



**U.S. Army Corps of Engineers
Walla Walla District**

Two-Dimensional Hydrodynamic, Water Quality, and Fish Exposure Modeling of the Columbia and Snake Rivers.

Part 7: John Day Reservoir

FINAL REPORT

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Abstract

One of the major goals for the U.S. Army Corps of Engineers Dissolved Gas Abatement Study is to identify measures that could reduce levels of dissolved gas supersaturation in the Columbia and Snake Rivers caused by spillway discharges. Attaining this goal could contribute significantly to meeting water quality criteria and lowering gas bubble trauma in resident and migrating fish in these rivers. To achieve this goal, the Corps of Engineers is studying various operational and structural alternatives using field investigations and computational modeling tools to simulate the transport of dissolved gas in the river system.

Part 7 of the report series summarizes the development and application of a two-dimensional depth-averaged hydrodynamic and water quality model (MASS2) to the John Day Reservoir of the Lower Columbia River system.

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Two-Dimensional Hydrodynamic, Water Quality, and Fish Exposure Modeling of the Columbia and Snake Rivers. Part 7: John Day Reservoir

Under Biological Services Contract DACW68-96-D-0002, Delivery Order No. 8, Battelle, Pacific Northwest Division is developing and applying a two-dimensional hydrodynamic, transport model, and fish exposure model to the Lower Columbia and Snake River systems. This work is an element of the U.S. Army Corps of Engineers Dissolved Gas Abatement Program (DGAS).

Part 7 of the report series describes the application of the model to the John Day Pool of the Columbia River. The modeled domain encompasses the following region:

- McNary Dam, at Columbia rivermile (RM) 292
- John Day Dam, at Columbia RM 217

1 Application of the Hydrodynamics and Water Quality Models to John Day Pool

A two-dimensional-depth averaged hydrodynamics and transport model has been developed and applied to the part of the Columbia River that forms the John Day Dam pool. The model simulates time-varying distributions of the depth-averaged velocities, water temperature, and total dissolved gas. Further details concerning the model including the governing equations and solutions procedures are provided in Part 1 of the report series (Richmond, Perkins, and Scheibe, 1998).

The section discusses the general aspects of the application of the models to John Day Pool. The data used to assign the bathymetry and boundary conditions are described in Appendix A. Summaries of the field data in the calibration and verification simulations are provided in Appendix B and Appendix C.

Hydrodynamics were verified using Spring 1997 and Summer 1997 Acoustic Doppler Current Profiler (ADCP) data. Dissolved gas and temperature verification used the Spring 1997 and Summer 1997 pool study data.

1.1 Model Grid

The computational grid was generated using the Gridgen 9.1 code. Gridgen 9.1 is software for the generation of 3D, multiple block, structured grids. The code was developed for NASA Ames Research Center (Steinbrenner and Chawner, 1995).

To create the grid, a data file containing discrete geographical locations that outline the river shoreline was imported to Gridgen. In Gridgen, curves containing the data points were created and joined to enclose 2-dimensional flow regions. Grid spacing was set in

each flow region and the grids were smoothed using the Gridgen elliptic solver. The elliptic solver was used to minimize grid twist and skew. The flow regions were then joined end to end in the downstream direction to make up the entire flow domain and the entire 2-dimensional grid was written to file. Once the grid was created bottom elevations in each cell were assigned using the bathymetric data and procedure described in Appendix A.

The model grid for John Day pool is shown in Figure 1. Larger scale maps of the model grid near the McNary dam and John Day dam boundaries are shown in Figure 2. Note that several small islands were not included in the model and these were replaced with bottom elevation approximately 2 ft below the low water surface elevation (the water is about 2 ft deep where the islands are).

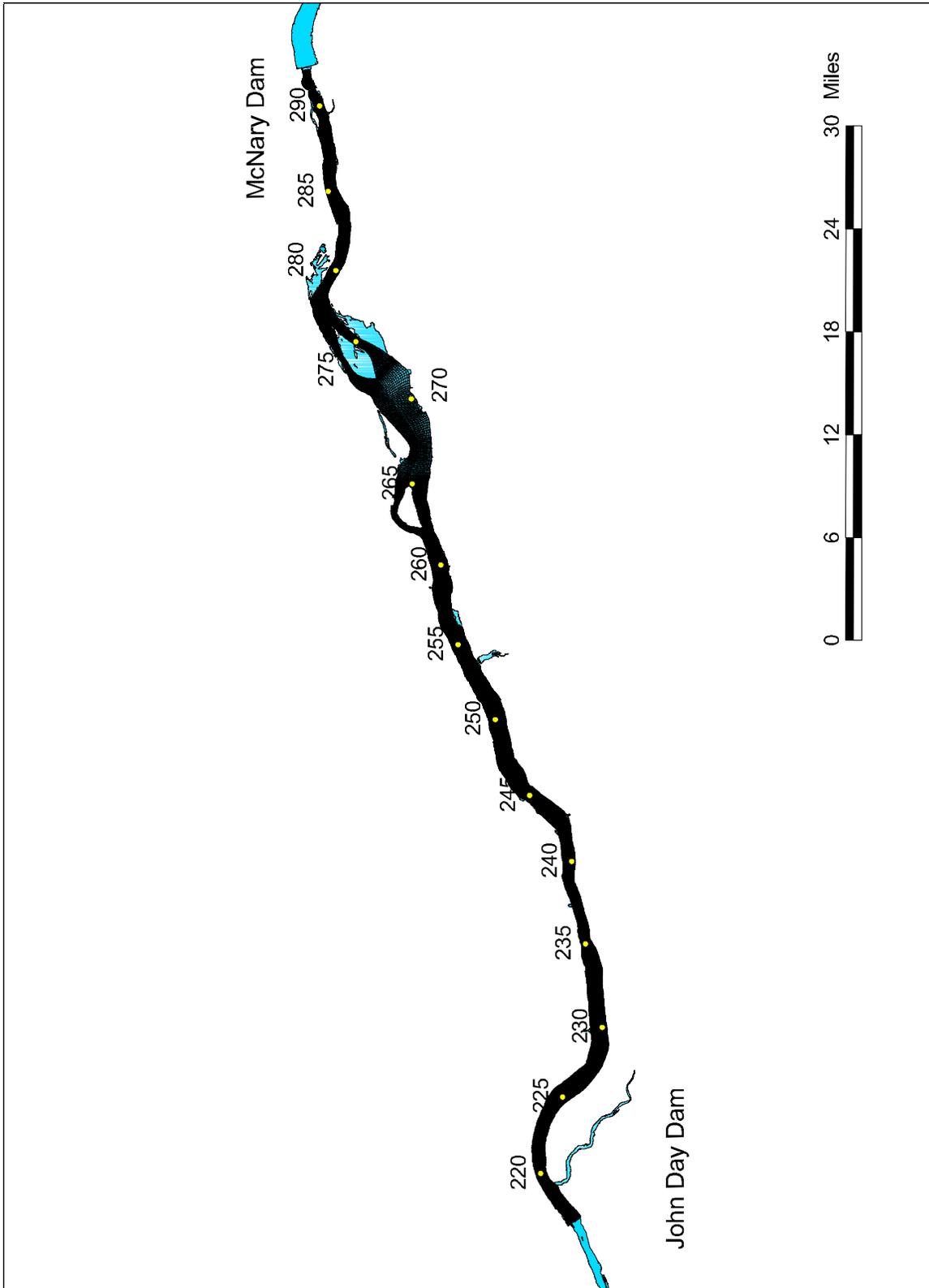


Figure 1. Model grid for John Day pool.

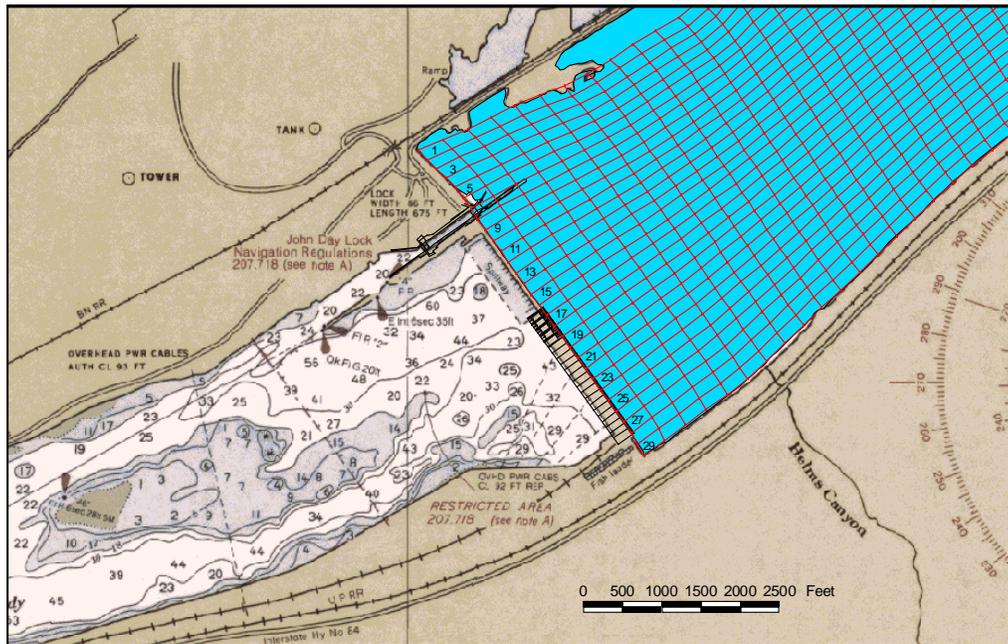
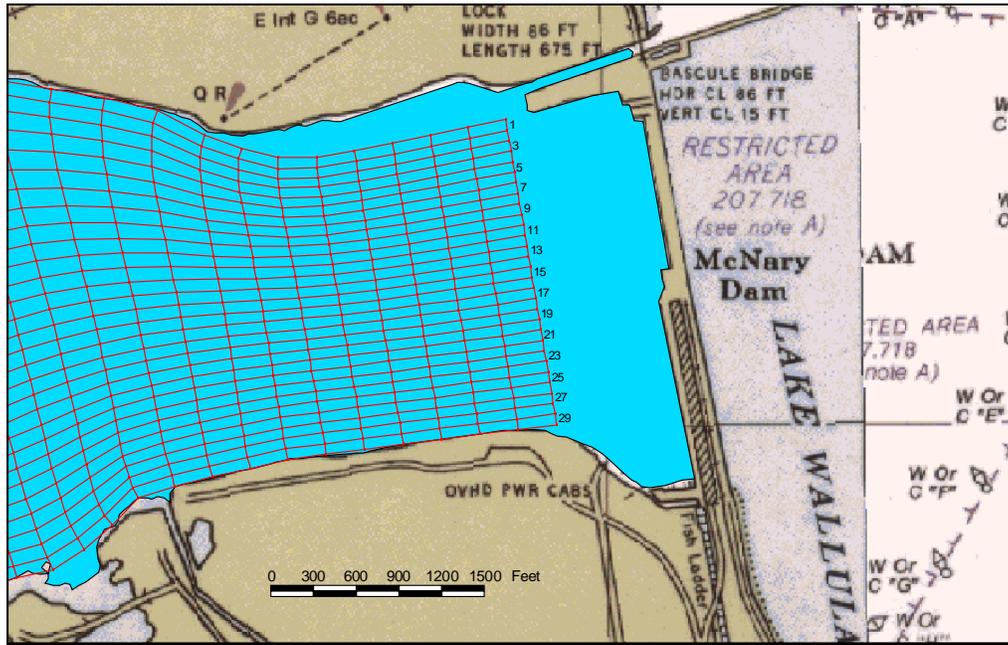


Figure 2. Model grid near McNary (above) and John Day (below) dams.

1.2 Boundary Conditions

1.2.1 McNary Dam Sourcing Function

Spillway TDG concentrations were estimated using the McNary dam TDG sourcing function presented by Schnieder and Wilhelms (1997):

$$S_s = 114.90 + 4.87 \times 10^{-5} Q_s \quad (1)$$

where

S_s = TDG saturation of spillway flow, percent; and

Q_s = spillway flow, cfs.

Forebay temperatures and barometric pressures were used to compute concentration from the saturation estimated using equation (1).

1.3 Hydrodynamics Calibration and Verification

The model hydrodynamics were calibrated primarily using the McNary dam tailwater elevation gage. ADCP velocity measurements were available for both John Day pool study periods. Due to instrumentation problems the coordinates of the ADCP data were subject to uncertain errors. Therefore, at this time, use of the ADCP data was restricted to qualitative comparisons with the model simulations.

In all simulations in this report a time step of 50 seconds was used. The simulations also used constant longitudinal and lateral turbulent eddy viscosities of 0.2 ft²/s.

1.3.1 McNary Tailwater

The first step in the calibration procedure was to select a spatially uniform value of the Manning roughness coefficient that would yield computed water surface elevations in satisfactory agreement with the McNary dam tailwater gage. The Spring 1997 pool study period was selected for calibration. Simulations were performed using Manning n values in the range of 0.027 to 0.029. Figure 3 compares the model simulation and measured tailwater elevation for a n-value of 0.027 which was chosen as the final parameter value to be used in the remainder of the John Day pool simulations.

The selected n-value was verified for the Summer 1997 study period. The verification results are shown in Figure 4.

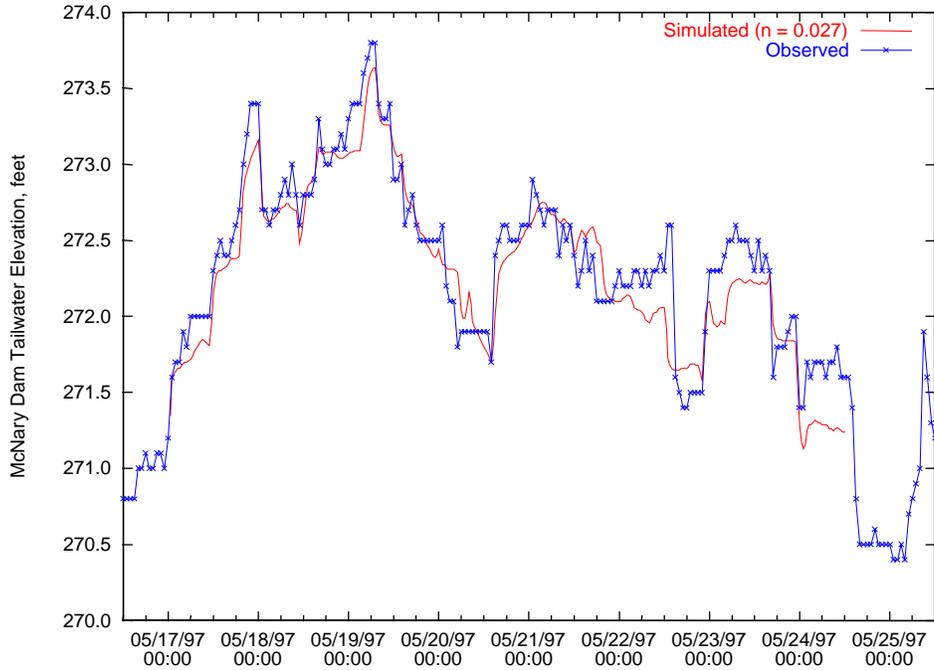


Figure 3. Comparison of simulated (Manning’s $n = 0.027$) and measured water surface elevation at the McNary dam tailwater gage during the Spring 1997 study period

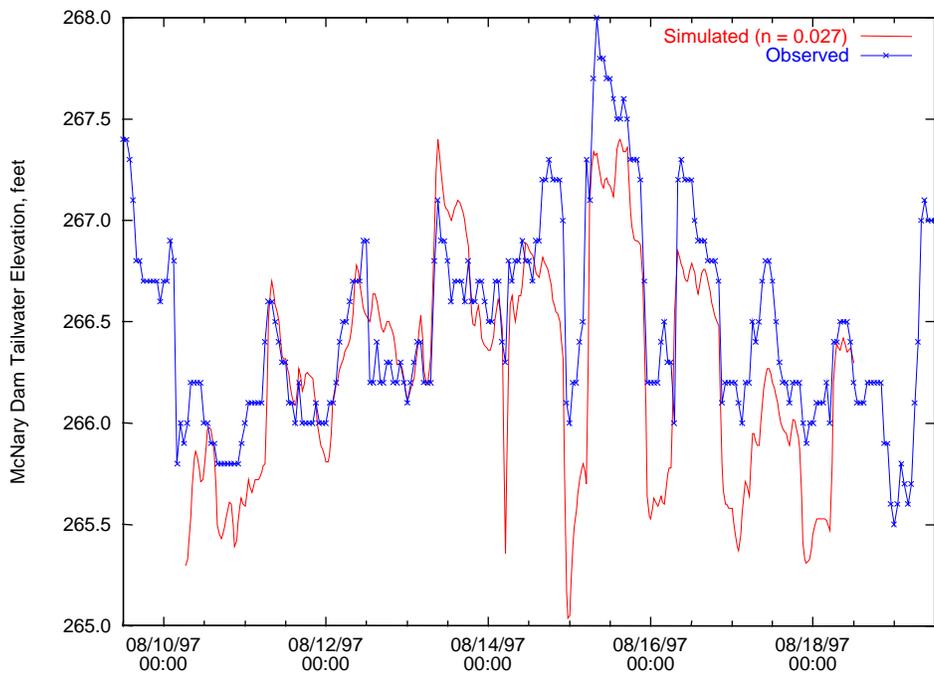


Figure 4. Comparison of simulated (Manning’s $n = 0.027$) and measured water surface elevation at the McNary dam tailwater gage during the Summer 1997 study period

1.3.2 Spring 1997 ADCP Data

Once the Manning n-value was selected, the model was run for the operational conditions that existed when the Spring 1997 ADCP measurements were performed. The Manning n value was not altered from the value of 0.027 selected from the tailwater calibration. Simulated velocities are compared to the depth-averaged ADCP data in Figure 5 through Figure 43.

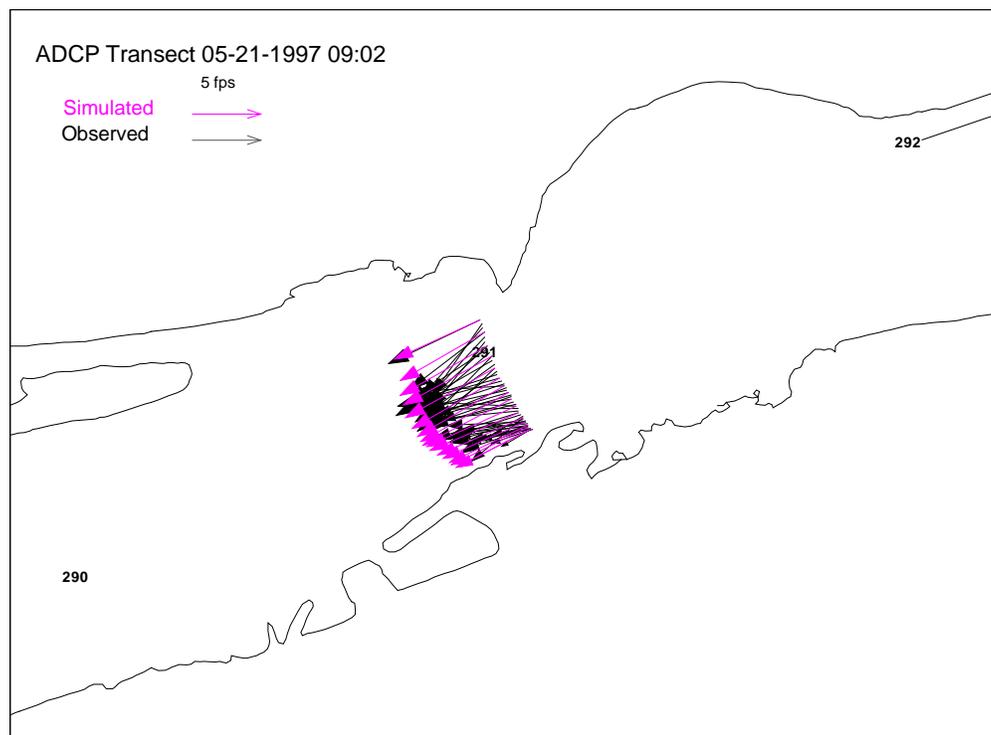


Figure 5. Simulated and observed velocities near Columbia River Mile 291 on May 21, 1997.

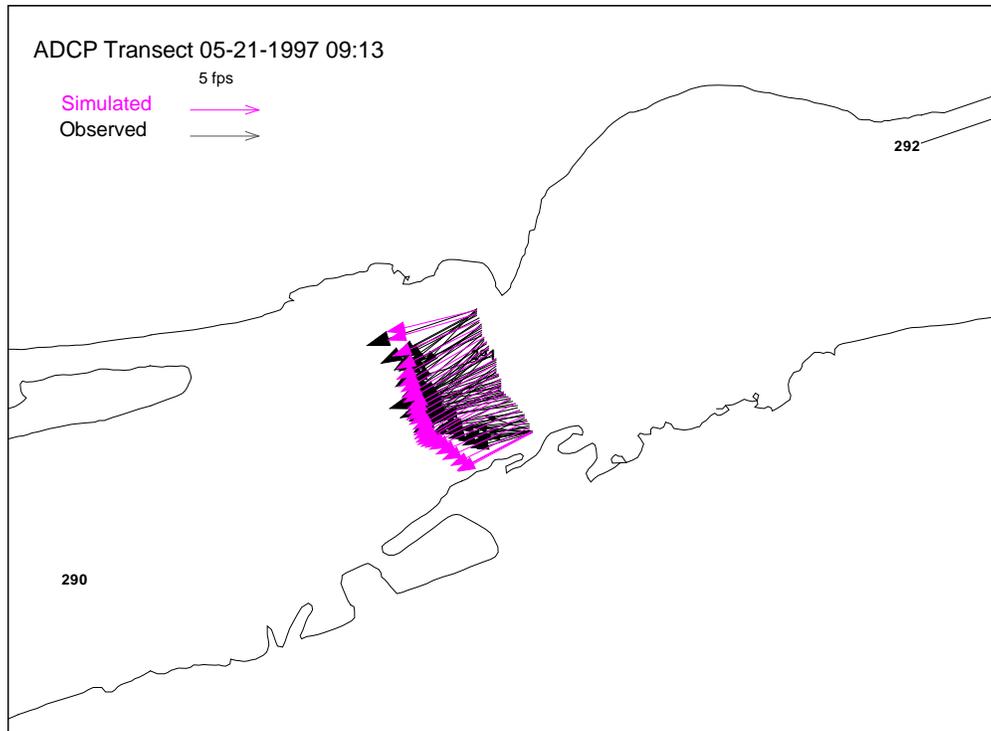


Figure 6. Simulated and observed velocities near Columbia River Mile 291 on May 21, 1997.

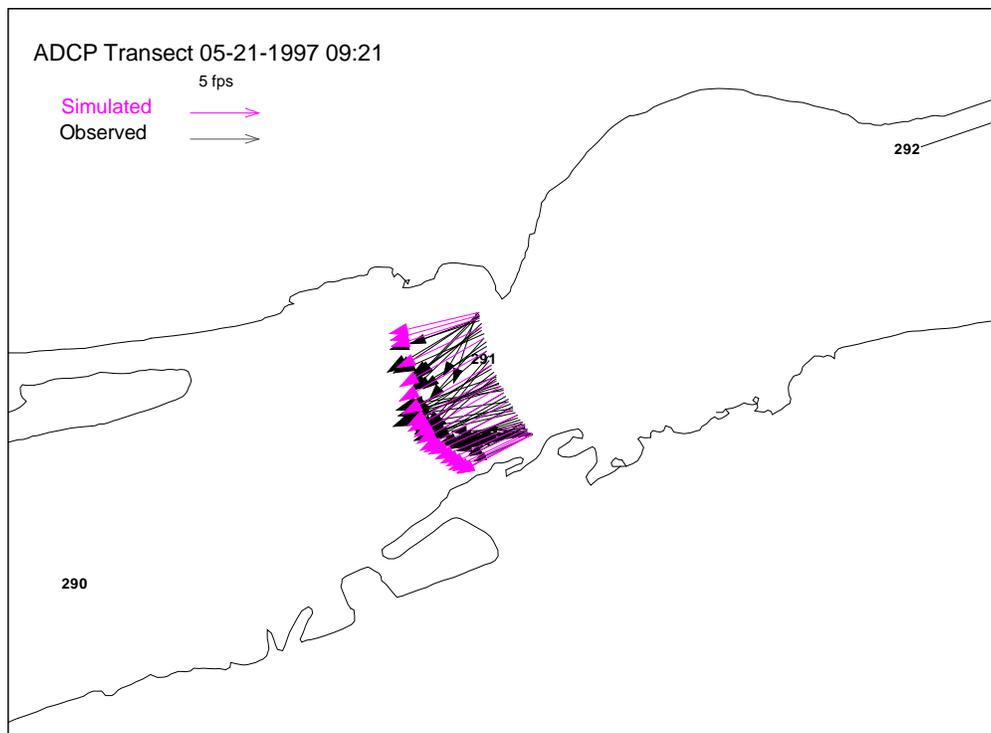


Figure 7. Simulated and observed velocities near Columbia River Mile 291 on May 21, 1997.

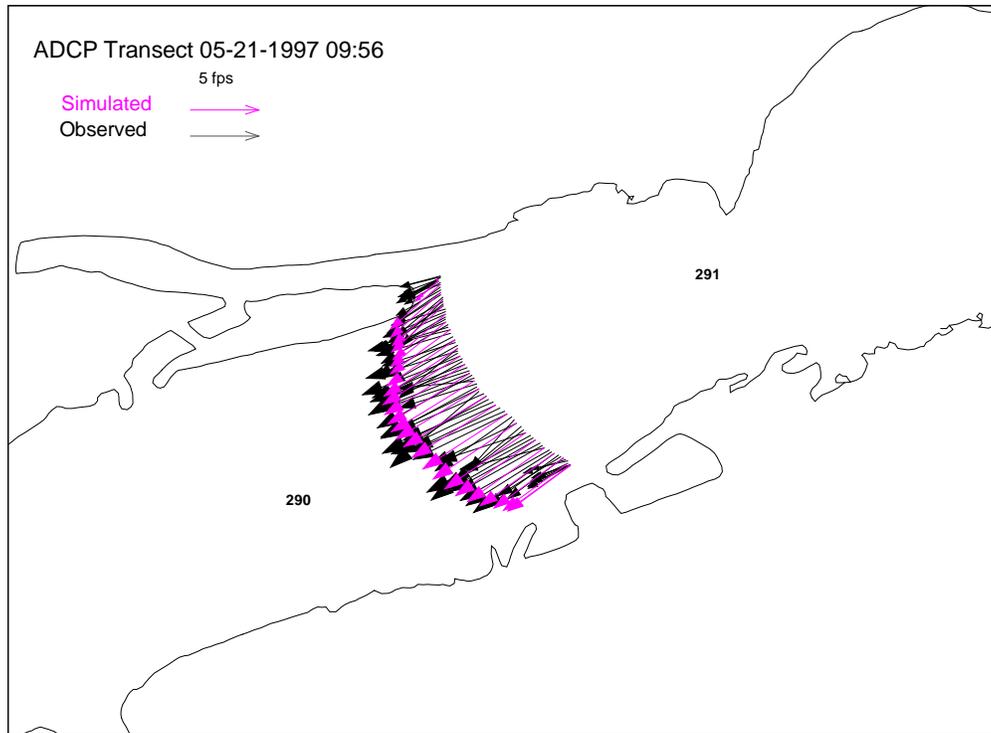


Figure 8. Simulated and observed velocities near Columbia River Mile 290.5 on May 21, 1997.

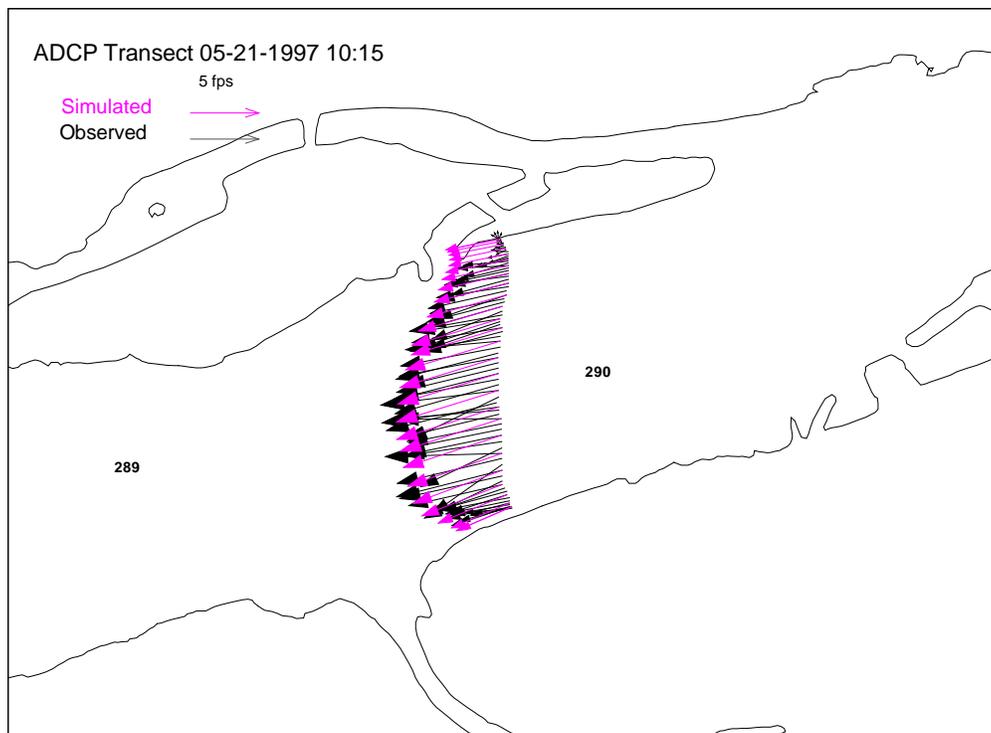


Figure 9. Simulated and observed velocities near Columbia River Mile 290 on May 21, 1997.

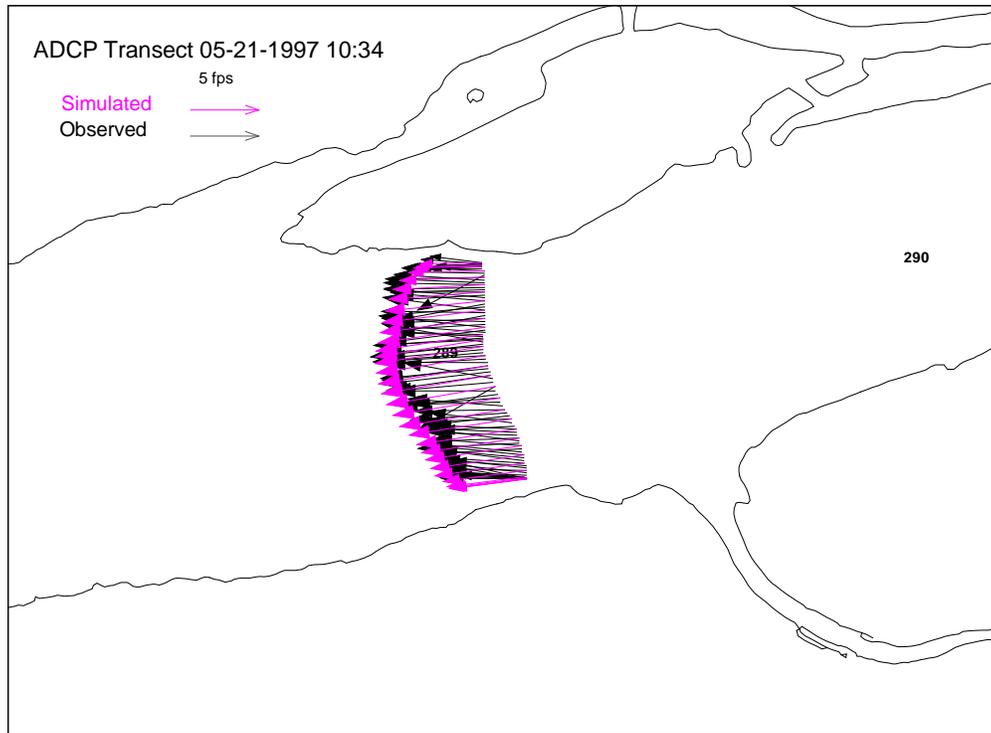


Figure 10. Simulated and observed velocities near Columbia River Mile 289 on May 21, 1997.

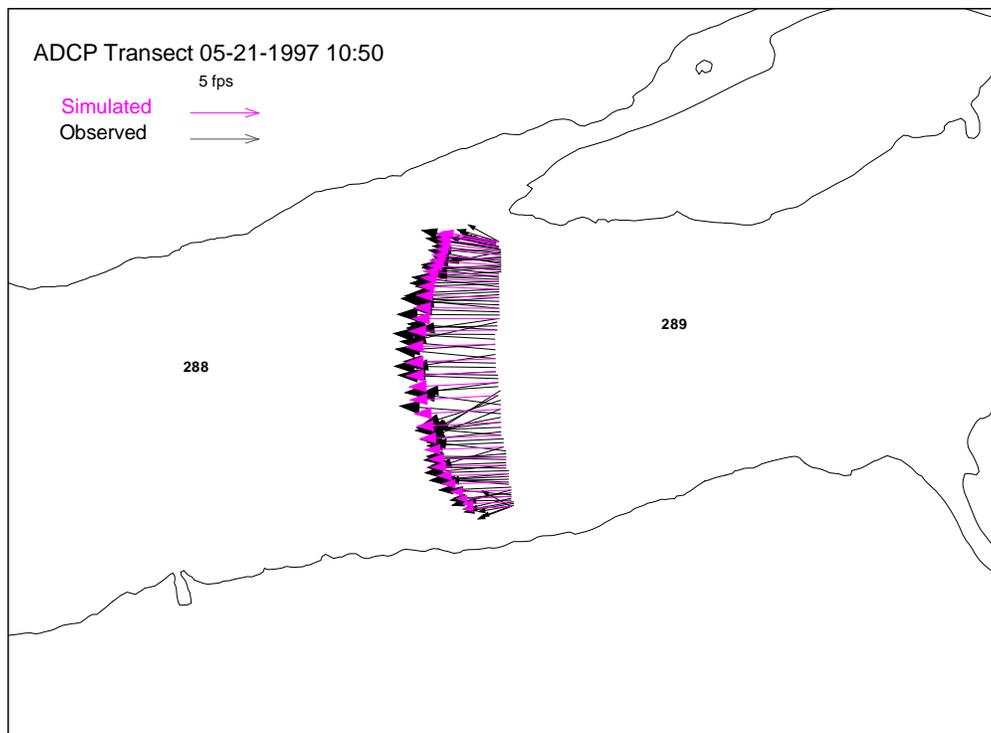


Figure 11. Simulated and observed velocities near Columbia River Mile 288.5 on May 21, 1997.

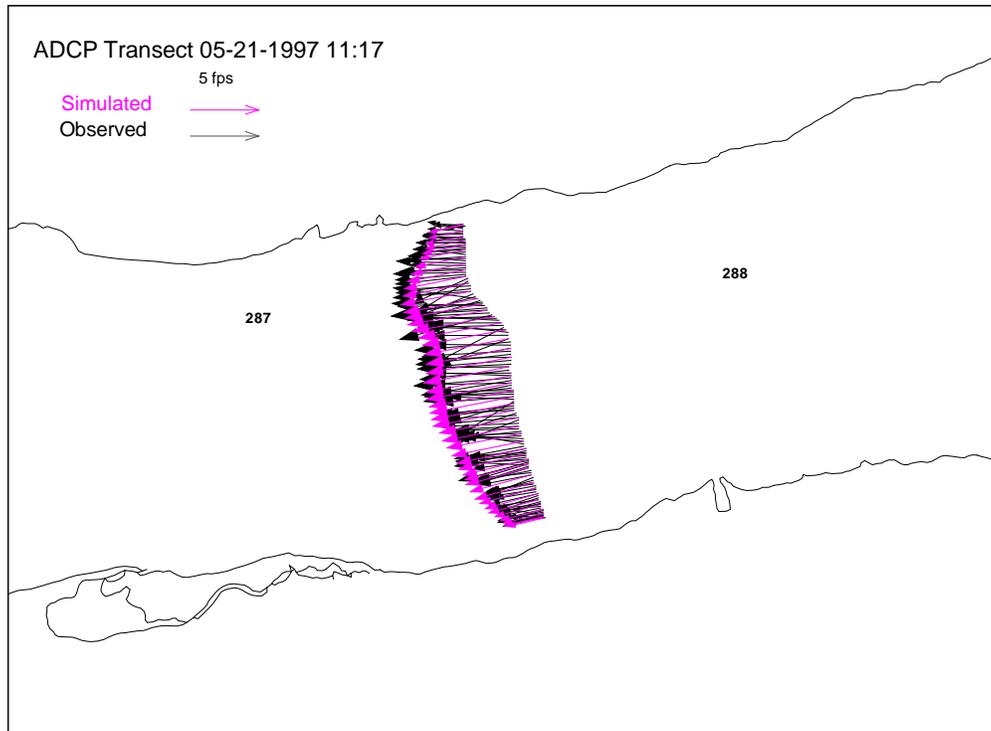


Figure 12. Simulated and observed velocities near Columbia River Mile 287.5 on May 21, 1997.

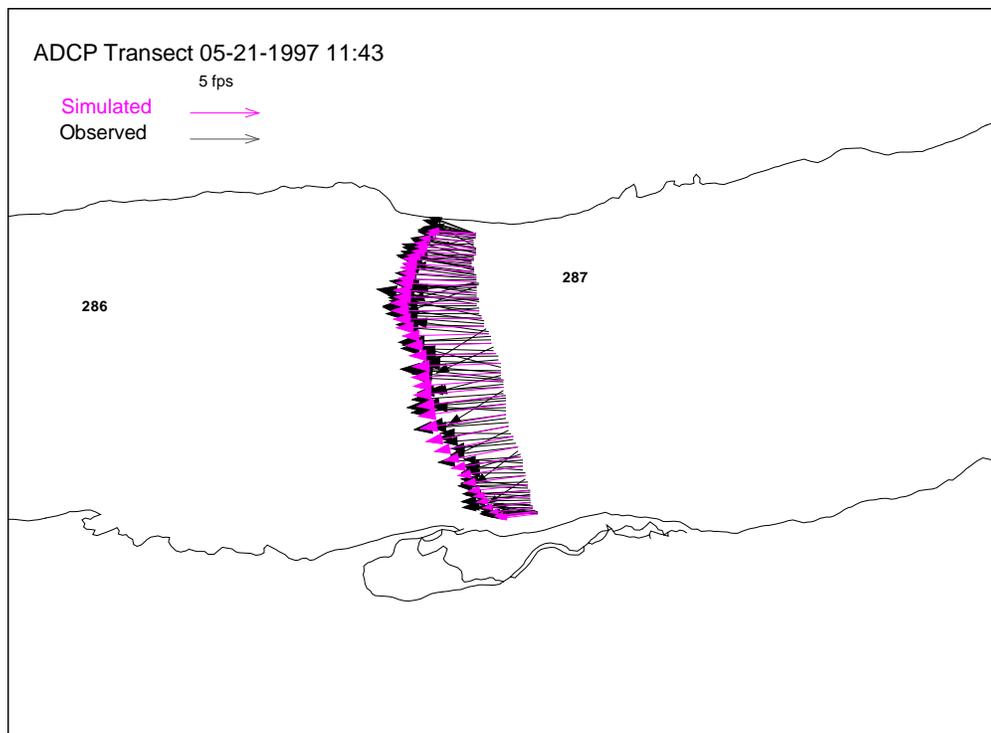


Figure 13. Simulated and observed velocities near Columbia River Mile 287 on May 21, 1997.

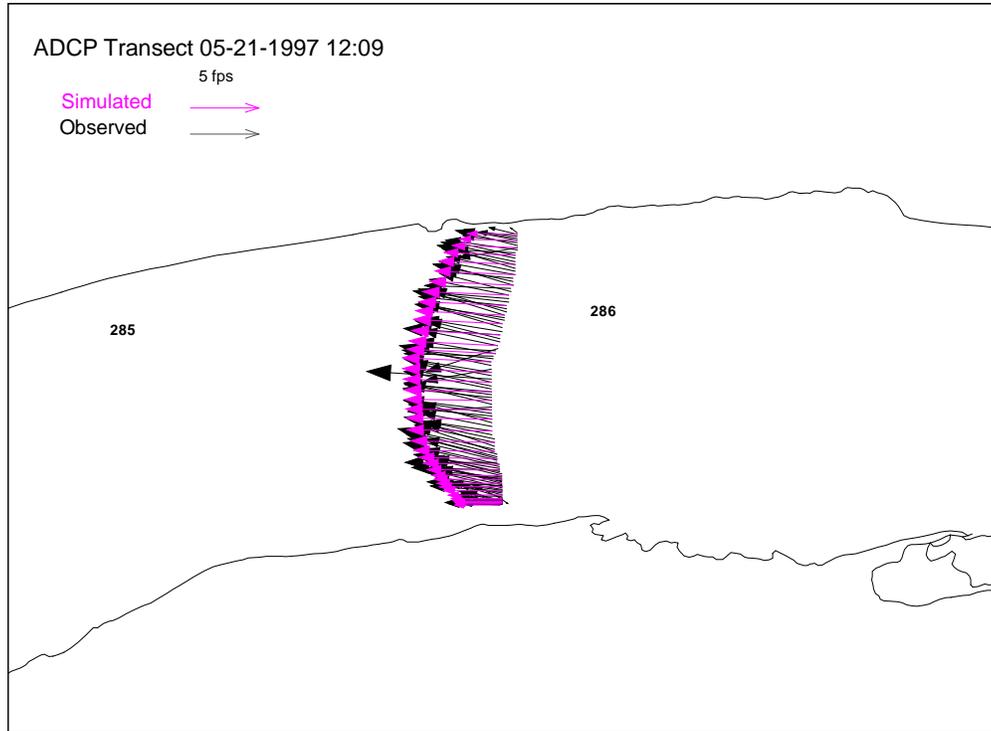


Figure 14. Simulated and observed velocities near Columbia River Mile 286 on May 21, 1997.

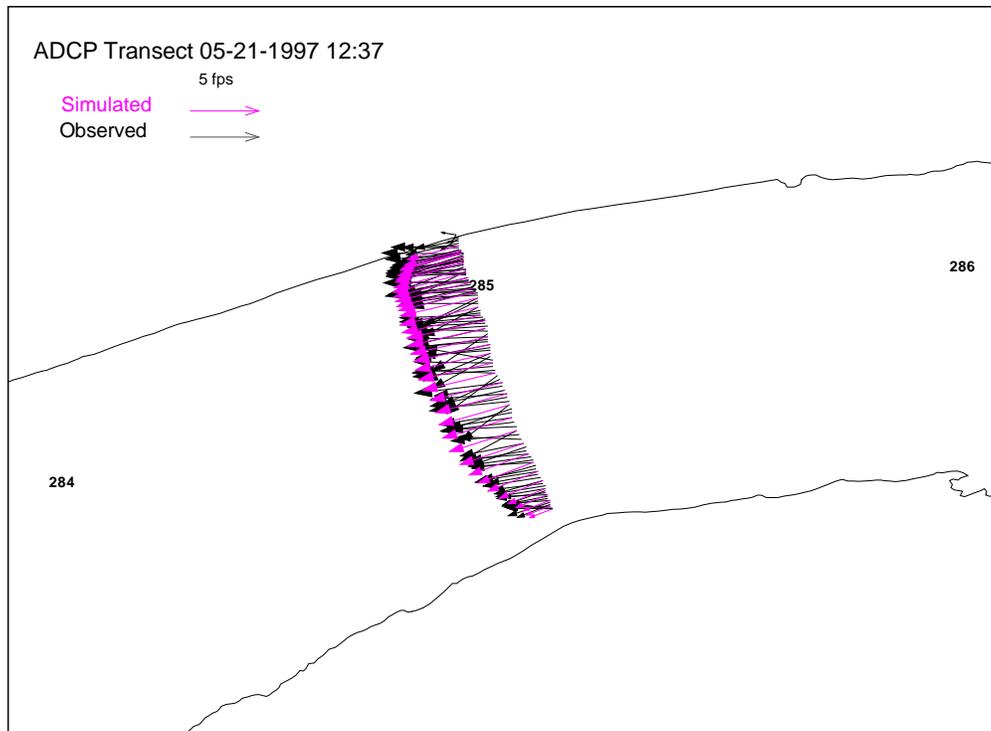


Figure 15. Simulated and observed velocities near Columbia River Mile 285 on May 21, 1997.

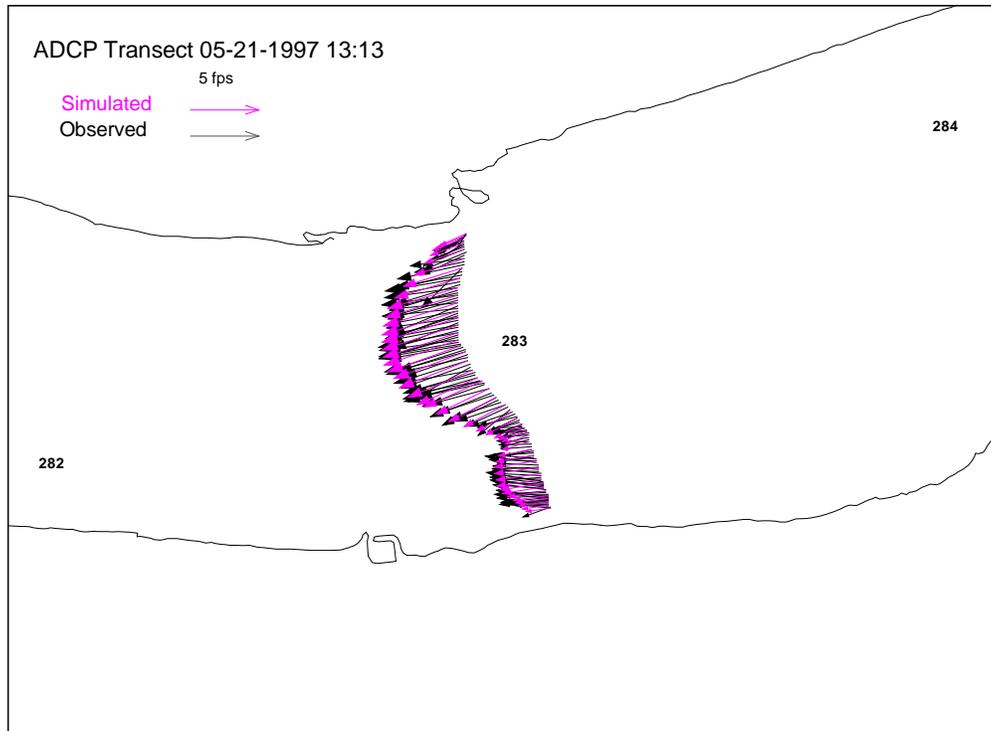


Figure 16. Simulated and observed velocities near Columbia River Mile 283 on May 21, 1997.

