

Memorandum

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Subject: 2020 Yuba River Sturgeon Spawning Study

Purpose

The report documents findings of the second year of a California Department of Fish and Wildlife (CDFW) study to determine if southern Distinct Population Segment (sDPS) green sturgeon (*Acipenser medirostris*) and/or white sturgeon (*Acipenser transmontanus*) spawn in the Yuba River, and, if so, what are the temporal, spatial, and habitat requirements associated with sturgeon spawning events.

Background

Southern DPS green sturgeon and white sturgeon populations have been severely reduced because of dams, diversions, habitat degradation, and both legal and illegal harvest. The Sacramento River system is the only river system supporting spawning of the federal threatened sDPS green sturgeon and is the primary river system supporting spawning of white sturgeon. Green sturgeon spawning has been documented in a 93 km section of the Sacramento River from Hamilton City (river kilometer [RK] 332.5) upstream to Cottonwood (RK 426) (Poytress et al. 2013) and in the Feather River in the vicinity of the Thermalito Bay Outlet in mid-June 2011 (Seesholtz et al. 2015). The majority of white sturgeon are thought to spawn in the middle Sacramento River between Knights Landing (RK 142) and Colusa (RK 237) (Schaffter 1997).

Because green sturgeon are federally listed as threatened, it is crucial to identify and support additional spawning populations. One of the Demographic Recovery Criteria points in the *Recovery Plan for Southern Distinct Population Segment of the North American Green Sturgeon (Acipenser medirostris)* is that “SDPS green sturgeon spawn successfully within two rivers in their historical range...”

Both green sturgeon and white sturgeon have been observed in the Yuba River. Southern DPS green sturgeon were observed in the Yuba River in 2011, 2016, and 2017; all three years with above average precipitation. In early May 2011, CDFW staff observed at least one green sturgeon below the Daguerre Point Dam (DPD) Pool (personal communication with C. McKibbin). Cramer Fish Sciences conducted underwater video surveys 24-26 May 2011 and determined that there were at least four green sturgeon holding in the pool below the Daguerre Point Dam (Cramer Fish Sciences 2011). In July of 2016, CDFW divers conducted a visual survey of the pool below the Daguerre Point Dam and observed at least eight adult SDPS green sturgeon holding in the pool (personal communication with M. Healy). CDFW conducted the initial sturgeon spawning survey in the Yuba River in 2017 but did not collect any sturgeon eggs, although staff observed green sturgeon in the pool below Daguerre Point Dam during egg mat deployment and retrieval site visits (CDFW 2017). In 2018, CDFW documented spawning of green sturgeon for the first time by collecting approximately 270 sturgeon eggs. Of these, 33 eggs were vouchered for species verification and developmental staging to determine a spawning date (CDFW 2018). CDFW documented a green sturgeon spawning event in the Yuba River in 2019 by the capture of one late stage larva or early stage juvenile (approximately 40 mm) 200 m downstream of Daguerre Point Dam on 19 August 2019.

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). Although DPD blocks upstream passage, the DPD plunge pool appears to be suitable sturgeon spawning habitat based on the combination of depth, flow turbulence, and substrate composition. Coupled with visual observations of sDPS green sturgeon in the pool in 2011, 2016 and 2017, and collection of green sturgeon eggs in 2018, CDFW staff again focused sturgeon egg mat sampling in this habitat unit (**Figure 1**). Larval sampling was conducted in two river reaches where flows were somewhat constricted in hopes that downstream migrating larvae could be more easily be captured. Green sturgeon larvae are primarily nocturnal, typically hiding in interstitial spaces during the day, and foraging and migrating during the night (Poytress et al 2015).

