet, two eggs were collected at site TIS-1 on 22 April from a mat deployed on 19 April at a depth of 19 feet, and two eggs were collected from site TIS-3 on 26 April from a mat deployed on 22 April at a depth of 12 feet. Egg diameters ranged from 3.23 mm to 3.86 mm, with a mean diameter of 3.48 mm, which is within the diameter range of 3.2 to 4.0 mm for white sturgeon eggs reported by Van Eenennaam *et. al.* (2006). The spawning events appeared to occur soon after a flow increase associated with runoff from recent rain events; Sacramento River flows at Colusa, the nearest gaging station upstream of the Tisdale sites, increased from 3,963 cubic feet per second (cfs) on 15 April to 6,030 cfs on 22 April. Based on the work of Colombo *et. al*. (2007), the embryonic stage of the eggs collected from site TIS-3 on 22 April ranged from stage 5 (second cleavage) to stage 8 (fifth cleavage) when they were preserved in 70 percent ethanol. Water temperatures during the period between when the egg mats were last deployed prior to egg collection and when the eggs were collected ranged from 18.1° C on 19 April to 14.4° C on 22 April, with an average calculated temperature of 16.2° C. Extrapolation of developmental data for white sturgeon eggs reported by Wang et. al. (1985) corresponds to six to nine hours from fertilization to reach stages 5 through 8. Given the relatively narrow range in development stages and that completion of oviposition in white sturgeon may take over 20 hours (Van Eenennaam *et. al.* 2006), it is likely that the white sturgeon eggs collected on 22 April at site TIS-3 were from a single spawning event which occurred between 0100 on 21 April and 0400 on 22 April. The two white sturgeon eggs collected on 22 April from site TIS-1 were covered in fine sediment and developmental stages could not be determined. Therefore, a more precise estimation of a spawning date and time could not be determined than sometime between 19 April at

1500 when the egg mat was deployed and 22 April at 1045 when the mat was retrieved. The two eggs collected from site TIS-3 on 26 April were apparently lost during transfer to the Whirl-Pak® plastic bag; however, it appeared that at least one of the eggs had heavy fungal growth on it at the time of collection, suggesting it was unfertilized and possibly overlooked when the mat was retrieved on 22 April. Egg stage data is presented in **Table 2.**

No other fish species eggs were collected on mats deployed in the Tisdale reach. Benthic macroinvertebrates commonly observed on the mats included Asian clams (*Corbicula fluminea*), amphipods (*Corophium* sp.), may fly larvae in the families Baetidae and Heptageniidae, and caddisfly larvae in the families Glossosomatidae and Hydropsychidae. Substrates within the Tisdale reach sites consist of mostly sand, with some fine gravel. Cobble or concrete revetment are present along the banks and nearshore inundated areas of the sites. Estimated surface velocities ranged from one to three feet per second. Deployment and retrieval dates and environmental parameters are presented in **Table 2.** Sacramento River flows at Colusa and water temperature measured during site visits are presented in **Figure 3.**

Colusa Reach. Seventeen white sturgeon eggs were collected from egg mats deployed in the Colusa Reach during the 2022 survey season. Twelve eggs were collected at site COL-1 on 19 April from mats deployed on 15 April at a depths of 12 feet, four eggs were collected at site COL-1 on 22 April from a mat deployed on 19 April at a depth of 12 feet, and one egg was collected at site COL-2 on 22 April from a mat deployed on 19 April at a depth of 13 feet. Egg diameters ranged from 3.12 mm to 3.83 mm, with a mean diameter of 3.61 mm, which is within the diameter range of 3.2 to 4.0 mm for white sturgeon eggs reported by Van Eenennaam *et. al.* (2006). Similar to the Tisdale reach, the spawning events appeared to occur soon after a flow increase associated with runoff from recent rain events; Sacramento River flows at Butte City the nearest gaging station upstream of the Colusa sites, increased from 3,940 cfs on 15 April to 6,229 cfs on 22 April. Based on the work of Colombo *et. al*. (2007), the embryonic stage of the eggs collected from site COL-1 on 19 April ranged from stage 13 (onset of gastrulation) to stage 22 (excretory rudiments elongate) when they were preserved in 70 percent ethanol. Water temperatures during the period between when egg mats were last deployed prior to egg collection and when the eggs were collected ranged from 13.3° C on 15 April to 14.4° C on 19 April, with an average calculated temperature of 13.8° C. Extrapolation of developmental staging data for white sturgeon eggs reported by Wang et. al. (1985) at a temperature of 13.8° C corresponds to 32 to 69 hours from fertilization to reach stages 13 through 22. Given that completion of oviposition in white sturgeon may take over 20 hours (Van Eenennaam *et. al.* 2006), it is likely that the white sturgeon eggs collected on 19 April at site COL-1 were likely from two or more spawning events which occurred between on 16 April at 1345 and 18 April at 0200. The four white sturgeon eggs on 22 April were at developmental stages ranging from 17 (small yolk plug) to stage 22, and by extrapolation of the temperature data, it appears that another spawning event occurred between 1800 on 19 April and 0500 on 21 April.