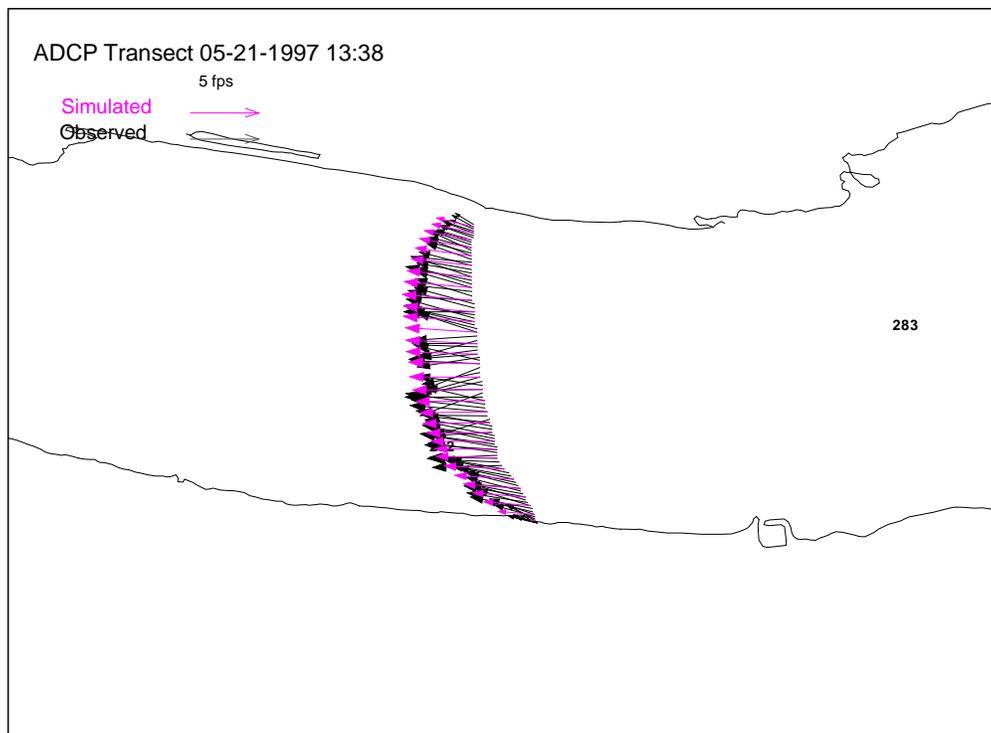


Figure 17. Simulated and observed velocities near Columbia River mile 282 on May 21, 1997.

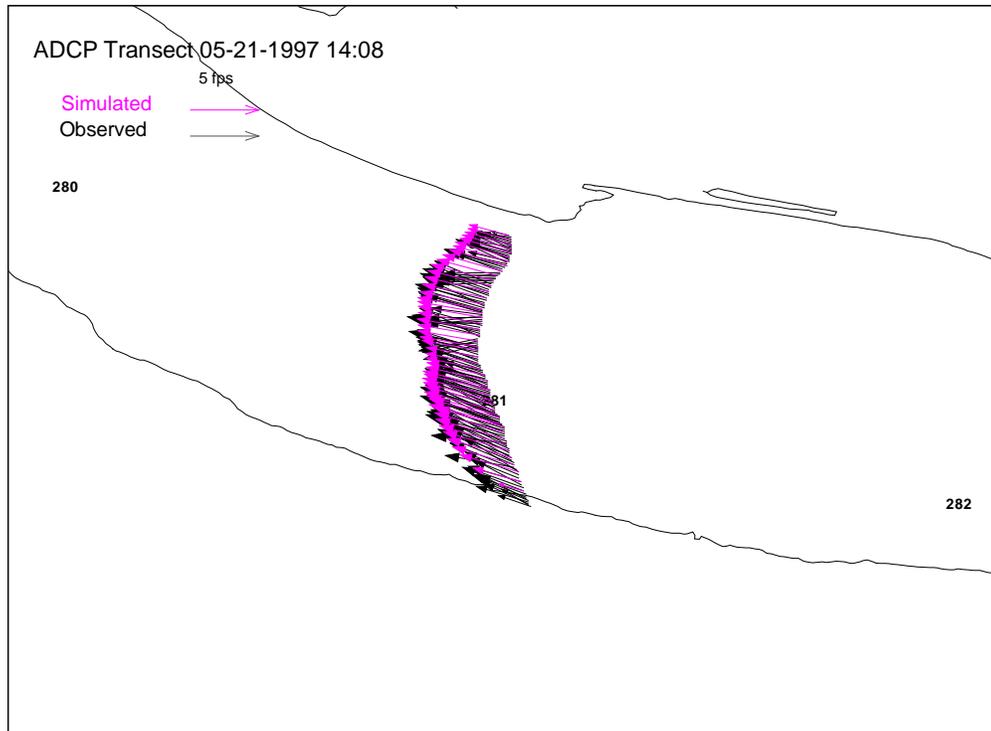


Figure 18. Simulated and observed velocities near Columbia River Mile 281 on May 21, 1997.

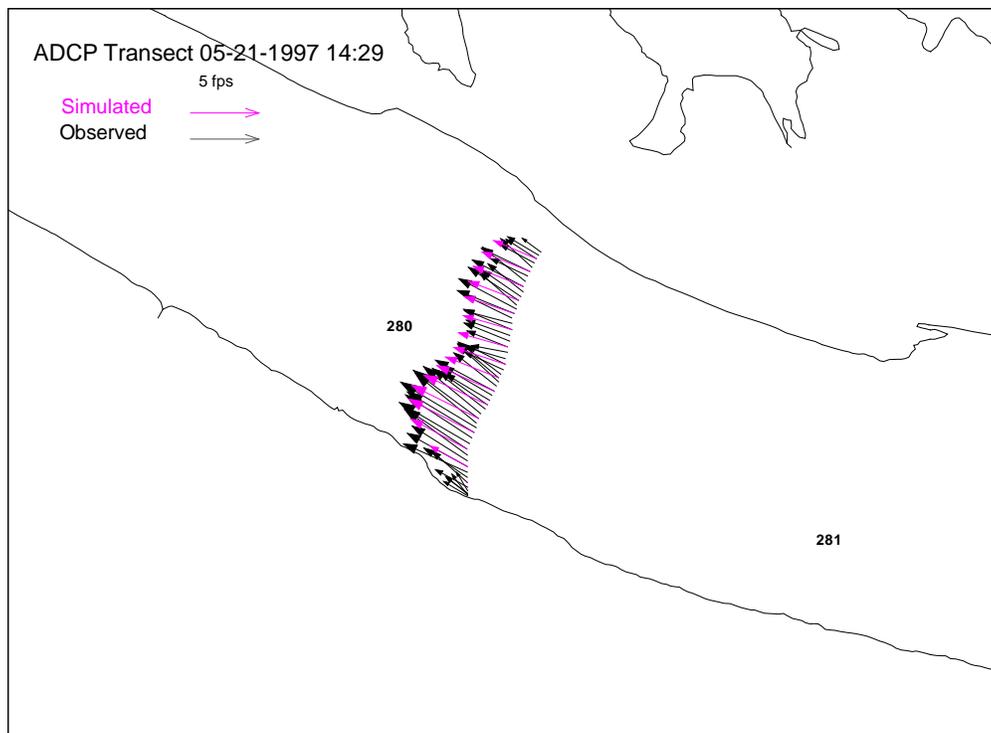


Figure 19. Simulated and observed velocities near Columbia River Mile 280 on May 21, 1997.

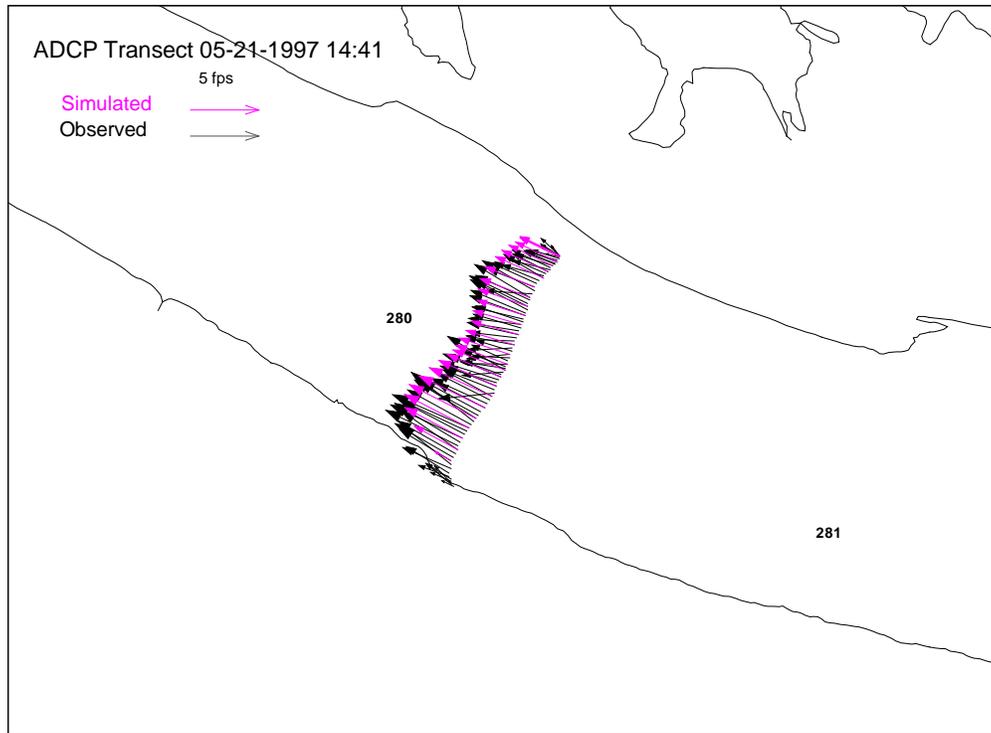


Figure 20. Simulated and observed velocities near Columbia River Mile 280 on May 21, 1997.

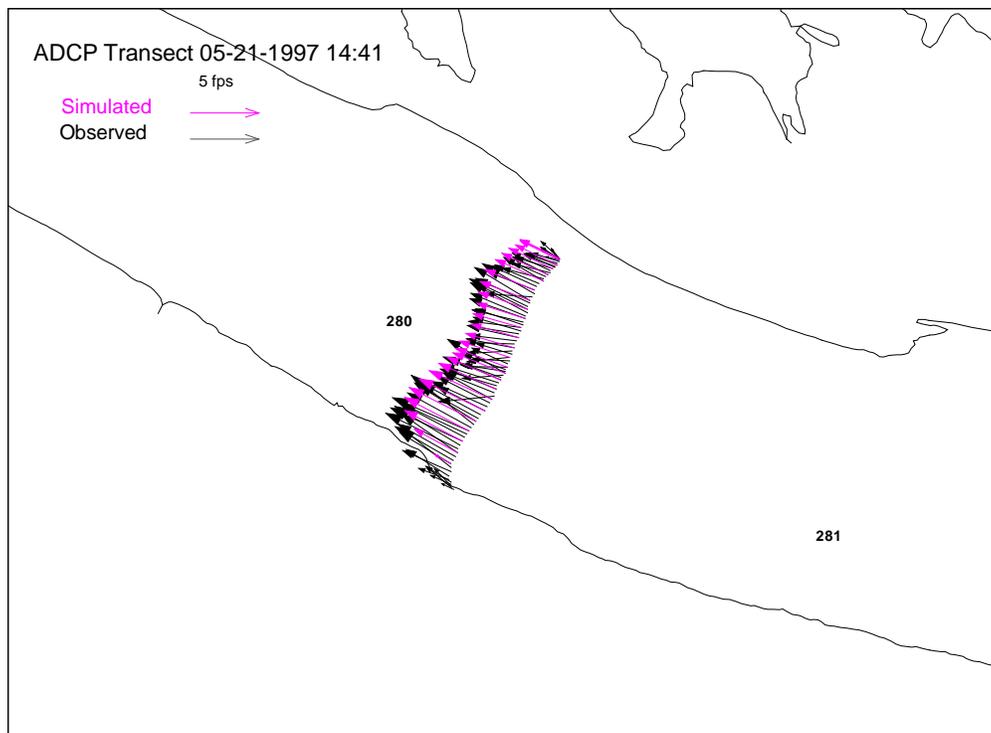


Figure 21. Simulated and observed velocities near Columbia River Mile 280 on May 21, 1997.

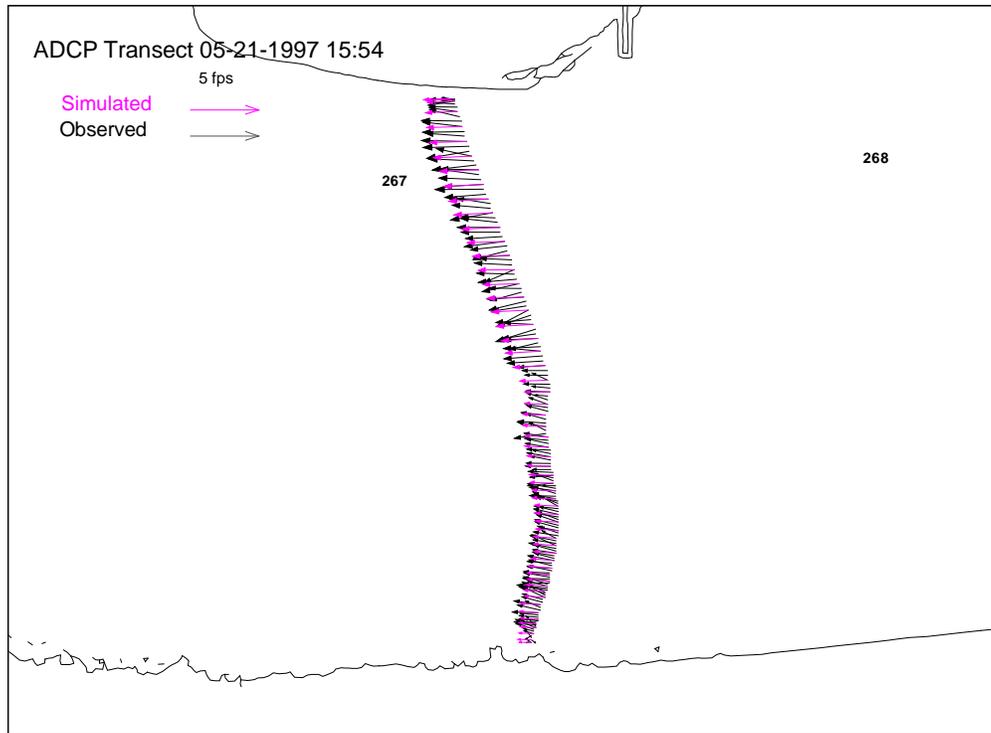


Figure 22. Simulated and observed velocities near Columbia River Mile 267 on May 21, 1997.

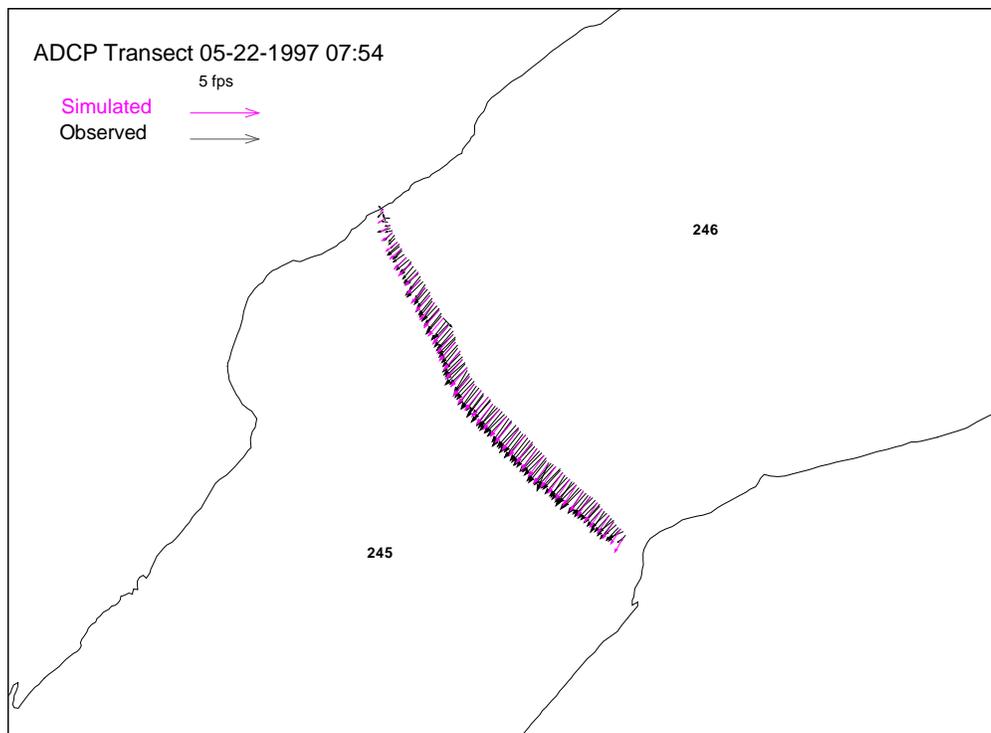


Figure 23. Simulated and observed velocities near Columbia River Mile 245.5 on May 22, 1997.

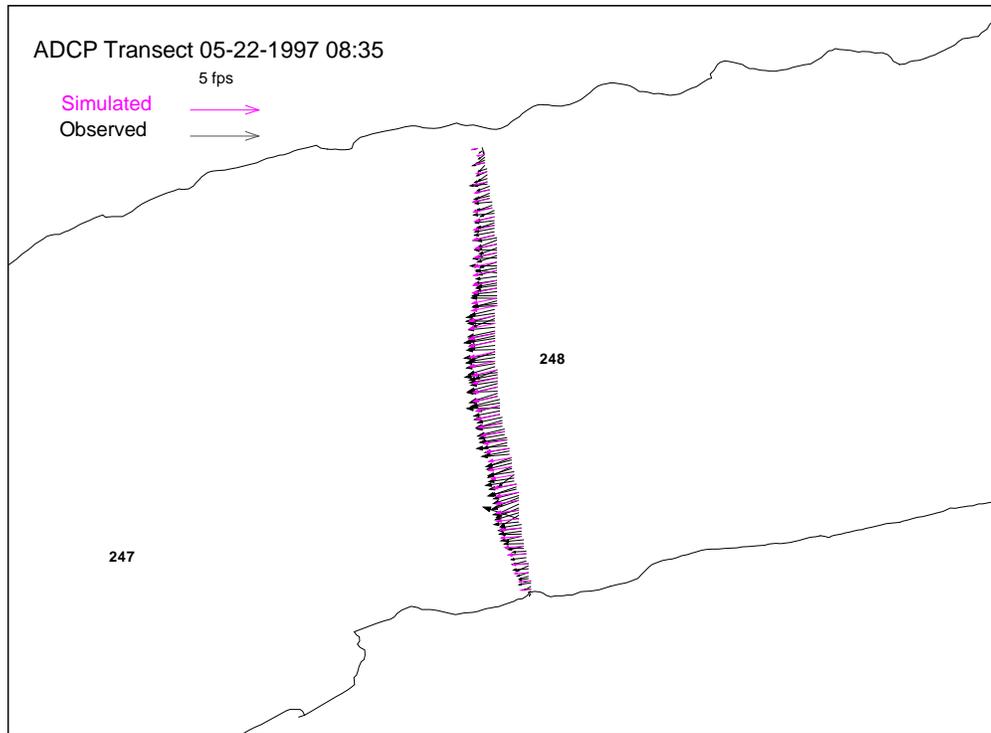


Figure 24. Simulated and observed velocities near Columbia River Mile 248 on May 22, 1997.

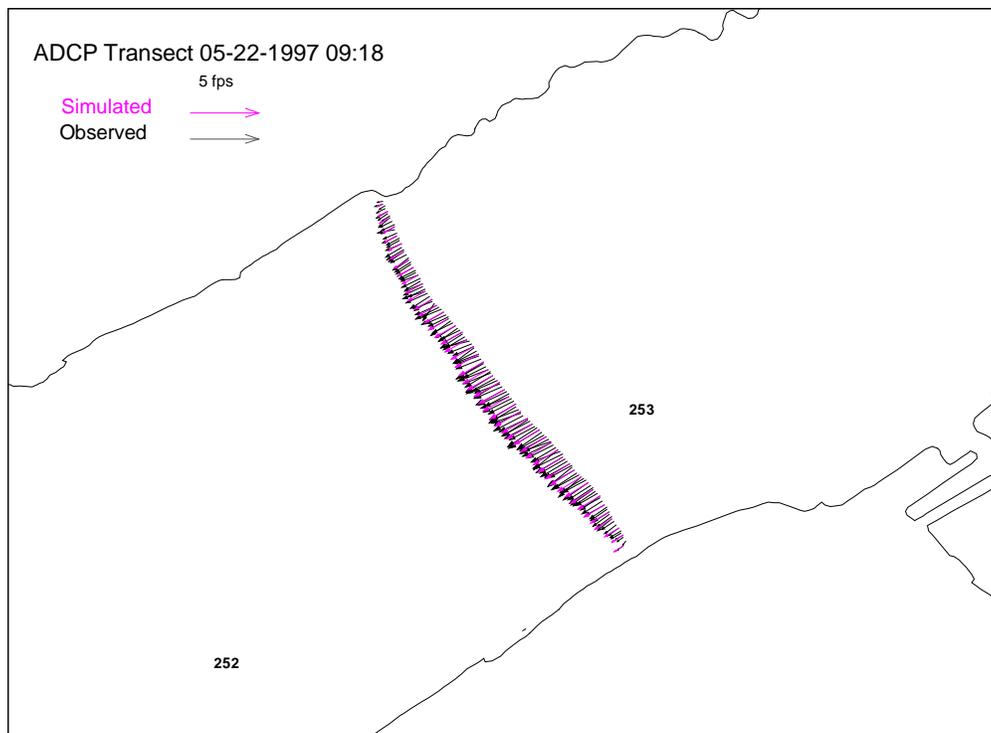


Figure 25. Simulated and observed velocities near Columbia River Mile 253 on May 22, 1997.

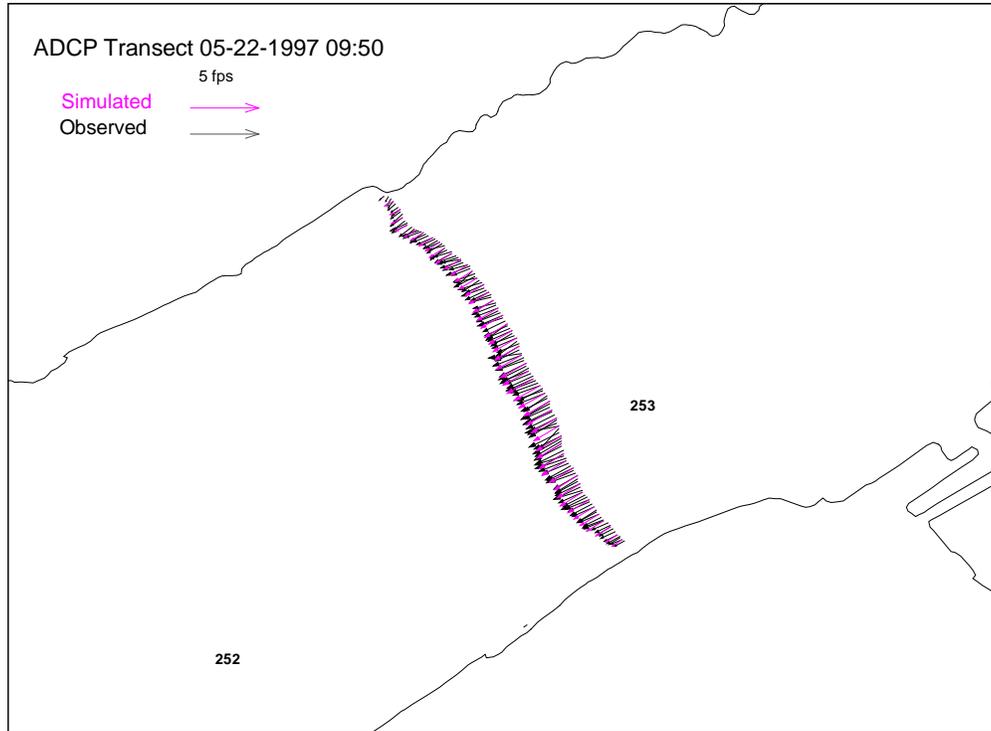


Figure 26. Simulated and observed velocities near Columbia River Mile 253 on May 22, 1997.

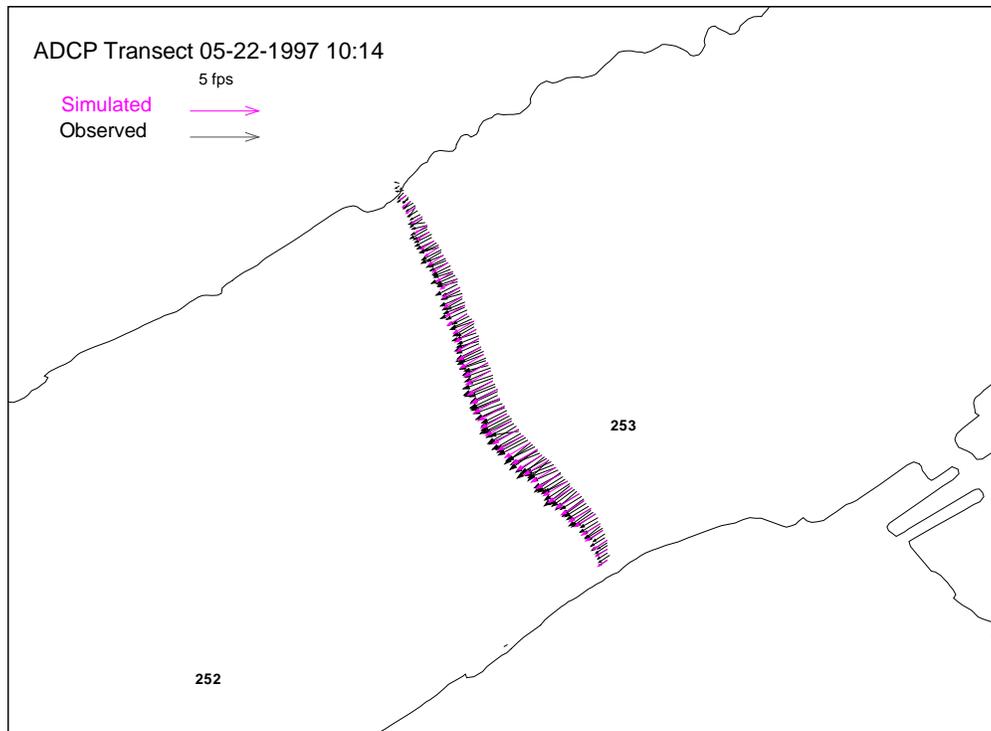


Figure 27. Simulated and observed velocities near Columbia River Mile 253 on May 22, 1997.

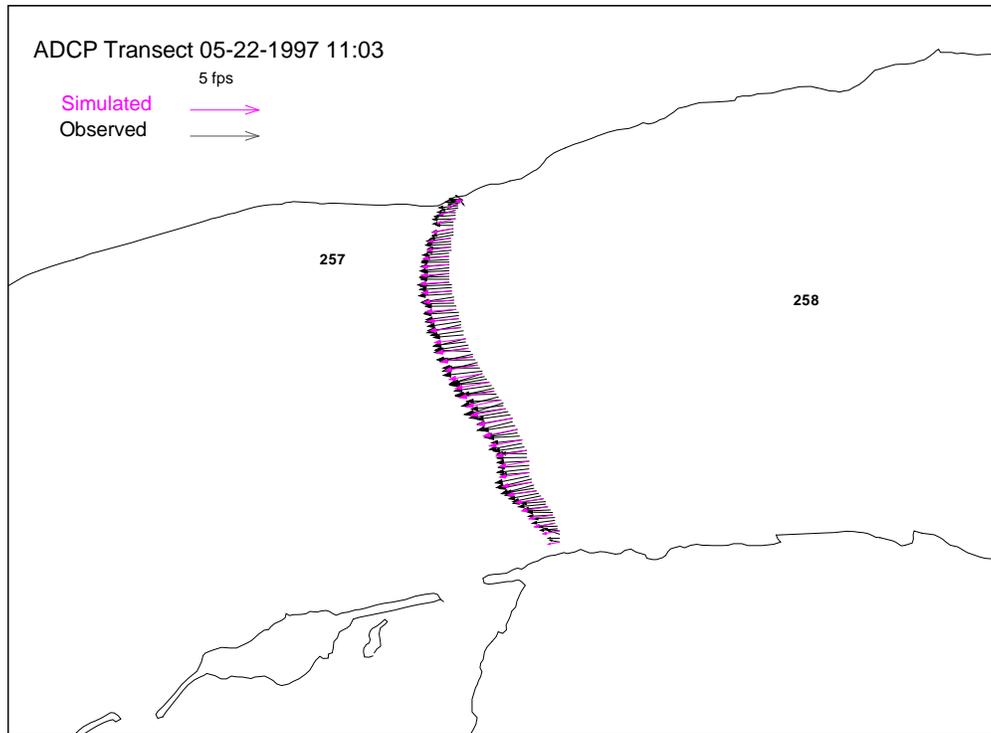


Figure 28. Simulated and observed velocities near Columbia River Mile 257 on May 22, 1997.

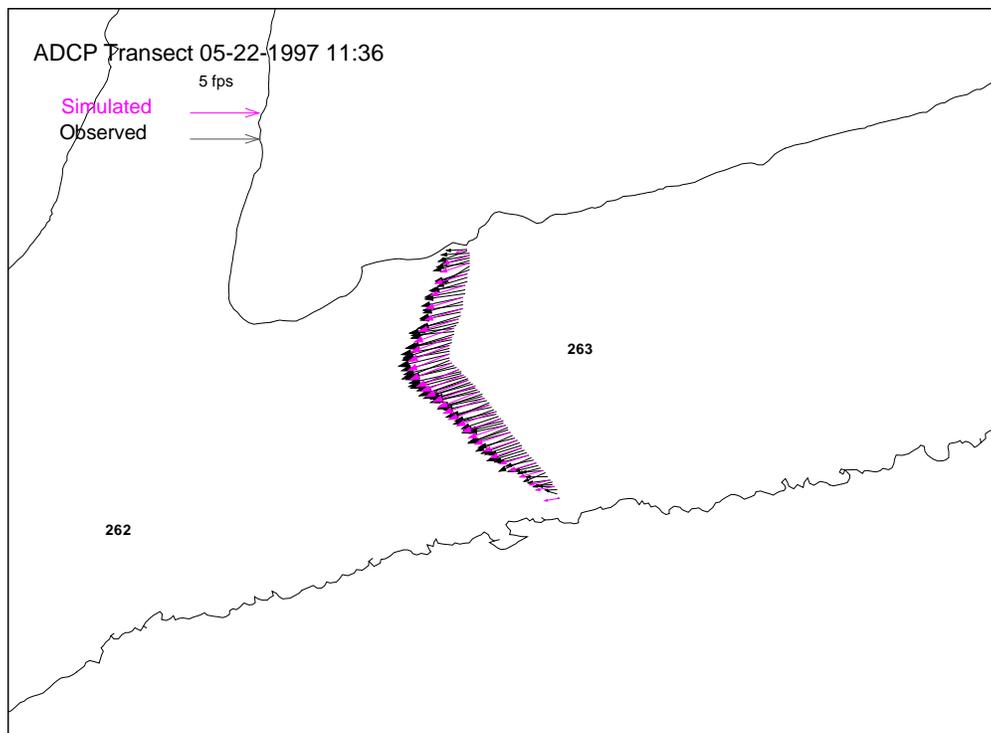


Figure 29. Simulated and observed velocities near Columbia River Mile 263 on May 22, 1997.

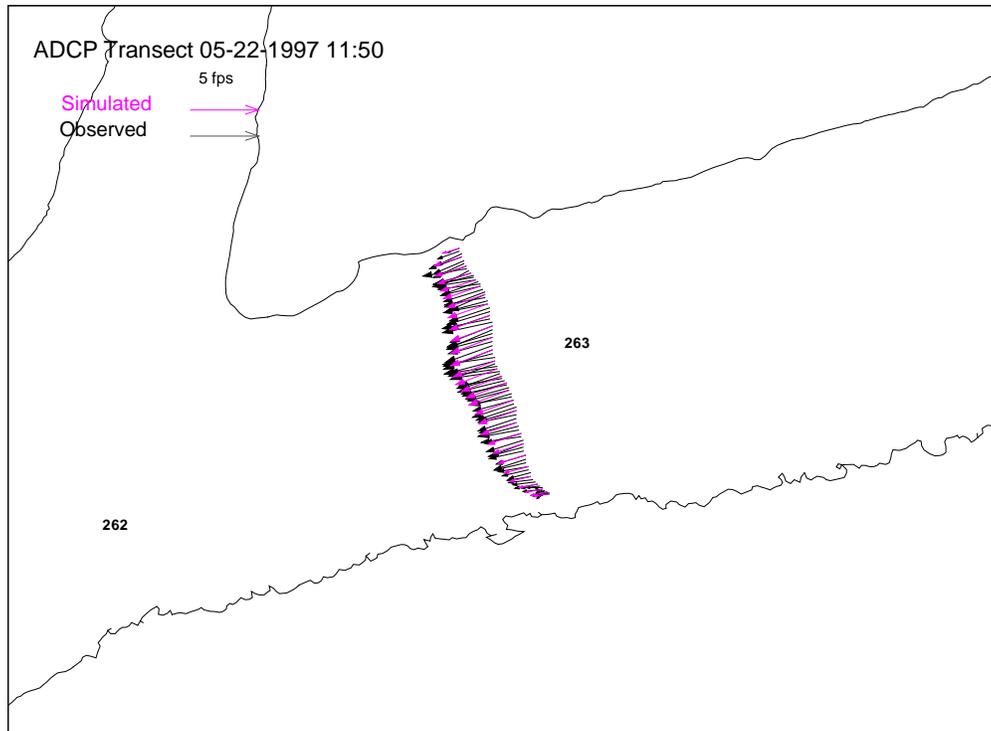


Figure 30. Simulated and observed velocities near Columbia River Mile 263 on May 22, 1997.

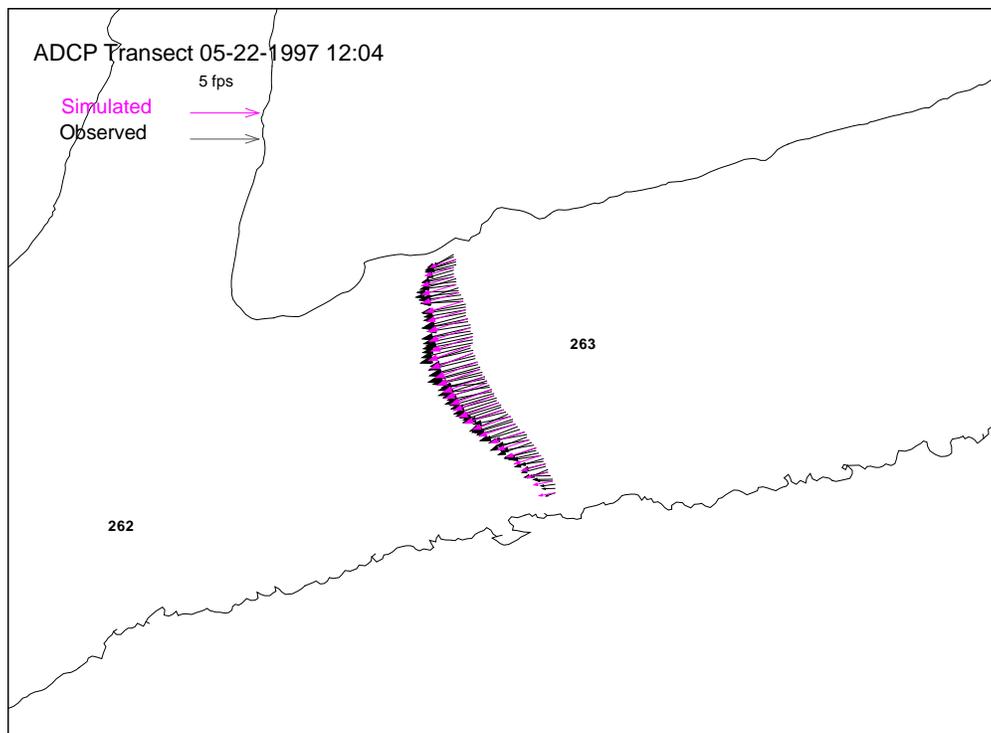


Figure 31. Simulated and observed velocities near Columbia River Mile 263 on May 22, 1997.

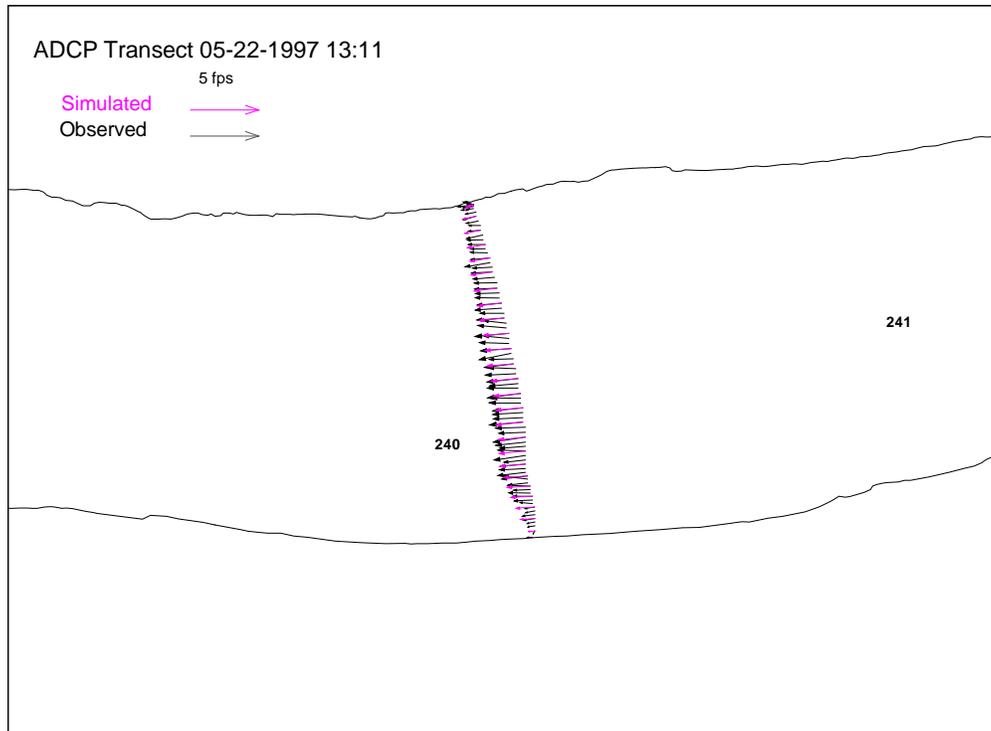


Figure 32. Simulated and observed velocities near Columbia River Mile 240 on May 22, 1997.

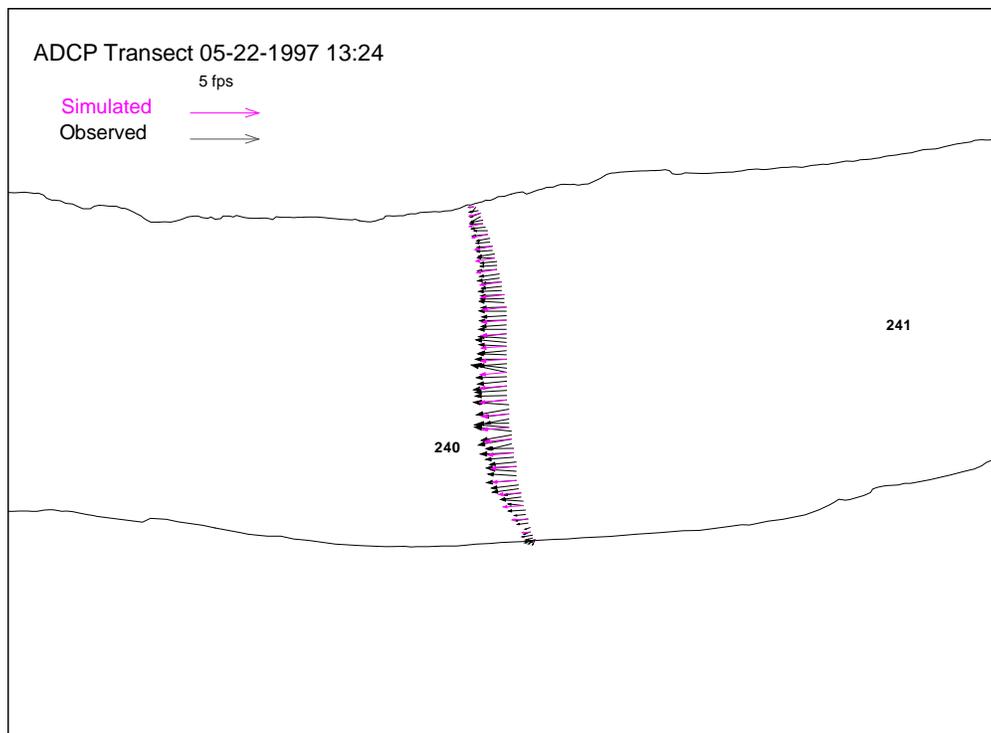


Figure 33. Simulated and observed velocities near Columbia River Mile 240 on May 22, 1997.

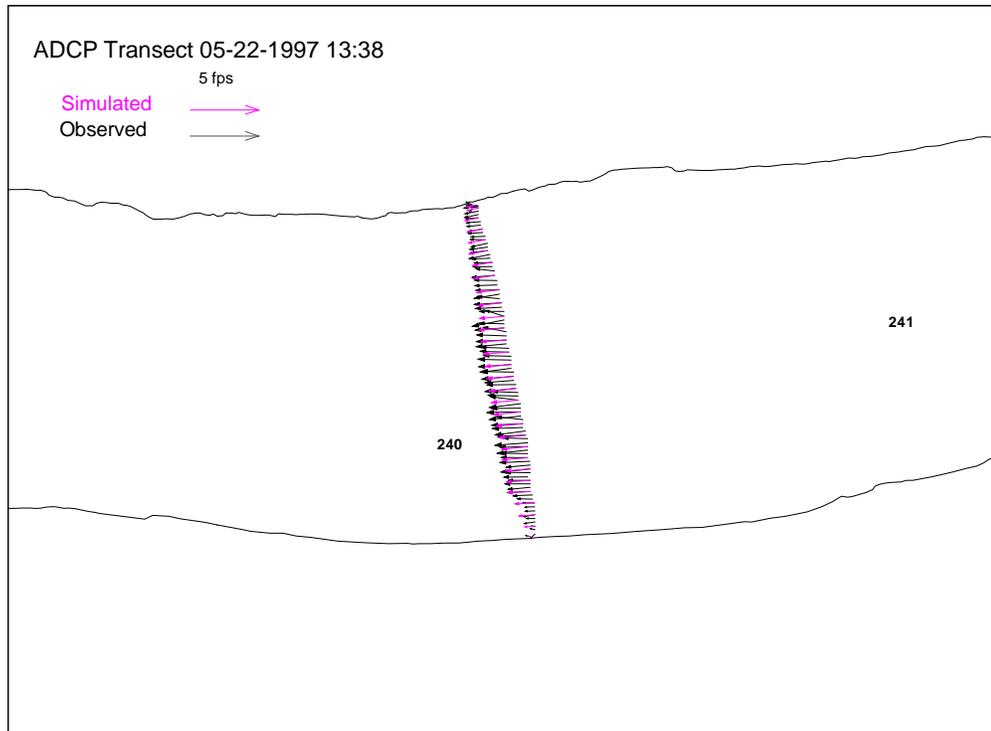


Figure 34. Simulated and observed velocities near Columbia River Mile 240 on May 22, 1997.

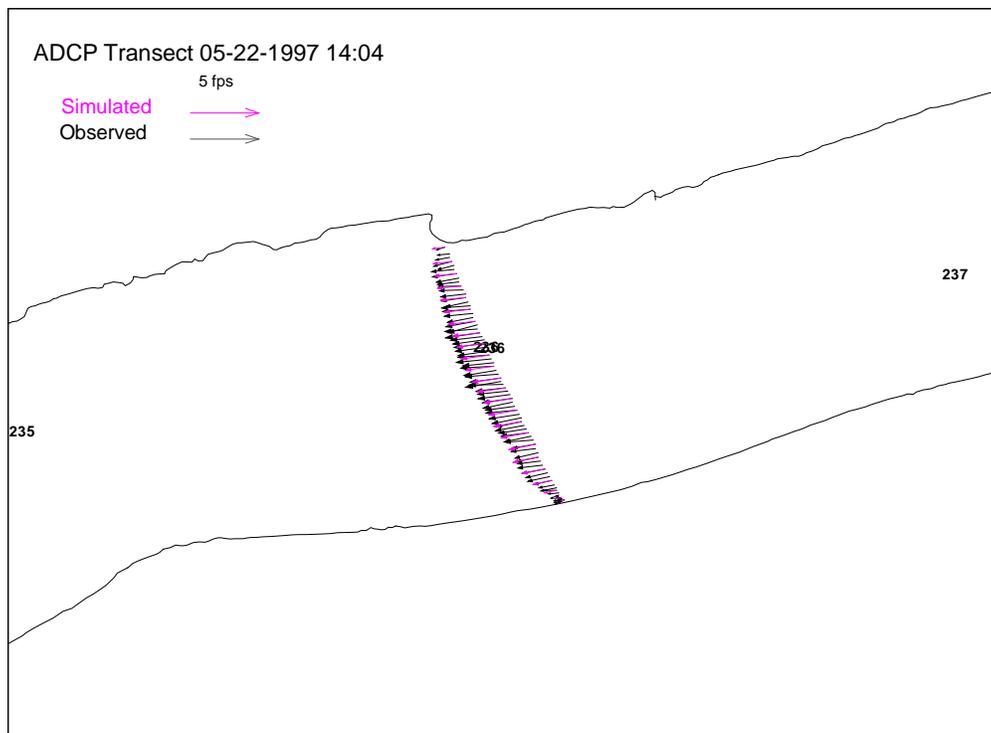


Figure 35. Simulated and observed velocities near Columbia River Mile 236 on May 22, 1997.



