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alone or in combination with the Merced River stock show a statistically significant relationship ($p<0.05$).

If smolts from Dos Reis survive at a higher rate because of increased flows at Stockton, a similar relationship should be observed for smolts released at Mossdale. The barrier would serve as the mechanism to increase flows at Stockton. It appears that a relationship does exist (Figure 4). It could be that survival is improved via the barrier because of the route, but also because of the increased flows. If this is true then the barrier did improve survival through the Delta in 1997.

One additional piece of evidence that appears to support the conclusion that the barrier did improve survival of smolts migrating through the Delta is shown when Delta survival is compared to tributary survival. In most past years, when Delta survival was low (1996) or high (1995), survival indices from the tributaries were of similar magnitude. For example in 1996, survival for smolts released at Mossdale was 0.02 whereas at the upper Merced and Tuolumne it was 0.01 and 0.04 - of the same magnitude (Table 6). Similarly in 1995, survival from smolts released at Mossdale was 0.22, when the upper tributary release groups survived at a rate of 0.15 and 0.25; again, of the same magnitude. In contrast, 1997 survival index from Mossdale was 0.19 and the upper tributary survival indices were 0.04, indicating that survival through the Delta in 1997 was higher relative to tributary survival than in 1995 and 1996. This indicates that Delta survival was higher in 1997, and could be a result of the barrier.

Although relative to tributary survival, Delta survival was greater in 1997 than in 1995 or 1996, on an absolute scale, survival through the Delta was actually similar to survival down the tributaries (0.28 and 0.18 for the Merced and Tuolumne rivers respectively, and 0.19 for the Mossdale release). As we did for the Mossdale group relative to the Jersey Point group, survival down the tributaries is estimated using the ratio of the survival index to Chipps Island of the upper tributary group divided by the lower tributary group. Again sampling was not conducted long enough at Jersey Point to generate similar indices or ratios from the tributary releases recovered at Jersey Point.

Real time monitoring and fish facility recoveries. Most recoveries made at real-time monitoring stations were at Turner Cut (Table 3). Although it is difficult to assess the magnitude, it appears salmon do migrate toward the facilities using these routes (i.e. Turner and Columbia Cuts, Webb Tract and False River). The number of expanded SWP and CVP recoveries from the two Dos Reis groups released while the barrier was in place were similar to those recovered from the Mossdale group, again indicating that the barrier was successful at keeping most fish out of Upper Old River (Table 3). Historically we have seen more fish at the facilities from Mossdale releases than from the Dos Reis releases when there is no barrier.

Conclusions and Recommendations for 1998

The barrier and resulting increased flows at Stockton appeared to increase the survival of CWT fish released at Mossdale. Delta survival for those released in the tributaries also seemed to improve over many previous years. The unmarked fish migrating from the San Joaquin basin while the barrier was in place and during the pulse flow period, likely also experienced improved survival.

Information generated in 1997 seemed to indicate that the impact of the culverts were minimal to smolts passing between Mossdale and Dos Reis.

It is unclear why the last Dos Reis group appeared to survive at a similar rate of earlier Dos Reis releases, after the barrier was removed, flows decreased and exports increased. MRFF smolts released at Dos Reis survived at a higher rate to Chipps Island, relative to the Jersey Point group, than Feather River smolts.

The additional recovery numbers at Jersey Point increases the precision of survival indices to Jersey Point, but needs to be evaluated in light of using paired releases (as done at Chipps Island) to factor out gear efficiency, size, and potentially temperature differences within and between years.

Releases should be continued at both Dos Reis and Mossdale to evaluate any design of a barrier (including no barrier) in Upper Old River. In addition, Jersey Point releases should be continued and paired with Delta and upstream releases to factor out background conditions and any potential bias.