Other fish species eggs collected included an unidentified sculpin (*Cottus* sp.) egg mass collected on 12 April from an egg mat deployed on 8 April at COL-2, and several striped bass (*Morone saxatilis*) eggs collected on 10 May from an egg mat deployed 2 May at COL-3. Benthic macroinvertebrates commonly observed on the mats included signal crayfish (*Pacifastacus leniusculus*), Asian clams, may fly larvae in the families Baetidae and Heptageniidae, and caddisfly larvae in the families Glossosomatidae and Hydropsychidae. Substrates at the three Colusa reach sites consist of mainly of gravel and coarse sand, and some small cobble. Some cobble revetment is present along the banks and nearshore inundated areas of the sites. Estimated surface velocities during the survey period ranged from one to four feet per second. Deployment and retrieval dates and environmental parameters are presented in **Table 2.** Sacramento River flows at the Butte City gaging station and water temperatures measured during site visits are presented in **Figure 4. Figure 5** is a photograph of white sturgeon eggs collected from site COL-1 on 19 April 2022.

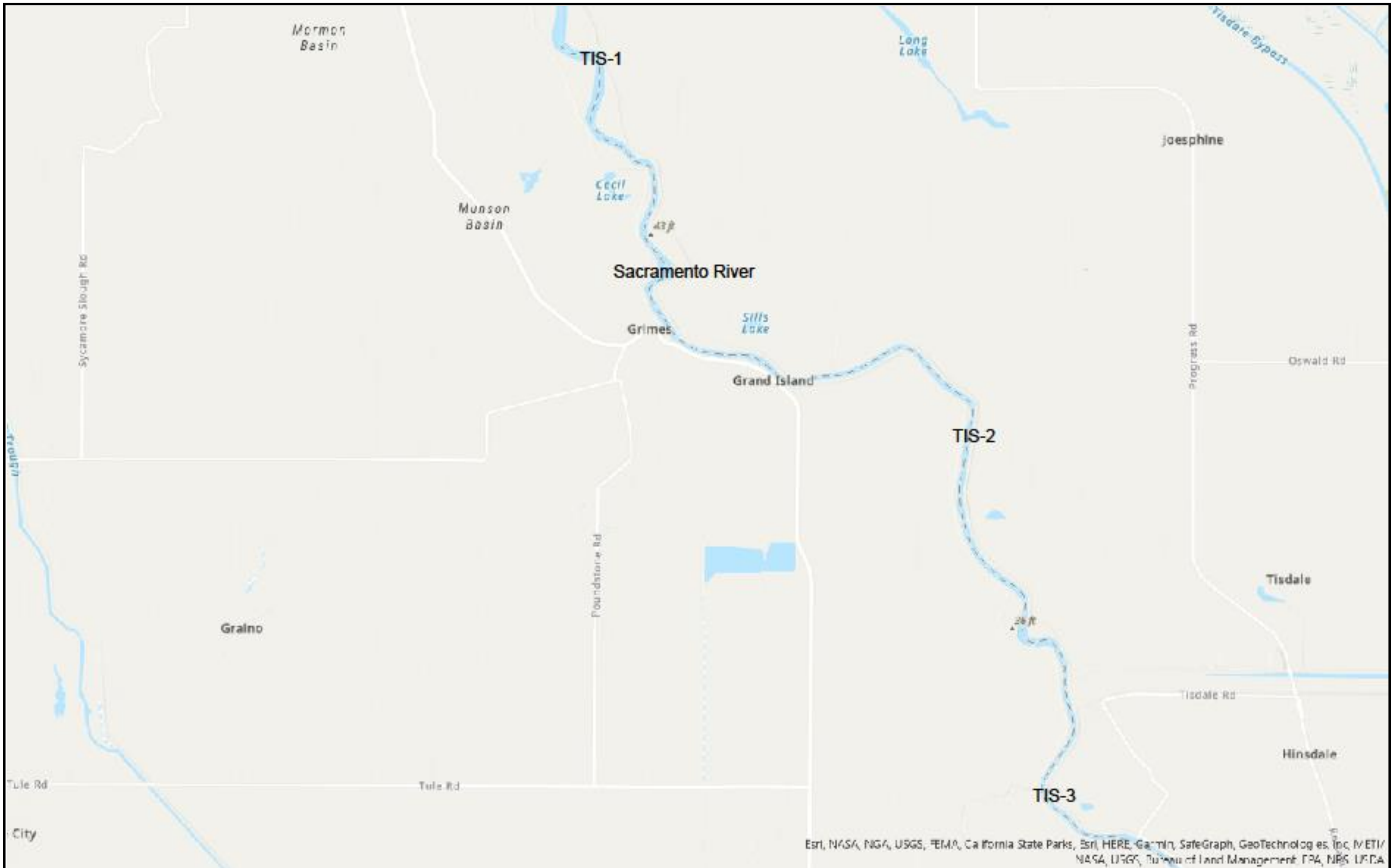

Figure 1. Sacramento River - Tisdale Reach 2022 sturgeon spawning survey sampling sites.

Figure 2. Sacramento River - Colusa Reach, 2022 sturgeon spawning survey sampling sites.