Figure 36. Simulated and observed velocities near Columbia River Mile 232 on May 22, 1997.



Figure 37. Simulated and observed velocities near John Day dam on May 23, 1997.



Figure 38. Simulated and observed velocities near John Day dam on May 23, 1997.



Figure 39. Simulated and observed velocities near John Day dam on May 23, 1997.

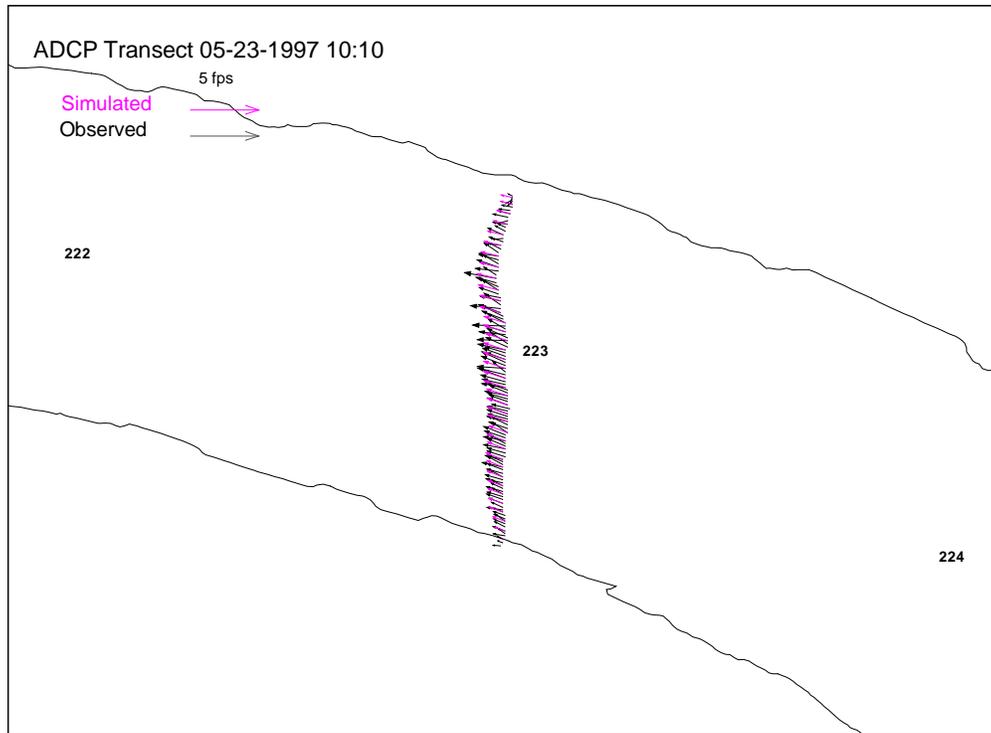


Figure 40. Simulated and observed velocities near Columbia River Mile 223 on May 23, 1997.

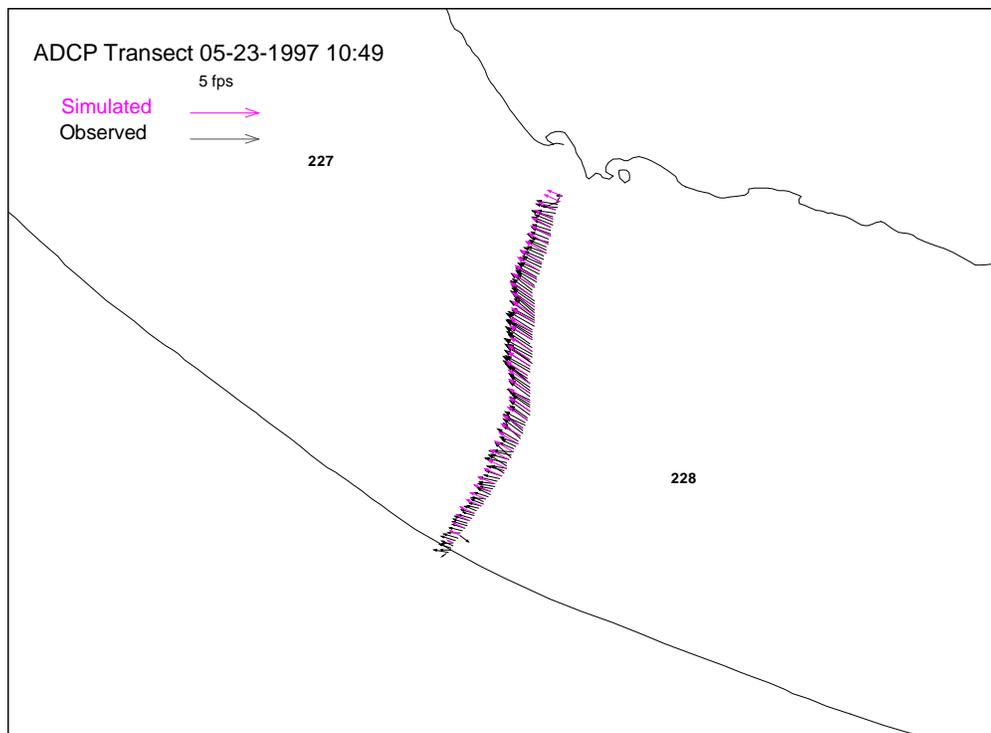


Figure 41. Simulated and observed velocities near Columbia River Mile 227.5 on May 23, 1997.

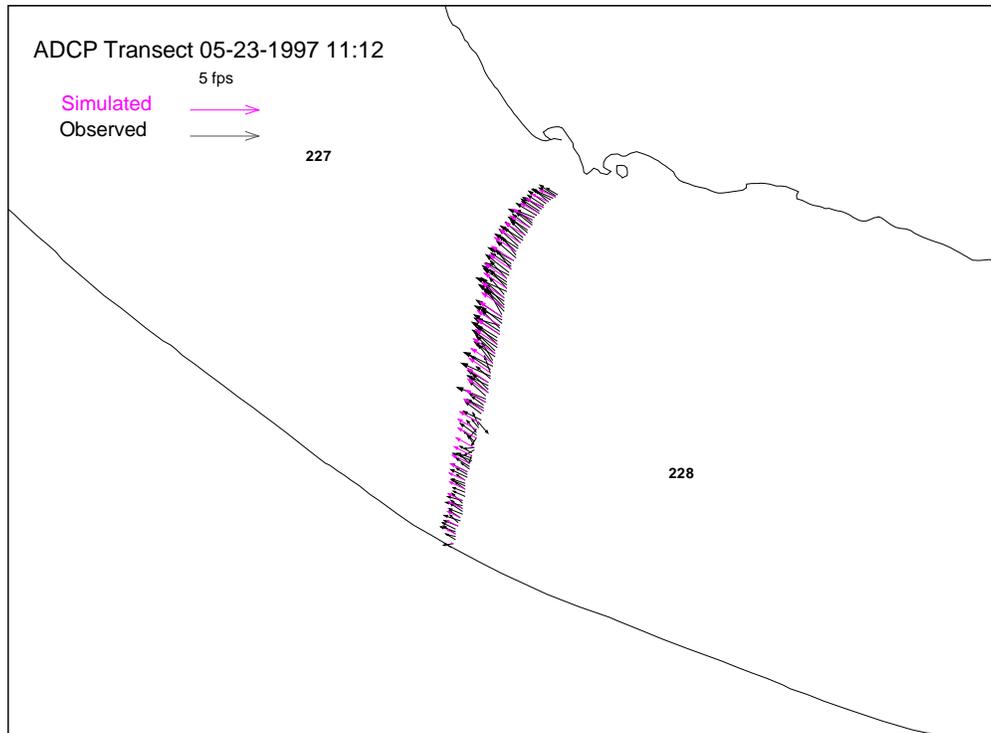


Figure 42. Simulated and observed velocities near Columbia River Mile 227.5 on May 23, 1997.

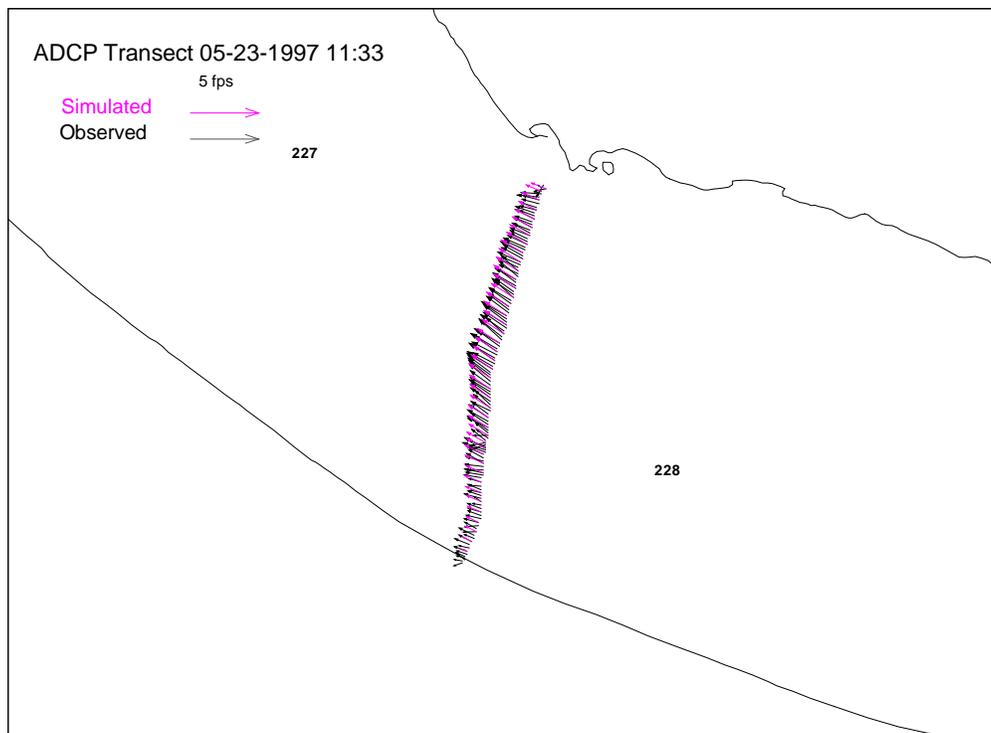


Figure 43. Simulated and observed velocities near Columbia River Mile 227.5 on May 23, 1997.

1.3.3 Summer 1997 ADCP Data

The model was also run for the operational conditions that existed when the Summer 1997 ADCP measurements were performed. The Manning n value was not altered from the value of 0.027 selected from the tailwater calibration. Simulated velocities are compared to the depth-averaged ADCP data in Figure 44 through Figure 84.

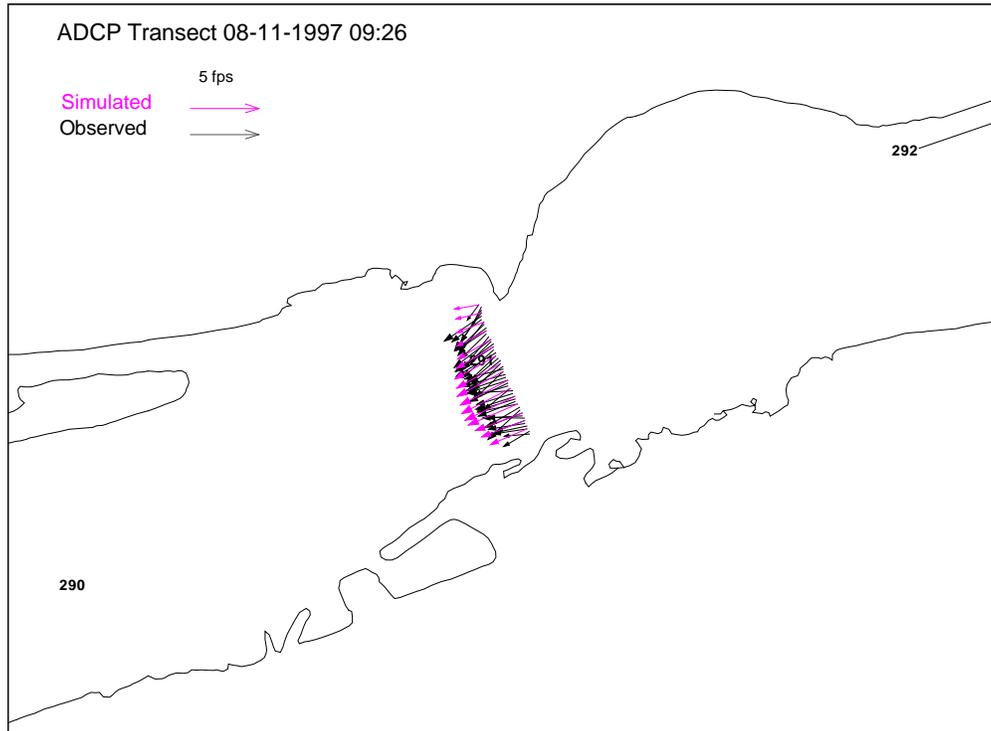


Figure 44. Simulated and observed velocities near Columbia River Mile 291 on August 11, 1997.

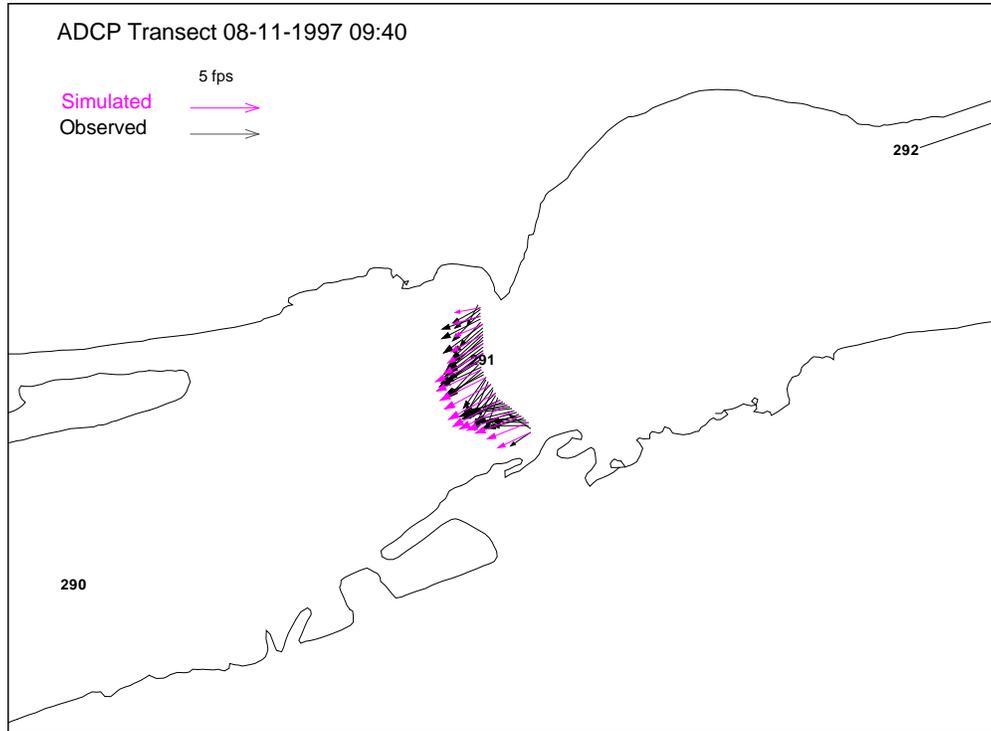


Figure 45. Simulated and observed velocities near Columbia River Mile 291 on August 11, 1997.

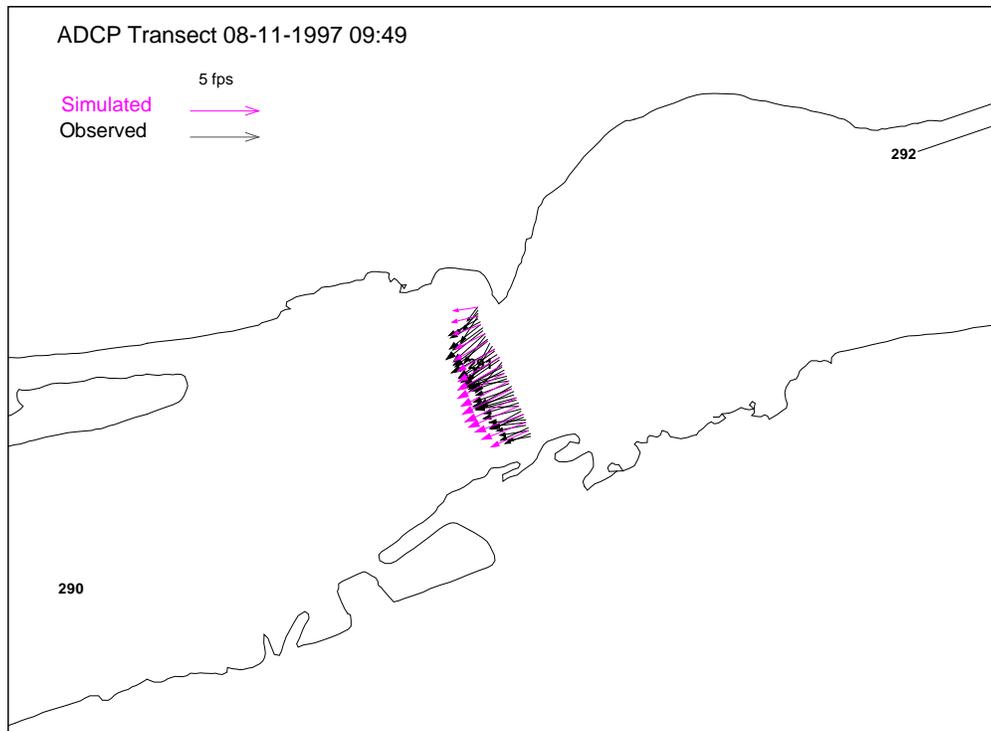


Figure 46. Simulated and observed velocities near Columbia River Mile 291 on August 11, 1997.

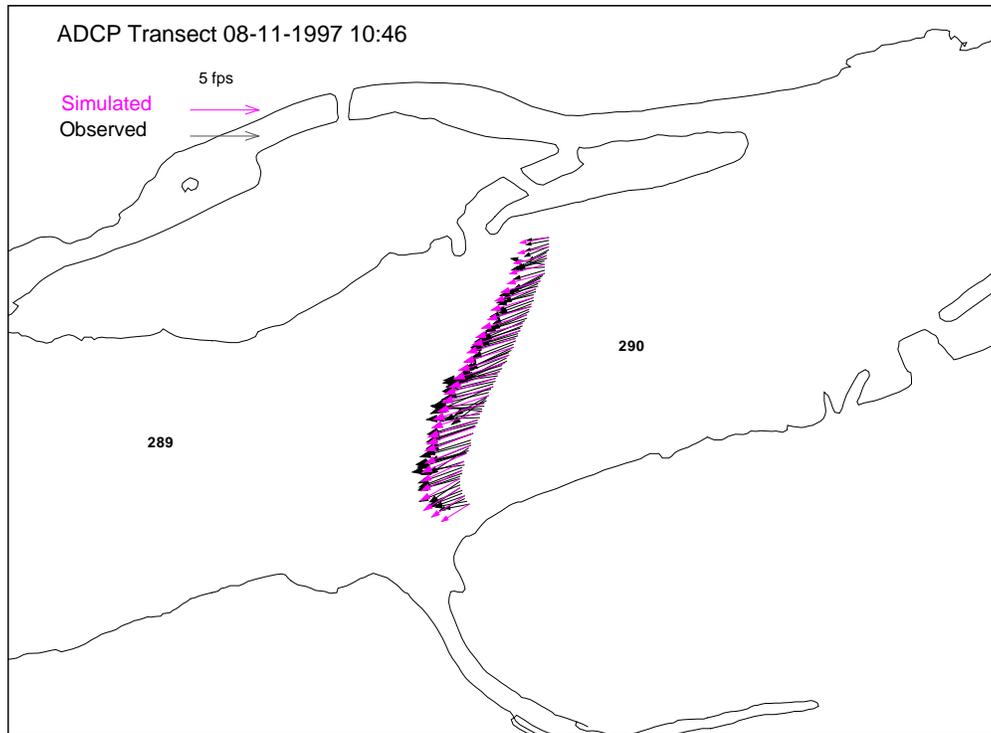


Figure 47. Simulated and observed velocities near Columbia River Mile 290 on August 11, 1997.

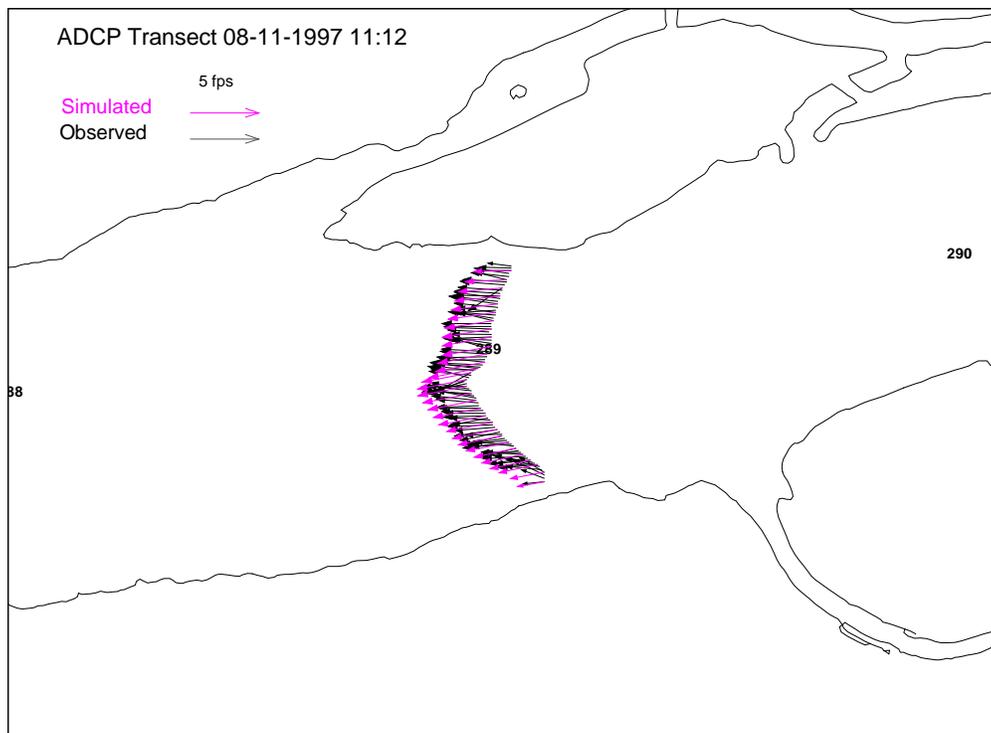


Figure 48. Simulated and observed velocities near Columbia River Mile 289 on August 11, 1997.

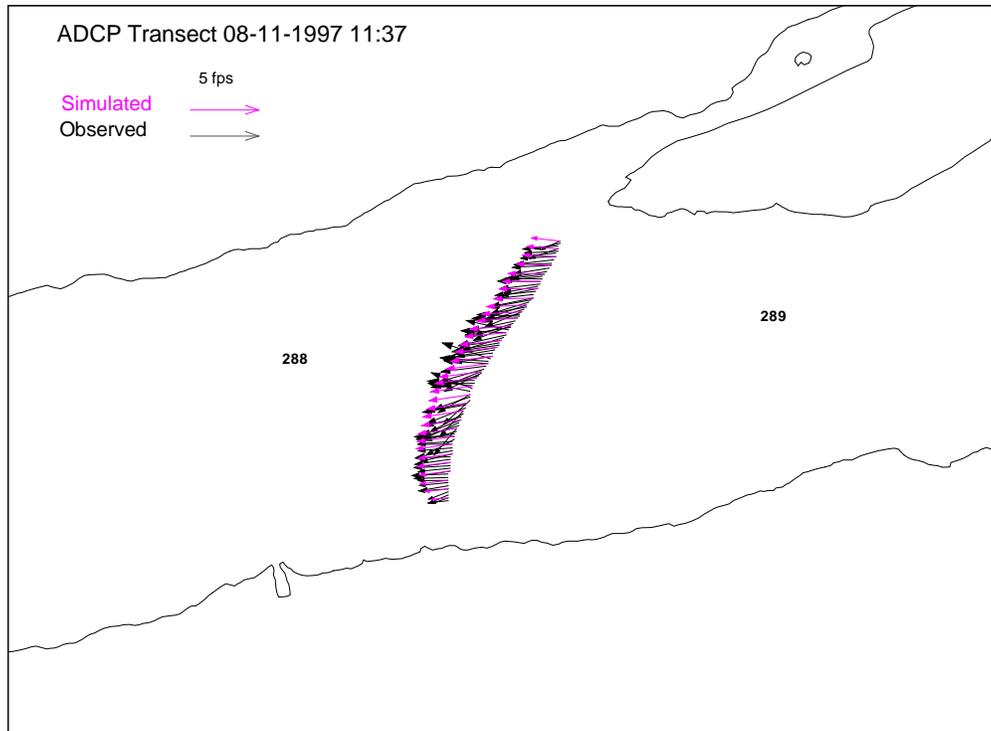


Figure 49. Simulated and observed velocities near Columbia River Mile 288.5 on August 11, 1997.

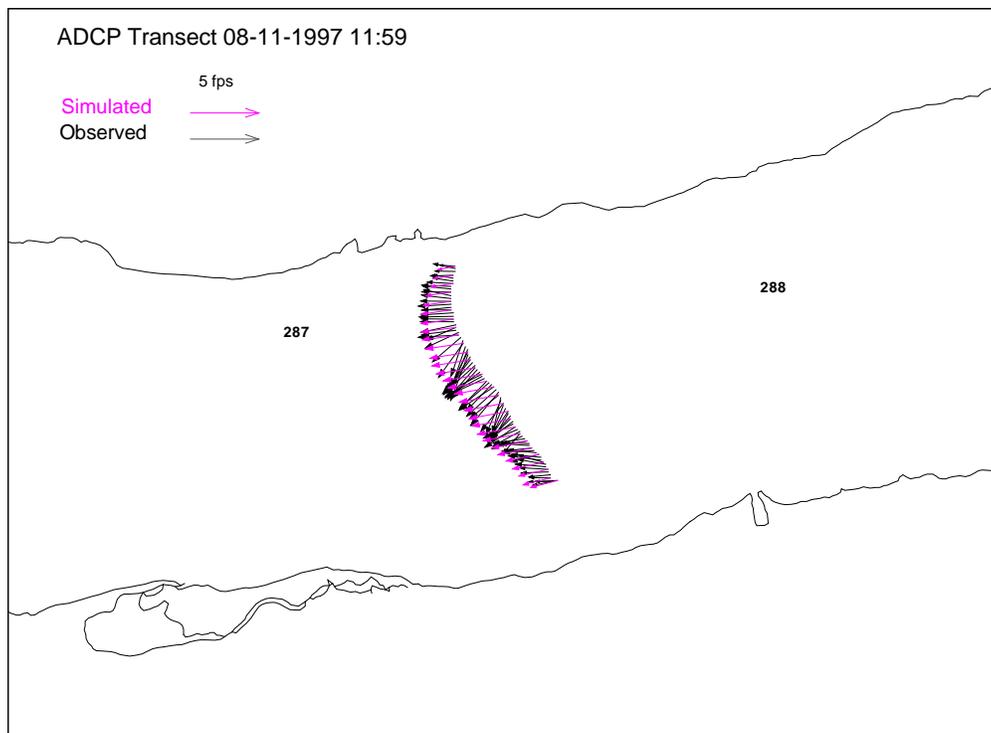


Figure 50. Simulated and observed velocities near Columbia River Mile 287 on August 11, 1997.

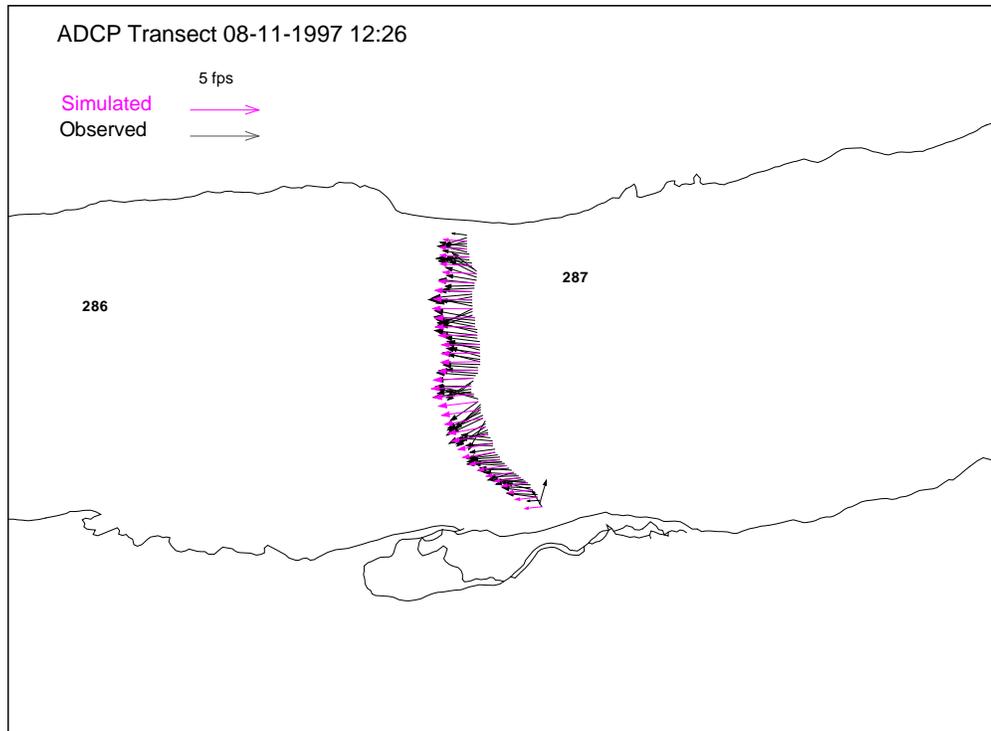


Figure 51. Simulated and observed velocities near Columbia River Mile 287 on August 11, 1997.

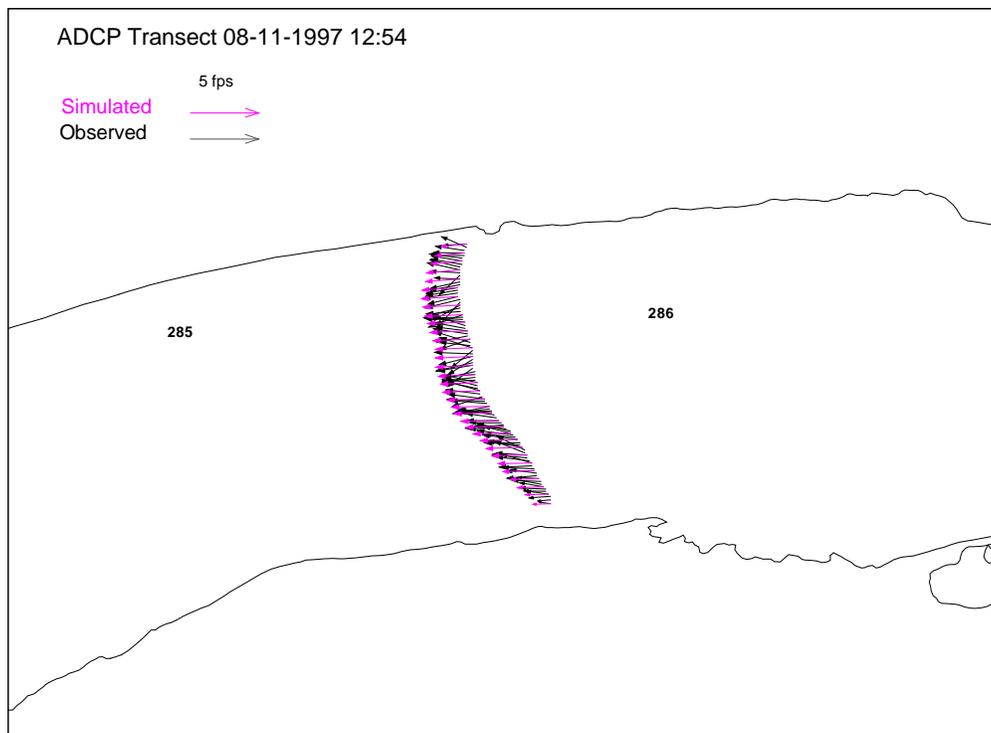


Figure 52. Simulated and observed velocities near Columbia River Mile 285.5 on August 11, 1997.

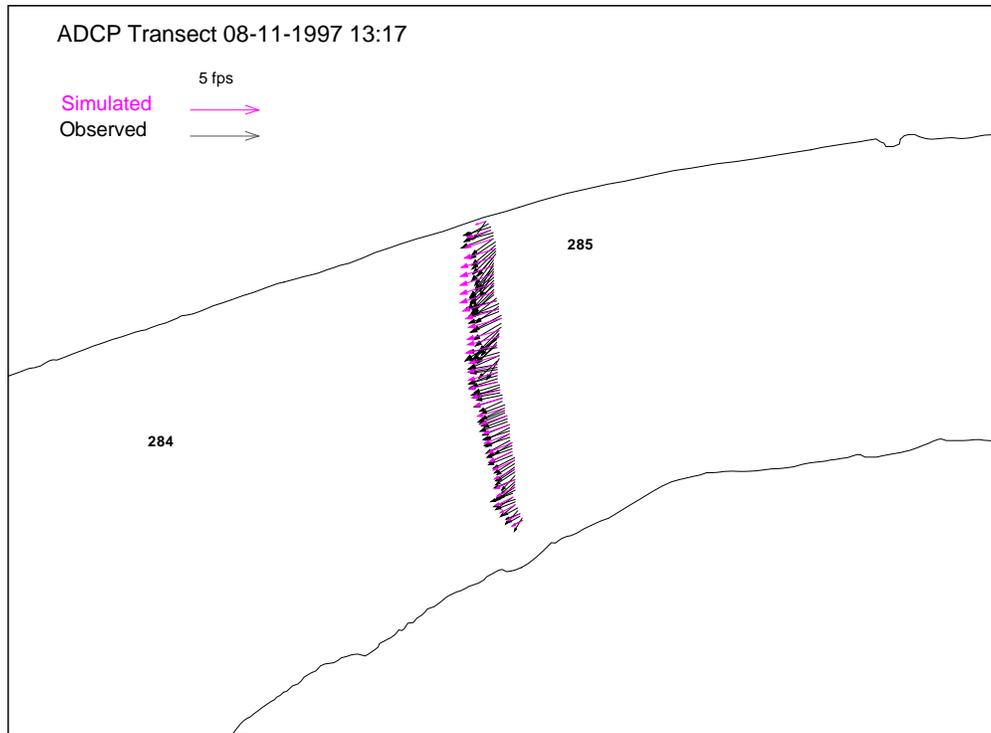


Figure 53. Simulated and observed velocities near Columbia River Mile 285 on August 11, 1997.

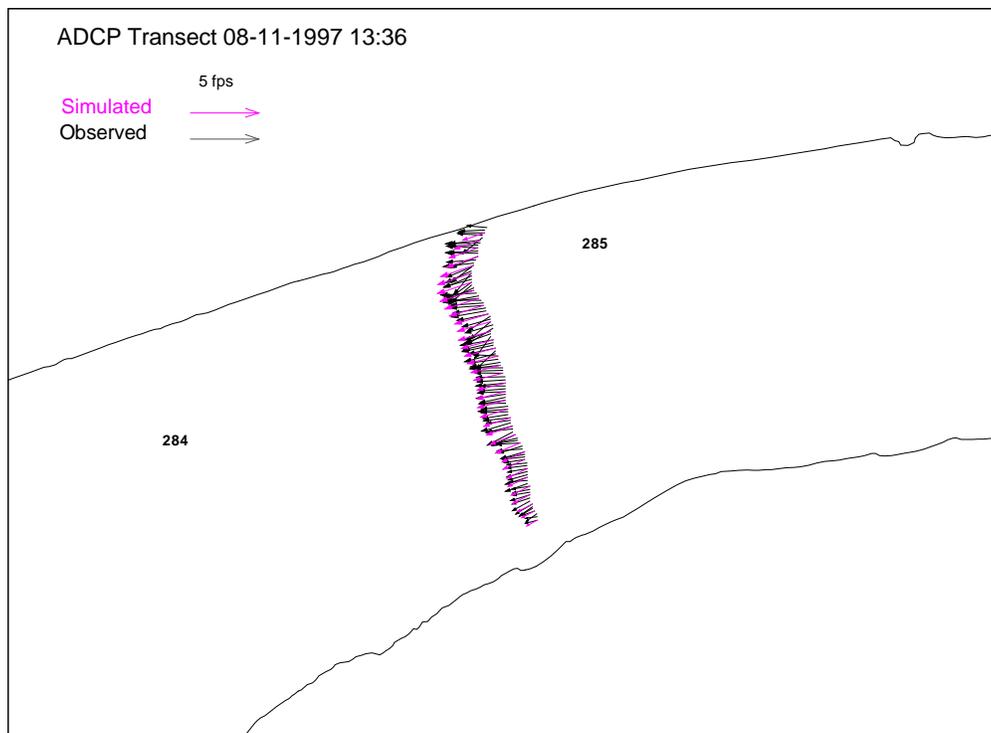


Figure 54. Simulated and observed velocities near Columbia River Mile 285 on August 11, 1997.

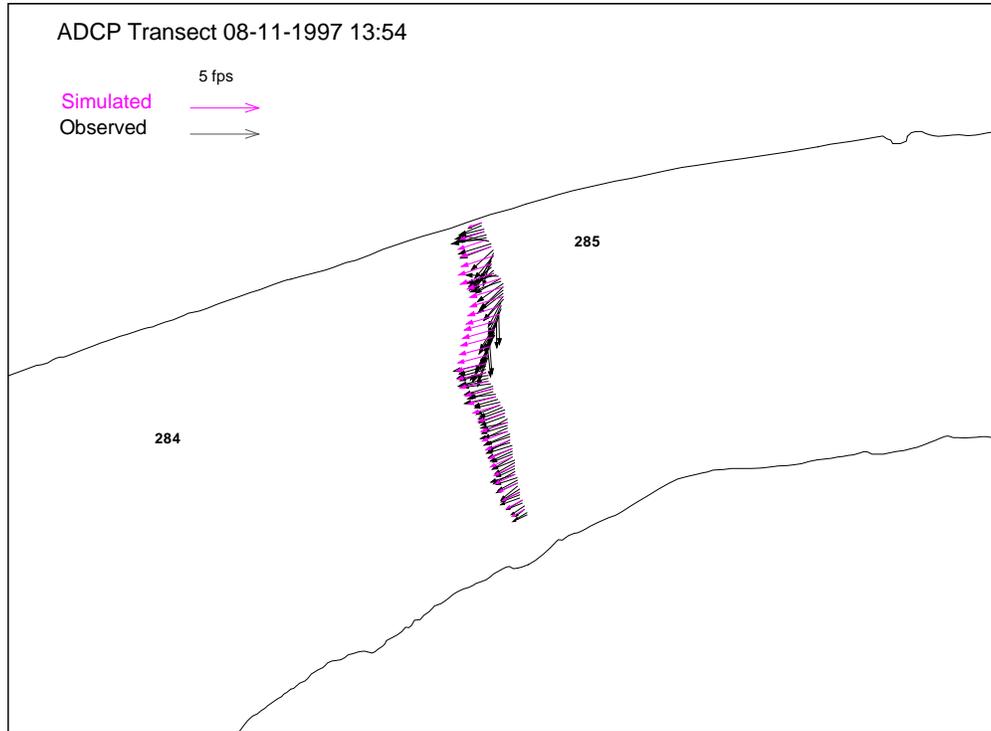


Figure 55. Simulated and observed velocities near Columbia River Mile 285 on August 11, 1997.

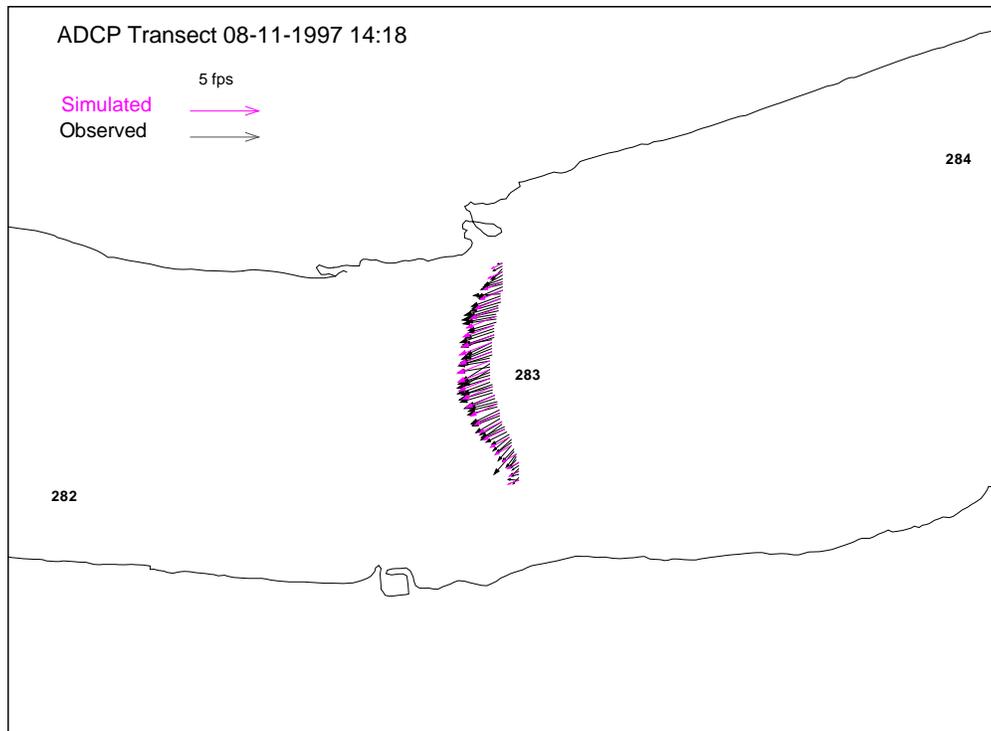


Figure 56. Simulated and observed velocities near Columbia River Mile 283 on August 11, 1997.

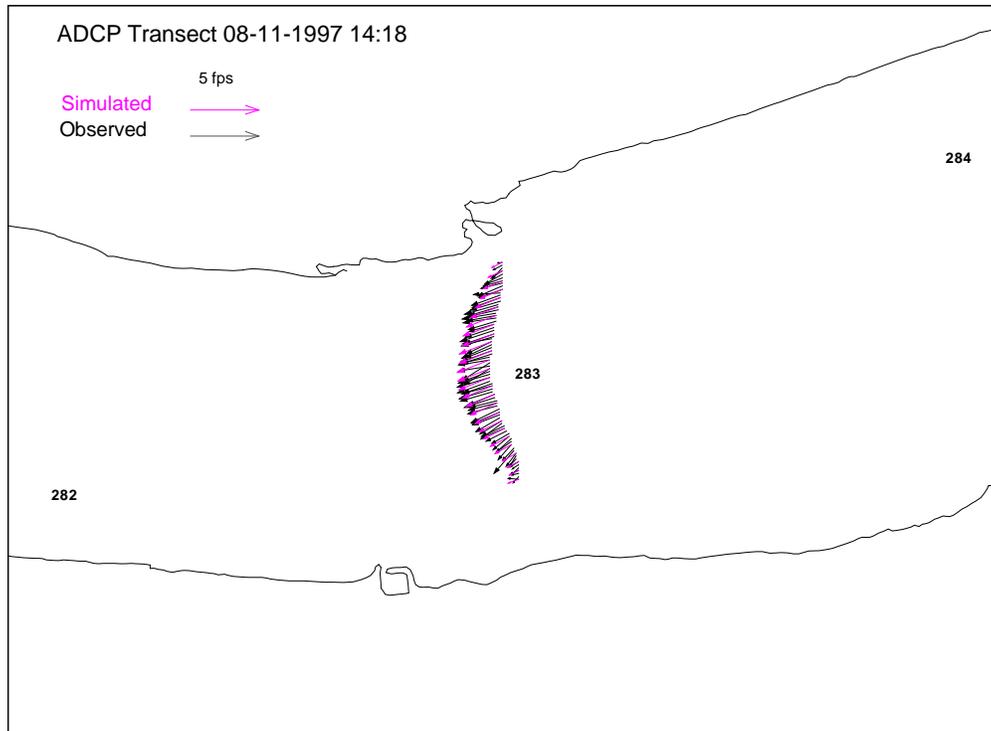


Figure 57. Simulated and observed velocities near Columbia River Mile 283 on August 11, 1997.

