Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

27th Annual Progress Report
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Chapter 10:
Using Particle Tracking to Generate Indexes of Fish Entrainment Potential

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10 Using Particle Tracking to Generate Indexes of Fish Entrainment Potential

10.1 Introduction

Using the Particle Tracking module of DWR's Delta Simulation Model II (DSM2), daily indexes of the potential for fish entrainment in Clifton Court Forebay were generated for historical and modified 2005 Delta conditions. Particles were continuously injected at eight locations in the central and south Delta and the total portion of particles by fate after 90 days was reported. Fate was broken down into six components: moving out of the Delta channels past Chipps Island, remaining in Delta Channels, removal by the State Water Project (SWP) and Central Valley Project (CVP) exports, removal by Contra Costa Canal diversions, and removal by Delta agricultural diversions. Results show that location of particle injection, San Joaquin River inflow, barrier operation, and SWP and CVP pumping all affect entrainment potential. Removing the historically installed temporary agricultural barriers in the south Delta had mixed results on entrainment potential depending upon the location of an injection.

10.2 Background

In the past, scientists studying Delta fish populations have attempted to relate fish salvage counts to the movement of water in Delta channels. This movement of water has mostly been accounted for only indirectly through such parameters as Delta inflow, cross-Delta flow, and Delta exports. These flows are either boundary flows that are measured or are internal flows that are calculated based upon empirical relationships developed from boundary Delta flows. Recently the United States Geological Survey (Armor, 2006) compared winter time (January through February) historical fish salvage to combined SWP and CVP pumping and to combined measured historical flows at Old River at Bacon Island (ROLD024) and Middle River at Lower Jones Tract (RMID015) (see Figure 10.1). The improvement in the regression by using measured internal flows instead of using combined SWP and CVP exports indicates that information describing Delta hydrodynamics may be important in understanding fish salvage.

The Particle Tracking Model (PTM) is a module of DSM2 and simulates the transport and fate of individual particles traveling in the channels of the Sacramento-San Joaquin Delta. It has been used to indirectly describe Delta hydrodynamics. The model utilizes velocity, flow, and stage output from DSM2-HYDRO in simulating longitudinal movement while transverse and vertical movements are accounted for by assuming a relationship between movement and water depth and velocity. PTM has been described in detail elsewhere (see Smith, 1998; Miller, 2000; Miller, 2002). PTM results of historical simulations have recently been used to create indexes of Delta residence time (see Chapter 3; Sommer et al., 2006) and to estimate the portion of San Joaquin River inflow water diverted by SWP and CVP exports (Sommer et al., 2006). In a similar fashion, PTM simulations with multiple injection locations have been conducted under historical conditions to track variations in potential for fish entrainment by SWP and CVP pumping. Below are a description of this work and a summary of the results.

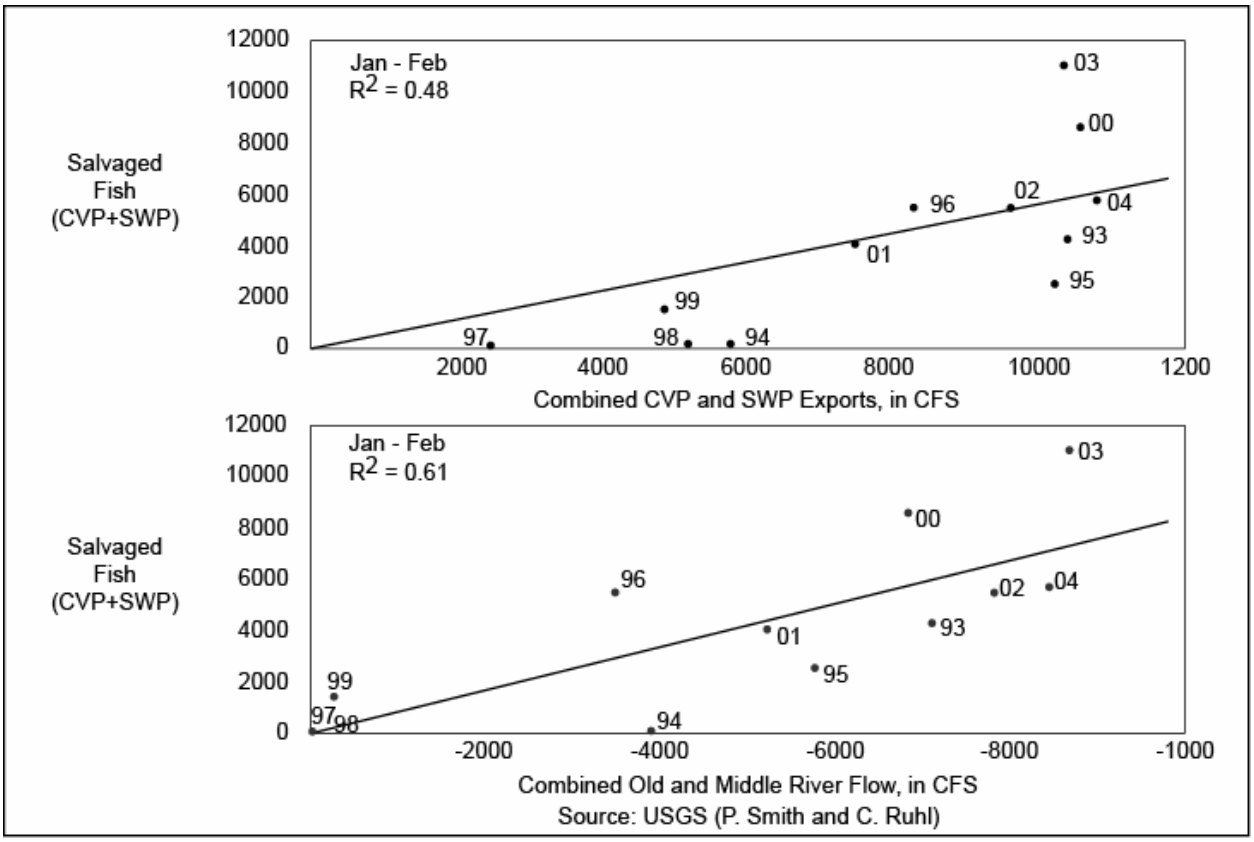

Figure 10.1: Comparison of average winter salvage to average winter exports and in-Delta flows (USGS).

