Summary of Fish Rescues Conducted at the Fremont Weir and Northern Yolo Bypass

Winter 2016 through Spring 2017

Prepared for the United States Bureau of Reclamation

By California Department of Fish and Wildlife

North Central Region

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SUMMARY OF 2016-2017 SEASON FISH RESCUES CONDUCTED WITHIN THE YOLO BYPASS

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1. Purpose

The purpose of this document is to summarize fish rescue efforts conducted within the Yolo Bypass (Fremont Weir splash basin and surrounding scour ponds, and Sacramento Weir) during the 2016-2017 water year.

The U.S. Bureau of Reclamation (USBR) operates the Federal Central Valley Project (CVP) in coordination with the State Water Project (SWP), which is operated by the California Department of Water Resources (DWR). Operation of the CVP and SWP can significantly affect water quantity and quality, fish distribution and survival, and available aquatic habitats in the Central Valley and San Francisco Bay-Delta. The National Marine Fisheries Service (NMFS) evaluated these stressors in their 2009 Biological Opinion on the Long-term Coordinated Operation of the CVP and SWP BIOP and concluded they are likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*; federal and state endangered), Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*; federal and state threatened) Central Valley steelhead *Oncorhynchus mykiss*; federal threatened), and the southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*; federal threatened).

Based on their conclusion, NMFS identified reasonable and prudent alternatives (RPAs) to the proposed action that is expected to avoid the likelihood of jeopardy to these species and adverse modification of their Critical Habitat. The RPAs include:

Action I.7." Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass"

This action requires the USBR and/or DWR to provide high quality, reliable fish passage beyond barriers in the Yolo Bypass. In the interim to completion of large-scale improvements addressing Action I.7, USBR has contracted CDFW to conduct fish rescues within the Yolo Bypass.

2. Background

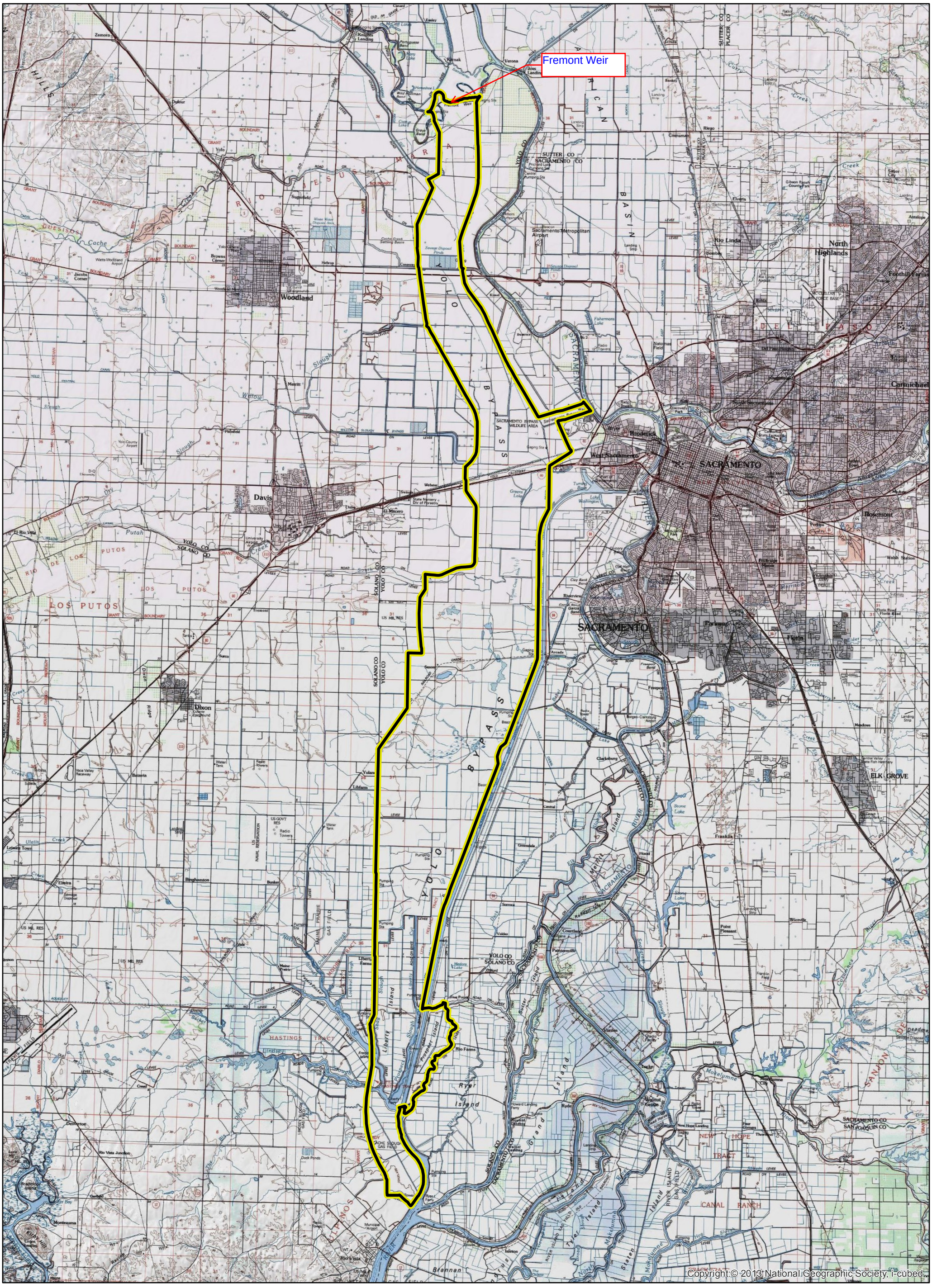
The approximately 59,000-acre Yolo Bypass is essentially a leveed floodplain designed to convey floodwaters from the Sacramento River and west side streams and drains around the populated regions of the central Sacramento Valley **(Figure 1)**. Inundation of the Yolo Bypass occurs when Sacramento River flows overtop the Fremont Weir, located at RKM 226 (RM 140.4). The Fremont Weir spills on average once every two to three years (USBR and DWR 2012). Inundation of the Yolo Bypass occurs when Sacramento River flows at the Fremont Weir exceeds a stage height of 32.3 feet above mean sea level North American Vertical Datum of 1988 (NAVD 1988) which occurs at a flow of approximately 1,622 cubic meters per second (57,290 cubic feet per second) (DWR 2016). Inundation of the Yolo Bypass is augmented by flows from west side tributaries including Cache Creek, Willow Slough, Willow

Slough Bypass, Putah Creek, and South Fork Putah Creek (**Figure 2)**. Up to 80 percent of the Sacramento River's floodwaters are conveyed for a distance of approximately 50 km (31 miles) through the Yolo Bypass and returned to the Sacramento River via the Cache Slough Complex approximately two miles upstream of the town of Rio Vista. The Yolo Bypass capacity is 9,713 cubic meters per second (343,000 cfs) (DWR 2010). The Sacramento Weir is opened to allow floodwaters to inundate the Sacramento Bypass by removal of flashboards when the Sacramento River stage at the weir reaches 29.7 feet above mean sea level (DWR 2012). Floodwaters from the Sacramento Bypass join flows from the Yolo Bypass 2.8 kilometers west of the Sacramento Weir (**see Figure 2**).

The Yolo Bypass serves as a migration corridor for adult and juvenile anadromous fish, rearing habitat for juvenile salmonids and other freshwater fish species. The perennially inundated areas of the Yolo Bypass such as the Knights Landing Ridge Cut, Tule Canal, and Toe Drain are habitat for a number of resident native and non-native fish species. Among these are federal and state anadromous listed species including Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the southern green sturgeon. Flows within the Yolo Bypass are typically much greater than flows within the Sacramento River during weir overtopping events, attracting anadromous fish migrating up the Sacramento River into the Yolo Bypass at the Cache Slough complex. Even in years when the Fremont Weir does not spill, west side tributary and drainage canal flows can attract anadromous fish into the Yolo Bypass at the Cache Slough complex, particularly during periods of high tides and low Sacramento River flows. Fish attracted by west side stream and drainage canal flows migrate upstream through the Toe Drain, Tule Canal, Knights Landing Ridge Cut, and Colusa Basin Drain Canal (CBDC). Similarly to fish isolated and stranded during weir spill events, fish attracted into the Yolo Bypass by west side tributary and drainage canal flows are unable to return to the Sacramento River when river flows are not overtopping weirs. CDFW initiated fish trapping and rescue efforts in the CBDC in 2013 and at the Wallace Weir in the Knights Landing Ridge Cut in 2014 to return anadromous fish that migrated upstream after entering the Yolo Bypass at the Cache Slough Complex.

Juvenile or young-of-year (YOY) anadromous fish species emigrating from the Sacramento River and its tributaries typically enter the Yolo Bypass when flows overtop the Fremont Weir. While YOY salmonids can make their way back to the Sacramento River when there is sufficient floodplain connectivity, YOY may also become isolated in weir aprons, shallow pools, drainages, and swales within the bypass when floodwaters recede and connectivity to the Sacramento River is lost.