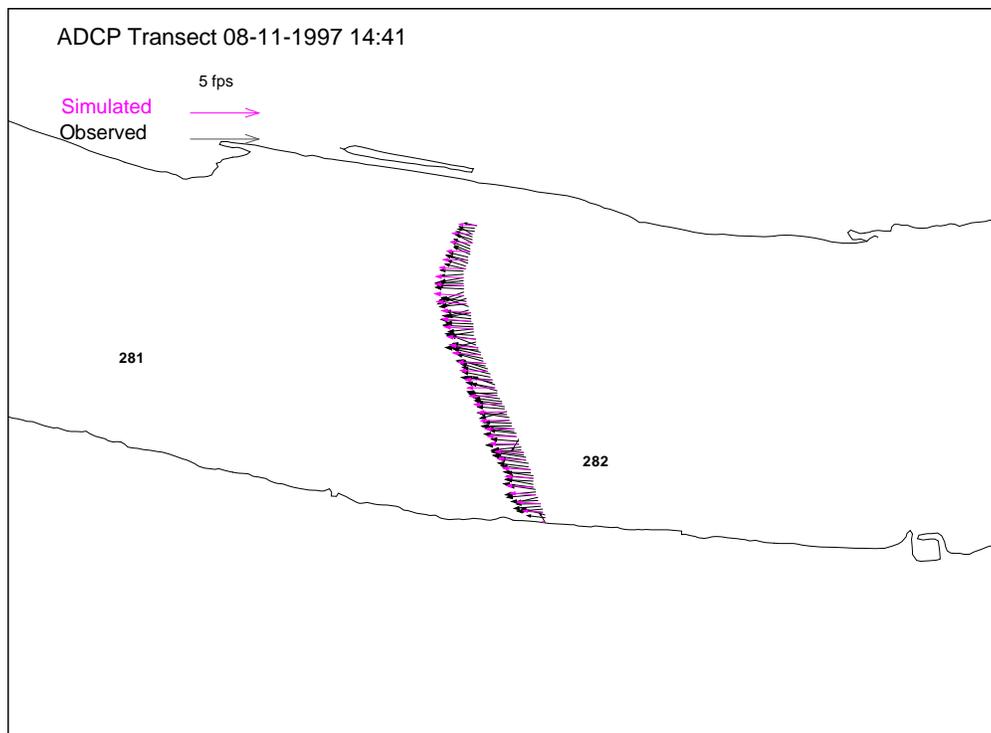


Figure 58. Simulated and observed velocities near Columbia River Mile 282 on August 11, 1997.

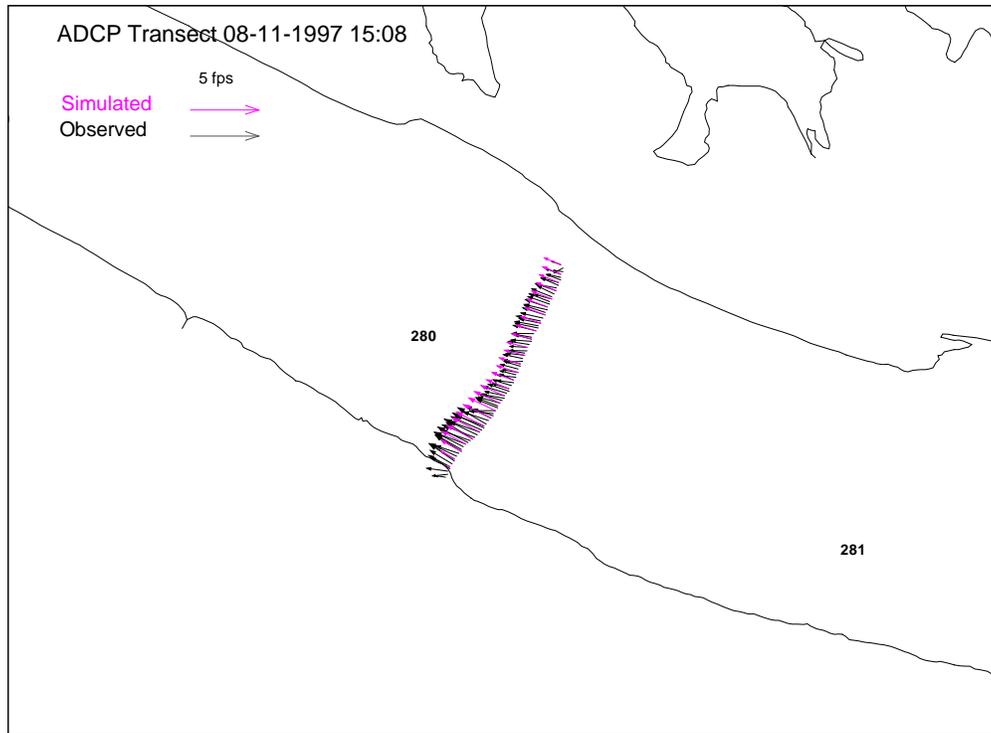


Figure 59. Simulated and observed velocities near Columbia River Mile 280 on August 11, 1997.

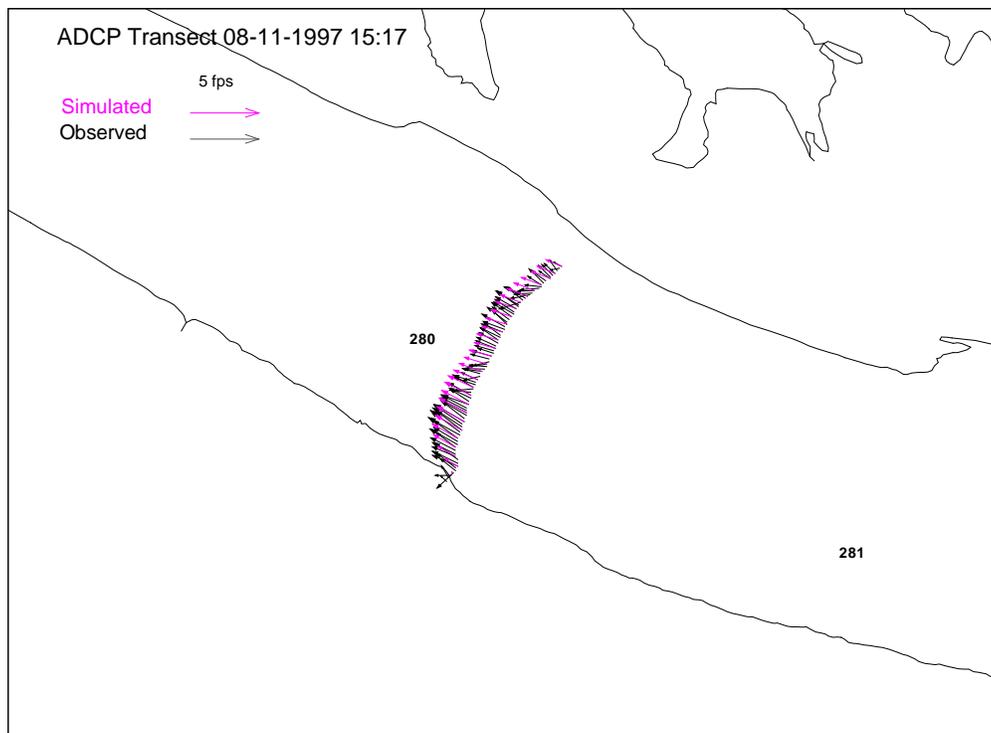


Figure 60. Simulated and observed velocities near Columbia River Mile 280 on August 11, 1997.

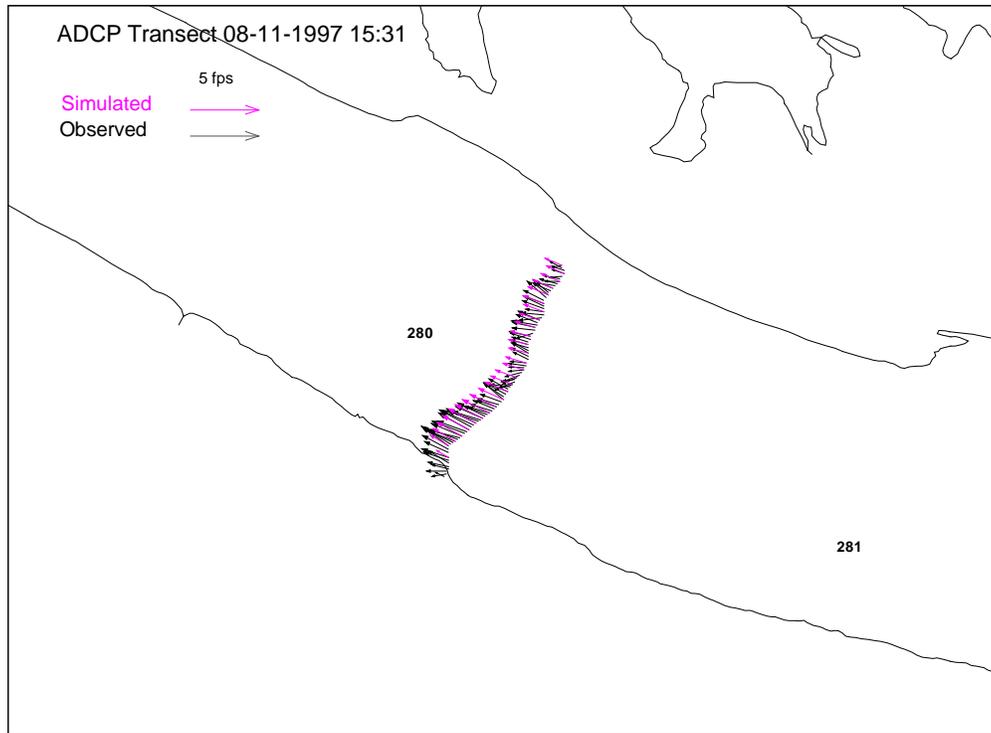


Figure 61. Simulated and observed velocities near Columbia River Mile 280 on August 11, 1997.

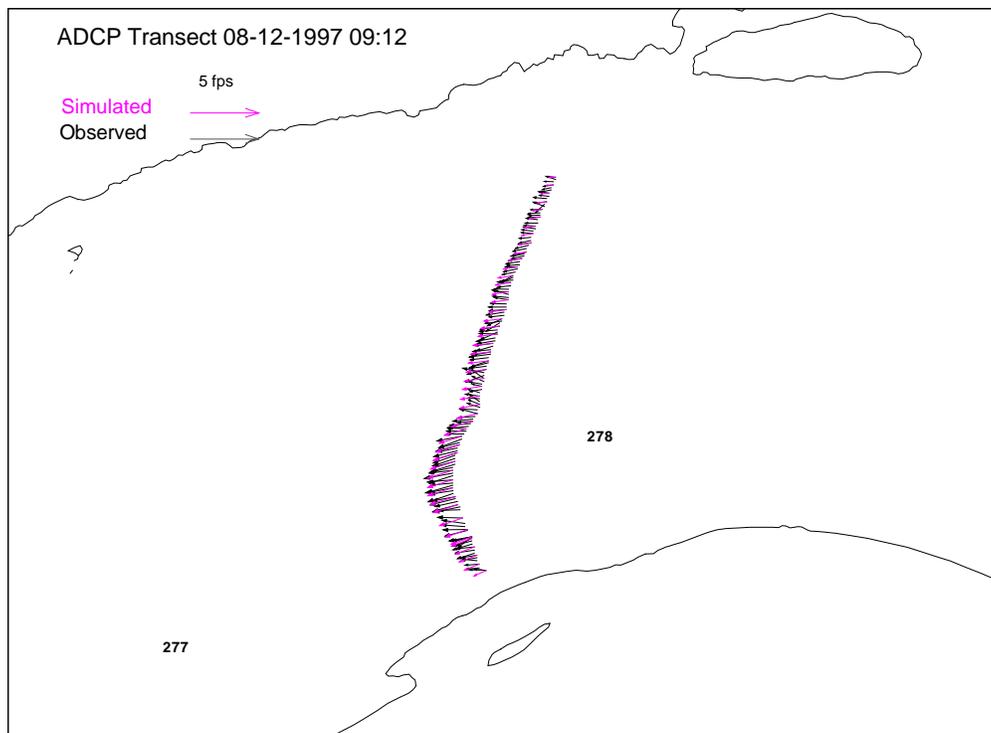


Figure 62. Simulated and observed velocities near Columbia River Mile 278 on August 11, 1997.

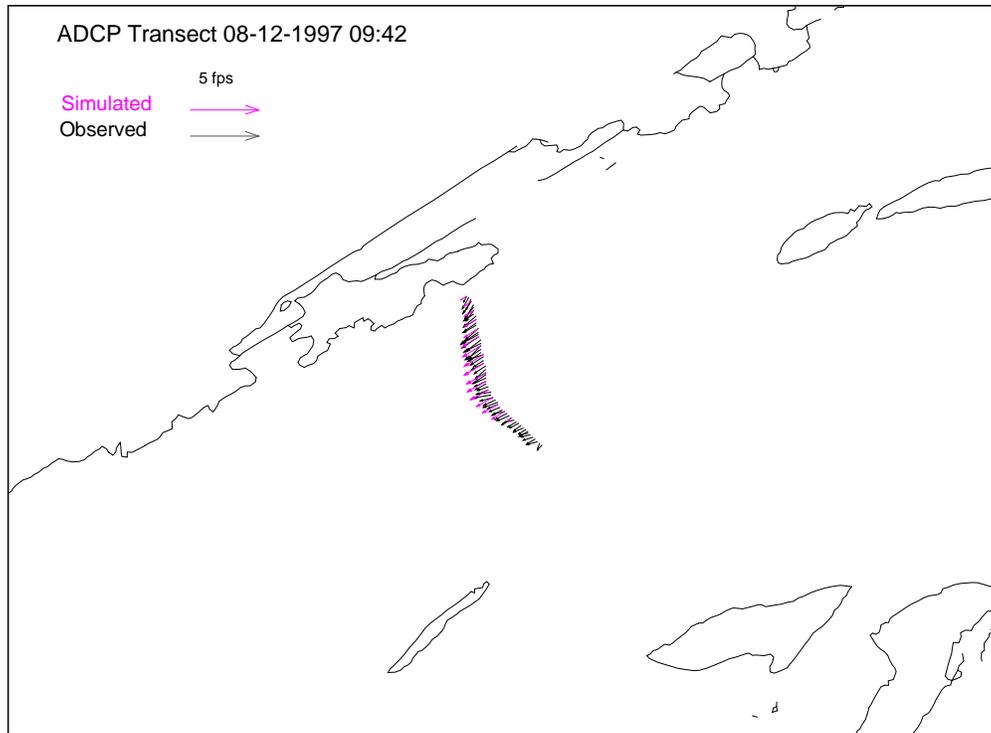


Figure 63. Simulated and observed velocities near Blalock Islands on August 11, 1997.

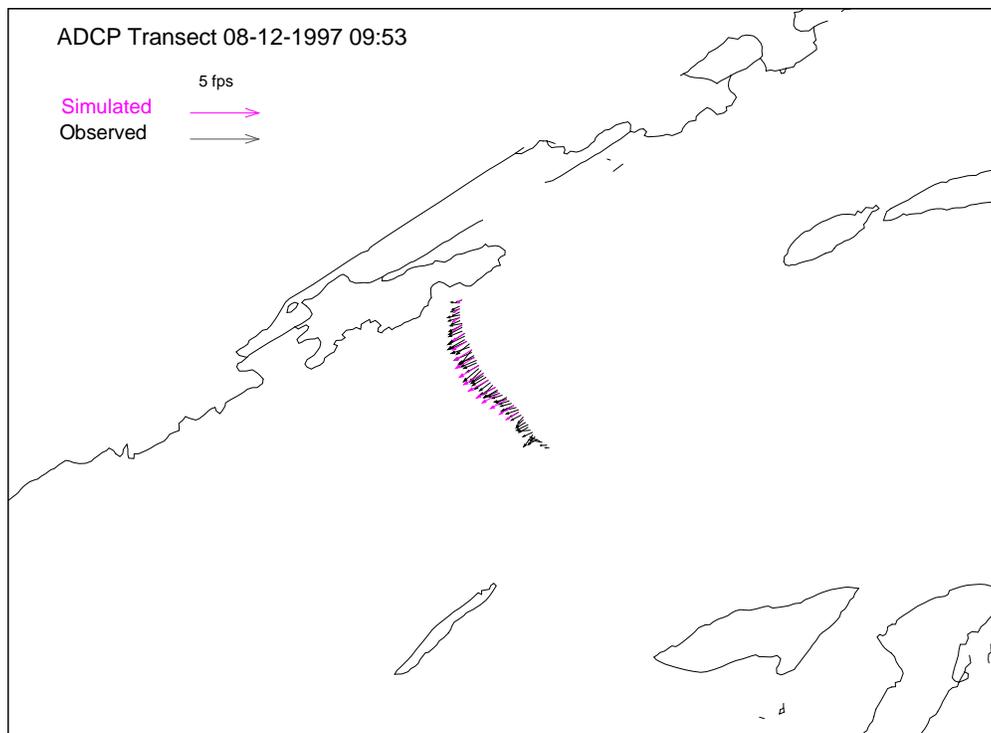


Figure 64. Simulated and observed velocities near Blalock Islands on August 11, 1997.

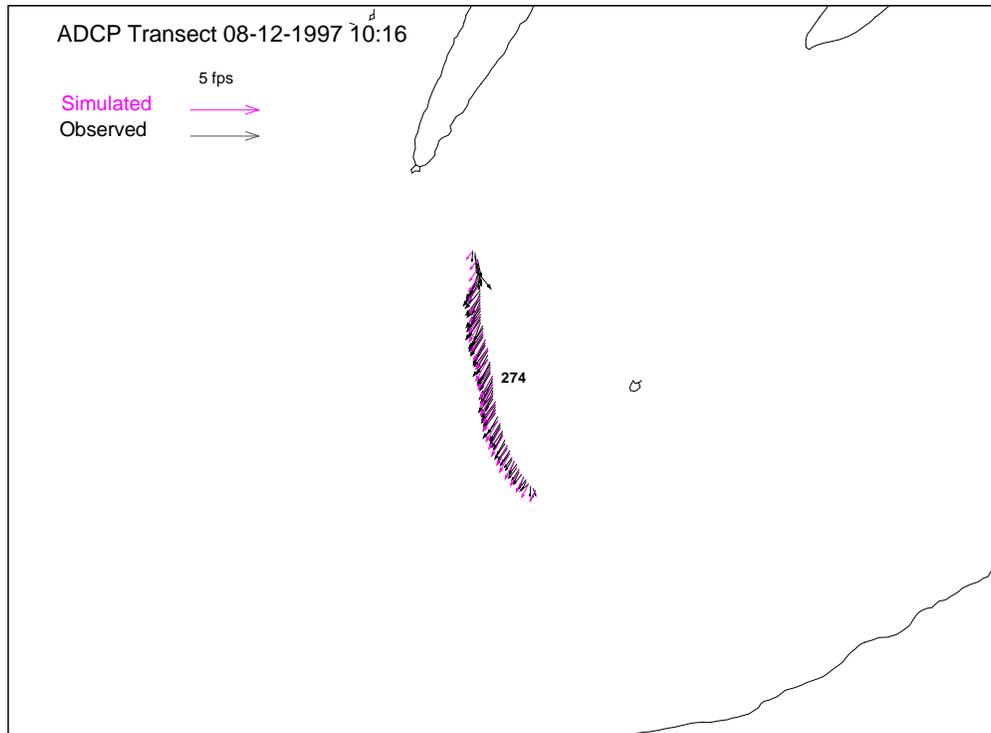


Figure 65. Simulated and observed velocities near Blalock Islands on August 11, 1997.

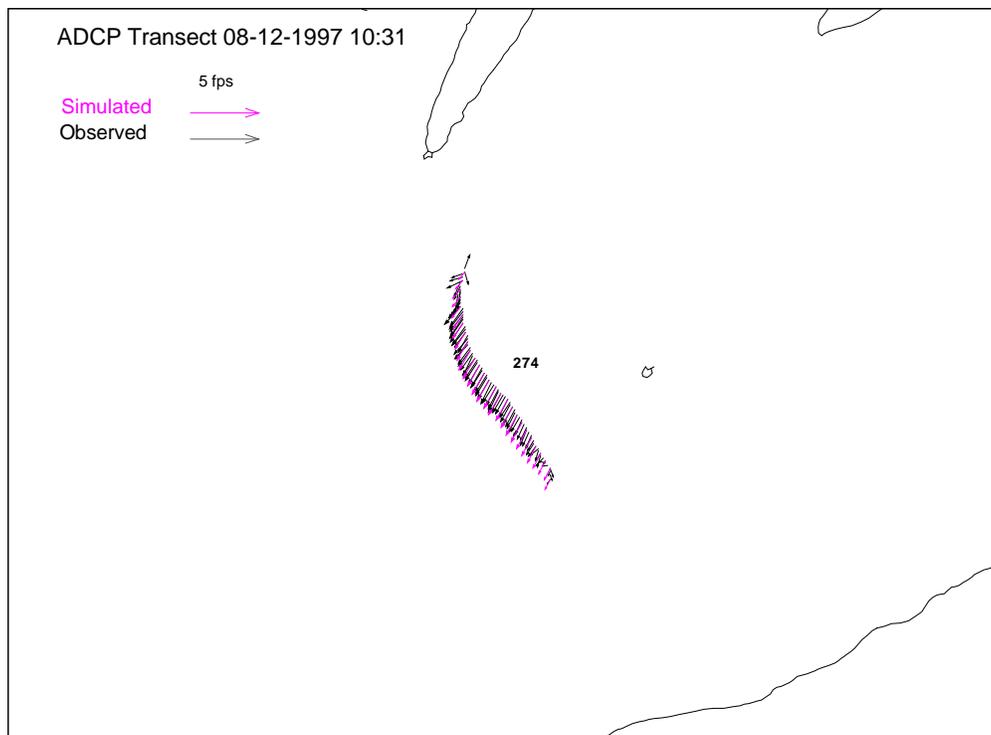


Figure 66. Simulated and observed velocities near Blalock Islands on August 11, 1997.

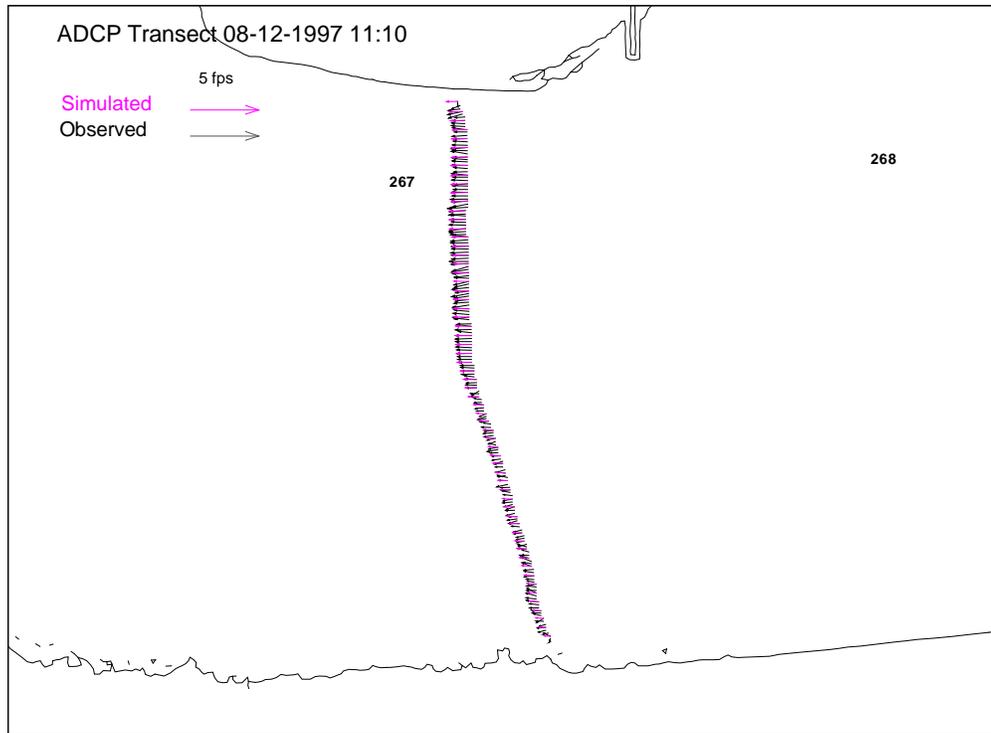


Figure 67. Simulated and observed velocities near Columbia River Mile 267 on August 11, 1997.

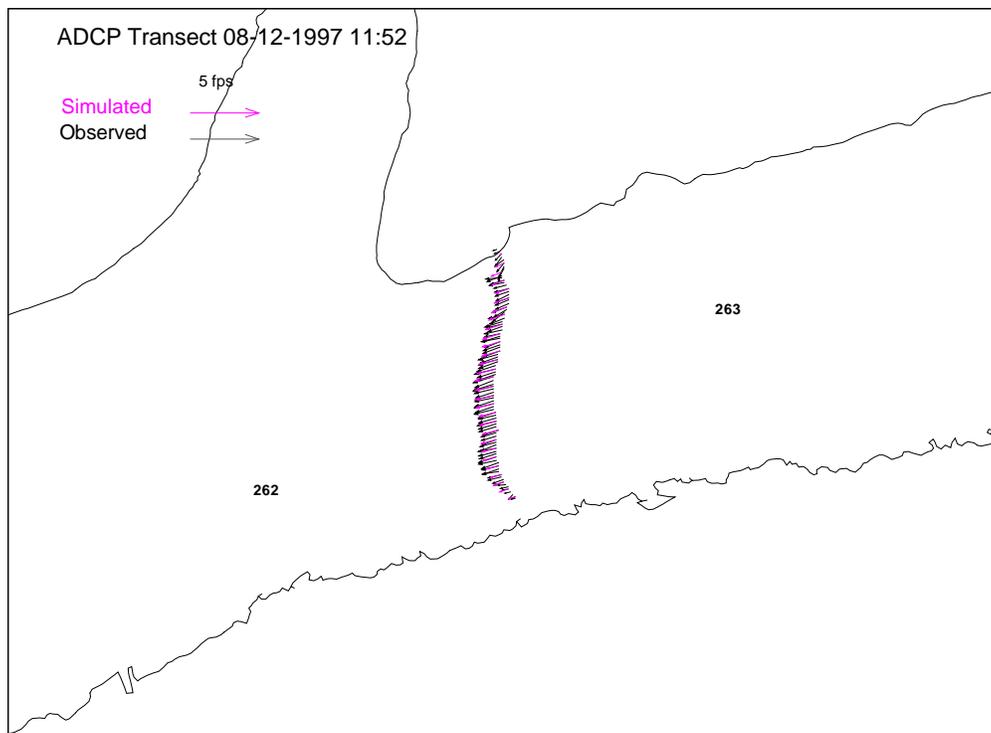


Figure 68. Simulated and observed velocities near Crow Butte on August 11, 1997.

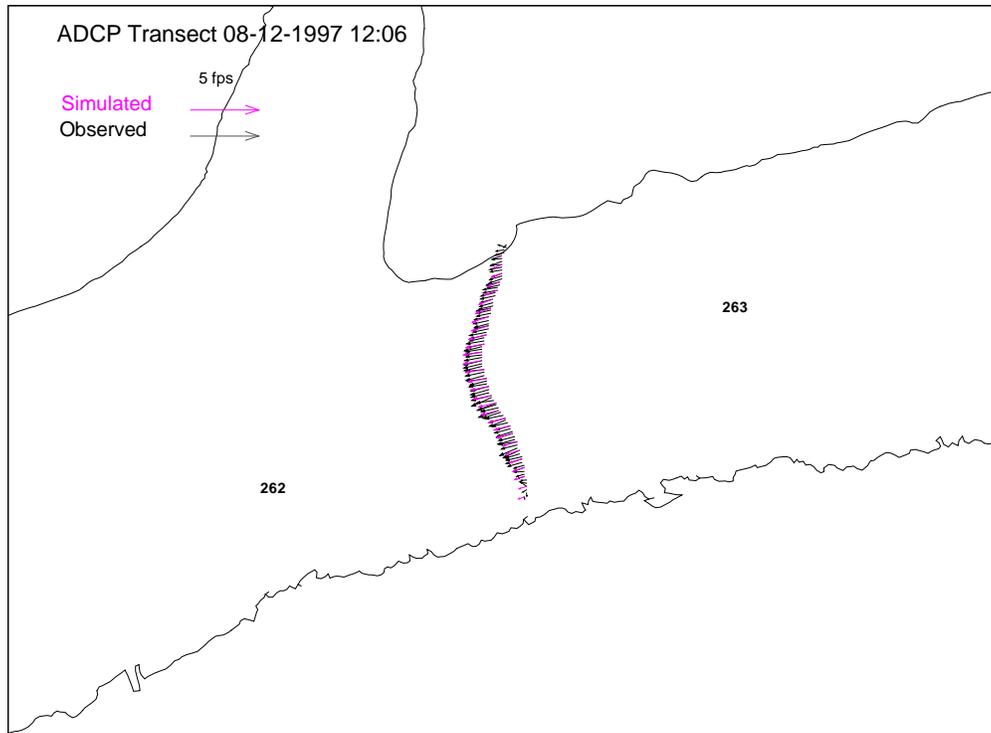


Figure 69. Simulated and observed velocities near Crow Butte on August 11, 1997.

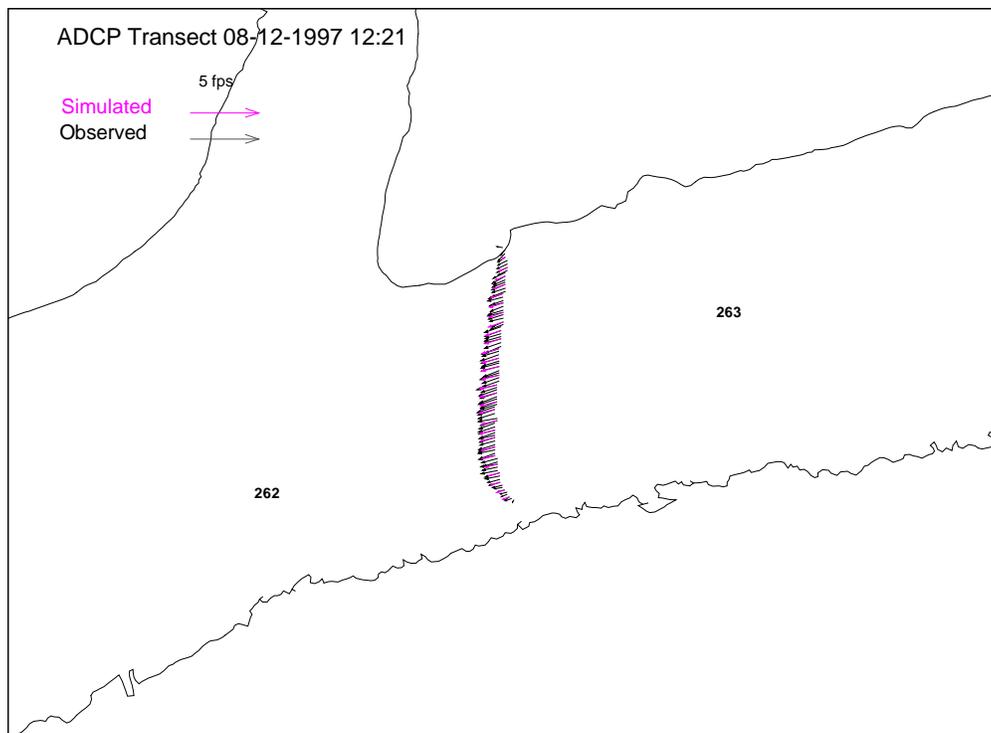


Figure 70. Simulated and observed velocities near Crow Butte on August 11, 1997.

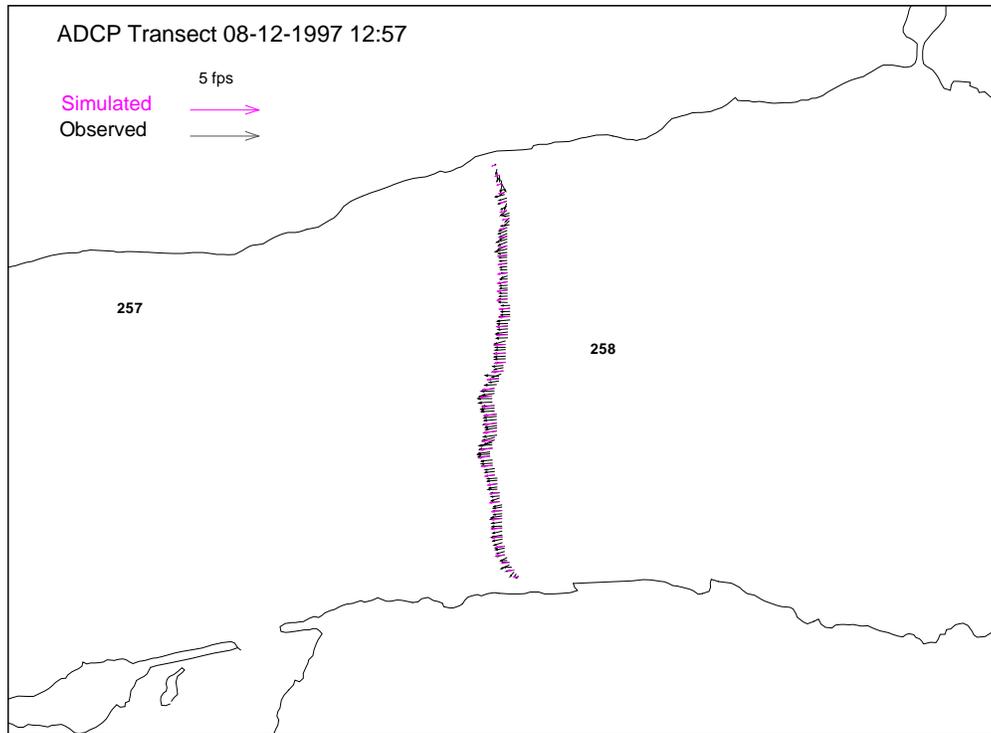


Figure 71. Simulated and observed velocities near Columbia River Mile 258 on August 11, 1997.

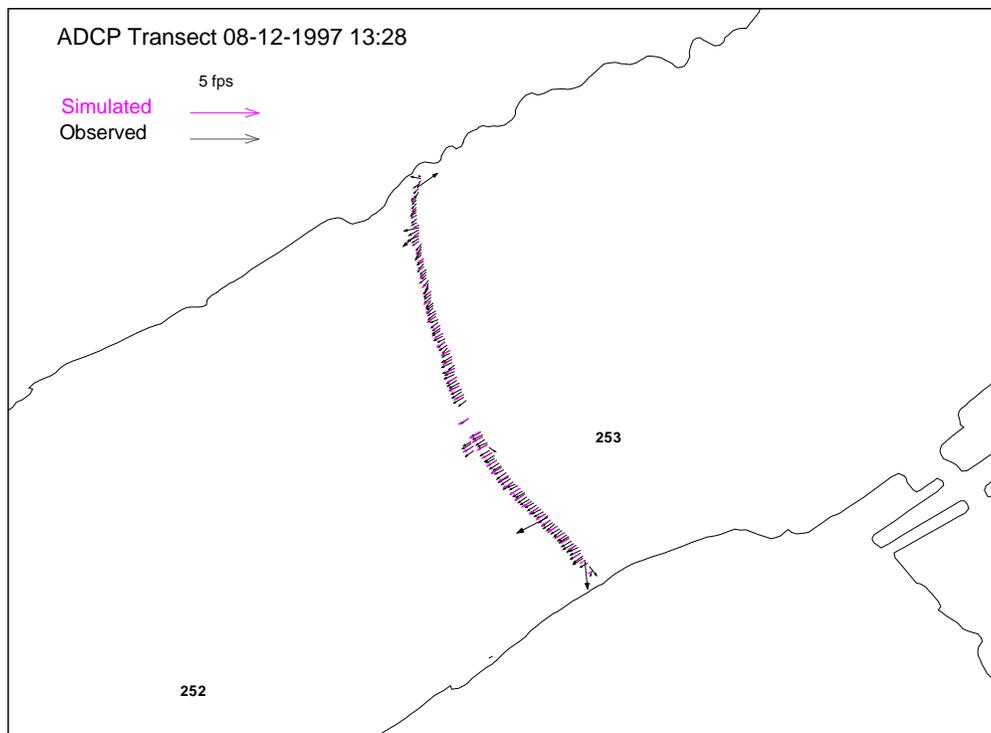


Figure 72. Simulated and observed velocities near Columbia River Mile 253 on August 11, 1997.

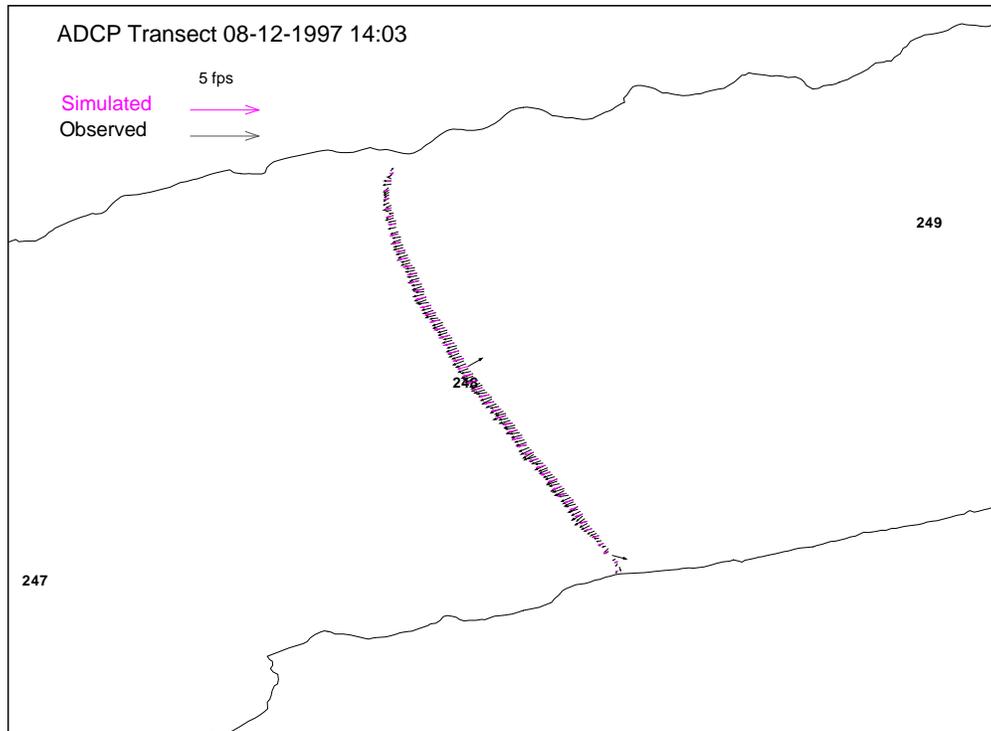


Figure 73. Simulated and observed velocities near Columbia River Mile 248 on August 11, 1997.

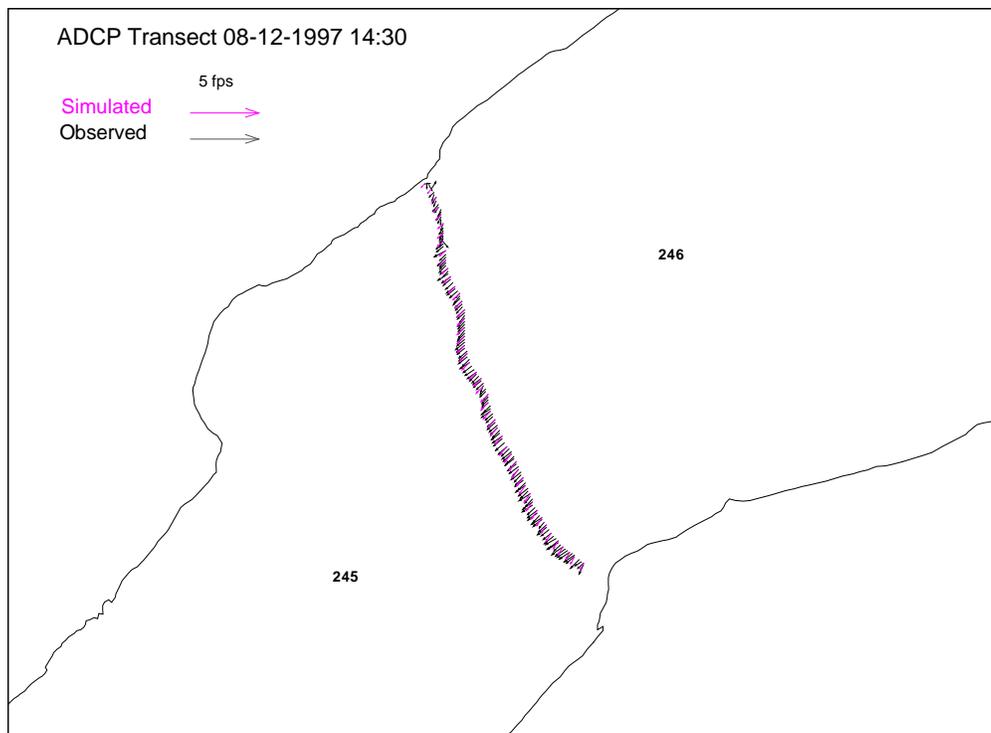


Figure 74. Simulated and observed velocities near Columbia River Mile 245.5 on August 11, 1997.

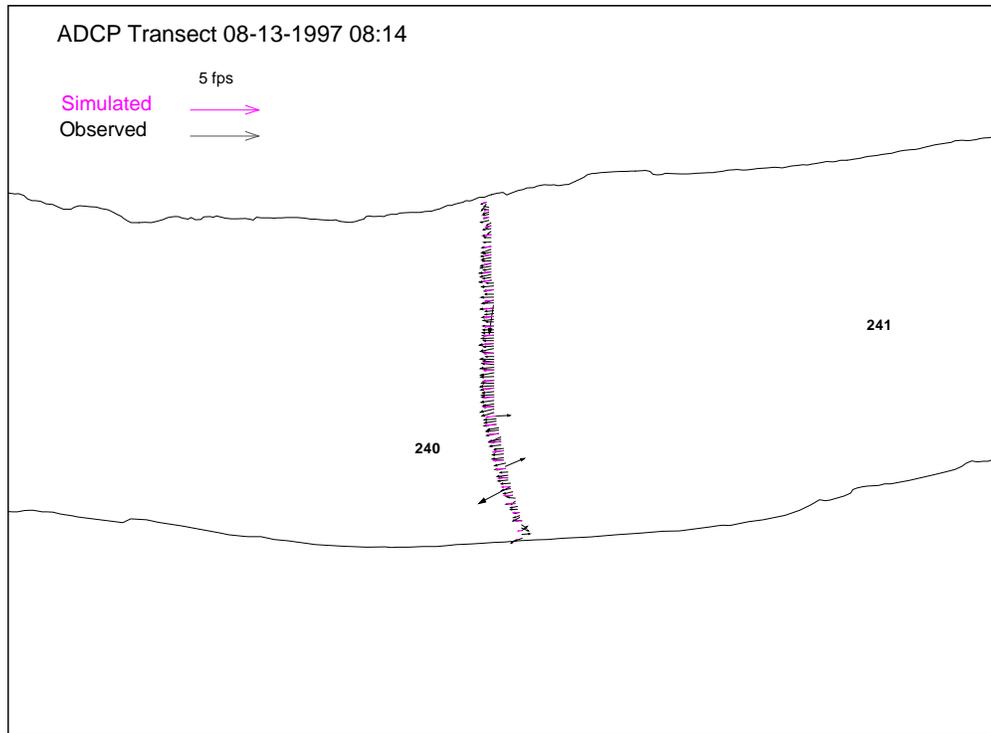


Figure 75. Simulated and observed velocities near Columbia River Mile 240 on August 13, 1997.

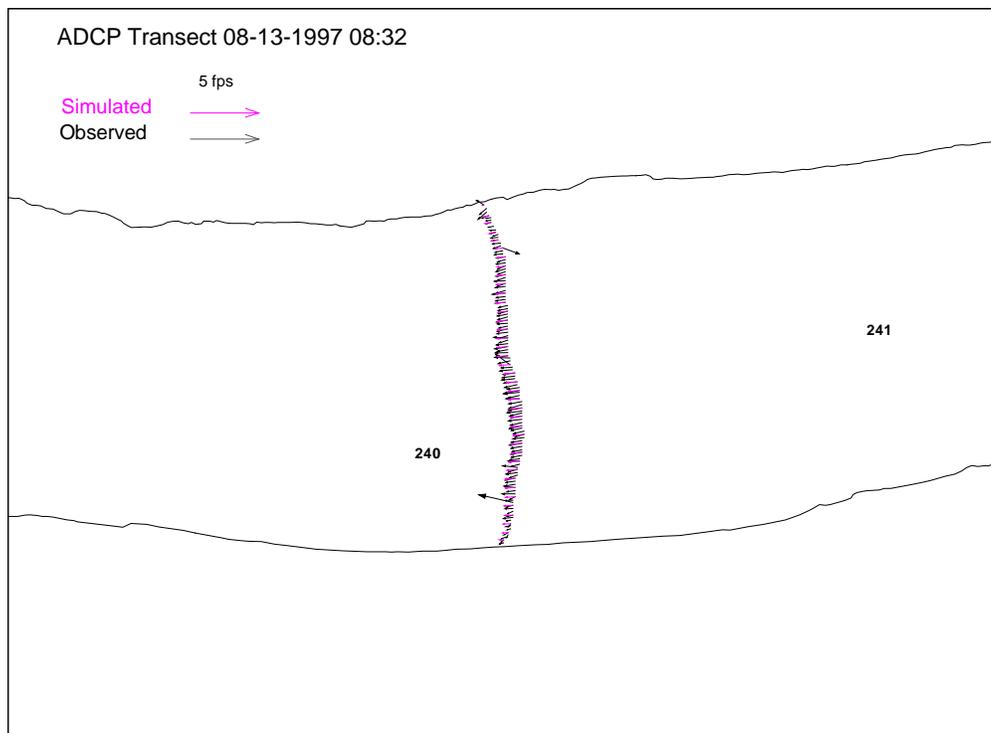


Figure 76. Simulated and observed velocities near Columbia River Mile 240 on August 13, 1997.

