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

25th Annual Progress Report
October 2004

Chapter 6:
Net Delta Outflow Computations for DSM2 Steady State Simulations

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6 Net Delta Outflow Computations for DSM2 Steady State Simulations

6.1 Introduction

Several steady state DSM2 simulations were conducted to investigate impacts of tidal dynamics on Net Delta Outflow (NDO) computations and are documented in this chapter. Three separate steady state DSM2 simulations were conducted to examine NDO computations:

- Monthly varying steady state inflows and exports with a constant stage boundary at Martinez
- Monthly varying steady state inflows and exports with a repeating 19-year mean tide boundary at Martinez
- Steady state (fixed) inflows and exports with an Adjusted Astronomical Tide boundary at Martinez

Descriptions of each study and results are presented in this chapter.

6.2 Time Varying Steady State Inflows and Exports with Constant Stage Boundary at Martinez

A steady state DSM2 simulation with constant stage boundary conditions at Martinez was run to verify that computing NDO by summing flows at the following locations reflects all of the Delta outflow sources (see Chapter 5; Anderson, 2004):

- Martinez (DSM2 channel 441)
- Chipps Island and Montezuma Slough (DSM2 channels 437, 442, and 511)
- Sacramento River at Rio Vista, 3-Mile Slough, San Joaquin River at Jersey Point, and Dutch Slough (DSM2 channels 430, 309, 83, and 274)

The input NDO for the steady state simulation will be computed as a mass balance between the inflows and withdrawals from the system. Previous studies have shown that the four-point solution technique used in DSM2 conserves mass (Nader, 1993). Thus, if the locations above reflect all of the Delta outflow sources, the NDO computed by summing the flows at those locations will be identical to the input NDO.

The simulation was run with steady boundary conditions that varied every two months for Sacramento and San Joaquin River flows and for SWP and CVP exports (Table 6.1). The simulation had a constant stage boundary condition at Martinez and did not include Delta Island Consumptive Use (DICU) or operations of the Delta Cross Channel, Montezuma Salinity Control Gates, or any South Delta barriers. The steady time varying boundary conditions represent NDO ranging from 7600 cfs to 52600 cfs (approximately 10, 50, 75 and 90th percentile NDO values from the South Delta Improvement Project's 2020 Integrated simulation). Months 1 to 8 of the simulation represent increasing NDO conditions. Months 8 to12 represent dramatic changes in NDO between the highest to the lowest values.

NDO was computed for the three locations (Martinez, Chipps, and Rio Vista/Jersey Point) based on the output from the DSM2 steady state simulation. The transition period between the different boundary conditions was three days. With the exception of this transition period, computed NDO values equaled the input NDO (Table 6.2). Computations for both 7600 cfs (months 1 to 2 and 9 to10) and 52600 cfs (months 7 to 8 and 11 to12) NDO time periods equaled the input NDO indicating that transient flows during the transitions were properly represented in DSM2.

Table 6.1: Boundary Conditions for a Steady State DSM2 Simulation with Constant Martinez Stage.

Month	Inflows (cfs)					Exports (cfs)					DICU (cfs)		Stage (ft)	NDO (cfs)
	Sac	SJR	Cal	Mok/Cos	Yolo	SWP	CVP	CCC	NBA	Vallejo	Nodal DICU	BBID CU	Martinez	Input NDO
1	**8000**	**1000**	50	300	50	**750**	**750**	200	75	25	0	0	1.0	***7600***
2	**8000**	**1000**	50	300	50	**750**	**750**	200	75	25	0	0	1.0	***7600***
3	**15000**	**2000**	50	300	50	**3000**	**3000**	200	75	25	0	0	1.0	***11100***
4	**15000**	**2000**	50	300	50	**3000**	**3000**	200	75	25	0	0	1.0	***11100***
5	**20500**	**5300**	50	300	50	**6300**	**4200**	200	75	25	0	0	1.0	***15400***
6	**20500**	**5300**	50	300	50	**6300**	**4200**	200	75	25	0	0	1.0	***15400***
7	**52500**	**13000**	50	300	50	**8500**	**4500**	200	75	25	0	0	1.0	***52600***
8	**52500**	**13000**	50	300	50	**8500**	**4500**	200	75	25	0	0	1.0	***52600***
9	**8000**	**1000**	50	300	50	**750**	**750**	200	75	25	0	0	1.0	***7600***
10	**8000**	**1000**	50	300	50	**750**	**750**	200	75	25	0	0	1.0	***7600***
11	**52500**	**13000**	50	300	50	**8500**	**4500**	200	75	25	0	0	1.0	***52600***
12	**52500**	**13000**	50	300	50	**8500**	**4500**	200	75	25	0	0	1.0	***52600***

Bold values vary over time.