Figure 1. Site and Vicinity – Yolo Bypass and Fremont Weir



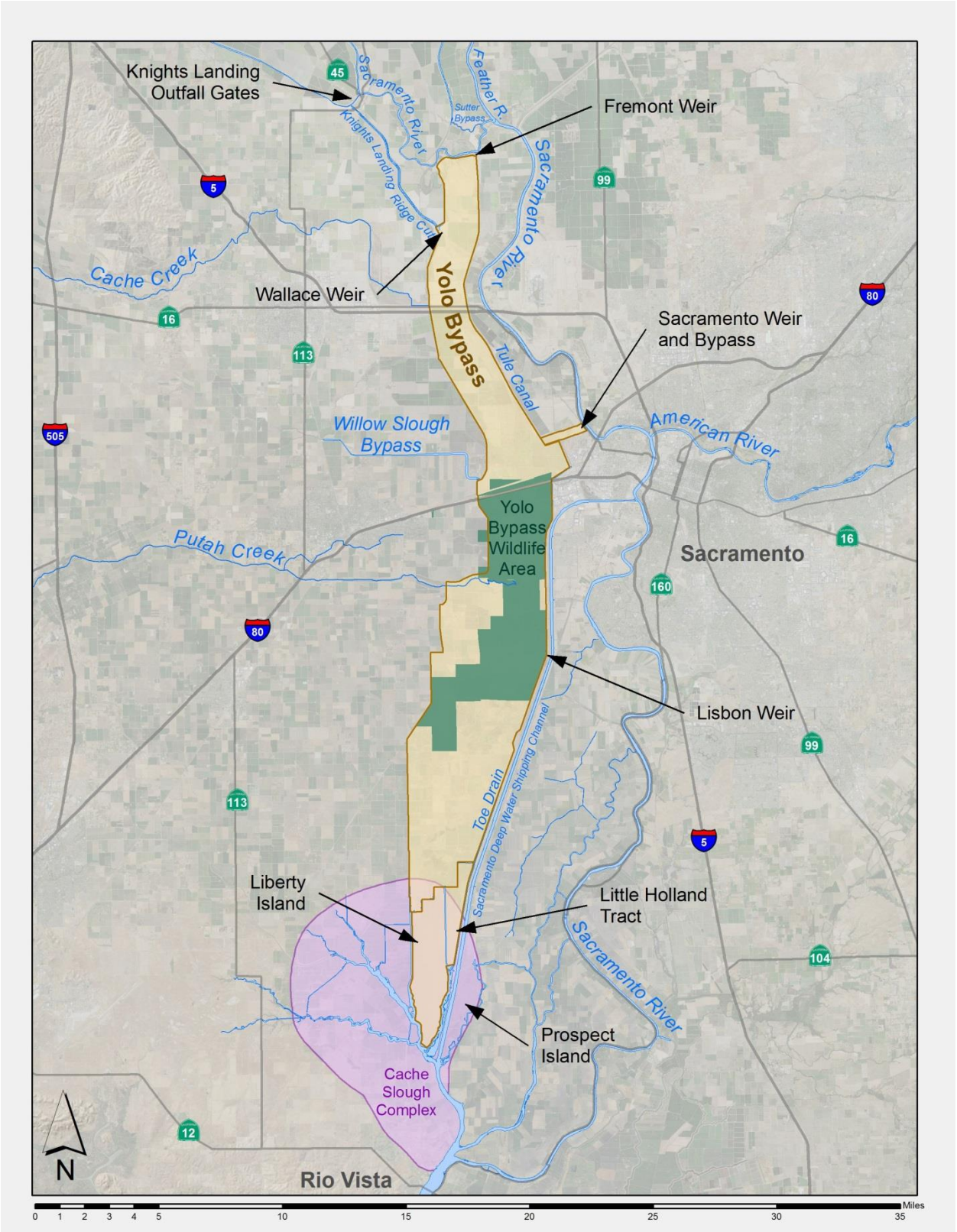


Figure 2. Yolo Bypass Westside Tributaries and Cache Slough Complex

A Denil fish ladder was constructed in the east section of Fremont Weir in 1966 to facilitate adult fish passage back into the Sacramento River following several years of Chinook salmon stranding in the Yolo Bypass. The Denil fish ladder is essentially a 1.2 meter-wide, zero percent gradient notch with wood baffles on the bottom of the structure. CDFW opens the fish ladder to initiate volitional fish passage through the weir to the Sacramento River by removing flashboards on the upstream side of the structure. The flashboards are removed upon cessation of weir overtopping events as authorized by Central Valley Flood Protection Board permit number 4899 issued to CDFG on 1 April 1965 (Central Valley Flood Protection Board 2016) **(Figure 3).**

Figure 3. View of Fremont Weir during after cessation of overtopping event in March 2017. Flashboards have been removed to facilitate volitional fish passage to the Sacramento River prior to rescue operations.

The ladder was originally designed for salmonid passage, and appears to be somewhat effective in facilitating passage of adult salmonids to the Sacramento River as shown from a reduction in the number of adult Chinook salmon stranded behind the weir after its construction in 1966 (CDFW unpublished data). However, the notch width of the ladder in relation to the overall weir length in combination with the magnitude and duration of attractant flows may not enable all adult salmonids to locate and utilize the fish ladder. The Denil fish ladder infrastructure was removed to facilitate sturgeon passage in 2012. However, based on the number of adult sturgeon stranded in the weir splash basin, the Denil fish ladder appears to be mostly ineffective for volitional passage of adult sturgeon (CDFW unpublished data, USBR and DWR 2012). Importantly, the western section of the weir does not have a fish ladder and is not hydrologically connected to the eastern section of the weir once overtopping flows

cease. Therefore, fish stranded and isolated on the western portion of the weir do not have the opportunity to return to the Sacramento River on their own volition.

In addition to the weir apron, isolation and subsequent stranding occurs in numerous ponds, scour pools, drainages, and swales in the Fremont Weir Wildlife area downstream of the Fremont Weir.

3. Methods

CDFW staff began monitoring conditions at the Fremont Weir when the California Data Exchange Center (CDEC) National Weather Service River Forecast Center forecasted Sacramento River stage height at the weir to drop to approximately 32.0 feet mean sea level (msl). After each overtopping event, CDFW staff conducted reconnaissance surveys by walking the entire length of the Fremont Weir to determine fish species composition present and estimates of numbers when possible; and potential safety issues regarding fish rescue operations. Rescue operations were focused on the weir splash basins and downstream inundated areas of the northern Yolo Bypass (Fremont Weir State Wildlife Area) (**Figure 4**). CDFW staff then developed rescue event-specific rescue logistics and methodology (e.g., number of personnel needed and equipment requirements). Rescue operations conducted during the 2016-2017 season consisted of eight to 14 CDFW staff. National Marine Fisheries Service, Pacific States Marine Fisheries Commission, and DWR staff provided assistance during two of the rescue operations. Equipment used to conduct fish rescues included specially designed crowder racks, ¼ inch mesh beach seines, dip nets, sturgeon hoop nets, and backpack electro-fishers. A typical rescue operation consisted of CDFW staff setting up a crowder rack barrier fitted with a ¼-inch beach seine to divide the weir apron into workable sections. CDFW staff then deployed a second crowder rack barrier fitted with a ¼-inch beach seine at the opposite end of the section and then slowly walked it toward the stationary barrier. When the distance between the crowder barriers was reduced to approximately two-three meters, CDFW staff used dip nets to capture fish and transfer them to aerated coolers or tubs. The distance between barriers was gradually decreased until all fish could be captured with dip nets or by pursing the beach seines. CDFW staff monitored water depth in the Sacramento Weir stilling basin weekly until it was determined conditions were suitable for rescue operations (i.e., wadeable depth).

CDFW staff identified and enumerated all fish captured during rescue operations. CDFW measured all juvenile salmonids captured during rescue operations when relatively few fish were encountered (<20) to determine run designation using length-at-date criteria (Greene 1992). If large numbers of juvenile salmonids were encountered, CDFW staff measured a subset of 20-30 fish. Sturgeon were captured by sliding a hoop net head first over the fish's body, then quickly sliding the hoop net containing the sturgeon into a specially designed sturgeon cradle. CDFW staff then removed the hoop net and used the cradle to lift the sturgeon from the weir basin. Sturgeon were measured (total and fork length) and tagged with surgically implanted acoustic transmitters to provide post-rescue survival and movement data (VEMCO V16 69 kHz; 10-year battery life). CDFW staff also collected tissue samples from green

Figure 4. Fremont Weir and Northern Yolo Bypass (Fremont Weir State Wildlife Area)

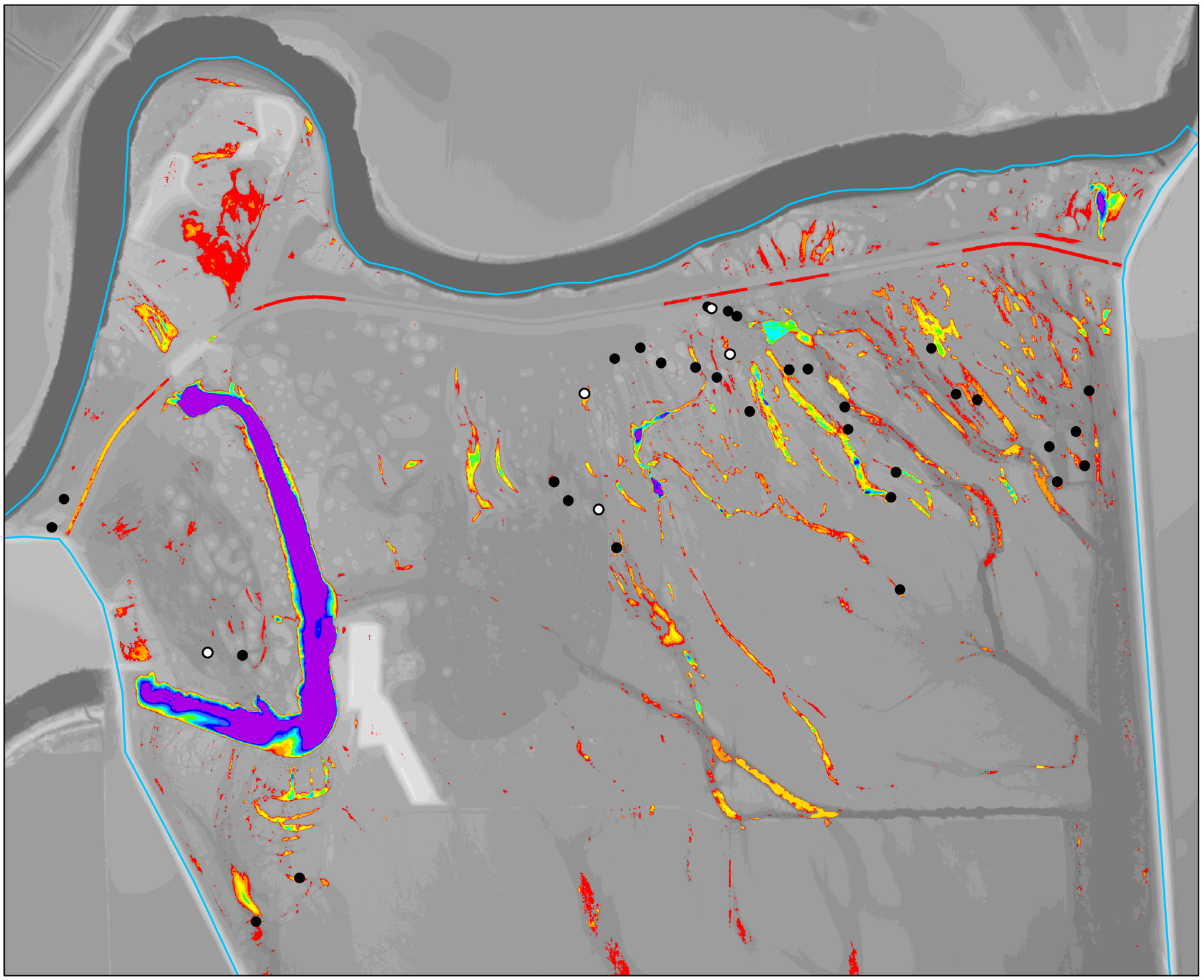
sturgeon for subsequent genetic analysis (2x2 mm anal fin clip.). CDFW or Pacific States Marine Fisheries' Commission staff tagged all Central Valley steelhead captured during rescue operations with passive integrated transponder (PIT) tags. Once identification, enumeration, and tagging were completed, CDFW staff transported all fish from the point of capture to the Sacramento River for release. In instances when large numbers of adult non-native fish were encountered, (e.g., American shad, striped bass), CDFW staff tallied numbers of each species after dip net capture and transferred them to fish cradles for immediate transport to the Sacramento River for release.