Methods

Egg mat sampling. Egg mats were constructed by securing a furnace filter insert to a 76x107x5-cm rectangular steel frame rigged with a 9.5 mm diameter braided polypropylene rope attachment bridle. A 9.5 mm diameter buoy line of sufficient length (depending on depth) and a 10-inch diameter inflatable buoy were used to mark the egg mat location from the surface and facilitate retrieval. Factors considered for mat deployment sites included presence of sDPS green sturgeon as determined by visual

observation or DIDSON imagery and depth, flow, and substrate regimes as reported in the literature. Once a suitable sampling site was selected, the mat was deployed by gradually lowering it to the river bottom from the bow of the boat while holding the boat stationary in the current. When the egg mat reached the river bottom, the buoy was deployed and observed for several minutes to ensure the egg mat remained in place. Egg mats were retrieved by slowly hauling in the float line to avoid dislodging adhered sturgeon eggs and gently lifting the mat into the boat. Two to three CDFW staff conducted a thorough visual inspection of each egg mat to check for sturgeon eggs prior to re-deployment.

Egg mat sampling to document spawning by sDPS green sturgeon was conducted in the Yuba River in the pool immediately downstream of Daguerre Point Dam (DPD) 19 May 2020 through 13 July 2020. Sampling was initiated on 19 May 2020 and terminated on 13 July 2020 for a sampling period of 48 days. Site visits to check egg mats were conducted on 22, 26, and 29 May; 2, 5, 8, 10, 12, 15, 17, 22, 24, 26 and 29 June; 1, 3, 8, and 13 July. Egg mats were numbered as mats 1 through 8 from north to south. Water temperature, mat deployment depth, water velocity, and Yuba River flow at Marysville were recorded for each site visit. Water temperature was measured with a multiprobe water quality meter or a hand-held thermometer, water depth was measured using a hand-held sonar device, and water velocity was estimated to the nearest 0.3 m per second (one foot per second) by observing floating debris. Yuba River flow data was obtained from the United States Geological Survey gage near Marysville (CDEC 2020).

Larval sampling. Larval sampling was conducted using a D-net constructed of 3.2-mm DuPont 66 nylon fiber mesh fashioned into a 3.0-m long tapered cone and attached to a steel frame with a circumference of 2.8-m including a flat base of 80 cm. An additional layer of 1.6-mm Delta knotless netting was sewn inside the latter 45.7 cm of the 3.2-mm netting to prevent larval sturgeon from being injured or escaping prior to entering the collection bucket. A 3,875-ml aquatic sample bucket was attached to the cod end allowing for easy access to collected samples. Two sites were selected for larval sampling, split channel run habitat approximately 200 m downstream of DPD (DPD sites), and in pool habitat approximately 1,500 m upstream of the confluence with the Feather River (Highway 70 Bridge site), (**Figures 1 and 2**). The DPD site consists of two channels; the south channel was sampled 21, 23, 28 and 30 July; and 4 and 6 August. The north channel was sampled 12, 20, and 26 August; and 2, 9, and 16 September. At the DPD sites, the D-net was deployed by wading into the thalweg of the channel and lowering it to the bottom. Several large cobbles were placed on the net frame to keep the net in place during sampling. Sampling at Highway 70 Bridge site was conducted 24 and 29 September; and 7 and 14 October. (**Figure 2**). At the Highway 70 site, the net was deployed from a vessel by lowering it to the bottom and tying off the bridle ropes to an abandoned bridge abutment. At both sites, the net was deployed in the late afternoon and retrieved the following morning. Net deployment depth, water temperature, and water velocity were recorded for each deployment. The D-net was retrieved by wading it to shore at the DPD sites, or by hoisting it into the

vessel at the Highway 70 Bridge site. The net was then rinsed with buckets of river water to ensure fish entrained in the net collected in the collection bucket. Any fish captured were identified to species and enumerated, and debris load (algae, leaves, etc.) was measured using a graduated cylinder.



Figure 1. Larval sampling locations downstream of Daguerre Point Dam (DPD site). Egg mats were deployed in the pool immediately downstream of the dam.



Figure 2. Larval sampling location approximately 1,500 m upstream of the Feather River confluence (Highway 70 Bridge site).