Results of 1997 Yolo Bypass Studies

Ted Sommer, Matt Nobriga, and Bill Harrell, DWR

The Yolo Bypass, the primary floodplain of southern Sacramento Valley, is engineered to carry flood flows from the Sacramento River, Feather River, American River, Sutter Bypass, and westside streams (Figure 1). Surface flow from the 59,000-acre region provides a major source of organic material to the estuary. The Bypass supports an impressive diversity of native and nonnative fish; however, there is also evidence that the basin is a source of mortality for species which become stranded after floodwaters recede. Contaminant inputs from streams and land use in the Yolo basin are additional concerns.

A major habitat restoration project, the Yolo Basin Wetlands (Figure 1), has been constructed in the Bypass. Moreover, CALFED is considering various actions including changing land use and water operations in the Yolo basin, designing bypasses in other regions, and constructing shallow water habitat. The aquatic effects of these changes are not yet well understood.

Recognizing the many unresolved issues in the Yolo Bypass, in late 1996 DWR received funding from IEP and CALFED's Category III program to study the region. A Yolo Bypass Project Work Team was formed in 1997 to initiate the project. The long-term objectives for this study are to examine the relationship between the Yolo Bypass and the rest of the estuary and to develop recommendations for restoration actions that would improve Bypass habitat for fisheries and other aquatic organisms. Our 1997 studies were designed primarily as a preliminary effort to gather more information about the region, select study sites, and test methods. However, to the extent possible, we were interested in collecting initial data about the status of fish in the basin, particularly chinook salmon. An additional goal was to evaluate trends in pesticide and sediment levels during the hydrologic cycle of the Bypass. The following are some of the highlights of the 1997 studies.

Fish Studies

Diversity, Abundance, Growth and Diet: Most fish sampling was delayed until February 1997, when we obtained the necessary permits from DFG and NMFS. At this point, staff conducted beach seining surveys of Yolo Bypass ponds formed by receding floodwaters. Data from adjacent USFWS Sacramento River beach seine stations were used for comparison.

Table 1 lists the top 10 fish species found in the Yolo Bypass and Sacramento River. In general, native species had higher relative abundance ranks in the Sacramento River, but chinook salmon ranked high in both data sets. Shannon indices showed that Yolo Bypass had higher diversity (H'=4.4) than the Sacramento River (H'=3.6).

Juvenile salmon were primarily in the fall-run and spring-run size classes, although 15 were in the winter-run size class. Salmon abundance based on March sampling was significantly higher in the Sacramento River (Figure 2), but it is likely that Bypass densities were originally higher before bird predation during ponding and before emigration during draining of the basin. The differences may also be due to the methodology or type of habitats sampled. Within the Bypass, there appeared to be higher salmon density in the central Bypass although the differences were not statistically significant.

Mean salmon size increased substantially faster in the Bypass than the Sacramento River, suggesting better growth rates (Figure 3). An alternative explanation is that the smaller mean size of Sacramento River salmon was the result of steady immigration of young fish from upstream areas or from race differences. Data on water temperature, stomach contents, and sizes of coded-wire-tagged salmon (described later) all support the hypothesis that growth was indeed faster in the Yolo Bypass.

February-April water temperatures were significantly higher in the Yolo Bypass than the Sacramento River (Figure 4). Warmer winter and early spring temperatures typically support faster salmon growth.

Stomach content analyses of 20 CWT salmon collected in Yolo Basin ponds during March and April suggest high feeding success. These salmon were hatchery-produced late fall-run released into the Sacramento River. All fish analyzed had prey items in their stomachs. Gut fullness

Table 1. Top Ten Most Abundant Fish Species in the Yolo Bypass and the Adjacent Reach of the Sacramento River

Native species are shown in italics.

Yolo Bypass	Sacramento River
Threadfin shad	*Chinook salmon*
Chinook salmon	Inland silverside
Golden shiner	Threadfin shad
Inland silverside	*Sacramento squawfish*
Fathead minnow	*Sacramento sucker*
Sacramento squawfish	Fathead minnow
Red shiner	Wakasagi
Bluegill	*Lamprey*
Mosquitofish	Mosquitofish
Sacramento sucker	Red shiner

estimates using a number between 0 (no food items) and 3 (stomach 100% full) gave a mean index of 2.1, representing full but not distended stomachs. The high mean stomach fullness value and the fact that all salmon had food in their stomachs, suggest that the Yolo ponds could have been a good nursery habitat if they had maintained a connection to the Delta. The significance of the stomach fullness number is uncertain without comparable values for Sacramento River chinook. However, the 100% feeding incidence is considerably higher than those previously reported for Delta habitats, which range from a low of 51% in the Sacramento River at Sherman Island to 82% on flooded islands (Sasaki 1966).