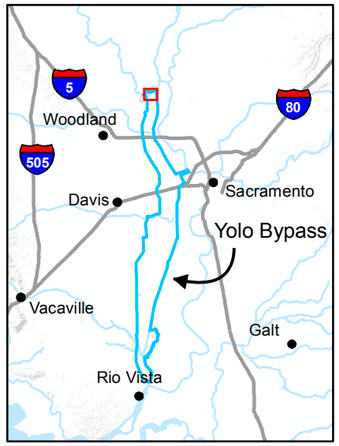
CDFW staff conducted three stranding surveys totaling approximately 40 isolated pools downstream of the Fremont Weir after the using backpack electro-fishers and dip nets and recorded fish species present, GPS coordinates, water temperature, average depth, estimated surface area of each feature sampled. All salmonids captured were enumerated, measured, and transported to the Sacramento River for release; steelhead were surgically implanted with PIT tags and monitored for recovery prior to release. The locations of scour pools and other inundated features sampled are shown in **Figures 5 and 6.**

4. Results

Runoff from the near-record precipitation during the 2016-2017 water year resulted in four distinct overtopping events of the Fremont Weir totaling 104 days (DWR 2017). The duration and magnitude of the overtopping events are shown in **Figures 7 through 10.** CDFW staff conducted 11 days of fish rescue operations at the Fremont Weir and in northern portion of the Yolo Bypass; typically initiating rescue operations within 24 hours of cessation of overtopping events. DWR staff opened the Sacramento Weir on 9 January 2017, allowing floodwaters to inundate the Sacramento Weir splash basin and Sacramento Bypass which flows into the Yolo Bypass. CDFW staff rescued 3,559 fish including 11 native species and 15 non-native species from the Fremont Weir splash basin and from numerous scour ponds and pools within the northernmost part of the Fremont Weir Wildlife Area (**Table 1**). Listed fish species rescued included adult southern DPS green sturgeon, juvenile Sacramento River winter run Chinook salmon, adult and juvenile Central Valley spring run Chinook salmon, and adult and juvenile Central Valley steelhead.

Figure 5. Location of Inundated Features Sampled for Fish Stranding, Fremont Weir Wildlife Area, March 2017 (LIDAR)





Legend

- Yolo Bypass

Spring 2017 Survey

- Features Surveyed
- Juvenile Central Valley Steelhead and/or Chinook Salmon Observed

Potential Inundation Depth (ft)

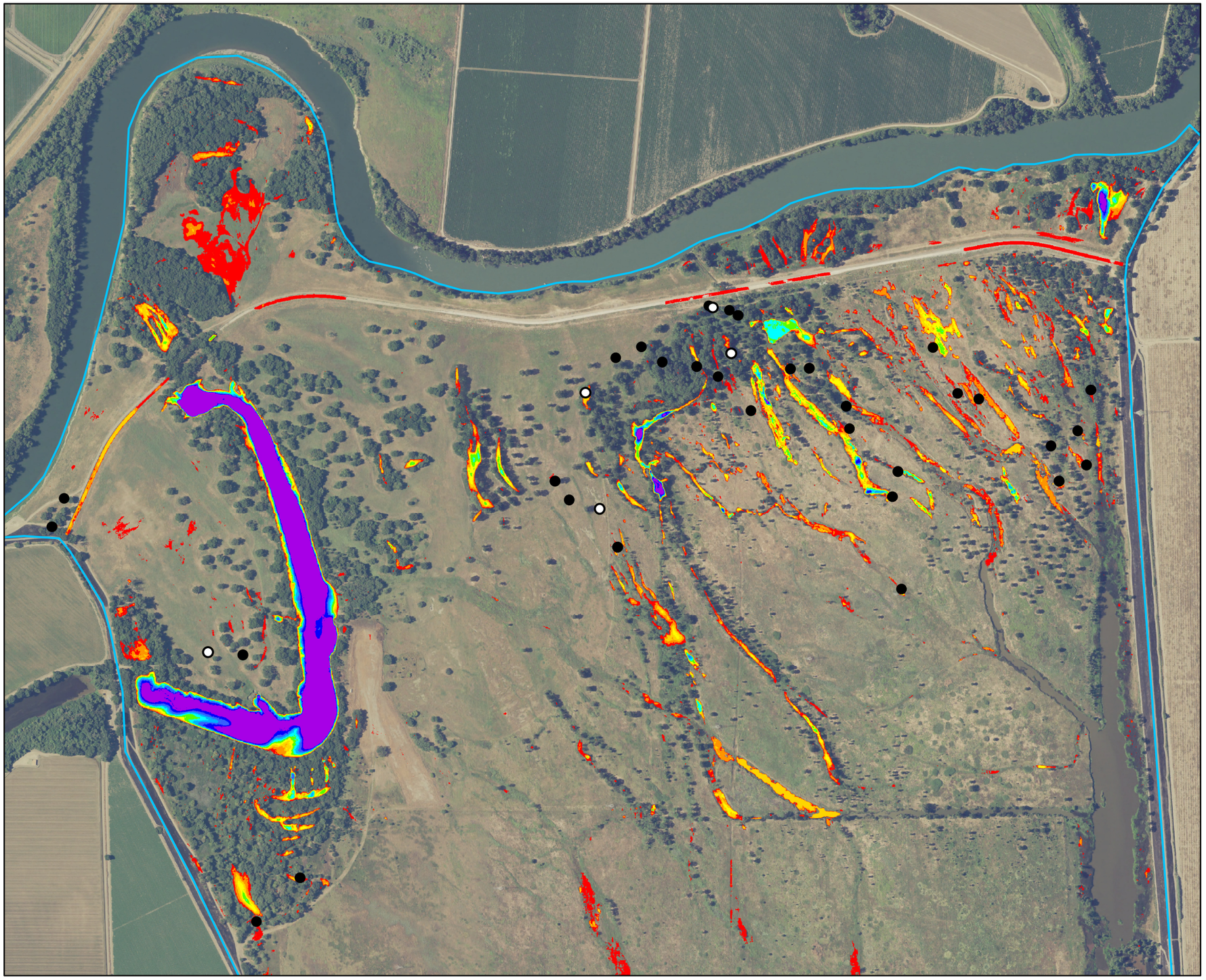
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 15
- 15 - 23

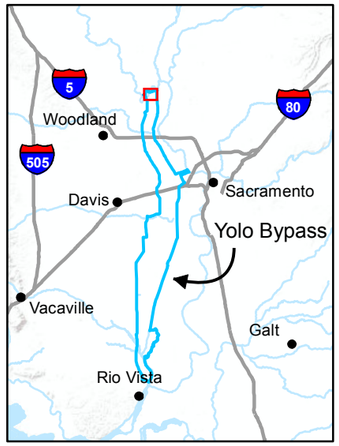
Background image: CVFED Digital Elevation Model
(from Lidar acquired March/April 2008 for Sacramento River and 2007 for the Delta)

Feet
0 250 500 750 1,000

Miles
0 0.05 0.1 0.2

Figure 6. Location of Inundated Features Sampled for Fish Stranding, Fremont Weir Wildlife Area, March 2017 (Aerial Photograph)





Legend

Yolo Bypass

Spring 2017 Survey

- Features Surveyed
- Juvenile Central Valley Steelhead and/or Chinook Salmon Observed

Potential Inundation Depth (ft)

- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 15
- 15 - 23

Background image: National Agriculture Imagery Program (NAIP) aerial photography acquired summer of 2016.

Feet
0 250 500 750 1,000

Miles
0 0.05 0.1 0.2

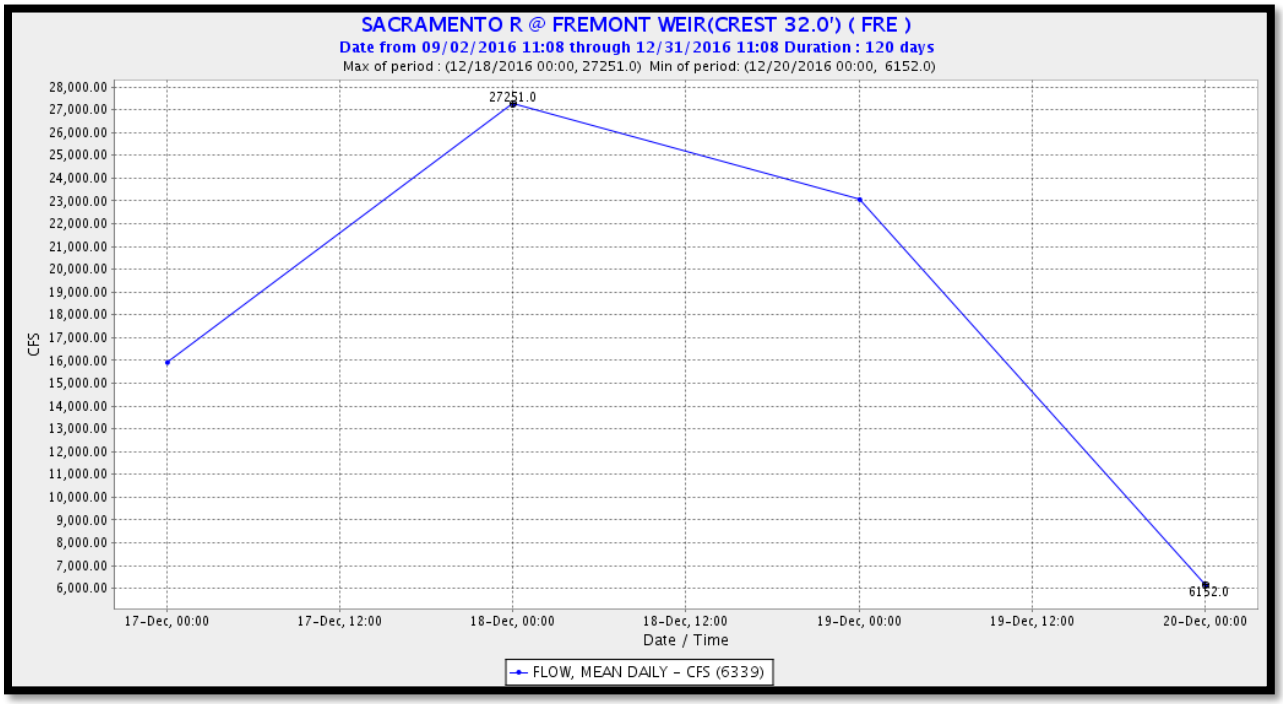


Figure 7. Hydrograph of Fremont Weir 4-day overtopping event, 17 through 20 December 2016. Mean daily flow during the period was 18,105 cubic feet per second.

