Effect of South Delta Exports on the Transport of Zooplankton in Eastern and Central Delta

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Overview

This technical memorandum documents the analysis performed to evaluate the effect of South Delta exports on the transport of zooplankton in the Delta. The objective of the analysis is to verify if the zooplankton originating in the eastern and central Delta channels are transported to the Suisun Bay during the June through September period by evaluating the impact of SWP and CVP delta pumping on particle movement and fate. An additional objective is to determine whether Suisun Marsh and/or Cache Slough zooplankton may be contributing to Suisun Bay populations during this period. The DSM2 Particle Tracking Model (PTM) and fingerprinting analysis using the DSM2-QUAL model were utilized to simulate Delta flows, particle movement (analogous for zooplankton), entrainment, and fate in the Delta.

Methodology

DWR provided CH2M HILL with the DSM2 historical simulation spanning the period of October 2001 through September 2010. This simulation was used as a base simulation from which other scenarios were developed.

The selected scenarios include exports ranging from observed "historical exports" to "no exports" as bookends to evaluate the particle transport and fate. The simulated scenarios are:

1. Historical hydrology, operations, and south Delta SWP and CVP exports ("historical exports")
2. Historical hydrology, operations, but no south Delta SWP and CVP exports ("no exports")
3. Historical hydrology, operations, but south Delta SWP and CVP exports limited to 50% of the Delta inflow ("reduced exports")

The limited exports in the third scenario are calculated as the minimum of one-half of the total Delta inflow and "historical exports". The Delta inflow includes the inflows of Sacramento River, San Joaquin River, Mokelumne River, Cosumnes River, Calaveras River, and Yolo Bypass.

DSM2-PTM

The DSM2-PTM simulates pseudo 3-dimesional transport of neutrally buoyant particles based on the flow field simulated by the HYDRO model. The PTM module simulates the transport and fate of individual particles traveling throughout the Delta. The model uses geometry files, velocity, flow, and stage output from the HYDRO module to monitor the location of each individual particle using assumed vertical and lateral velocity profiles and specified random movement to simulate mixing. The PTM has multiple applications ranging from visualization of flow patterns to simulation of discrete particles to approximate transport of organisms such as fish eggs and zooplankton.

Through the particle tracking modeling analysis, particles released into the Delta are tracked in space and time as they are transported via ambient currents driven by tides, river inflows, and diversions. For each scenario, the DSM2 PTM was simulated for 20 selected representative periods that included five each of June, July, August, and September months. Four thousand (4000) particles were inserted at each of the 39 locations identified below in Table 1 and Figure 1, over one tidal day. The inserted particles were then tracked over a 60 day period to determine their fate. Figure 1 also shows the Delta locations where the particles were tracked (green lines).

Table 1. List of Particle Insertion Locations for Fate Computation

Location	DSM2 Node
San Joaquin River at Vernalis	1
San Joaquin River at Mossdale	7
San Joaquin River D/S of Rough and Ready Island	21
San Joaquin River at Buckley Cove	25
San Joaquin River near Medford Island	34
San Joaquin River at Potato Slough	39
San Joaquin River at Twitchell Island	41
Old River near Victoria Canal	75
Old River at Railroad Cut	86
Old River near Quimby Island	99
Middle River at Victoria Canal	113
Middle River u/s of Mildred Island	145
Grant Line Canal	174
Frank's Tract East	232
Threemile Slough	240
Little Potato Slough	249
Mokelumne River d/s of Cosumnes confluence	258
South Fork Mokelumne	261

Location	DSM2 Node
Mokelumne River d/s of Georgiana confluence	272
North Fork Mokelumne	281
Georgiana Slough	291
Miner Slough	307
Sacramento Deep Water Ship Channel	314
Cache Slough at Shag Slough	321
Cache Slough at Liberty Island	323
Lindsey slough at Barker Slough	324
Sacramento River at Sacramento	330
Sacramento River at Sutter Slough	339
Sacramento River at Ryde	344
Sacramento River near Cache Slough confluence	350
Sacramento River at Rio Vista	351
Sacramento River d/s of Decker Island	353
Sacramento River at Sherman Lake	354
Sacramento River at Port Chicago	359
Montezuma Slough near National Steel	420
Montezuma Slough at Suisun Slough	428
San Joaquin River d/s of Dutch Slough	461
Sacramento River at Pittsburg	465
San Joaquin River near Jersey Point	469

The release locations were grouped into distinct regions in the Delta to assist in the interpretation and presentation of model results as shown in Figure 1. The regions include:

1. Cache Slough
2. Central Delta
3. Mokelumne and Cosumnes Rivers
4. Old and Middle River Corridor
5. Upper Sacramento River
6. Upper San Joaquin River
7. Western Delta
8. Suisun Marsh

For this analysis only the eastern Delta regions are considered. The regions considered for this analysis include Central Delta, Mokelumne and Cosumnes Rivers, Old and Middle River Corridor, and Upper San Joaquin River.

PTM Period Selection

The PTM simulation periods for particle fate computations were selected based on the Delta inflows and the exports from the DSM2 historical conditions boundary flow time series. A two-pronged approach was used to identify the particle insertion periods such that the selected periods cover the entire range of hydrology and also represent full range of export operations that occurred in the 10-year simulation period (2001-2010). Representative periods with various combinations of total inflow and exports were identified over the range of flows. Total Delta inflow was computed using Calaveras River, Cosumnes River, Mokelumne River, Sacramento River, Yolo, and Vernalis flows. Total exports were computed including the SWP and CVP export flows.

The Delta inflow distribution during June through September months show high variability in June and July and less variability during August and September months, as shown in Figure 2. The export distribution shows a relatively steady pattern regardless of inflow variability during these months.

Therefore, selection of PTM periods was first based on the range of inflows and second on the range of exports. Inflows were ranked and the percent exceedance of each month's inflow value was calculated (June to September). For the same season, the exports were selected to cover the 10 % to 90% exceedance range for both inflows and exports. The periods corresponding approximately to 10%, 30%, 50%, 70% and 90% exceedance values were selected. The selected periods are shown in Table 2.

The water year type is considered as an indicator of Delta hydrologic conditions. Table 3 shows the water year types of the selected PTM periods. As shown in Table 3, half of the selected periods occur in Dry and Critical years, one-quarter occur in Above Normal and Below Normal year types, and one-quarter in Wet years.

Fingerprinting Analysis

For each scenario, source water fingerprinting was simulated using the DSM2-QUAL model for the 2001 to 2010 period. The flow originating from the rivers in the eastern Delta, namely Mokelumne, Cosumnes and Calaveras is tracked in the western Delta downstream of the Sacramento and San Joaquin River confluence over the entire simulation period.

Table 2. Summary of Selected Periods for PTM Analysis using Historical Inflows and Exports from 2001 to 2010 Period

Year	Water Year Type	Selected Months			
		Jun	Jul	Aug	Sep
2001	Dry	√	√	√	
2002	Dry		√	√	√
2003	Above Normal		√		√
2004	Below Normal	√			
2005	Above Normal			√	
2006	Wet	√	√	√	√
2007	Dry		√	√	
2008	Critical	√			
2009	Dry				√
2010	Below Normal	√			√

Table 3. Number of PTM Periods Selected by Water Year Type

Water Year Type	Water Year Classification	Number of PTM Periods	Total Number of PTM Periods
Dry	Dry	9	10
	Critical	1	
Normal	Below Normal	3	6
	Above Normal	3	
Wet	Wet	4	4

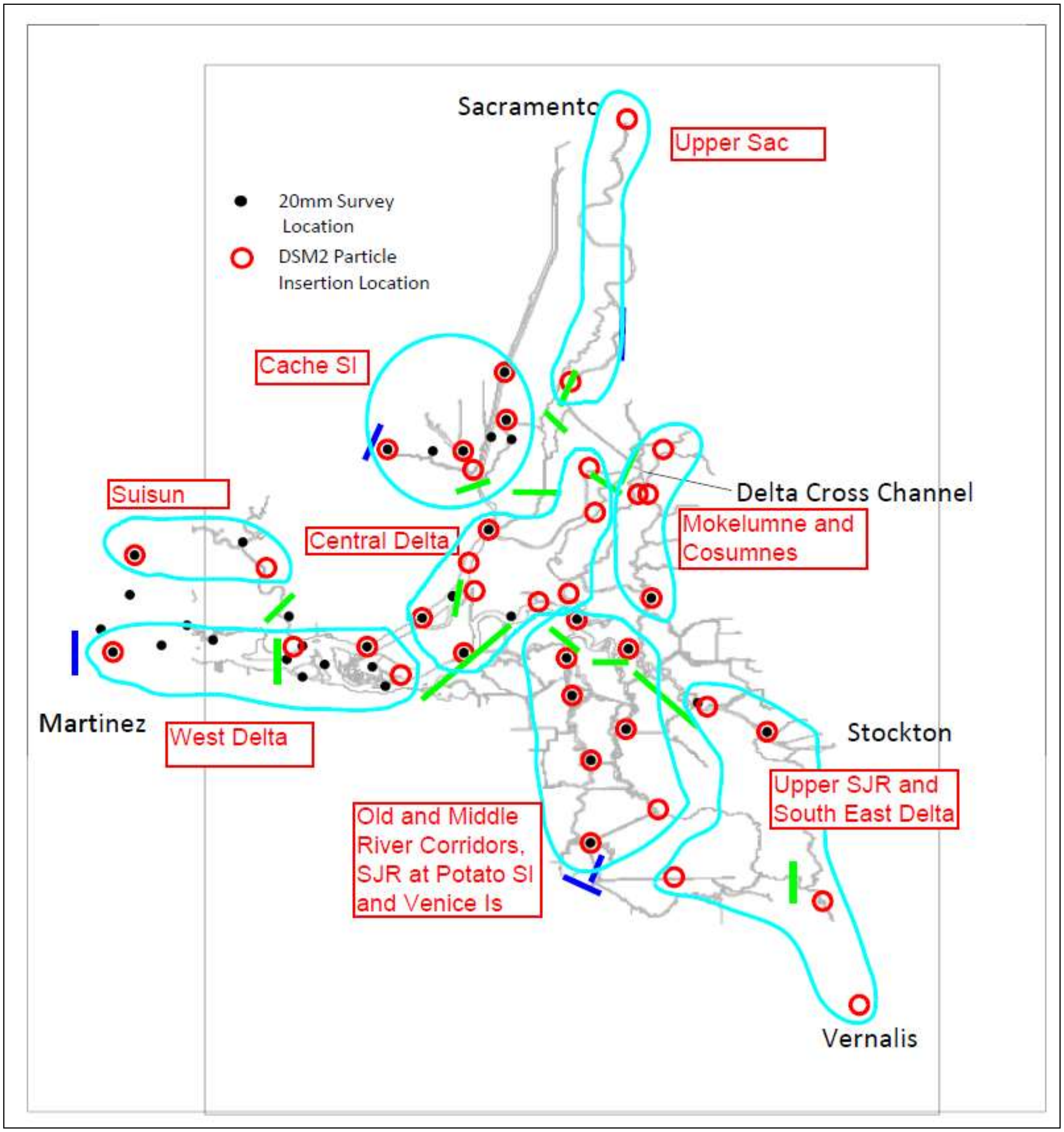


Figure 1. Grouping of 39 Particle Release Locations into Eight Delta Regions.

