# SUMMARY OF 2024 SEASON FISH RESCUES CONDUCTED WITHIN THE FREMONT WEIR AND SACRAMENTO WEIR.

## CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE NORTH CENTRAL REGION (REGION 2)

# SUMMARY OF 2024 SEASON FISH RESCUES CONDUCTED WITHIN THE FREMONT WEIR, AND SACRAMENTO WEIRS

## CONTENTS



## LIST OF FIGURES

## LIST OF TABLES

## Purpose

The purpose of this document is to summarize fish rescue efforts conducted within the Yolo Bypass Fremont Weir stilling basin, and the Sacramento Weir and stilling basin during the 2024 water year. The U.S. Bureau of Reclamation (USBR) operates the 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 alters the hydrology in the Central Valley and San Francisco Bay-Delta and as a consequence, has a significant influence on fish distribution, migration, survival, and available aquatic habitats. 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 Biological Opinion (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) intended to avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the adverse modification of 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."* There are a number of actions already implemented or planned for implementation to address this RPA. In the interim to completion of large-scale improvements addressing Action I.7, DWR has contracted the California Department of Fish and Wildlife (CDFW) to conduct fish rescues within the Yolo Bypass.

## Introduction and Background

The approximately 59,000-acre Yolo Bypass is essentially designed to convey floodwaters from the Sacramento River and west side streams and drains around the populated regions of the Sacramento Valley **(Figure 1)**. Inundation of the Yolo Bypass primarily occurs when Sacramento River flows overtop the Fremont Weir, located at Sacramento River kilometer (RK) 226 (River Mile 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 cfs) (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 1)**. 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 Yolo Bypass serves as a migration corridor for adult and juvenile anadromous fish during overtopping events as well as rearing habitat for juvenile salmonids and other freshwater fish species. Flows within the Yolo Bypass can be 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. When Sacramento River stage height drops below 32 feet mean sea level, flows over the Fremont Weir cease, resulting in fish stranding within the Fremont Weir stilling basin and various ponded areas within the Yolo Bypass. Importantly, 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. 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 Distinct Population Segment (sDPS) green sturgeon are also known to utilize these areas during low flow periods.

In 1966, a Denil fish ladder was constructed in the east section of Fremont Weir to facilitate adult fish passage back into the Sacramento River following several observations of stranded Chinook salmon and sturgeon in the weir stilling basin and downstream scour ponds. Central Valley Flood Protection Board permit number 4899 issued to the California Department of Fish and Game on 1 April 1965 authorized CDFW to operate the fish ladder by removing flashboards on the river side of the structure following an overtopping event. The ladder was essentially a 1.2 meter-wide, zero percent gradient notch structure in the Fremont Weir which facilitated volitional fish passage from the splash basin back into the Sacramento River. While installation and operations of the ladder appeared to reduce the magnitude of the stranding at the weir, it did not eliminate it. The Denil fish ladder appeared to be mostly ineffective for

volitional passage of adult sturgeon; as many as 13 sDPS green sturgeon and 17 white sturgeon were rescued from the splash basin following overtopping events in 2011 (CDFW 2016). Additionally, as the Fremont Weir consists of two separate sections, the Denil fish ladder does not address stranding in the west section splash basin or in numerous ponds, scour pools, drainages, and swales in the Fremont Weir Wildlife Area downstream of the weir. Most of the historical observations of stranding and rescue efforts were focused on adult fish, more recent studies and fish rescues have shown juvenile or young-of-year (YOY) anadromous fish also become stranded in the weir splash basin, scour ponds, drainages, and swales within the Yolo Bypass when floodwaters recede and connectivity to the Sacramento River is lost.