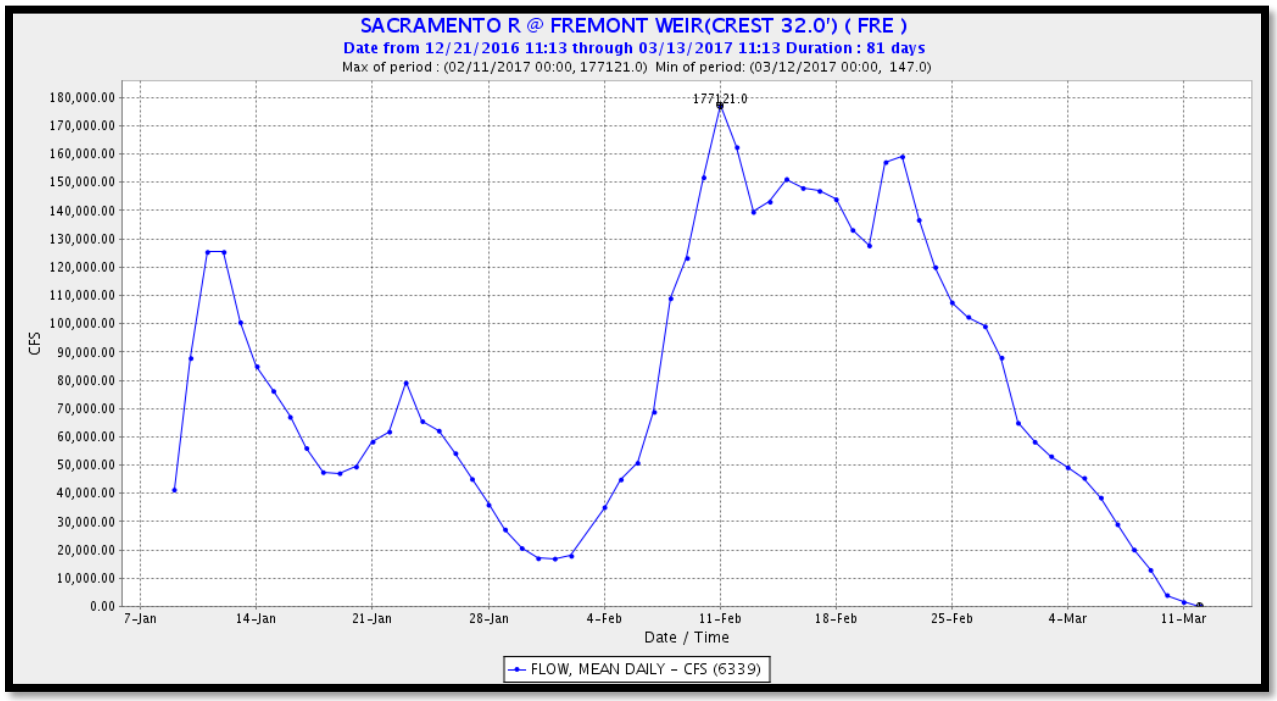


Figure 8. Hydrograph of Fremont Weir 62-day Overtopping Event, 9 January through 12 March 2017. Mean daily flow during the period was 78,649 cubic feet per second.

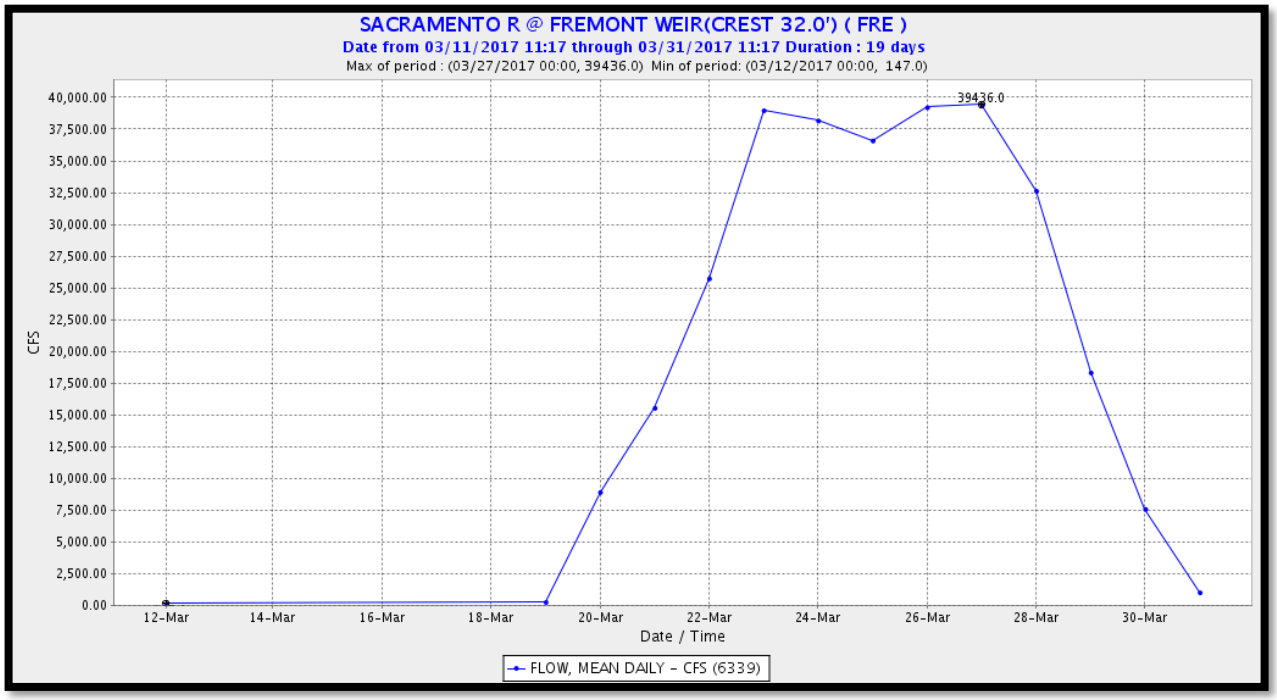


Figure 9. Hydrograph of Fremont Weir 13-day Overtopping Event, 19 through 31 March 2017. Mean daily flow during the period was 23,281 cubic feet per second.

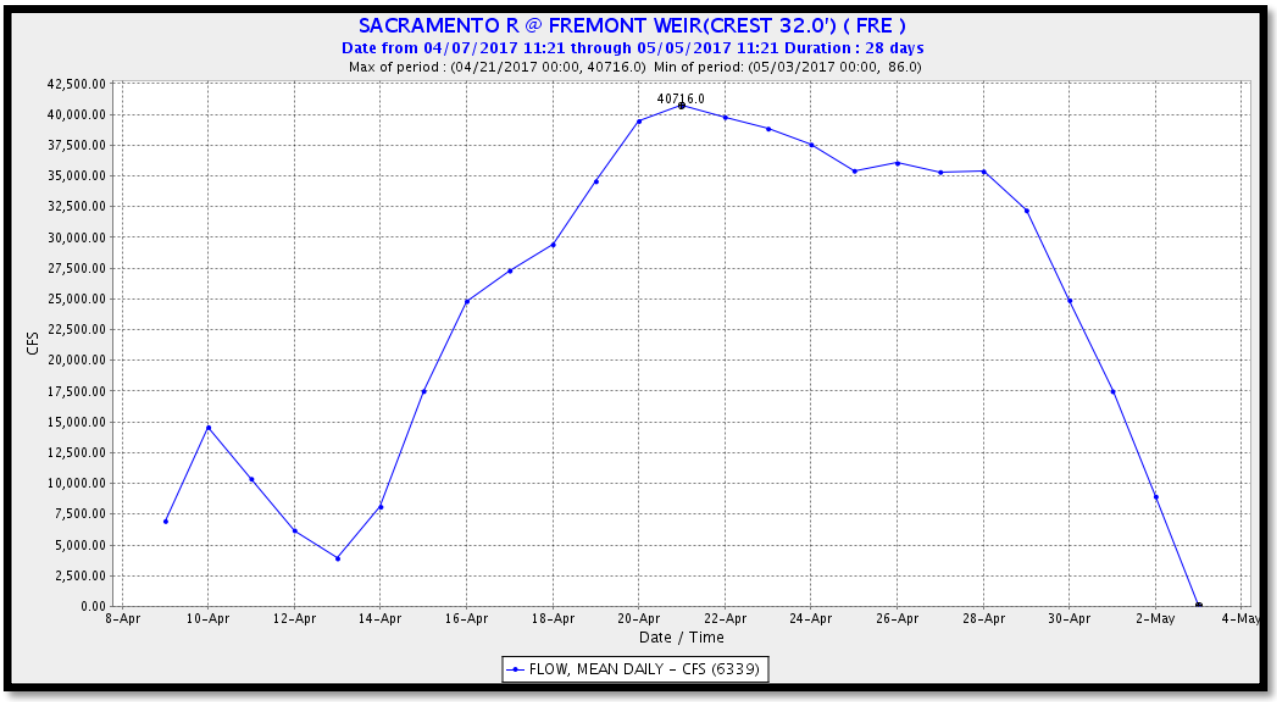


Figure 10. Hydrograph of Fremont Weir 25-day Overtopping Event, 9 April through 3 May 2017. Mean daily flow during the period was 24,236 cubic feet per second.