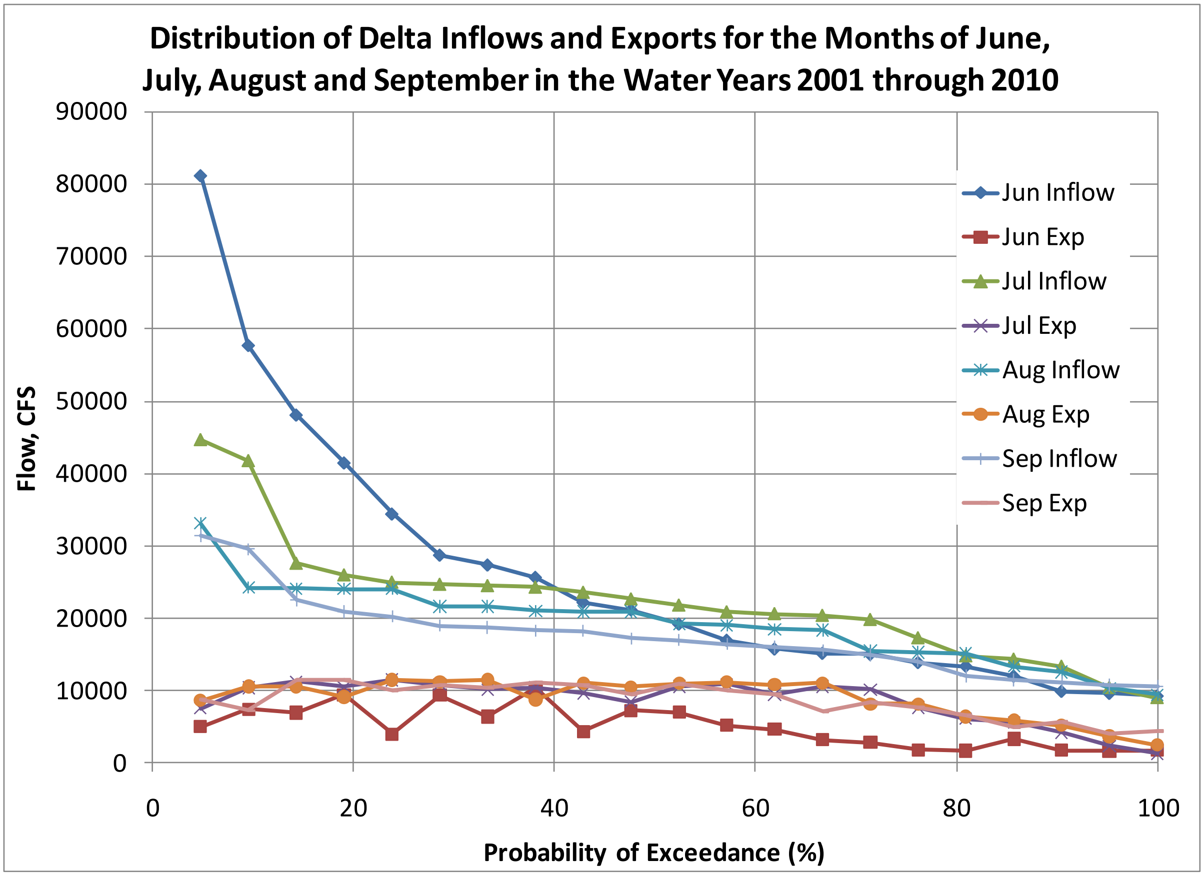


Figure 2. Delta Inflow and Exports Distribution for the Months from June to September for the period from 2001 to 2010

Modeling Results and Discussion

The modeling results from the particle transport and fate analysis and the fingerprinting analysis are presented in this section. The modeling results are presented and discussed below in relation to the study objectives. The first objective is to verify if particles (zooplankton) originating in the eastern and central Delta channels are transported to the Suisun Bay during the June through September months with and without SWP and CVP exports in the south Delta. The second objective is to determine whether Suisun Marsh and/or Cache Slough zooplankton may be contributing to the Suisun Bay populations during this period.

Analysis of Particle Transport from Eastern and Central Delta Regions to Suisun Region

The results discussion focused on evaluating the movement of particles inserted in the eastern and central Delta regions to the Suisun Region. The Chipps Island location in the western Delta was selected as the representative location for measuring whether particles were transported to the Suisun Region. The total particles travelling past Chipps Island in the Sacramento River and entering Suisun Marsh channels via Montezuma Slough are reported at the end of 15, 30, 45 and 60 days. Graphical and tabular summaries are provided to summarize the results of the analysis. The results for “historical exports” and “no exports” scenarios are presented together to show the range of particle transport for the two export scenarios.

Regional Trends

The average percent of particles reaching the Suisun region for the two scenarios are summarized for the particles inserted in the eastern Delta regions at the end of 15, 30, 45 and 60 day tracking periods in Figure 3. Both the “historical exports” and “no exports” scenarios show that particles originating in the eastern and central Delta regions reach the Suisun region. However, the “no exports” scenario shows significantly more particles in the Suisun region than the “historical exports” scenario at the end of 30, 45 and 60 days. At the end of 15 days, the differences in transport to the Suisun Region between scenarios is less than 10% for upper San Joaquin River and southeast Delta, OMR Corridors and Mokelumne and Cosumnes regions. Particles originating in the central Delta, Mokelumne and Cosumnes and OMR corridors regions show significantly higher percentage in the Suisun Region for both scenarios, but are more than 30% higher in the “no exports” scenario. The particles originating from the upper San Joaquin and southeast Delta regions show lowest percent of particles reaching the Suisun Region in both the scenarios.

Table 4 shows the progress of particles transported to Suisun region from the easter Delta locations at different tracking periods. Particles inserted at various Delta locations reach Suisun region at different rates as shown in Table 4 and Figure 4. Except for the Central Delta Region, “historical exports” and “no exports” scenarios show similar levels of particle transport at the end of 15 days. Under the “historical exports”, particle transport does not change significantly with time. Conversely, with “no exports” particles transport increases significantly after 30 days.

Temporal Analysis of Particle Transport (by month and Water Year Type)

A detailed analysis of particle transport at selected time intervals is provided in the following discussion. Results are presented by month to evaluate monthly trend. Also, results are presented by water year to evaluate hydrologic conditions effects.

Particle Transport at the End of 15 Day Period

The average percent of particles going past Chipps Island and entering Suisun Marsh region are summarized for the particles inserted in the four eastern and central Delta Regions by month. Particles originating from Central Delta reach Chipps and Suisun locations at levels higher than other eastern regions as shown in Figure 5. About 10% of the particles originating in the eastern regions reach Suisun region, except for those inserted in the Central Delta in July, August and September months, in the “no exports” scenario. However, none of the particles originating in these regions make it in the “historical exports” scenario.

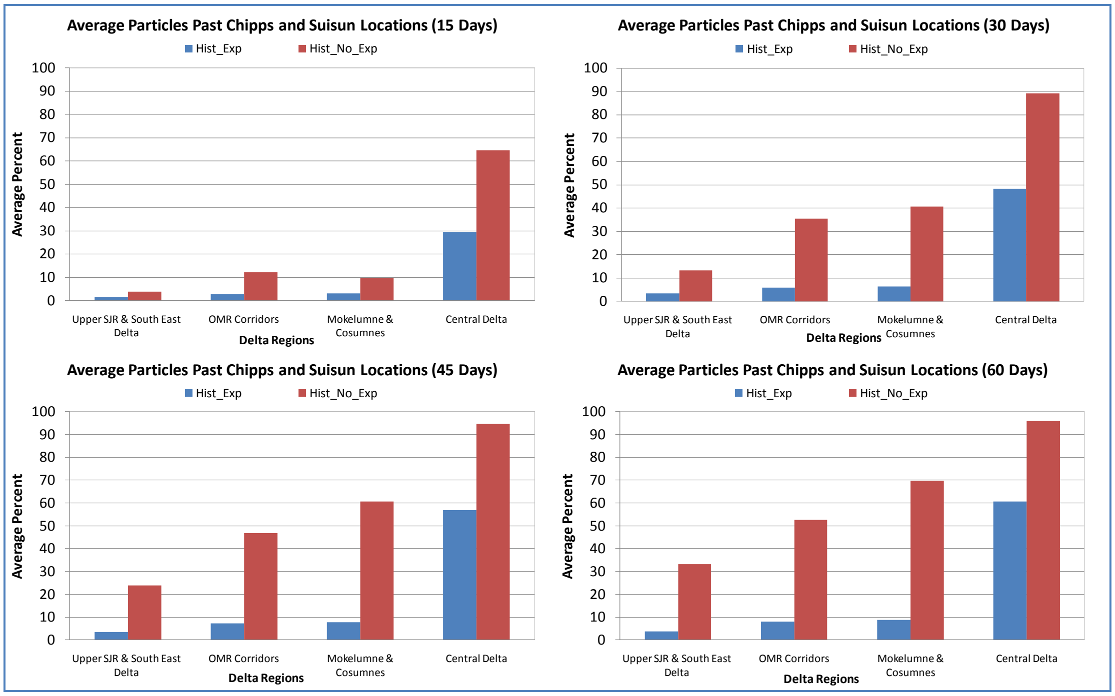


Figure 3. Average Percent of Particles Reaching Suisun Region from Eastern Delta Regions at the end of 15, 30, 45 and 60 Day Periods for the Historical exports and No Exports Scenarios

Table 4. Summary of the Average Percent Particles Reaching Suisun Region from the Regions in Eastern Delta

Delta Region	Tracking Period	Historical Exports	No Exports
Central Delta	15 Day	29.23	63.71
	30 Day	47.88	87.99
	45 Day	56.02	93.22
	60 Day	59.78	94.51
Mokelumne and Cosumnes	15 Day	3.19	9.67
	30 Day	6.26	39.97
	45 Day	7.71	59.45
	60 Day	8.55	68.21
OMR Corridors with San Joaquin	15 Day	2.82	12.05
	30 Day	5.83	34.85
	45 Day	7.19	45.99
	60 Day	7.83	51.56
Upper San Joaquin and South East Delta	15 Day	1.68	3.76
	30 Day	3.27	13.01
	45 Day	3.53	23.33
	60 Day	3.61	32.52

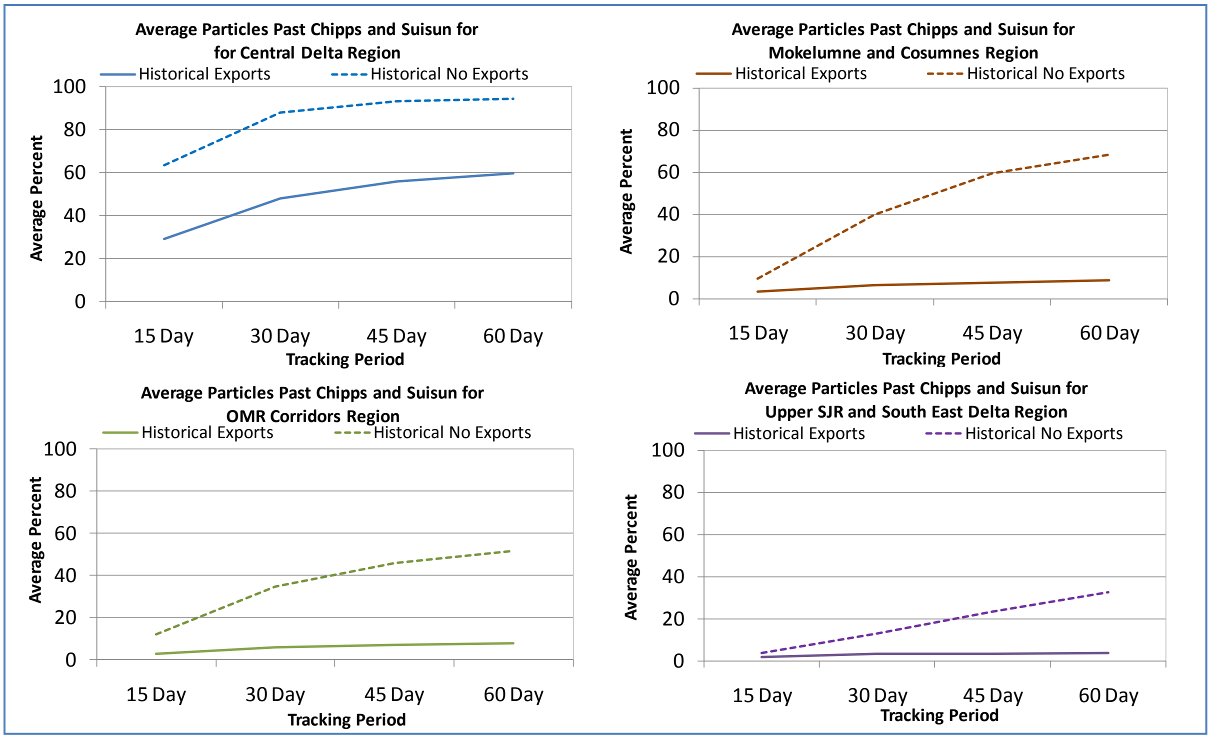


Figure 4. Progress of Particles Originating from Eastern Delta Regions Reaching Suisun Region at 15, 30, 45, and 60 days for the Historical Exports Scenario and the No Exports Scenario

Hydrologic conditions affect particles transport significantly, especially under the "historical exports" scenario. As shown in Figure 6, only wet conditions cause particles originating from Mokelumne and Cosumnes, OMR Corridors, and Upper SJR regions to reach Suisun region at significant levels at the end of 15 days.

Particle Transport at the End of 30 Day Period

As shown in Figure 7, about 10% of the particles originating in the upper SJR region reach Suisun region by the end of 30 day period in July, August and September months in the no exports scenario whereas for the "historical exports" scenario the particles show up in the Suisun region only in June. The results are similar for the "historical exports" scenario for Mokelumne and Cosumnes region and the OMR corridors region, although the "no exports" scenario shows more than 30% particles show up in the Suisun region by the end of 30 days. Figure 8 shows no particles from Upper SJR region reach Suisun region in dry and less than 10% particles in normal years for the "no exports" scenario and no particles make it to the Suisun region in the "historical exports" scenario for dry and normal years. Both scenarios show particles reaching the Suisun region in the wet years, although "no exports" scenario has significantly high percent than the "historical exports" scenario. Particles from the other regions in the eastern Delta reach Suisun region in all the year types by the end of 30 day period.

