

San Joaquin River White Sturgeon Telemetry Study
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Background

Little is known about the migratory habits of San Francisco Estuary White Sturgeon (*Acipenser transmontanus*) and their use of the San Joaquin River, California. In 2007, California Department of Fish and Wildlife (CDFW) implemented Sturgeon Report Cards to monitor and evaluate sturgeon populations. This program requires all individuals participating in the White Sturgeon Recreational Fishery to purchase a Sturgeon Report Card (SRC). The adoption of SRC program has helped the CDFW document all sturgeon captured or recreationally harvested each year. These SRCs are either returned to CDFW when a White Sturgeon is harvested within the slot limit of 40 to 60 inches or at the end of the year to provide additional data and help with setting recreational harvest limits. The CDFW SRC data has shown that White Sturgeon are captured throughout the San Joaquin River. The U.S. Fish and Wildlife Service's (USFWS) Anadromous Fish Restoration Program first surveyed and successfully detected White Sturgeon eggs in the San Joaquin River in 2011, approximately 40 river kilometers (rkm) downstream from the San Joaquin River Restoration Program's (SJRRP) Restoration Area (Jackson et al. 2016). Discovery of eggs led the USFWS to initiate an acoustic tagging and telemetry program for White Sturgeon in Spring 2012 to better understand the spawning migration, periodicity, and reproductive success of this species within the San Joaquin River below the confluence with the Merced River. These studies suggested a spring migration and spawning window for White Sturgeon from February through May (Heironimus et al. 2015) and the potential for spawning activity and success in the San Joaquin River even during dry water years (e.g., 2012 and 2016). Furthermore, the migratory path of this species includes at least the downstream entrance of the SJRRP Restoration Area (RA) (i.e., the river's confluence with the Merced River near Hills Ferry). From 2016 to 2018, Lodi Fish and Wildlife Office (LFWO) fish biologists successfully detected twelve tagged White Sturgeon at Hills Ferry, the furthest downstream entrance to the RA.

The capture of two White Sturgeon and the first documented capture of a Green Sturgeon (*A. medirostris*) in the RA occurred during SJRRP salmonid monitoring efforts at Hills Ferry in March and April 2019, further supporting that sturgeon use the RA. However, LFWO's effort to track White Sturgeon has been constrained by funding and prior to 2022, acoustic receivers only extended to directly upstream from Hills Ferry, the downstream entrance of the RA. This has prevented the LFWO from fully understanding migratory corridors, distribution, and potential

barriers that require remediation to facilitate upstream migration and habitat utilization by White Sturgeon and other native fishes.

Study Description

This study tracked the migration and habitat use of White Sturgeon that were acoustically tagged since 2012, as well as additional sturgeon that have been tagged annually below major migratory barriers in the RA. An array of 24 acoustic receivers previously existed in the main stem of the San Joaquin River and its tributaries (Merced, Stanislaus, and Tuolumne Rivers), stretching from directly upstream of the confluence of the San Joaquin and Merced Rivers downstream to directly upstream of Mossdale (Figure 1). In 2022, LFWO extended this array by installing 3 additional acoustic receivers further upstream into the RA (marked in blue in Figure 1). New receiver site locations, include: (1) the Valley Grasslands State Park on the San Joaquin River (labeled SJR LVG); (2) near Van Clief Road in the San Joaquin River directly downstream of the Eastside Bypass (labeled SJR VC); and (3) at a site directly downstream of the Kelley Weir/Diversion in the Eastside Bypass (labeled EB DS KRW) (Figure 1).

Methods

Acoustic tagging occurred from February through May. Adult White Sturgeon were captured using gill and trammel nets used in the previous White Sturgeon studies conducted by the LFWO. Captured and tagged sturgeon followed standard operating procedures that were previously established by the LFWO. Acoustic receivers (VR2W–69 kHz stationary receivers, Vemco®, Bedford, Nova Scotia) were installed below the Eastside Bypass Control Structure and Kelley Weir/Diversion, Van Clief Road, and at Valley Grasslands State Park. The remaining 24 receivers within the array were maintained by offloading data, installing new batteries, and updating each device to the latest firmware. From 2012 through 2018, 91 White Sturgeon were tagged with 69 kHz Vemco acoustic transmitters and Passive Integrated Transponder (PIT) tags. Acoustic detections of each individual fish provide invaluable data supporting spatial and temporal trends of White Sturgeon migration and habitat use within the San Joaquin River and RA. General River flow and water temperature data can be acquired from U.S. Geological Survey gauge stations located near these receivers to provide further insight into potential drivers for White Sturgeon migratory behavior and habitat use.