Table 1. Fish rescue dates, species and numbers rescued from the Fremont Weir and Yolo Bypass, 2016-2017 water year.

Date	Species/ESU/DPS	Life Stage	Number Rescued
12/23/2016; east and west sections of weir	Winter-run Chinook salmon (adipose intact)	Juvenile	11
	Winter-run Chinook salmon (adipose clip)	Juvenile	1
	Spring-run Chinook salmon (adipose intact)	Juvenile	3
	Late fall-run Chinook salmon (adipose intact)	Juvenile	1
	Late fall-run Chinook salmon (adipose clip)	Juvenile	12
	Fall-run Chinook salmon (adipose intact)	Juvenile	1
	Sacramento pikeminnow (*Ptychochelilus grandis*)	Juvenile, adult	10
	Striped bass (*Morone saxatilis*)	Juvenile	1
	Inland silverside (*Menidia beryllina*)	Juvenile	3
3/13/2017; east section	White sturgeon (*Acipenser transmontanus*)	Adult	1
	Spring-run Chinook salmon (adipose intact)	Juvenile	2
	Fall-run Chinook salmon (adipose intact)	Juvenile	22
	Central Valley steelhead (adipose intact)	Juvenile	1
	Prickly sculpin (*Cottus asper*)	Juvenile	1
	Golden shiner (*Notemigonus crysoleucas*)	Juvenile	13
	Bigscale logperch (*Percina macrolepida*)	Adult	1
	Inland silverside	Juvenile	7
3/14/2017; west section	Green sturgeon	Adult	1
	Winter-run Chinook salmon (adipose clip)	Juvenile	7
	Spring-run Chinook salmon (adipose intact)	Juvenile	16
	Fall-run Chinook salmon	Juvenile	247
	Sacramento pikeminnow	Juvenile, adult	2
	Hardhead (*Mylopharodon conocephalus*)	Adult	2
	Sacramento blackfish (*Orthodon microlepidotus*)	Adult	1
	Sacramento sucker (*Catostomus occidentalis*)	Adult	8
	Striped bass	Adult	10
	Bigscale logperch (*Percina macrolepida*)	Adult	4
	Smallmouth bass (*Micropterus salmoides*)	Juvenile, adult	2
	Largemouth bass (*Micropterus salmoides*)	Adult	1
	Golden shiner	Juvenile	4
	Inland silverside	Juvenile	1
3/15-3/16/2017; scour ponds downstream	Central Valley steelhead (adipose clip)	Juvenile	6
	Fall-run Chinook salmon (adipose intact)	Juvenile	7
	Sacramento sucker	Juvenile	3

Date	Species/ESU/DPS	Life Stage	Number Rescued
of weir basin			
3/17/2017; east section	Spring-run Chinook salmon (adipose intact)	Juvenile	36
	Fall-run Chinook salmon	Juvenile	243
	Pacific lamprey (*Entosphenus tridentatus*) (rescued from isolated rip-rap pools immediately downstream of fishway)	Juvenile	35
	Sacramento pikeminnow	Juvenile	14
	Bigscale logperch	Adult	2
	Golden shiner	Juvenile	15
	Inland silverside	Juvenile	40
4/3/2017; west section	White sturgeon	Adult	1
	Spring-run Chinook salmon (adipose intact)	Juvenile	1
	Fall-run Chinook salmon (adipose intact)	Juvenile	19
	Fall-run Chinook salmon (adipose clip)	Juvenile	3
	Central Valley steelhead (adipose intact)	Juvenile	1
	Central Valley steelhead (adipose clip)	Juvenile	7
	Sacramento pikeminnow	Juvenile	1
	Striped bass	Adult	1
	Threadfin shad (*Dorosoma petenense*)	Adult	1
4/4/2017; east section	Fall run Chinook salmon	Juvenile	972
	Central Valley steelhead (adipose clip)	Juvenile	11
	Sacramento pikeminnow	Juvenile	6
	Sacramento sucker	Juvenile	36
	Hardhead	Juvenile	1
	Smallmouth bass	Juvenile	2
	Bluegill (includes hybrid) (*Lepomis macrochirus*)	Not determined	3
	Largemouth bass	Juvenile	1
	Bigscale logperch	Not determined	12
	Fathead minnow	Adult	4
	Inland silverside	Juvenile	1
4/5/2107; scour ponds downstream of weir basin	Central Valley steelhead (adipose clip)	Juvenile	12
	Fall-run Chinook salmon	Juvenile	4
	Pacific lamprey	Adult	3
5/4/2017; west section	Green sturgeon	Adult	1
	White sturgeon	Adult	1

Date	Species/ESU/DPS	Life Stage	Number Rescued
	Spring-run Chinook salmon (adipose intact)	Juvenile	1
	Spring-run Chinook salmon (adipose clip)	Juvenile	1
	Fall run Chinook salmon	Juvenile	112
	Late-fall run Chinook salmon	Juvenile	1
	Striped bass	Adult	6
	American shad (*Alosa sapidissima*)	Adult	50
	White catfish (*Ameiurus catus*)	Adult	5
	Brown bullhead (*Ameiurus nebulosus*)	Adult	27
	Threadfin shad	Adult	32
5/5/2017; east section	Spring-run Chinook salmon (adipose clip)	Juvenile	2
	Fall run Chinook salmon	Juvenile	242
	Late-fall run Chinook salmon	Juvenile	1
	Central Valley steelhead (adipose intact)	Juvenile	1
	Sacramento pikeminnow	Juvenile	3
	Sacramento sucker	Juvenile	1
	Pacific lamprey	Adult	1
	American shad	Adult	266
	Spotted bass (*Micropterus punctulatus*)	Juvenile	6
	Smallmouth bass	Juvenile	4
	Largemouth bass	Juvenile	2
	Bluegill	Juvenile	1
	Golden shiner	Juvenile	1
	Threadfin shad	Adult	1
	Inland silverside	Juvenile	1
5/11/2017; west section	Central Valley steelhead (adipose intact; 460 mm)	Adult	1
	Sacramento blackfish	Adult	1
	Sacramento pikeminnow	Juvenile	1
	Sacramento splittail (*Pogonichthys macrolepidotus*)	Juvenile	9
	Sacramento sucker	Adult	52
	Pacific lamprey	Adult	2
	American shad	Adult	125
	Striped bass	Adult	81
	White catfish	Juvenile, adult	43
	Brown bullhead	Adult	101
	Bluegill	Adult	5
	Green sunfish (*Lepomis cyanellus*)	Adult	3
	Black crappie (*Pomoxis nigromaculatus*)	Adult	1

CDFW staff rescued listed fish species after all four Fremont Weir overtopping events that occurred during the 2016-2017 water year. Listed fish species rescued on 23 December 2016 after a four-day overtopping event included juvenile Sacramento River winter run Chinook salmon (11 adipose fin-intact; 1 adipose fin-clipped) and juvenile Central Valley spring run Chinook salmon (3 adipose fin-intact). Listed fish species rescued from 13 March 2017 through 17 March 2017 after the 62-day overtopping event included juvenile Sacramento River winter run Chinook salmon (7 adipose fin-clipped) juvenile Central Valley spring run Chinook salmon (3 adipose fin-intact, 52 adipose fin-clipped), juvenile Central Valley steelhead (1 adipose-intact), and one adult southern DPS green sturgeon. Listed fish species rescued from 3 April through 5 April 2017 after the 13-day overtopping event included one juvenile Central Valley spring run Chinook salmon (adipose fin intact) and one juvenile Central Valley steelhead (1 adipose-fin intact). Listed fish species rescued on 4, 5 and 11 May after the 25-day overtopping event included one adult southern DPS green sturgeon, two adult Central Valley steelhead (adipose fin-intact), and three Central Valley spring run Chinook salmon (1 adipose fin-intact, 2 adipose fin-clipped). Although listed fish species were not rescued from inundated features downstream of the weir basin, juvenile hatchery origin Central Valley steelhead and juvenile Central Valley fall run Chinook salmon were observed in and/or rescued from five of the approximately 40 scour pools, ponds, swales, and other inundated features surveyed after the 62-day overtopping event (**Table 1**).

One of two southern DPS green sturgeon and all three white sturgeon rescued from the Fremont Weir and released into the Sacramento River were subsequently detected on a real-time receiver in the Sacramento River at the Interstate-80 Bridge (approximately 38 river kilometers downstream of the release site). **Table 2** presents a summary of detection data for sturgeon rescued, tagged, and released into the Sacramento River. Detection data for tagged sturgeon moving upstream were not available during the post-rescue and release period through completion of this report due to receiver maintenance and upgrades. Survival and post-rescue migration data of PIT-tagged Central Valley steelhead rescued from the Fremont Weir and downstream scour pools may eventually become available if the tagged steelhead are detected at instream or hatchery PIT receiver arrays.

Table 2. Detection data for sturgeon rescued from Fremont Weir and released into the Sacramento River, 2016-2017 water year.

Species	Rescue date	Fork length (cm)	Tag ID	Detection date: Sacramento River at I-80 Bridge	Days from rescue to detection
White sturgeon	3/13/2017	115	25753	5/02/2017	48
White sturgeon	4/03/2017	189	25751	4/12/2017	9
White sturgeon	5/04/2017	130	25741	5/27/2017	23
Green sturgeon	5/04/2017	165	25755	5/19/2017	15

CDFW conducted a one-day fish rescue operation at Sacramento Weir on 25 May 2017, when the water depth in the splash basin became wadeable. A total of 569 fish including five native and 11 non-native species were rescued and relocated to the Sacramento River at the Elkhorn Slough Boat Launch, including three adult adipose fin-clipped Chinook salmon that were likely Feather River Hatchery-produced spring run (**Table 3**). Genetic samples taken from the adult Chinook salmon are pending analysis. CDFW recovered a coded wire tag from an adult adipose-clipped adult Chinook carcass (one of three carcasses observed in the splash basin) and determined the fish was a Feather River hatchery-produced spring run spring run Chinook salmon.