Table 1. 2022 Sacramento River sturgeon spawning survey egg mat deployment and retrieval dates, water temperatures, deployment depth range, and number of sturgeon eggs collected.

Site code	Deployment date	Temperature (° C)	Deployment depth range (ft)	Retrieval date	Temperature (° C)	Sturgeon eggs (n)
TIS-1	3/18	14.5	13-22	3/22	14.5	0
TIS-2	3/18	14.5	13-18	3/22	14.2	0
TIS-3	3/18	15.0	16-19	3/22	14.8	0
TIS-1	3/22	14.5	15-22	3/25	17.2	0
TIS-2	3/22	14.2	18-23	3/25	17.2	0
TIS-3	3/22	14.8	16-17	3/25	17.2	0
TIS-1	3/25	17.2	13-21	3/29	17.2	0
TIS-2	3/25	17.2	17-18	3/29	17.2	0
TIS-3	3/25	17.2	16-17	3/29	17.2	0
TIS-1	3/29	17.2	18-23	4/5	17.3	0
TIS-2	3/29	17.2	15-24	4/5	17.3	0
TIS-3	3/29	17.2	16-18	4/5	17.3	0
TIS-1	4/5	17.3	18-23	NR[1]	NR[2]	0
TIS-2	4/5	17.3	15-24	NR[1]	NR[2]	0
TIS-3	4/5	17.3	16-18	4/8	16.7	0
TIS-1	4/5	17.3	18-23	4/15	13.4	0
TIS-2	4/5	17.3	15-24	4/15	13.5	0
TIS-3	4/8	16.7	12-13	4/15	13.8	0
TIS-1	4/15	13.4	16-20	4/19	18.2	0
TIS-2	4/15	13.5	12-14	4/19	18.2	0
TIS-3	4/15	13.8	12-13	4/19	18.0	0
TIS-1	4/19	18.2	16-20	4/22	18.2	2
TIS-2	4/19	19.1	12-14	4/22	18.2	0
TIS-3	4/19	18.0	12-13	4/22	18.2	15
TIS-1	4/22	18.2	16-20	4/26	18.8	0
TIS-2	4/22	18.2	12-13	4/26	20.4	0
TIS-3	4/22	18.2	12	4/26	18.1	2
TIS-1	4/26	18.8	16-22	4/29	19.3	0
TIS-2	4/26	20.4	12-14	4/29	19.6	0
TIS-3	4/26	18.1	12	4/29	18.7	0
TIS-1	4/29	19.3	17-22	5/2	19.9	0
TIS-2	4/29	19.6	12-13	5/2	19.9	0
TIS-3	4/29	18.7	12-14	5/2	19.3	0
TIS-1	5/2	19.9	16-21	5/10	17.4	0
TIS-2	5/2	19.9	12-15	5/10	17.4	0

