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Department of Fish and Wildlife

M e m o r a n d u m

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Subject: 2019-2020 Sacramento River Sturgeon Spawning Study

Purpose

The purpose of this report is to document findings regarding surveys conducted in 2019 and 2020 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 special concern, and has an important recreational fishery managed by CDFW. Recent white sturgeon population monitoring shows 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 in California. 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). However, no sturgeon spawning surveys were conducted on the middle Sacramento River from the early 1990s until 2017 and 2018, when CDFW Region 2 staff conducted spawning surveys.

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 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 (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).

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.

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 (California Data Exchange Center 2019-2020). Four egg mats were initially deployed at each site, however; several egg mats were lost over the duration of the survey due to vandalism or burial by a mobile bedload of sand or fine sediment and were not replaced.

Egg mats were retrieved every three to seven days over the duration of the sampling period. 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.

2019 Sites

Knights Landing Reach. Two sites were selected for egg mat sampling within the Knights Landing reach in 2019, KL-3 (rkm 161.1) and KL-4, (rkm 158.9). (**Figure 1**). Sampling was initiated 25 January and terminated 8 March 2019 for a period of 42 days. Egg mats used to sample the Knights Landing reach were moved to the Colusa reach on 15 March.

Colusa Reach. Three sites were selected for egg mat sampling within the Colusa reach in 2019, COL-3 (rkm 243.5), COL-2 (rkm 247.6) and COL-1 (rkm 249.0) (**Figure 2**). Sampling was initiated 15 March and terminated 7 May for a period of 53 days.

2020 Sites

Knights Landing Reach. Four sites were selected for egg mat sampling within the Knights Landing reach in 2020, KL-1 (rkm 179.0), KL-2 (rkm 169.5), KL-3 (rkm 161.1), and KL-4 (rkm 158.9) (**Figure 1**). Sampling was initiated 2 March and terminated 8 May 2020 for a sampling period of 67 days.

Colusa Reach. Egg mat sampling was not conducted in the Colusa Reach during the 2020 sturgeon spawning season due to logistical issues resulting from Covid-19 work restrictions.

Figure 1. Sacramento River - Knights Landing Reach 2019-2020 sturgeon spawning survey sampling sites.

Figure 2. Sacramento River - Colusa Reach, 2019 sturgeon spawning survey sampling sites.

Results

2019 Sites

Knights Landing Reach. No sturgeon eggs were collected from egg mats deployed in the Knights Landing Reach during the 2019 survey season, and no other fish eggs were observed on the mats. Several lamprey ammocetes were found partially buried into the mats during the latter part of the survey period. Benthic macroinvertebrates commonly observed on the mats included Asian clams (*Corbicula fluminea*), mayfly larvae (Baetidae, Heptageniidae), and caddisfly larvae (Glossosomatidae). Water temperatures during the survey period ranged from 48° F on 25 January to 53° F on 5 March April and 7 May. Sacramento River flows at Wilkins Slough, the nearest gaging station upstream of the Knights Landing sites, ranged from 27,948 on cubic feet per second (cfs) on 1 March to 10,762 cfs on 2 February. Substrates at the two Knights Landing reach sites consisted of mostly sand and fine sediment. Cobble and concrete revetment was present along the banks and nearshore inundated areas of the sites. Estimated surface velocities ranged from one to three feet per second. Several egg mats were lost as a result of vandalism, or burial by a mobile bedload of sand or fine sediment and were not replaced over the duration of the survey. Deployment and retrieval dates and environmental parameters are presented in **Table 1.** Sacramento River flows for Wilkins Slough, the nearest gaging station upstream of the Knights Landing sites, are presented in **Figure 3.**

Table 1. 2019 Sacramento River sturgeon spawning survey site sampling dates, water temperatures, deployment depth range, and number of sturgeon eggs collected.