Table 3. Fish species, life stages, and numbers rescued from the Sacramento Weir, 25 May 2017.

Species/ESU	Life Stage	Number Rescued
Chinook salmon	Adult	3
Chinook salmon/fall run	Juvenile	122
Sacramento pikeminnow	Adult, juvenile	3
Sacramento splittail	Adult	1
Prickly sculpin	Adult	1
American shad	Adult	383
Black crappie	Adult	23
Bluegill sunfish	Adult	10
Redear sunfish	Adult	2
Spotted bass	Adult	2
Largemouth bass	Adult	2
White catfish	Adult	7
Channel catfish	Adult	1
Striped bass	Adult	1
Threadfin shad	Adult	6
Inland silverside	Adult	2

Approximately 10 scavenged adult Chinook salmon carcasses were observed along the shoreline of a 0.4-hectare pool located 100 meters downstream of the weir. It could not be determined if these fish were adipose-clipped and genetic samples were not collected from them due to their degraded condition.

5. Discussion

Fish rescue efforts conducted at the Fremont Weir/Yolo Bypass during the 2016-2017 water year prevented over 3,000 fish from perishing from factors such as desiccation, poor water quality conditions, increased predation, and poaching. Of these, 67 were federally or State listed fish species including Sacramento River winter run Chinook salmon, Central Valley spring run Chinook salmon, Central Valley steelhead, and southern DPS green sturgeon. CDFW rescued over 500 fish, including

federal and state listed Central Valley spring-run Chinook salmon, from the Sacramento Weir splash basin. This was the first time that CDFW staff conducted fish rescue operations at Sacramento Weir. While overtopping of the Sacramento Weir occurs on a much less frequent basis than the Fremont Weir, it has now shown to be a significant stranding location for anadromous fish species migrating up the Yolo and Sacramento bypasses. Surface water temperatures within the Sacramento Weir splash basin of up to 27° C were recorded several days prior to the rescue effort, and although bottom temperatures may have been a few degrees less, it is likely that the Chinook salmon rescued from the splash basin experienced some degree of thermal stress which could impact spawning success.

While biotelemetry data for rescued sturgeon is somewhat inconclusive regarding post-rescue movements, it would appear that at least one of the green sturgeon survived and "dropped back" after being returned to the Sacramento River. The green sturgeon that was not detected at the I-80 Bridge receiver may have continued upstream to spawn, however; upstream migration could not be verified, as the only real-time receiver upstream of the release location (Tisdale) was non-operational during the post-rescue period. Two of the white sturgeon rescued and tagged were detected at the Sacramento River I-80 receiver 23 and 48 days after rescue, which suggests that these sturgeon may have continued upstream to spawn before moving downstream. Even if the green sturgeon and white sturgeon rescued from the Fremont Weir did not spawn this year, their rescue will provide the opportunity for these fish to spawn in subsequent years. Both sturgeon species are long-lived fish that reach sexual maturity at approximately 15-20 years of age and are capable of spawning multiple times over their lifespan (Van Eenennaam *et al*. 2006) (Chapman et al. 1996).

Interestingly, hatchery origin Central Valley steelhead were the most numerous fish species encountered during stranding surveys of scour pools within the northern portion of the Fremont Wildlife area. A possible explanation is that the steelhead were rearing and foraging in the various scour channels which are similar in function to perennial stream habitat. The steelhead likely retreated to the deeper pools of these features after flows receded. Almost all of the salmonids encountered during the survey of downstream of weir features were captured or observed in relatively deep pools with complex habitat. Although salmonids or other fish were not observed in the majority of the scour pools and large ponds, conditions such as excessive depth, presence of woody debris, and turbidity limited the ability of staff to adequately sample these features, and it is likely that fish were present within them. Relatively few live juvenile salmonids or other fish species were encountered in the isolated shallow, grassy swales. Oftentimes considerable numbers of wading bird (e.g. blue heron, great egret) tracks were observed in these features, indicating avian predation may have occurred prior to our surveys.

While fish rescues do provide benefits in terms of saving listed fish species and preventing indirect mortality associated with CVP and SWP operations, there are potential drawbacks associated with fish rescues. The rescue effort itself is stressful to fish and has the potential to result in injury and possibly delayed mortality from capture and handling. Several of the rescued sturgeon showed considerable abrasions to their eyes, fins, and ventral surfaces likely caused by contact with the concrete surfaces of the weir splash basin while attempting to escape capture efforts or while seeking passage back to the

Sacramento River. For salmonids, the loss of slime coat and scales observed during capture and handling could increase the risk of infection from various fish pathogens.

Ultimately, implementation of the Yolo Bypass Fish Passage Project or one of the alternatives of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project should result in a significant reduction in the stranding and loss of listed fish species. In the interim, USBR and/or DWR should continue to provide funding for CDFW staff to conduct fish stranding reconnaissance surveys and fish rescue operations as needed to prevent the loss threatened and endangered fish species. Upon completion of one of the aforementioned projects, monitoring for fish stranding after weir overtopping events should continue to help determine the overall effectiveness of the improvements designed to increase volitional fish passage to the Sacramento River in addition to identifying areas within the Yolo Bypass that remain problematic for adult fish passage.

6. References

California Department of Water Resources California Data Exchange Center. 2017. http://cdec.water.ca.gov/riv_flows.html.

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Green, S. 1992. Daily fork-length table from Frank Fisher, California Department of Fish and Game. California department of Water Resources, Environmental Services Department, Sacramento, California.

Van Eenennaam, J. P., J. Linares, S. I. Doroshov, D. C. Hillemeier, T. E. Willson and A. A. Nova. 2006. Reproductive conditions of the Klamath River green sturgeon. Transactions of the American Fisheries Society 135:151-163.

LIST OF ATTACHMENTS

Attachment A. Memorandum Report: 2017 Yolo Bypass Tule Pond and Oxbow Pond Sturgeon Rescue
Attachment B. Representative Photographs of Fremont Weir, rescue operations, and inundated scour pools and ponds within the Fremont Weir State Wildlife Area (northern Yolo Bypass).

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EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

M e m o r a n d u m

Date: 29 September 2017

To: Colin Purdy
Senior Environmental Scientist, Supervisor
Department of Fish and Wildlife

From: Marc Beccio
Environmental Scientist
Department of Fish and Wildlife

Cc: Document Library

Subject: Yolo Bypass Tule Pond and Oxbow Pond Sturgeon Rescue

Purpose

This memorandum report documents sturgeon rescue efforts conducted during June, July and August of 2017 in the Tule Pond and Oxbow Ponds, located within the Fremont Weir Wildlife Area of the Yolo Bypass (**Figures 1 and 2**).

Background

The near record precipitation that occurred during the 2016-2017 water year resulted in four distinct overtopping events of the Fremont Weir totaling 104 days (DWR 2017) resulting in prolonged flooding of the Yolo Bypass. During overtopping events, flows within the Yolo Bypass are typically much greater than flows within the Sacramento River, thereby attracting migrating anadromous fish from the Sacramento River into the Yolo Bypass at the Cache Slough complex. Sturgeon migrating through the Yolo Bypass may follow deeper channel routes such as the Toe Drain-Tule Canal-Tule Pond. Sturgeon that select this route may end up isolated in the Tule Pond or Oxbow Pond when floodwaters recede to a point where flows do not permit passage over the Fremont Weir. CDFW staff conducted a DIDSON survey in the Tule Pond during mid-June 2016 and verified the presence of adult sturgeon within the feature. CDFW staff conducted five rescue operations during July 2016 resulting in the capture, tagging, and relocation of nine adult white sturgeon. CDFW staff documented nine sturgeon carcasses in the Oxbow Pond in early October 2016. Subsequent genetic analysis of tissues collected from the four of the sturgeon carcasses determined that all four carcasses were white sturgeon.

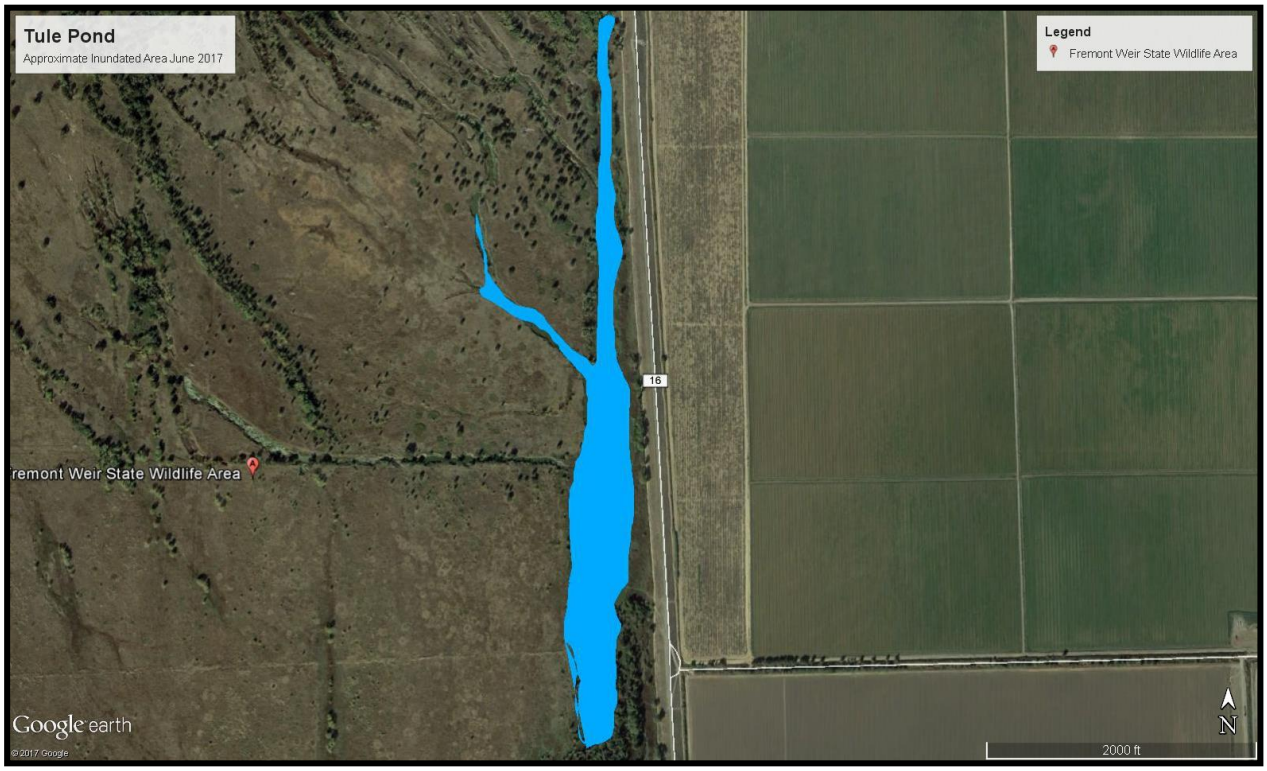


Figure 1. Tule Pond approximate area of inundation, June 2017.