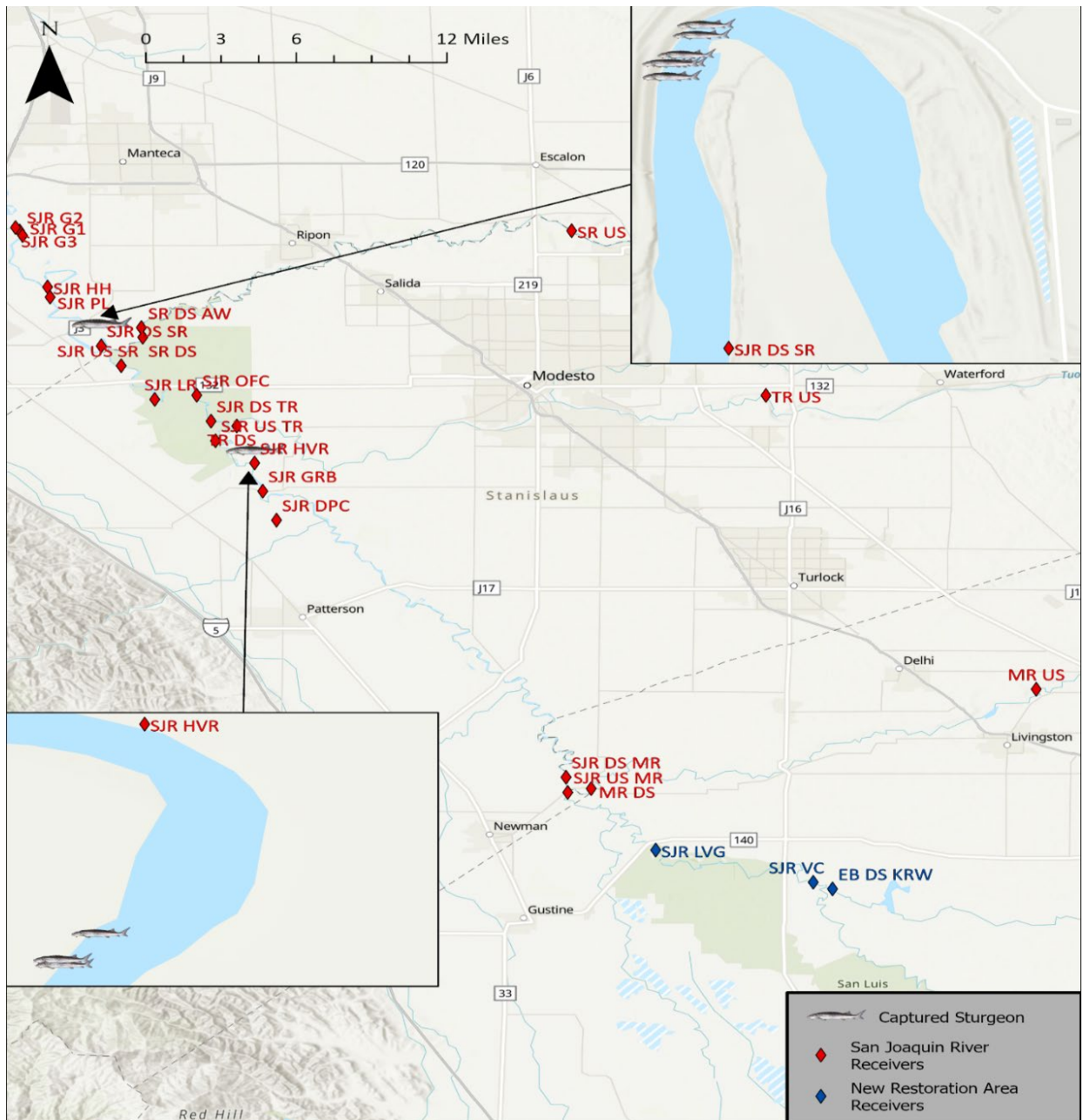


Figure 1. Site Locations for 16 White Sturgeon captures in 2022 and 27 Sturgeon VR2W 69 kHz Sturgeon Receivers in the San Joaquin River. The three new receivers that were installed within Reach 5 of the San Joaquin River Restoration Area are displayed in blue, the 24 receivers that were already monitoring prior to 2022 are displayed in red, and the locations where White Sturgeon were captured in 2022 are displayed with sturgeon icons.