Site code	Deployment date	Temperature (° C)	Deployment depth range (ft)	Retrieval date	Temperature (° C)	Sturgeon eggs (n)
TIS-3	5/2	19.3	11	5/10	16.8	0
COL-1	3/29	16.1	10-17	4/5	15.7	0
COL-2	3/29	16.1	15-19	4/5	15.8	0
COL-3	3/29	16.1	16-20	4/5	16.0	0
COL-1	4/5	15.7	11-14	4/8	16.7	0
COL-2	4/5	15.8	12-19	4/8	16.7	0
COL-3	4/5	16.0	16-18	4/8	16.7	0
COL-1	4/8	16.7	12-15	4/12	14.4	0
COL-2	4/8	16.7	15-18	4/12	14.4	0
COL-3	4/8	16.7	16-21	4/12	14.4	0
COL-1	4/12	14.4	11-14	4/15	13.3	0
COL-2	4/12	14.4	13-18	4/15	13.3	0
COL-3	4/12	14.4	9-22	4/15	13.3	0
COL-1	4/15	13.3	10-15	4/19	14.1	12
COL-2	4/15	13.3	14-20	4/19	14.1	0
COL-3	4/15	13.3	19-22	4/19	14.1	0
COL-1	4/19	14.1	12-14	4/22	14.1	3
COL-2	4/19	14.1	13-17	4/22	14.4	1
COL-3	4/19	14.1	11-21	4/22	14.3	0
COL-1	4/22	14.1	11-12	4/26	17.2	0
COL-2	4/22	14.4	16-21	4/26	17.4	0
COL-3	4/22	14.3	10-18	4/26	17.3	0
COL-1	4/26	17.2	12-15	4/29	17.8	0
COL-2	4/26	17.4	14-17	4/29	17.8	0
COL-3	4/26	17.3	10-20	4/29	17.8	0
COL-1	4/29	17.8	11-16	5/2	18.6	0
COL-2	4/29	17.8	13-19	5/2	18.6	0
COL-3	4/29	17.8	18-19	5/2	18.7	0
COL-1	5/2	18.6	11-13	5/10	16.1	0
COL-2	5/2	18.6	13-16	5/10	16.1	0
COL-3	5/2	18.7	18-19	5/10	16.1	0

Table 2. White sturgeon egg collection site, date collected, egg diameter, egg stage number, and egg stage description.

Site	Date collected	Egg number	Diameter (mm)	Stage number	Stage description
COL-1	4/19	1	3.12	UF	Unfertilized
COL-1	4/19	2	3.47	13	Onset of gastrulation
COL-1	4/19	3	3.62	21	Excretory rudiments appear
COL-1	4/19	4	3.81	21	Excretory rudiments appear
COL-1	4/19	5	3.62	22	excretory rudiments elongate
COL-1	4/19	6	3.65	17	Small yolk plug
COL-1	4/19	7	3.79	22	excretory rudiments elongate
COL-1	4/19	8	3.83	22	excretory rudiments elongate
COL-1	4/19	9	3.55	22	excretory rudiments elongate
COL-1	4/19	10	3.48	21	Excretory rudiments appear
COL-1	4/19	11	3.82	20	Wide neural plate
COL-1	4/19	12	3.46	17	Small yolk plug
COL-2	4/19	1	3.66	Undetermined, covered in sediment	
COL-2	4/19	2	Missing; did not end up in sample container		
COL-1	4/22	1	3.59	22	excretory rudiments elongate
COL-1	4/22	2	3.72	20	Wide neural plate
COL-1	4/22	3	3.65	17	Small yolk plug
COL-1	4/22	4	Damaged; could not determine diameter or stage		
TIS-3	4/22	1	3.52	7	16-cell stage
TIS-3	4/22	2	3.22	6	Eight blastomere
TIS-3	4/22	3	3.40	Undetermined, covered in sediment	
TIS-3	4/22	4	3.77	7	16-cell stage
TIS-3	4/22	5	3.56	7	16-cell stage
TIS-3	4/22	6	3.51	7	16-cell stage
TIS-3	4/22	7	3.46	6	Eight blastomere
TIS-3	4/22	8	3.56	6	Eight blastomere
TIS-3	4/22	9	3.39	8	Fifth cleavage
TIS-3	4/22	10	3.29	5	Second cleavage
TIS-3	4/22	11	3.37	7	16-cell stage
TIS-3	4/22	12	3.49	Undetermined, covered in sediment	
TIS-3	4/22	13	3.43	6	Eight blastomere
TIS-3	4/22	14	3.54	6	Eight blastomere
TIS-3	4/22	15	3.66	6	Eight blastomere
TIS-3	4/22	16	3.47	6	Eight blastomere
TIS-3	4/22	17	3.86	5	Second cleavage
TIS-3	4/22	18	3.30	6	Eight blastomere