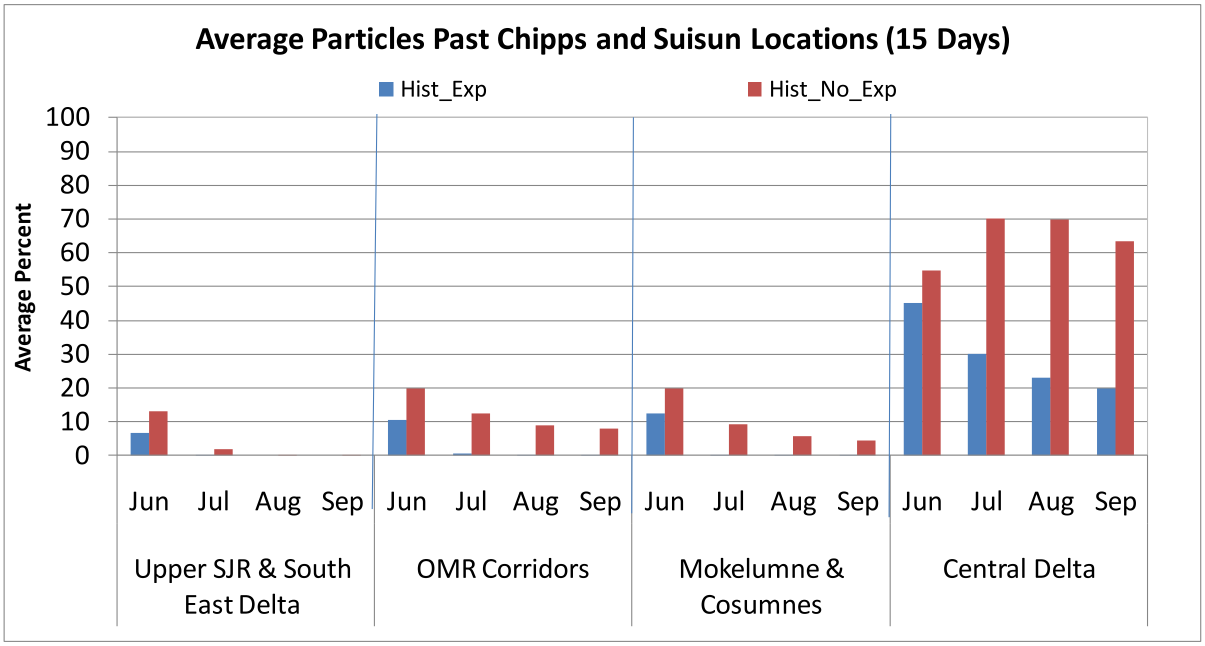


Figure 5. Average Percent of Particles Reaching Suisun Region for Particles Originating from Eastern Delta Regions by Month at the End of 15 Days for the Historical Exports Scenario and the No Exports Scenario

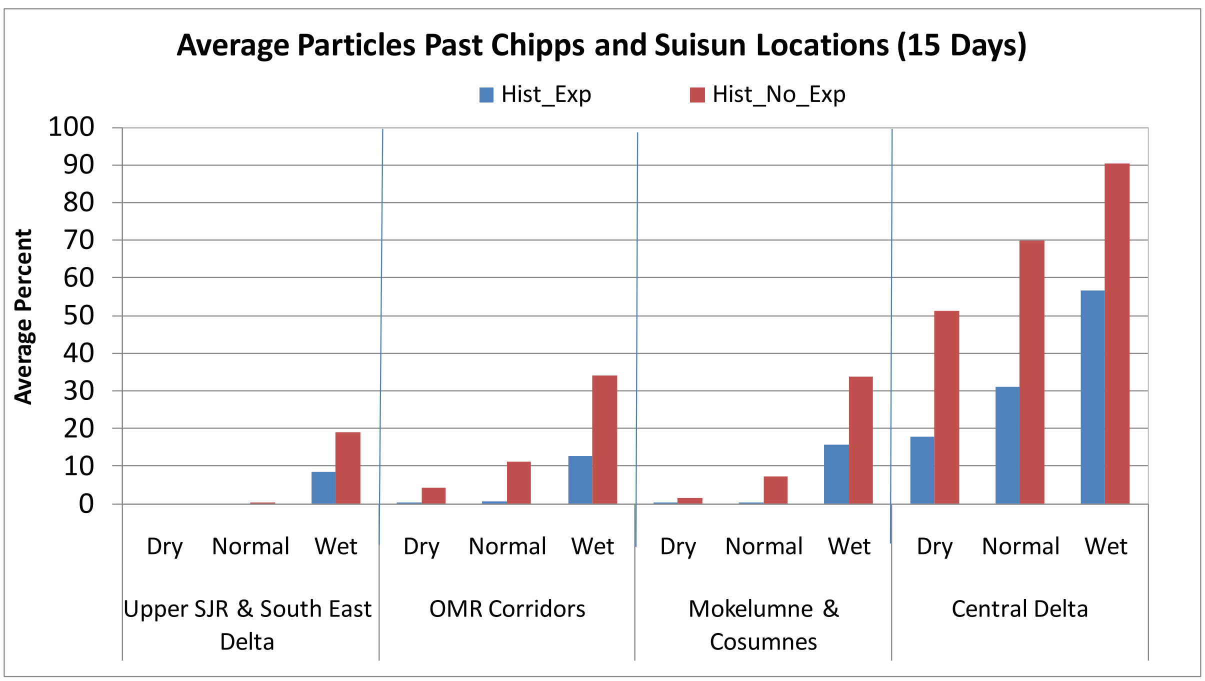


Figure 6. Average Percent of Particles Reaching Suisun Region for Particles Originating from Eastern Delta Regions by Water Year Type at the End of 15 Days for the Historical Exports Scenario and the No Exports Scenario

Particle Transport at the End of 45 Day Period

Figures 9 and 10 show the average percent of particles reaching Suisun region from the eastern Delta regions at the end of 45 days by month and by water year type, respectively. The trends for particles transport is the same as the previous periods (15 day and 30 day) for the "historical exports" scenario. "No exports" scenario shows particles reaching Suisun region from all the eastern Delta regions in June through September months and in all year types by the end of 45 days. Particles from Upper SJR Region show up in the Suisun region even for the Dry years at the end of 45 day under the "no exports" scenario.

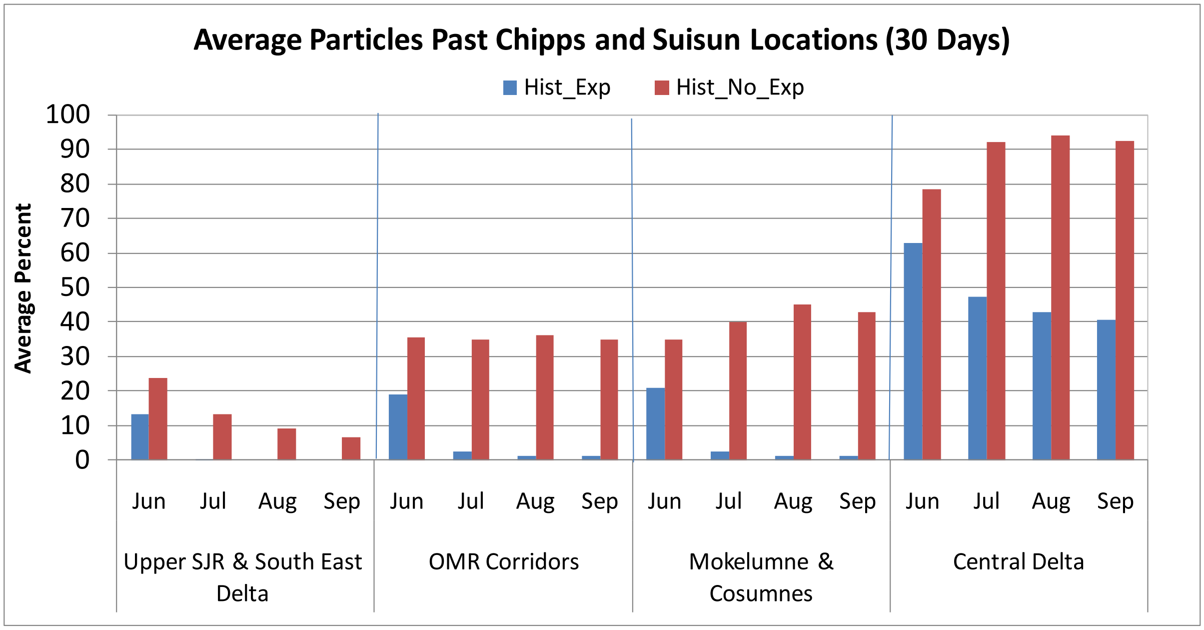


Figure 7. Average Percent of Particles Reaching Suisun Region for Particles Originating from Eastern Delta Regions by Month at the End of 30 Days for the Historical Exports Scenario and the No Exports Scenario

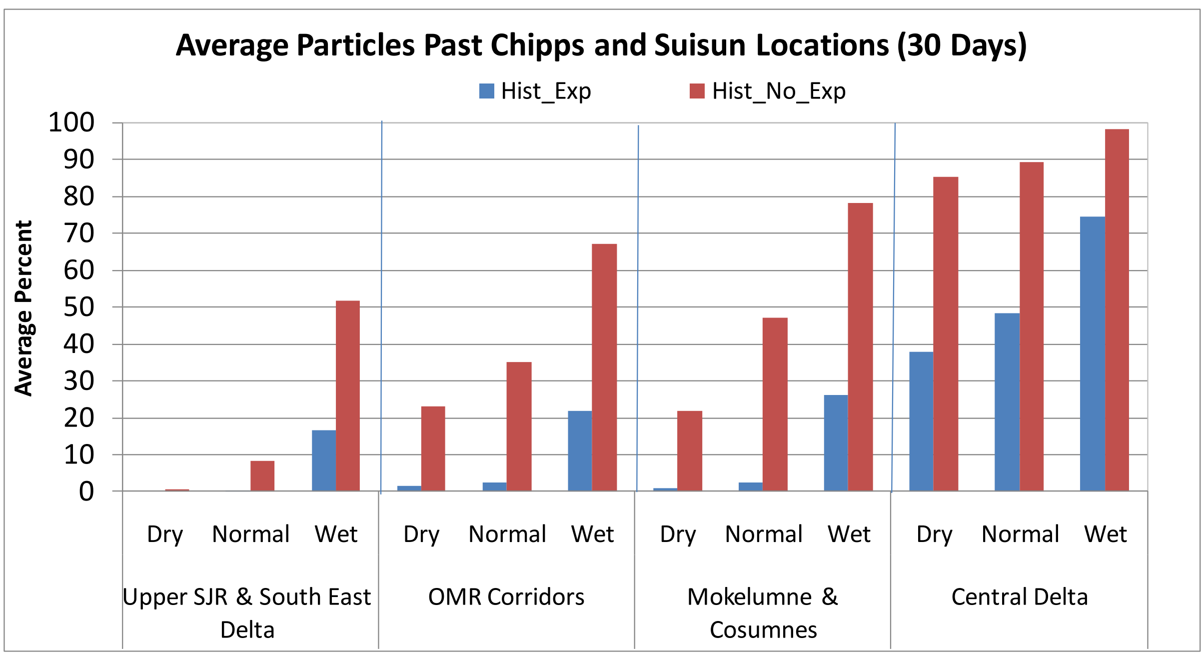


Figure 8. Average Percent of Particles Reaching Suisun Region for Particles Originating from Eastern Delta Regions by Water Year Type at the End of 30 Days for the Historical Exports Scenario and the No Exports Scenario

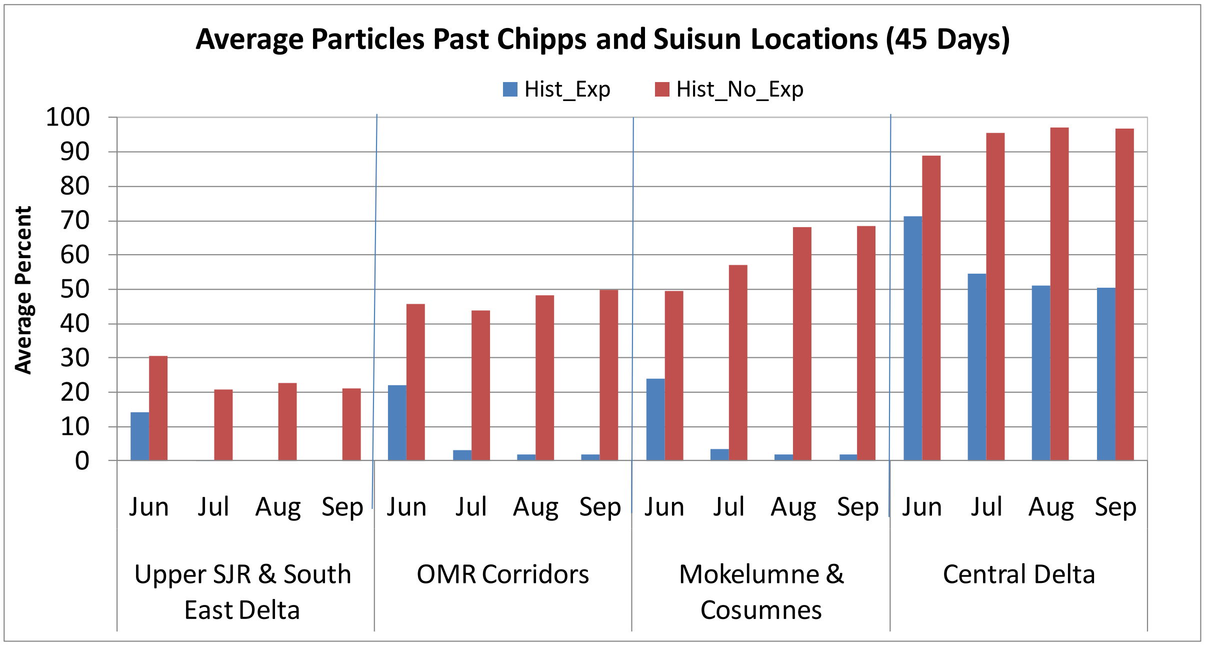


Figure 9. Average Percent of Particles Reaching Suisun Region for Particles Originating from Eastern Delta Regions by Month at the End of 45 Days for the Historical Exports Scenario and the No Exports Scenario