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Table 6.2: Monthly Average NDO Computations for a DSM2 Steady State Simulation with Time Varying Boundary Conditions and Constant Stage at Martinez.

Location	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)
Input NDO	***7,600***	***11,100***	***15,400***	***52,600***
Martinez	7,600	11,100	15,400	52,600
Total NDO at Martinez	***7,600***	***11,100***	***15,400***	***52,600***
Chipps S	7,338	10,717	14,869	50,788
Chipps N	107	156	217	741
Montezuma Slough Upstream	155	226	314	1,070
Total NDO at Chipps Island	***7,600***	***11,100***	***15,400***	***52,600***
Rio Vista	5,076	9,495	12,997	33,892
3-Mile Slough	-160	-880	-1,171	-434
Jersey Point	2,606	2,683	3,862	18,407
Dutch Slough	78	-199	-287	734
Total NDO at Rio Vista/Jersey Point	***7,600***	***11,100***	***15,400***	***52,600***

+ flows are downstream (ebb), - flows are upstream (flood)

6.3 Time Varying Steady State Inflows and Exports with a Repeating 19-Year Mean Tide Boundary at Martinez

Analysis of results from a steady state DSM2 simulation with a constant stage boundary condition at Martinez verified that NDO could be estimated by summing flows at three different locations in the Delta, Martinez, Chipps Island, and Rio Vista/Jersey Point (see section 6.2 for details). In order to investigate impacts of a changing tidal boundary condition on the NDO computations, another steady state DSM2 simulation was run with identical flow and export boundary conditions (Table 6.1) and a repeating 25-hour tidal boundary condition at Martinez. A 25-hour time series of hourly values representing the 19-year mean tide was repeated for the one year simulation period to provide the tidal boundary condition at Martinez (Table 6.3 and Figure 6.1). This tide, more commonly referred to as a design repeating tide, does not take into account spring-neap tidal affects (Nader, 2001). The simulation did not include DICU or operations of the Delta Cross Channel, Montezuma Salinity Control Gates, or any South Delta barriers.

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Table 6.3: 25-Hour 19-Year Mean Tidal Stage Values.

Hour	19-Year Mean Tidal Stage, ft	Hour	19-Year Mean Tidal Stage, ft
1	3.02	13	4.05
2	2.75	14	3.32
3	2.08	15	2.24
4	1.28	16	0.85
5	0.36	17	-0.33
6	-0.01	18	-1.18
7	0.07	19	-1.77
8	0.78	20	-1.80
9	1.87	21	-1.15
10	2.66	22	-0.08
11	3.48	23	1.01
12	4.03	24	1.97
		25	2.70