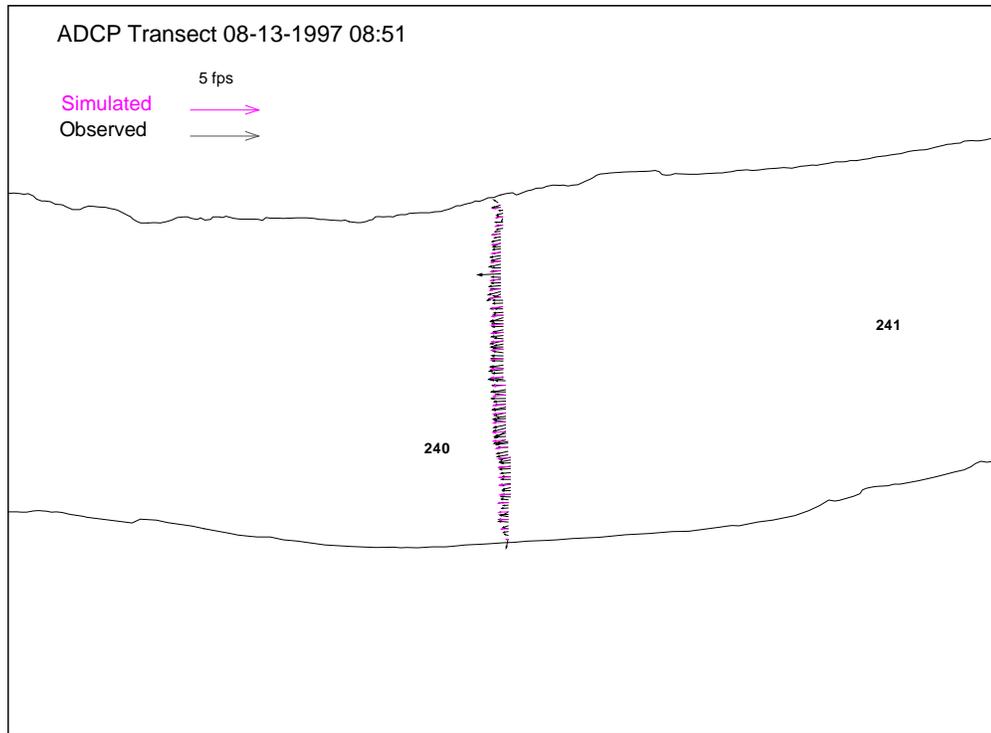


Figure 77. Simulated and observed velocities near Columbia River Mile 240 on August 13, 1997.

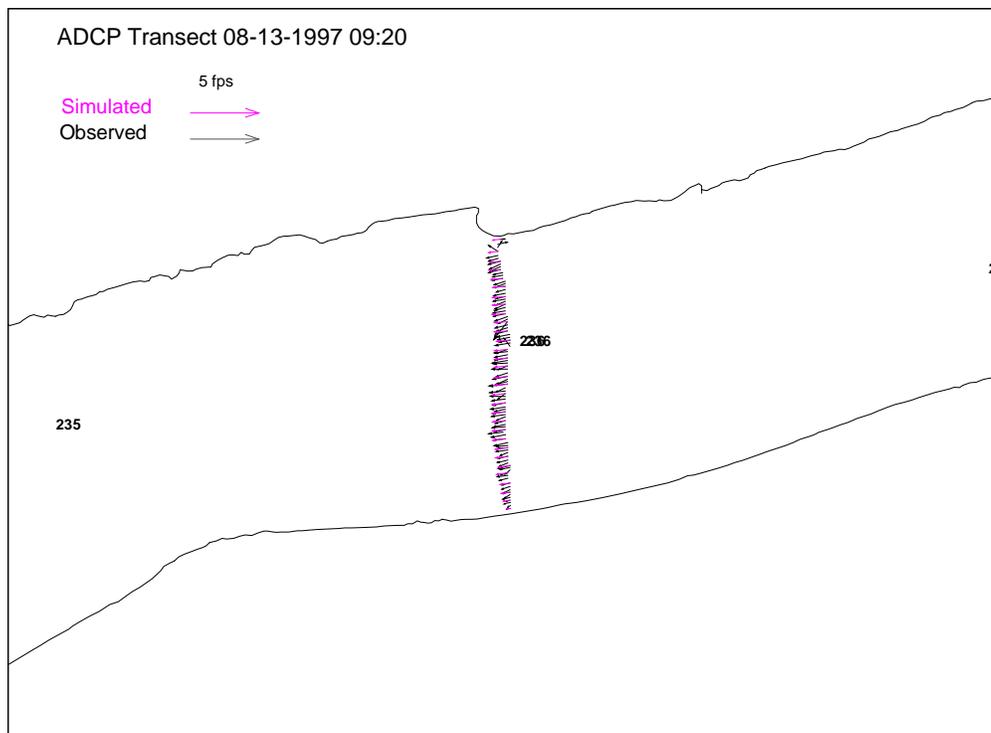


Figure 78. Simulated and observed velocities near Columbia River Mile 236 on August 13, 1997.

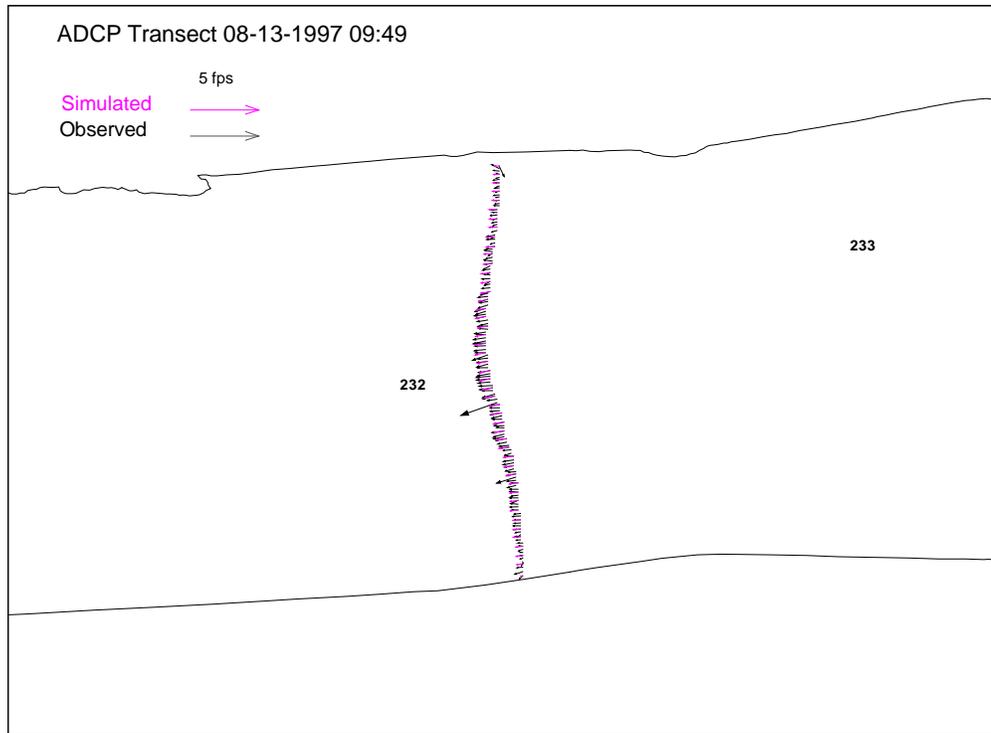


Figure 79. Simulated and observed velocities near Columbia River Mile 232 on August 13, 1997.

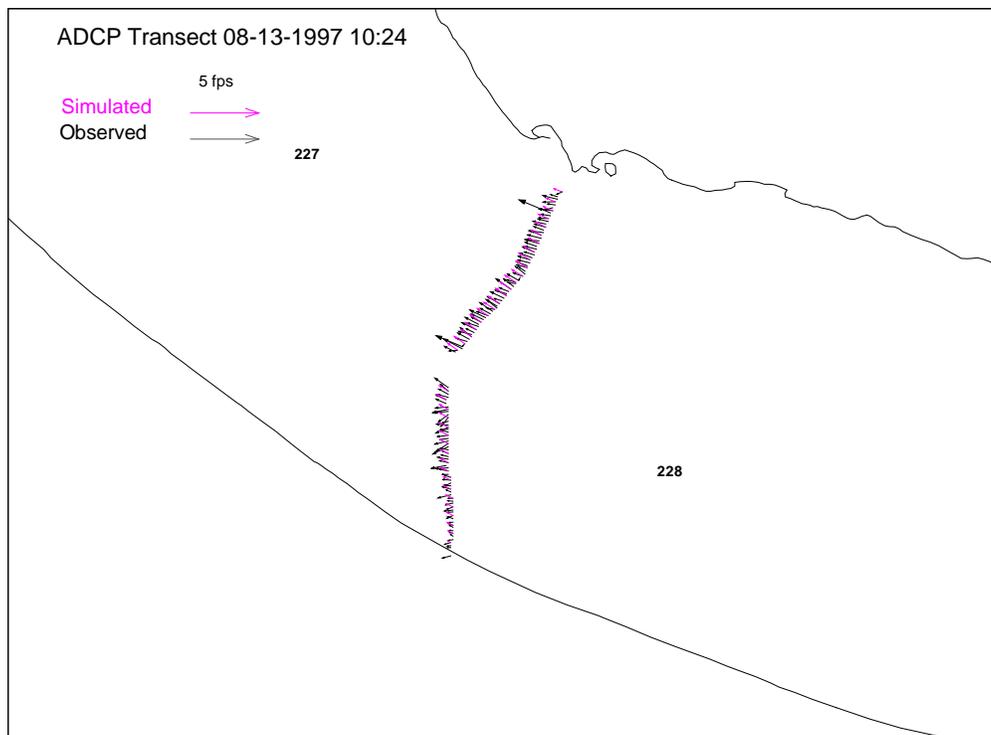


Figure 80. Simulated and observed velocities near Columbia River Mile 227.5 on August 13, 1997.

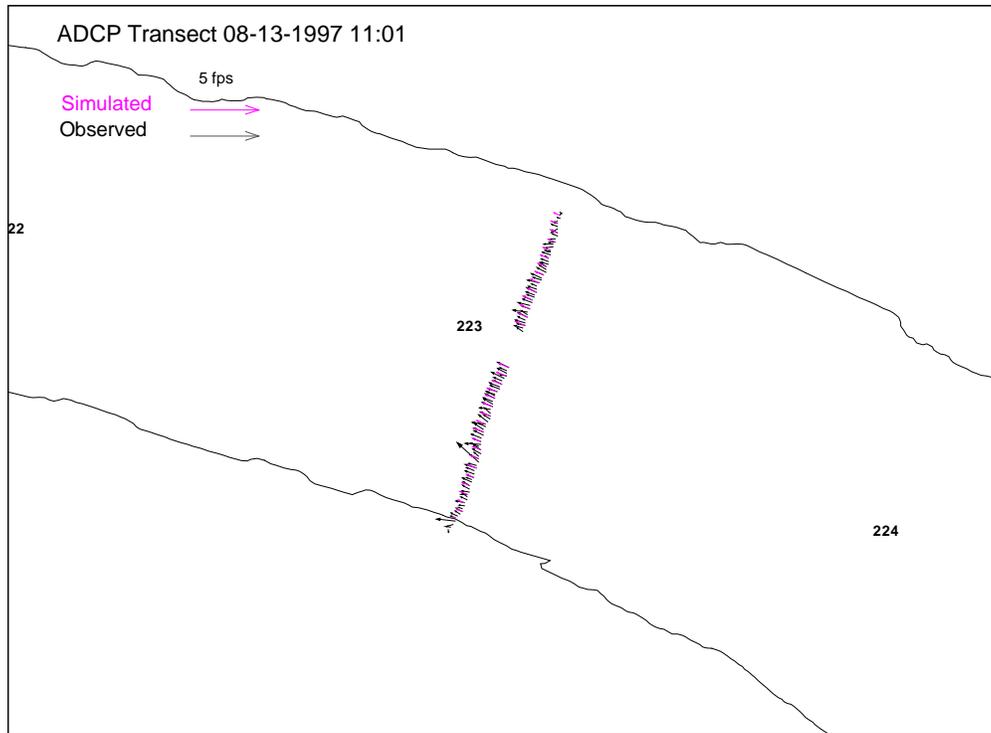


Figure 81. Simulated and observed velocities near Columbia River Mile 223 on August 13, 1997.

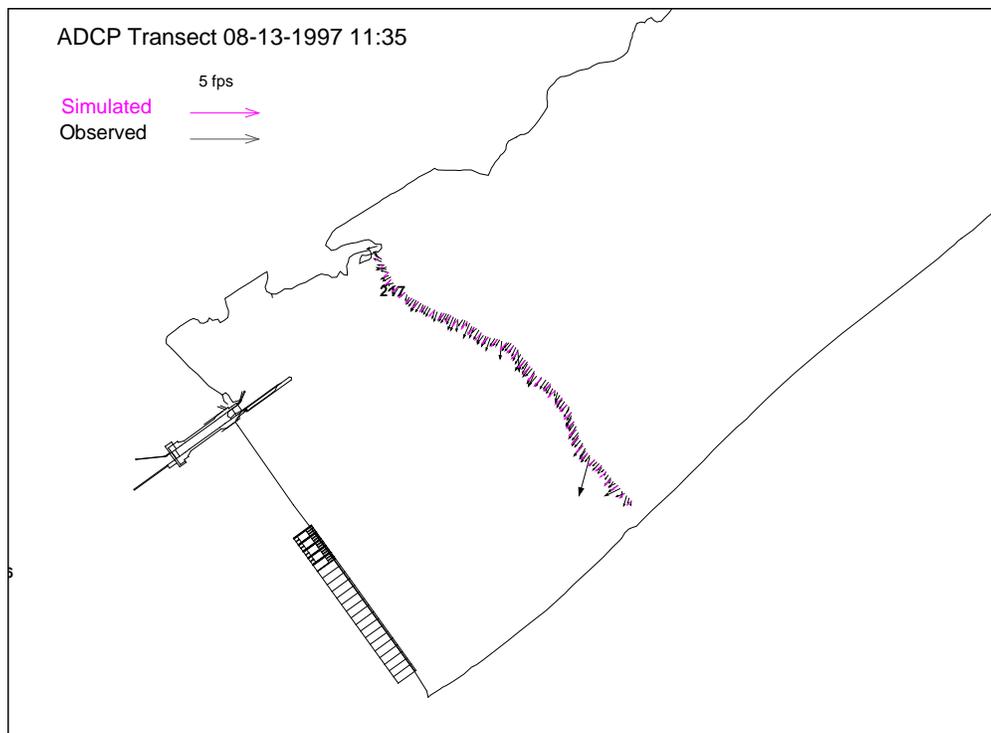


Figure 82. Simulated and observed velocities near John Day dam on August 13, 1997.

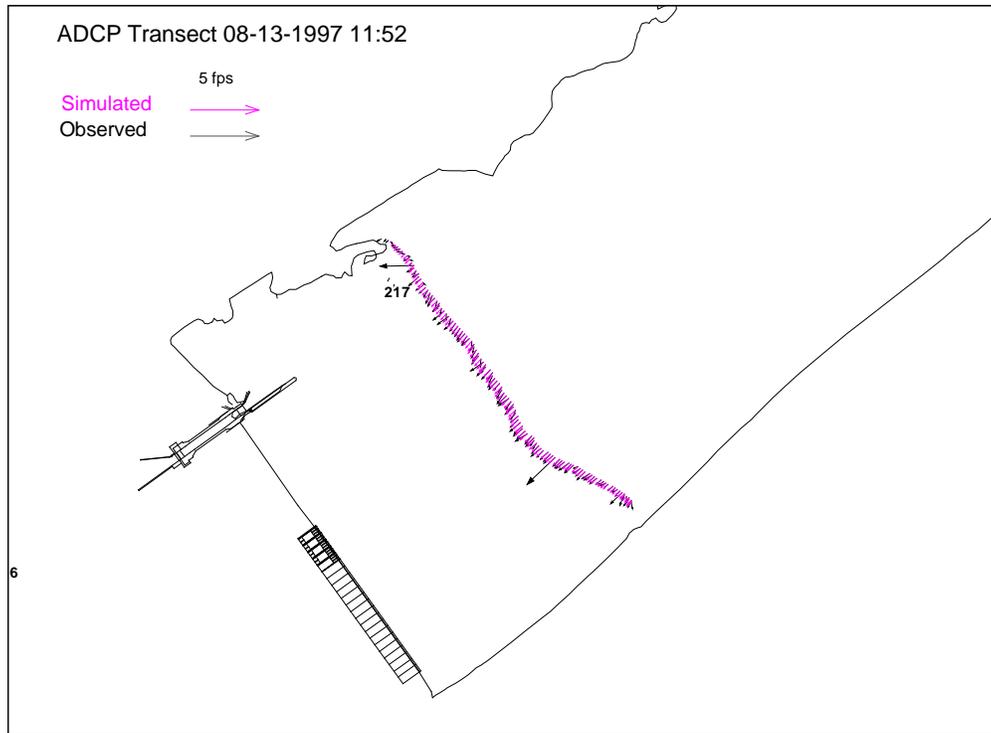


Figure 83. Simulated and observed velocities near John Day dam on August 13, 1997.

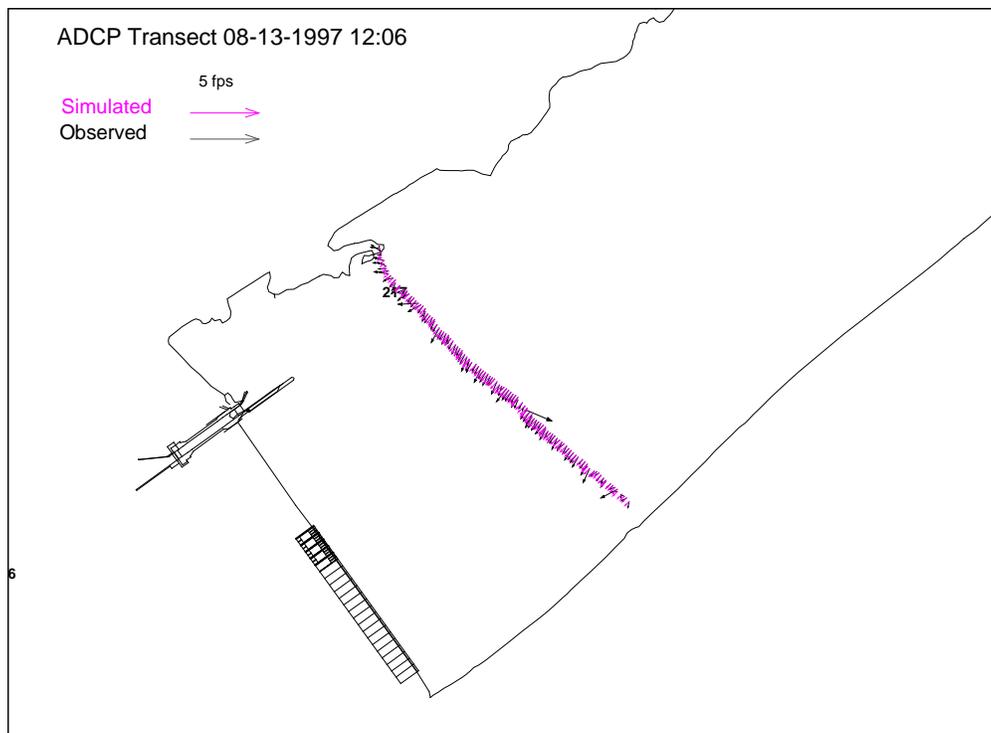


Figure 84. Simulated and observed velocities near John Day dam on August 13, 1997.

1.3.4 Simulated spatial velocity distribution during the Summer 1997 study.

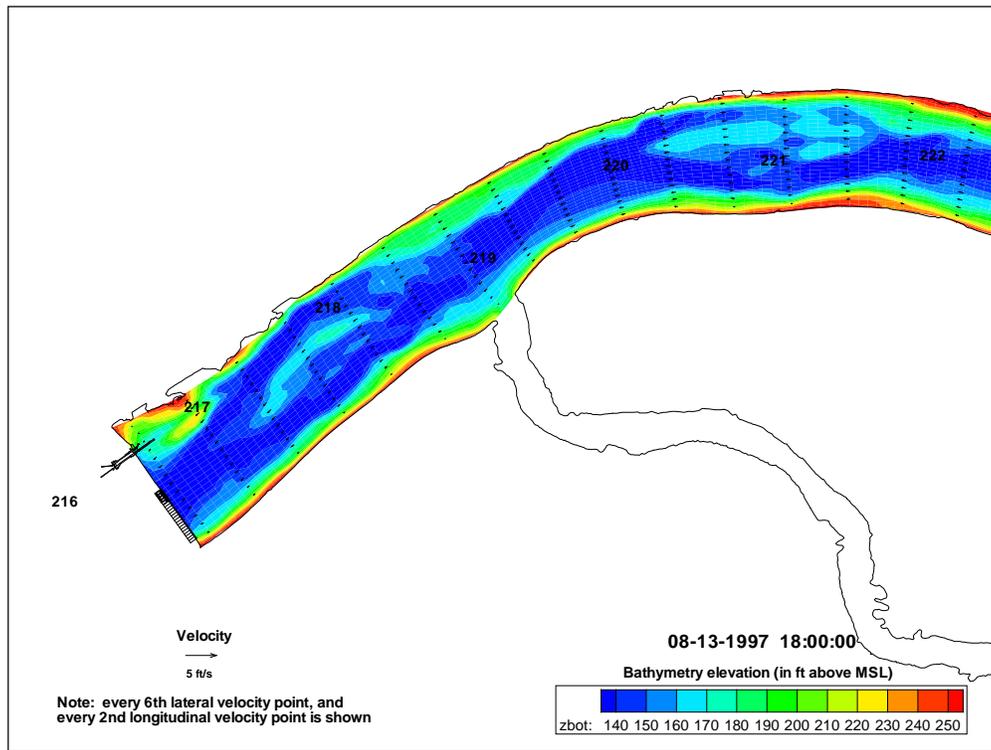


Figure 85. Spatial velocity distribution during the Summer 1997 study period.

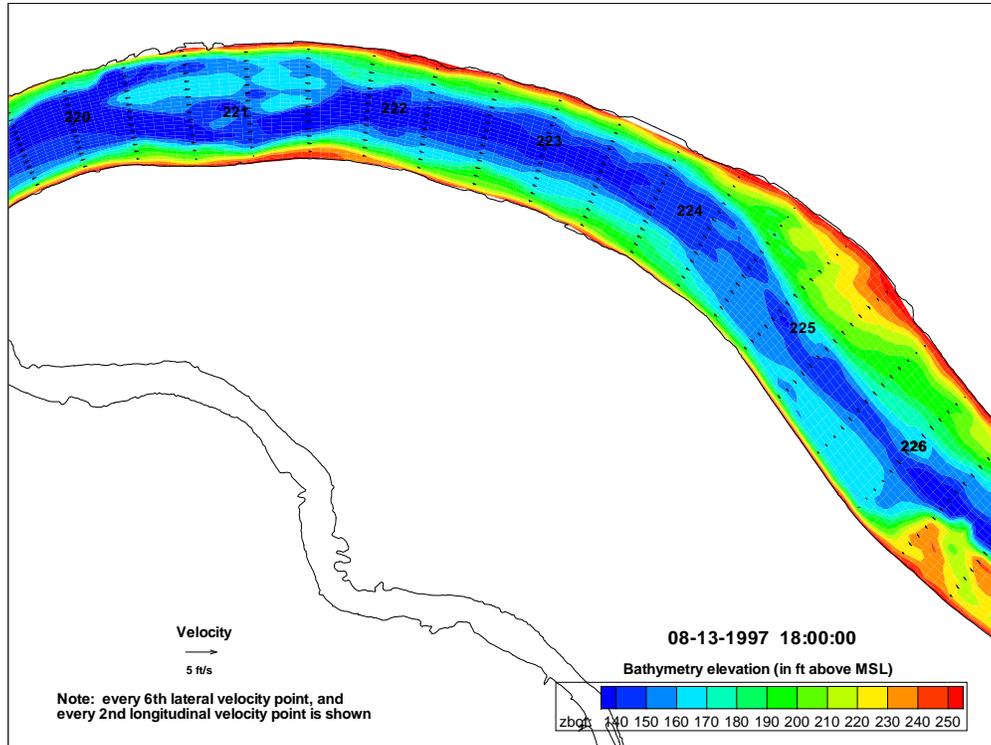


Figure 86. Spatial velocity distribution during the Summer 1997 study period.

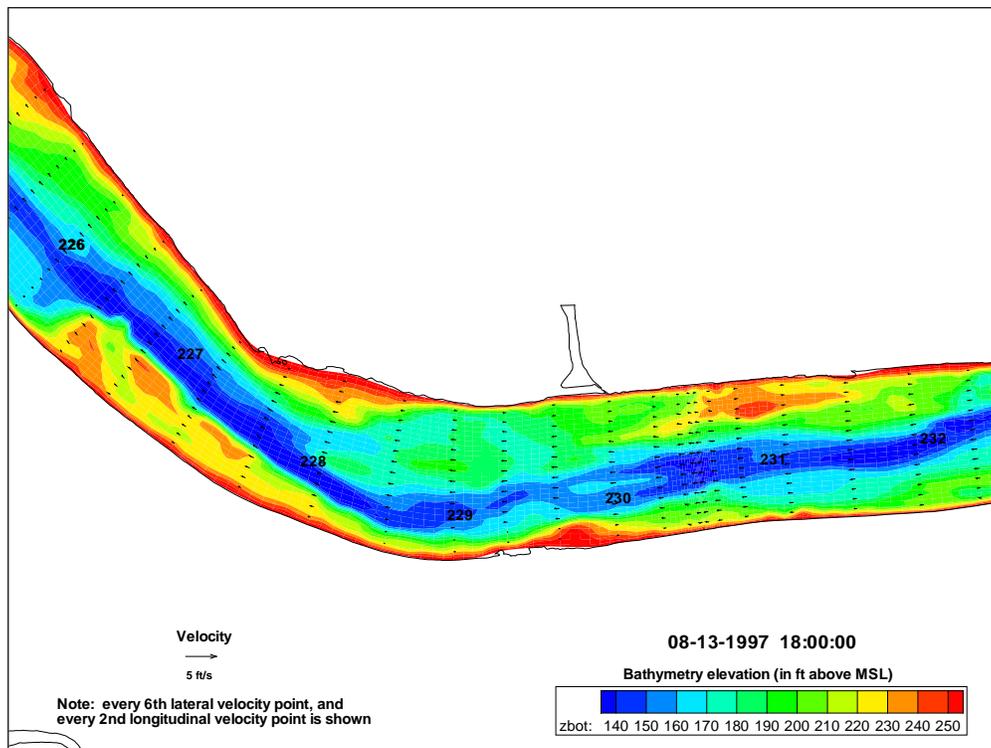


Figure 87. Spatial velocity distribution during the Summer 1997 study period.

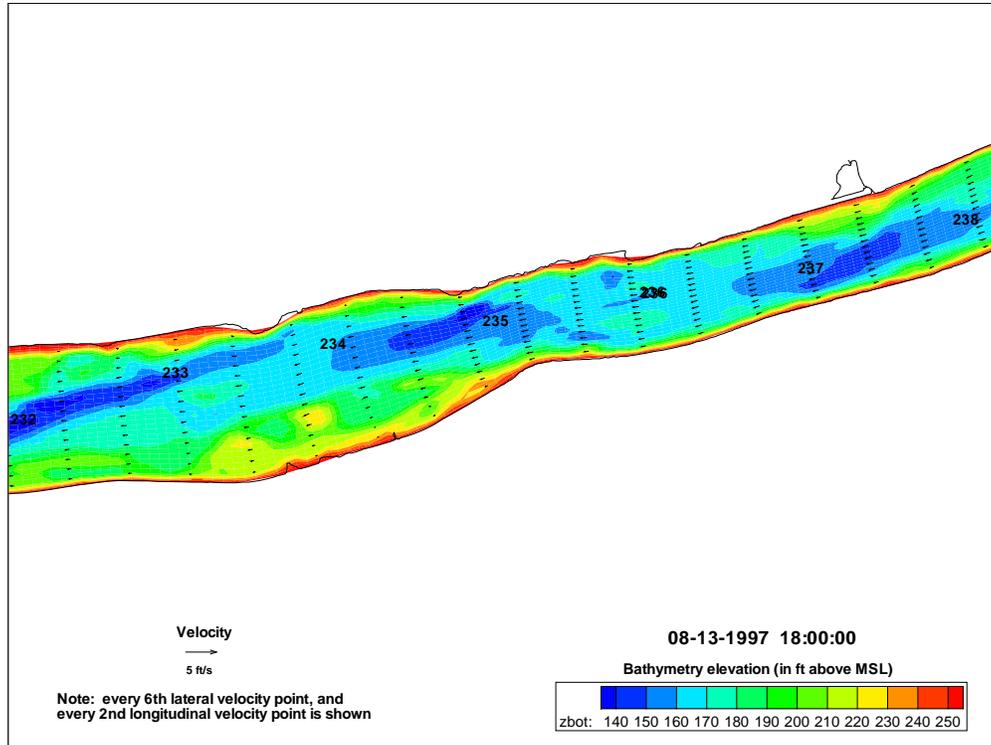


Figure 88. Spatial velocity distribution during the Summer 1997 study period.

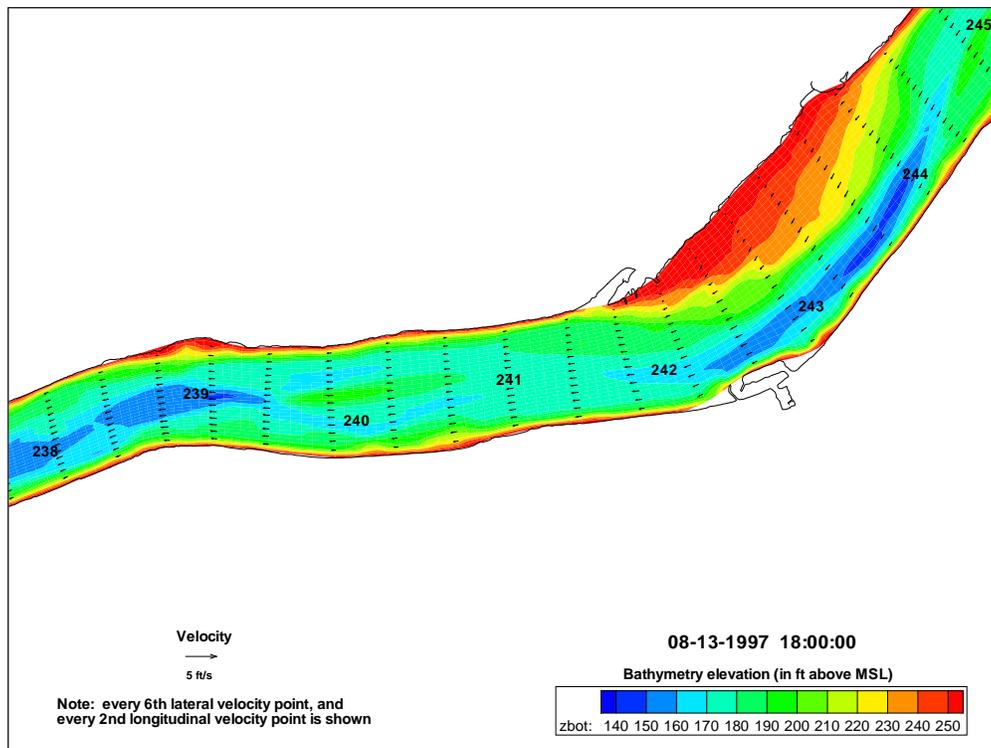


Figure 89. Spatial velocity distribution during the Summer 1997 study period.

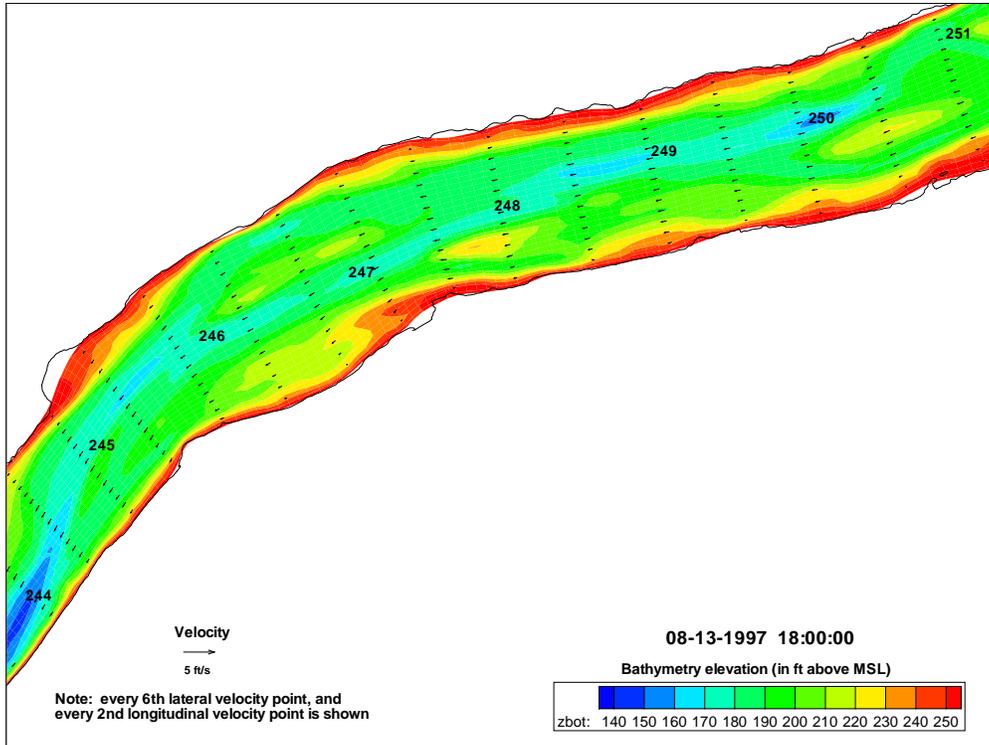


Figure 90. Spatial velocity distribution during the Summer 1997 study period.

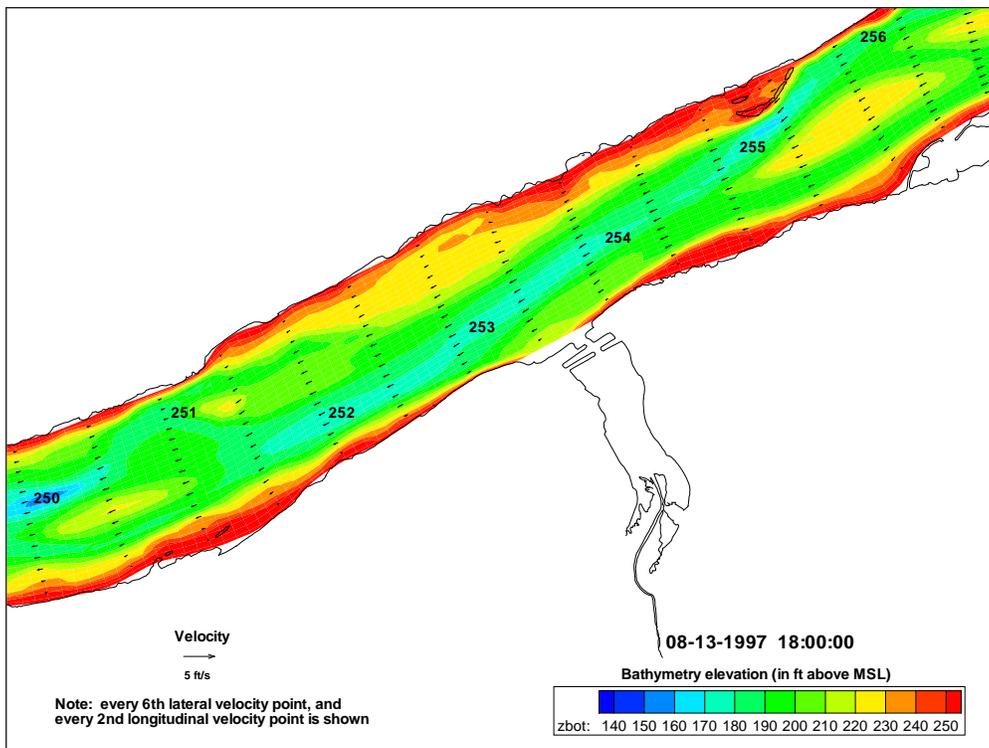


Figure 91. Spatial velocity distribution during the Summer 1997 study period.

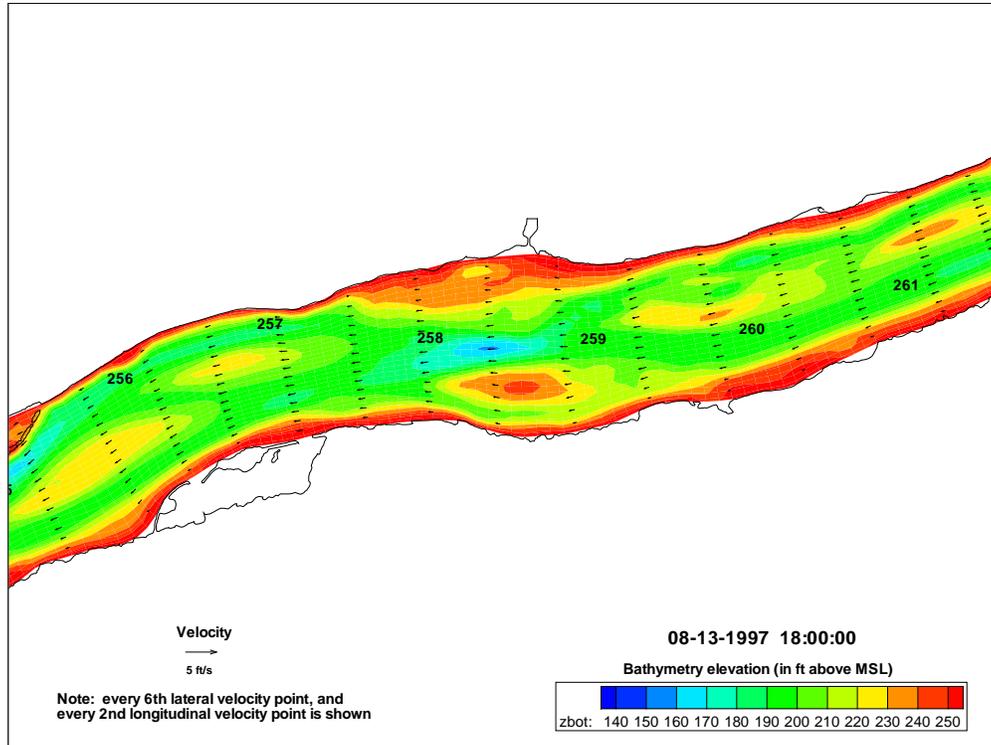


Figure 92. Spatial velocity distribution during the Summer 1997 study period.

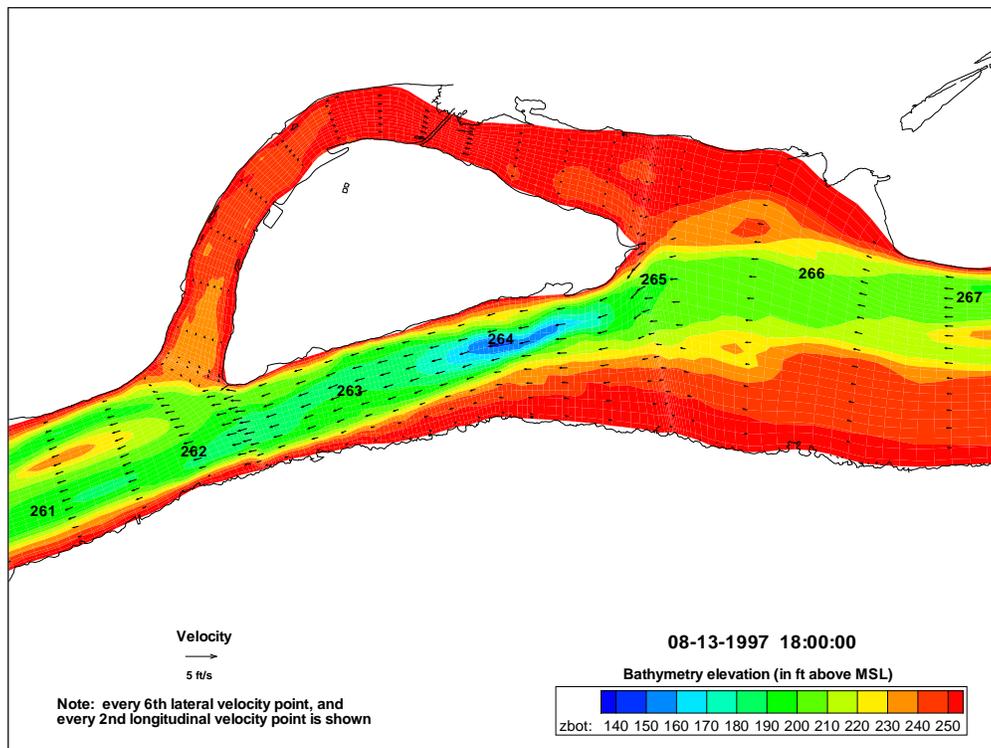


Figure 93. Spatial velocity distribution during the Summer 1997 study period.

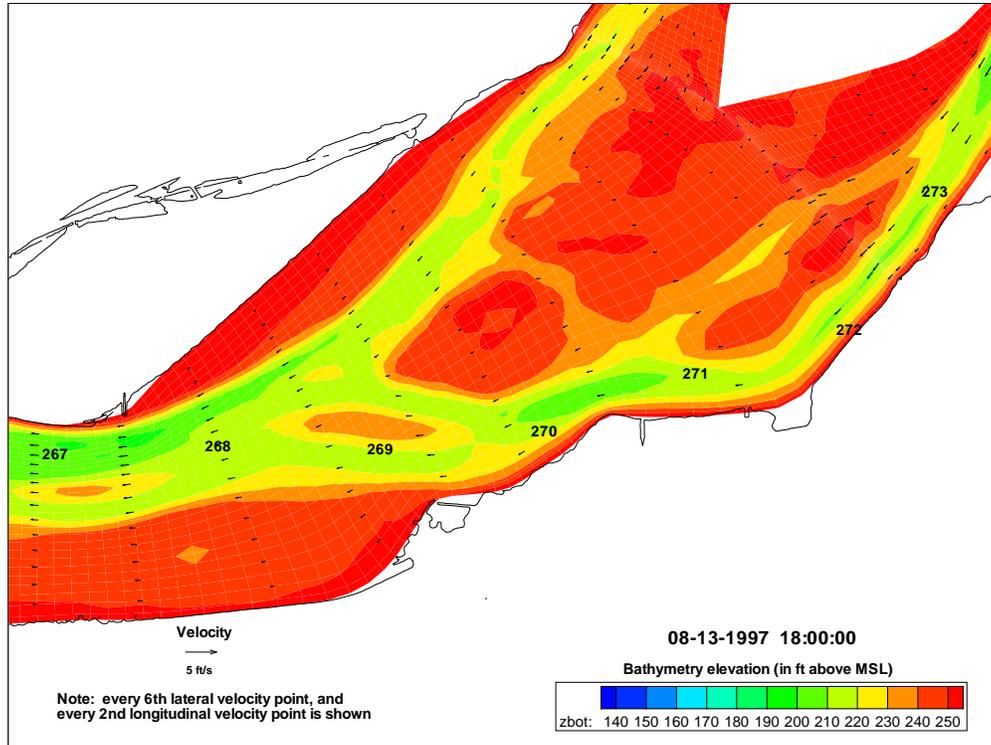


Figure 94. Spatial velocity distribution during the Summer 1997 study period.

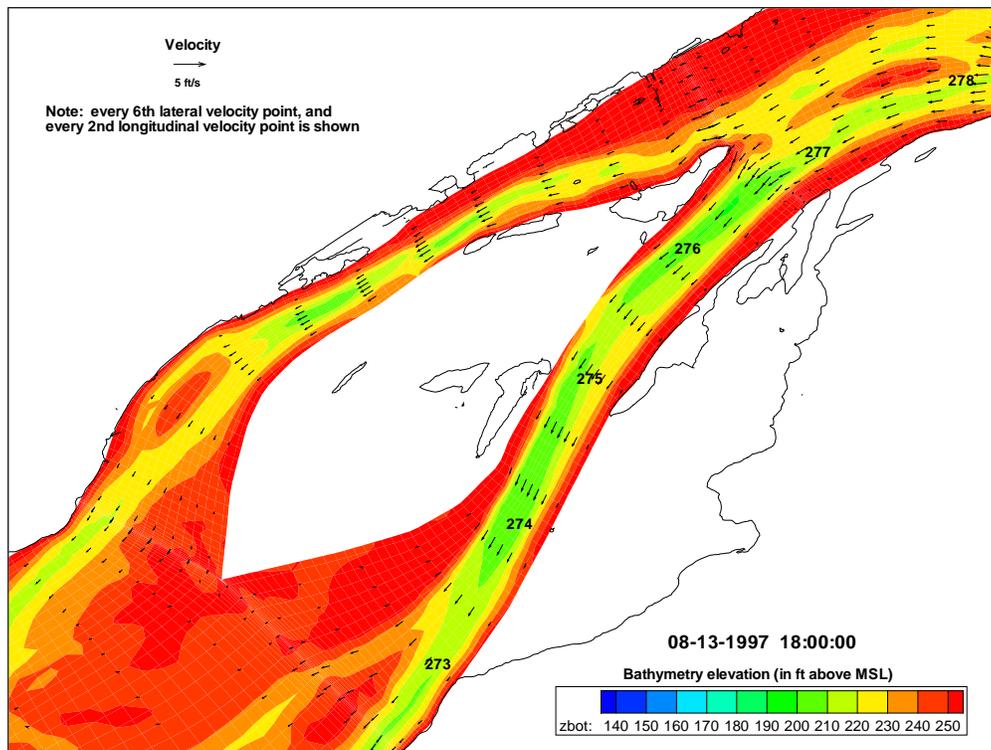


Figure 95. Spatial velocity distribution during the Summer 1997 study period.