10.3 PTM Setup for Historical 2005 Delta Conditions

Historical 2005 Delta conditions were used in order to test using PTM to generate an index of the potential for fish entrainment. Historical 2005 Delta hydrodynamics were first simulated using DSM2-HYDRO with historical Delta inflows and exports (Figures 10.2 and 10.3) along with historical operations of Delta structures (Table 10.1). PTM was then run by daily injecting particles at nine locations (Figure 10.4). The particles injected on any given day were separately tracked for 90 days and the fate of these particles was noted. Fate was broken down into six categories: moving out of the Delta channels past Chipps Island, remaining in Delta Channels, removal by the State Water Project (SWP) and Central Valley Project (CVP) exports, removal by Contra Costa Canal diversions, and removal by Delta agricultural diversions. The fates of injected particles after 90 days were assigned to the date of injection. In this way the portion of particles injected that are removed by SWP and CVP pumping within 90 days of the injection can be used to create an index of the potential entrainment. Such an index then is associated with the date and location of the injection and accounts for changes in Delta inflows, exports, and barrier operations and indirectly reflects the Delta hydrodynamics which might contribute to fish entrainment.

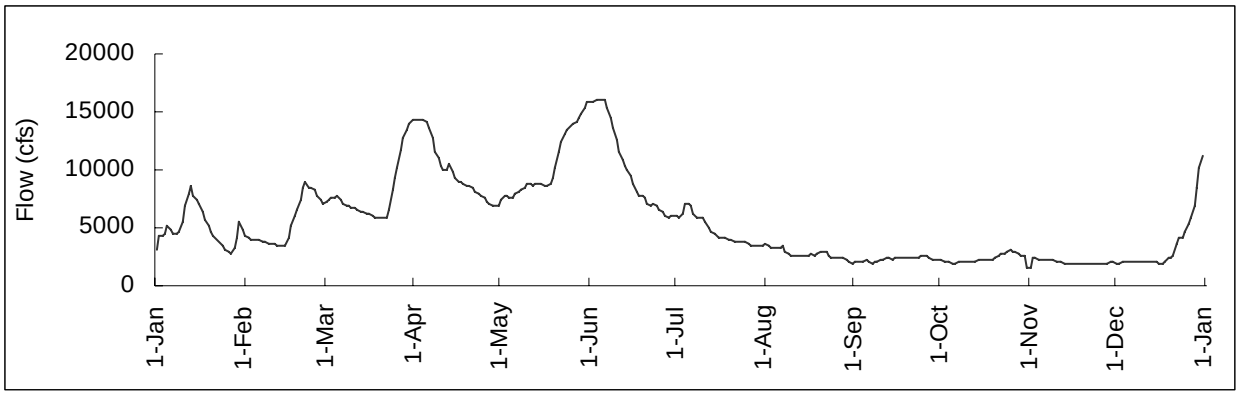

Figure 10.2: Historical San Joaquin River inflow at Vernalis, 2005.

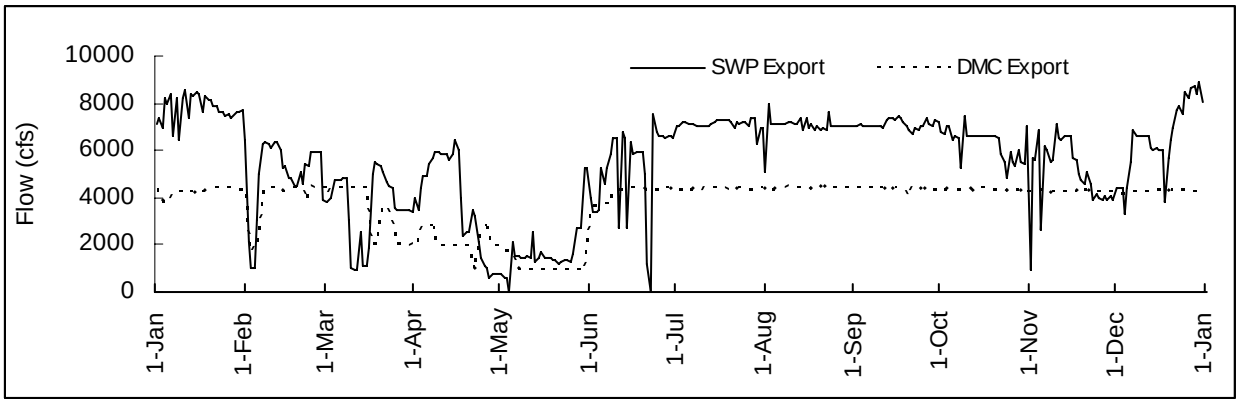

Figure 10.3: Historical State Water Project and Central Valley Project pumping from the Delta, 2005.

Table 10.1: Timing of temporary barrier installation and removal for 2005.

Barrier	Installation	Removal
Middle River	5/12/05	11/8/05
Old River near Delta Mendota Canal	5/31/05	11/10/05
Grant Line Canal	7/14/05	11/15/05
Old River @ Head (spring)	--	--
Old River @ Head (fall)	9/29/05	11/8/05