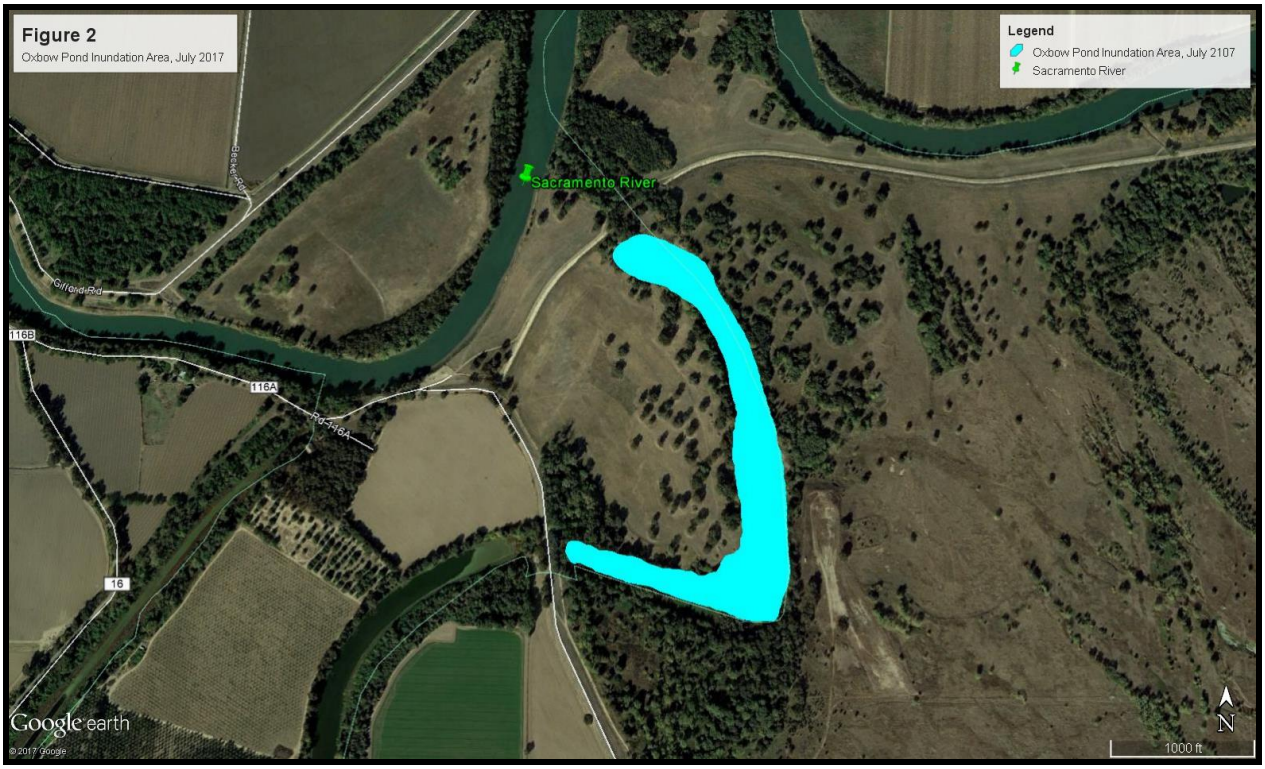


Figure 2. Oxbow Pond approximate area of inundation, July 2017.

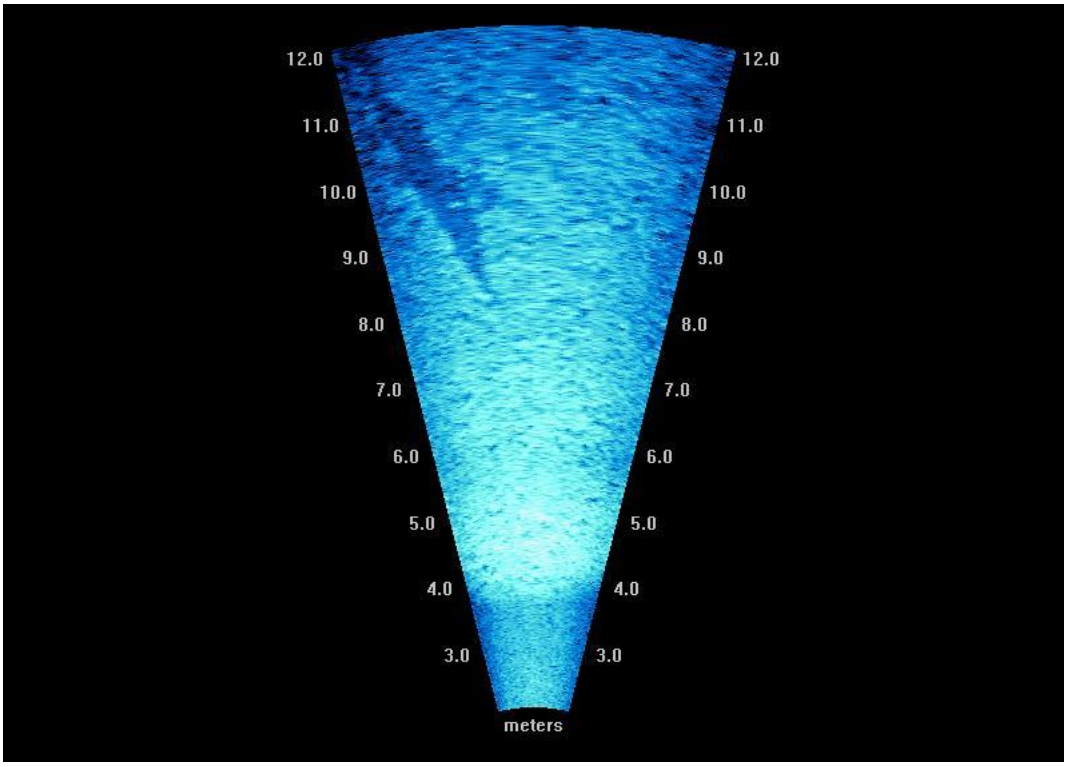


Figure 3. DIDSON imagery of adult sturgeon in the Tule Pond, June 2017

Methods

CDFW staff conducted DIDSON camera surveys of the Tule and Oxbow ponds on 7 June 2017 and identified at least two sturgeon in the Tule Pond (**Figure 3**) and possibly one sturgeon in the Oxbow Pond. CDFW staff initiated sturgeon rescues in Tule Pond on 9 June 2017, with subsequent efforts conducted 16, 20, 23, and 28 June 2017; and 20 July 2017. CDFW conducted rescue efforts in the Oxbow Pond on 29 June 2017; 12 July 2017, and 4 August 2017. Prior to net deployment, CDFW staff deployed a DIDSON camera from an inflatable boat to determine sturgeon holding locations or movement patterns within the ponds. Once holding locations or movement corridors were identified, one or two 100-ft trammel net consisting of an eight-inch gill net mesh with two 24-inch mesh trammel panels were deployed by inflatable boat and anchored with 10 to 25 lb weights (**Figure 4**). CDFW staff monitored the net to determine sturgeon captures. All sturgeon captured were removed from the net and secured in a dorsal recumbent position while remaining submerged during transport to shore, then placed in a specially designed sturgeon cradle and provided with water flow over their gills. CDFW staff then surgically implanted a VEMCO® V16 acoustic transmitter in the sturgeon's peritoneal cavity and recorded the fish's fork length, total length, and condition (**Figure 5**). Tagged sturgeon were placed in an aerated tank and monitored for recovery before transport to the Sacramento River Elkhorn Boat Launch for release. Water temperature in the sturgeon transport tank was maintained at 25 °C or less through the addition of ice. Non-native fish captured during rescue efforts were released back into Tule Pond. Surface water temperatures were recorded in the Tule Pond at the time of capture; and in the sturgeon tank and Sacramento River prior to release. Temperature loggers (HOBO® Water Temperature Data Logger, Onset Computer Corporation) set to log at one-hour intervals were deployed in the Tule

Figure 4. Trammel net deployed in the Tule Pond, June 2017.

Figure 5. Adult white sturgeon rescued from the Tule Pond receiving an acoustic transmitter.

Pond on 20 June 2017 and Oxbow Pond on 26 June 2017 to provide water temperature profiles throughout the rescue period. The Tule Pond temperature logger was deployed in the approximate location where sturgeon were observed during DIDSON surveys.

