

SMSCG during three operational phases: (1) when the gates are not operating (flashboards out and gates held open); (2) during full-bore gate operation; and (3) during full-bore gate operation with the modified flashboard structure installed. The evaluation is proposed for three consecutive control seasons (October through May), with the fish tagging to occur approximately between September 15 and October 31 of each year. The fish-tagging period is limited to the time when fall-run chinook salmon are present in the Suisun Marsh. Once installed, the modified flashboard structure will remain in place for the remainder of the control season, as long as SMSCG operation is needed.

There are a number of tasks to complete in order to begin evaluating the modification of the flashboards by this fall. These include: (1) preparing the appropriate environmental documentation; (2) petitioning SWRCB to temporarily waive, for the duration of the evaluation, salinity compliance in the Marsh in the event that salinities are exceeded during the evaluation; (3) reinstate consultation with NMFS to resolve this issue in the winter-run Biological Opinion; and finally (4) apply to

the Corps for approval of the modification of the flashboards.

For a copy of the Steering Group's summary of findings, please contact Heidi Rooks at the DWR Environmental Services Office at (916) 227-2557.

### Literature Cited

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## Fall Dissolved Oxygen Conditions in the Stockton Ship Channel for 1997

Stephen P. Hayes and Jeannie S. Lee, DWR

Dissolved oxygen concentrations in the Stockton Ship Channel are closely monitored during the late summer and early fall of each year because levels can drop below 5.0 mg/L in the eastern portion of the channel. The dissolved oxygen depression in this area is apparently due to low San Joaquin River inflows, warm water temperatures, high biochemical oxygen demand (BOD), reduced tidal mixing, and intermittent reverse flow conditions in the San Joaquin River past Stockton. These low dissolved oxygen levels can cause physiological stress to fish and hinder upstream migration of salmon.

As part of a 1969 Memorandum of Understanding between DWR, USFWS, USBR, and DFG, DWR usually closes the head of Old River by installing a temporary rock barrier (the Old River Closure) during periods of projected low fall outflow. The closure increases net flows down the San Joaquin River past Stockton, and helps alleviate dissolved oxygen concerns in the eastern Channel. Water Year 1997<sup>1</sup> was classified as wet, and the closure was not installed because late summer and early fall

(August through October) flow conditions in the San Joaquin River appeared to be sufficient to alleviate concerns. Average daily flows in the San Joaquin River past Vernalis approached 2,000 cfs in August and September, and exceeded 2,000 cfs in October and November. These flows exceeded the late summer and early fall average daily flows of 1,000 cfs or less experienced in this area during drought years. In spite of the relatively high average daily flows, intermittent reverse flow conditions past Stockton existed throughout much of fall 1997.

Compliance monitoring of dissolved oxygen levels in the Stockton Ship Channel was conducted by vessel on eight monitoring runs between August 4, 1997 and November 17, 1997.<sup>2</sup> During each of the monitoring runs, 14 sites were sampled from Prisoner's Point in the central delta (Station 1) to the Stockton Turning Basin (Station 14) at the terminus of the channel (Figure 1). Dissolved oxygen and water temperature data were collected for each site at the top and bottom of the water column during ebb slack tide using continuous monitoring in-

1. The Water Year spans October 1 to September 30, and is numbered using the year in which it ends. Thus, Water Year 1997 began on October 1, 1996, and ended on September 30, 1997.

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2. WR staff involved in sample collection included Heather Peterson, Katherine Tribol, Colette Zermis, Scott Waller, Eric Sambas, and Lloyd Brenn. USBR staff included Michelle Prouse.

strumentation (Hydrolab Multiparameter Surveyor, Model DS-3). A continuous year-round automated multiparameter water quality recording station near Stockton at the western end of Rough and Ready Island at Burns Cutoff also supplements monitoring of the channel by vessel.

Monitoring from August through October 1997 showed a gradual drop in surface and bottom dissolved oxygen levels in the western portion of the Channel from Prisoner's Point to Columbia Cut (Station 5), with levels ranging from 6.5 to 8.6 mg/L (Figure 2). A more distinct dissolved oxygen decrease developed east of this region with an area of maximum sag (levels less than 5.0 mg/L) developing and persisting in the eastern portion of the channel, especially within the area from west of Turner Cut (Station 7) to the eastern end of Rough and Ready Island (Station 13).

Dissolved oxygen values in the heart of the sag area (east of Turner Cut (Station 8) to Buckley Cove (Station 10)) ranged from 3.1 to 5.6 mg/L at the surface and 2.6 to 5.2 mg/L at the bottom. The lowest surface and bottom dissolved oxygen values were measured at Buckley Cove on October 1, 1997.