**Figure 1. Fremont Weir, Yolo Bypass, Westside Tributaries, Sacramento Weir, and Cache Slough Complex.**

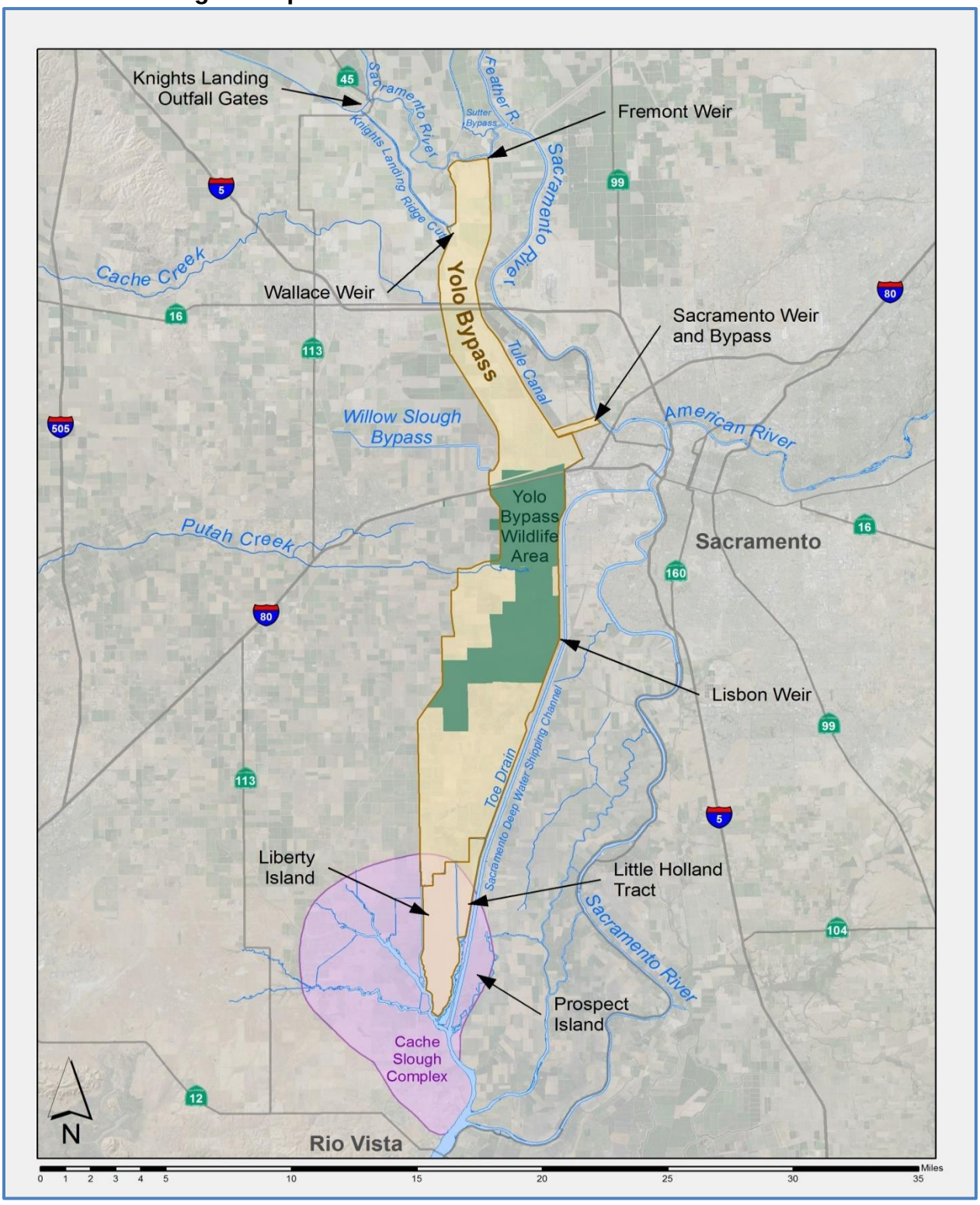

**Figure 2. Adult Fish Passage Structure with gate open. Flow in the channel is from right to left; the majority of which is from the Sacramento River and to a lesser degree from water draining from the east side stilling basin. Photograph date 12 February 2024.**

In the fall of 2018, DWR completed the Adult Fish Passage Modification Project, which consisted of widening the existing notch to a bottom width of 15 feet, decreasing the elevation of the notch to 22 feet, widening and re-grading the channels located immediately upstream and downstream of the new weir notch, and connecting the downstream channel to the Deep Pond **(Figures 2 and 3)**. The Adult Fish Passage Structure (AFPS) is operated by DWR, and the gates are opened and closed using inflatable air bladders. Three gate operational scenarios were approved as part of the Department of Fish and Wildlife (DFW) California Endangered Species Act (CESA) Incidental Take Permit (ITP) No. 2081-2017-015-02-A1 for the project.

**Scenario 1**: The AFPS remains open until the upstream channel no longer receives water from the river at a stage of 22 feet. Scenario 1 was determined to be infeasible due to the increased duration of inundation of agricultural lands in the southern portion of the Yolo Bypass. **Scenario 2**: The AFPS remains open for three days after Fremont Weir stops overtopping. **Scenario 3**: The AFPS remains open for one day after Fremont Weir stops overtopping and reopens when the river stage falls below 27 feet and closes when the river stage reaches 24 feet, for no longer than five days.