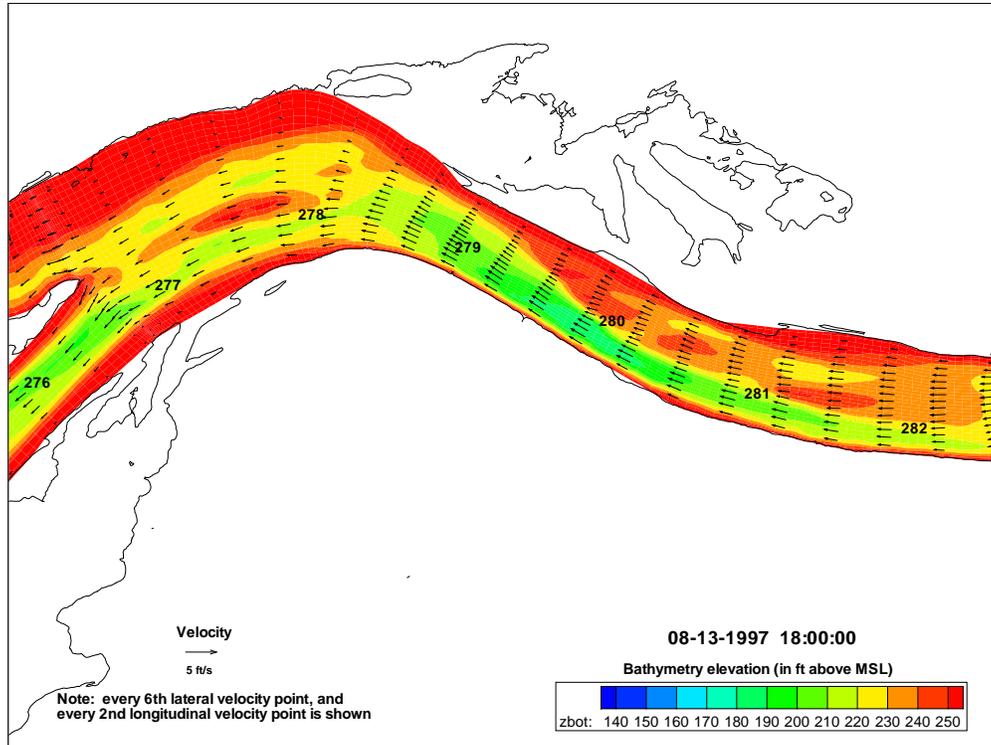


Figure 96. Spatial velocity distribution during the Summer 1997 study period.

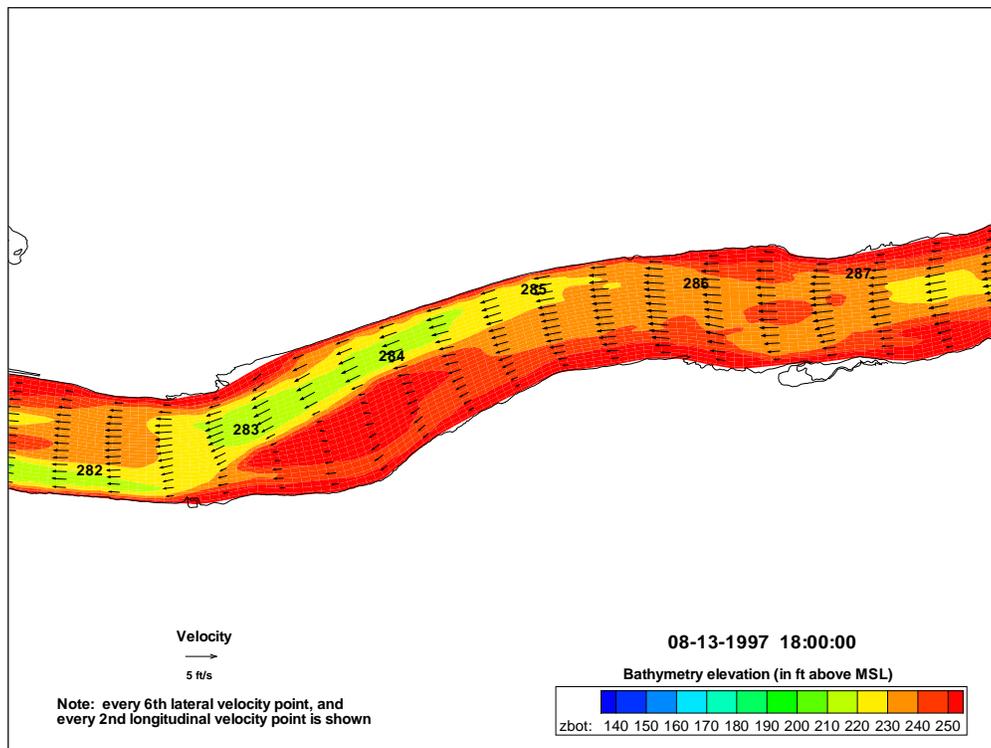


Figure 97. Spatial velocity distribution during the Summer 1997 study period.

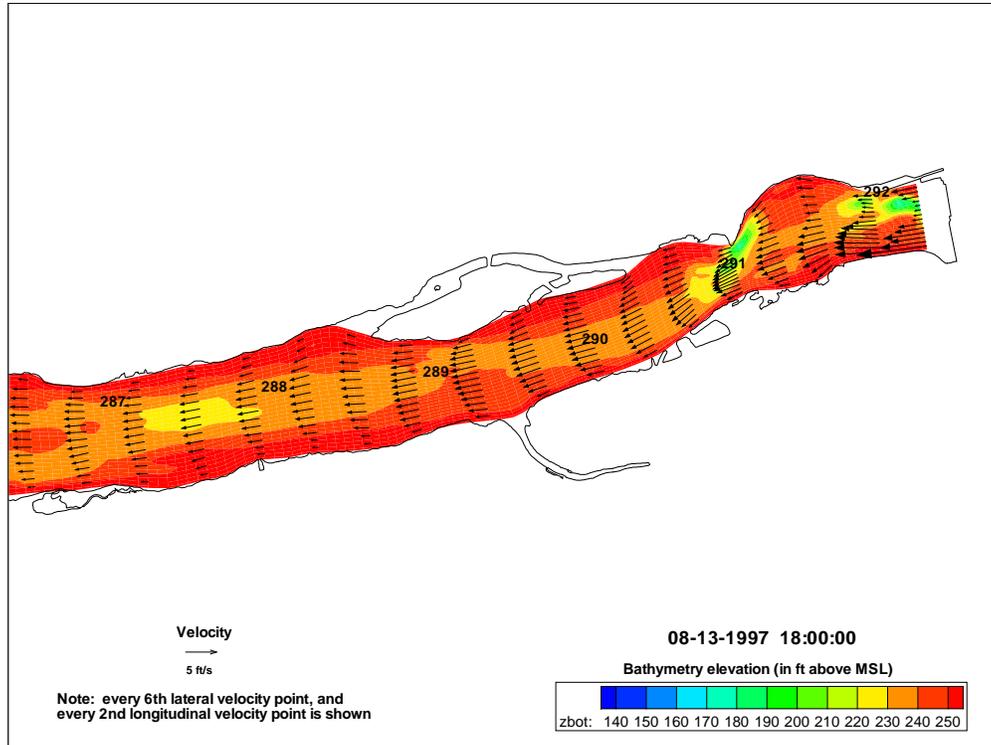


Figure 98. Spatial velocity distribution during the Summer 1997 study period.

1.4 Water Quality Calibration and Verification

1.4.1 Spring 1997 Simulation

Boundary Conditions using McNary Sourcing Function and Forebay FMS Data

Comparisons between the measurements and simulations using an upstream boundary condition developed from the empirical project gas sourcing function and the forebay FMS are shown in the figures below. Statistics on comparisons between measured and simulated temperatures and total dissolved gas are also presented. The case is denoted as FMS-BC in the figure and table captions.

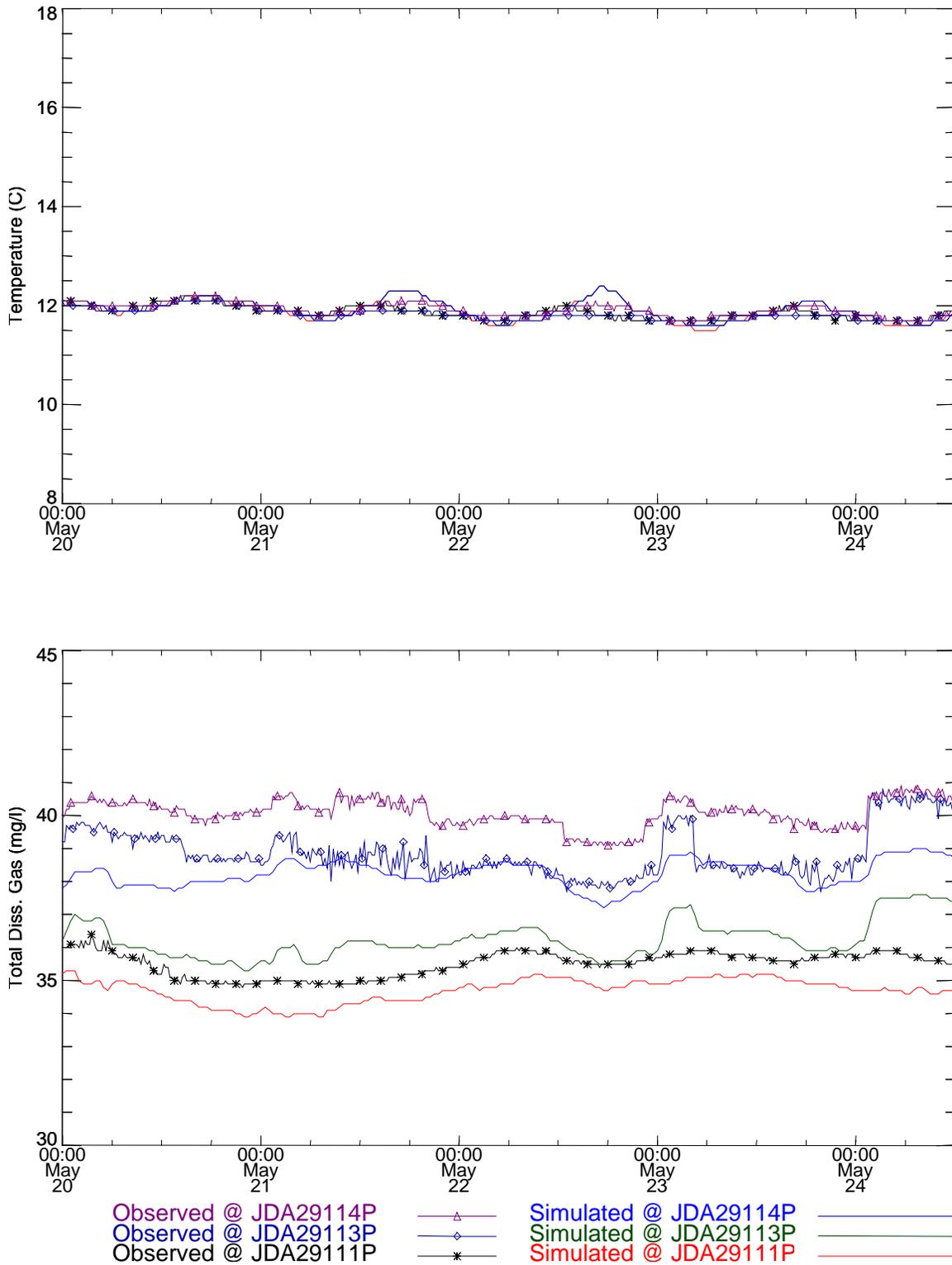


Figure 99. Temperature and total dissolved gas time series near Columbia River Mile 291.1 for the Spring 1997 study (FMS-BC).

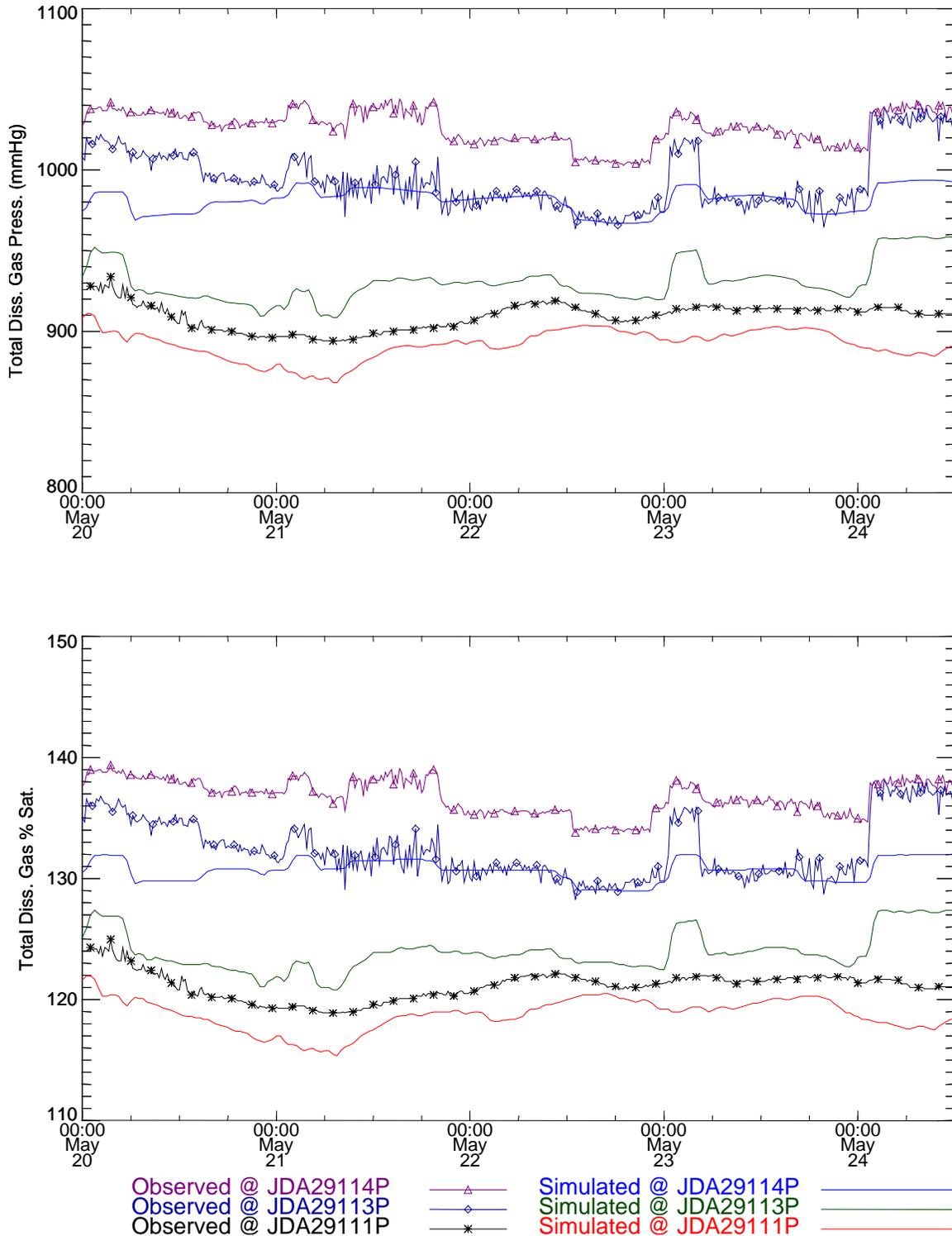


Figure 100. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 291.1 for the Spring 1997 study (FMS-BC).

Table 1. Statistical summary of measurements and simulations at river mile 291.1 during Spring 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA29111P	11.86	11.9	0.13	0.21	0.17
JDA29113P	11.84	11.91	0.11	0.2	0.17
JDA29114P	11.92	11.91	0.13	0.2	0.11
Concentration					
JDA29111P	35.5	34.7	0.37	0.37	0.82
JDA29113P	38.85	36.24	0.73	0.57	2.66
JDA29114P	40.09	38.24	0.43	0.4	1.87
Gas Pressure					
JDA29111P	909.28	891.81	8.28	9.2	18.47
JDA29113P	993.65	930.68	18.51	12.36	64.46
JDA29114P	1026.8	981.48	10.68	7.47	45.98
% Saturation					
JDA29111P	121.14	118.77	1.19	1.33	2.49
JDA29113P	132.38	123.95	2.49	1.62	8.63
JDA29114P	136.79	130.71	1.44	0.88	6.17

Table 2. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 291.1 for the Spring 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA29111P	100	90.78	100	100
JDA29113P	100	0	0	0
JDA29114P	100	0	20.74	18.43

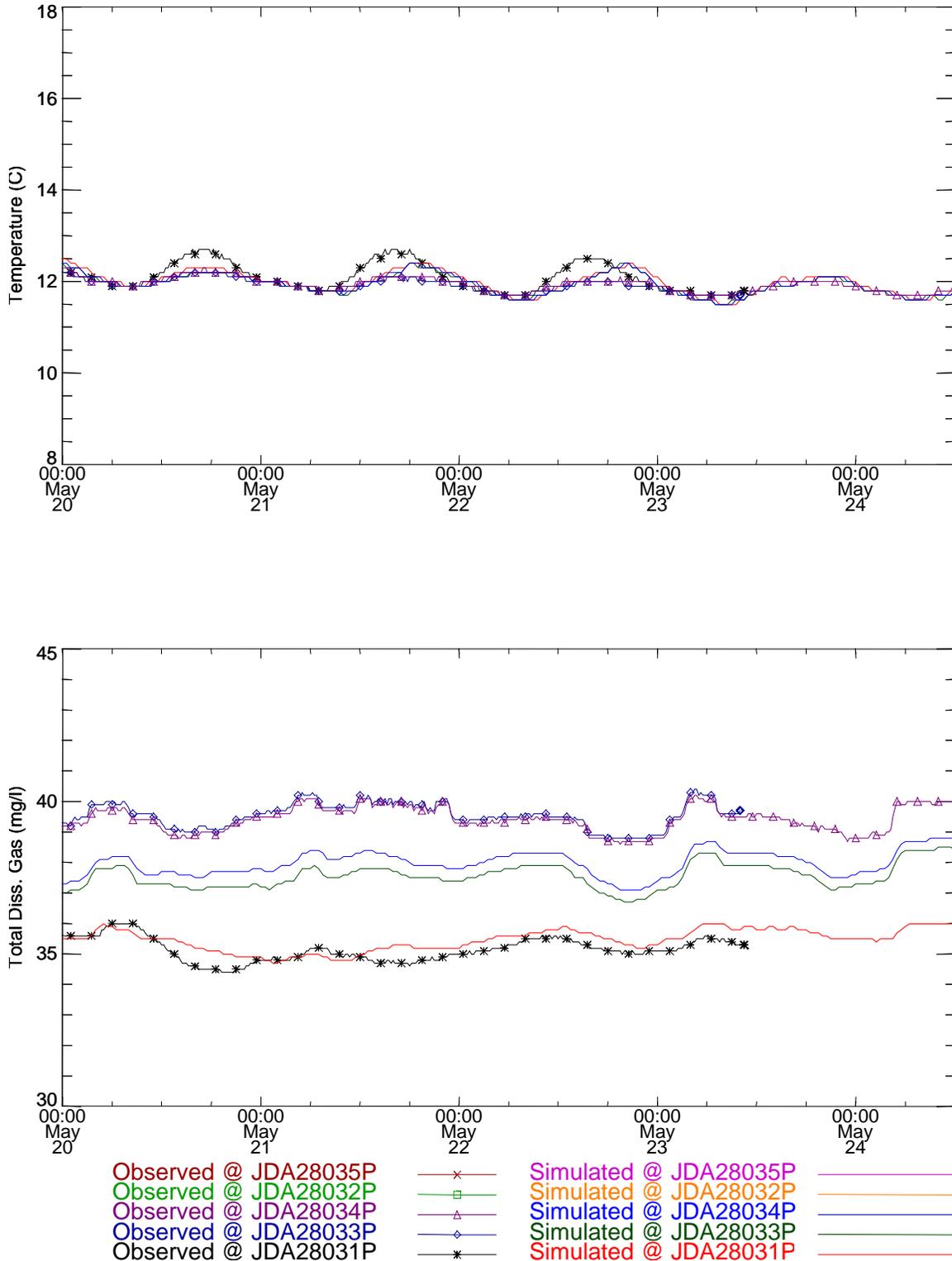


Figure 101. Temperature and total dissolved gas time series near Columbia River Mile 280.3 for the Spring 1997 study (FMS-BC).

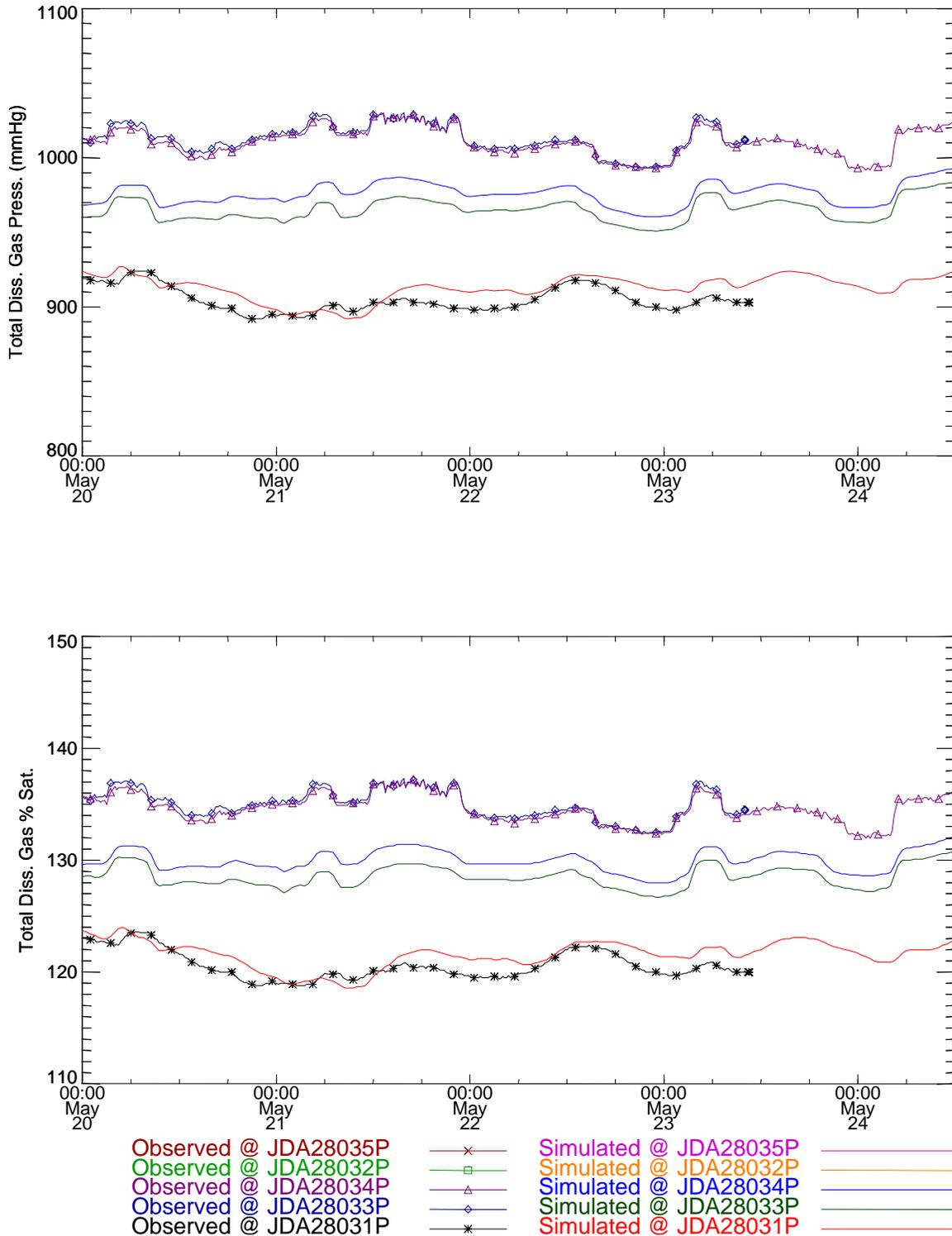


Figure 102. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 280.3 for the Spring 1997 study (FMS-BC).

Table 3. Statistical summary of measurements and simulations at river mile 280.3 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA28031P	12.03	11.98	0.29	0.24	0.21
JDA28033P	11.87	11.94	0.16	0.22	0.16
JDA28034P	11.94	11.95	0.15	0.23	0.12
Concentration					
JDA28031P	35.18	35.47	0.34	0.35	0.39
JDA28033P	39.59	37.56	0.36	0.41	2.06
JDA28034P	39.43	37.97	0.41	0.41	1.48
Gas Pressure					
JDA28031P	904.34	912.84	7.34	8.16	10.79
JDA28033P	1012.89	965.09	8.49	7.57	48.38
JDA28034P	1010.54	975.86	9.73	7.55	35.14
% Saturation					
JDA28031P	120.43	121.57	1.13	1.21	1.47
JDA28033P	134.9	128.53	1.16	0.97	6.44
JDA28034P	134.63	129.97	1.29	0.94	4.72

Table 4. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 280.3 for the Spring 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA28031P	100	100	100	100
JDA28033P	100	0	6.91	6.91
JDA28034P	100	0	66.82	65.44

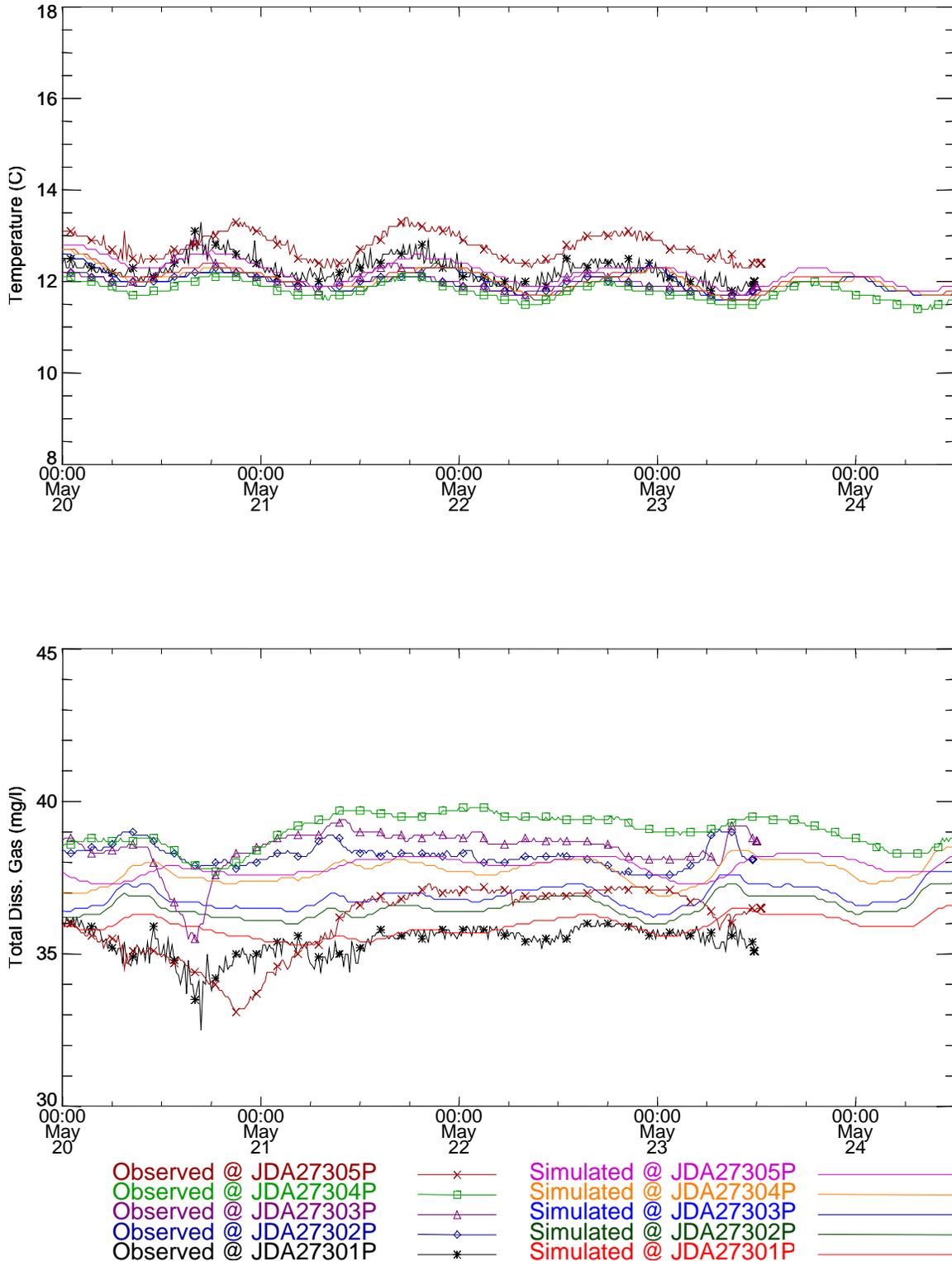


Figure 103. Temperature and total dissolved gas time series near Columbia River Mile 273.0 for the Spring 1997 study (FMS-BC).

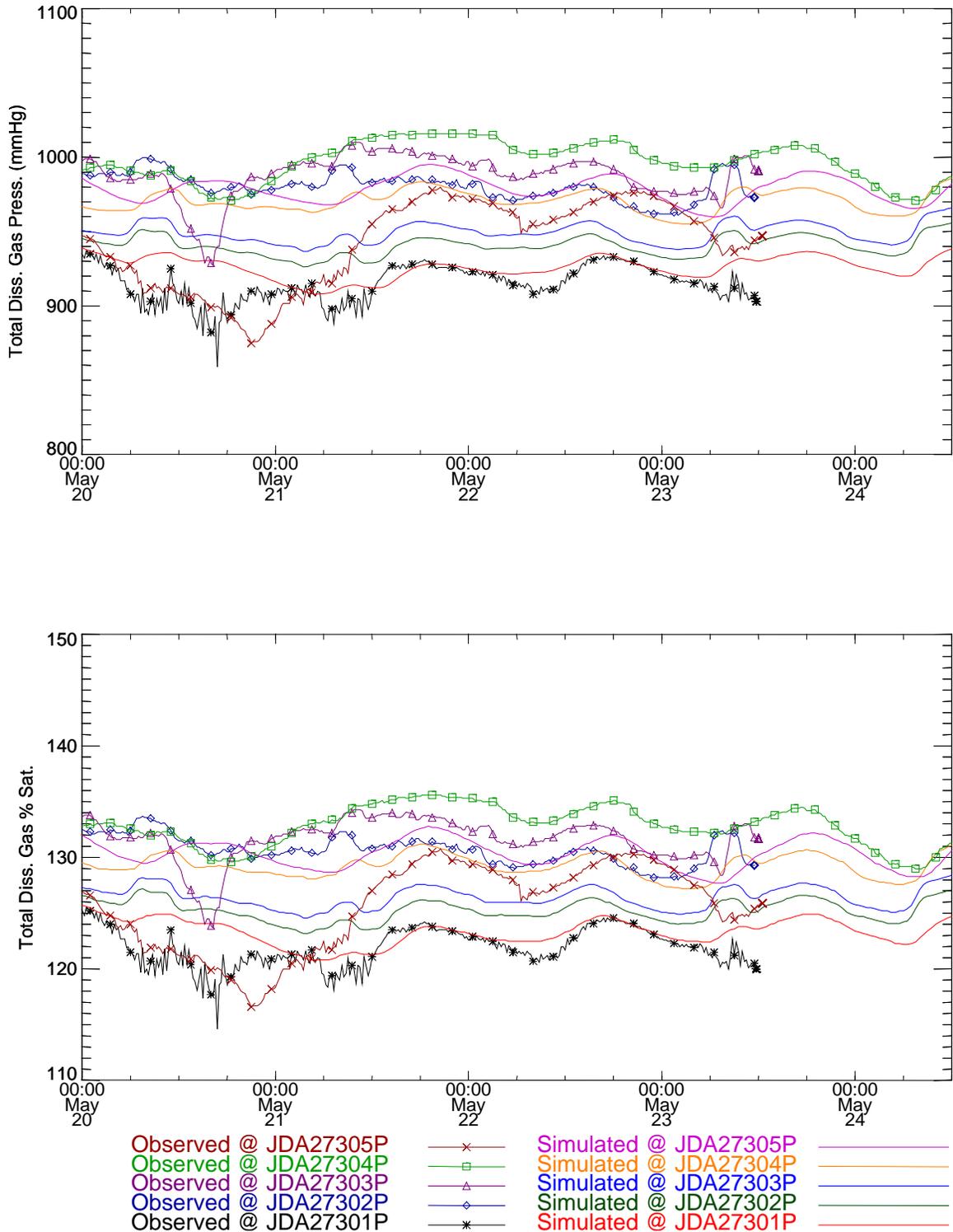


Figure 104. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 273.0 for the Spring 1997 study (FMS-BC).

Table 5. Statistical summary of measurements and simulations at river mile 273.0 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA27301P	12.21	12.06	0.26	0.24	0.26
JDA27302P	11.93	11.99	0.15	0.23	0.17
JDA27303P	12.02	11.99	0.22	0.22	0.22
JDA27304P	11.79	12.03	0.19	0.23	0.28
JDA27305P	12.7	12.21	0.29	0.26	0.53
Concentration					
JDA27301P	35.32	35.91	0.47	0.32	0.82
JDA27302P	38.2	36.54	0.32	0.34	1.7
JDA27303P	38.51	36.89	0.62	0.35	1.74
JDA27304P	39.04	37.7	0.53	0.38	1.43
JDA27305P	36.15	37.86	1.03	0.29	1.95
Gas Pressure					
JDA27301P	911.89	925.84	11.66	7.53	19.26
JDA27302P	978.9	940.37	8.54	6.65	39.66
JDA27303P	988.55	949.18	13.42	6.71	41.75
JDA27304P	997.24	970.44	13.34	7.32	29.29
JDA27305P	942.76	978.38	26.2	8.59	43.52
% Saturation					
JDA27301P	121.44	123.31	1.67	1.15	2.61
JDA27302P	130.36	125.24	1.27	0.98	5.29
JDA27303P	131.65	126.41	1.73	0.96	5.56
JDA27304P	132.86	129.24	1.78	1.01	3.94
JDA27305P	125.56	130.31	3.47	1.26	5.81

Table 6. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 273.0 for the Spring 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA27301P	100	76.04	95.39	95.85
JDA27302P	100	4.15	51.15	47.93
JDA27303P	100	11.52	39.63	36.41
JDA27304P	100	25.81	82.95	80.18
JDA27305P	100	20.74	62.67	60.83

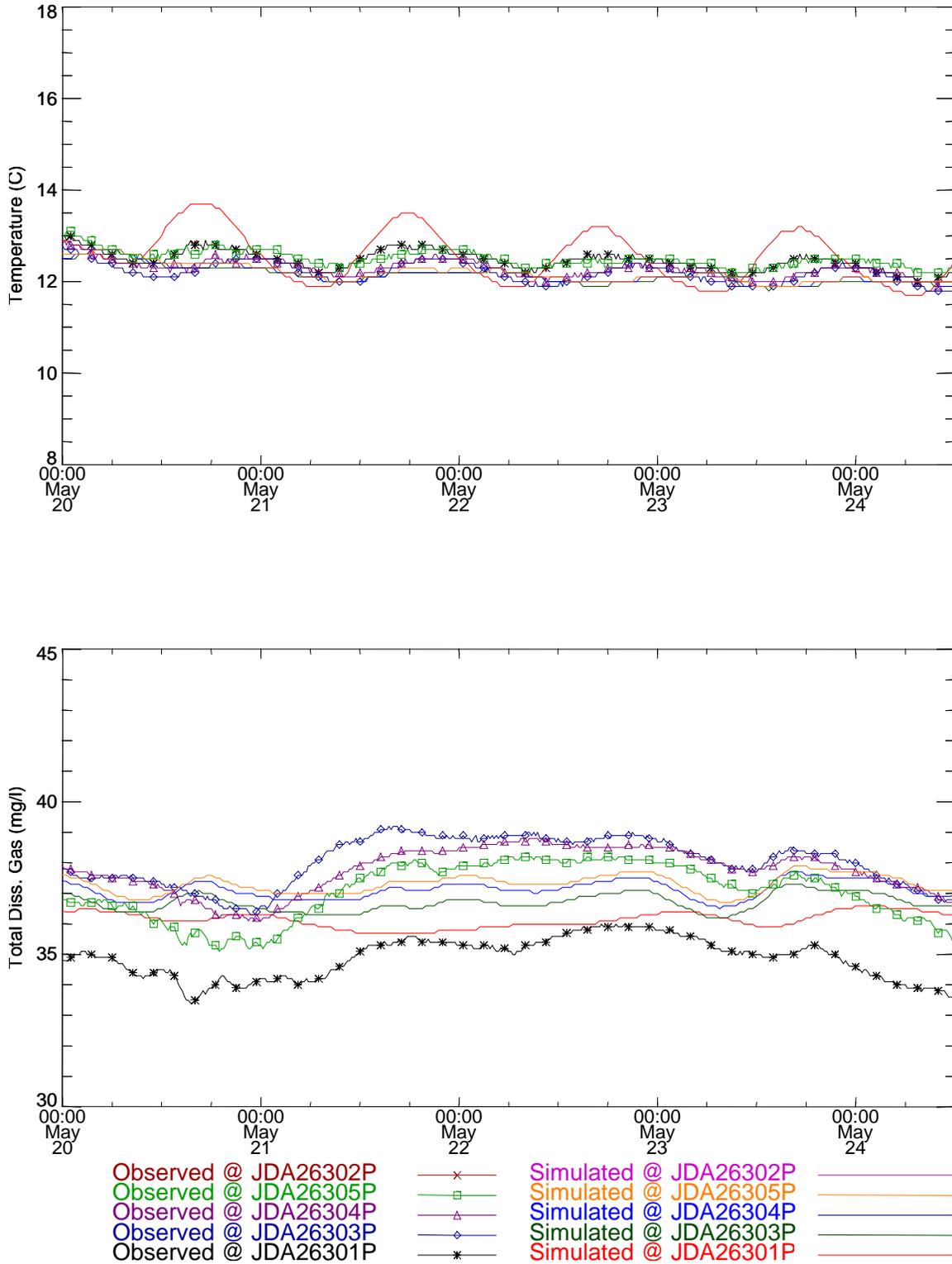


Figure 105. Temperature and total dissolved gas time series near Columbia River Mile 263.0 for the Spring 1997 study (FMS-BC).

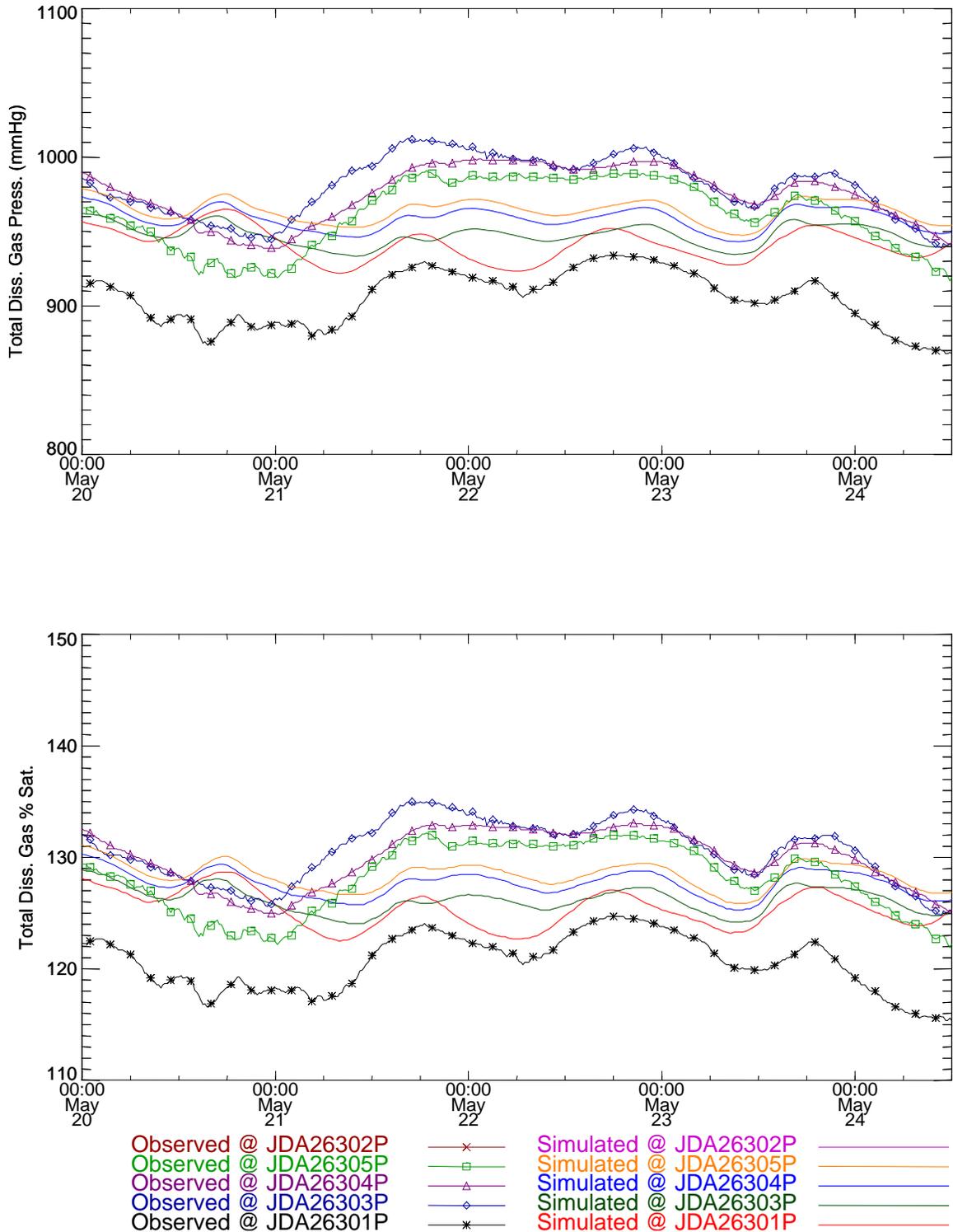


Figure 106. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 263.0 for the Spring 1997 study (FMS-BC).

Table 7. Statistical summary of measurements and simulations at river mile 263.0 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA26301P	12.46	12.55	0.21	0.55	0.42
JDA26303P	12.2	12.14	0.22	0.2	0.2
JDA26304P	12.29	12.16	0.18	0.2	0.19
JDA26305P	12.5	12.19	0.18	0.21	0.35
Concentration					
JDA26301P	34.88	36.14	0.66	0.26	1.48
JDA26303P	38.04	36.7	0.79	0.28	1.56
JDA26304P	37.77	37.12	0.73	0.28	0.95
JDA26305P	37.06	37.31	0.92	0.3	0.91
Gas Pressure					
JDA26301P	905.19	941.28	18.26	10.92	41.74
JDA26303P	980.6	947.47	20.17	7.18	39.23
JDA26304P	975.59	958.4	18.5	7.31	24.81
JDA26305P	961.73	963.9	22.96	7.45	22.66
% Saturation					
JDA26301P	120.59	125.36	2.51	1.65	5.53
JDA26303P	130.64	126.19	2.72	1.14	5.26
JDA26304P	129.97	127.64	2.51	1.15	3.33
JDA26305P	128.12	128.38	3.08	1.16	3.02

Table 8. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 263.0 for the Spring 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA26301P	100	51.15	52.53	52.53
JDA26303P	100	36.41	53.92	53.92
JDA26304P	100	59.91	94.93	93.55
JDA26305P	100	77.42	89.86	89.86

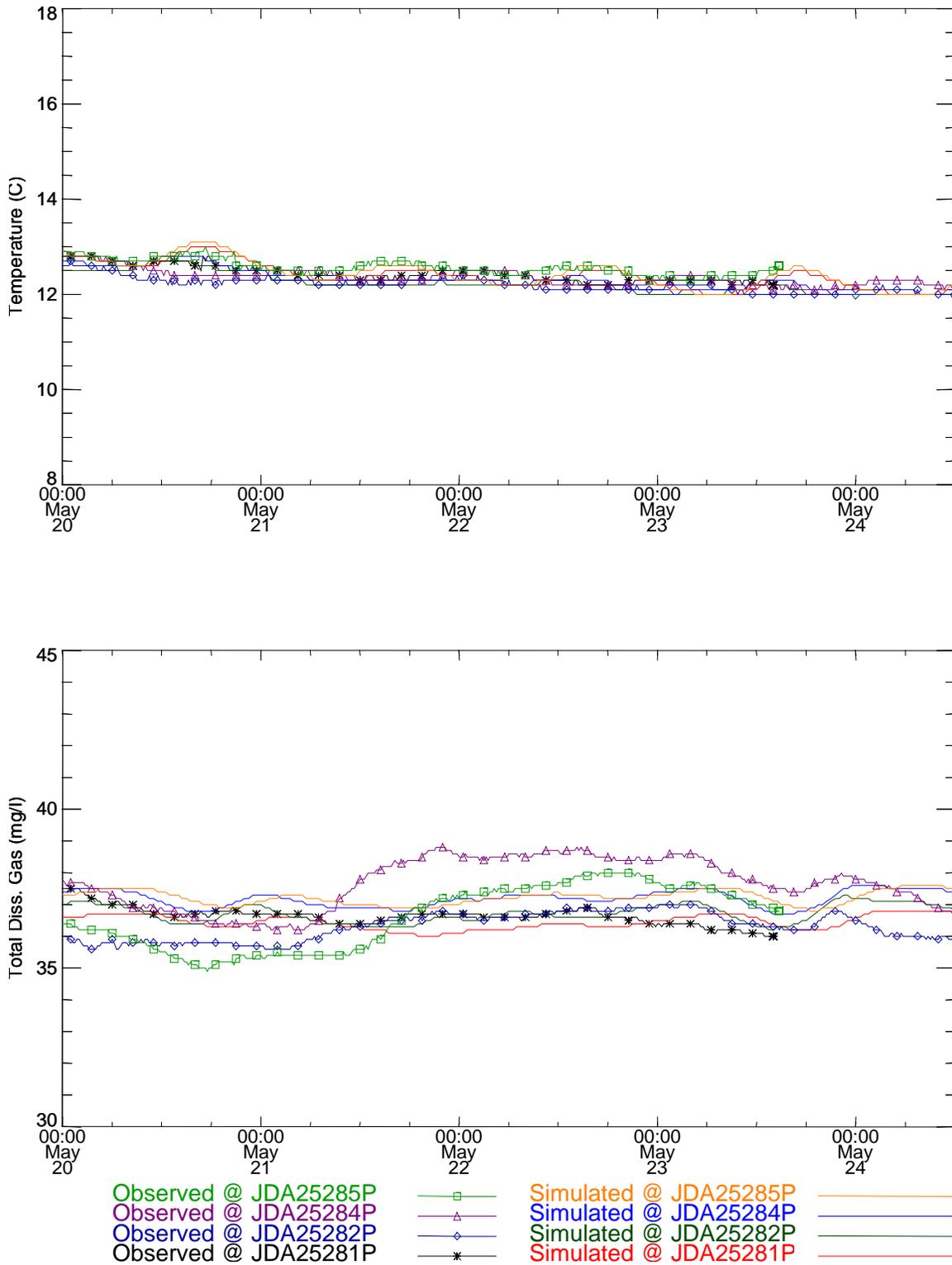


Figure 107. Temperature and total dissolved gas time series near Columbia River Mile 252.8 for the Spring 1997 study (FMS-BC).