Site code	Deployment date	Temperature (° F)	Deployment depth range (ft)	Retrieval date	Temperature (° F)	Sturgeon eggs (n)
KL-3	1/25	48	19-23	1/30	51	0
KL-3	1/30	51	18-23	2/2	54	0
KL-3	2/2	54	18-22	2/5	51	0
KL-3	2/5	51	19-23	2/8	50	0
KL-3	2/8	50	19-21	2/12	52	0
KL-3	2/12	52	20-21	2/15	47	0
KL-3	2/15	47	19-23	2/19	53	0
KL-3	2/19	53	19-22	2/26	52	0
KL-3	2/26	52	21-28	3/5	53	0
KL-3	3/5	53	20-22	3/8	50	0
KL-4	1/25	48	18-24	1/30	51	0
KL-4	1/30	51	18-23	2/2	54	0

Site code	Deployment date	Temperature (° F)	Deployment depth range (ft)	Retrieval date	Temperature (° F)	Sturgeon eggs (n)
KL-4	2/2	54	19-22	2/5	51	0
KL-4	2/5	51	18-21	2/8	50	0
KL-4	2/8	50	18-20	2/12	52	0
KL-4	2/12	52	20-21	2/15	47	0
KL-4	2/15	47	19-23	2/19	53	0
KL-4	2/19	53	19-22	2/26	52	0
KL-4	2/26	52	17-20	3/5	53	0
KL-4	3/5	53	22-25	3/8	50	0
COL-1	3/15	56	18-23	3/19	52	0
COL-1	3/19	52	17-23	3/22	53	0
COL-1	3/22	53	17-21	3/26	57	0
COL-1	3/26	57	18-23	3/29	56	0
COL-1	3/29	56	17-22	4/2	55	0
COL-1	4/2	55	17-21	4/5	55	0
COL-1	4/5	55	17-22	4/9	57	0
COL-1	4/9	57	17-23	4/12	56	0
COL-1	4/12	56	19-23	4/19	63	0
COL-1	4/19	63	18-20	4/23	66	0
COL-1	4/23	66	16-20	4/26	67	0
COL-1	4/26	67	17-20	4/30	66	0
COL-1	4/30	66	16-20	5/7	67	0
COL-2	3/15	56	16-24	3/19	52	0
COL-2	3/19	52	17-23	3/22	53	0
COL-2	3/22	53	16-24	3/26	57	0
COL-2	3/26	57	16-22	3/29	56	0
COL-2	3/29	56	21-23	4/2	55	0
COL-2	4/2	55	16-24	4/5	55	0
COL-2	4/5	55	17-24	4/9	57	0
COL-2	4/9	57	17-21	4/12	56	0
COL-2	4/12	56	17-21	4/19	63	0
COL-2	4/19	63	17-22	4/23	66	0
COL-2	4/23	66	15-21	4/26	67	0
COL-2	4/26	67	17-22	4/30	66	0
COL-2	4/30	66	15-19	5/7	67	0
COL-3	3/15	56	17-19	3/19	52	0
COL-3	3/19	52	16-24	3/22	53	0
COL-3	3/22	53	17-20	3/26	57	0
COL-3	3/26	57	15-21	3/29	56	0

Site code	Deployment date	Temperature (° F)	Deployment depth range (ft)	Retrieval date	Temperature (° F)	Sturgeon eggs (n)
COL-3	3/29	56	17-20	4/2	55	0
COL-3	4/2	55	17-20	4/5	55	0
COL-3	4/5	55	17-21	4/9	57	0
COL-3	4/9	57	19-21	4/12	56	0
COL-3	4/12	56	17-20	4/19	63	0
COL-3	4/19	63	16-17	4/23	66	0
COL-3	4/23	66	17-19	4/26	67	0
COL-3	4/26	67	16-17	4/30	66	0
COL-3	4/30	66	16-20	5/7	67	0