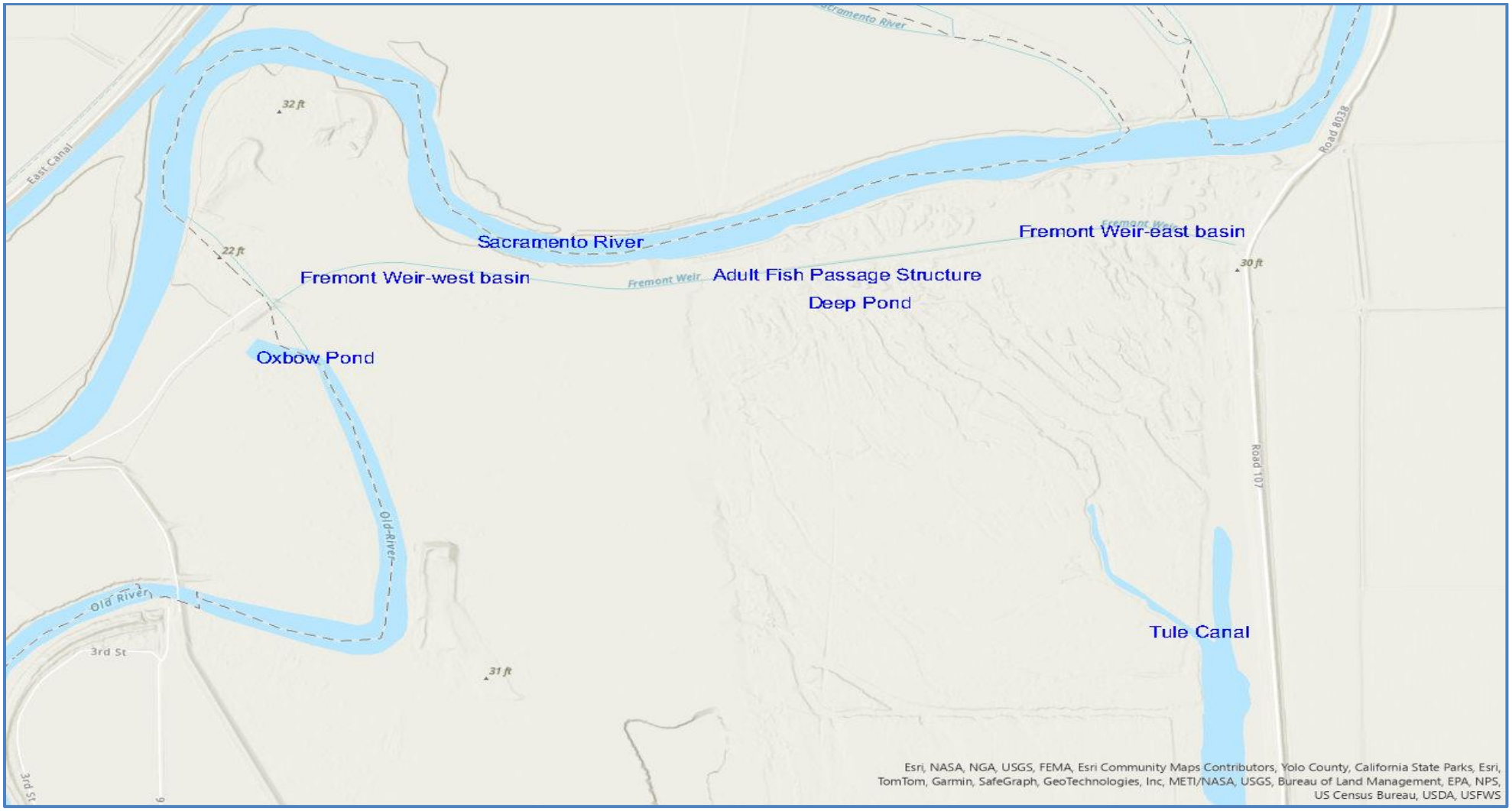


**Figure 3. Fremont Weir, Adult Fish Passage Structure, Deep Pond, Oxbow Pond, Tule Pond, and Sacramento River.**

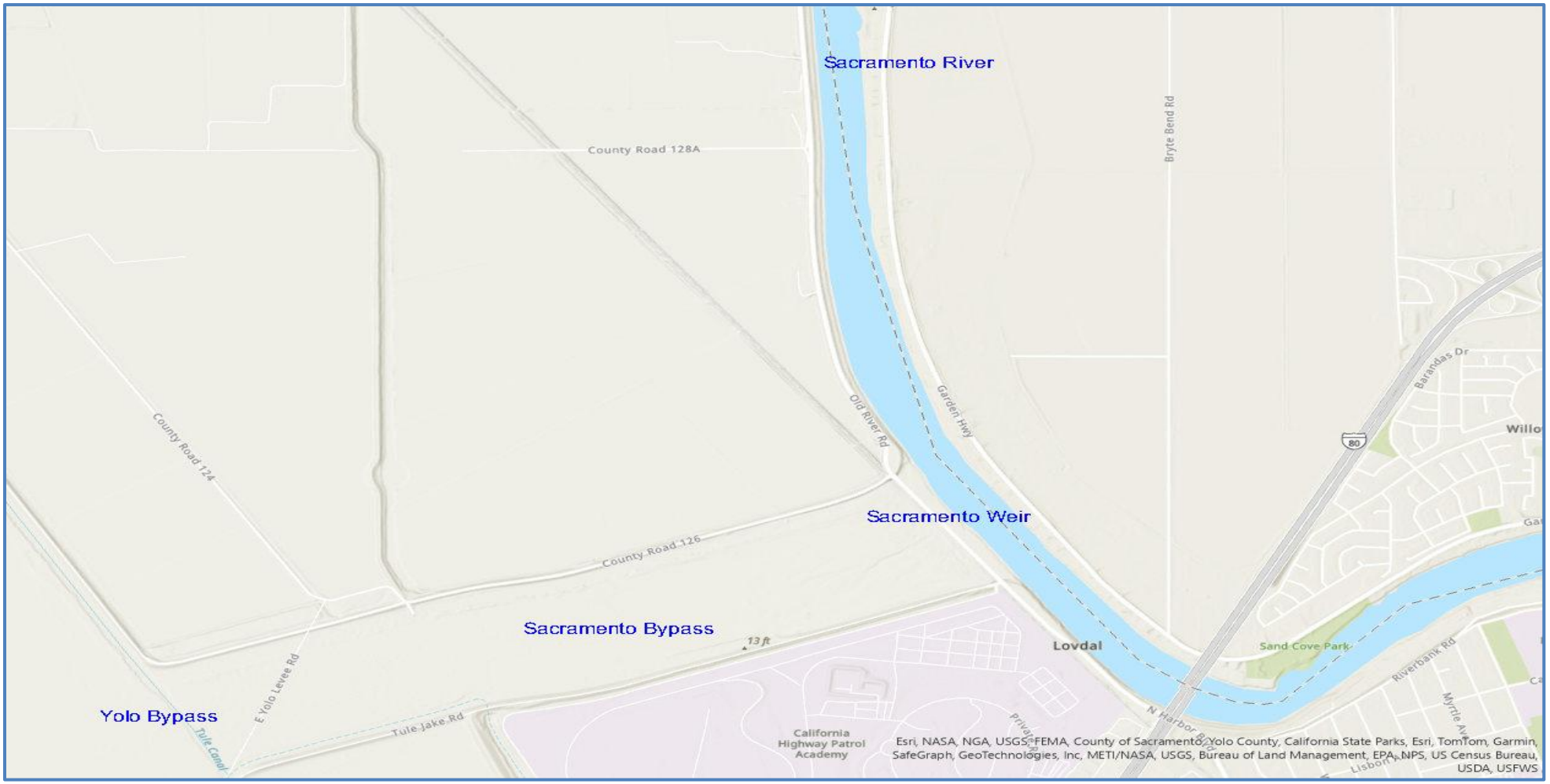


**Figure 4. Sacramento Weir, Sacramento River, Sacramento Bypass, and Yolo Bypass.**

*Initial operations were to follow Scenario 2 and would be evaluated for performance. If fish remain stranded in the stilling basin following overtopping events, Scenario 3 would be operated for future overtopping events and would undergo evaluation for stranded fish. The scenario that performed the best would continue to be used.*

## Methods

The Sacramento River overtopped Fremont Weir two times during the 2024 water year which resulted in fish stranding and necessitated CDFW to conduct fish rescue operations after each overtopping event **(Figures 4 and 5)**.