Preliminary Results

Three new receivers were installed in the RA by LFWO on February 23 and 25, 2022. Data was offloaded from these receivers on May 17 and 19, 2022. Two of three (site codes SJR LVG and SJR VC) receivers were offloaded on February 15 and 17, 2023. The most upstream receiver, EB DS KRW, was unable to be offloaded due to high flows that overtopped the stream bank preventing access to the receiver. A partnership was also developed between LFWO and CDFW to replace batteries of receivers, update firmware, and offload and share data for the other 24 receivers within LFWO's acoustic receiver array. Partnering with CDFW in 2022 has helped improve efficiency for acoustic receiver array maintenance. Additionally, there are many 69kHz acoustic receivers in use within the region. Data from these other receivers is easily accessible online and can be used to provide further insight into surgeon migratory corridors and habitat use.

During the first year (February 2022 through January 2023) that the three new receivers were active and collecting data in the RA, a female White Sturgeon was detected for 4 minutes on January 14, 2023, near Valley Grassland State Park (site code SJR LVG). This female White Sturgeon was previously tagged in the San Joaquin River by the LFWO in 2015 where it was immediately released back into the San Joaquin River. The female White Sturgeon was 154 cm (60.6 in.) with a 66 cm (26 in.) girth when it was originally tagged in the San Joaquin River on April 1, 2015 (acoustic tag ID A69-9001-23895, PIT tag ID 985F121021183483). These acoustic detections at the Valley Grasslands State Park (site code SJR LVG) receiver indicate that this female White Sturgeon migrated at least 7.5 river miles upstream from the downstream entrance of the RA at the San Joaquin and Merced River confluence. Since the furthest upstream acoustic receiver in the Eastside Bypass Downstream of the Kelly Weir (site code EB DS KRW) was inaccessible due to high flows on February 23 and 27, 2023, this receiver will need to be checked later when flood flows recede, and the site becomes safe and accessible to download the data. This data may provide further insight about this individual's migration path and habitat use within the RA after being detected at Valley Grasslands State Park.

From February 28 through May 3, 2022, sampling with gill and trammel nets occurred on 16 days. A total of 16 White Sturgeon, 19 Common Carp (*Cyprinus carpio*), and 1 Striped Bass (*Morone saxatilis*) was captured from March 23 through May 3, 2022 (Table 1). These captures included 14 White Sturgeon that had not been previously captured or tagged by LFWO or other Central Valley monitoring projects. The remaining two captures were recaptured individuals. One White sturgeon was originally captured and tagged with a PIT tag by the LFWO on March 20, 2012, and had a measured fork length of 125 cm (49.2 in). When it was recaptured on March 23, 2022, it had a measured fork length of 143 cm (56.3 in) with a 55 cm (21.7 in) girth which equates to a growth rate of 1.8 cm or 0.71 in of length per year since 2012. The other recaptured White Sturgeon was originally captured, tagged, and released at Sturgeon Bend on March 24, 2022, and then was recaptured at Sturgeon Bend on March 28, 2022. When this sturgeon was recaptured on March 28, 2022, the suture condition and overall biological condition was visually assessed. The sutures were still intact, and the incision showed no signs separation or secondary infection.

prior to its immediate release back into the San Joaquin River. On March 23, 2022, seven White Sturgeon were captured in the first 30 minutes of sampling. To minimize stress and risk of mortality, three were released without being tagged, and only one of the three was measured prior to being released. The remaining four were measured, tagged with PIT and acoustic tags, and released after recovering from surgery. The remaining eight sturgeon captures included seven individuals that were measured, tagged, and released. The 2022 tagging season was successful and allowed the LFWO to implant PIT and acoustic tags into 11 new White Sturgeon. This effort also provided growth information from a sturgeon that was tagged by the LFWO a decade ago.

Table 1. Fish captures from gill and trammel netting surveys in the San Joaquin River from March 1 through May 3, 2022. The data table includes capture dates, fish common names, fork lengths (cm), Girth (cm), Recapture (Yes/No), PIT tag inserted (Yes/No), PIT tag ID, Acoustic Tag inserted (Yes/No), and Acoustic Tag ID.