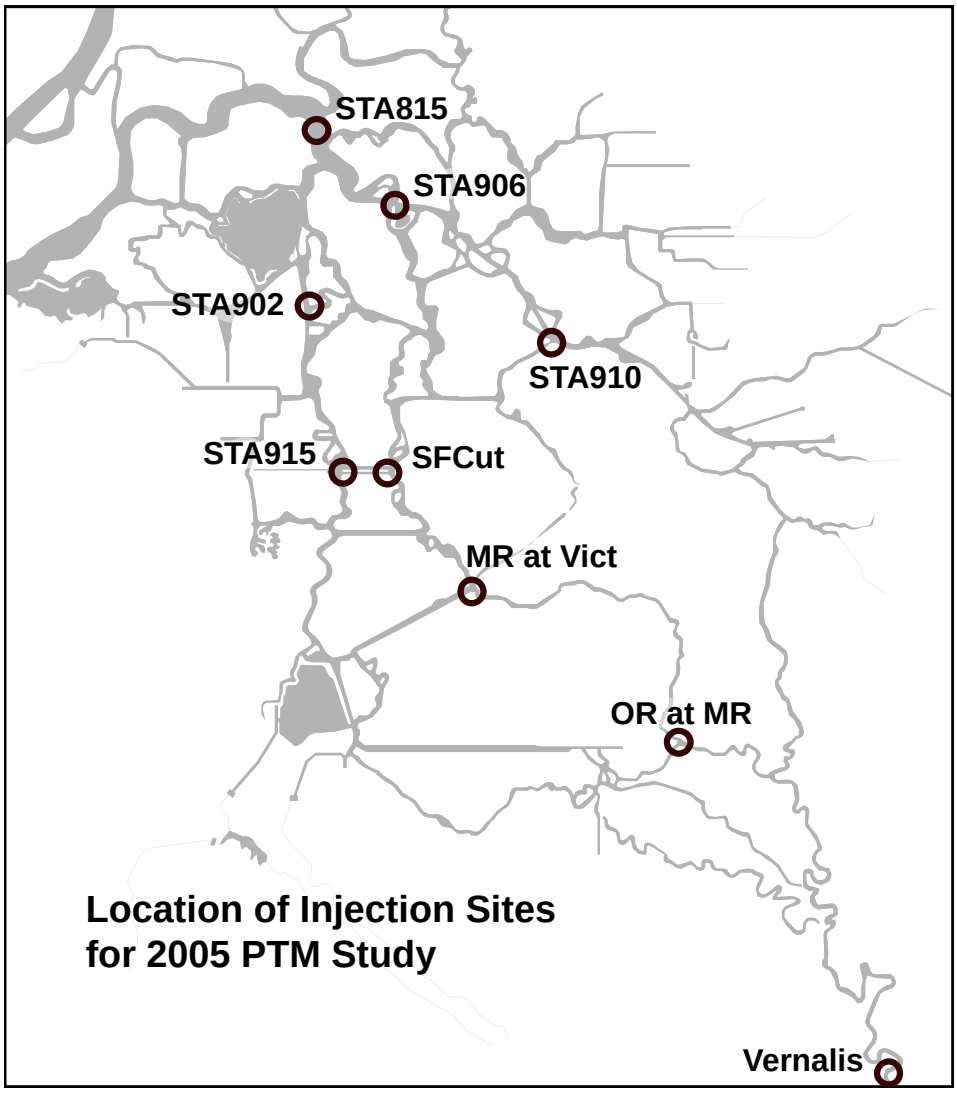

Figure 10.4: Locations particles injected for PTM study of historical 2005 Delta conditions.

10.4 PTM Results for Historical and Modified 2005 Delta Conditions

Figure 10.5 shows the fate of daily injected particles after 90 days of tracking for the nine locations of injection for historical 2005 conditions and the change in particle fate if the temporary barriers in the south Delta are assumed not installed. Highlighted are the contributions to fate of SWP and CVP pumping compared to having a fate of moving past Chipps Island. Figure 10.6 shows the PTM results for just the historical 2005 conditions as averaged over monthly or semi-monthly periods. For simplicity, only the portion of particles lost to SWP and CVP pumping and lost to agriculture diversions are presented. The balance of the particles were nearly always those particles moving out of the Delta past Chipps Island.

10.4.1 PTM Results for Historical Conditions

Figure 10.5 indicates that particle fate can vary widely from one day of injection to the next, depending upon Delta hydrodynamics. Figure 10.2 shows that significant increases in San Joaquin River inflow occurred in the periods of approximately March 20 through April 7 and from May 15 through June 15. Also, historical SWP pumping was significantly lower from mid April through May (Figure 10.3). Thus, one might predict that entrainment potential would have decreased during these periods. Figure 10.5 supports this hypothesis with generally decreased portions of particles pumped by SWP; however, interpreting results beyond this is tenuous. The brief decrease in particles lost to SWP in March is made up by an increase in particles lost to the CVP when the injection is at Middle River at Victoria Canal, Old River at Middle River, SFCut, and STA915. However, at injection locations STA815, STA902, STA906, and STA910, the decrease in particles removed by SWP translated to increased particles moving past Chipps Island. Particles injected at the locations which are further downstream on Old River or on the San Joaquin River responded to decreased SWP pumping and/or increased San Joaquin River inflows quite differently than particles injected nearer the south Delta.

The lower pumping and higher San Joaquin River inflows during the mid April through May period nearly uniformly resulted in sharply less particles being lost to the SWP and more particles moving past Chipps Island. The one exception was for the particles injected upstream of the south Delta barriers in Old River at Middle River. These particles did not significantly respond to the change in hydrology.

10.4.2 PTM Results for Modified Conditions (No Temporary Barriers)

Running the PTM simulation without the temporary agricultural barriers in Old River, Middle River and Grant Line Canal tended to shift some of the particle fate between the SWP pumping and CVP pumping. For Vernalis and Old River at Middle River injection locations, both of which are upstream of the SWP and CVP exports, removing the barriers shifted some particle fate from the SWP to the CVP with a net small change in overall particle fate. For the other injection locations, all of which are downstream of the barriers and the SWP and CVP exports, removing the barriers shifted some particle fate from the CVP to the SWP, again with a relatively small net change in combined portions of particles lost to CVP and SWP exports.

10.4.3 Period Average PTM Results for Historical Conditions

The interaction between location of particle injection, SWP pumping, San Joaquin River inflow, and the portion of injection particles entrainment by SWP and CVP exports, diverted by Delta agriculture, and moving out of the Delta past Chipps Island can be better seen in Figure 10.6. Particles injected in Old River at STA915 have approximately the same fate as those injected in Middle River at SFCut. The same holds for the fate of particles injected in the San Joaquin River at STA910 compared to Old River at STA902 and the fate of particles injected in the San Joaquin River at STA815 and STA906. Compared to the fate of particles injected elsewhere, the fate of the particles injected at Old River at Middle River is fairly insensitive to Delta hydrology. At this injection location, few particles move past Chipps and only shift somewhat from CVP

entrainment to SWP entrainment when exports decreased and San Joaquin River inflow increased.