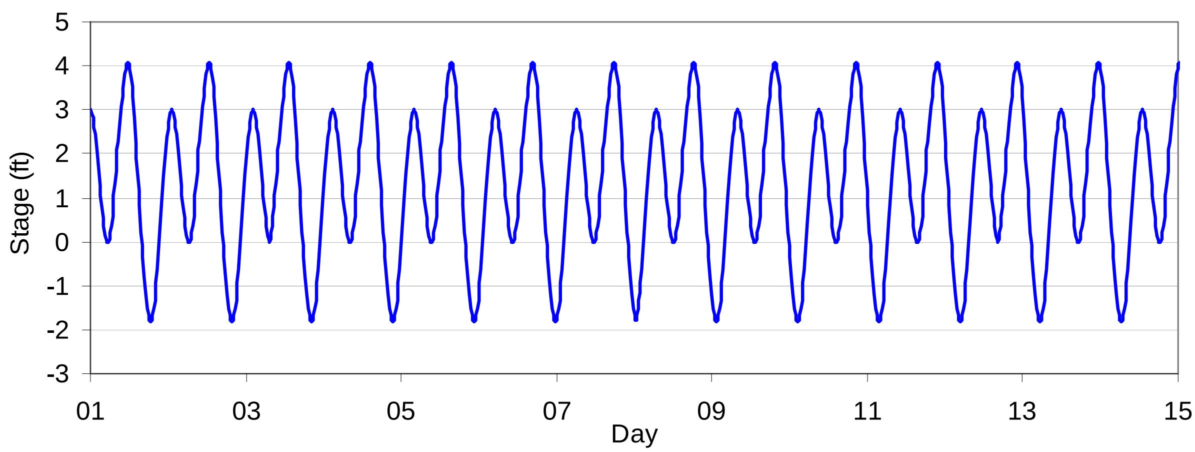

Figure 6.1: Repeating 25-Hour 19-Year Mean Tide.

Monthly NDO was computed for the three NDO locations (Martinez, Chipps, and Rio Vista/Jersey Point) using 15-minute instantaneous DSM2 flow results (Table 6.4). Monthly NDO results are reported for the months in which there was no transition in the boundary flows from the previous month (months 2, 4, 6, and 8 in Table 6.1; Note that results for month 2 and 10 and months 8 and 12 were equivalent). The computed NDO values did not match the input NDO values since the monthly average values were computed based on calendar months. Monthly time periods do not coincide with equal intervals of the tidal cycle, 25 hours in this case, and thus the monthly average computations include partial tidal cycles. Tidal flows at the locations used in the NDO computations can vary dramatically. For the 7600cfs NDO case, Martinez flows vary between 625,000 cfs (ebb) and -525,000 cfs (flood). Thus flow values during a partial tidal cycle can have a dramatic impact on the monthly averages, as illustrated by the comparison of input NDO and calculated NDO in Table 6.4. At Martinez the largest difference between input NDO and computed NDO was nearly 50% for the 7600 cfs NDO conditions. For the NDO computations at Rio Vista/Jersey Point, the largest difference between input NDO and computed NDO was about 13% for the 7600 cfs NDO conditions.

To improve the NDO estimates, 25-hour running averages were computed from the 15-minute instantaneous DSM2 flow output so that the data averaging reflected the same time period as the tidal cycle, a 25-hour repeating tide in this case. Monthly averages were then computed from the 25-hour running average flow data. Using the monthly average of the 25-hour running average data to compute NDO for the three different locations produced results that were nearly identical to the input NDO for the 7600cfs NDO scenario (maximum difference of 4 cfs), and identical for the other NDO scenarios (11,100 cfs to 52,600 cfs) (Table 6.5). The NDO computations produced identical NDO values to the input NDO because the 25-hour running average represents the entire 25-hour tidal cycle used in the repeating 19-year mean tide. These results indicate the importance using a data processing technique to compute NDO values that reflects the tidal cycle.

Table 6.4: Monthly Average NDO Computations based on 15-Minute Data for a DSM2 Steady State Simulation with Time Varying Boundary Conditions and a 25-Hour Repeating 19-Year Mean Tide at Martinez.

Location	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)
Simulation Month	2 and 10	4	6	8 and 12
Input NDO	***7,600***	***11,100***	***15,400***	***52,600***
Martinez	3,815	9,358	15,842	55,761
Total NDO at Martinez	***3,815***	***9,358***	***15,842***	***55,761***
Chipps N	378	433	509	972
Chipps S	5,340	9,551	14,115	52,600
Montezuma Slough Upstream	-101	-28	22	720
Total NDO at Chipps Island	***5,617***	***9,956***	***14,647***	***54,292***
Rio Vista	2,597	6,604	10,538	34,084
3-Mile Slough	-593	-794	-970	785
Jersey Point	4,748	4,895	5,046	18,104
Dutch Slough	-148	-192	-208	448
Total NDO at Rio Vista/Jersey Point	***6,605***	***10,513***	***14,405***	***53,420***

+ flows are downstream (ebb), - flows are upstream (flood)

Table 6.5: Monthly Average NDO Computations based on 25-Hour Running Average Data for a DSM2 Steady State Simulation with Time Varying Boundary Conditions and a 25-Hour Repeating 19-Year Mean Tide at Martinez.