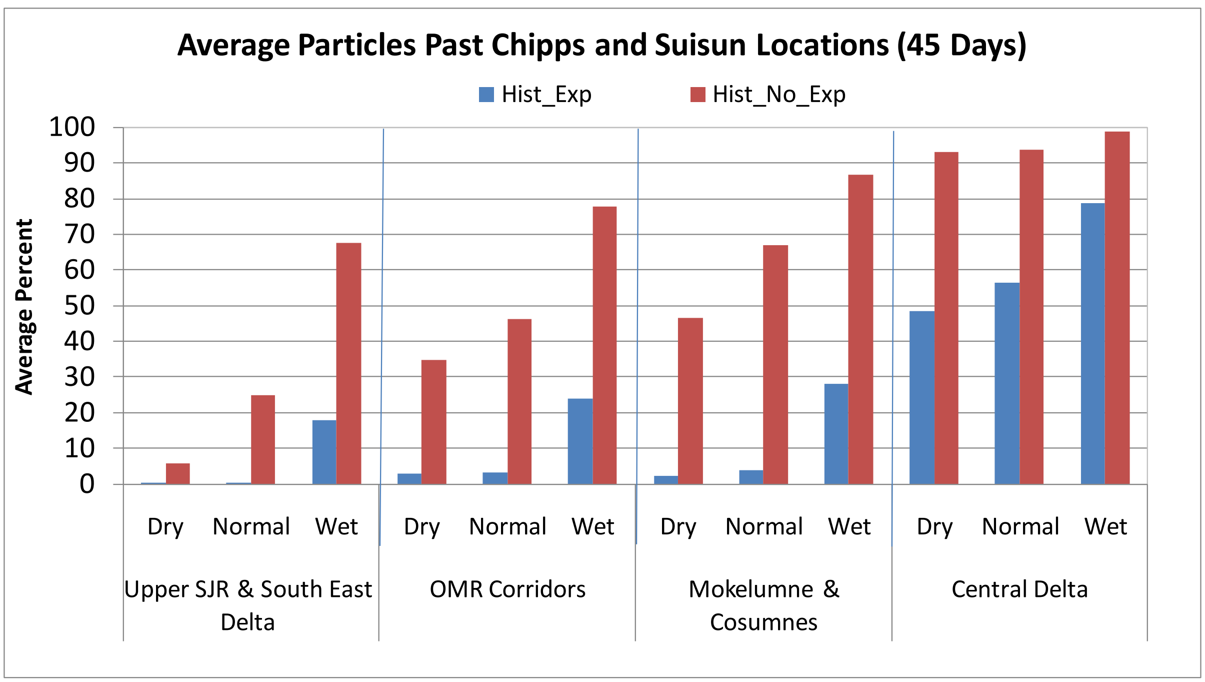


Figure 10. Average Percent of Particles Reaching Suisun Region for Particles Originating from Eastern Delta Regions by Water Year Type at the End of 45 Days for the Historical Exports Scenario and the No Exports Scenario

Particle Transport at the End of 60 Day Period

For the "no exports" scenario, all regions show a higher percent of particles from the eastern Delta regions show up in the Suisun region during June to September months and all year types at the end of 60 days. For the "historical exports" scenario the results show similar trend as the 45 day results as shown in Figure 11. Particles transport per water year type show similar trends as for the 45 day case as shown in Figure 12.

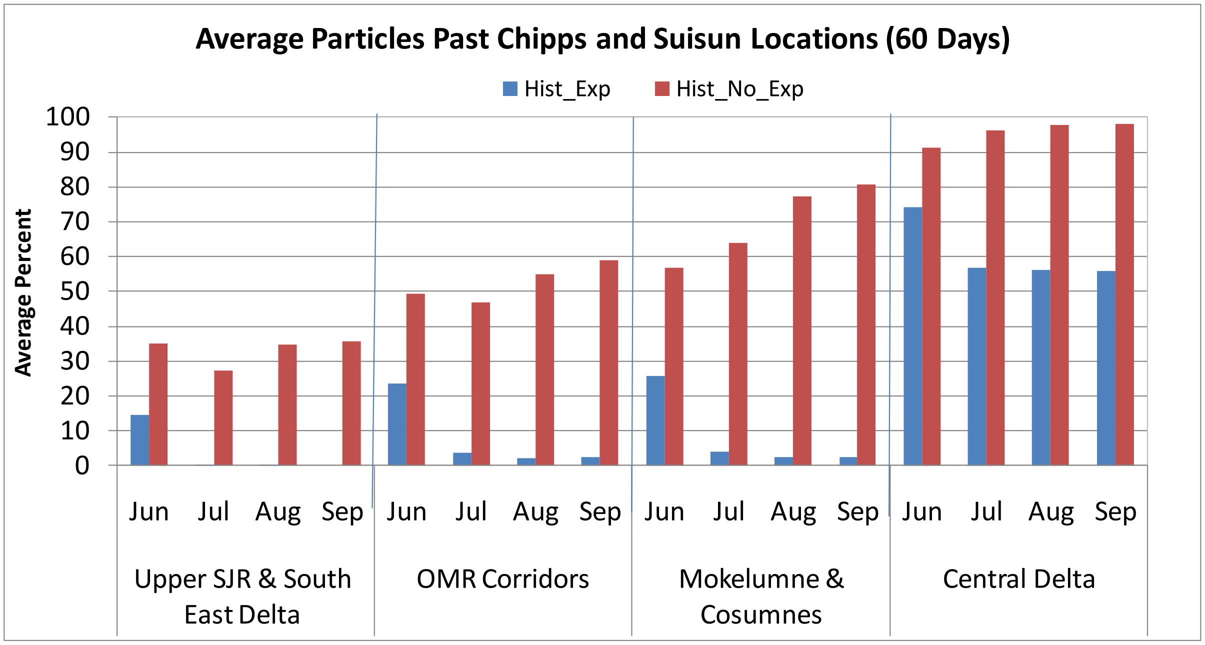


Figure 11. Average Percent of Particles Reaching the Suisun Region for Particles Originating from Eastern Delta Regions by Month at the End of 60 Days for the Historical Exports Scenario and the No Exports Scenario

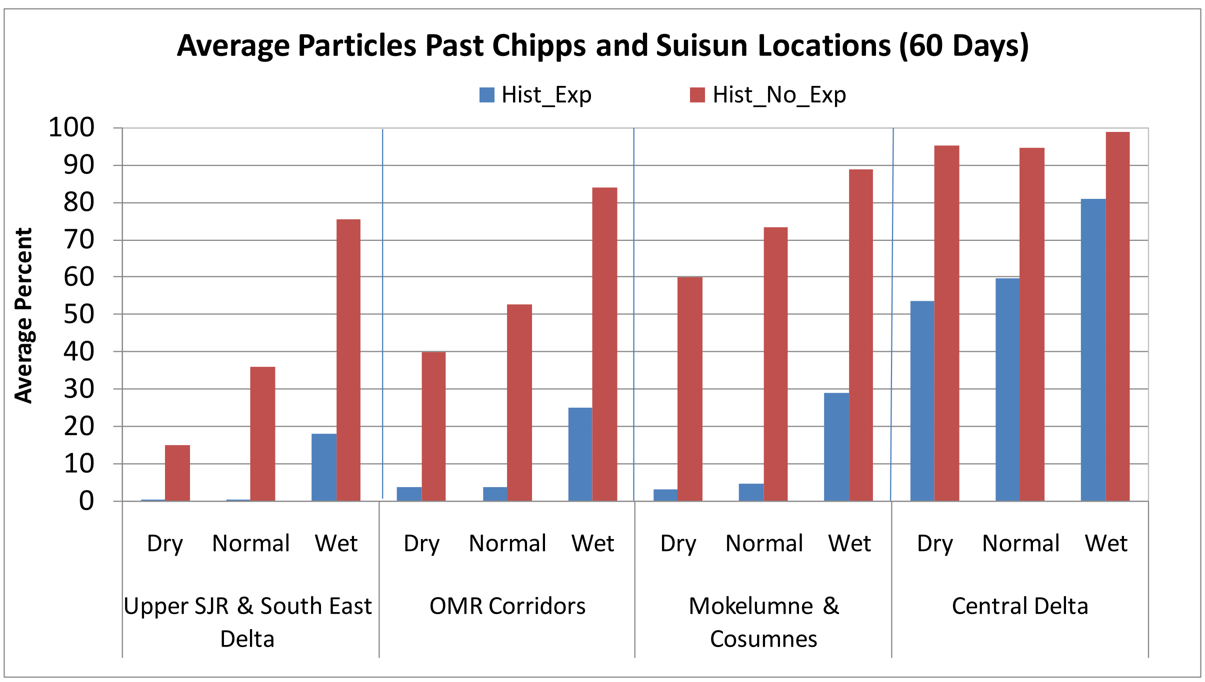


Figure 12.Average Percent of Particles Reaching the Suisun Region for Particles Originating from Eastern Delta Regions by Water Year Type at the End of 60 Days for the Historical Exports Scenario and the No Exports Scenario

Figures 13 and 14 show the percent of particles going past the Chipps Island from the 39 release locations at the end of 30 day period for a dry (August 2001) and a wet (June 2006) period, respectively. Under the dry period, none of the particles released east of OMR corridor go past the Chipps Island in the "historical exports" and the "no exports" scenarios. For wet conditions particles inserted in eastern Delta reach Chipps Island in both the scenarios, although at lower percents in the "historical exports" scenario compared to the "no exports" scenario.

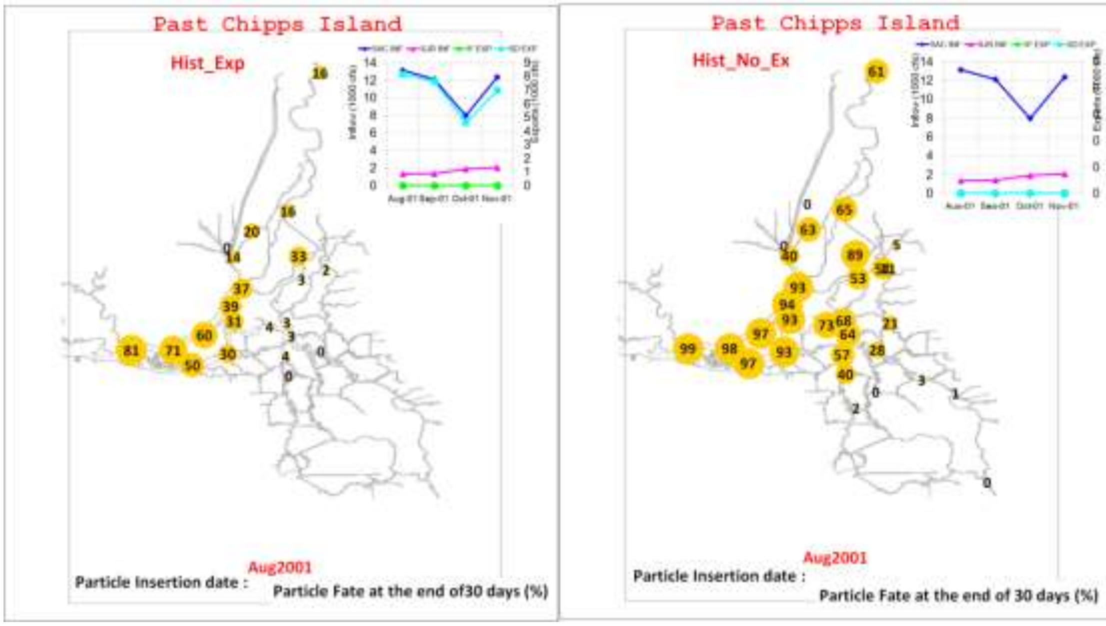


Figure 13. Percent of Particles Going Past Chipps Island for a Dry Period at the End of 30 Day Period (Aug 2001) for the Historical Exports Scenario and the No Exports Scenario

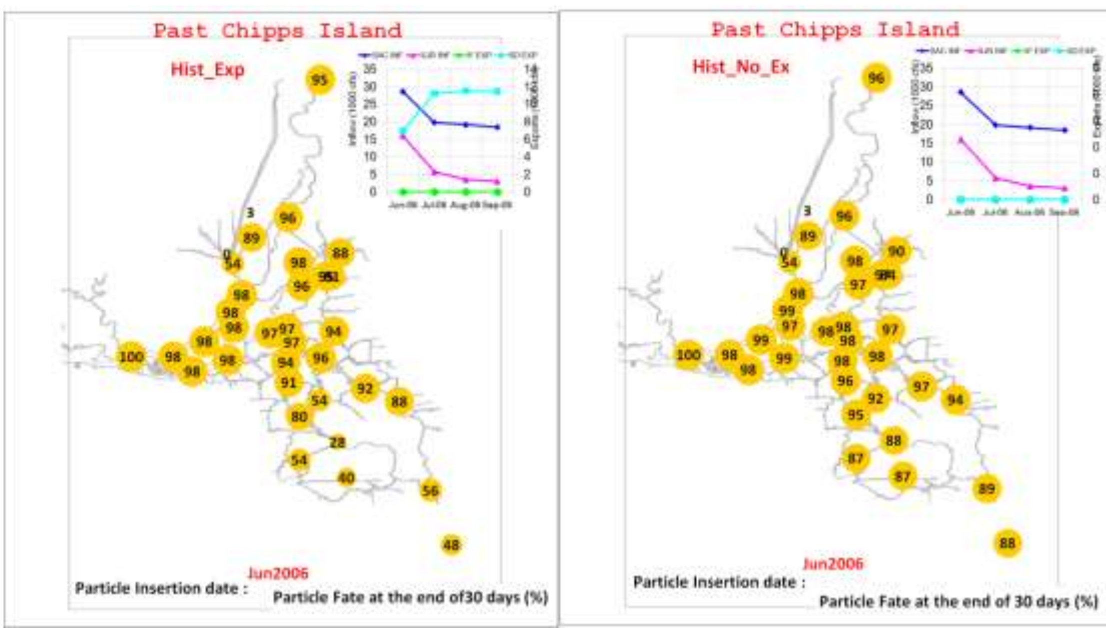


Figure 14. Percent of Particles Going Past Chipps Island for a Wet Period at the End of 30 Day Period (June 2006) for the Historical Exports Scenario and the No Exports Scenario

Particle Transport for Reduced Exports Scenario

In this section the particle tracking results for the "no exports" scenario are compared to a "reduced exports" scenario. The "reduced exports" scenario included "historical exports" limited to 50% of the total Delta inflow. The goal of this comparison is to evaluate the sensitivity of the percent of particles originating in the eastern Delta regions reaching the Suisun region with respect to two different levels of exports. The results from the "reduced exports" scenario show similar trends as the "historical exports" scenario as shown in the Figure 15.