Results

No green sturgeon eggs or larvae were collected during the 2020 sampling season, although CDFW staff made visual observations of between two and at six adult green sturgeon holding in the pool below the Daguerre Point Dam during most site visits. Tagging operations conducted by Pacific Marine Fisheries staff confirmed the presence of at least six adult green sturgeon holding in the DPD pool (personal communication with A. Seesholtz, DWR). Other fish species observed in the Daguerre Point Dam pool during site visits included adult Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*), adult steelhead or rainbow trout (*O. mykiss*), Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow, (*Ptychocheilus grandis*), prickly sculpin (*Cottus asper*), riffle sculpin (*Cottus gulosus*), American shad (*Alosa sapidissima*), and striped bass (*Morone saxatilis*). Benthic macroinvertebrates such as stonefly nymphs (*Calinuria californica* and *Hesperoperla pacifica*), caddisfly larvae (Hydropsychidae, Glossosomatidae), and Ephemeroptera larvae (Baetidae, Heptageniidae) were commonly observed on the egg mats. Although no sDPS green sturgeon larvae were collected during the larval sampling season, the methodology appeared to be successful for capturing benthic oriented fish species, as two riffle

sculpin (*Cottus gulosus*) were collected from D-net deployments at the DPD site. Yuba River flows during the sampling period ranged from a high of 53.0 meters per second (m^3/s) on 20 August to a low of 15.5 m^3/s on 7 September 2020. Water temperatures over the duration of the study (egg and larval sampling) ranged from a low of 15.6° C on 17 June to a high of 17.9° C on 26 May 2020 (**Figure 3**). Water depth and substrate composition at Daguerre Point Dam sampling site were also within ranges reported in the literature for green sturgeon spawning habitat. Although flow velocity measurements were not taken, estimated surface velocities where egg mats were deployed ranged of 0.3 to 1 meter per second, which were similar to velocities estimated the during the 2017, 2018, and 2019 sampling seasons and also to spawning habitat velocities reported in the literature (Poytress *et. al.* 2015, Seesholtz *et. al.* 2015).

Table 1. Deployment and retrieval dates, metadata, and number of sturgeon eggs sampled, 2020 Yuba River Sturgeon Spawning Study.

Deployment date	Retrieval date	Water temp (° C)	Mat depth range (m)	Flow (m³/s)	Number of sturgeon eggs; notes
Egg mat sampling					
5/19	5/22	16.0	1.6-4.3	31.7	0; 2 adult green sturgeon observed
5/22	5/26	16.0	4.1-4.5	29.7	0; 2 adult green sturgeon observed
5/26	5/29	17.9	4.1-4.5	29.7	0; 2-3 adult green sturgeon observed
5/29	6/02	17.3	3.8-4.4	30.3	0; 2-3 adult green sturgeon observed
6/02	6/05	16.8	3.4-4.3	24.6	0; 2-3 adult green sturgeon observed
6/05	6/08	16.8	3.4-4.3	24.3	0; 2-3 adult green sturgeon observed
6/08	6/10	16.8	3.6-4.8	24.3	0; 5-6 adult green sturgeon observed
6/10	6/12	16.0	3.9-4.2	24.1	0; 2-3 adult green sturgeon observed
6/12	6/15	16.0	3.9-4.3	23.1	0; 2-3 adult green sturgeon observed
6/15	6/17	15.6	3.7-4.2	22.6	0; 5-6 adult green sturgeon observed
6/17	6/19	15.8	3.8-4.1	22.4	0; 5-6 adult green sturgeon observed
6/19	6/22	16.5	3.7-4.2	22.1	0; 5-6 adult green sturgeon observed
6/22	6/24	15.8	3.4-4.1	23.1	0; 2-3 adult green sturgeon observed
6/24	6/26	15.8	3.9-4.1	22.7	0; 2-3 adult green sturgeon observed
6/26	6/29	16.6	4.1-4.3	22.9	0; 3-4 adult green sturgeon observed
6/29	7/01	16.6	4.1-4.3	28.2	0; 3-4 adult green sturgeon observed
7/01	7/03	15.7	4.0-4.8	31.4	0; 5-6 adult green sturgeon observed
7/03	7/08	16.0	3.7-4.5	31.3	0; 5-6 adult green sturgeon observed
7/08	7/10	15.6	3.2-4.3	31.1	0; 5-6 adult green sturgeon observed
7/10	7/13	17.8	3.7-4.3	31.1	0; 5-6 adult green sturgeon observed