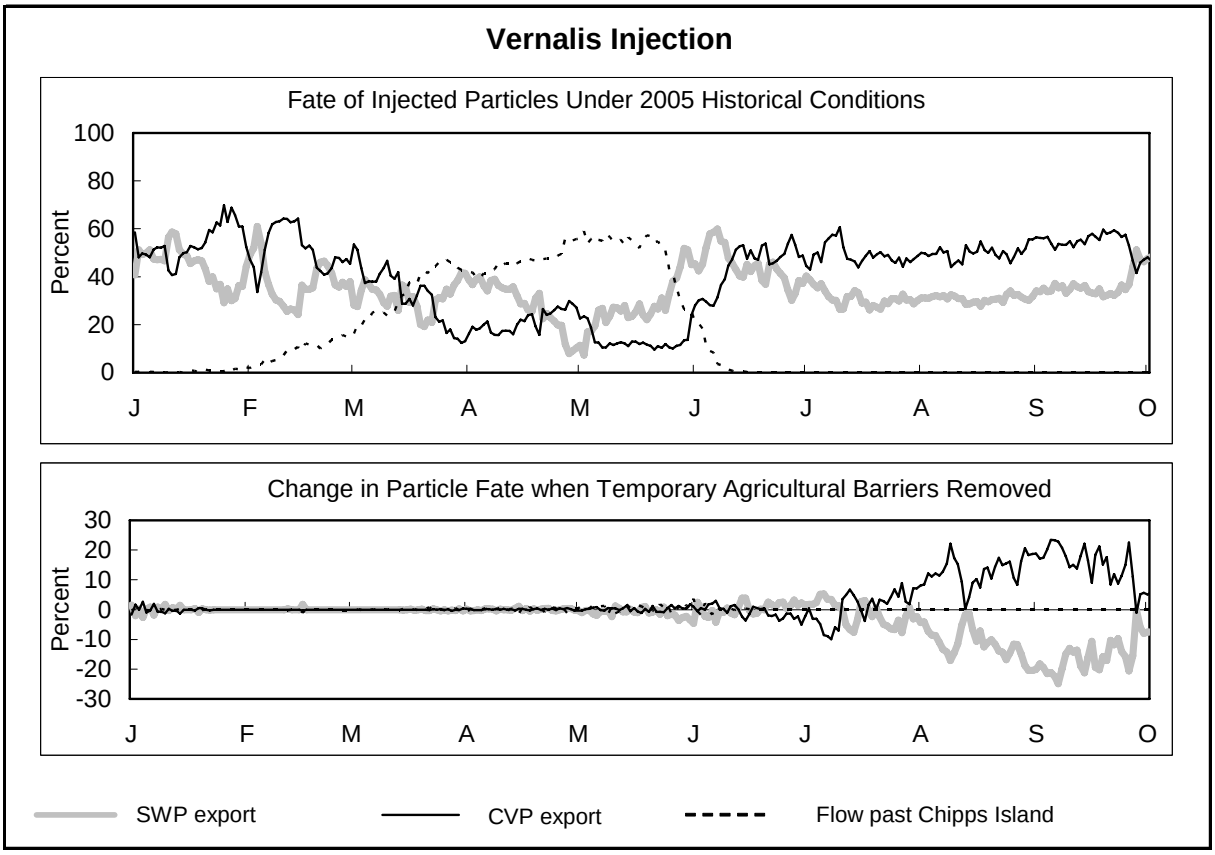

Figure 10.5: Daily PTM results for historical and modified 2005 conditions, variable locations of injections.

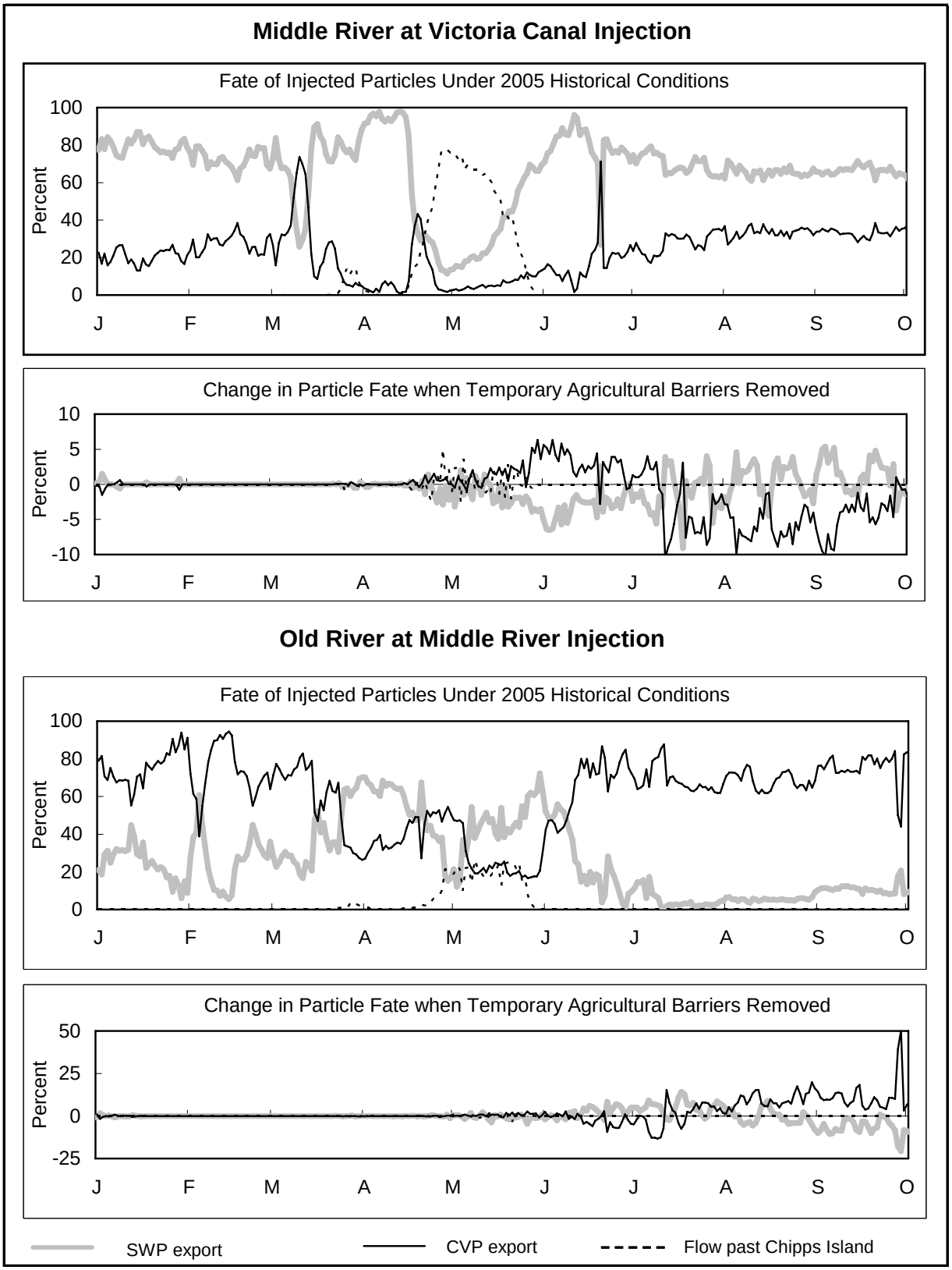

Figure 10.5 (cont.): Daily PTM results for historical and modified 2005 conditions, variable locations of injections.