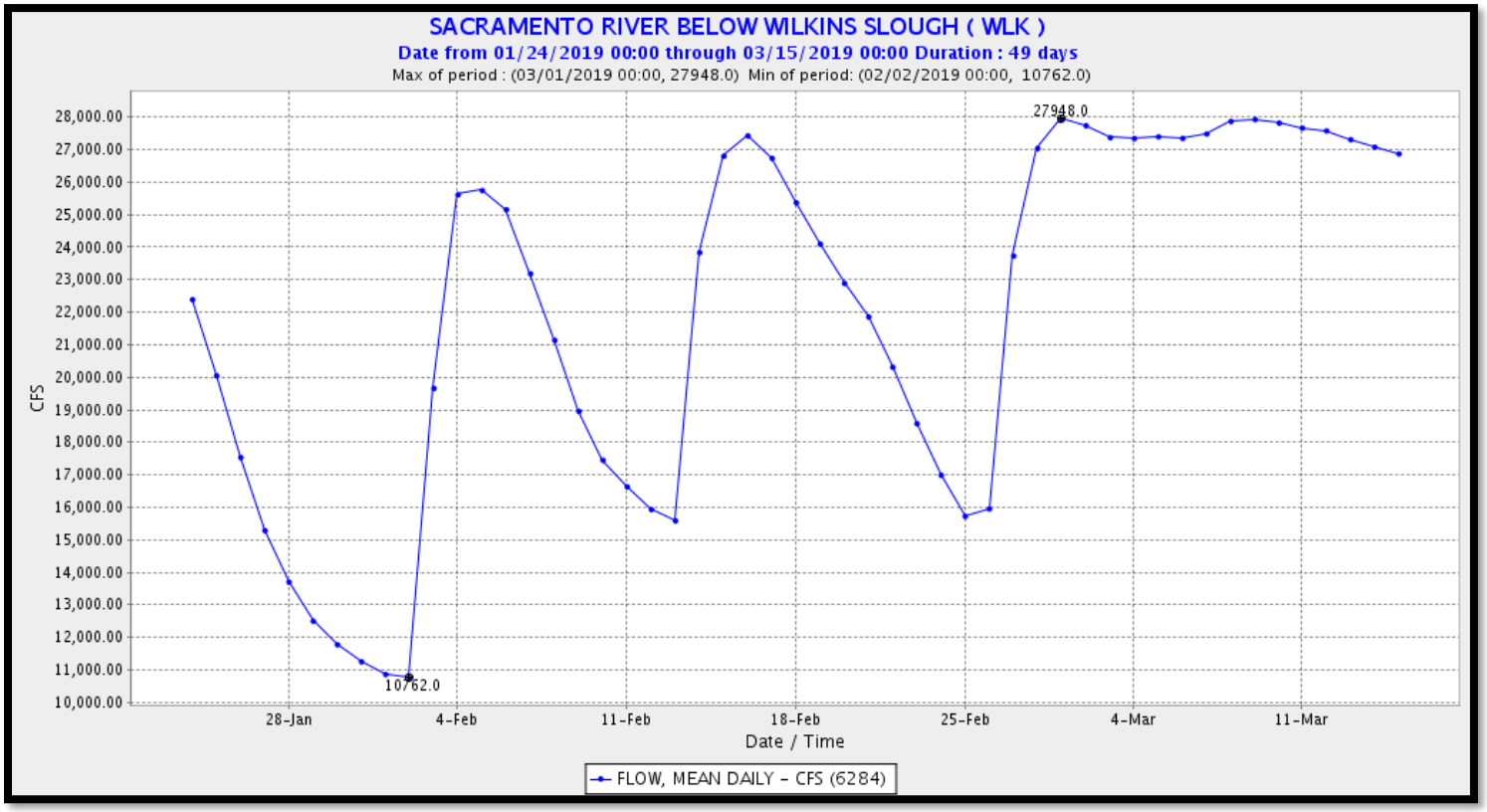


Figure 3. Sacramento River flows at Wilkins Sough during the 2019 sturgeon spawning survey.