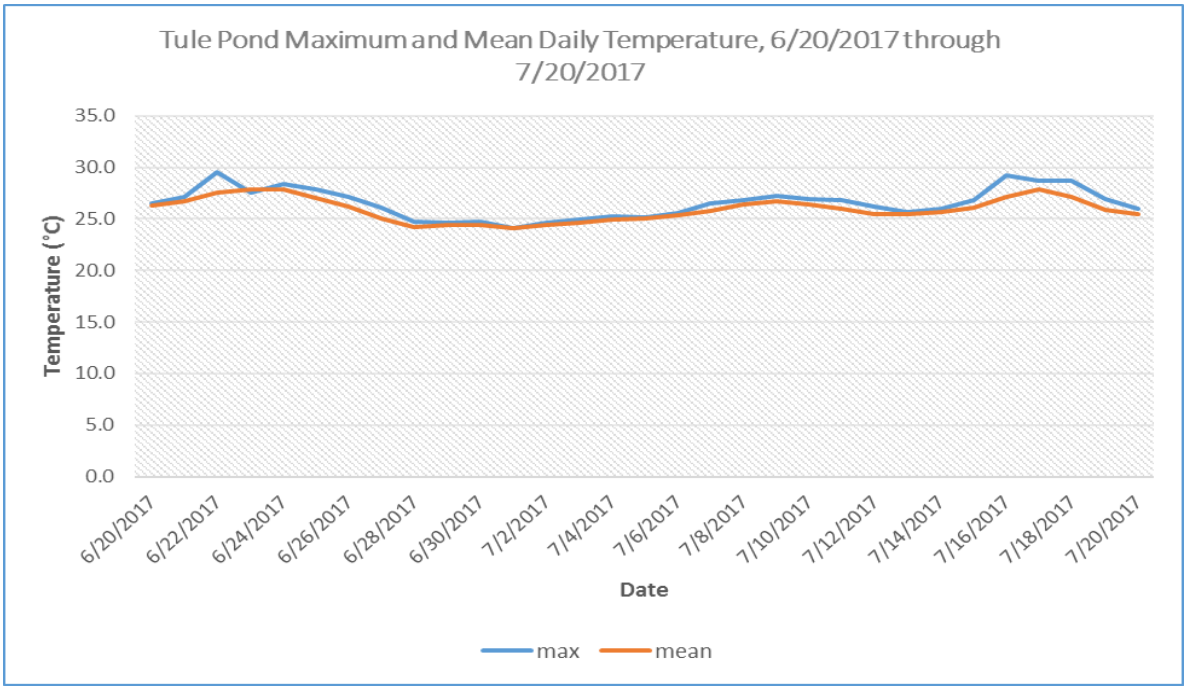
Results

CDFW staff captured and relocated two adult white sturgeon from the Tule Pond; one adult white sturgeon (193-cm fork length) on 28 June 2017 and one adult white sturgeon (148-cm fork length) on 20 July 2017. Both sturgeon appeared to be in good condition and were tagged and released in the Sacramento River at the Elkhorn Boat Launch Facility. No sturgeon were captured or observed during the three rescue efforts/DIDSON surveys conducted in the Oxbow Pond. Other fish captured in the trammel net during sturgeon rescue efforts included American shad (*Alosa sapidissima*) and brown bullhead (*Ameiurus nebulosus*). Both white sturgeon rescued from the Tule Pond were subsequently detected approximately 20 hours post-rescue detected by a real-time acoustic receiver deployed 11.3 km downstream in the Sacramento River at the Interstate 80 Freeway Bridge (**Table 1**). Daily mean and maximum water temperatures logged by the HOBO® data logger for the Tule Pond during the rescue period are shown in **Figure 6**. The rescue period is defined as the logger deployment date until the last sturgeon was rescued; 20 June to 20 July 2017. The highest daily mean temperature recorded (27.9° C) occurred on 23 and 24 June 2017; and 17 July 2017; while the highest daily maximum temperature recorded (29.5° C) occurred on 22 June 2017. The mean water temperature over the duration of the rescue period was 25.9° C. Water temperatures in the Sacramento River at the Elkhorn Slough release location ranged from 23 °C to 25 °C at the time of release.

Table 1. Capture and detection data of sturgeon rescued from the Yolo Bypass Tule Pond, June-July 2017.

Rescue/Release Date	Release Location	Species	Fork Length (cm)	Tag ID	Detection Date	Detection Location
6/28/2016	Elkhorn Boat Launch	white sturgeon	193	15826	6/29/2017	I-80 Bridge
7/20/2017	Elkhorn Boat Launch	white sturgeon	148	25745	7/21/2017	I-80 Bridge

Figure 6. Daily mean and daily maximum water temperatures recorded in the Tule Pond, 20 June through 20 July 2017.



Discussion

2017 was the second consecutive year that CDFW staff documented adult sturgeon in Tule Pond and pond and that rescues were successfully executed (Tule Pond). CDFW rescued nine adult white sturgeon from the Tule Pond in 2016 (CDFW 2016). The smaller number of adult sturgeon stranded and subsequently rescued from Tule Pond in 2017 may be the result of the relatively long duration (104 day) and timing of the four overtopping events during the 2016-2017 water year (DWR 2017). It is possible that the majority of white sturgeon and green sturgeon which entered the Yolo Bypass at the Cache Slough Complex migrated up the Yolo Bypass and were able to continue past the Tule and Oxbow ponds and over Fremont Weir and re-enter the Sacramento River prior to the cessation of the weir overtopping events. In contrast, during the 2015-2016 water year, a single weir-overtopping event lasting eight days resulted in at least 10 white sturgeon (nine of which were rescued) stranding in the Tule Pond and at least nine adult sturgeon stranding (observed mortalities) in the Oxbow Pond (CDFW 2016a, 2016b). The shorter duration (eight day) and earlier timing of the March 2016 overtopping event likely coincided with greater numbers of sturgeon in the Yolo Bypass at the time of cessation of the overtopping event, which in turn, led to a greater number of sturgeon stranded in both ponds.

While the two white sturgeon rescued from Tule Pond in 2017 appeared to be in good condition, they were somewhat lethargic during capture and handling. It is possible that the relatively high water

temperatures recorded in Tule Pond during the capture period could result in chronic stress levels in sturgeon, which in turn could lead to a reduction in activities such as movement, foraging, and ultimately overall health. Literature reporting the upper lethal temperature and/or the effects of sub-lethal temperatures for adult white sturgeon is lacking. Adult white sturgeon occupy riverine or estuarine habitats such as the Sacramento River, Sacramento-San Joaquin Delta, and San Francisco Bay where water temperatures rarely exceed 23° C. The observed lethargy may in part have contributed to capture success, as there were numerous instances of sturgeon bumping the nets at low swimming velocities and then navigating around or through the nets. Sturgeon captures in trammel nets fished in Tule Pond typically occurred when fish hit the net at relatively swift velocities. There appears to be an adequate prey base to support at least a small number of adult sturgeon in the Tule Pond; potential prey items observed during rescue efforts included red swamp crayfish (*Procambarus clarkii*), American bullfrog larvae and adults (*Lithobates catesbeianus*), brown bullhead (*Ameiurus nebulosus*), and inland silverside (*Medinia beryllina*).

Given the timing of the rescue efforts and the fact that detections of both rescued sturgeon indicated a pattern of relatively rapid downstream migration provides evidence to suggest that the sturgeon stranded in the Tule Pond did not contribute to the 2017 spawning population. It is highly probable that historical overtopping events of the Fremont Weir resulted in numerous adult sturgeon stranding in the Tule and Oxbow ponds and ultimately being lost from the breeding population through poaching or poor water quality. The number of stranded sturgeon observed in the last two water years suggests that stranding and potential mortality may be a substantial issue for adult sturgeon migrating through the bypass during or following weir overtopping events. Stranding, which can result in direct mortality or delaying upstream migration, reduces or eliminates the potential for individuals to contribute to the spawning population. While successful fish rescues are important, they should be considered a last resort and avoiding the stranding altogether is crucial.

The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) will address fish passage improvement issues for Fremont Weir and the adjacent up and downstream channels, including increased hydraulic connectivity of the Tule and Oxbow ponds to newly created fishway notches in both sections of the Fremont Weir. Depending on the alternative selected, construction will not begin until 20220 at the earliest. While it is anticipated that the Project will improve sturgeon passage through Yolo Bypass and Fremont Weir t in the northern Yolo Bypass, continued stranding of sturgeon in Tule Pond, Oxbow Pond, and other inundated features downstream of Fremont Weir is likely after overtopping events for at least the next three-four water years. Therefore, CDFW will continue to conduct reconnaissance DIDSON surveys in these features to determine the presence of sturgeon after Yolo Bypass flooding events and conduct rescues of stranded sturgeon as necessary.

References

California Department of Fish and Wildlife (CDFW) 2017a. Summary of 2016-2017 Season Fish Rescues Conducted within the Yolo Bypass. Prepared for the U.S. Bureau of Reclamation. August 2017.

CDFW 2017b. Tule Pond Sturgeon Rescue. Prepared for the Yolo Bypass Fisheries Engineering Technical Team. January 2017.

CDFW 2016. Yolo Bypass Oxbow Pond Sturgeon Mortalities. Prepared for the Yolo Bypass Fisheries Engineering Technical Team. October 2016.

East section of Fremont Weir two days prior to Denil fish ladder flashboard removal. Photograph taken 9 March 2017.

West section of Fremont Weir two days prior to 14 March 2017 fish rescue. Photograph taken 12 March 2017.

View of temporary fish barrier deployed at the fishway on the east section of Fremont Weir. Photograph taken 14 March 2017.

Close-up view of temporary fish barrier deployed at the fishway on the east section of Fremont Weir. The barrier is constructed of specially designed crowder racks and ¼ inch mesh beach seine. Photograph taken 14 March 2017.

CDFW staff Initiating fish rescue effort at east section of Fremont Weir.
The seine is slowly walked toward the temporary fish barrier shown on the previous page to crowd fish prior to capture and rescue.
Photograph taken 14 March 2017.

West section of Fremont Weir one day prior to 4 May 2017 fish rescue.
Photograph taken 3 May 2017.

West section of Fremont Weir prior to 4 May 2017 fish rescue.
Photograph taken 4 May 2017.

Green sturgeon rescued from west Section of Fremont Weir being released into the Sacramento River. Photograph taken 4 May 2017.

View of scour pool approximately 30 m southeast of the Fremont Weir Denil fish ladder. Hatchery origin Central Valley steelhead and fall run Chinook salmon were rescued from this pool on 15 March and 5 April 2017. Photograph taken 15 March 2017.

View of scour pool in the northern portion of the Fremont Weir State Wildlife Area. Central Valley steelhead were observed in this pool, however; excessive depth prevented capture and rescue. Photograph taken 15 March 2017.

View of scour pool in the northern portion of the Fremont Weir State Wildlife Area. Central Valley steelhead were observed in this pool, however; excessive depth prevented capture and rescue. Photograph taken 15 March 2017.

View of scour pool in the northern portion of the Fremont Weir State Wildlife Area. Central Valley steelhead were observed in this pool on 15 March 2017.
Excessive depth prevented capture and rescue. Photograph taken 15 March 2017.

View of shallow pool 20 downstream of Fremont Weir. No fish were observed in this feature and in several others with similar characteristics. Abundant wading bird tracks were often observed in these features which may be an indication of avian predation. Photograph taken 15 March 2017.

Sothern DPS green sturgeon rescued from Tisdale Weir on 11 May 2017. Note abrasions on the snout. Similar abrasions and abrasions to eyes, fins, and ventral scutes were observed on green sturgeon and white sturgeon rescued from the Fremont Weir. Photograph taken 11 May 2017.