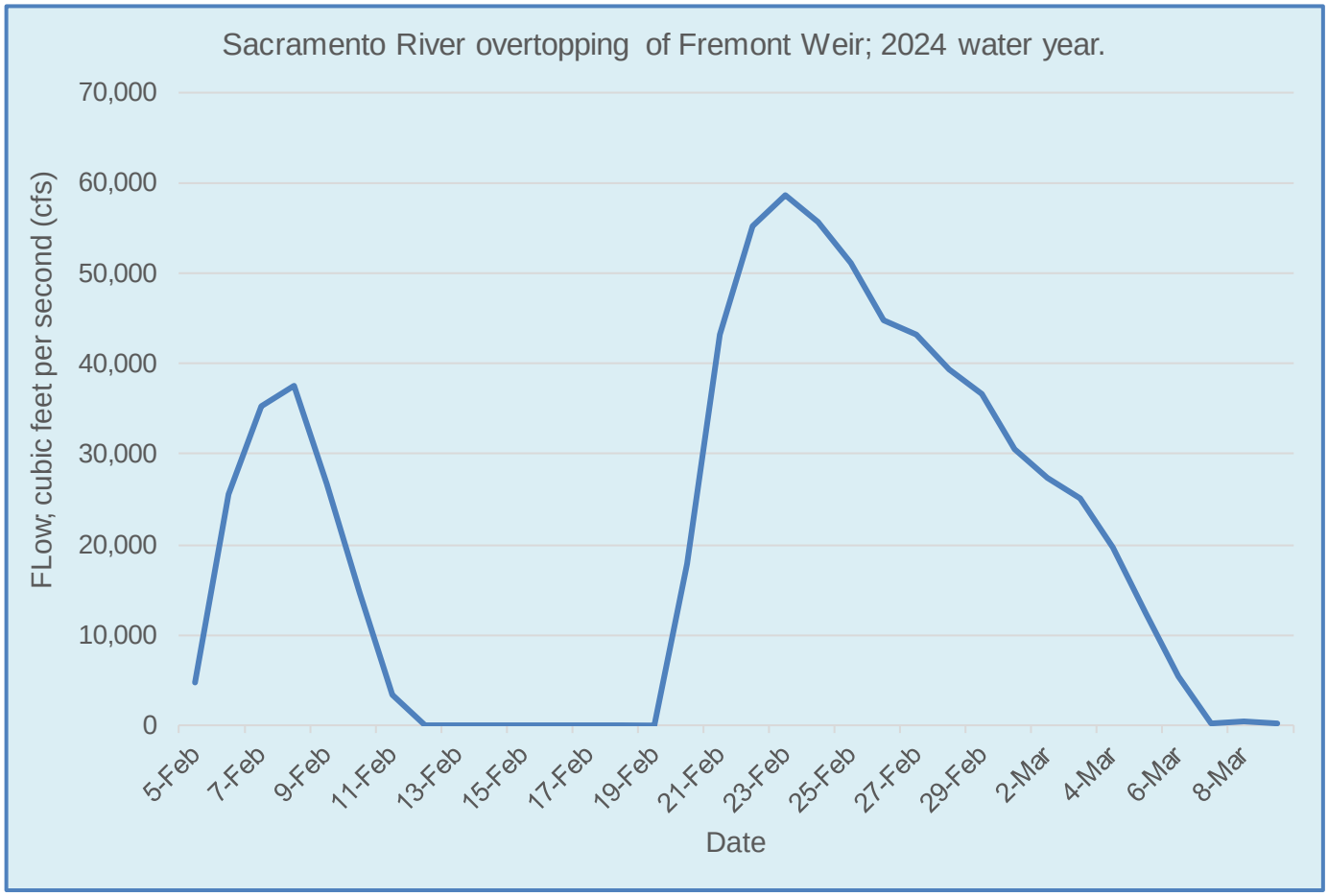


**Figure 5. Hydrograph of Fremont Weir 2024 overtopping events, 5 February through 9 March 2024. Maximum flow during the period was 58,658 cfs on 23 February.**

CDFW staff monitored the California Data Exchange Center (CDEC) National Weather Service River Forecast Center website during overtopping events to determine when Sacramento River stage height at Fremont Weir was forecast to drop to approximately 32.0 feet mean sea level (msl) on the receding hydrograph curve. At 32.0 feet msl, flow over the weir essentially ceased, at which point CDFW staff conducted reconnaissance surveys of the east and west sections of the Fremont Weir stilling basin to determine rescue timing, logistics, and potential safety issues regarding fish rescue operations. The Sacramento Weir, unlike the Fremont Weir, is not a passive flood control structure and is opened by Department of Water Resources staff removing flashboards when the Sacramento River stage height reaches 39.5 feet. The Sacramento Weir is located approximately 33 river km downstream of Fremont Weir (**Figures 6 and 7**). Although the Sacramento Weir was not opened during the 2024 water year, river flows reached the weir infrastructure resulting in water flowing through gaps between broken or damaged flashboards and filling the stilling basin bays. CDFW staff were concerned that given the timing of the stilling basin inundation events that emigrating juvenile Chinook salmon would be particularly susceptible to stranding in the stilling basin and downstream scour pools within the Sacramento Bypass.

