

## Migratory Patterns and Survival of Juvenile Salmonids in the Yolo Bypass

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The Yolo Bypass is likely an important rearing habitat for outmigrating juvenile salmonids. We deployed seven monitors within the Toe Drain in order to assess usage of the Yolo Bypass by juvenile salmonids during a dry year. Twenty-five juvenile chinook salmon (100-125mm FL) and twenty-five juvenile steelhead trout were implanted with VEMCO V5 and V7 coded tags, respectively. The smolts were released 91 river kilometers upstream from the base of the Cache Slough Complex. The migratory patterns of chinook salmon down the Toe Drain and out to Chipps Island were monitored with an array of VEMCO VR2W 180kHz receivers. Steelhead trout were monitored using the 69kHz receiver array maintained by the California Fish Tracking Consortium, allowing us to monitor their movements to the Golden Gate. We calculated residence time in the Toe Drain, as well as rates of survival. All survival rates were calculated using Program MARK. Juvenile chinook salmon survival rate from the release site to Lisbon Weir was 0.92 (0.05+/- SE). Survival from Lisbon Weir to the base of the Toe Drain was 0.80 (0.09+/- SE). The average observed movement rate of chinook salmon was 5.94 km/day from the release site to the base of the Toe Drain.

**Keywords:** salmonids, outmigration, Yolo Bypass, floodplain, telemetry

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## Testing Hypotheses about Fish and Food Web Responses in Managed Habitat in Yolo Bypass Floodplain

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Monitoring data in Yolo Bypass and other seasonal habitat of the Central Valley suggests that floodplain habitat has major benefits to downstream migrating juvenile Chinook salmon. These results have led to increased interest in the use of managed floodplain to improve the aquatic habitat of the region. To begin examining the potential use of managed habitat for fish rearing, we stocked hatchery juvenile Chinook salmon into a flooded Yolo Bypass field constructed with three basic habitats: rice, fallow, and disked soil. During a winter 2012 study we examined the responses of physical, chemical, and biological metrics to seasonal inundation. Overall, water quality was consistently good throughout the study. Water temperatures were warmer than the adjacent Sacramento River channel, although trends were highly influenced by wind forcing. Salmon growth was high relative to historical data for Yolo Bypass, Sacramento River, and Cosumnes River. Growth rates were likely enhanced as a result of relatively warm temperatures and high densities of zooplankton (ostracods). Salmon survival could not be estimated accurately because an unknown number of fish escaped, but appeared relatively good. Chlorophyll *a* levels in the pilot study were high relative to measurements in Sacramento River and a perennial channel of Yolo Bypass. Contrary to predictions, chlorophyll *a* levels decreased between the pond inlet and outlet, likely because of grazing pressure from zooplankton.

**Keywords:** Yolo Bypass, floodplain, Chinook salmon, restoration, food web, zooplankton, habitat

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## **Residence Time of White Sturgeon in the Yolo Bypass and Subsequent Movements in the Sacramento River Watershed in a Dry Year**

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Although the Yolo Bypass floodplain has been demonstrated to benefit a suite of native fishes, particularly in flood years, little is known about movement patterns and residence time of native fishes in the Yolo Bypass. In cooperation with the Department of Water Resources (DWR), we implanted 68 white sturgeon with VEMCO V16 coded tags. The sturgeon were caught in the DWR fyke net, located just below Lisbon Weir in the Toe Drain (the perennial channel that runs along the eastern side of the Yolo Bypass). Using an array of VEMCO VR2W 69kHz monitors, including those maintained by the California Fish Tracking Consortium, the sturgeon's movement patterns were monitored within and throughout the Toe Drain (a total reach of 38.45 river kilometers) and into the San Francisco Bay. Variables of consideration for behavioral movement analysis included sex and fork length. Average individual residence time in the Yolo Bypass was 19 days (2.94+/- SE).

**Keywords:** white sturgeon, Yolo Bypass, telemetry, animal movement, floodplain, residence

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## **A Long-Term Examination of Juvenile Fall-Run Chinook Salmon (*Oncorhynchus tshawytscha*) Utilization of the Yolo Bypass as Rearing Habitat**

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Natural floodplains of the Sacramento-San Joaquin River Delta historically supported aquatic ecosystems with high biological productivity, but are largely absent from the Central Valley today due to large-scale construction of levees on river channels. The Yolo Bypass is a 59,000 acre floodplain originally engineered to provide flood protection for cities in the Sacramento region. When the Bypass floods (approximately 70% of years), it provides the most extensive floodplain habitat in the northern Delta and is thus a model system for understanding how fish species of concern use this rare, but important habitat.

Since 1997, the Department of Water Resources' Yolo Bypass fisheries monitoring program has been collecting data on fishes that utilize the bypass, including fall-run juvenile Chinook salmon. In addition, the program released groups of coded wire tagged (CWT) juvenile hatchery Chinook at the north end of the bypass each February/early March during 1998-2009. We used these long-term datasets to examine how environmental factors such as flow, floodplain inundation and temperature influence juvenile Chinook residence time, apparent growth, survival, and emigration timing in the Yolo Bypass. Previous analyses using CWT, wild fish, and experimental enclosures have shown that such rearing result in elevated growth rates in comparison to the Sacramento River, and may enhance survival. Analyses on the larger long-term dataset show that apparent growth rates varied from -0.09 to nearly 0.9 mm/day, while median residence times ranged from 12 to 66 days. In wet years, emigration from the floodplain occurs after peak seasonal flows have subsided and as stage descends from their highest January-March levels. This information will be particularly relevant for restoration projects planned for the Delta, and for the management of seasonal shallow water habitat to benefit native fishes.

**Keywords:** juvenile Chinook salmon, floodplain, Yolo Bypass, rearing habitat

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## Parameterizing a System Optimization Model for Flood Extent, Location, and Timing on the Yolo Bypass

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A comprehensive plan for fish habitat expansion in the Yolo Bypass and other managed floodplains requires analysis of a broad range of topics, including agricultural economics, waterfowl habitat, and hydrodynamics (both for fish habitat and to evaluate changes in flood carrying capacity). A balanced management approach for ecosystem services attempts to minimize economic costs to all human land/resource uses, while still satisfying habitat requirements. On the Yolo Bypass, this habitat requirement can take the form of acres flooded, residence time of water, depth, and/or a sum value that depends on type of land flooded, duration of flooding, accessibility for fish, and other relevant factors.

This presentation focuses specifically on the metrics developed to quantify important physical habitat and bioenergetic factors for fish and waterfowl success on the bypass, and their integration into an optimization model built to assess tradeoffs between these and other economic functions within the system. These metrics are being developed from various tools and concurrent efforts, including hydrodynamic models, expert surveys, and invertebrate (food base) studies.

The high-resolution hydrodynamic modeling capability and parameterized optimization model developed in this study will eventually represent a decision analysis tool to identify management alternatives that provide desired ecosystem services while maximizing economic returns to land owners in the Yolo Bypass. The methodology will be broadly applicable to similar floodplains with the potential for conjunctive use for human and ecosystem services.

**Keywords:** Yolo Bypass, systems optimization, salmon, splittail, waterfowl, agricultural economics, RMA

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