Date	Common Name	Length (cm)	Girth (cm)	Recapture	Pit Tag Inserted	Pit Tag ID	Acoustic Tag Inserted	Acoustic Tag ID
3/1/22	Common Carp	72	N/A	No	No	N/A	No	N/A
3/23/22	White Sturgeon	145	74.5	No	Yes	900226000765244	Yes	19529
3/23/22	White Sturgeon	N/A	N/A	No	No	N/A	No	N/A
3/23/22	White Sturgeon	184	68	No	Yes	900226000765288	Yes	19532
3/23/22	White Sturgeon	N/A	N/A	No	No	N/A	No	N/A
3/23/22	White Sturgeon	143	55	Yes	No	985121021183148	No	63053
3/23/22	White Sturgeon	104	N/A	No	No	N/A	No	N/A
3/23/22	White Sturgeon	174	62	No	Yes	900226000765276	Yes	19531
3/24/22	White Sturgeon	152	61	No	Yes	900226000765278	Yes	19536
3/24/22	Common Carp	71	N/A	No	No	N/A	No	N/A
3/28/22	Common Carp	N/A	N/A	No	No	N/A	No	N/A
3/28/22	White Sturgeon	N/A	N/A	Yes	No	900226000765278	No	19536

Date	Common Name	Length (cm)	Girth (cm)	Recapture	Pit Tag Inserted	Pit Tag ID	Acoustic Tag Inserted	Acoustic Tag ID
3/28/22	Common Carp	76	N/A	No	No	N/A	No	N/A
3/28/22	White Sturgeon	162	65	No	Yes	900226000765286	Yes	19530
3/28/22	Common Carp	86	N/A	No	No	N/A	No	N/A
3/28/22	Common Carp	74	N/A	No	No	N/A	No	N/A
3/30/22	Common Carp	75	N/A	No	No	N/A	No	N/A
3/30/22	Common Carp	70	N/A	No	No	N/A	No	N/A
3/31/22	White Sturgeon	155	61	No	Yes	900226000765213	Yes	19533
3/31/22	White Sturgeon	121	44	No	Yes	900226000765249	Yes	19527
4/4/22	Common Carp	N/A	N/A	No	No	N/A	No	N/A
4/4/22	Common Carp	77	N/A	No	No	N/A	No	N/A
4/5/22	White Sturgeon	130	51	No	Yes	900226000765256	Yes	19528
4/5/22	White Sturgeon	153	65	No	Yes	900226000765279	Yes	19539
4/5/22	Common Carp	73	N/A	No	No	N/A	No	N/A
4/5/22	Common Carp	75	N/A	No	No	N/A	No	N/A
4/6/22	Common Carp	N/A	N/A	No	No	N/A	No	N/A
4/7/22	Common Carp	N/A	N/A	No	No	N/A	No	N/A
4/12/22	Common Carp	67	N/A	No	No	N/A	No	N/A
4/12/22	Common Carp	80	N/A	No	No	N/A	No	N/A
4/25/22	Common Carp	75	N/A	No	No	N/A	No	N/A
4/25/22	Common Carp	81	N/A	No	No	N/A	No	N/A

Date	Common Name	Length (cm)	Girth (cm)	Recapture	Pit Tag Inserted	Pit Tag ID	Acoustic Tag Inserted	Acoustic Tag ID
4/28/22	Common Carp	74	N/A	No	No	N/A	No	N/A
4/28/22	Striped Bass	48.5	N/A	No	No	N/A	No	N/A
4/28/22	White Sturgeon	154	62	No	Yes	900226000765238	Yes	19534
4/28/22	Common Carp	78	N/A	No	No	N/A	No	N/A
5/3/22	White Sturgeon	114	47	No	Yes	900226000765205	Yes	19537