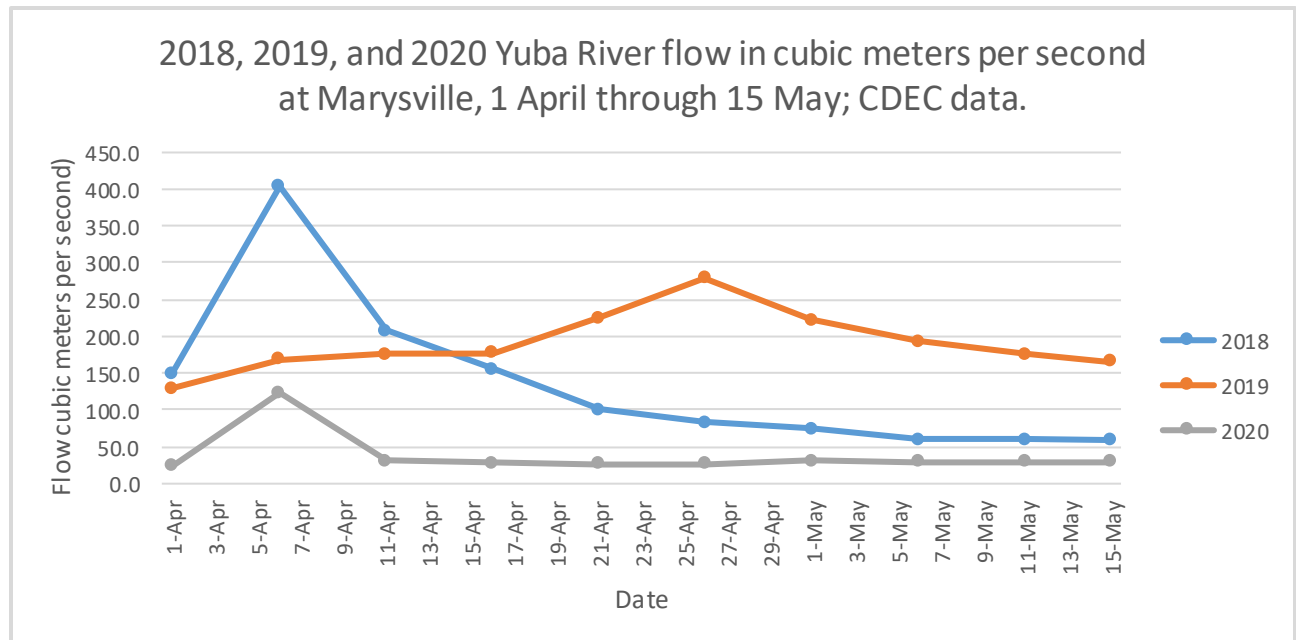
Table 2. Deployment and retrieval dates, metadata, and number of sturgeon larvae sampled, 2020 Yuba River Sturgeon Spawning Study.

Site	Date + time deployed	Temperature (°C)	Depth (m)	Velocity (f/s)	Flow (m ³ /s)	Date + time retrieved	Fish species (number captured)
DPD-south channel	7/21/2020 16:15	17.9	1.1	0.61	34	7/22/2020 14:45	0
DPD-south channel	7/23/2020 14:45	17.8	1.1	0.48	34	7/24/2020 09:45	0
DPD-south channel	7/28/2020 14:30	17.2	1.2	0.58	34	7/29/2020 09:45	0
DPD-south channel	7/30/2020 15:30	17.2	1.1	0.55	34	7/31/2020 10:45	0
DPD-south channel	8/4/2020 14:45	16.1	1.1	0.55	35	8/5/2020 10:45	0
DPD-south channel	8/6/2020 15:00	16.7	1.0	0.61	35	8/7/2020 10:15	0
DPD-north channel	8/12/2020 15:00	16.7	1.0	0.61	34	8/13/2020 10:30	0
DPD-north channel	8/20/2020 13:04	15.6	1.1	0.74	63	8/21/2020 10:35	riffle sculpin (1)
DPD-north channel	8/26/2020 14:30	15.6	1.1	0.74	45	8/27/2020 10:15	0
DPD-north channel	9/2/2020 15:30	16.7	1.0	0.55	16	9/3/2020 11:00	riffle sculpin (1)
DPD-north channel	9/9/2020 14:20	13.9	1.0	0.48	16	9/10/2020 10:15	0
DPD-north channel	9/16/2020 02:30	16.1	1.0	0.52	16	9/17/2020 11:00	0
Highway 70 Bridge	9/24/2020 14:12	17.2	3.5	NR	16	9/25/2020 10:30	0
Highway 70 Bridge	9/29/2020 11:30	16.1	3.6	NR	16	9/30/2020 11:30	0
Highway 70 Bridge	10/7/2020 15:15	16.7	3.5	NR	16	10/8/2020 11:30	0
Highway 70 Bridge	10/14/2020 15:00	16.7	2.3	NR	17	10/15/2020 10:15	0