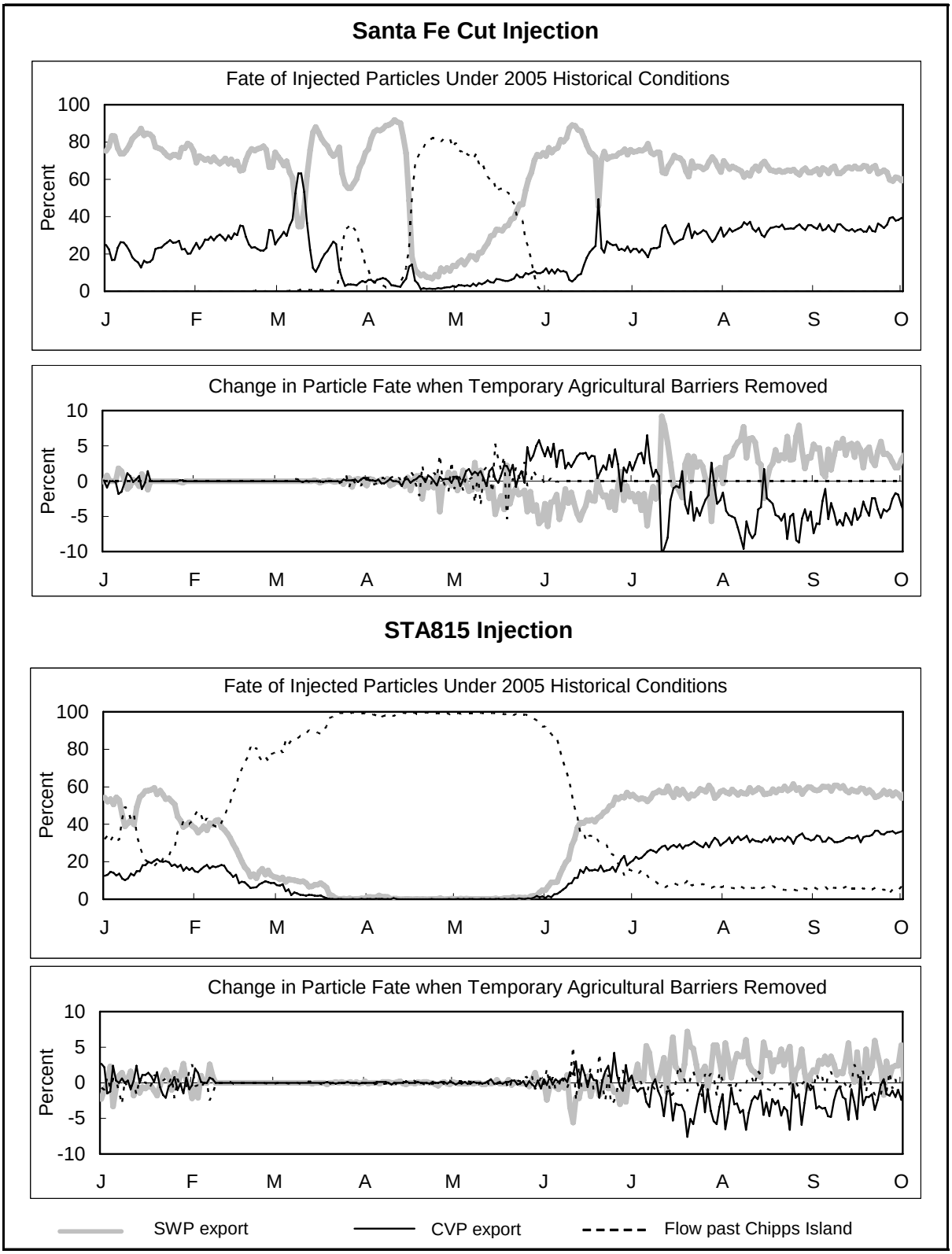

Figure 10.5 (cont.): Daily PTM results for historical and modified 2005 conditions, variable locations of injections.