Site	Date collected	Egg number	Diameter (mm)	Stage number	Stage description
TIS-3	4/22	19	3.23	Undetermined, covered in sediment	
TIS-3	4/22	20	3.40	8	Fifth cleavage
TIS-3	4/22	21	3.43	UF	Unfertilized
TIS-1	4/22	1	3.63	Undetermined, covered in sediment	
TIS-1	4/22	2	3.48	Undetermined, covered in sediment	
TIS-3	4/26	1	Missing; not in sample container		
TIS-3	4/26	2	Missing; not in sample container		

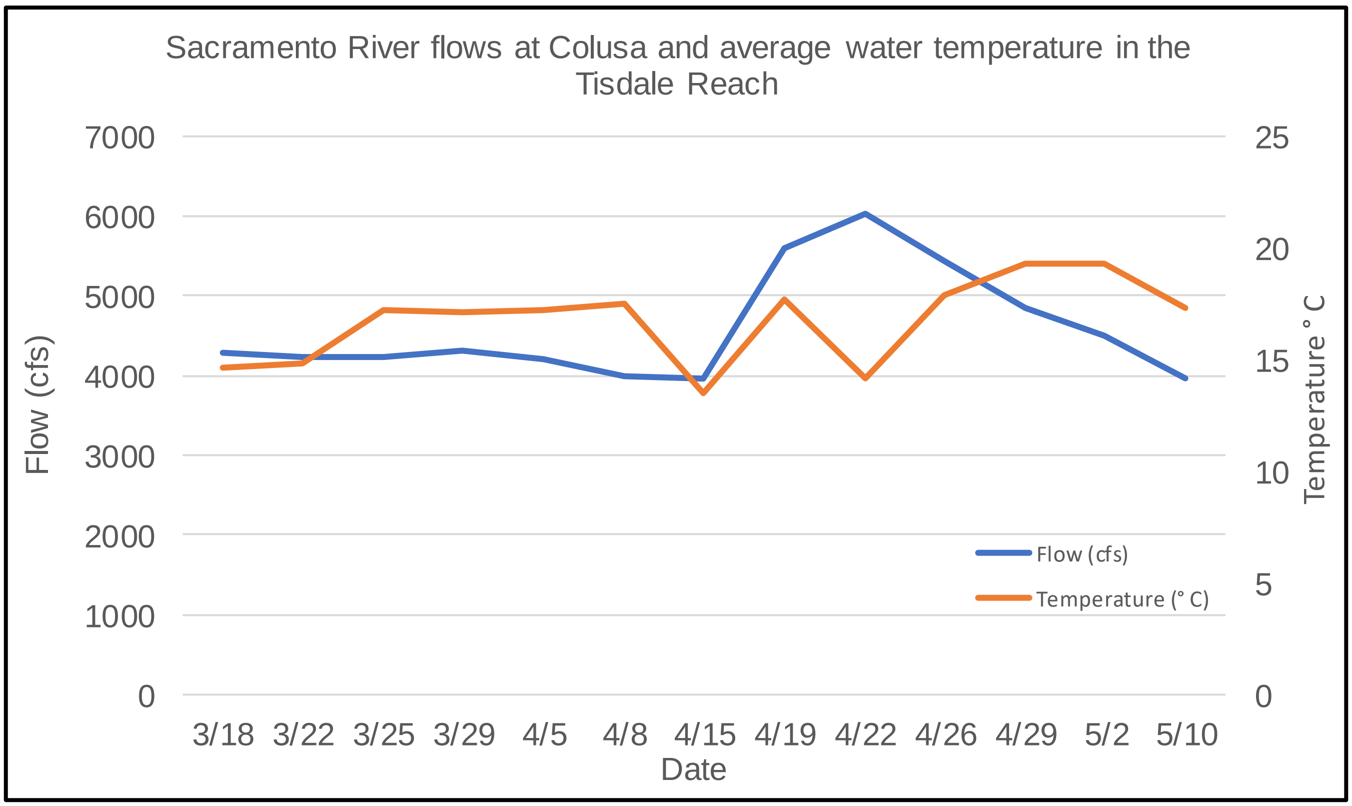