Discussion

The 11 White Sturgeon tagged in 2022 increased the total number of LFWO-tagged White Sturgeon to 102 individuals. Although 102 individuals have been tagged since 2012, the battery life for V16-4x acoustic tags is approximately 10 years. Therefore, we can safely assume that the 10 acoustic tags implanted in 2012 stopped transmitting acoustic signals by May 2022, and the 18 acoustic tags implanted in 2013 stopped transmitting acoustic signals by May 2023. These losses in ability to detect sturgeon tagged in 2012 and 2013 doesn't account for losses of individuals due to recreational harvest, predation, ship strikes, and potential losses from the harmful algal bloom that led to White Sturgeon mortality in the San Francisco Bay Estuary in 2022. California Department of Fish and Wildlife also reported that one of the PIT and acoustic tagged White Sturgeon tagged by LFWO in 2014 (PIT tag ID 985F121021195803, acoustic tag ID A69-9001-27467) was harvested in the California White Sturgeon recreational fishery in 2022. Based on this information, the maximum number of White Sturgeon tagged by LFWO and transmitting acoustic signals for the acoustic telemetry project in the San Joaquin River consists of only 73 individuals. However, the CDFW has also tagged White Sturgeon and even one Green Sturgeon and installed acoustic receivers at alternate locations within the San Joaquin Basin. The combination of these two receiver arrays allowed both the LFWO and the CDFW receivers to detect the holding and outmigration of the tagged Green Sturgeon in 2022 through 2023. Although effort to tag sturgeon in the San Joaquin River has continued, the total number of sturgeon available to provide data for understanding migratory corridors, distribution, and potential barriers that require remediation is a moving target because each year the total number of acoustically tagged sturgeon in the San Joaquin River will decrease as batteries expire. It's pertinent that LFWO continues this baseline effort to maintain its acoustic array and continually capture and tag White Sturgeon in the San Joaquin River to better understand how they're using the RA and identify if future fish passage projects successfully allow sturgeon passage.

Although LFWO has been focused on tagging and tracking the movement of adult and sub-adult White Sturgeon in the San Joaquin River, expanding this effort to collect data for all life stages of both Green Sturgeon and White Sturgeon should be prioritized for the San Joaquin and Sacramento rivers, as well as all tributaries in the Central Valley of California. The Anadromous Fish Restoration Program developed a charter in 2023 specifying Green and White Sturgeon information needs for the Central Valley Project Improvement Act (CVPIA) to guide activities to inform the Near-Term Restoration Strategy and further the development of the sturgeon decision support model. This charter specifies metrics for both Green and White Sturgeon: 1) identifying habitat suitability criteria for juveniles and adults based on field validation; 2) estimating habitat availability in acres at various flows; 3) estimating juvenile abundance; 4) estimating adult abundance; 5) and developing a 2-D hydrodynamic model based on the availability of existing models. The tasks outlined within the sturgeon Near-Term Restoration Strategy (NTRS) included five information priorities. These five priorities included: 1) early juvenile survival and growth of wild fish (larvae to age-1 [first ocean migration]); 2) adult and sub-adult survival and movement (system wide); 3) spawner abundance monitoring; 4) estimate juvenile rearing and adult spawning habitat availability (system wide); 5) White Sturgeon spawning distribution. Although these tasks have been identified as priorities, only a few ongoing efforts are collecting data that could be used to inform the sturgeon NTRS.

The LFWO is currently collecting data that could be used to help inform priority 2 but this effort is only focused on White Sturgeon and is constrained to 0.5 river kilometers (rkm) in the Eastside Bypass, from rkm 62 to rkm 135 in the San Joaquin, from rkm 3 to rkm 32 in the Stanislaus, from rkm 1 to rkm 23 in the Tuolumne, and from rkm 1 to rkm 23 in the Merced Rivers. From 2011 through 2018, LFWO conducted White Sturgeon spawning surveys to confirm and identify where spawning occurred in the San Joaquin River. However, spawning surveys were discontinued due funding constraints. If additional funding was provided, the funding could be used to identify suitable habitat at various flows to help address information needs of priority 4, adult spawning habitat availability in the San Joaquin River. In addition, these surveys could provide invaluable information to initiate studies focused on capturing, tagging, and tracking the movement of young-of-year White Sturgeon to address information priority 1, information about early juvenile survival and growth, as well as the first half of information priority 4, to estimate juvenile rearing habitat availability. While these efforts would not fill all the data gaps that have been prioritized, it could ramp-up White Sturgeon monitoring activities in the San Joaquin River and its tributaries and could collect initial data on Green Sturgeon to inform the CVPIA NTRS and further the development of a decision support model.

Acknowledgments

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Bureau of Reclamation under the CVPIA Anadromous Fish Restoration Program. Various contributors and partners, including universities and the California Department of Fish and Wildlife, are involved in maintaining and deploying new acoustic tag receiver arrays downstream that contribute to the network of shared data in the sturgeon monitoring community. Special thanks to the California Fish Passage Forum for funding and supporting the new receiver installation, existing receiver maintenance, sturgeon tagging, and reporting activities planned for 2024.