CDFW staff conducted five days of fish rescue operations within the Fremont Weir stilling basin during the 2024 water year: 12 and 14 February; and 11, 18 and 21 March 2024; and two days of fish rescue operations within the Sacramento Weir stilling basin: 17 April and 9 May 2024. Equipment used to conduct fish rescue operations included 50-foot long 1/8 and 1/4-inch mesh beach seines, 1/8 and 1/4-inch mesh dip nets, and a 12-ft diameter throw net. Fish capture was conducted by seining isolated sections of the weir stilling basins and upon reaching the end of a haul, pursuing the seine and using dip nets to aid in capturing fish. Fish were then transferred to 5-gallon buckets or an aerated cooler for subsequent identification, enumeration, and measurement. Sturgeon were placed in a specially designed cradle ventral side up to induce a catatonic state and internally tagged with 69 kHz acoustic transmitters and passive integrated transponder (PIT) tags. Fin clips were collected from adult Chinook salmon for Evolutionary Significant Unit (ESU) designation via genetic determination. Juvenile Chinook salmon were assigned an ESU designation using length-at-date (LAD) criteria (Green 1992); and fin clips were collected from selected juvenile Chinook salmon to verify or refute LAD ESU assignment. Chinook salmon from the winter-run and spring-run ESUs were considered to be of wild origin if they possessed an intact adipose fin and of hatchery origin if they their adipose fin was clipped, as 100 percent of hatchery produced winter-run and spring-run Chinook salmon are marked by clipping the adipose

fin. All fish rescued from the Fremont Weir stilling basin were released in the Sacramento River near the point of capture; fish rescued from the Sacramento Weir were transported via aerated cooler to the Tule Canal on 17 April and the Elkhorn Boat Launch Facility on 9 May.

**Figure 6. Sacramento Weir Bay 5 facing west. Heavy algal growth prevented rescue efforts in bays 4 and 5. Photograph taken 9 May 2024.**

## Results

### Fremont Weir stilling basin

Opening of the AFPS gates likely allowed for the volitional passage of numerous anadromous fish that were holding downstream of the Fremont Weir in the Yolo Bypass Deep Pond, Tule Pond, and Tule Canal, although the Adaptive Resolution Imaging

Sonar (ARIS) unit deployed by DWR in the AFPS channel was ripped loose from its recessed bay in the AFPS channel during the overtopping event by large woody debris and therefore did not record volitional fish passage while the AFPS gates were open. However, fish stranding still occurred after each of the two overtopping events in sections of the east side stilling basin where receding flows pond in deeper sections of the stilling basin, and in the entire west stilling basin where there is currently no opportunity for volitional passage after cessation of weir overtopping events. CDFW staff rescued a total of 678 fish consisting of eight native and 10 non-native species. The fish were rescued in seven days of rescue effort conducted within the Fremont Weir stilling basin during the 2024 water year. Listed fish species rescued included Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. Other native fish species rescued included white sturgeon (*Acipenser transmontanus*), Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento splittail (*Pogonichthys macrolepidotus*), hardhead (*Mylopharodon conocephalus*), and riffle sculpin (*Cottus gulosus*). Non-native species rescued included spotted bass (*Micropterus punctulatus*), black crappie (*Pomoxis nigromaculatus*), white crappie (*Pomoxis annularis*), bluegill (*Lepomis macrochirus*), bigscale logperch (*Percina macrolepida*), brown bullhead (*Ameiurus nebulosus*), threadfin shad (*Dorosoma petenense*), inland silverside (*Menidia beryllina*), western mosquitofish (*Gambusia affinis*), and fathead minnow (*Pimephales promelas*). **Tables 1 through 4** present rescue data by weir stilling basin section and rescue date.

**Table 1. Summary of fish rescued from east stilling basin of Fremont Weir; 12 and 14 February 2024.**

| Species, ESU or DPS, origin | Life Stage | Number Rescued |
|---|---|---|
| White sturgeon | Adult | 4 |
| Winter-run Chinook salmon (wild) | Juvenile | 4 |
| Winter-run Chinook salmon (hatchery) | Juvenile | 17 |
| Spring-run Chinook salmon (wild) | Juvenile | 4 |
| Fall-run Chinook salmon (wild + hatchery) | Juvenile | 63 |
| Central Valley steelhead (hatchery) | Adult | 1 |
| Hardhead | Juvenile | 6 |
| White crappie | Juvenile | 19 |
| Threadfin shad | Adult | 40 |
| Inland silverside | Adult | 7 |
| Golden shiner | Adult | 2 |