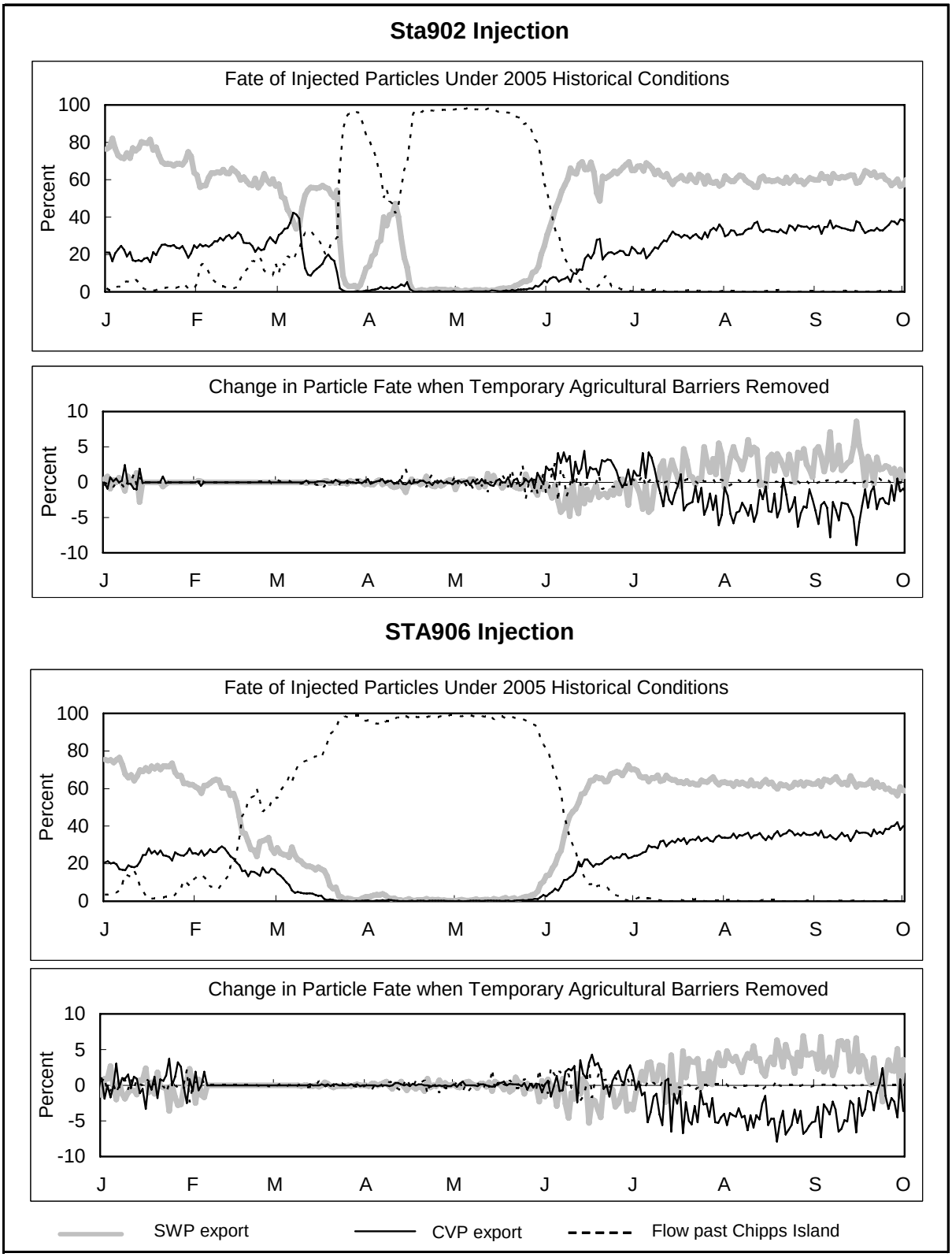

Figure 10.5 (cont.): Daily PTM results for historical and modified 2005 conditions, variable locations of injections.

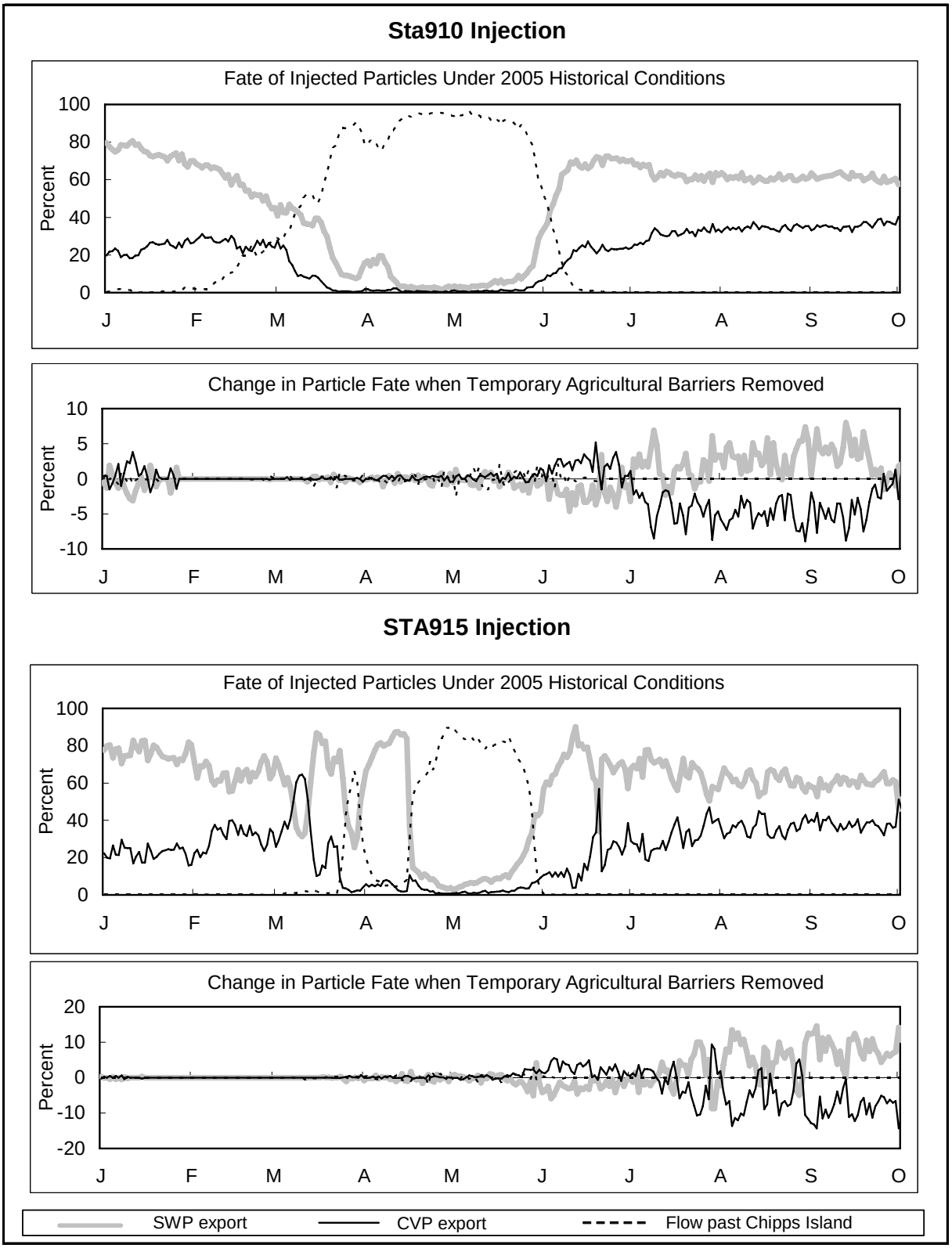

Figure 10.5 (cont.): Daily PTM results for historical and modified 2005 conditions, variable locations of injections.