Location	Flow (cfs)	Flow (cfs)	Flow (cfs)	Flow (cfs)
Simulation Month	2 and 10	4	6	8 and 12
Input NDO	***7,600***	***11,100***	***15,400***	***52,600***
Martinez	7,604	11,099	15,397	52,599
Total NDO at Martinez	***7,604***	***11,099***	***15,397***	***52,599***
Chipps N	412	456	507	938
Chipps S	7,291	10,671	14,837	50,938
Montezuma Slough Upstream	-104	-27	56	724
Total NDO at Chipps Island	***7,600***	***11,100***	***15,400***	***52,600***
Rio Vista	3,029	6,909	10,615	33,725
3-Mile Slough	-490	-738	-809	699
Jersey Point	5,166	5,095	5,767	17,764
Dutch Slough	-106	-167	-172	412
Total NDO at Rio Vista/Jersey Point	***7,600***	***11,100***	***15,400***	***52,600***

+ flows are downstream (ebb), - flows are upstream (flood)

6.4 Steady State Inflows and Exports with an Adjusted Astronomical Tide Boundary at Martinez

To examine effects of the spring-neap tidal cycle on NDO computations, a steady state DSM2 simulation was run using an Adjusted Astronomical Tide boundary condition at Martinez. Except for the tide boundary, the boundary conditions for the Adjusted Astronomical Tide simulation were identical to the time periods in the previous scenarios corresponding to a NDO of 7600 cfs (Table 6.6). The simulation did not include DICU or operations of the Delta Cross Channel, Montezuma Salinity Control Gates, or any South Delta barriers.

An Adjusted Astronomical Tide is a computed 15-minute varying tidal stage time series that estimates observed tidal stage data. An Adjusted Astronomical Tide is computed by modifying (adjusting) the astronomical tide at a given location to incorporate long-period wave components. For DSM2, an Adjusted Astronomical Tide is computed at Martinez using long-period wave components from observed data at San Francisco. The Adjusted Astronomical Tide represents both the daily tidal cycle and the spring-neap tidal cycle (Figure 6.2) (Ateljevich, 2001).

Table 6.6: Boundary Conditions for Steady State DSM2 Simulation with an Adjusted Astronomical Tide Boundary at Martinez.

Inflows (cfs)					Exports (cfs)					DICU (cfs)		Stage (ft)	NDO (cfs)
Sac	SJR	Cal	Mok/Cos	Yolo	SWP	CVP	CCC	NBA	Vallejo	Nodal DICU	BBID	Martinez	Computed NDO
8000	1000	50	300	50	750	750	200	75	25	0	0	AAT	7600

AAT=Adjusted Astronomical Tide

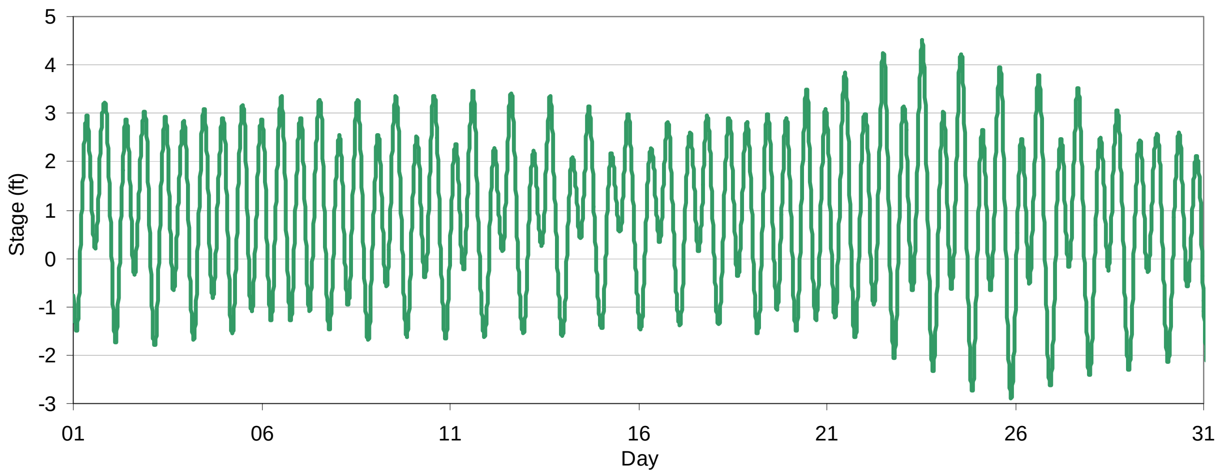

Figure 6.2: Adjusted Astronomical Tide for First Month of Steady State Simulation.