**Table 2. Summary of fish rescued from east and west stilling basins of Fremont Weir; 11 March 2024.**

| Section | Species, ESU or DPS, origin | Life Stage | Number Rescued |
|---|---|---|---|
| East | Winter-run Chinook salmon (wild) | Juvenile | 1 |
| | Winter-run Chinook salmon (hatchery) | Juvenile | 7 |
| | Spring-run Chinook salmon (wild) | Juvenile | 1 |
| | Spring-run Chinook salmon (hatchery) | Juvenile | 1 |
| | Fall-run Chinook salmon (wild + hatchery) | Juvenile | 239 |
| | Central Valley steelhead (hatchery) | Juvenile | 1 |
| | Sacramento sucker | Adult | 1 |
| | Black crappie | Juvenile | 2 |
| | White crappie | Juvenile | 1 |
| | Black bullhead | Juvenile | 1 |
| | Threadfin shad | Adult | 5 |
| | Inland silverside | Adult | 12 |
| | Fathead minnow | Adult | 1 |
| West | Winter-run Chinook salmon (wild) | Juvenile | 3 |
| | Winter-run Chinook salmon (hatchery) | Juvenile | 14 |
| | Spring-run Chinook salmon (wild) | Juvenile | 3 |
| | Spring-run Chinook salmon (hatchery) | Juvenile | 2 |
| | Fall-run Chinook salmon (wild + hatchery) | Juvenile | 122 |
| | Central Valley steelhead (hatchery) | Juvenile | 1 |
| | Wakasagi | Adult | 2 |
| | Threadfin shad | Adult | 1 |
| | Golden shiner | Adult | 1 |

**Table 3. Summary of fish rescued from west stilling basin of Fremont Weir; 18 March 2024.**

| Species, ESU or DPS, origin | Life Stage | Number Rescued |
|---|---|---|
| Winter-run Chinook salmon (wild) | Juvenile | 9 |
| Winter-run Chinook salmon (hatchery) | Adult | 14 |
| Spring-run Chinook salmon (wild) | Juvenile | 4 |
| Spring-run Chinook salmon (hatchery) | Juvenile | 2 |
| Fall-run Chinook salmon (wild) | Juvenile | 83 |
| Central Valley steelhead (hatchery) | Juvenile | 3 |

| Species | Life Stage | Number Rescued |
|---|---|---|
| White sturgeon | Adult | 1 |
| Sacramento splittail | Adult | 1 |
| Sacramento pikeminnow | Juvenile | 5 |
| Hardhead | Adult | 2 |
| Sacramento sucker | Juvenile | 1 |
| Spotted bass | Adult | 1 |
| Black crappie | Juvenile | 4 |
| Threadfin shad | Adult | 4 |
| Golden shiner | Adult | 8 |

**Table 4. Summary of fish rescued from west stilling basin of Fremont Weir; 21 March 2024.**

| Species, ESU or DPS, origin | Life Stage | Number Rescued |
|---|---|---|
| Winter-run Chinook salmon (wild) | Juvenile | 1 |
| Spring-run Chinook salmon (wild) | Juvenile | 1 |
| Fall-run Chinook salmon (wild) | Juvenile | 24 |
| Central Valley steelhead (hatchery) | Juvenile | 2 |
| Sacramento pikeminnow | Adult | 3 |
| Sacramento pikeminnow | Juvenile | 13 |
| Hardhead | Juvenile | 1 |
| Sacramento sucker | Adult | 4 |
| Sacramento sucker | Juvenile | 20 |
| Sculpin (unidentified to species) | Adult | 1 |
| Spotted bass | Juvenile | 11 |
| Black crappie | Juvenile | 1 |
| Bluegill | Juvenile | 1 |
| Bigscale logperch | Adult | 7 |
| Fathead minnow | Adult | 2 |

**Sacramento Weir**

CDFW staff rescued a total of 2,700 fish consisting of three native and seven non-native species during two days of rescue effort conducted within the Sacramento Weir stilling basin during the 2024 water year, 17 April and 9 May. Of these, the majority were western mosquitofish and juvenile Chinook salmon. Other native species rescued included Sacramento sucker and prickly sculpin (*Cottus asper*). Other non-native

species rescued included white crappie, green sunfish (*Lepomis cyanellus*), redear sunfish (*L. microlophus*), wakasagi (*Hypomesus nipponensis*), and inland silverside (**Tables 5 and 6).**

**Table 5. Summary of fish rescued from Sacramento Weir stilling basin bays 1 and 2; 17 April 2024.**

| Species, ESU, origin | Life Stage | Number Rescued |
|---|---|---|
| Winter-run Chinook salmon (wild) | Juvenile | 1 |
| Spring-run Chinook salmon (wild) | Juvenile | 15 |
| Fall-run Chinook salmon (wild) | Juvenile | 15 |
| Chinook salmon (not measured) | Juvenile | 55 |
| Sacramento sucker | Juvenile | 38 |
| Redear sunfish | Juvenile | 1 |
| Unidentified cyprinid | Juvenile | 1 |
| Black crappie | Adult | 2 |
| Inland silverside | Adult | 2 |
| Western mosquitofish | Adult | 1,753 |

**Table 6. Summary of fish rescued from Sacramento Weir stilling basins 1-3; 9 May 2024.**

| Species, ESU, origin | Life Stage | Number Rescued |
|---|---|---|
| Spring-run Chinook salmon (wild) | Juvenile | 7 |
| Fall-run Chinook salmon (wild) | Juvenile | 34 |
| Chinook salmon (not measured) | Juvenile | 469 |
| White crappie | Juvenile | 1 |
| Green sunfish | Juvenile | 1 |
| Western mosquitofish | Adult | 200 |

CDFW staff collected fin clips from five adipose fin intact juvenile Chinook salmon for genetic analysis to determine ESU designation. Fork length of the five fish ranged from 88 mm to 103 mm, which according to length-at-date-range of 84 mm to 112 mm for 17 April place these fish in the spring-run ESU. Genetic analysis will likely place these fish in the fall-run ESU, as juvenile Chinook salmon rescued from the Sacramento Weir in 2023 that were winter-run or spring-run ESUs by length-at-date criteria were determined to be fall-run ESU via genetic analysis. Similar to juvenile Chinook salmon rescued from the Sacramento Weir stilling basin in 2023, the majority of the juvenile Chinook salmon

rescued in 2024 were in excellent condition and appeared to have growth rates similar to floodplain-reared juvenile Chinook salmon. Staff observed juvenile Chinook salmon chasing and feeding on schools of cyprinid fry and western mosquitofish prior to rescue efforts.