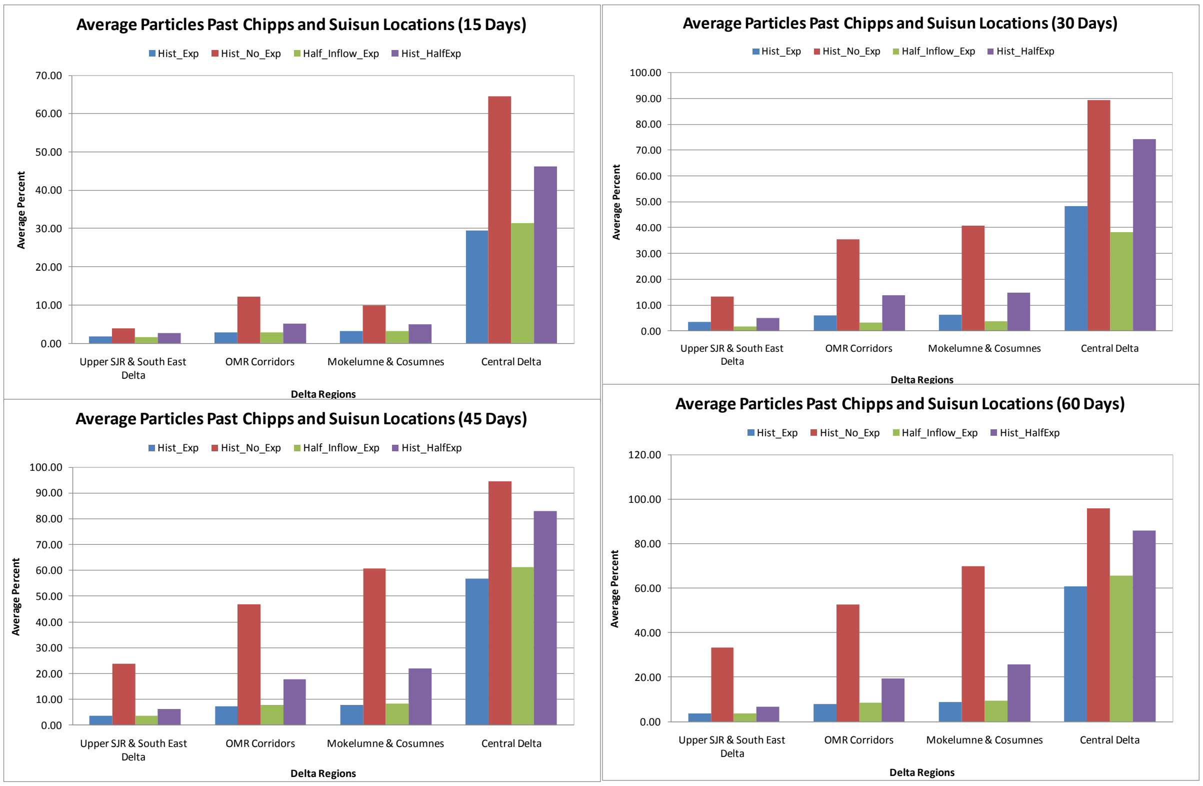


Figure 15. Average Percent of Particles Reaching Suisun Region from Eastern Delta Regions at the end of 15, 30, 45 and 60 Day Periods for the Reduced Exports and No Exports Scenarios

Finger Printing Analysis Results

Figure 16 shows the monthly timeseries of source water fingerprinting results for the "historical exports", "no exports" and "reduced exports" scenarios at Mallard Island location on the Sacramento River for the water originating in the eastern Delta Rivers (Mokelumne, Cosumnes and Calaveras). The percent volume of eastern Delta rivers in the "historical exports" and the "reduced exports" scenarios are nearly identical. The percent volume of eastern Delta rivers is consistently higher by 1 to 2% in the "no exports" scenario compared to the two with-exports scenarios, except in the wet conditions, where the three scenario show similar results. In 7 out of the 10 simulation years the volume percent of eastern Delta rivers is less than 4% in all the scenarios at the Mallard Island location indicating that very little water from the eastern Delta rivers exists in the Suisun region even under the "no exports" scenario. On an average, August to December months show less than 0.5% contribution from the eastern Delta rivers at the Mallard Island location and in June and July it is greater than 2% in the with-exports scenarios compared to 1.5% to 3.5% in the "no exports" scenario.

The monthly trend of the percent volume of the water originating in the eastern Delta Rivers that reach the Sacramento River at Mallard Island location is shown in the Figure 17. The "no exports" scenario results are consistently higher than the two with-exports scenarios in all the months by about 1 to 1.5%. The two with-exports runs show nearly identical results. Both scenarios show that less than 0.5% eastern Delta Rivers is present in the August through December months at the Mallard Island location in the Sacramento River.

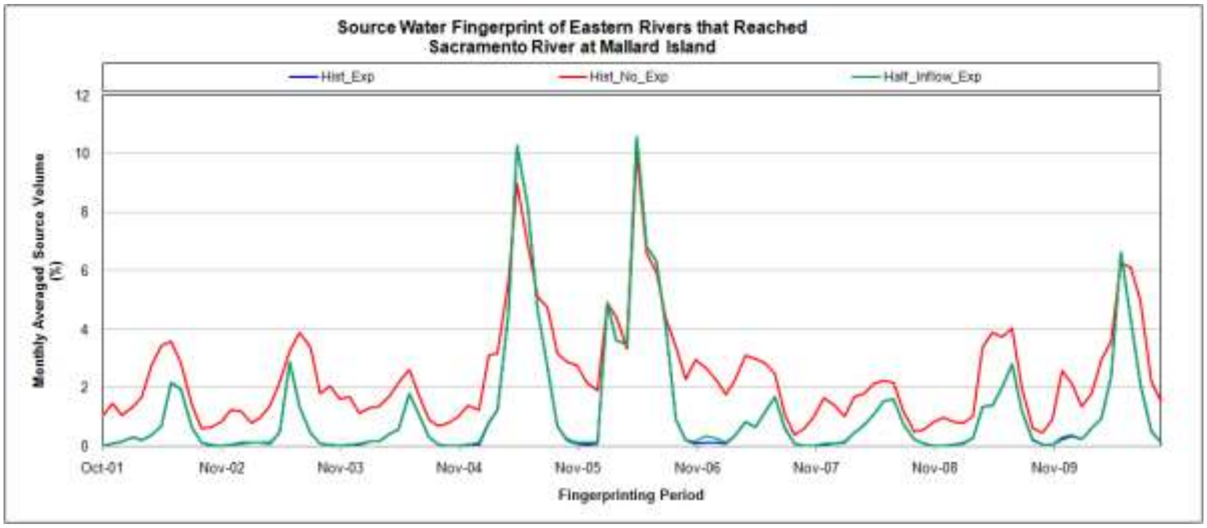


Figure 16. Monthly Time Series of Percent Volume of the Water Originating in the Eastern Delta Rivers at Mallard Island Location on the Sacramento River (2001 to 2010)

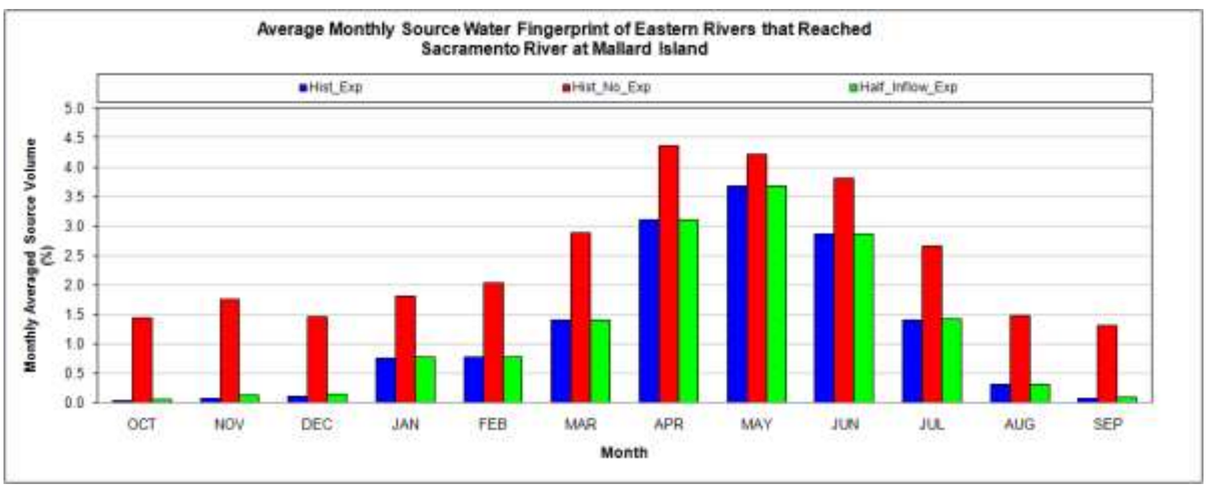


Figure 177. Monthly Average Trend of Percent Volume of the Water Originating in the Eastern Delta Rivers at Mallard Island Location on the Sacramento River

Fate of Particles from Cache Slough and Suisun Marsh Regions

The average percent of particles originating in Cache Slough and Suisun Marsh regions reaching or remaining in the Suisun region at the end of 15, 30, 45 and 60 day periods are summarized in Figure 18. By the end of 45 days the particles originating from Cache Slough Region reach the Suisun region at steady level. About 15% particles from Cache Slough reach Suisun region under the "historical exports" scenario and about 25% particles for the "no exports" scenario. The plot shows that for the particles originating in the Suisun Marsh the averages remain close to zero indicating that particles tend to remain in the Suisun region or leave the Delta, and less than 1% particles in the "historical exports" scenario and none of them in the "no exports" scenario travel to the upstream Delta channels. This plot indicates that the particles originating in Cache Slough and Suisun Marsh regions are likely contributing to the overall particles in the Suisun region.

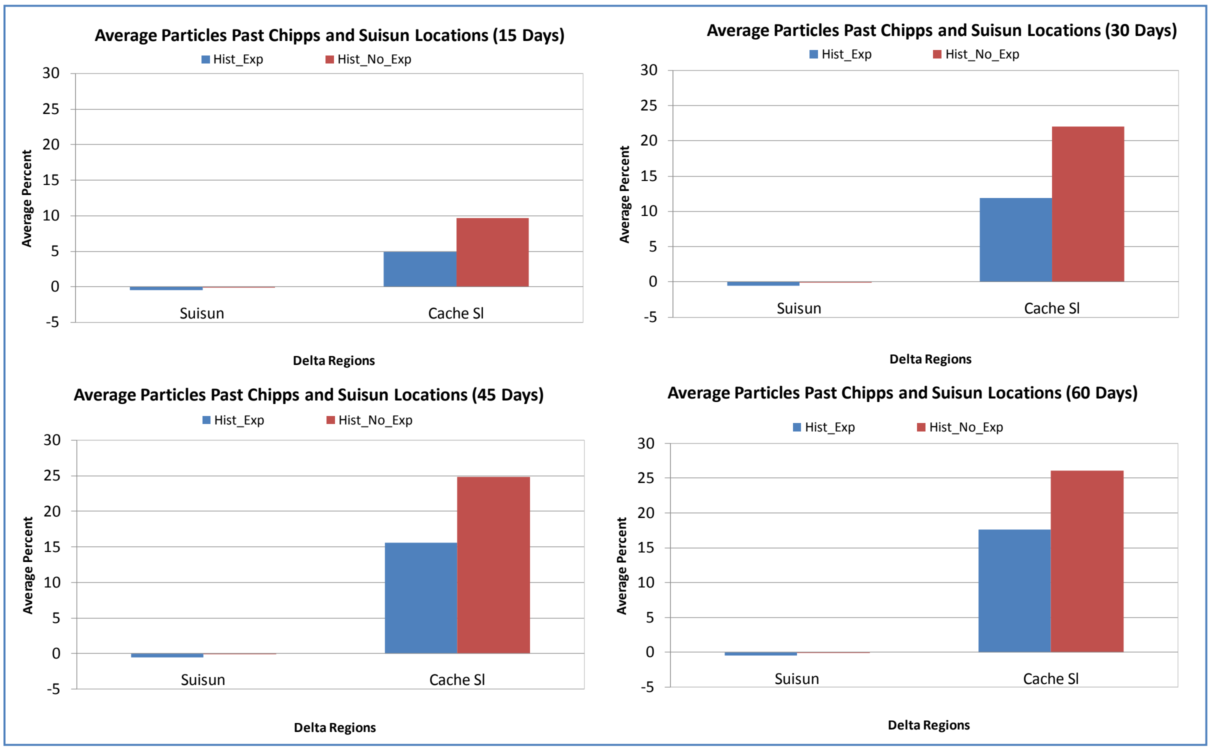


Figure 18. Average Percent of Particles Past Chipps and Suisun Locations Originating in Suisun and Cache Slough Regions.