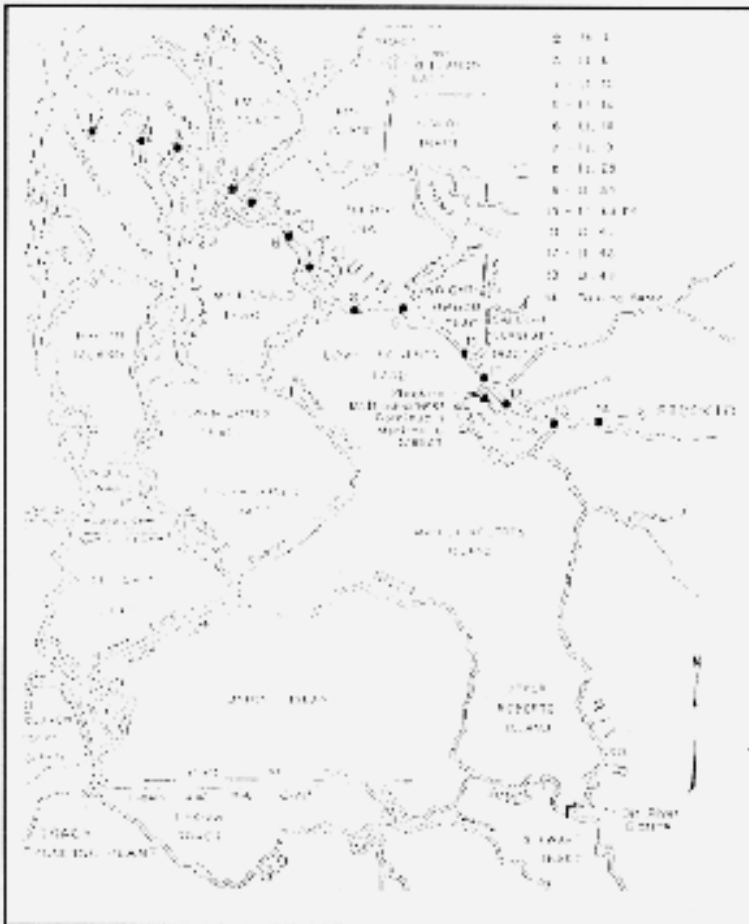


Figure 1  
Map of the Dissolved Oxygen monitoring sites in the

Warm water temperatures, reduced tidal mixing, and intermittent reverse flows in the San Joaquin River past Stockton appear to have contributed to the low dissolved oxygen levels measured in the eastern portion of the channel in the late summer and early fall. Water temperatures in the sag area remained high in August and September (22-27°C), and only gradually cooled by mid-October to 17-19°C. Intermittent reverse flow conditions in the San Joaquin River past Stockton also persisted from September through October. Average daily river flows past Stockton ranged from -466 cfs to +198 cfs in August, -329 cfs to +117 cfs in September, and -233 cfs to +508 cfs in October.

The dramatic, local improvement of surface and bottom dissolved oxygen levels in the Rough and Ready Island area on October 15, 1997, could have been due in part to significantly improved flow conditions in the San Joaquin River. The San Joaquin River enters the Stockton Ship Channel immediately east of Rough and Ready Island. Average daily flows in the San Joaquin River past Vernalis exceeded 3,000 cfs in mid-October for the first time in fall 1997, and reverse flow conditions in the river past Stockton were finally eliminated by October 10. In the Rough and Ready Island area, surface dissolved oxygen levels peaked at 7.4 to 7.7 mg/L and bottom dissolved oxygen levels peaked at 6.0 to 7.6 mg/L. The higher average daily San Joaquin River flows into the eastern end of the channel appear to have contributed to this improvement and a shift of the sag area down channel and west of Rough and Ready Island.

Dissolved oxygen conditions gradually improved in November as a result of cooler water temperatures and the maintenance of improved flow conditions in the San Joaquin River. On November 3, all dissolved oxygen levels exceeded 5.0 mg/L in the eastern channel, although a dissolved oxygen depression was still present. By November 17, all levels in the eastern channel had improved to 5.8 mg/L or greater and the dissolved oxygen depression had been essentially eliminated. This improvement was apparently due to cooler water temperatures (14-18°C) and the elimination of reverse flows past Stockton. Average daily flows past Stockton through mid-November ranged from +5 cfs to +189 cfs. The lack of late fall rainfall in the San Joaquin River drainage appears to have delayed the full recovery of dissolved oxygen levels in the channel to those historically measured in November.

Exceptionally high surface and low bottom dissolved oxygen levels were periodically measured in the Stockton Turning Basin throughout the study period. Sampling on August 4, August 18, September 2, October 1, and

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Map of the Dissolved Oxygen monitoring sites in the  
Stockton Ship Channel.

Turning Basin throughout the study period. Sampling  
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November 3, 1997, showed surface dissolved oxygen levels ranging from 9.7 to 13.1 mg/L, and bottom dissolved oxygen levels ranging from 1.1 to 5.1 mg/L. On September 15, October 15, and November 17, 1997, however, the distinct dissolved oxygen stratification subsided. Surface dissolved oxygen levels ranged from 5.4 to 6.4 mg/L, and bottom dissolved oxygen levels ranged from 4.5 to 6.3 mg/L.