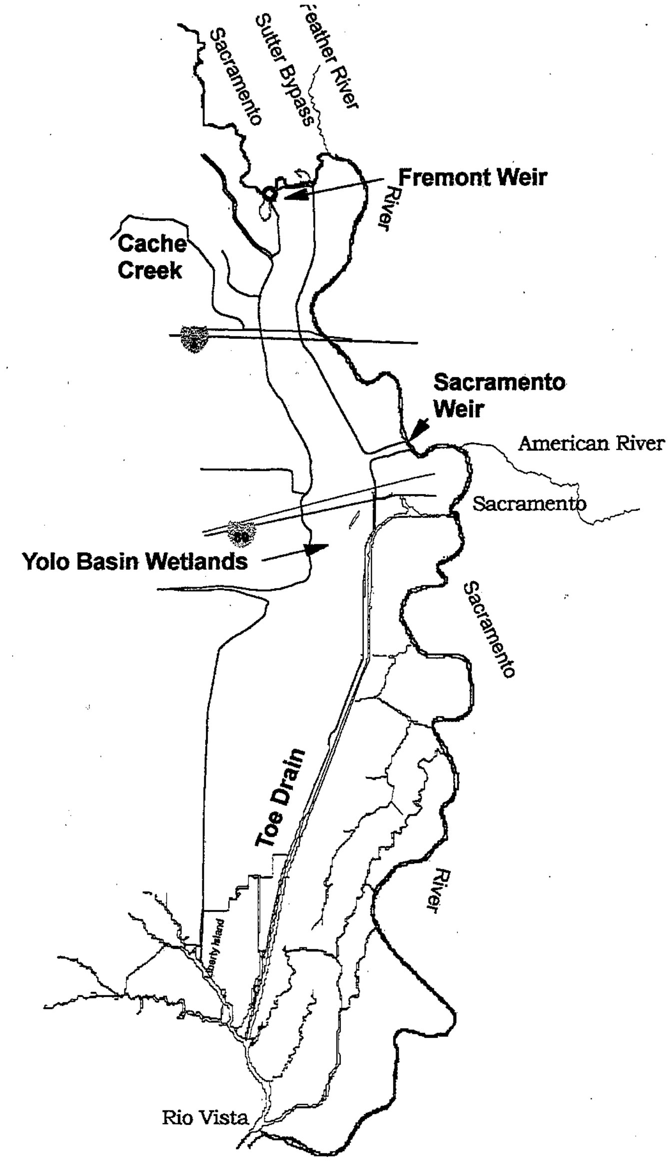

Figure 1
Map of the Yolo Bypass

Length comparison of the previously-described CWT with individuals of the same tag groups captured downstream by the Chipps Island trawl provided additional evidence that growth was faster in the Bypass. Figure 5 shows the fork lengths of CWT salmon in the Yolo Bypass versus individuals with the same tag code collected within a two week period at Chipps Island. In all but one case, the Yolo Bypass individuals were larger than the mean length of the Chipps Island fish. Assuming that most of the Chipps Island fish migrated downstream through the Sacramento River, this supports the hypothesis of faster growth in the Yolo Bypass. It is possible these differences might be due to more efficient collection of larger smolts by Yolo Bypass seining than Chipps Island trawling, however historical trends in gear catch are opposite to this explanation. The Chipps Island trawl tends to collect more smolts, while beach seines such as those used in the Bypass are more efficient at capturing fry. Alternatively, perhaps the smallest CWT fish had higher mortality rates in the Yolo Bypass than the Sacramento River. Even if this was true, the majority of Yolo Bypass CWT salmon were still larger than the largest Chipps Island fish, again suggesting faster growth of the Yolo Bypass group. A similar alternative hypothesis to explain the larger size of Yolo Bypass smolts is that the smallest CWT salmon had higher emigration rates from the Yolo Bypass than larger individuals. However, emigration rates are typically higher for larger smolts than smaller ones.