Summary

The effect of exports on the transport of zooplankton from the eastern Delta channels to the Suisun region in the summer months (June to September) months is studied in this analysis. Particle tracking modeling and source water fingerprinting analysis were performed using the DSM2 model for the historical conditions from water year 2001 to water year 2010. Three scenarios were considered in this analysis: "historical exports", "no exports" and "reduced exports". PTM simulations were conducted for 20 periods for 60 days each with particles inserted at 39 locations in the Delta. PTM results were grouped into regions to evaluate particle transport from the eastern Delta to the Suisun region.

The results indicate that particles originating in the eastern Delta region do not generally reach the Suisun region under the "historical exports" scenario except in the wet year types and wet months (only June), even by the end of 60 days, especially particles originating in the upper San Joaquin River and southeastern Delta region. Few particles originating in the OMR corridors, Mokelumne and Cosumnes regions reach Suisun region. Particles in the

Central Delta reach Suisun region under the historical exports scenario under all conditions. In the “no exports” scenario, except in the dry years and dry months (August and September), more than 20% of the particles originating in the upper San Joaquin region, reach the Suisun region by the end of 30 days. Particles originating in other eastern Delta regions (OMR corridors, Mokelumne and Cosumnes and Central Delta regions) are reaching the Suisun Marsh by end of 15 days. The results also indicate that the “reduced exports” scenario does not substantially increase particle transport from the eastern Delta to the Suisun region.

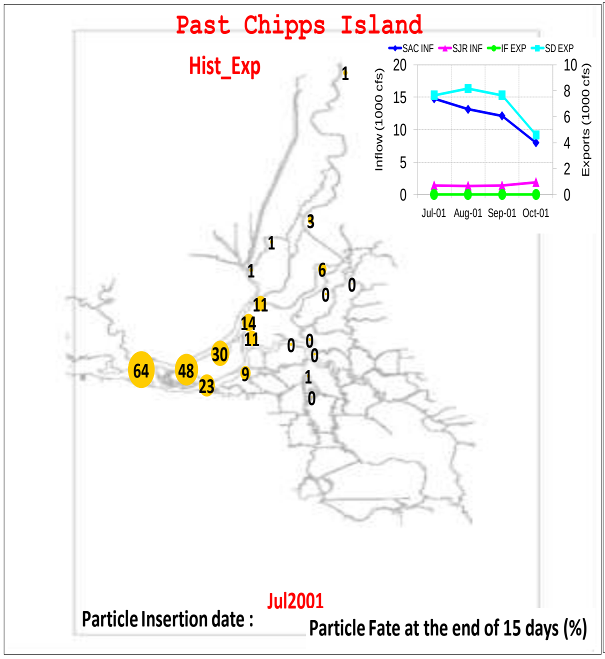
Source water finger printing results at the Mallard Island location on the Sacramento River for water originating in the eastern Delta rivers (Mokelumne, Cosumnes and Calaveras) indicate that the “no exports” scenario has consistently higher percent volume than the two with-exports scenarios. Also, the results from the two with-exports scenarios are nearly identical.

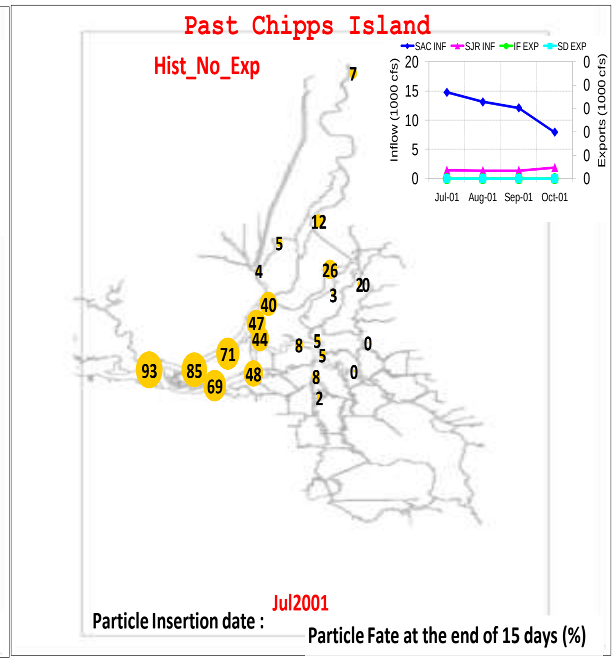
The particle tracking results for the Cache Slough region indicate that about 15% and 25% of the particles reach Suisun region under the “historical exports” and “no exports” scenarios, respectively. Also, the PTM results for Susiun Marsh region indicate that the particles originating in this region remain west of Chipps Island and do not travel to the upstream Delta channels, under all scenarios. Both these results indicate that particles originating in the Cache Slough and the Suisun Marsh regions likely contribute to the particles in the Suisun region.

Appendix A. Percent particles from Historical Exports and No Exports Scenarios going Past Chipps Island at the 39 Locations for several representative periods for various hydrologic conditions.

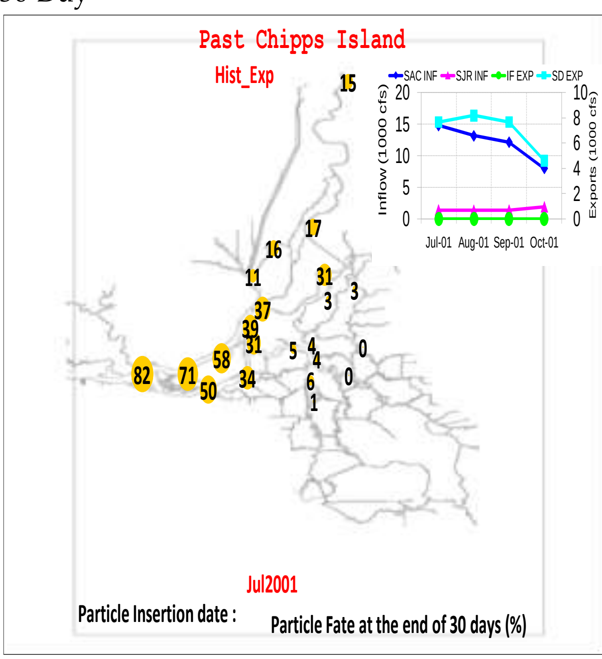
A1. Dry year: July 2001

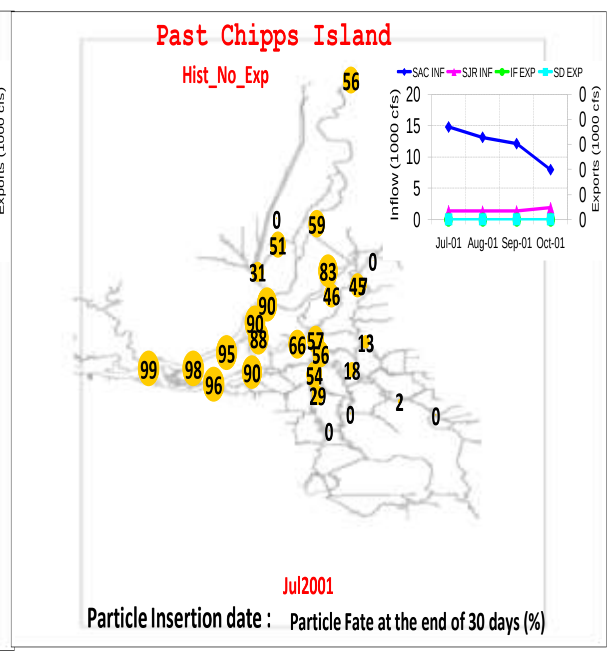
15 Day



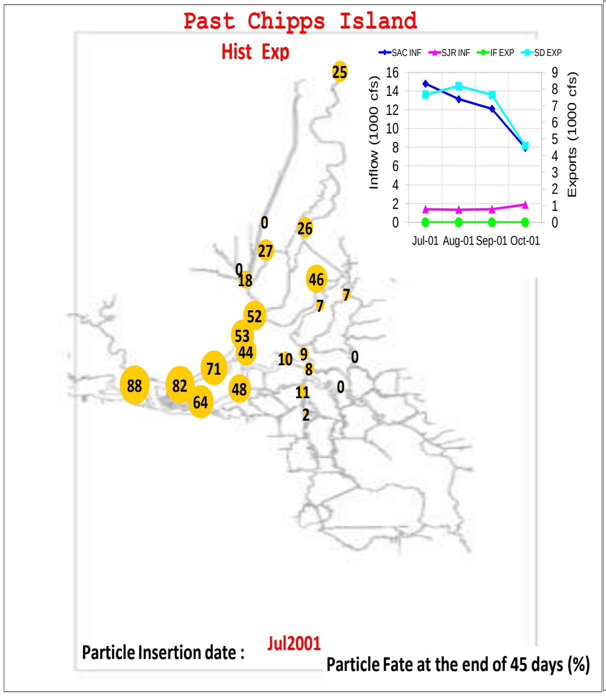


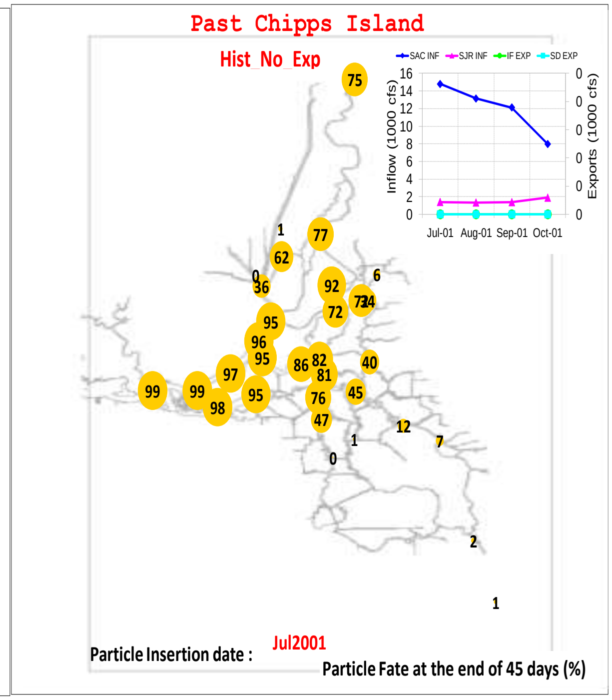
30 Day



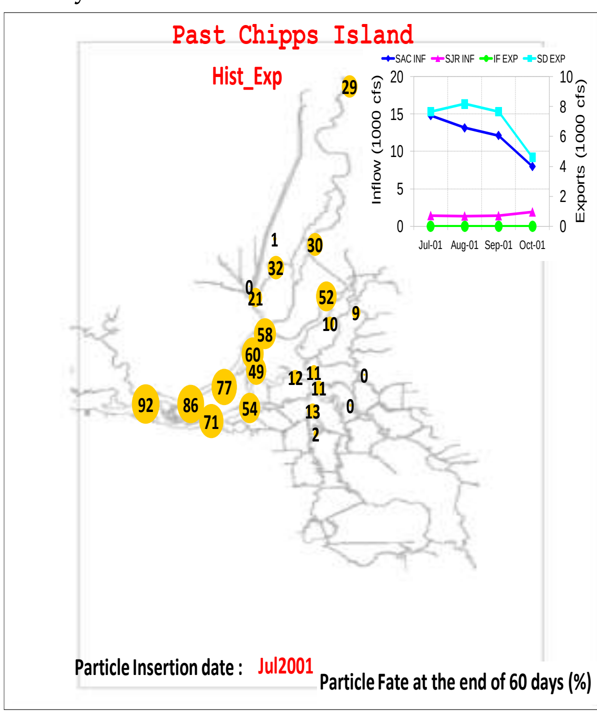


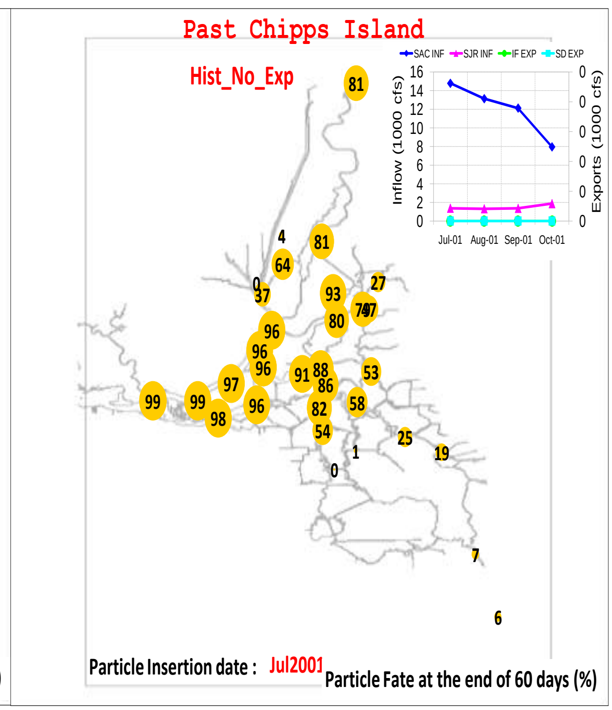
45 Day


Past Chipps Island
Hist Exp
SAC INF
SJR INF
IF EXP
SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Jul-01
Aug-01
Sep-01
Oct-01
Particle Insertion date :
Jul2001
Particle Fate at the end of 45 days (%)