Colusa Reach. No sturgeon eggs were collected from egg mats deployed in the Colusa Reach during the 2019 survey season, and no other fish eggs were observed on the mats. Benthic macroinvertebrates commonly observed on the mats included signal crayfish (*Pacifastacus leniusculus*), Asian clams, mayfly larvae in the families Baetidae and Heptageniidae, and caddisfly larvae in the family Glossosomatidae. Water temperatures during the survey period ranged from 52° F on 19 March to 67° F on 26 April and 7 May. Sacramento River flows at Butte City, the nearest gaging station upstream of the Colusa sites, ranged from 50,419 cfs on 15 March to 9,001 cfs on 4 May. Substrates at the three Colusa reach sites consisted of mostly of small gravel and coarse sand. Cobble revetment was present along the banks and nearshore inundated areas of the sites. Estimated surface velocities ranged from one to four feet per second. Deployment and retrieval dates and environmental parameters are presented in **Table 1.** Sacramento River flows for Butte City, the nearest gaging station upstream of the Colusa sites, are presented in **Figure 4.**

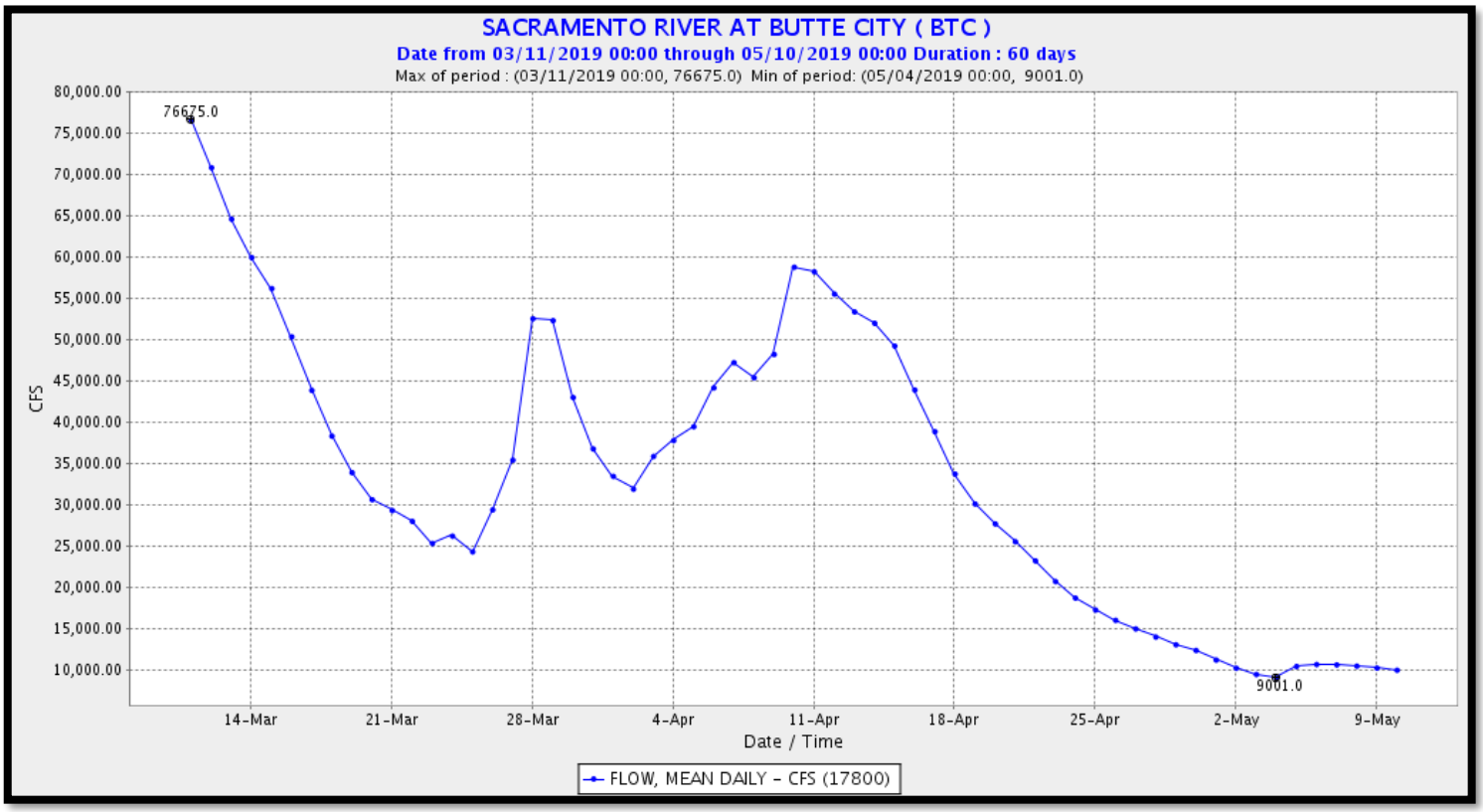


Figure 4. Sacramento River flows at Butte City during the 2019 sturgeon spawning survey.

2020 Sites