**Post-rescue Movement Patterns of Adult Sturgeon Rescued from Fremont Weir stilling basin.** Four white sturgeon rescued from the Fremont Weir splash basin and tagged with 69 kHz acoustic transmitters were subsequently detected in the Sacramento River at the Rio Vista Bridge 69 kHz receiver array located approximately 135 km downstream from Fremont Weir (**Table 7**). The receivers were most recently downloaded 11 June 2024. The period of time between rescue and tagging and detection at Rio Vista Bridge can be used to infer continuation of the sturgeon's spawning migrations after rescue. The caveat associated with this inference is that there are currently no 69 kHz receiver arrays upstream of Fremont Weir, therefore; some uncertainty exists as to whether the rescued white sturgeon did indeed continue upstream migration to their spawning grounds.

**Table 7. Post rescue detection and spawning migration status of white sturgeon rescued and tagged with 69 kHz acoustic transmitters from the Fremont Weir stilling basin, 2024 water year.**

| Date Rescued | Tag ID | Tagging to detection at Rio Vista Bridge (days) | Post-rescue spawning migration fate |
|---|---|---|---|
| 2/12 | A69-9001-61144 | 49 | Likely continued spawning migration |
| 2/12 | A69-9001-61146 | 61 | Likely continued spawning migration |
| 2/12 | A69-9001-61147 | 71 | Likely continued spawning migration |
| 2/14 | A69-9001-61145 | 57 | Likely continued spawning migration |

In the Sacramento River, white sturgeon spawn between February and June from near the confluence with the Feather River (rkm 129) upstream to at least Colusa (rkm 252) and typically migrate back to the San Francisco Bay-Delta Estuary soon after spawning (CDFW 2023, CDFW 2022, CDFW 2021, Kohlhorst 1976; Schaffter 1997; Moyle 2002). The time between post-rescue release and detection at the Rio Vista Bridge 69 kHz receiver array ranged from 49 to 71 days; which suggests all four white sturgeon rescued 12 and 14 February continued their spawning migrations prior to detection at the Rio Vista Bridge receiver array on their downstream return to the lower estuary.

## Discussion

Fish rescue operations conducted following Sacramento River overtopping of Fremont Weir and the inundation of the Sacramento Weir during the 2023 water year resulted in 3,378 fish being returned to the Sacramento River rather than from perishing from factors such as desiccation, poor water quality conditions, increased predation, and poaching. Federal or State listed fish species rescued included Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. Juvenile fall-run Chinook salmon were assumed to be all natural origin, as no hatchery releases were conducted prior to the overtopping events. Tagging of rescued sturgeon with acoustic transmitters provided data regarding post-rescue survival and movement patterns including evidence to suggest that 100 percent of the rescued white sturgeon likely continued migration to their spawning grounds. The acoustic transmitters used have a ten-year battery life which will continue to provide data regarding seasonal movement patterns and subsequent spawning migrations, as white sturgeon are iteroparous species with spawning periodicity ranging from two to five years (Moyle 2002).

There is considerable information in the literature regarding comparison of length-at-date and genetic analysis for ESU determination. Length-at-date ESU assignments were created by observing growth rates for juvenile Chinook salmon rearing in riverine habitat and do not accurately account for growth of juvenile Chinook rearing in floodplain habitat, where growth rates can be significantly greater (Brandes et. al. 2021). Fish rescue operations involving the capture of numerous juvenile Chinook salmon are time consuming, and typically only a sub-set of 20 or so fish are measured for length-at-date ESU determination to avoid excessive handling. However, future rescue efforts involving juvenile Chinook salmon that are classified as winter-run or spring-run by length at date criteria should include sampling fin clips or swabbing of slime coat for genetic ESU determination. Comparison of length-at-date and genetic ESU determination could then be used to provide a more accurate representation of Chinook salmon ESUs rescued from flood control weirs and other stranding areas.

While fish rescues do provide benefits in terms of saving listed fish species and preventing indirect mortality associated with CVP, SWP and flood control operations, there are potential drawbacks associated with fish rescues and it is generally considered better to address the issue causing the stranding than relying on fish rescues. Although fish rescue operations conducted for listed fish species are of high priority, they are costly and also result in CDFW staff being redirected from regular

duties. Stranded fish are often subjected to stressful or lethal conditions prior to rescue including elevated water temperature, low dissolved oxygen levels, increased predation, and abrasion injuries from contact with concrete structures. Rescue operations also cause considerable stress to fish and the potential to result in injury and delayed mortality from capture and handling (Donaldson *et. al.* 2011; Gale *et. al.* 2011; Raby *et. al*. 2011; Teffer *et. al*. 2017). For salmonids, the loss of slime coat and scales observed during capture and handling could increase the risk of infection from various fish pathogens. Several sturgeon rescued from the Fremont Weir stilling basin had abrasions to their snouts, barbels, pelvic fins, and ventral surfaces caused by repeated contact with concrete surfaces. These injuries could result in increased susceptibility to pathogens; and decreased function of sensory organs such as barbels and ampullae of Lorenzini, which could in turn impact foraging efficiency and predator avoidance.