Past Chipps Island
Hist No Exp
SAC INF
SJR INF
IF EXP
SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Jul-01
Aug-01
Sep-01
Oct-01
Particle Insertion date :
Jul2001
Particle Fate at the end of 45 days (%)

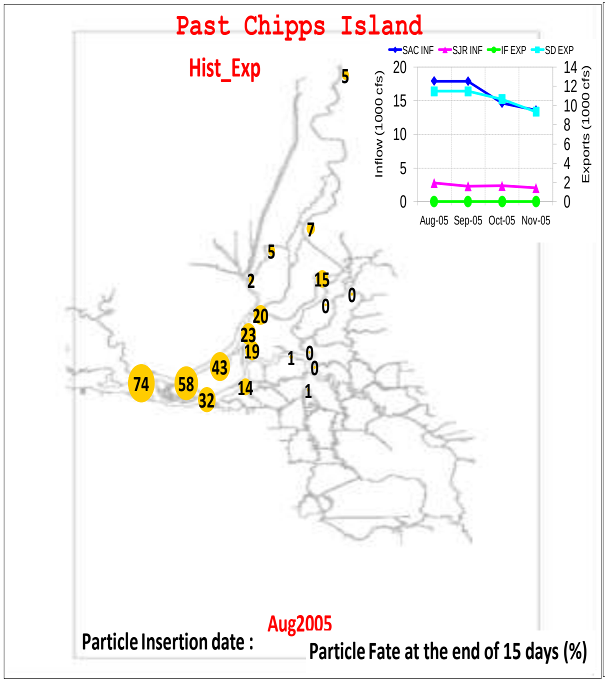
60 Day

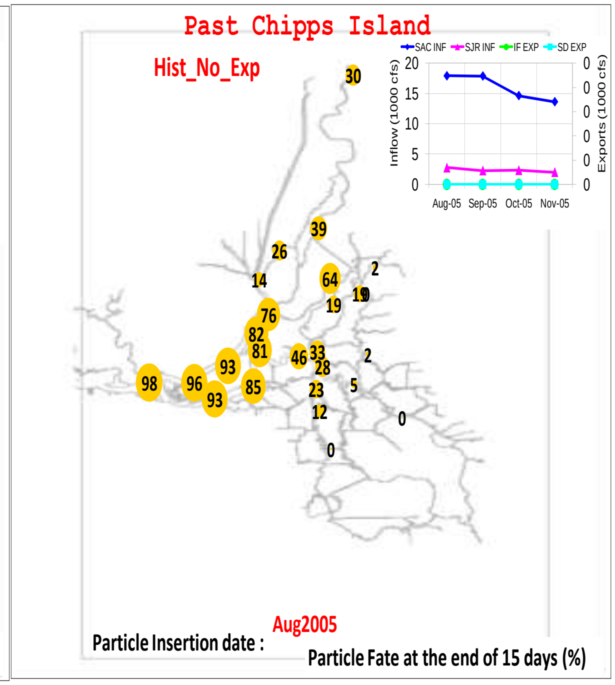

Past Chipps Island
Hist_Exp
SAC INF
SJR INF
IF EXP
SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Jul-01
Aug-01
Sep-01
Oct-01
Particle Insertion date :
Jul2001
Particle Fate at the end of 60 days (%)


Past Chipps Island
Hist_No_Exp
SAC INF
SJR INF
IF EXP
SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Jul-01
Aug-01
Sep-01
Oct-01
Particle Insertion date :
Jul2001
Particle Fate at the end of 60 days (%)

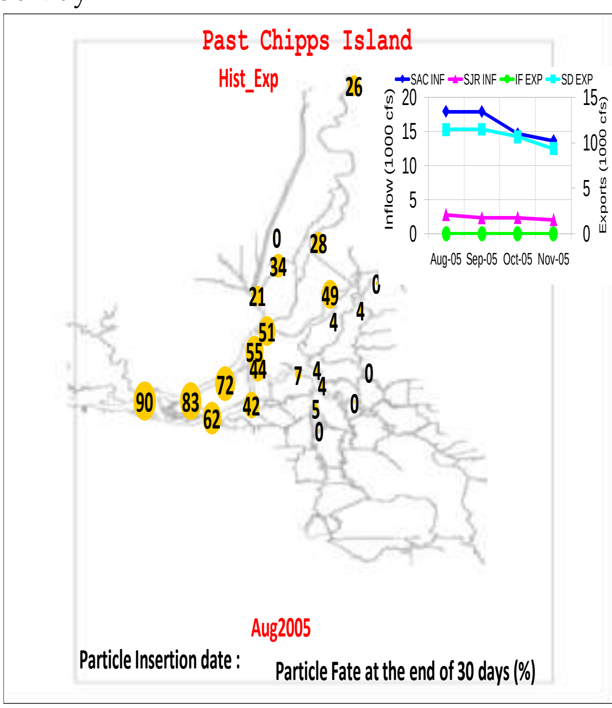
A2. Normal Year: Aug 2005

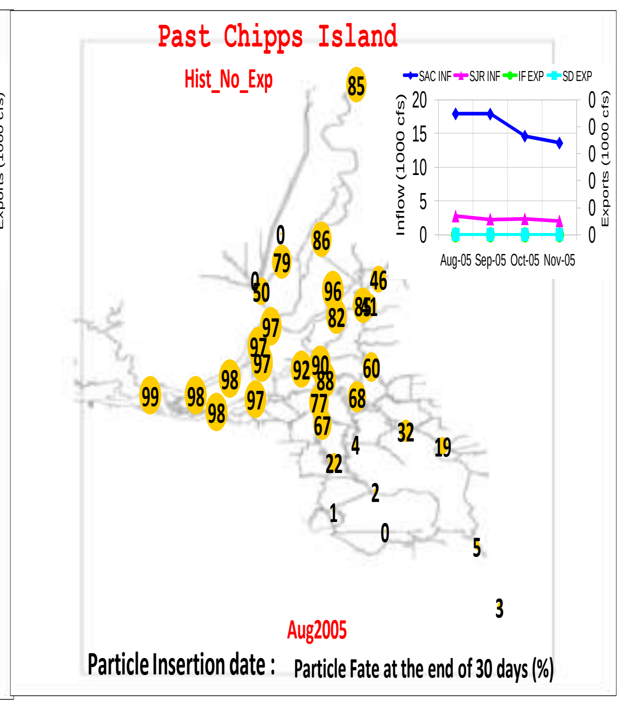
15 Days



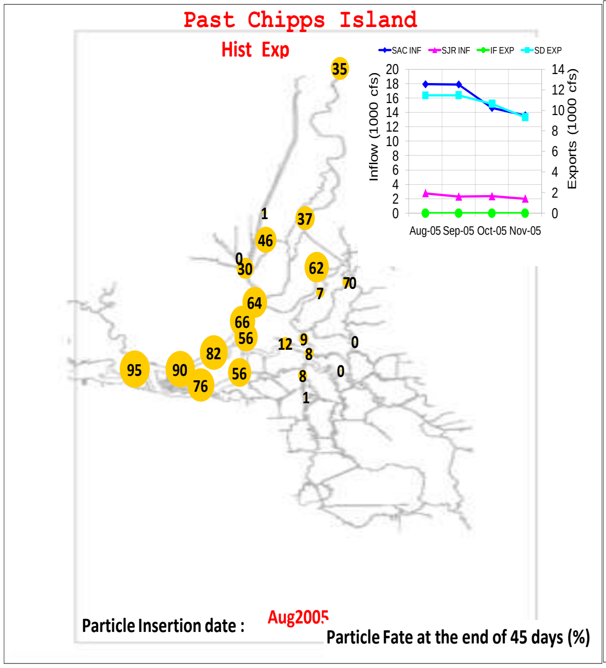


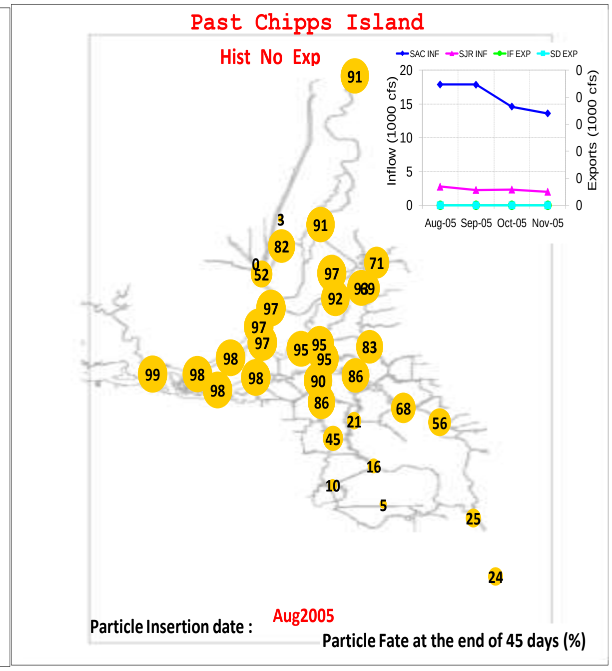
30 Day



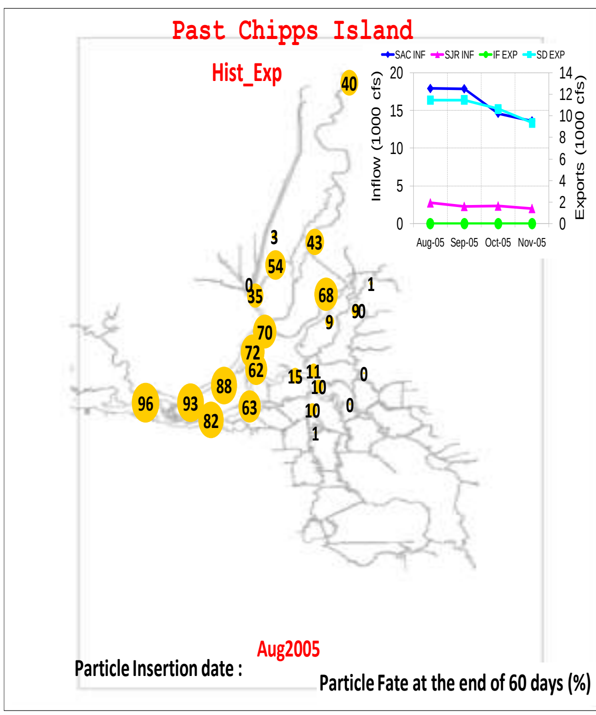


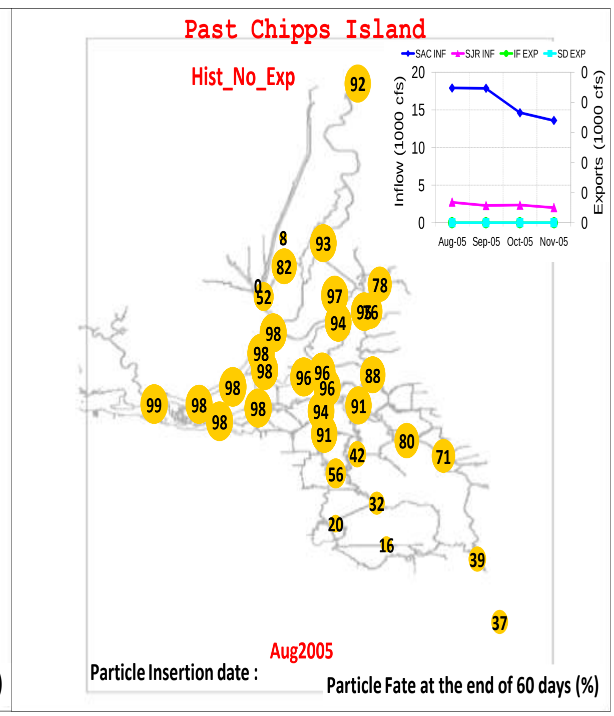
45 Day


Past Chipps Island
Hist Exp
SAC INF SJR INF IF EXP SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Aug-05 Sep-05 Oct-05 Nov-05
Particle Insertion date :
Aug2005
Particle Fate at the end of 45 days (%)