Knights Landing Reach. No sturgeon eggs were collected from egg mats deployed in the Knights Landing Reach during the 2020 survey season, and no other fish eggs were observed on the mats. Several lamprey ammocetes were found partially buried into the mats during the latter part of the survey period. Benthic macroinvertebrates commonly observed on the mats included Asian clams, mayfly larvae in the families Baetidae and Heptageniidae, and caddisfly larvae in the family Glossosomatidae. Water temperatures during the survey period ranged from 51.6° F on 20 March to 68.6° F on 1 May. Sacramento River flows at Wilkins Slough, the nearest gaging station upstream of the Knights Landing sites, ranged from 9,292 cubic feet per second (cfs) on 8 April to 5,707 cfs on 8 May. Substrates at the four Knights Landing reach sites consisted of mostly sand and fine sediment. Cobble and concrete revetment was present along the banks and nearshore inundated areas of the sites. Estimated surface velocities ranged from one to three feet per second. As in 2019, several egg mats were lost as a result of vandalism, or burial by a mobile bedload of sand or fine sediment and were not replaced over the duration of the survey. Deployment and retrieval dates, and environmental parameters are presented in **Table 2.** Sacramento River flows for Wilkins Slough, the nearest gaging station upstream of the Knights Landing sites, are presented in **Figure 5.**

Table 2. 2020 Sacramento River sturgeon spawning survey site sampling dates, water temperatures, deployment depth range, and number of sturgeon eggs collected.