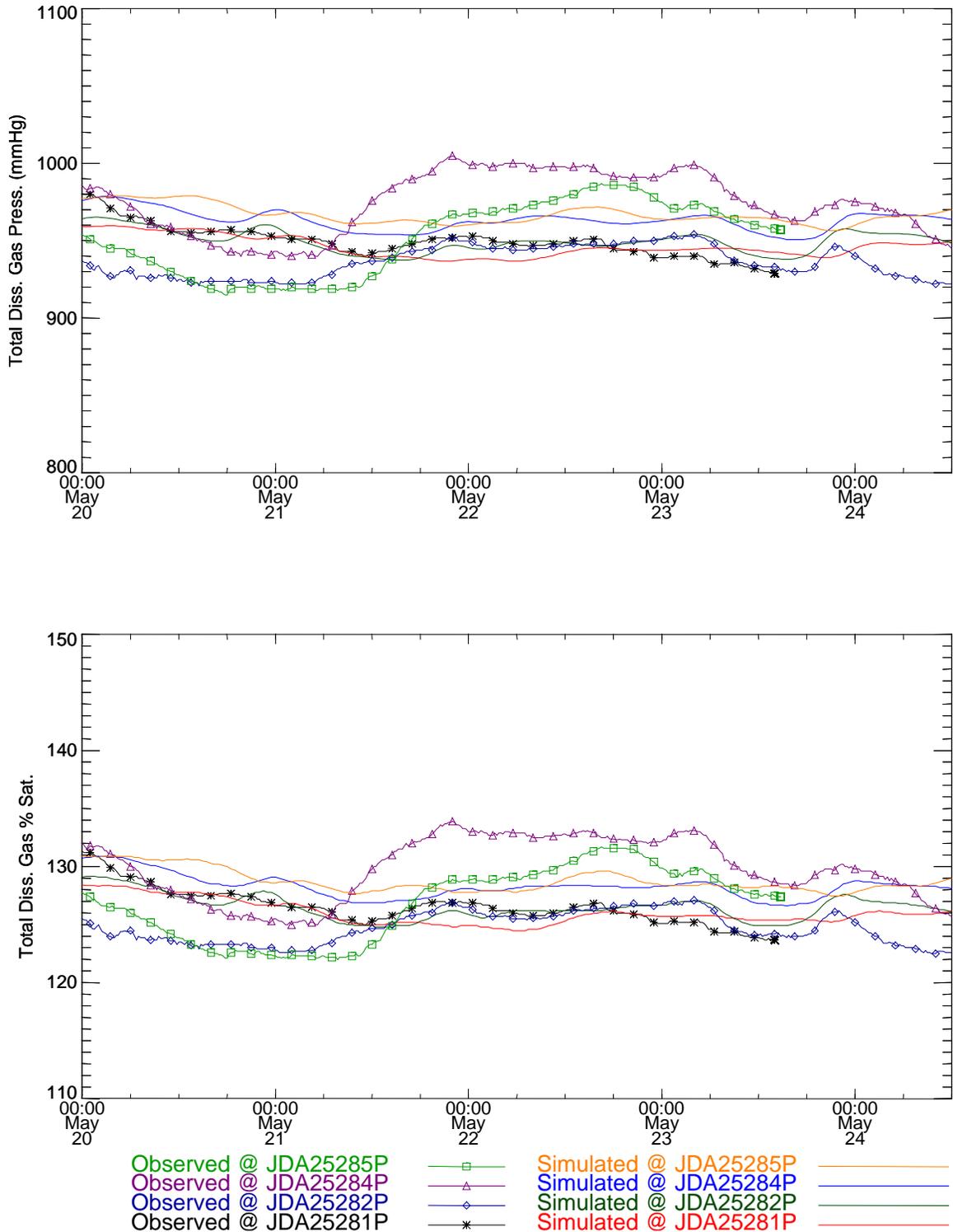


Figure 108. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 252.8 for the Spring 1997 study (FMS-BC).

Table 9. Statistical summary of measurements and simulations at river mile 252.8 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA25281P	12.39	12.39	0.18	0.27	0.17
JDA25282P	12.2	12.23	0.15	0.2	0.16
JDA25284P	12.36	12.31	0.17	0.23	0.19
JDA25285P	12.57	12.43	0.15	0.29	0.26
Concentration					
JDA25281P	36.51	36.45	0.36	0.22	0.46
JDA25282P	36.3	36.72	0.43	0.28	0.67
JDA25284P	37.67	37.19	0.8	0.25	0.94
JDA25285P	36.63	37.23	0.89	0.22	1.06
Gas Pressure					
JDA25281P	945.45	946.2	12.26	6.78	10.46
JDA25282P	936.45	949.73	10.19	7.11	19.24
JDA25284P	974.68	963.24	19.92	6.59	24.32
JDA25285P	952.36	966.79	21.3	6.05	27.78
% Saturation					
JDA25281P	125.96	126.02	1.79	1.06	1.37
JDA25282P	124.76	126.49	1.37	1.08	2.54
JDA25284P	129.85	128.29	2.68	1.01	3.26
JDA25285P	126.88	128.76	2.82	0.98	3.68

Table 10. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 252.8 for the Spring 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA25281P	100	100	100	100
JDA25282P	100	81.11	100	100
JDA25284P	100	63.59	94.93	94.47
JDA25285P	100	66.36	73.73	73.73

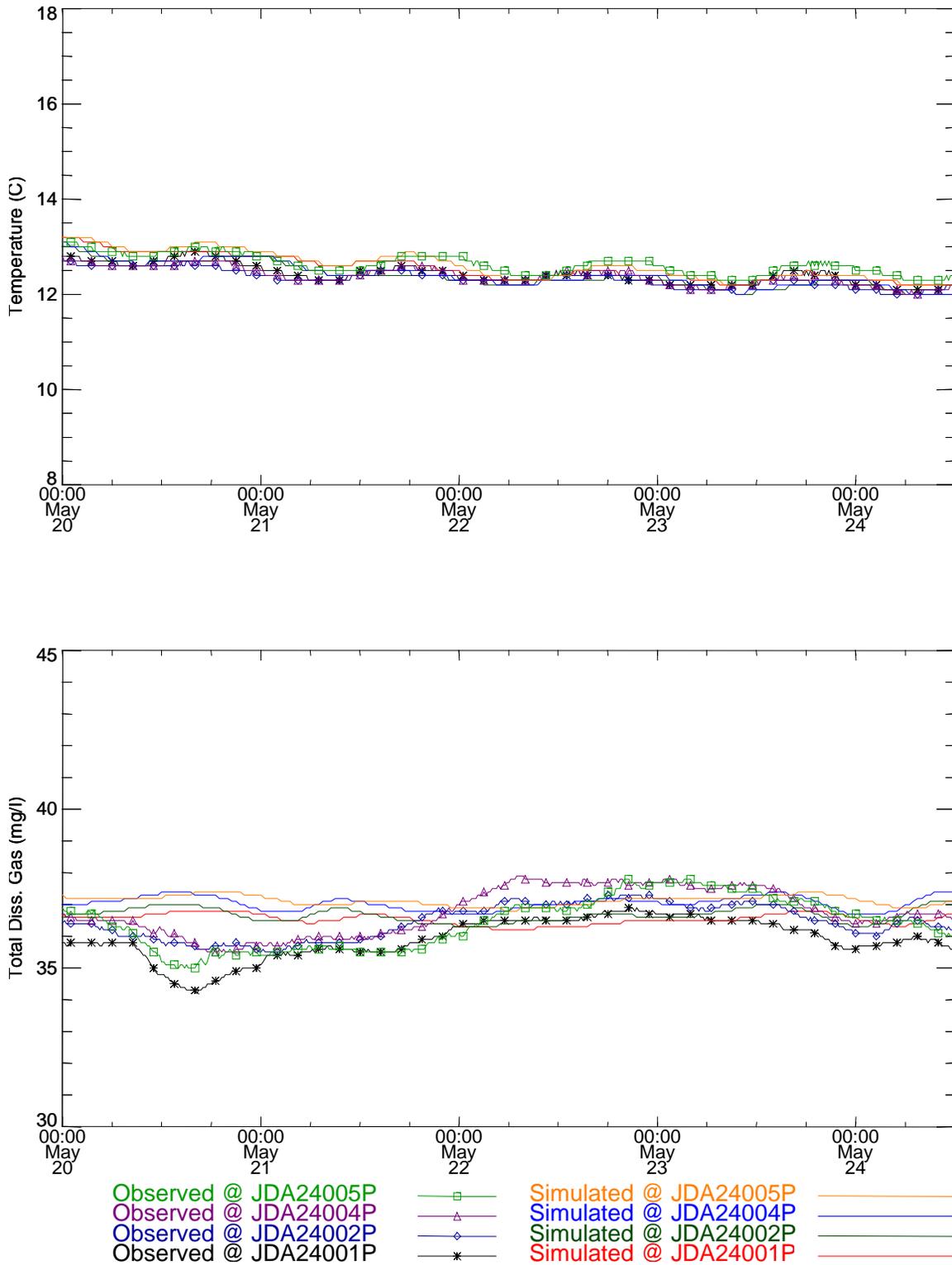


Figure 109. Temperature and total dissolved gas time series near Columbia River Mile 240.0 for the Spring 1997 study (FMS-BC).

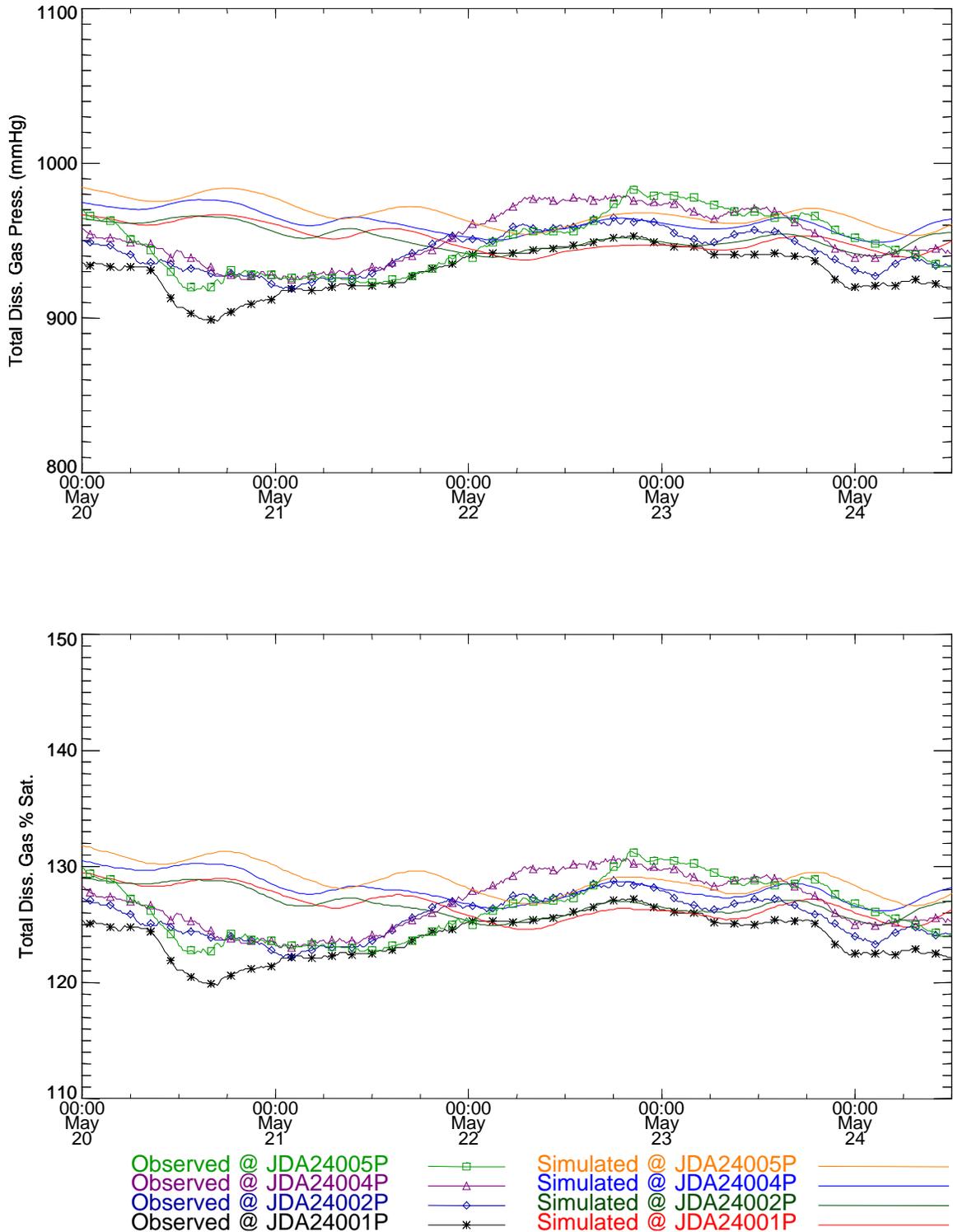


Figure 110. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 240.0 for the Spring 1997 study (FMS-BC).

Table 11. Statistical summary of measurements and simulations at river mile 240.0 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA24001P	12.42	12.54	0.21	0.27	0.18
JDA24002P	12.34	12.38	0.18	0.25	0.16
JDA24004P	12.39	12.41	0.19	0.26	0.15
JDA24005P	12.63	12.6	0.21	0.29	0.13
Concentration					
JDA24001P	35.91	36.54	0.64	0.17	0.98
JDA24002P	36.45	36.68	0.54	0.22	0.66
JDA24004P	36.76	37.04	0.73	0.21	0.81
JDA24005P	36.43	37.13	0.8	0.16	1.08
Gas Pressure					
JDA24001P	930.63	951.31	13.99	8.42	28.99
JDA24002P	942.85	951.81	12.89	7.46	19.46
JDA24004P	951.87	961.81	17.51	7.33	23.11
JDA24005P	948.16	967.67	18.9	8.4	29.93
% Saturation					
JDA24001P	123.98	126.7	1.87	1.31	3.84
JDA24002P	125.61	126.76	1.75	1.15	2.58
JDA24004P	126.82	128.1	2.34	1.15	3.06
JDA24005P	126.32	128.87	2.56	1.33	3.96

Table 12. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 240.0 for the Spring 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA24001P	100	76.04	84.79	84.79
JDA24002P	100	89.4	98.62	98.62
JDA24004P	100	79.26	91.71	91.24
JDA24005P	100	64.52	68.2	69.12

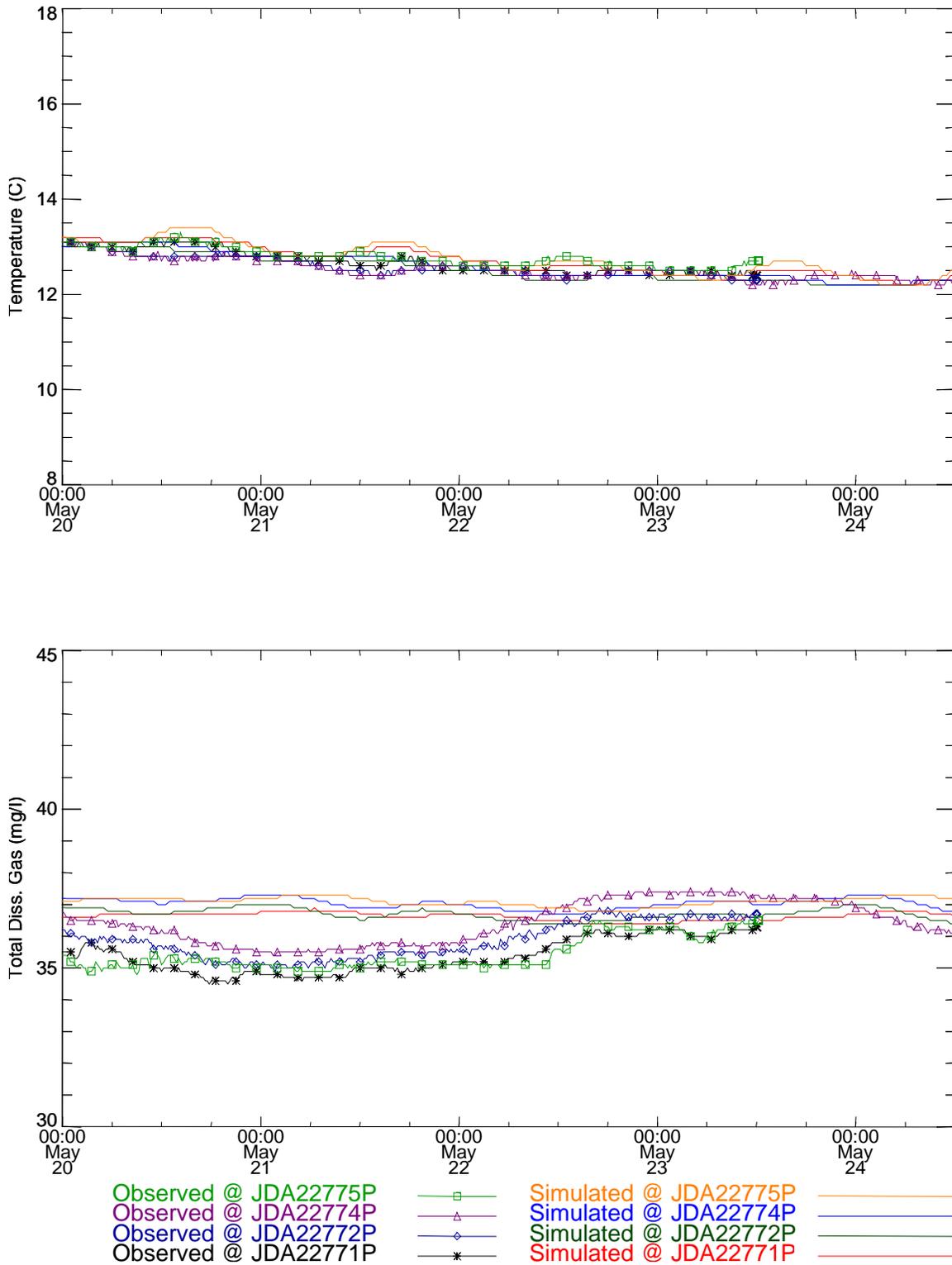


Figure 111. Temperature and total dissolved gas time series near Columbia River Mile 227.7 for the Spring 1997 study (FMS-BC).

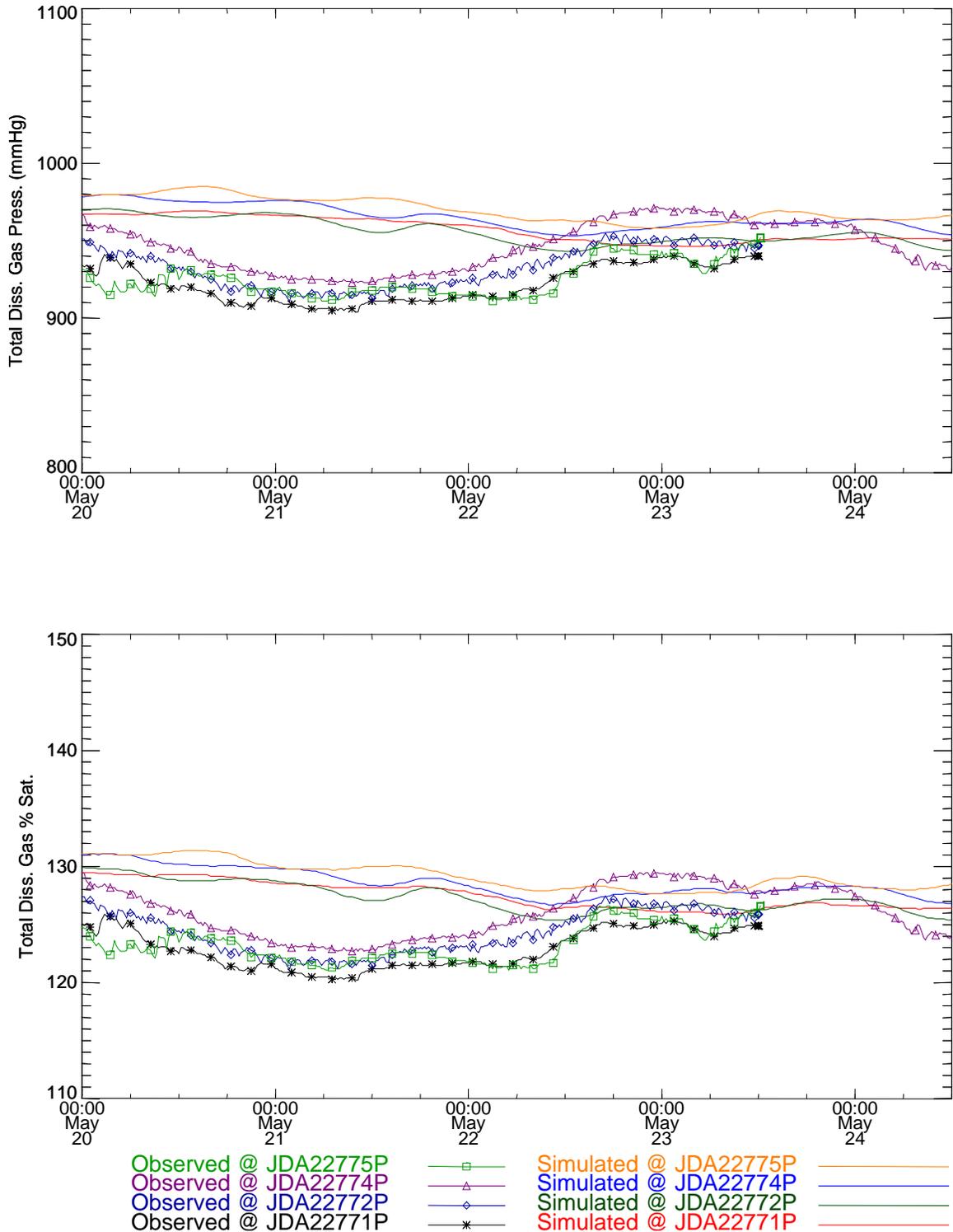


Figure 112. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 227.7 for the Spring 1997 study (FMS-BC).

Table 13. Statistical summary of measurements and simulations at river mile 227.7 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA22771P	12.62	12.71	0.24	0.31	0.15
JDA22772P	12.54	12.54	0.22	0.28	0.13
JDA22774P	12.53	12.59	0.22	0.29	0.17
JDA22775P	12.76	12.74	0.18	0.33	0.21
Concentration					
JDA22771P	35.56	36.63	0.62	0.12	1.27
JDA22772P	36.04	36.72	0.61	0.17	0.97
JDA22774P	36.44	37.04	0.67	0.16	0.94
JDA22775P	35.65	37.1	0.63	0.14	1.59
Gas Pressure					
JDA22771P	925.84	957.27	12.91	8.01	36.99
JDA22772P	935.87	955.99	13.02	8.29	27.48
JDA22774P	946.67	965.38	15.93	7.94	27.59
JDA22775P	931.09	970.08	14.98	8.1	44.02
% Saturation					
JDA22771P	123.29	127.49	1.71	1.19	4.92
JDA22772P	124.64	127.32	1.76	1.26	3.64
JDA22774P	126.12	128.57	2.21	1.21	3.65
JDA22775P	124.01	129.19	1.96	1.21	5.84

Table 14. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 227.7 for the Spring 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA22771P	100	48.85	56.22	56.22
JDA22772P	100	65.44	75.58	75.12
JDA22774P	100	66.82	72.81	72.35
JDA22775P	100	41.01	45.16	45.16

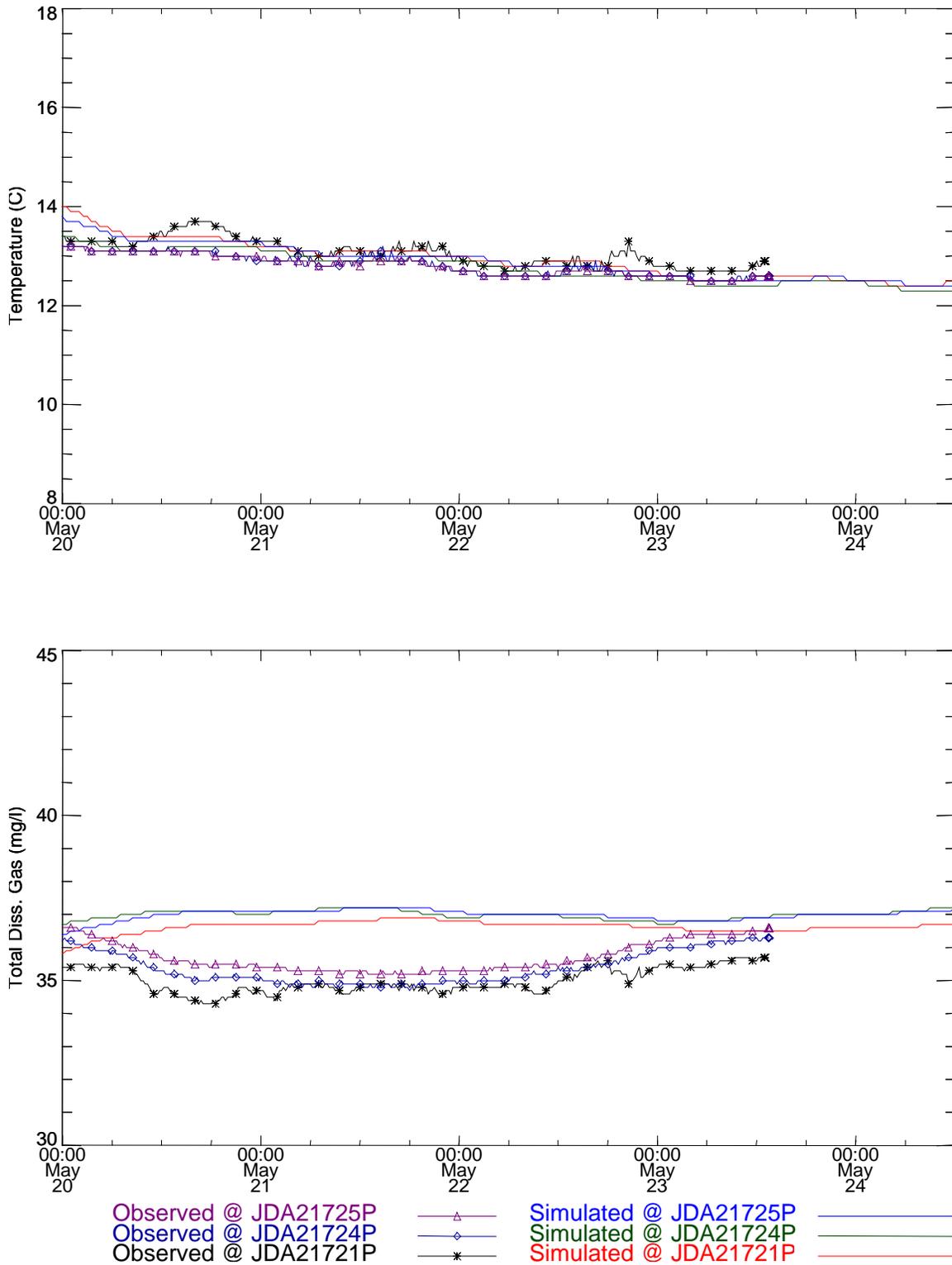


Figure 113. Temperature and total dissolved gas time series near Columbia River Mile 217.2 for the Spring 1997 study (FMS-BC).

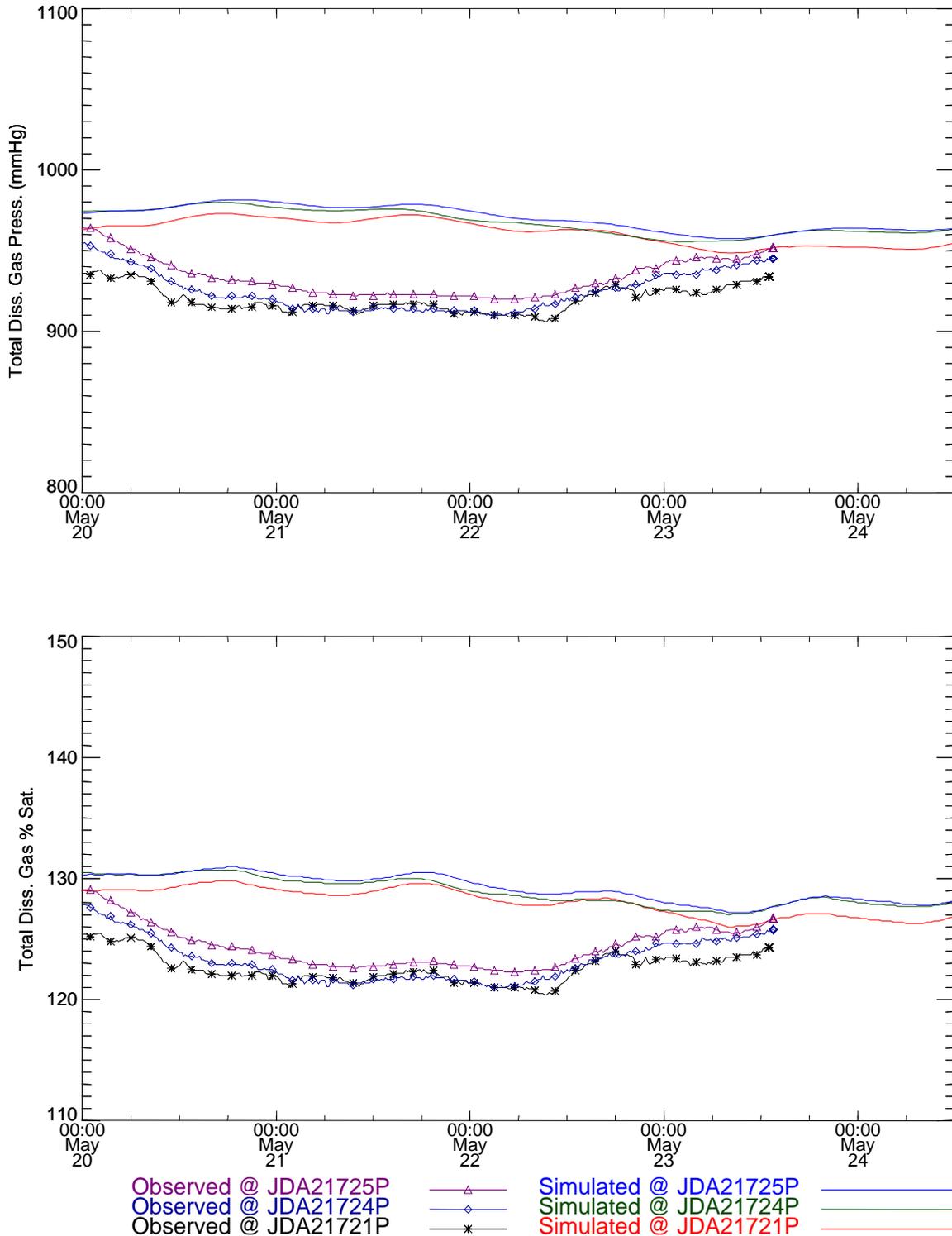


Figure 114. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 217.2 for the Spring 1997 study (FMS-BC).

Table 15. Statistical summary of measurements and simulations at river mile 217.2 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA21721P	13.04	12.93	0.26	0.38	0.26
JDA21724P	12.78	12.77	0.21	0.32	0.15
JDA21725P	12.77	12.89	0.21	0.35	0.21
Concentration					
JDA21721P	35.15	36.63	0.44	0.18	1.58
JDA21724P	35.57	36.99	0.57	0.13	1.56
JDA21725P	35.89	36.99	0.54	0.16	1.27
Gas Pressure					
JDA21721P	922.94	961.68	9.1	7.96	41.78
JDA21724P	929.1	967.76	13.5	7.85	42.92
JDA21725P	937.25	970.1	12.87	7.69	37.62
% Saturation					
JDA21721P	122.95	128.08	1.29	1.17	5.53
JDA21724P	123.78	128.89	1.88	1.16	5.69
JDA21725P	124.86	129.2	1.8	1.13	4.98

Table 16. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 217.2 for the Spring 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA21721P	100	35.94	49.31	48.85
JDA21724P	100	41.47	50.23	50.23
JDA21725P	100	47.47	52.53	52.07

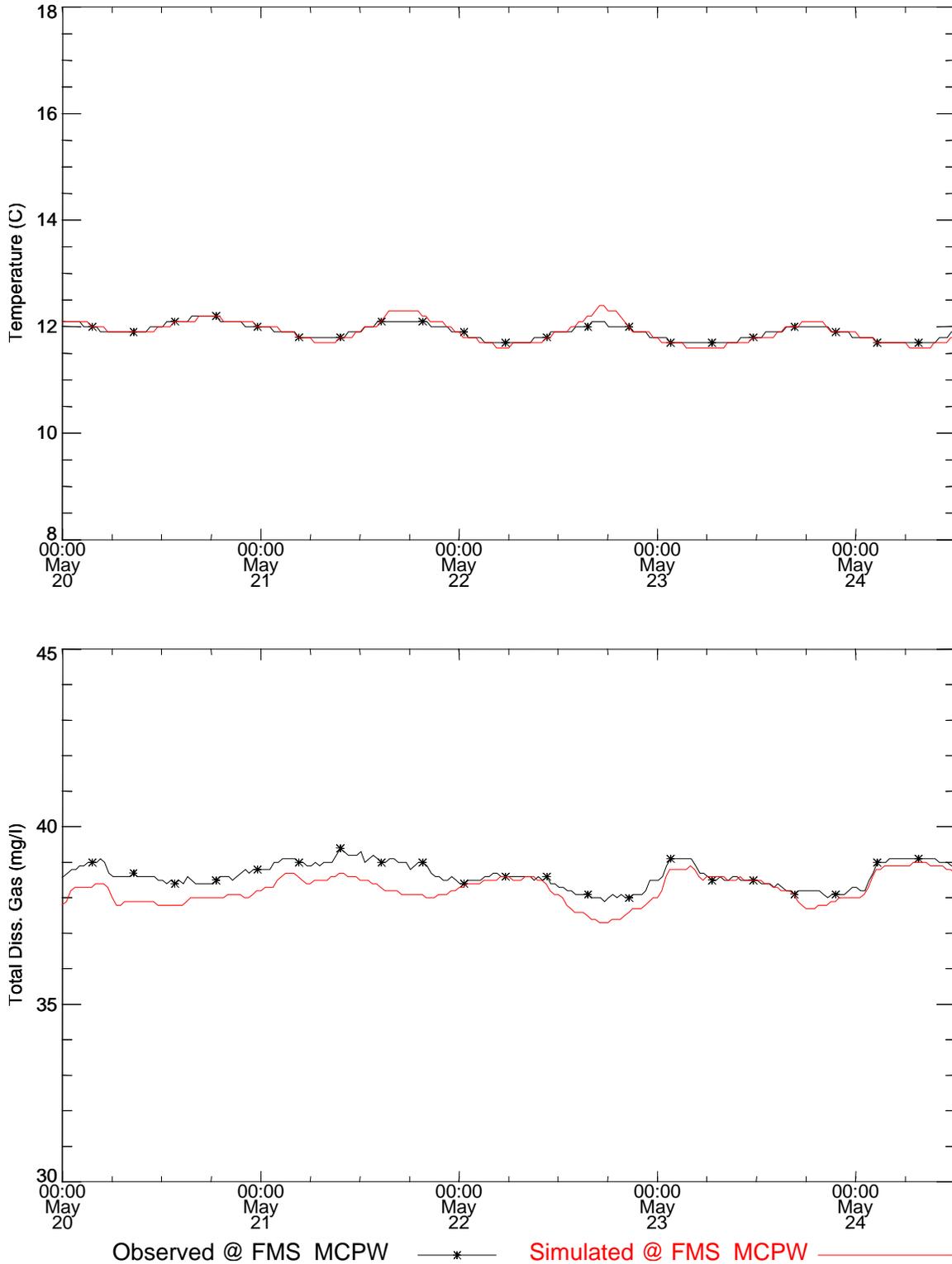


Figure 115. Temperature and total dissolved gas time series near fixed monitor MCPW for the Spring 1997 study (FMS-BC).

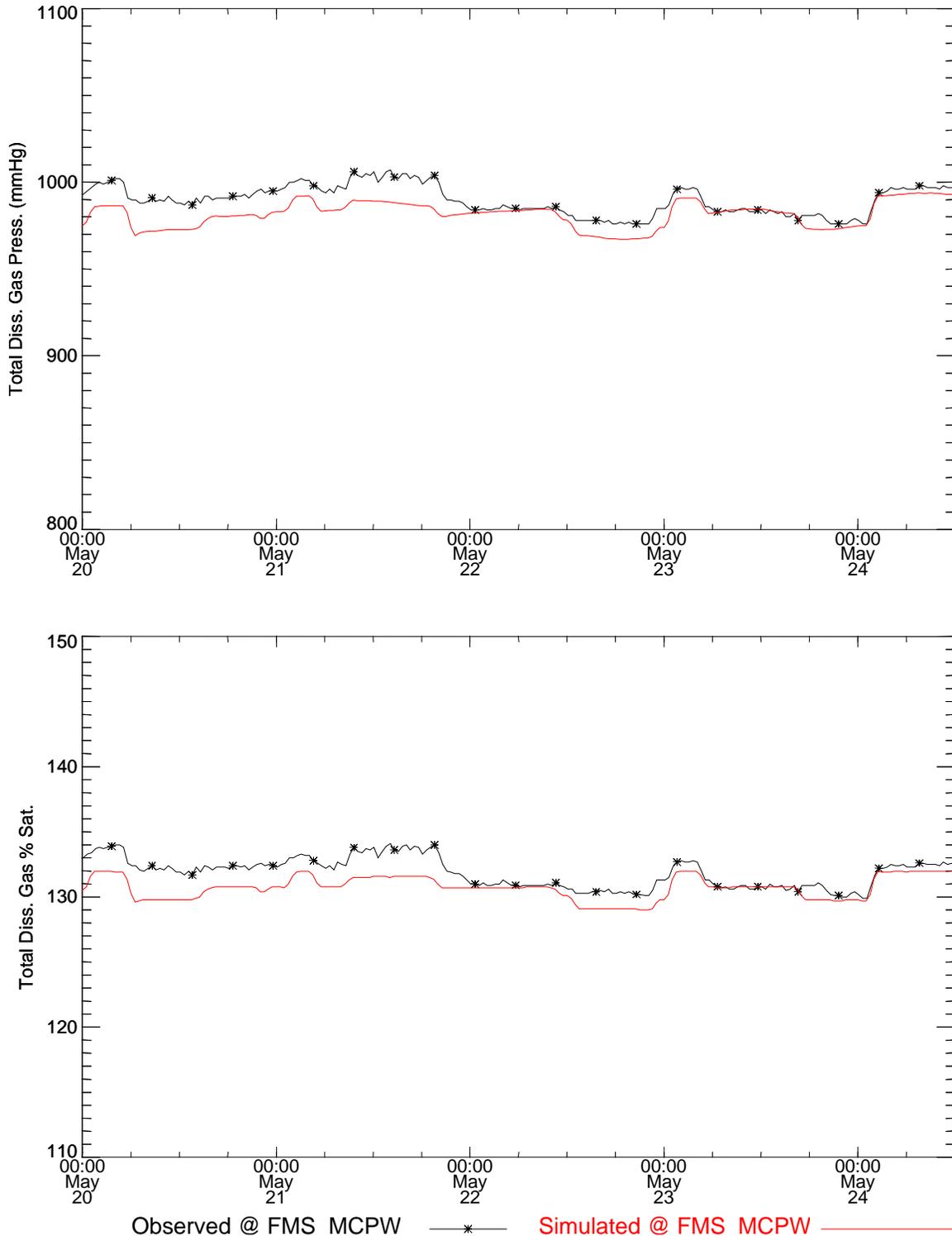


Figure 116. Total dissolved gas pressure and saturation time series comparisons near fixed monitor MCPW for the Spring 1997 study (FMS-BC).

Table 17. Statistical summary of measurements and simulations fixed monitor MCPW for the Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature FMS_MCPW	11.9	11.91	0.14	0.2	0.09
Concentration FMS_MCPW	38.64	38.25	0.35	0.4	0.47
Gas Pressure FMS_MCPW	989.77	981.66	8.44	7.42	10.05
% Saturation FMS_MCPW	131.86	130.74	1.14	0.88	1.37

Table 18. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements fixed monitor MCPW for the Spring 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_MCPW	100	100	100	100

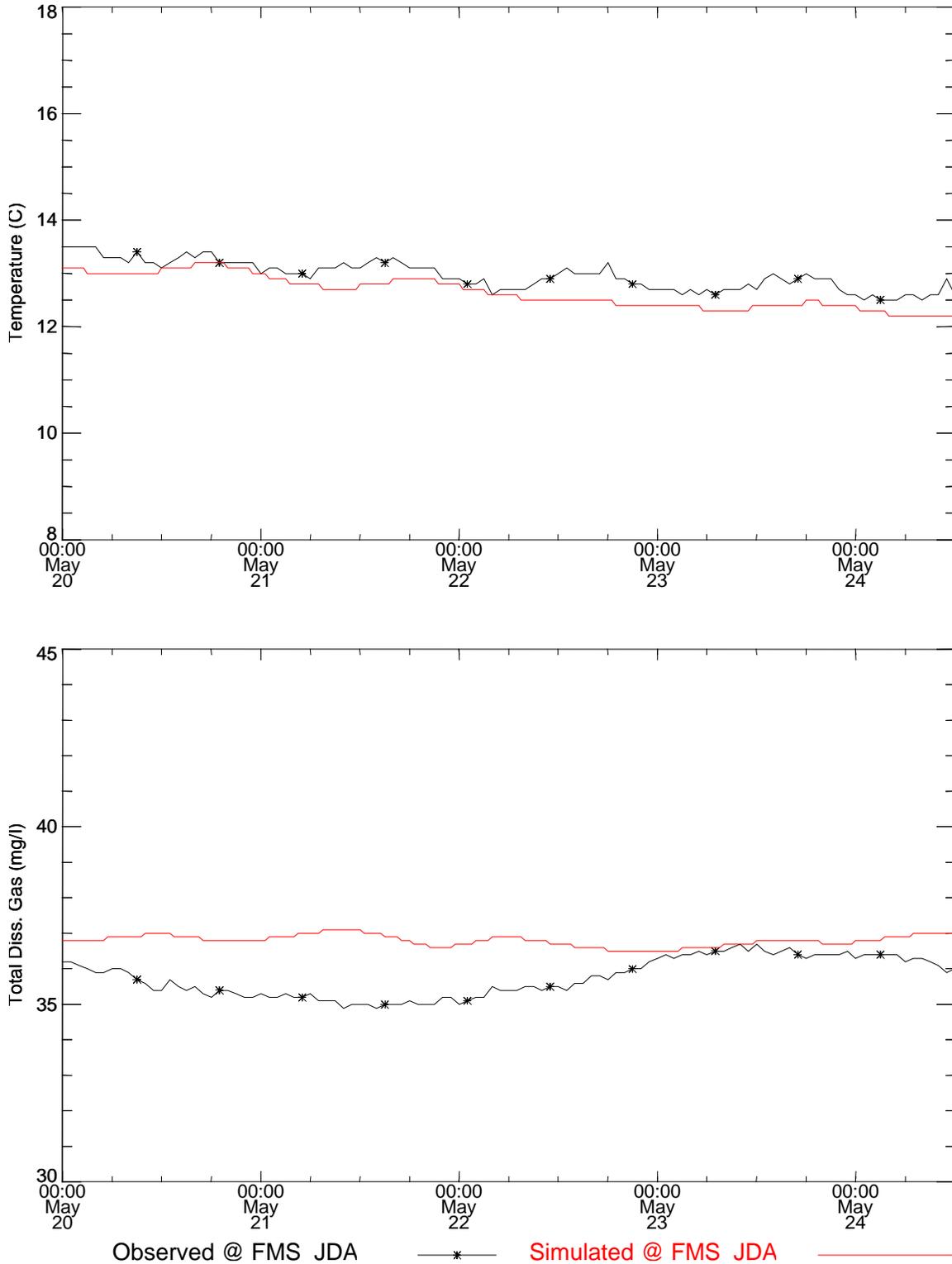


Figure 117. Temperature and total dissolved gas time series fixed monitor JDA for the Spring 1997 study (FMS-BC).

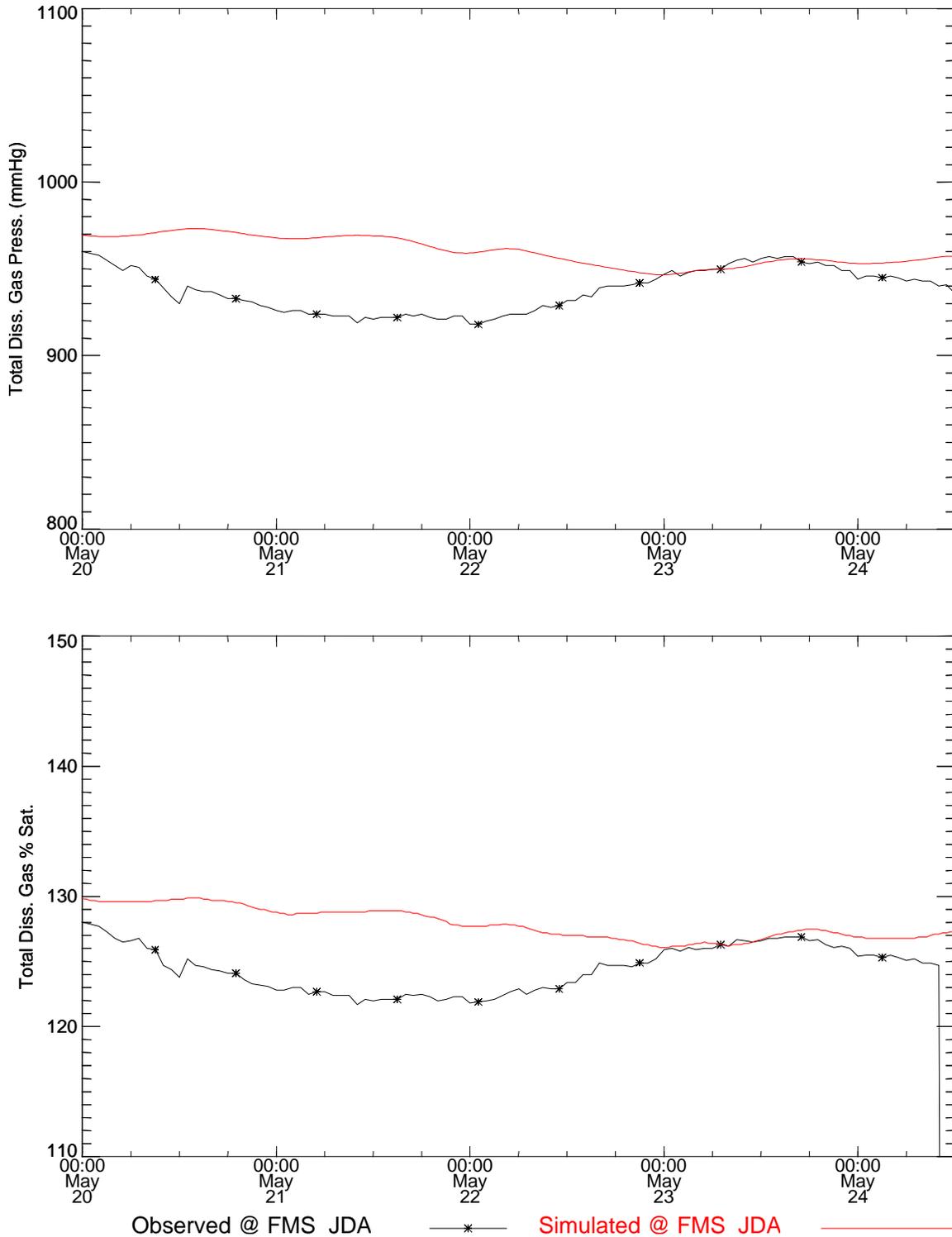


Figure 118. Total dissolved gas pressure and saturation time series comparisons near fixed monitor JDA for the Spring 1997 study (FMS-BC).