Figure 3. Sacramento River flow at the Colusa gaging station and water temperature within the Tisdale Reach during the 2022 sturgeon spawning survey. White sturgeon eggs were collected on 22 and 26 April.

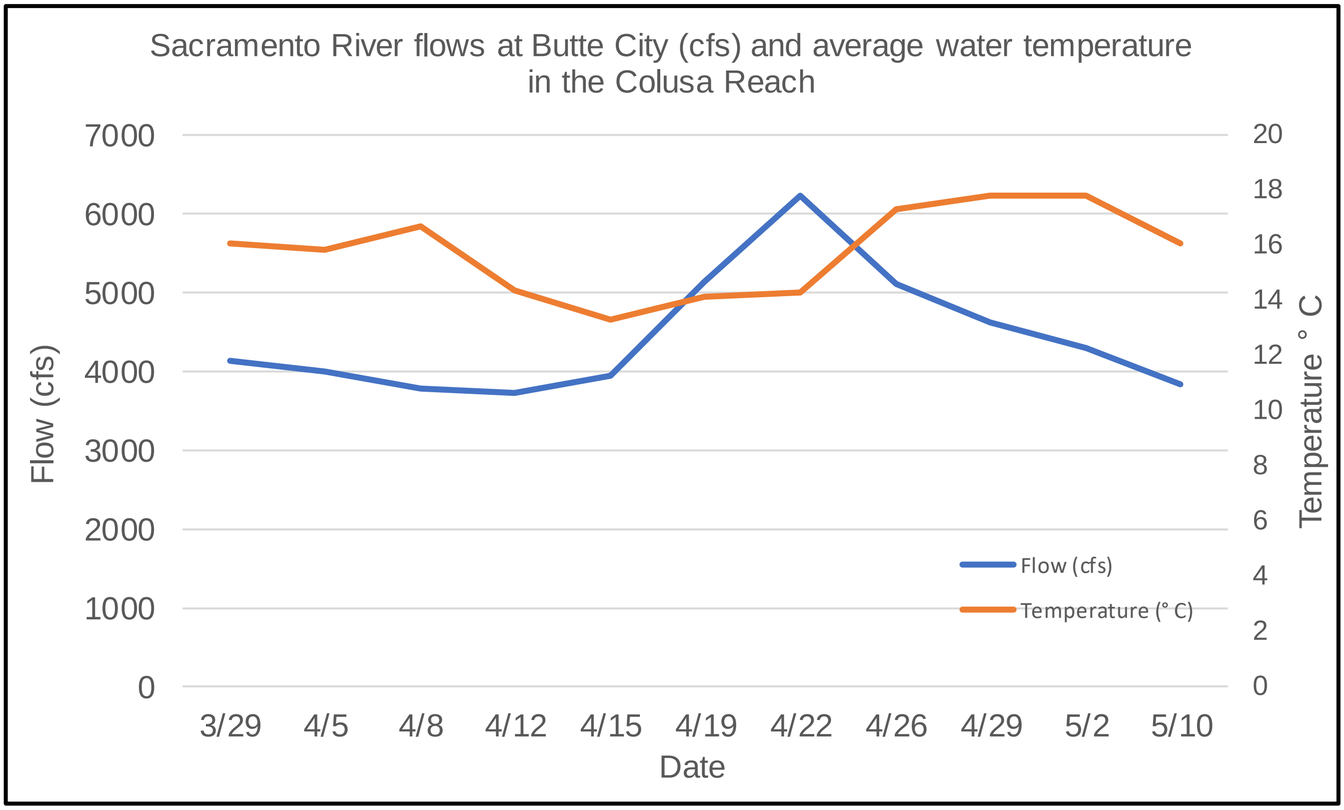

Figure 4. Sacramento River flow at the Butte City gaging station and water temperature in the Colusa Reach during the 2022 sturgeon spawning survey. White sturgeon eggs were collected on 19 and 22 April.