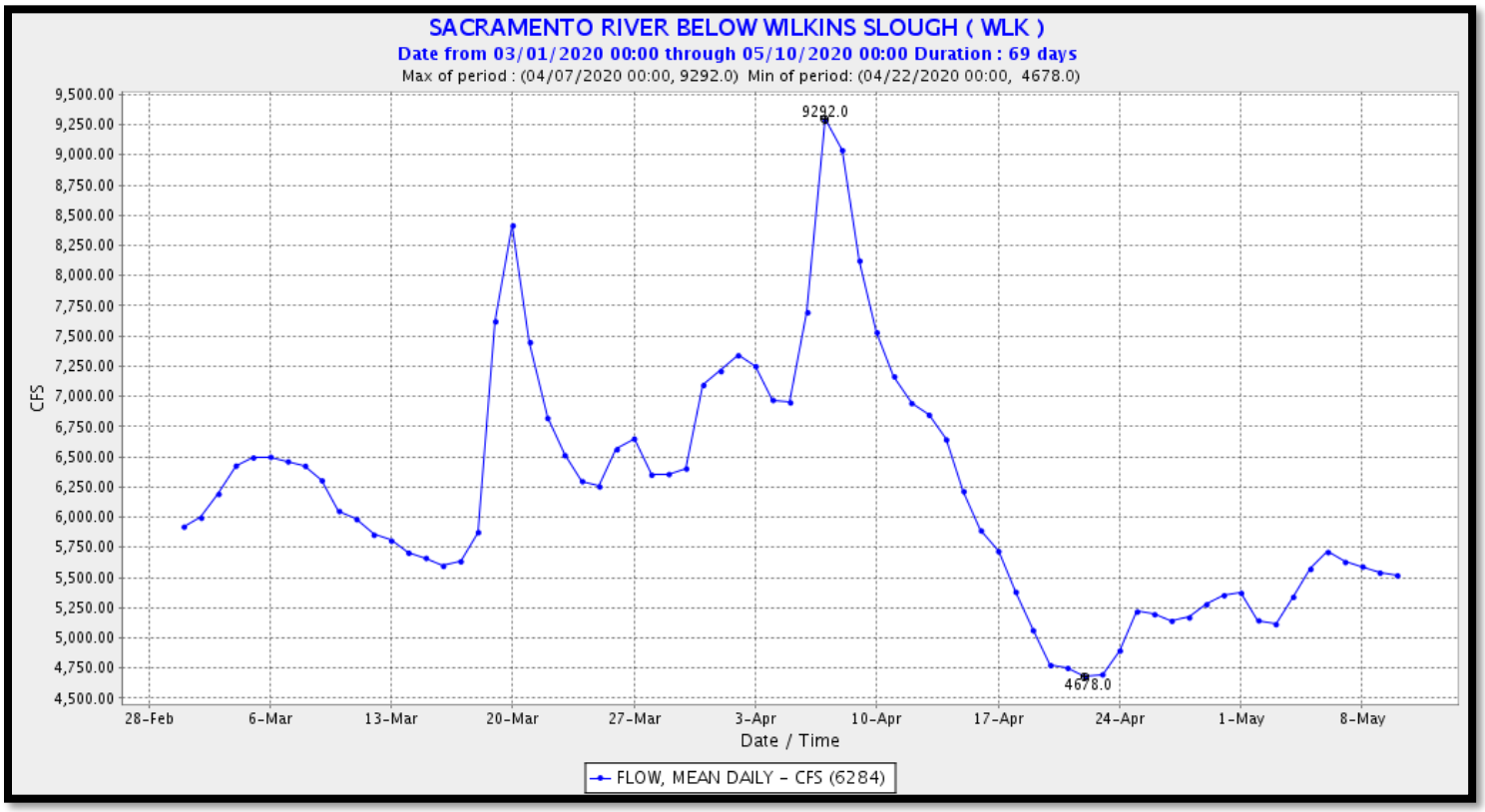
Site code	Deployment date	Temperature (° F)	Deployment depth range (ft)	Retrieval date	Temperature (° F)	Sturgeon eggs (n)
KL-1	3/2	54.5	22-24	3/9	56.0	0
KL-1	3/9	56.0	21-32	3/11	56.6	0
KL-1	3/11	56.6	21-32	3/13	57.4	0
KL-1	3/13	57.4	22-24	3/18	52.6	0
KL-1	3/18	52.6	19-22	3/20	51.6	0
KL-1	3/20	51.6	26-28	3/25	56.5	0
KL-1	3/25	56.5	19-23	3/27	56.5	0
KL-1	3/27	56.5	20-25	3/30	56.3	0
KL-1	3/30	56.3	20-25	4/1	58.0	0
KL-1	4/1	58.0	20-25	4/3	56.9	0
KL-1	4/3	56.9	20-25	4/6	54.9	0
KL-1	4/6	54.9	23-25	4/8	55.3	0
KL-1	4/8	55.3	20-26	4/10	57.5	0
KL-1	4/10	57.5	22-23	4/13	61.9	0
KL-1	4/13	61.9	18-20	4/15	63.7	0