Simulation results were analyzed for a one year time period with the Martinez Adjusted Astronomical Tide input for water year (wy) 1977. Note that the tidal input is reflective of wy1977, however the inflows and exports were steady values representative of a 7600 cfs NDO (Table 6.6). In addition to the approximately two week spring-neap tidal cycle, the Adjusted Astronomical Tide represents seasonal patterns in tidal stage. The monthly average stage at Martinez for the one year time period was 0.71 ft. However, monthly averages ranged from a maximum of 0.97 ft (Sep.) to a minimum of 0.27 ft (Mar. and Apr.) (Table 6.7). The monthly average stage is affected by the spring-neap tidal cycle, the amount of fresh water inflow to the system, and atmospheric pressure conditions. Higher stages are correlated to lower fresh water inflows, and thus more intrusion of ocean water. Monthly average stage values in Table 6.7 indicate a typical seasonal pattern of stage at Martinez with lower stages in the winter and spring and higher stages in the summer and fall.

Table 6.7: Average Martinez Stage (ft) for Steady State Simulation with an Adjusted Astronomical Tide Boundary at Martinez

Mon/WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	*AVG*
AAT 1977	0.91	0.86	0.95	0.83	0.58	***0.27***	***0.27***	0.45	0.71	0.77	0.92	**0.97**	*0.71*

AAT=Adjusted Astronomical Tide, Bold indicates maximum and minimum values

NDO computations for the 25-hour repeating tide scenario discussed in the previous section indicated the importance of using a data processing technique that reflects the tidal cycle. The Adjusted Astronomical Tide occurs on a lunar calendar not on a Gregorian calendar. A tidal day (or lunar day) is 24 hour and 50 minutes long, and a tidal month (or lunar month) is 29.53 days long (USDC, 2000). A single spring-neap tidal cycle occurs over half of a lunar month (14.77 days).

If calendar monthly average flows are used to compute NDO using data from an Adjusted Astronomical Tide simulation, the length of the month does not correspond to exactly two spring-neap tidal cycles. In certain months, there may be more spring flows (highest tidal amplitude), and in others there may be more neap flows (lowest tidal amplitude). For the steady state simulation, monthly average flow values were used to compute NDO at three locations (Figure 6.3 and Table 6.8). For the 7,600 cfs NDO steady state simulation, the largest positive difference between computed and input NDO (computed NDO > input NDO) occurred during July 1977, a month that had more spring flows than neap flows. Similarly, the largest negative difference between computed and input NDO (computed NDO < input NDO) occurred during April 1977, a month that had more neap flows than spring flows.

For the monthly averaged data NDO computations, the NDO values were typically closer to the input NDO as the NDO computation sites move further upstream from Martinez, i.e. the computed NDO using the furthest upstream sites (Rio Vista/Jersey Point) was closer to the input NDO than NDO computed from sites further downstream (Chipps Island and Martinez) (Figure 6.3 and Table 6.8). For Martinez, the average difference in monthly NDO was 199 cfs with differences ranging from approximately -1420 cfs to 1817 cfs. For Chipps Island, the average difference in monthly NDO was 151 cfs with differences ranging from -916 cfs to 1003 cfs. For Rio Vista/ Jersey Point, the average difference in monthly NDO was 105 cfs with differences ranging from -606 cfs to 513 cfs. The NDO estimates typically followed a seasonal pattern with NDO estimates greater than the input NDO when average Martinez stage was higher and with NDO estimates lower than the input NDO when average Martinez stage was lower (Figure 6.3).