Stranding Estimates: We developed "ballpark" estimates of juvenile salmon stranding using mean density (per square meter seined) estimates for each of the sampling regions shown in Figure 1. Pond areas were calculated for these regions using aerial photographs taken on February 25, 1997, at a scale of 1:24:000. Each photo was computer scanned, georeferenced to satellite imagery, then printed. We delineated ponds on the prints according to three classes: I–isolated ponds; II–ponds which might drain to the delta and; III–shallow puddles. Pond boundaries and classifications were added to the digital images using AUTOCAD and processed through a GIS system to calculate areas.

Expansion of the regional salmon density by the corresponding pond areas resulted in stranding estimates ranging from 300,000 salmon for isolated ponds to 2,000,000 salmon for the combination of all three types of ponds. We suspect that a level of a few hundred thousand is more reasonable because many of the salmon in Class II ponds would have successfully migrated to the delta and the areas with Class III ponds were fairly well-drained. The remaining water on Class III ponds was primarily very shallow puddles a few inches deep between row crops. Note, however, that these results should be interpreted with extreme caution because of the many assumptions required.

We also compared the 1997 results for the Sacramento Bypass region to 1996 data collected by Jones and Stokes Associates and USFWS (Table 2). The results show that densities of salmon were much lower in 1997 for both concrete weir and earthen ponds.

A likely reason is that there were much higher flows though Sacramento Weir in 1997, which could have helped move most salmon further downstream of Sacramento Bypass. Note that Sacramento Weir was never actually opened in 1996—most flow probably occurred as leakage through or over the flashboards.

Pesticide and Sediment Studies

Suspended sediment and dissolved pesticide samples were periodically collected by Kathy Kuivila and Dave Schollhamer of USGS from the Sacramento River at Tower Bridge and from the Yolo Bypass toe drain at Interstate 80 from December 1996 to early March 1997. Suspended-solids concentration (SSC) varied similarly at the two sites while the Bypass was flowing (Figure 6). During the flood in early January, the flow in the Yolo Bypass was several times greater than the flow in the Sacramento River at Freeport, and the greatest SSC was observed in both channels. In late January a smaller flow peak had a small effect on SSC. When Fremont Weir was spilling, SSC was greater in the Sacramento River, probably due to greater velocity and less deposition. In late February and early March, however, SSC was greater in the Bypass, probably due to shallower water depths as the Bypass drained, which enhanced wind wave resuspension of bottom sediments.

The dissolved pesticide concentrations at the two sites varied in a different pattern than the SSC. Two dormant spray pesticides, diazinon and methidathion, were detected during the sampling period with similar concentrations at both sites. In contrast to SSC, pesticide concentrations were low during the first high flow event in early January. The highest pesticide concentrations (<100 ng/L) were detected during the second, but much lower, flow event in late January. This pattern is likely due to application of dormant spray pesticides occurring between the two rainfall events as seen in previous years (Kuivila and Foe 1995).

Conclusions

Although the 1997 sampling program was designed primarily as an initial study, the field work yielded some interesting results. Fish sampling during draining and ponding of the Yolo Bypass indicated that the basin supported richer species diversity than the Sacramento River, although native species including chinook salmon were more common in the Sacramento River. The fact

Table 2. Numbers of Chinook Salmon Captured in the Scour Ponds of the Sacramento Weir and Estimated Numbers of Chinook Stranded in Earthen Ponds of the Sacramento Bypass