Site code	Deployment date	Temperature (° F)	Deployment depth range (ft)	Retrieval date	Temperature (° F)	Sturgeon eggs (n)
KL-1	4/15	63.7	15-16	4/17	64.3	0
KL-1	4/17	64.3	20-24	4/20	63.9	0
KL-1	4/20	63.9	20-31	4/22	64.0	0
KL-1	4/22	64.0	17-28	4/24	66.1	0
KL-1	4/24	66.1	16-28	4/27	67.4	0
KL-1	4/27	67.4	14-23	5/1	68.6	0
KL-1	5/1	68.6	21-22	5/4	65.4	0
KL-1	5/4	65.4	21-28	5/6	65.7	0
KL-1	5/6	65.7	20-23	5/8	66.4	0
KL-2	3/2	54.5	14-20	3/9	54.5	0
KL-2	3/9	56.0	24-28	3/11	56.0	0
KL-2	3/11	56.0	20-25	3/13	56.0	0
KL-2	3/13	57.6	25-27	3/18	57.6	0
KL-2	3/18	52.1	22-25	3/20	52.1	0
KL-2	3/20	50.6	22-30	3/25	50.6	0
KL-2	3/25	56.9	18-30	3/27	56.9	0
KL-2	3/27	56.1	20-28	3/30	56.1	0
KL-2	3/30	55.8	20-28	4/1	55.8	0
KL-2	4/1	57.9	20-30	4/3	57.9	0
KL-2	4/3	57.0	20-23	4/6	57.0	0
KL-2	4/6	57.0	21-24	4/8	57.0	0
KL-2	4/8	54.6	19-25	4/10	54.6	0
KL-2	4/10	55.4	15-25	4/13	55.4	0
KL-2	4/13	58.0	16-28	4/15	58.0	0
KL-2	4/15	64.5	18-23	4/17	64.5	0
KL-2	4/17	64.7	19-22	4/20	64.7	0
KL-2	4/20	64.1	15-16	4/22	64.1	0
KL-2	4/22	64.2	18-19	4/24	64.2	0
KL-2	4/24	66.3	16-19	4/27	66.3	0
KL-2	4/27	67.2	14-19	5/1	67.2	0
KL-2	5/1	68.4	20-22	5/4	68.4	0
KL-2	5/4	65.4	21-28	5/6	65.4	0
KL-2	5/6	65.4	20-23	5/8	66.4	0
KL-3	3/2	54.8	17-22	3/9	54.8	0
KL-3	3/9	56.0	22-26	3/11	56.0	0
KL-3	3/11	56.6	22-26	3/13	56.6	0
KL-3	3/13	57.9	12-23	3/18	57.9	0
KL-3	3/18	52.1	20-24	3/20	52.1	0

Site code	Deployment date	Temperature (° F)	Deployment depth range (ft)	Retrieval date	Temperature (° F)	Sturgeon eggs (n)
KL-3	3/20	50.6	25 (all)	3/25	50.6	0
KL-3	3/25	56.9	19-23	3/27	56.9	0
KL-3	3/27	56.0	15-19	3/30	56.0	0
KL-3	3/30	55.7	15-20	4/1	55.7	0
KL-3	4/1	58.0	12-25	4/3	58.0	0
KL-3	4/3	54.5	15-20	4/6	54.5	0
KL-3	4/6	54.5	20-25	4/8	54.5	0
KL-3	4/8	55.4	19-24	4/10	55.4	0
KL-3	4/10	58.1	15-20	4/13	58.1	0
KL-3	4/13	62.7	16-24	4/15	62.7	0
KL-3	4/15	64.1	15-18	4/17	64.1	0
KL-3	4/17	64.9	19-22	4/20	64.9	0
KL-3	4/20	64.1	17-25	4/22	64.1	0
KL-3	4/22	64.5	18-23	4/24	64.5	0
KL-3	4/24	66.3	18-19	4/27	66.3	0
KL-3	4/27	66.9	13-19	5/1	66.9	0
KL-3	5/1	68.4	17-22	5/4	68.4	0
KL-3	5/4	65.2	18-22	5/6	65.2	0
KL-3	5/6	65.4	11-15	5/8	66.4	0
KL-4	3/2	54.6	25-31	3/9	56.0	0
KL-4	3/9	56.0	16-28	3/11	56.6	0
KL-4	3/11	56.6	15-34	3/13	58.1	0
KL-4	3/13	58.1	15-24	3/18	52.1	0
KL-4	3/18	52.1	17-30	3/20	50.6	0
KL-4	3/20	50.6	20-24	3/25	56.7	0
KL-4	3/25	56.7	15-23	3/27	56.0	0
KL-4	3/27	56.0	15-23	3/30	55.7	0
KL-4	3/30	55.7	15-25	4/1	57.8	0
KL-4	4/1	57.8	16 (all)	4/3	56.7	0
KL-4	4/3	56.7	20 (all)	4/6	54.4	0
KL-4	4/6	54.4	11-18	4/8	55.4	0
KL-4	4/8	55.4	13-30	4/10	58.0	0
KL-4	4/10	58.0	20-25	4/13	62.8	0
KL-4	4/13	62.8	23-24	4/15	65.5	0
KL-4	4/15	65.5	20-21	4/17	65.0	0
KL-4	4/17	65.0	16 (all)	4/20	65.2	0
KL-4	4/20	65.2	17-22	4/22	64.5	0
KL-4	4/22	64.5	15-16	4/24	66.1	0