The highly stratified dissolved oxygen conditions detected in the basin throughout much of fall 1997 appear to be the result of localized biological and water quality conditions occurring in the basin. The basin is at the eastern dead-end terminus of the Ship Channel and is subject to reduced tidal activity, restricted water circulation, and increased residence times when compared to the remainder of the channel. As a result, water quality and biological conditions within the basin have historically differed from those within the main downstream

channel, and have led to extensive summer and fall algal blooms and dieoffs. The late summer and early fall of 1997 were no exception, and a series of intense algal blooms composed primarily of Cryptomonads, diatoms, and blue green and green flagellated algae were detected. Stratified dissolved oxygen conditions appear to be produced in the water column of the basin by the blooms in the following manner: (1) high algal productivity at the surface of the basin produces elevated surface dissolved oxygen levels; and, (2) dead or dying bloom algae settle out of the water column and sink to the bottom to contribute to high BOD. Bottom dissolved oxygen levels in the basin are further degraded by additional BOD loadings in the area such as regulated discharges into the San Joaquin River and from recreational activities adjacent to the basin. When bloom activity subsides, the dissolved oxygen stratification is reduced, and basin surface and bottom dissolved oxygen levels become less diverse.

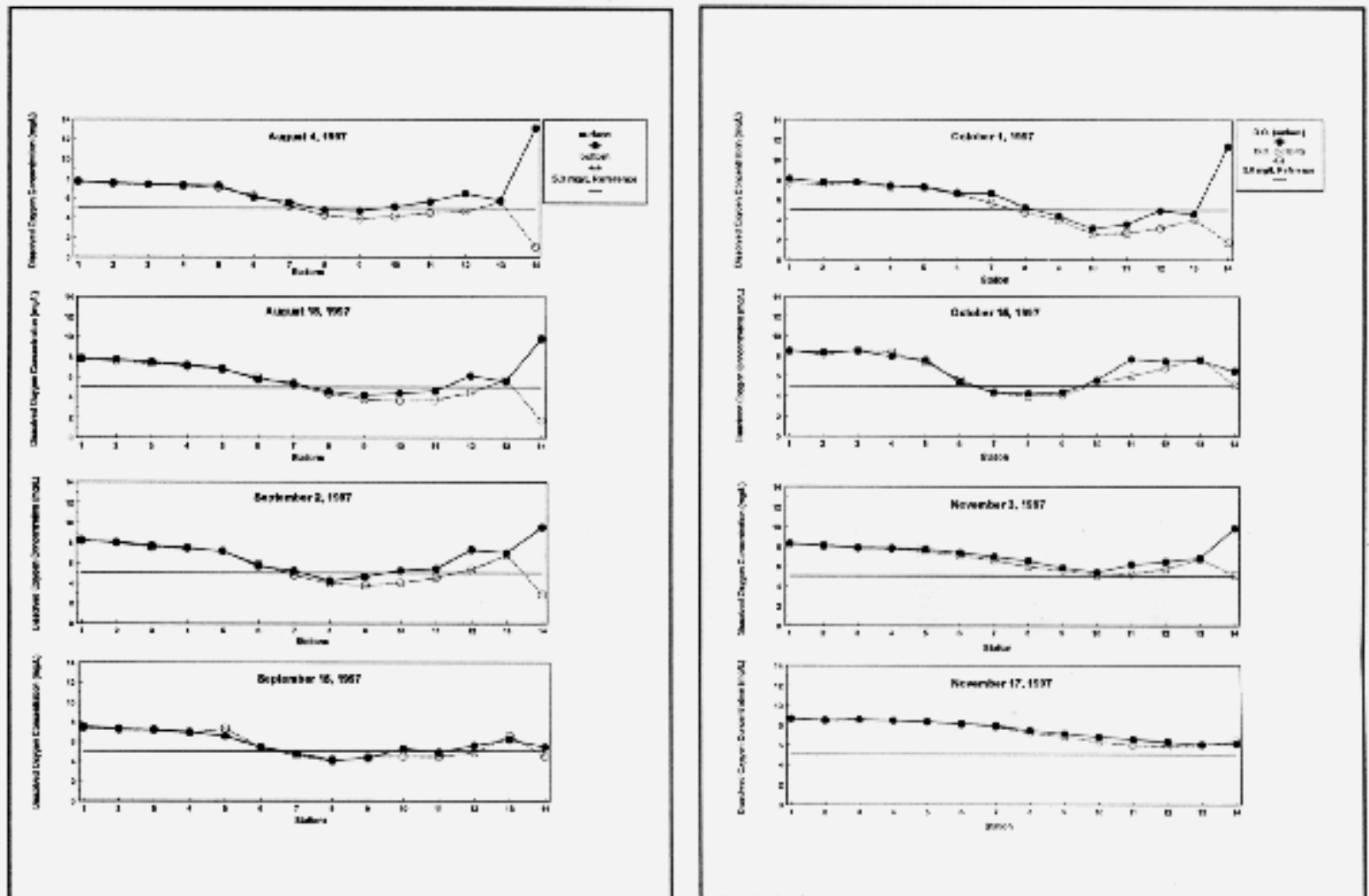


Figure 2  
Dissolved Oxygen concentrations in the Stockton Ship Channel in 1997.

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