The completion of the Yolo Bypass Fish Passage Project resulted in volitional fish passage through the Fremont Weir as demonstrated by ARIS sonar data of sturgeon and other unidentified fish passing through the structure (DWR unpublished data). However, fish stranding in the Fremont Weir stilling basin and Yolo Bypass ponds continues to be an issue for several reasons. There are several low spots in the east section of the stilling basin that become hydraulically disconnected from the middle of the east section where the fish passage is located. Fish holding in these low spots have a limited window of opportunity to move toward the passage structure as water levels recede in the stilling basin. The west section of the Fremont Weir will not have a fish passage structure until the completion of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Big Notch Project) and therefore continues to be an area of concern for fish stranding. Ultimately, the completion 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. However, stranding could still occur if equipment failure, equipment damage during overtopping events, or vandalism prevents adherence to the operational scenarios of the fish passage structure. Therefore, 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 and in identifying areas within the Yolo Bypass that remain problematic for fish stranding.

## References


Brandes, P.L., B. Piper, M. Banks, D. Jacobson, T. Garrison, S, Cramer. 2021. Comparison of Length at Date Criteria and Genetic Run Assignments of Juvenile Chinook Salmon Caught at Sacramento and Chipps Island in the Sacramento-San Joaquin Delta of California. San Francisco Estuary and Watershed Science. Volume 19, Issue 3.

Brown, K. 2007. Evidence of Spawning by Green Sturgeon, *Acipenser medirostris*, in the Upper Sacramento River, California. Environmental Biology of Fishes 79(3-4):297-303.

California Department of Fish and Wildlife. 2023. 2023 Sacramento River Sturgeon Spawning Study. Available at: https://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=R2-Fish

California Department of Fish and Wildlife. 2022. 2022 Sacramento River Sturgeon Spawning Study. Available at: https://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=R2-Fish

California Department of Fish and Wildlife. 2022. 2021 Sacramento River Sturgeon Spawning Study. Available at: https://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=R2-Fish

California Department of Fish and Wildlife. 2019. Summary of Fish Rescues Conducted within the Yolo Bypass, 2018 Water Year. Prepared for the U.S. Department of Reclamation.

California Department of Fish and Wildlife. 2017a. 2017 Fish Rescue Efforts at Tisdale Weir. Memorandum Report from M. Beccio to C. Purdy. Available at: https://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=R2-Fish

California Department of Fish and Wildlife. 2017b. 2016 Yolo Bypass – Tule Pond Sturgeon Rescue. Memorandum Report from M. Beccio to C. Purdy. Available at: https://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=R2-Fish

California Department of Fish and Wildlife. 2017c. Yolo Bypass Tule Pond and Oxbow Pond Sturgeon Rescue. Memorandum Report from M. Beccio to C. Purdy. Available at: https://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=R2-Fish

California Department of Fish and Wildlife. 2016. Summary of Fish Rescues Conducted within the Yolo and Sutter Bypasses. July 2016. Prepared for the U.S. Department of Reclamation.

California Department of Water Resources California Data Exchange Center. 2019. http://cdec.water.ca.gov/riv_flows.html.

California Department of Water Resources. 2010. Fact Sheet Sacramento River Flood Control Project Weirs and Flood Control Structures Flood Operations Branch. December 2010.

Donaldson, M. R., S. G. Hinch, D. A. Patterson, J. Hills, J. O. Thomas, S. J. Cooke, S. G. Rady, L. A. Thompson, D. Robichaud, K. K. English, A. P. Farrell. 2011. The consequences of angling, beach seining, and confinement on the physiology, post-release behaviour and survival of adult sockeye salmon during upriver migration. Fisheries Research 108 (2011) 133–141.

Gale, M. K, S. G. Hinch, E. J. Eliason, S. J. Cooke, D. A. Patterson. 2011. Physiological impairment of adult sockeye salmon in fresh water after simulated capture-and-release across a range of temperatures. Fisheries Research 112 (2011) 85–95.

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.

Jackson, Z. J, J. J. Gruber, J. P. Van Eenennaam. 2016. White Sturgeon Spawning in the San Joaquin River, California, and Effects of Water Management. Journal of Fish and Wildlife Management: June 2016, Vol. 7, No. 1, pp. 171-180.

Moyle PB. 2002. Inland fishes of California, 2nd edition. Berkeley (CA): University of California Press.

National Marine Fisheries Service. 2015. 5-Year Summary and Evaluation: Southern Distinct

Population Segment of the North American Green Sturgeon. U.S. Department of Commerce, pp. 42.

Poytress, W. R., J. J. Gruber, and J. P. Van Eenennaam. 2012. 2011 Upper Sacramento River
Green Sturgeon Spawning Habitat and Larval Migration Surveys U.S. Fish and Wildlife
Service and University of California Davis, pp. 1-46.

Poytress W. R., J. J. Gruber J. P. Van Eenennaam, M. Gard. 2015. Spatial and temporal distribution
1168 of spawning events and habitat characteristics of Sacramento River green sturgeon.
1169 Trans Am Fish Soc 144(6):1129-1142.

Raby, G. D., M. R. Donaldson, D. A. Patterson, S. G. Hinch, A. G. Lotto, D. Robichaud, K. K. English, W. G. Willmore, A. P. Farrell, M. W. Davis, S. J. Cooke. 2011. Journal of Applied Ecology.

Teffer, A. K., S. G. Hinch, K. M. Miller, D. A. Patterson, A. P. Farrell, S. J. Cooke, A. L. Bass, P. Szekeres, F. Jaunes. 2017. Capture severity, infectious disease processes and sex influence post-release mortality of sockeye salmon bycatch. Conservation Physiology. Volume 5.