Typically NDO computations using Adjusted Astronomical Tide data can be improved by using a data processing technique that reflects the tidal cycle. Since DSM2 uses 15-minute computational time steps, simulated data were processed using a 24.75 hour running average, the closest 15-minute interval to a 24 hour 50 minute lunar day. Monthly NDO was computed at the three locations (Martinez, Chipps Island, and Rio Vista/Jersey Point) using monthly averages of 24.75 hour running average flow data (Figure 6.4 and Table 6.9). For the one year of data analyzed, the overall average difference between computed NDO and input NDO was lower for the 24.75 hour running average computation than for the monthly average computation (51 cfs vs 199 cfs for Martinez NDO, 32 cfs vs 151 cfs for Chipps NDO, and 22 cfs vs 105 cfs for Rio Vista/Jersey Point NDO). However for individual months, there is not a consistent trend as to which estimation technique provides the closest NDO estimate to the input NDO, and neither approximation matches the input NDO exactly. For the 24.75 hour running average NDO computations, the ranges in differences in NDO for the computed values compared to the input NDO were smaller than for the NDO computed from monthly averages (-704 to1093 cfs vs -1420 to 1817 cfs for Martinez, -402 to 688 cfs vs -916 to 1003 cfs for Chipps, and -337 to 478 cfs vs -606 to 513 cfs for Rio Vista/Jersey Point).

Regardless of data processing technique used (monthly average and 24.75 hour running average), the computed NDO based on DSM2 output was closer to the input NDO at the site furthest upstream (Rio Vista/Jersey Point). This site would be least impacted by complex tidal dynamics. Also for both data processing techniques, the largest positive difference between computed and input NDO (computed NDO > input NDO) occurred during a month that had more spring flows than neap flows (July), and the largest negative difference between computed and input NDO (computed NDO < input NDO) occurred during a month that had more neap flows than spring flows (April).

Computing NDO based on DSM2 simulation data for Adjusted Astronomical Tide simulations does not produce NDO values that are identical to the input NDO. The input NDO computation does not incorporate complex tidal dynamics such as:

- Filling and draining of the Delta during spring-neap tidal cycles
- Seasonal variations in stage at Martinez
- Transient flows

Typically NDO estimates can be improved by using data processing techniques that account for the length of a tidal cycle such as a 24.75 hour running average or a Godin filter (Godin, 1972).

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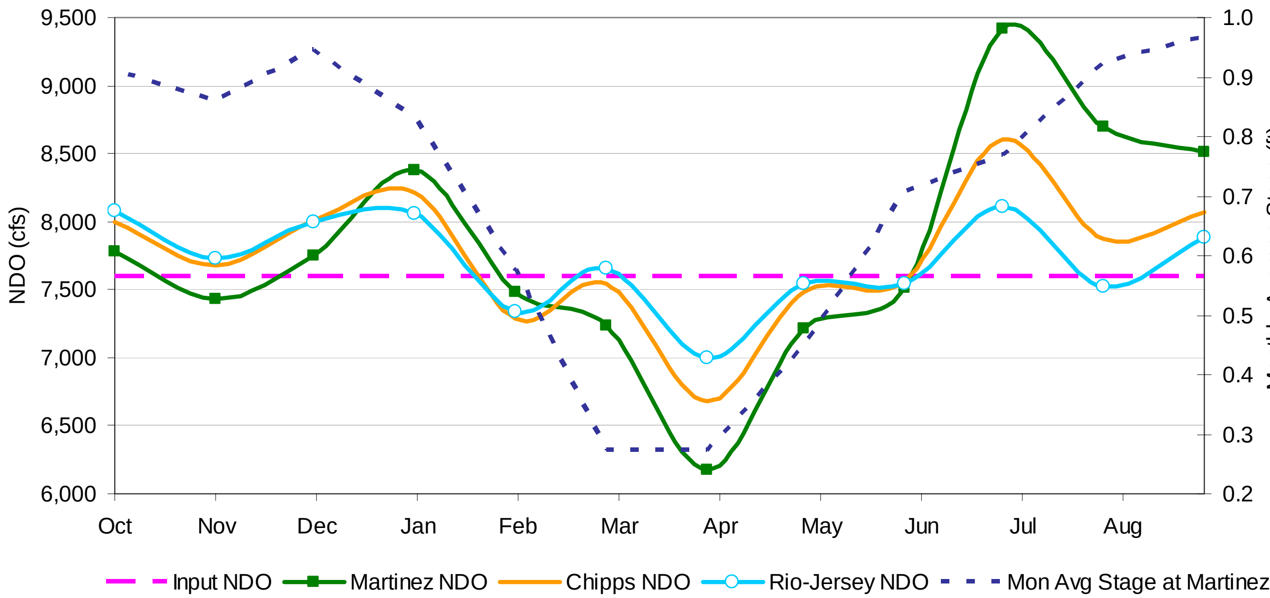

Figure 6.3: Monthly NDO Computed from Monthly Averaged 15-Minute Data for a Steady State Simulation with an Adjusted Astronomical Tide at Martinez.