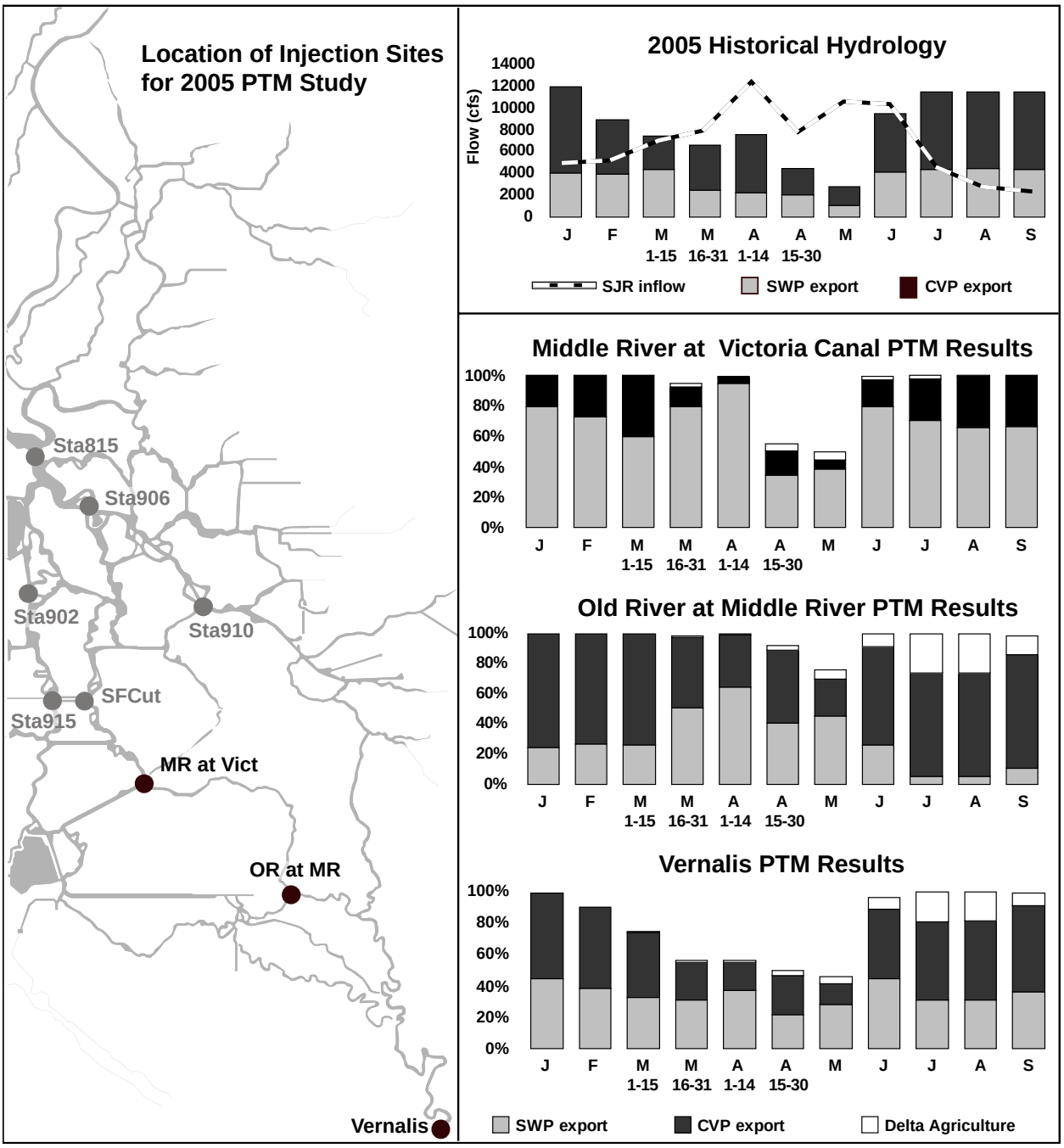

Figure 10.6: PTM results per injection location averaged over time intervals.