Past Chipps Island
Hist No Exp
SAC INF SJR INF IF EXP SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Aug-05 Sep-05 Oct-05 Nov-05
Particle Insertion date :
Aug2005
Particle Fate at the end of 45 days (%)

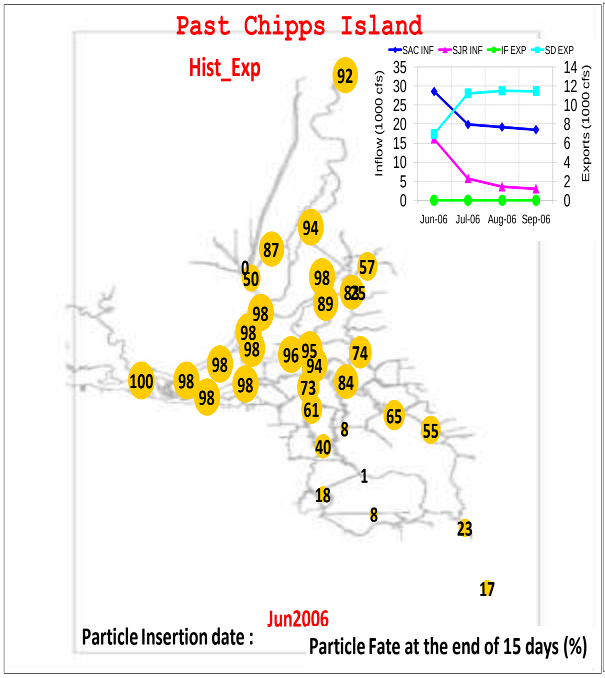
60 Day

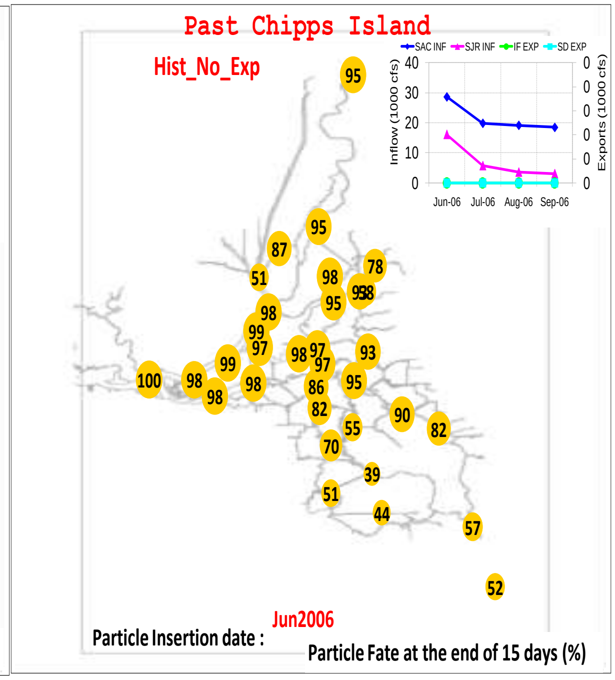

Past Chipps Island
Hist_Exp
SAC INF SJR INF IF EXP SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Aug-05 Sep-05 Oct-05 Nov-05
Particle Insertion date :
Aug2005
Particle Fate at the end of 60 days (%)


Past Chipps Island
Hist_No_Exp
SAC INF SJR INF IF EXP SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Aug-05 Sep-05 Oct-05 Nov-05
Particle Insertion date :
Aug2005
Particle Fate at the end of 60 days (%)

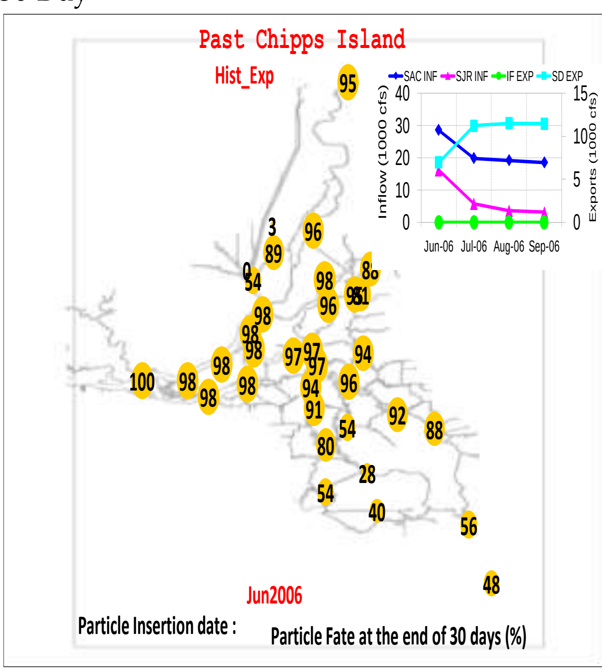
A3. Wet Year: Jun 2006

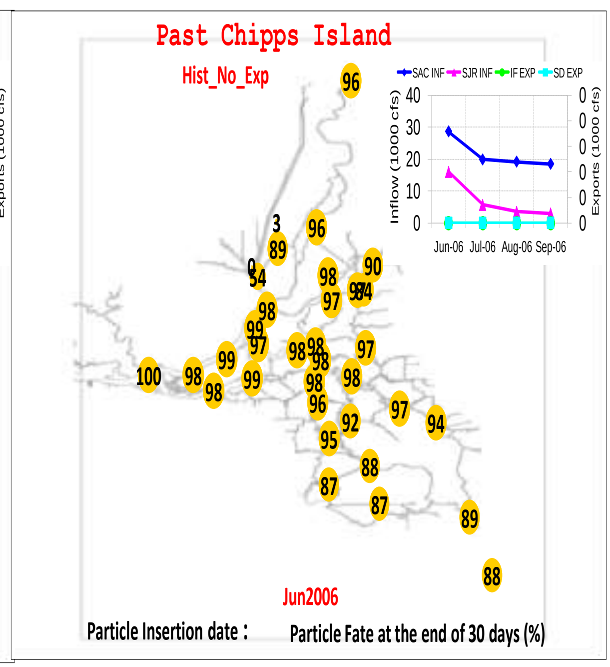
15 Day



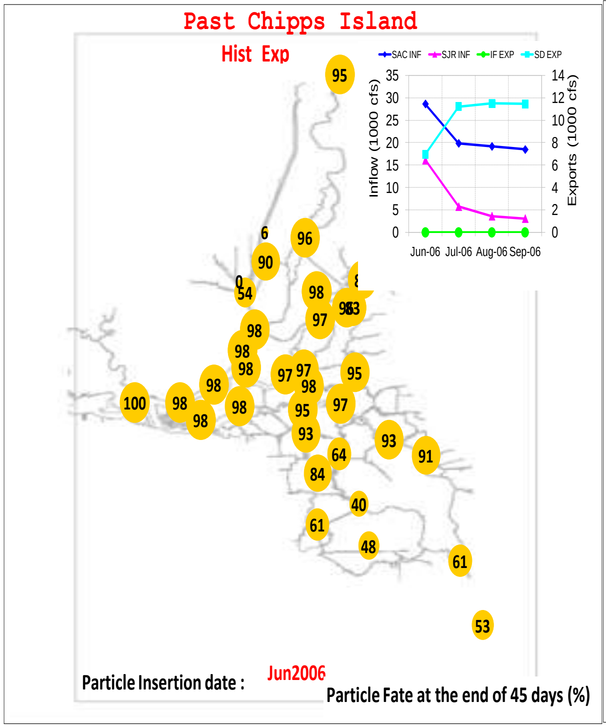


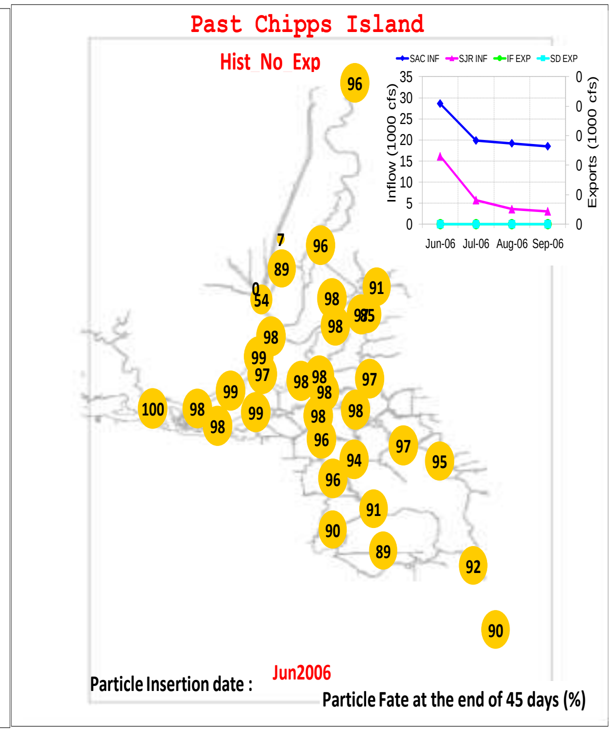
30 Day



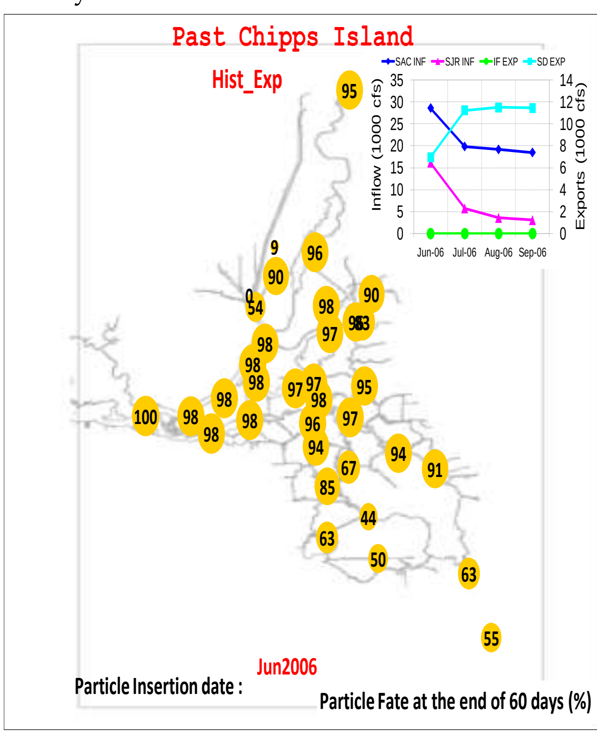


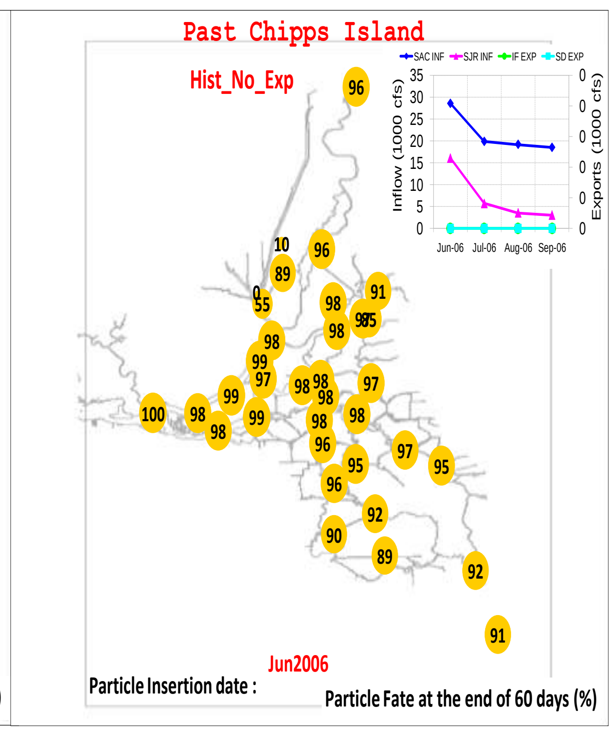
45 Day


Past Chipps Island
Hist Exp
SAC INF
SJR INF
IF EXP
SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Jun-06 Jul-06 Aug-06 Sep-06
Particle Insertion date :
Jun2006
Particle Fate at the end of 45 days (%)


Past Chipps Island
Hist No Exp
SAC INF
SJR INF
IF EXP
SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Jun-06 Jul-06 Aug-06 Sep-06
Particle Insertion date :
Jun2006
Particle Fate at the end of 45 days (%)

60 Day


Past Chipps Island
Hist_Exp
SAC INF
SJR INF
IF EXP
SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Jun-06 Jul-06 Aug-06 Sep-06
Particle Insertion date :
Jun2006
Particle Fate at the end of 60 days (%)


Past Chipps Island
Hist_No_Exp
SAC INF
SJR INF
IF EXP
SD EXP
Inflow (1000 cfs)
Exports (1000 cfs)
Jun-06 Jul-06 Aug-06 Sep-06
Particle Insertion date :
Jun2006
Particle Fate at the end of 60 days (%)