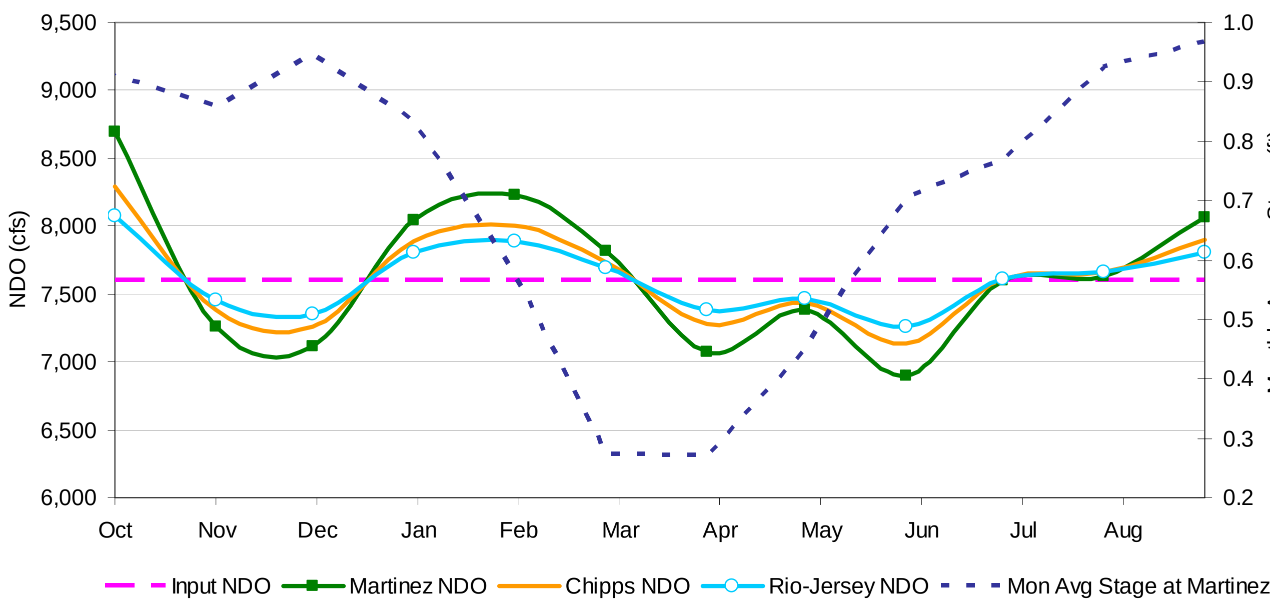

Figure 6.4: Monthly NDO Computed from Monthly Averages of 24.75 Hour Running Average Data for a Steady State Simulation with an Adjusted Astronomical Tide at Martinez.

Table 6.8: Monthly NDO Computed from Monthly Averaged 15-Minute Data for a Steady State Simulation with an Adjusted Astronomical Tide at Martinez.

Tide Date	Inflow NDO	Martinez		Chipps Island		Rio Vista/Jersey Point	
		Computed NDO	NDO Difference	Computed NDO	NDO Difference	Computed NDO	NDO Difference
Oct-76	7,600	7,781	181	7,995	395	8,077	477
Nov-76	7,600	7,428	-172	7,674	74	7,724	124
Dec-76	7,600	7,745	145	8,008	408	7,994	394
Jan-77	7,600	8,374	774	8,211	611	8,055	455
Feb-77	7,600	7,487	-113	7,291	-309	7,339	-261
Mar-77	7,600	7,237	-363	7,548	-52	7,661	61
Apr-77	7,600	6,180	-1,420	6,684	-916	6,994	-606
May-77	7,600	7,214	-386	7,484	-116	7,544	-56
Jun-77	7,600	7,510	-90	7,568	-32	7,546	-54
Jul-77	7,600	9,417	1,817	8,603	1,003	8,113	513
Aug-77	7,600	8,697	1,097	7,873	273	7,529	-71
Sep-77	7,600	8,516	916	8,073	473	7,886	286
Max	*7,600*	*9,417*	*1,817*	*8,603*	*1,003*	*8,113*	*513*
Avg	*7,600*	*7,799*	*199*	*7,751*	*151*	*7,705*	*105*
Min	*7,600*	*6,180*	*-1,420*	*6,684*	*-916*	*6,994*	*-606*

Note: NDO differences are computed NDO minus Inflow NDO.