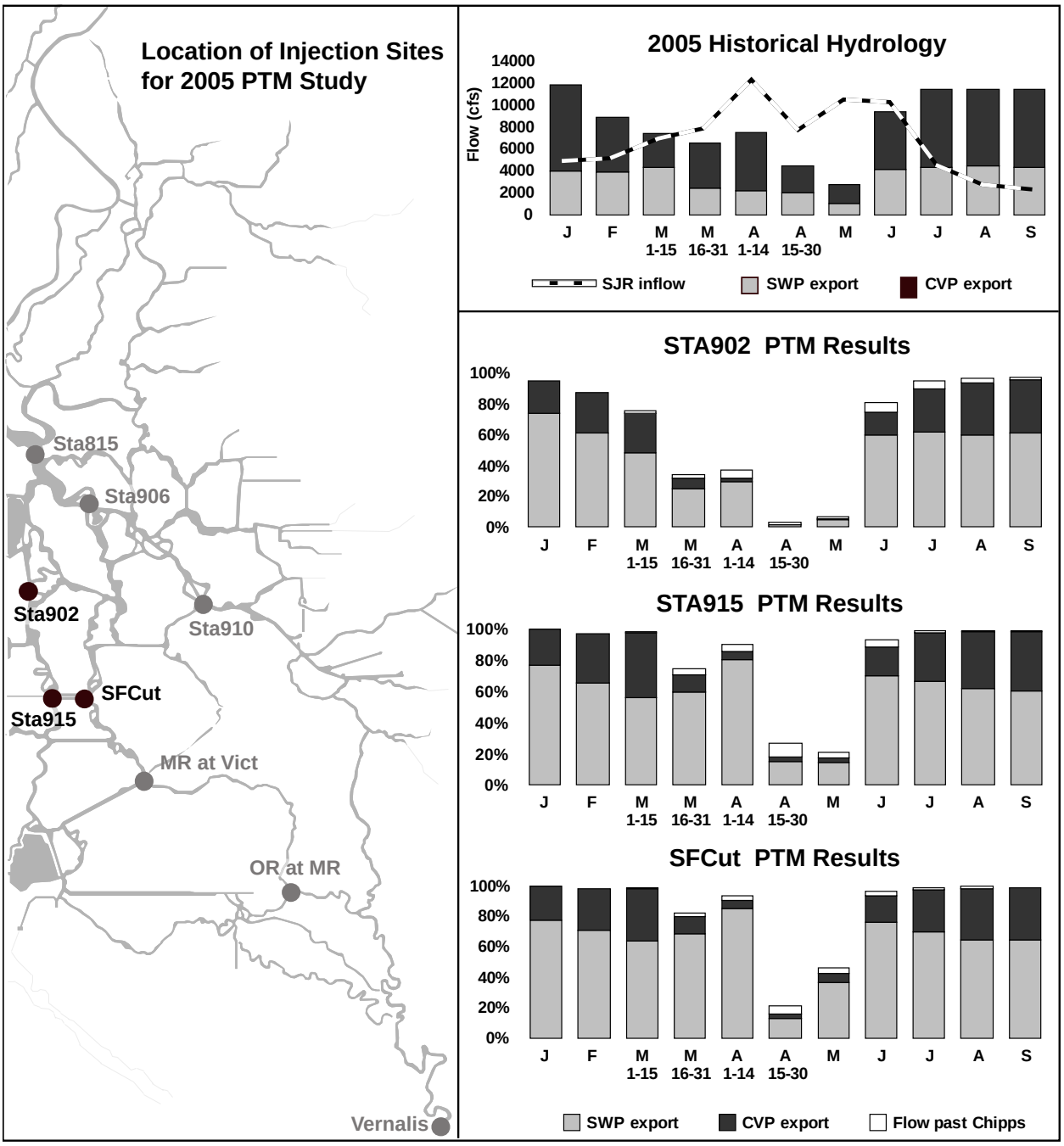

Figure 10.6 (cont.): PTM results per injection location averaged over time intervals.

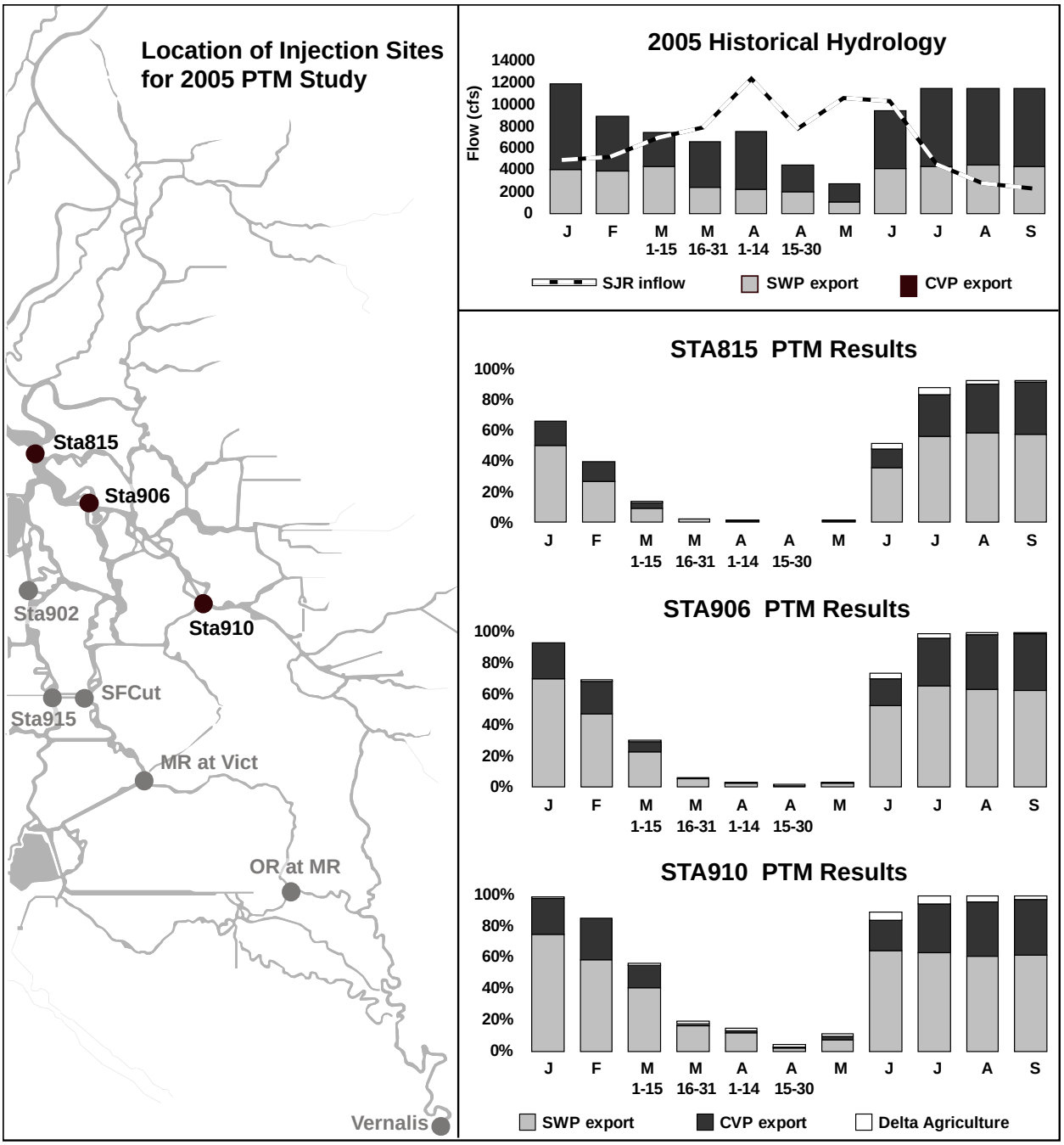

Figure 10.6 (cont.): PTM results per injection location averaged over time intervals.

10.5 Summary and Conclusions

PTM-generated particle fate has promise as an index of the potential for fish entrainment by the SWP. Two areas of interest which could be investigated in the future are varying the time duration over which particle fate is determined (i.e. shortening the 90-day criteria) and attempting to relate salvage to fate weighted by location of injection. If an index for fish entrainment potential is to be generated from particle tracking simulations, it appears that the index needs to be based upon multiple injection locations and be daily. As can be expected, the higher the San Joaquin River inflows, the lower the SWP and CVP pumping, and the further downstream the injection location, the greater the portion of injected particles move out of the Delta past Chipps Island. The installation of the three temporary barriers for agricultural diverters does not appear to strongly affect the fate of particles injected outside of the area affected by the barriers. The fate of particles injection upstream of the agricultural barriers sites tends to shift somewhat from removal by SWP exports to removal by CVP exports when barriers are not installed, but more injection locations and different hydrologic conditions need to be investigated in order to draw any strong conclusions. For locations downstream of the agricultural barriers, injected particles tend to either pass by Chipps Island or be entrained by SWP, depending upon the Delta hydrology.

10.6 References

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