Year	Number in Scour Ponds	Number per Acre
1996	10,790	5,808
1997	512	55

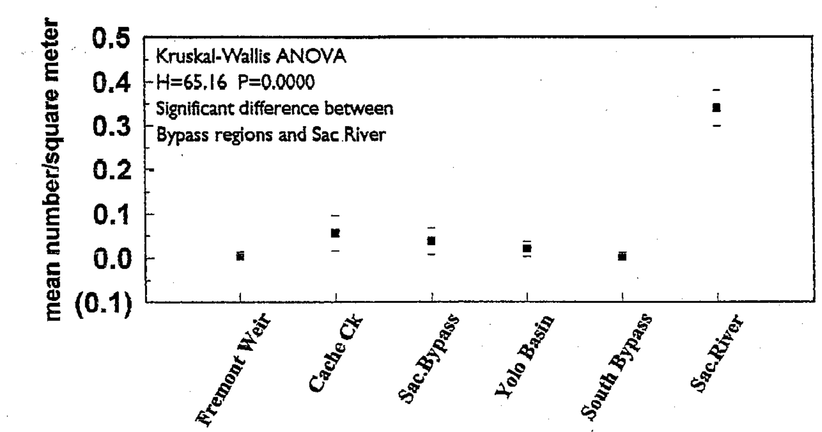

Figure 2
Mean chinook salmon density per square meter seined plus 95% confidence intervals for five Yolo Bypass regions and the adjacent reach of the Sacramento River.

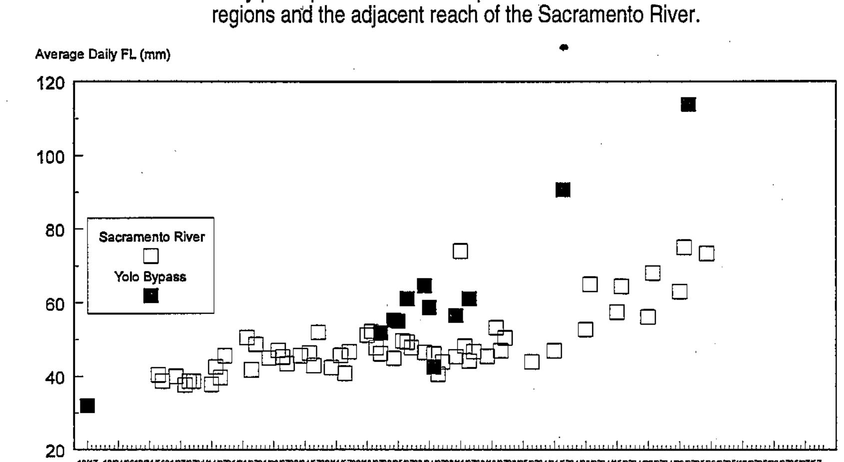

Figure 3
Average daily fork length of juvenile chinook salmon in the Yolo Bypass and the adjacent reach of the Sacramento River.

that young salmon collected in the Yolo Bypass were larger than the Sacramento River, experienced higher water temperatures, and had exceptional feeding success suggests that growth is faster in the Yolo Bypass. Like previous results for splittail (Sommer *et al* 1997), these results support the idea that the Yolo Bypass provides at least some benefits to fish of the Sacramento-San Joaquin Estuary. However, we observed moderately high levels of salmon trapped in ponds after floodwaters receded, demonstrating that growth benefits can be offset by stranding mortality.