Table 6.9: Monthly NDO Computed from Monthly Averages of 24.75 Hour Running Average Data for a Steady State Simulation with an Adjusted Astronomical Tide at Martinez.

Tide Date	Inflow NDO	Martinez		Chipps Island		Rio Vista/Jersey Point	
		Computed NDO	NDO Difference	Computed NDO	NDO Difference	Computed NDO	NDO Difference
Oct-76	7,600	8,693	1,093	8,288	688	8,078	478
Nov-76	7,600	7,260	-340	7,388	-212	7,455	-145
Dec-76	7,600	7,118	-482	7,258	-342	7,351	-249
Jan-77	7,600	8,046	446	7,887	287	7,803	203
Feb-77	7,600	8,229	629	8,000	400	7,892	292
Mar-77	7,600	7,820	220	7,731	131	7,694	94
Apr-77	7,600	7,076	-524	7,276	-324	7,384	-216
May-77	7,600	7,386	-214	7,436	-164	7,466	-134
Jun-77	7,600	6,896	-704	7,138	-462	7,263	-337
Jul-77	7,600	7,598	-2	7,612	12	7,611	11
Aug-77	7,600	7,634	34	7,663	63	7,658	58
Sep-77	7,600	8,061	461	7,904	304	7,809	209
Max	*7,600*	*8,693*	*1,093*	*8,288*	*688*	*8,078*	*478*
Avg	*7,600*	*7,651*	*51*	*7,632*	*32*	*7,622*	*22*
Min	*7,600*	*6,896*	*-704*	*7,138*	*-462*	*7,263*	*-337*

Note: NDO differences are computed NDO minus Inflow NDO.

6.5 Summary

Monthly varying steady state DSM2 simulations were run with a variety of tidal boundary conditions at Martinez (constant stage, 25-hour repeating 19-year mean tide, and Adjusted Astronomical Tide) to investigate effects of tidal dynamics on Net Delta Outflow computations. Conclusions from the studies are summarized below.

Time Varying Steady State Simulation with Constant Stage Boundary at Martinez

- ❑ The following three methods of computing NDO reflect all sources of Delta outflow:
  - NDO = Average Martinez Flow
  - NDO = Average Flow Chipps Island + Montezuma Slough
  - NDO = Average Flow Rio Vista + 3-Mile Slough + Jersey Point + Dutch Slough
- ❑ Verifying the above NDO equations with a constant stage steady state DSM2 simulation also demonstrated that DSM2 conserves mass (see also Nader, 1993)
- ❑ DSM2 accurately represents large transitions in boundary flows

Time Varying Steady State Simulation with a 25-Hour Repeating 19-Year Mean Tide Boundary at Martinez

- ❑ Data used in NDO computations needs to be processed to reflect the tidal cycle in order to calculate the correct NDO (e.g. 25-hour running average)
- ❑ For a 25-hour repeating 19-year mean tide, the exact length of the tidal cycle is known, therefore NDO computed using average flows at three locations (Martinez, Chipps Island, and Rio Vista/Jersey Point) will be equivalent to the DSM2 input NDO
- ❑ After a several day transition period when boundary flows changed, the NDO computed using average flows at three locations (Martinez, Chipps Island, and Rio Vista/Jersey Point) was equivalent to the DSM2 input NDO, even for very large changes in NDO (7,600 cfs to 52,600 cfs)

Steady State Simulation with an Adjusted Astronomical Tide Boundary at Martinez

- ❑ When spring-neap tidal effects are incorporated into a DSM2 simulation, NDO computations at different locations may not result in values identical to the input NDO or to each other due to a variety of reasons related to complex dynamics of unsteady flows in tidal systems:
  - Filling and draining of the Delta during spring-neap cycles
  - Travel time of transient Delta flows
  - Ability of data processing technique used to compute NDO parameters to reflect tidal dynamics (monthly average, 24.75 hour running average, Godin filter, etc)
  - Seasonal pattern of stage at Martinez (typically lower in winter and spring and higher in summer and fall)

6.6 References

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