Discussion

Possible explanations why eggs or larvae were not collected during the 2020 sampling season include much lower flows in the Feather River drainage and higher early season water temperatures in the Yuba River. Yuba and Feather river flows were much lower this season as compared to the 2018 and 2019 during the sDPS green sturgeon spawning migration period (**Figure 3**). Southern DPS green sturgeon enter the Feather and Yuba rivers between mid-April and mid-May (CDFW and DWR unpublished data). Spawning by sDPS green sturgeon was documented during the 2018 and 2019 sampling seasons, when at least 20 adult sDPS green sturgeon were observed holding in the pool immediately below DPD from mid-May until at least mid-August of each year. The lower flows during the 2020 spawning migration period resulted in far fewer sDPS green sturgeon being attracted into the Feather River and hence the Yuba River than in the previous two seasons. Fewer spawning individuals may have decreased the likelihood of detecting spawning events through egg mat and larval sampling. The approximate potential spawning habitat area in the DPD pool is 8,400 m², and the total area of the eight egg mats deployed over the course of the sampling season was 6.5 m², or about 0.07 percent of the potential spawning area. The low number of adult sDPS green sturgeon, coupled with patchiness of egg distribution of spawning sturgeon (Carrofino *et. al.* 2010) and the relatively small area of potential spawning habitat sampled may individually or in combination contributed to the inability to document spawning by egg mat sampling in 2020. Another possibility is that sDPS sturgeon spawned prior to the initiation of egg mat sampling. The water temperature at the beginning of the 2020 sampling season was 16.0° C and ranged from 15.6° C to 17.9° C during the egg mat survey period. In 2018, a single spawning event was documented 13 June 2018. In 2019, one sDPS green sturgeon larva was collected 19 August 2019, and an estimated spawning date of 15 July 2019 was determined based on egg incubation and larval development. Water temperatures were considerably cooler during the 2018 and 2019 egg mat spawning surveys, ranging from 10.0° C to 14.5° C. Larvae or early stage juveniles may be more susceptible to entrainment by water diversions when flows are relatively low, and diversions are at maximum levels. Larval and early stage juvenile green sturgeon have relatively weak swimming capabilities and have been shown to be susceptible to entrainment in diversion pipes (Polleto *et al.* 2014). The combination of lower flows and higher temperatures would also likely increase predation of eggs and developing larvae. Lower flows decrease the amount of available interstitial habitat for eggs and developing larvae, making them more susceptible to predation. Warmer water temperatures increase metabolic rates of predators which in turn would likely increase predation rates of eggs and larval sturgeon. As in previous years, an abundance of several fish species known to prey on fish eggs or larvae including steelhead/rainbow trout, Sacramento sucker, Sacramento pikeminnow, riffle sculpin, prickly sculpin, striped bass, and smallmouth bass were observed in the pool immediately downstream of DPD pool. Although American shad (*Alosa sapidissima*) have not been documented to feed on sturgeon eggs, the Yuba River supports a considerable spawning run of this species, with thousands of individuals typically present in the pool immediately below DPD during the sDPS green sturgeon spawning season. Stomach content analysis through direct observation of consumed eggs or environmental-DNA analysis would provide evidence of egg or larval predation by American shad.