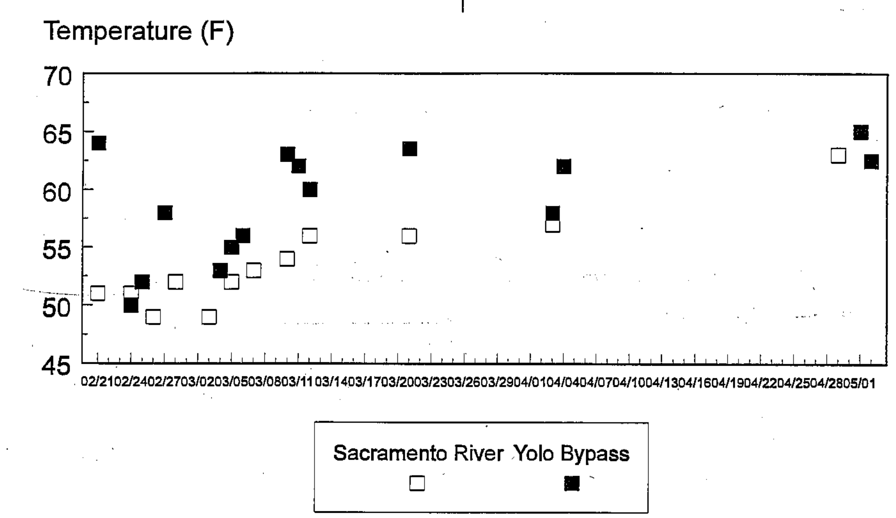

Figure 4
Average surface water temperatures in the Yolo Bypass and the adjacent reach of the Sacramento River; temperatures are significantly different (Wilcoxon matched pairs test, $p<0.05$).

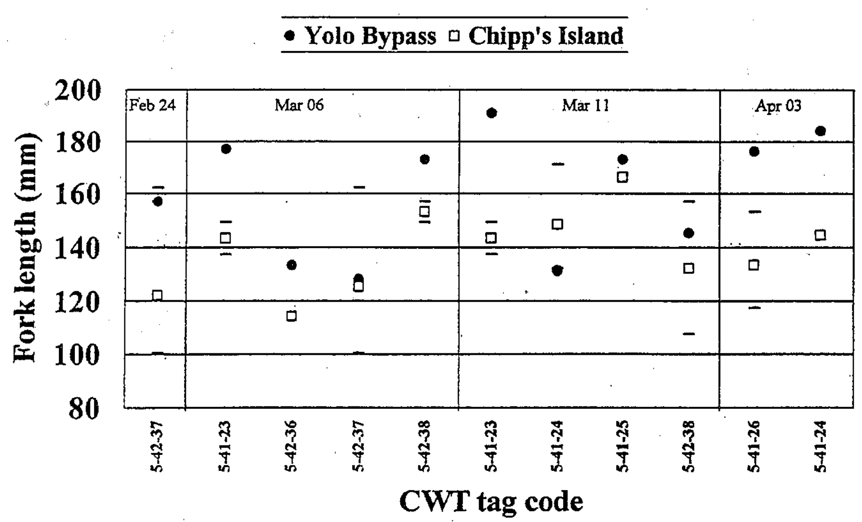

Figure 5
Fork lengths of CWT chinook captured in the Yolo Bypass, and mean fork lengths of CWT chinook captured in the USFWS Chipps Island trawl. Error bars are minimum and maximum fork lengths for Chipps Island data. Chipps Island mean fork lengths were calculated from chinook captured ± 14 days from the Yolo Bypass capture. Bypass capture dates are shown at the top of the figure.

In the next field season we will conduct more intensive sampling to determine whether salmon show evidence of growth benefits throughout the full hydrologic cycle of the Yolo Bypass and hope to conduct juvenile salmon survival studies in the Sacramento River versus the Yolo Bypass.

Acknowledgments

Pesticide and sediment data were collected and analyzed by Kathy Kuivila and Dave Schoelhammer of USGS. This study would not have been successful without the valuable contributions of the Yolo Bypass PWT, USFWS, DFG Inland Fisheries Division, DFG Environmental Services Division, DFG Region 2, DFG Region 4, DFG Bay-Delta Division, and DWR Environmental Services Office.