Site code	Deployment date	Temperature (° F)	Deployment depth range (ft)	Retrieval date	Temperature (° F)	Sturgeon eggs (n)
KL-4	4/24	66.1	13-19	4/27	66.8	0
KL-4	4/27	66.8	21 (all)	5/1	66.4	0
KL-4	5/1	66.4	16-20	5/4	65.1	0
KL-4	5/4	65.1	19-22	5/6	65.4	0
KL-4	5/6	65.4	14-19	5/8	66.4	0

Figure 5. Sacramento River flows at Wilkins Sough during the 2020 sturgeon



spawning survey.

Discussion

The 2019 and 2020 Sacramento River sturgeon spawning surveys were the third and fourth consecutive years that CDFW conducted sturgeon spawning surveys in the Sacramento River. Sites KL-3 and KL4 in the Knights Landing reach were the same sites sampled in 2018 and 2019, however; sites KL-1 and KL-2 were not sampled in 2019 due to an insufficient number of egg mats. All three Colusa reach sites were the same sites sampled in 2018; COL-1 was in the same general location where white sturgeon eggs were collected by Schaffter in 1992. There are several possible

explanations as to why white sturgeon eggs were not collected during the 2019 and 2020 spawning surveys. Firstly, white sturgeon spawning may have occurred in locations downstream, upstream, or between sampling sites. While reconnaissance surveys were conducted prior to site selection, no large aggregations of sturgeon were detected at the sites ultimately selected for egg mat deployment, and therefore may have not been utilized as spawning sites. Secondly, spawning events may have occurred prior to or after the survey period, although based on the findings of Schaffter (1997) and Kohlhurst (1991), the 2019 and 2020 surveys overlapped the timing of previously documented white sturgeon spawning events on the Sacramento River. Another possible explanation is the patchiness of distribution of eggs after spawning events (Carrofino *et. al.* 2010). The broadcast spawning behavior of white sturgeon coupled with site hydraulics and bottom substrate composition influence egg contact with the bottom, and in locations where sand is the dominant substrate egg "drift" may be considerable due to the adherence of sand on the egg membrane. The 1991 and 1992 white sturgeon spawning surveys conducted by Schaffter (1997) resulted in the collection of only nine white sturgeon eggs in 1991 and 32 in 1992 with considerably more egg mats deployed than in the 2019 and 2020 surveys. Between 32 and 36 total mats were deployed in the 1991 and 1992 surveys versus the initial deployment between 12 and 16 egg mats for the 2019 and 2020 surveys.

Recommendations

More intensive reconnaissance surveys for sturgeon aggregations should be considered beginning in late January or early February to determine timing and other possible locations for egg mat deployments. The use of side-scan sonar units has 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).

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