Figure 5. White sturgeon eggs on an egg mat retrieved 19 April 2022 from site COL-1. Five eggs are visible immediately above the penny.

Discussion

The 2022 Sacramento River sturgeon spawning survey was the first year that white sturgeon spawning was documented in the Tisdale Reach, and the second consecutive year that white sturgeon spawning was documented in the Colusa Reach. The collection of the white sturgeon eggs at site COL-1 (rkm 249.0) and site COL-2 (247.6) was approximately 2.4 km and 3.8 km downstream from the site where white sturgeon eggs were collected by Schaffter (2007) in 1992. The timing of the 2022 spawning events are within the temporal range documented by Schaffter (1997) in 1992, when 32 white sturgeon eggs were collected from the Colusa Reach between 24 March and 21 April. Water temperatures during the 1992 survey ranged from 12° C to 16° C, which are within the range of water temperatures recorded when white sturgeon eggs were collected in both reaches of this survey. Schaffter (1997) found that white sturgeon spawning usually occurs on a receding hydrograph after recent flow increases, whereas spawning events in 2022 coincided with flow increases following a fairly long period of minimal flow changes.

Substrate composition is likely and important factor in survival of sturgeon eggs and developing larvae. The predominance of sand and fine sediment substrate within the Tisdale reach does not provide interstitial spaces for oviposited eggs to collect, and likely results in higher predation rates of eggs and developing larvae than in habitat consisting of large substrate such as the gravel and limited cobble which occurs in the Colusa Reach. However, in high flow years, bank and nearshore revetment present within the Tisdale reach may provide increased interstitial spaces which could result in better recruitment. Five white sturgeon eggs collected from the Tisdale reach were completely covered in fine sediment and could not be staged; nor was it possible to determine if they were still viable when collected. Fine sediment adhering to the egg membrane may reduce the oxygen diffusion to the developing embryo and could result in egg mortality or delayed hatching.

Documentation of the spatial and temporal parameters of white sturgeon spawning in the Sacramento River is important for several reasons. As the California white sturgeon numbers continue to decline (Blackburn 2018), a number of conservation measures should be considered to maximize spawning success and recruitment to the juvenile life stage. Spawning habitat enhancement through the addition of large substrates such as cobble and boulder would increase survival of eggs and developing larvae by providing more suitable interstitial spaces which should decrease predation and increase available oxygen. The addition of large substrate such as cobble and boulder to known or potential sturgeon spawning habitat has been shown to be beneficial for lake sturgeon (*Acipenser fulvescens*) in the Detroit River. Egg mat monitoring at an artificial reef of cobblestone placed in the Detroit River resulted in the collection of lake sturgeon eggs where Lake sturgeon spawning had not been documented since the removal of large substrates during shipping channel construction in the 1900s (Fisher 2018). In the Des Prairies River, a nearly five-fold increase in drifting lake sturgeon larvae was observed for multiple years after a spawning substrate augmentation project was completed at a known spawning site (Dumont et al. 2011). While there is some cobble and gravel sand in the Colusa Reach, spawning habitat could be enhanced by the addition of small boulders and additional cobbles. The addition of cobble and small boulder in suitable areas could result in increased spawning habitat and greater recruitment of white sturgeon to the late larval and early juvenile life stages.

Seasonal closures of recreational fishing in known white sturgeon spawning reaches of the Sacramento River system should also be considered as a measure to optimize spawning success. Catch and release of white sturgeon on spawning grounds or during spawning migration may result in abortion of spawning. Radio telemetry data suggest that nearly one-half of white sturgeon captured on set lines in the Sacramento River near Freeport in 1991 and 1992 appeared to abort their spawning migration (Schaffter 1997). Washington's sport fishing regulations include recreational white sturgeon fishing closures for catch and release fishing in spawning reaches of the Columbia River during spawning and post-spawning periods to minimize stress which may result in aborted spawning or delayed mortality from excessive handling associated with catch and release angling.

References

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