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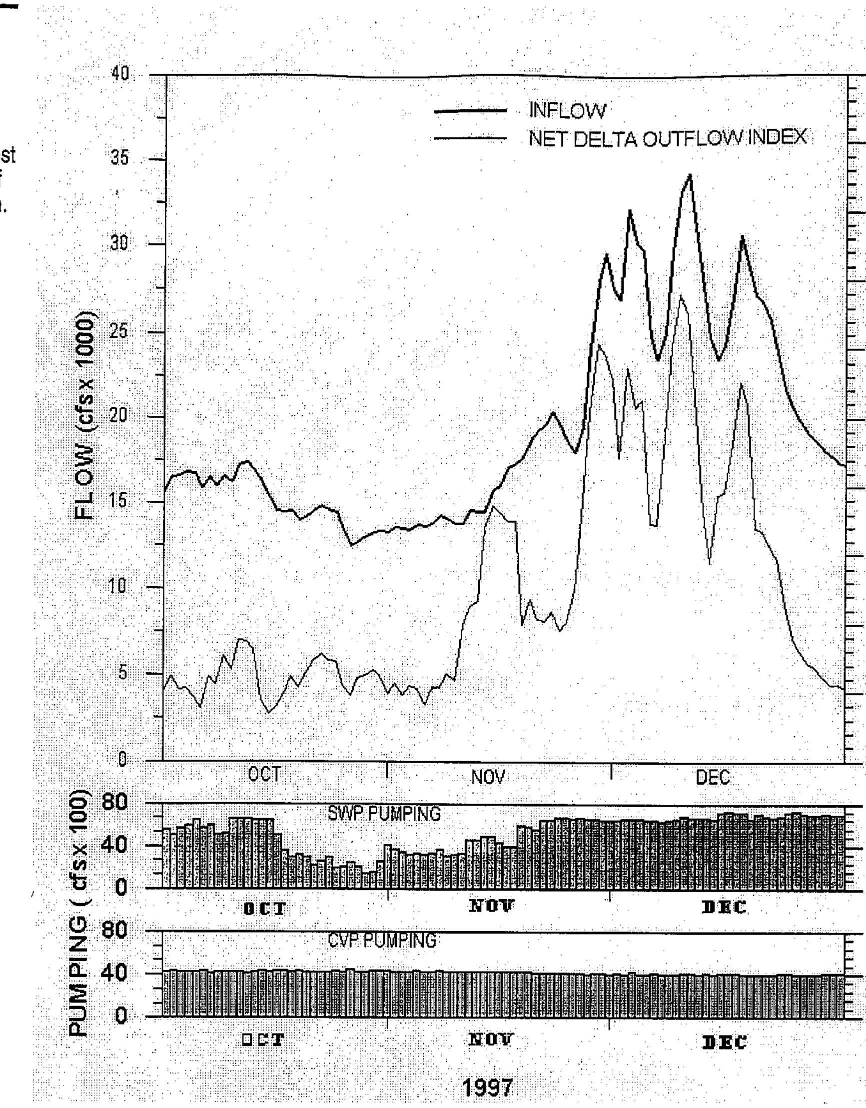
Delta Outflow Index

Between October 1 and December 31, 1997, the average Delta Outflow Index was 9,863 cfs. The largest outflow occurred on December 10, 1997, at a rate of 26,738 cfs. This high outflow was due to precipitation. Combined SWP and CVP pumping averaged about 9,500 cfs during this period.



Contaminants, CALFED, and the IEP

Randall Brown, DWR

Through use of Category III and federal restoration funds, CALFED has recently allocated several million dollars to contaminant related projects. These projects include source control, monitoring, research and education. The contaminants of concern range from pesticides such as diazinon to mercury to selenium.

Two allocations involve the IEP's Contaminant Effects Project Work Team. This PWT, now chaired by Chris Foe of the Central Valley Regional Water Quality Control Board, was established a few years ago and includes representatives of State and federal agencies, SFEI, stakeholders, and private consultants. The PWT has been quite effective in evaluating and recommending projects to fund with their limited resources. The recent CALFED grant of $1.5 million will increase the team's role and visibility.

The $1.5 million grant will focus on pesticides and their effects on riverine and Delta aquatic biota. A portion of the money will go develop a study plan, the overall objective of which is to evaluate the effects of pesticides on priority fish species and their supporting foodwebs. The remainder of the funds will be allocated to studies. A second CALFED action tentatively allocates an additional $1.5 million to four specific pesticide-related projects, but these allocations may change based on the PWT's findings and recommendations.

Since the two grants are "designated actions" (i.e., they are not in response to specific proposals) details such as timing, statement of work, resources required and deliverables are still being worked out. Within the next few weeks the team will be provided with more details and assigned the task of developing a detailed proposal.