Adult sDPS green sturgeon have been observed in the Yuba River for five consecutive years, 2016 through 2020. Sturgeon spawning surveys were not conducted in the Yuba River in 2016, although adult sDPS green sturgeon presence in the Daguerre Point Dam pool was documented by members of the CDFW dive team (personal communication with M. Healy). CDFW initiated sturgeon spawning surveys in the Yuba River at Daguerre Point Dam in 2017, and although no sturgeon eggs were collected, adult sDPS green sturgeon were observed at the sampling site during most site visits. This highlights that patchiness of distribution and the relatively small sampling area of the total available spawning habitat makes it challenging to document spawning through egg collection. Although spawning and larval recruitment of sDPS green sturgeon was not confirmed during the 2020 sampling season, the presence of five or six adult green sturgeon holding in the pool immediately downstream of DPD suggests that spawning may have still occurred. Therefore, it is possible that green sturgeon spawned in the Yuba River over five consecutive years (2016 through 2020). Removal of the Daguerre Point Dam would provide access to additional upstream habitat in the lower Yuba River for sDPS green sturgeon and would also likely decrease predator densities during



spawning events.

References

- Caroffino D. C., T. M. Sutton, R. F. Elliott, and M. C. Donofrio. 2010. Early life stage mortality rates of lake sturgeon in the Peshtigo river, Wisconsin. *N Am J Fish Management* 30:295–304.
- CDEC. 2019. Yuba River mean daily flow at Marysville. Available at: <http://cdec.water.ca.gov/dynamicapp/QueryDaily?s=MRY&d=now>. Accessed November 2019.
- California Department of Fish and Wildlife. 2019 Yuba River sturgeon spawning survey report.
- California Department of Fish and Wildlife. 2018 Yuba River sturgeon spawning survey report.
- California Department of Fish and Wildlife. 2017 Yuba River sturgeon spawning survey report.
- Cramer Fish Sciences. 2011. Memo: Green Sturgeon Observations at Daguerre Point Dam, Yuba River, CA.
- Deng X., Van Eenennaam J.P., Doroshov S. I. 2002. Comparison of early life stages and growth of Green and White Sturgeon. In: Van Winkle W et al., editors. 2002. *Biology, management, and protection of North American sturgeon*. American Fisheries Society, Symposium 28, Bethesda, Maryland. p. 237-248.
- Heublein, J. C., J. T. Kelly, C. E. Crocker, A. P. Klimley, S. T. Lindley. 2009. Migration of green sturgeon (*Acipenser medirostris*), in the Sacramento River. *Env. Biol. Fish.* 84: 245-258.
- Kynard, B., E. Parker, and T. Parker. 2005. Behavior of early life intervals of Klamath River green sturgeon (*Acipenser medirostris*) with a note on body color. *Env. Biol. Fish.* 72:85-97.
- Klimley, A. P., E. D. Chapman, J. J. Cech, D. E. Cocherell, N. A. Fangué, M. Gingras, Z. Jackson, E. A. Miller, E. A. Mora, J. B. Polleto. 2015. Sturgeon in the Sacramento-San Joaquin watershed: new insights to support conservation and management. *San Francisco Estuary and Watershed Science* 13(4).
- Polleto, J.B, D.E. Cocherell, T.D Mussen, A. Erca, H. Bandeh, M.L. Kavvas, J.J.Cech, N.A. Fangué. 2014. Efficacy of a sensory deterrent and pipe modifications in decreasing entrainment of juvenile green sturgeon (*Acipenser medirostris*) at unscreened water diversions. *Conservation Physiology: Volume 2, Issue 1*.

Poytress, W. R., Gruber, J. J., Van Eenennaam, J. P. 2015. Spatial and temporal distribution of spawning events for Sacramento River green sturgeon. *Trans. Am. Fish. Soc.* 144(6): 1129-1142.

Seesholtz, A.M., Manuel, M. J., Van Eenennaam, J. P. 2014. First documented spawning and associated habitat conditions for green sturgeon in the Feather River, California. *Environ. Biol. Fishes* 98(3): 905-912.

Shaffter, R. G. 1997. White sturgeon spawning migrations and locations of spawning habitats in the Sacramento River, California. *California Fish and Game*: 83: 1-20.