Table 19. Statistical summary of measurements and simulations at fixed monitor JDA for the Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_JDA	12.96	12.65	0.27	0.3	0.34
Concentration					
FMS_JDA	35.76	36.8	0.54	0.16	1.21
Gas Pressure					
FMS_JDA	937.7	960.3	12.3	8.19	28.55
% Saturation					
FMS_JDA	123.31	127.9	10.43	1.2	11.43

Table 20. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor JDA for the Spring 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_JDA	100	49.77	68.66	59.45

Boundary Conditions using Temporary Monitored Field Data

Comparisons between the measurements and simulations using an upstream boundary condition developed from water temperatures and TDG pressures measured by temporary monitors are shown in the figures below. Statistics on comparisons between measured and simulated temperatures and total dissolved gas are also presented. The case is denoted as TM-BC in the figure and table captions.

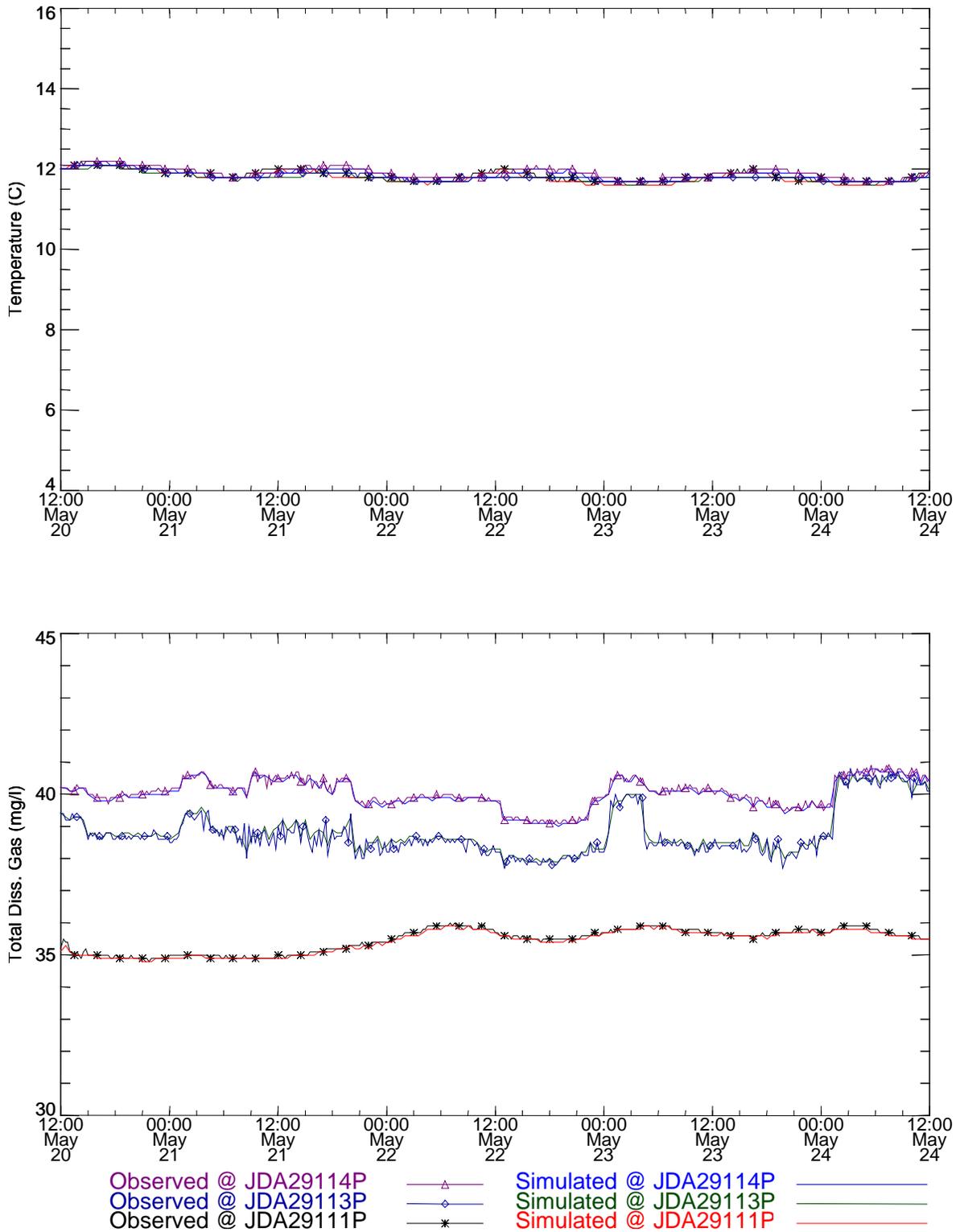


Figure 119. Temperature and total dissolved gas time series near Columbia River Mile 291.1 for the Spring 1997 study (TM-BC).

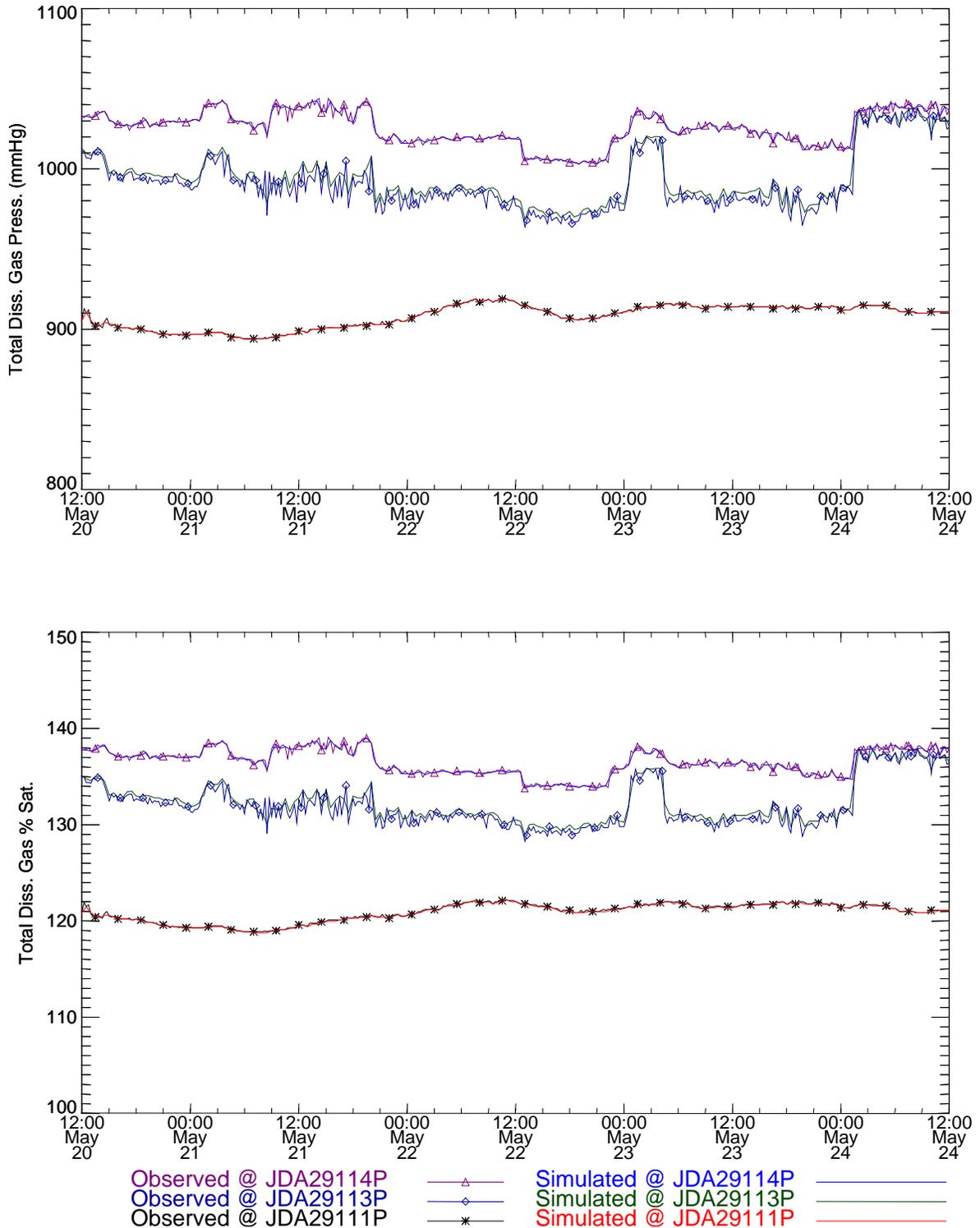


Figure 120. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 291.1 for the Spring 1997 study (TM-BC).

Table 21. Statistical summary of measurements and simulations at river mile 291.1 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA29111P	11.85	11.8	0.13	0.14	0.07
JDA29113P	11.82	11.79	0.11	0.11	0.05
JDA29114P	11.91	11.86	0.14	0.13	0.08
Concentration					
JDA29111P	35.46	35.41	0.36	0.35	0.07
JDA29113P	38.77	38.84	0.73	0.7	0.1
JDA29114P	40.06	40.01	0.44	0.44	0.07
Gas Pressure					
JDA29111P	907.89	907.87	7.3	7.28	0.19
JDA29113P	991.32	994.42	18.24	17.21	3.5
JDA29114P	1025.64	1025.58	10.73	10.61	0.55
% Saturation					
JDA29111P	120.89	120.85	0.95	0.95	0.07
JDA29113P	132	132.38	2.37	2.23	0.44
JDA29114P	136.57	136.52	1.37	1.35	0.1

Table 22. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 291.1 for the Spring 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA29111P	100	100	100	100
JDA29113P	100	100	100	100
JDA29114P	100	100	100	100

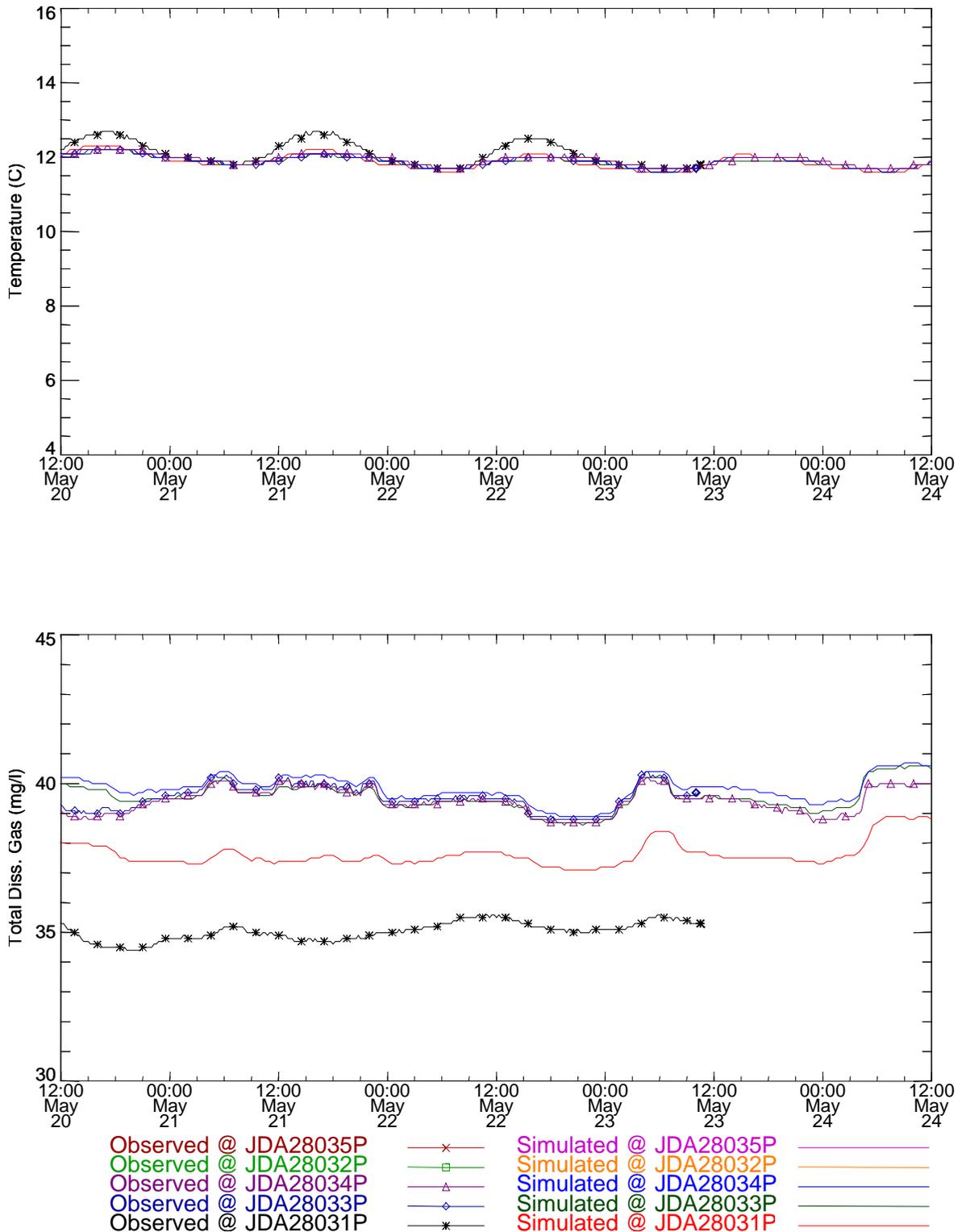


Figure 121. Temperature and total dissolved gas time series near Columbia River Mile 280.3 for the Spring 1997 study (TM-BC).

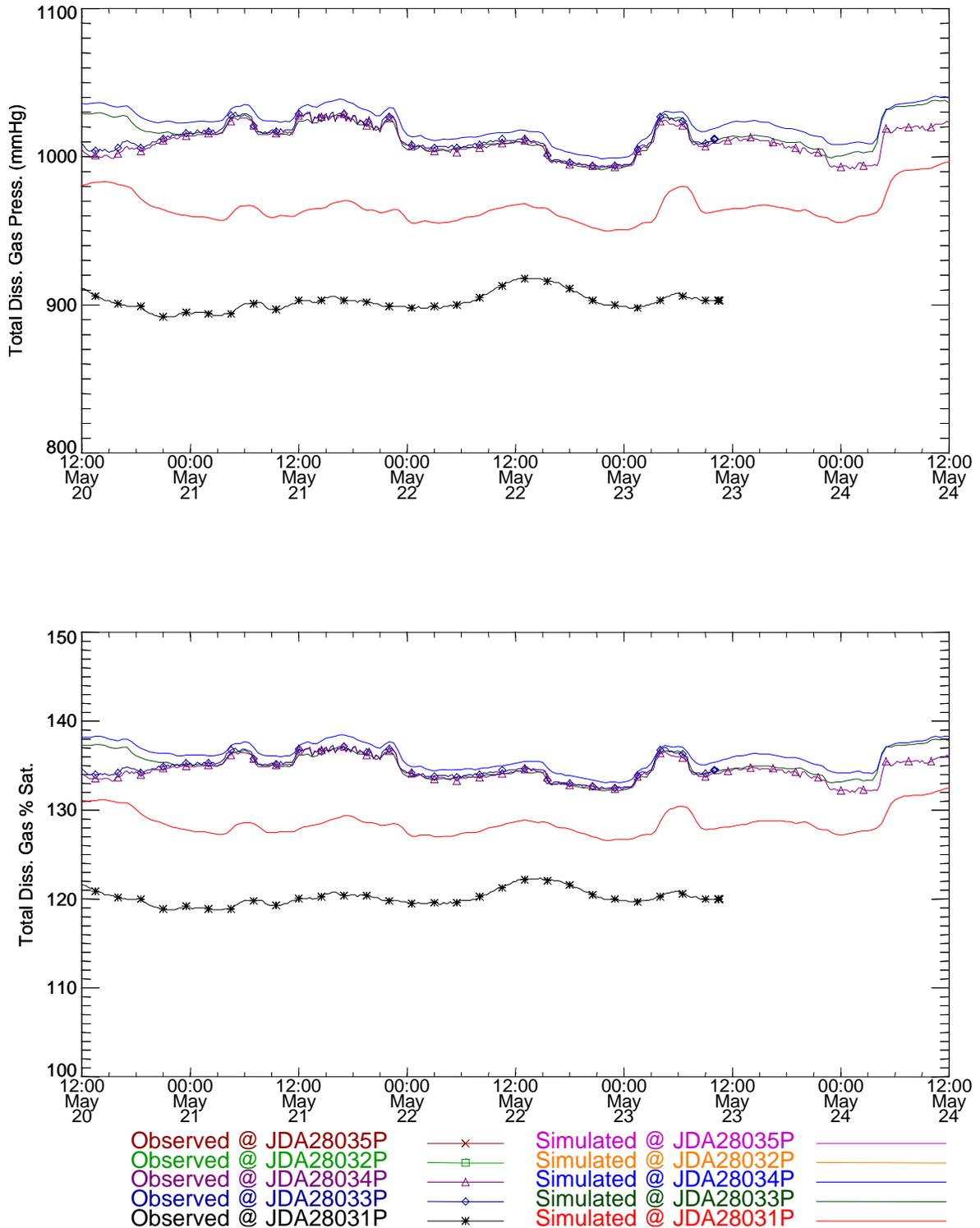


Figure 122. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 280.3 for the Spring 1997 study (TM-BC).

Table 23. Statistical summary of measurements and simulations at river mile 280.3 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA28031P	12.03	11.88	0.31	0.2	0.23
JDA28033P	11.86	11.88	0.16	0.15	0.08
JDA28034P	11.93	11.9	0.15	0.16	0.06
Concentration					
JDA28031P	35.11	37.63	0.29	0.42	2.56
JDA28033P	39.58	39.55	0.37	0.46	0.37
JDA28034P	39.42	39.83	0.43	0.44	0.47
Gas Pressure					
JDA28031P	902.54	965.66	5.45	10.3	64.01
JDA28033P	1012.36	1014.32	8.67	11.63	9.29
JDA28034P	1010.1	1021.77	10.11	11.03	13.42
% Saturation					
JDA28031P	120.13	128.55	0.76	1.36	8.53
JDA28033P	134.75	135.02	1.13	1.52	1.21
JDA28034P	134.5	136.02	1.3	1.46	1.75

Table 24. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 280.3 for the Spring 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA28031P	100	0	0	0
JDA28033P	100	100	100	100
JDA28034P	100	94.82	100	100

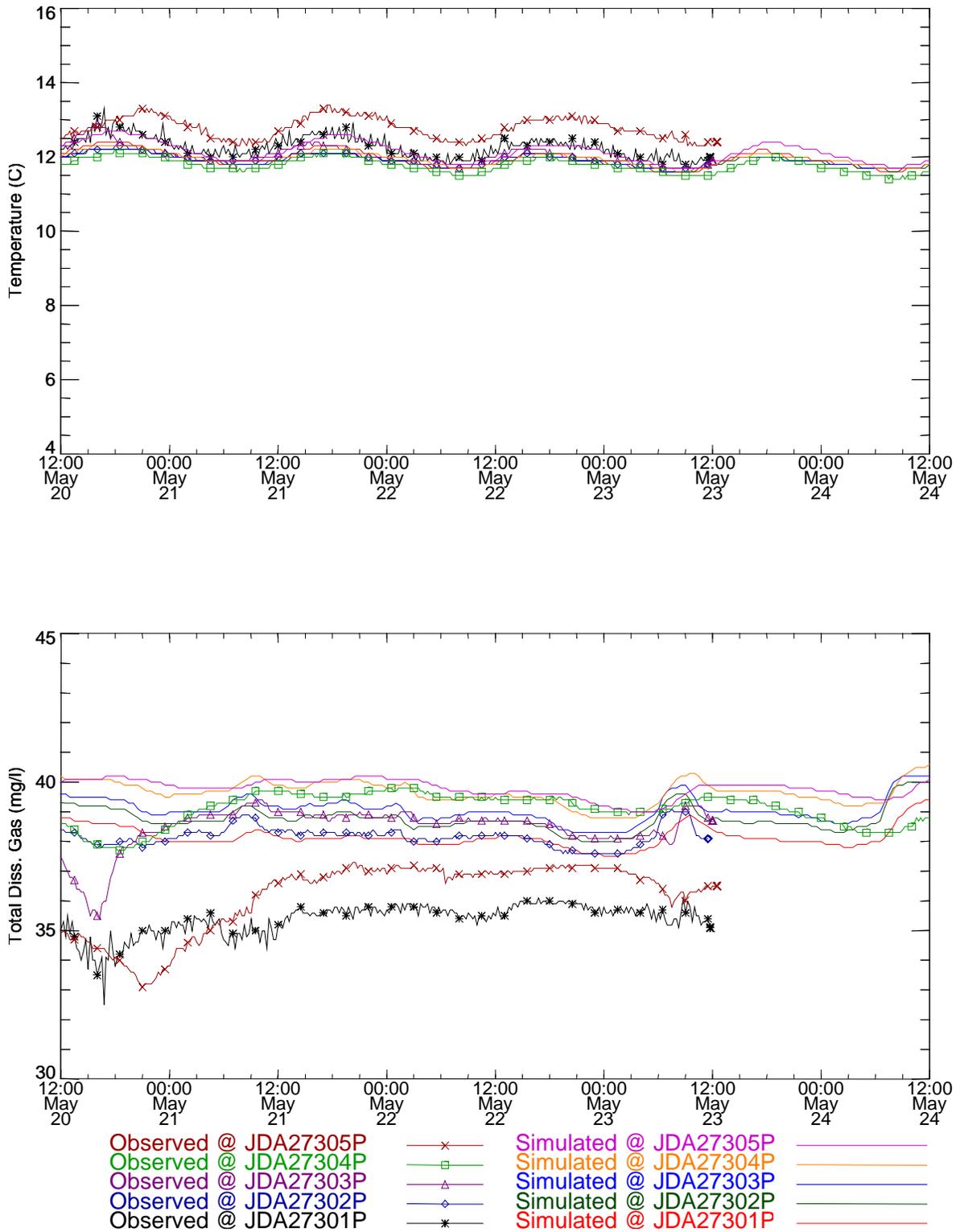


Figure 123. Temperature and total dissolved gas time series near Columbia River Mile 273.0 for the Spring 1997 study (TM-BC).

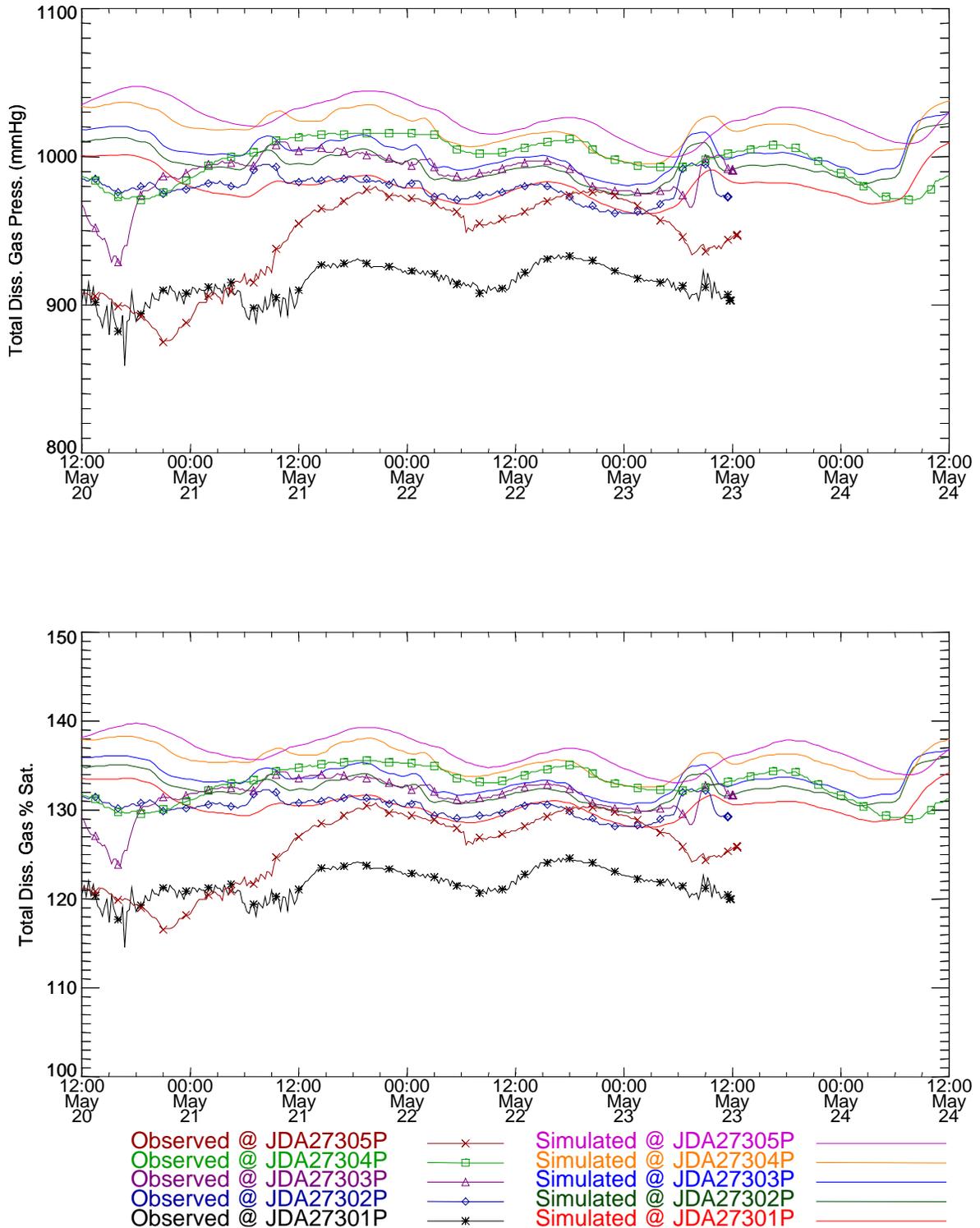


Figure 124. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 270.3 for the Spring 1997 study (TM-BC).

Table 25. Statistical summary of measurements and simulations at river mile 273.0 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA27301P	12.2	11.95	0.27	0.22	0.3
JDA27302P	11.92	11.89	0.15	0.16	0.09
JDA27303P	12.01	11.9	0.23	0.16	0.18
JDA27304P	11.78	11.95	0.19	0.18	0.19
JDA27305P	12.69	12.13	0.3	0.27	0.6
Concentration					
JDA27301P	35.31	38.15	0.47	0.36	2.93
JDA27302P	38.15	38.76	0.29	0.42	0.71
JDA27303P	38.51	39.07	0.65	0.42	0.97
JDA27304P	39.08	39.66	0.55	0.39	0.89
JDA27305P	36.24	39.78	1.05	0.31	3.74
Gas Pressure					
JDA27301P	911.36	980.26	11.23	10.48	71.13
JDA27302P	977.25	994.73	7.4	11.02	19.61
JDA27303P	988.63	1002.55	14.07	11.3	23.47
JDA27304P	997.96	1018.77	13.96	11.25	27.16
JDA27305P	945	1025.9	26.56	12.11	87.02
% Saturation					
JDA27301P	121.31	130.49	1.59	1.46	9.49
JDA27302P	130.08	132.42	1.01	1.48	2.63
JDA27303P	131.59	133.46	1.8	1.52	3.12
JDA27304P	132.89	135.62	1.88	1.56	3.58
JDA27305P	125.79	136.57	3.55	1.73	11.6

Table 26. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 273.0 for the Spring 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA27301P	100	0	0	0
JDA27302P	100	89.64	95.34	95.34
JDA27303P	100	84.46	89.64	89.64
JDA27304P	100	81.87	83.42	83.42
JDA27305P	100	0	0	0

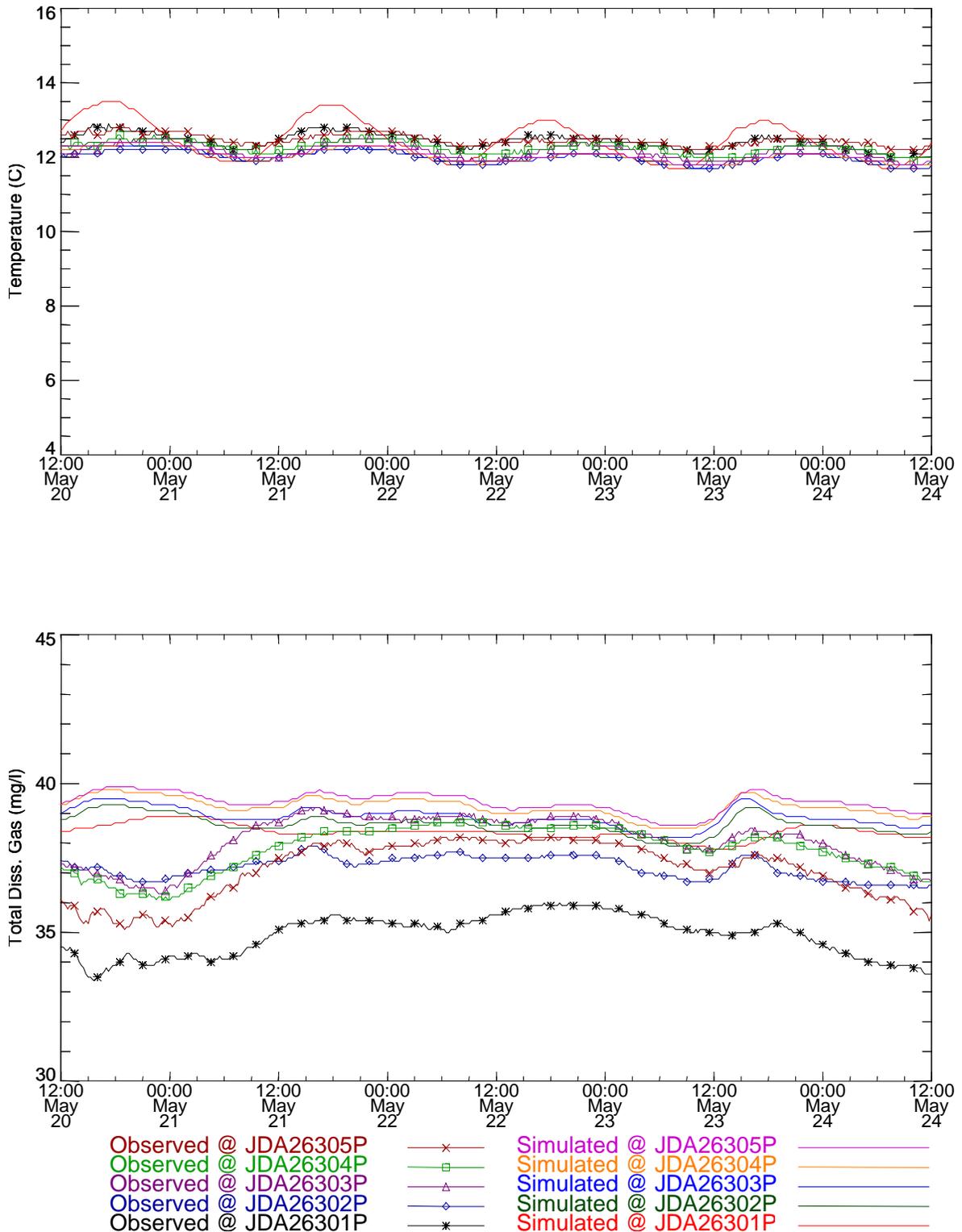


Figure 125. Temperature and total dissolved gas time series near Columbia River Mile 263.0 for the Spring 1997 study (TM-BC).

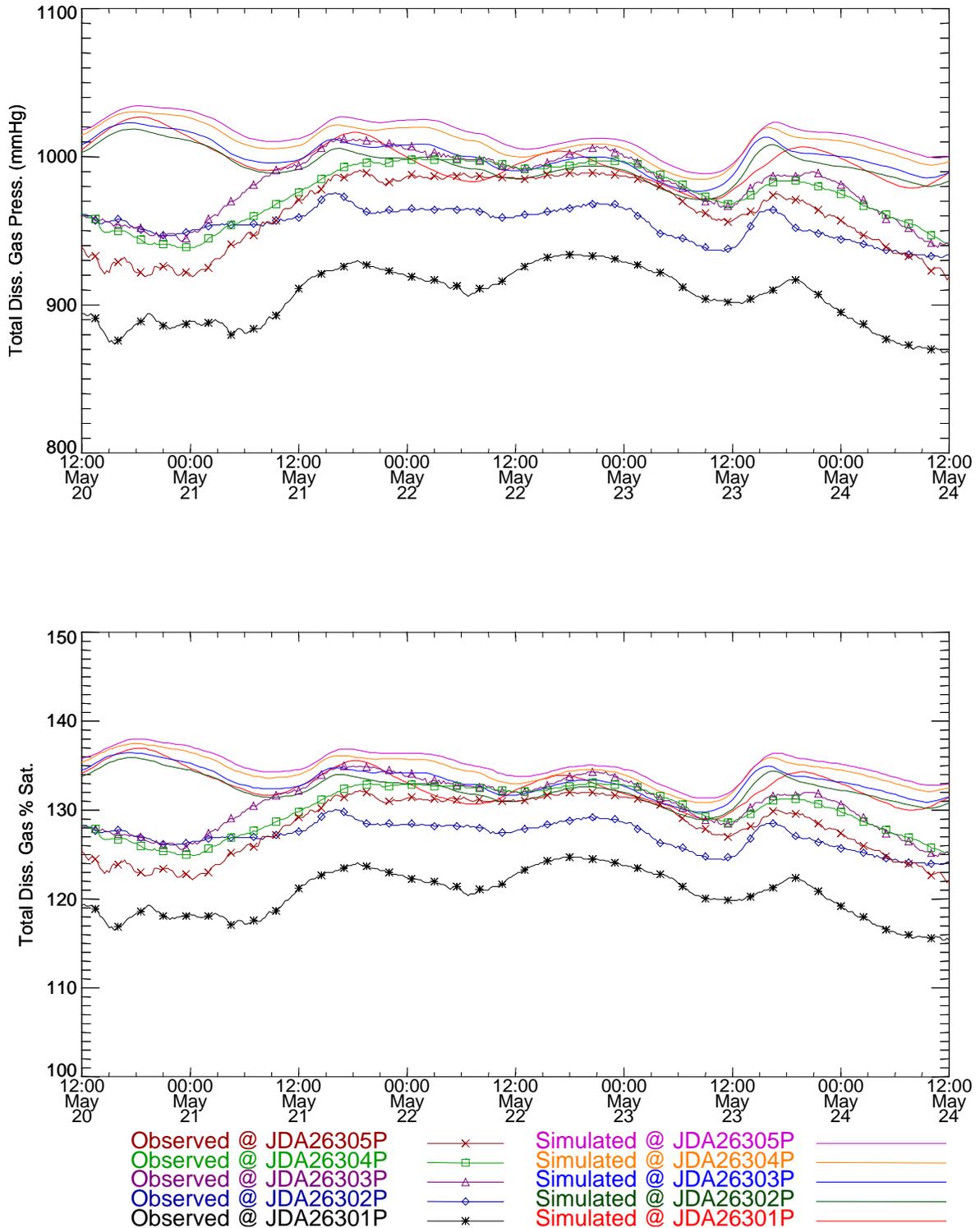


Figure 126. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 263.0 for the Spring 1997 study (TM-BC).

Table 27. Statistical summary of measurements and simulations at river mile 263.0 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA26301P	12.44	12.46	0.21	0.53	0.36
JDA26302P	11.99	12.05	0.16	0.18	0.1
JDA26303P	12.17	12.02	0.2	0.17	0.18
JDA26304P	12.26	12.05	0.16	0.18	0.22
JDA26305P	12.47	12.08	0.15	0.18	0.4
Concentration					
JDA26301P	34.9	38.38	0.7	0.25	3.58
JDA26302P	37.18	38.63	0.37	0.32	1.51
JDA26303P	38.1	38.88	0.81	0.33	1.22
JDA26304P	37.79	39.22	0.77	0.33	1.7
JDA26305P	37.12	39.38	0.96	0.33	2.51
Gas Pressure					
JDA26301P	905.35	997.07	19	13.63	94.63
JDA26302P	954.76	994.54	10.61	11.26	41.54
JDA26303P	981.73	1000.56	20.99	11.23	30.98
JDA26304P	975.63	1009.82	19.41	11.35	41.96
JDA26305P	962.69	1014.43	23.98	11.35	58.98
% Saturation					
JDA26301P	120.56	132.73	2.61	1.96	12.57
JDA26302P	127.14	132.39	1.52	1.62	5.49
JDA26303P	130.73	133.2	2.84	1.61	4.1
JDA26304P	129.92	134.43	2.62	1.62	5.56
JDA26305P	128.19	135.04	3.23	1.61	7.82

Table 28. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 263.0 for the Spring 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA26301P	100	0	0	0
JDA26302P	100	25.39	53.89	54.4
JDA26303P	100	68.39	79.27	79.27
JDA26304P	100	42.49	64.77	64.77
JDA26305P	100	5.18	37.82	38.86

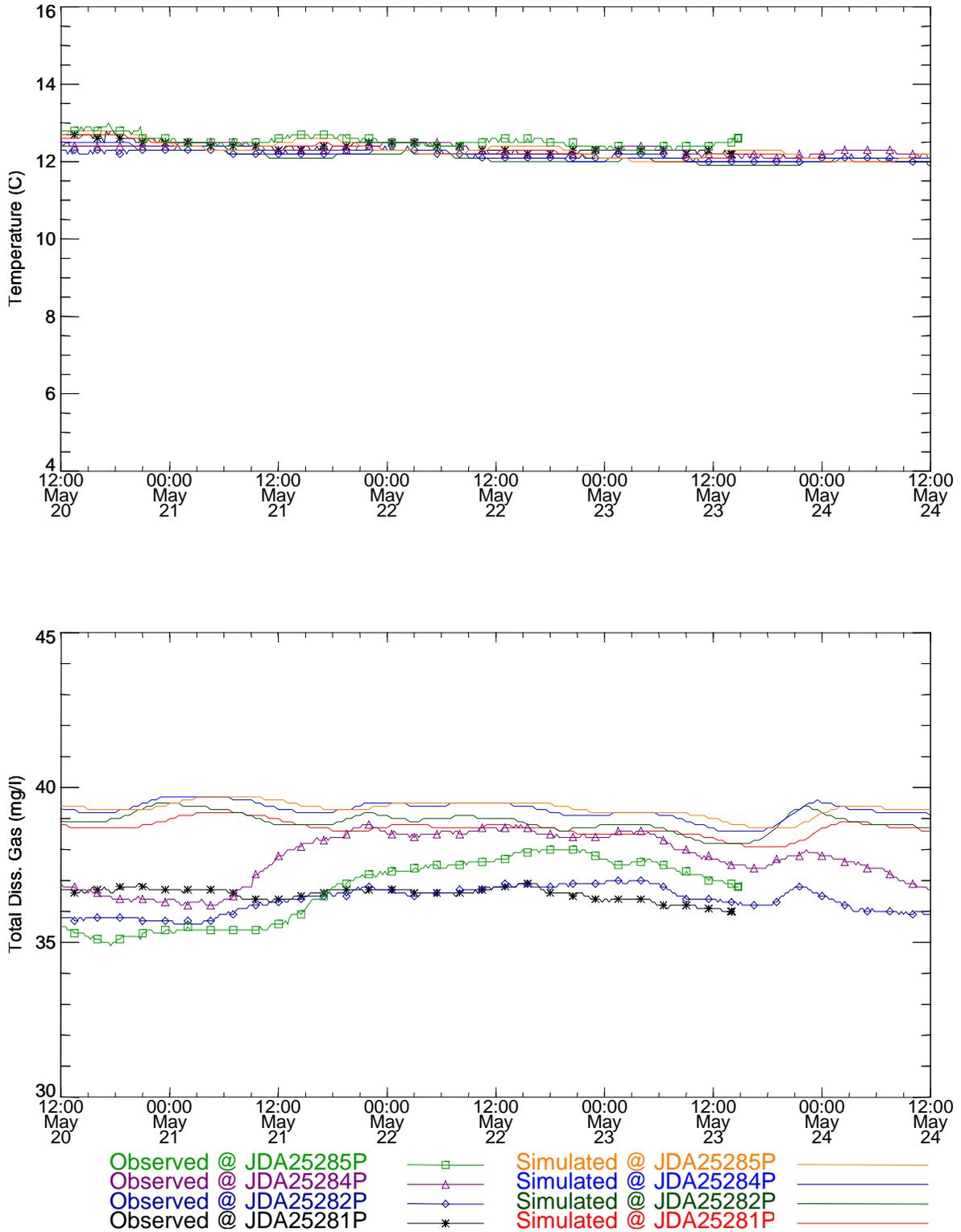


Figure 127. Temperature and total dissolved gas time series near Columbia River Mile 252.8 for the Spring 1997 study (TM-BC).

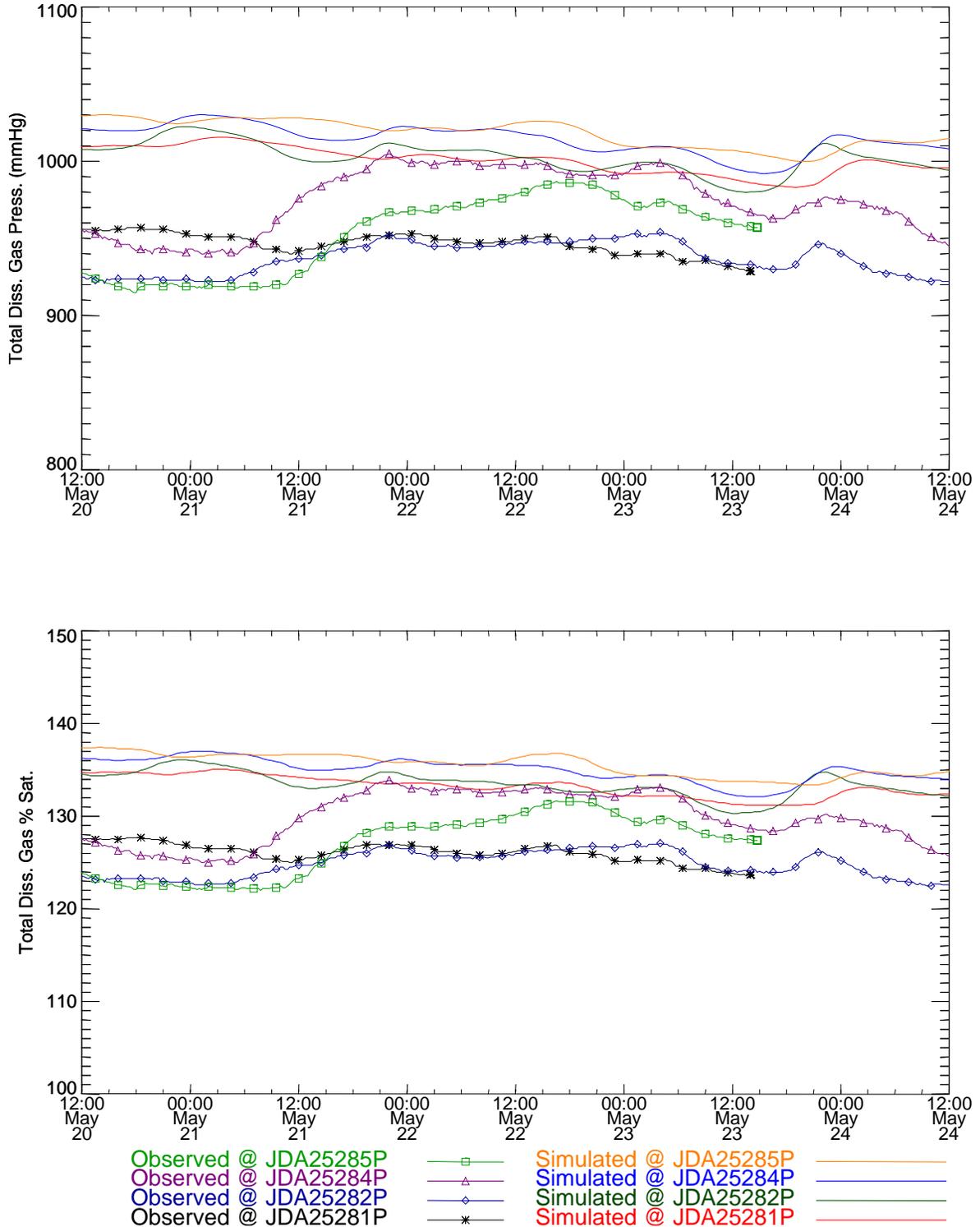


Figure 128. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 252.8 for the Spring 1997 study (TM-BC).

Table 29. Statistical summary of measurements and simulations at river mile 252.8 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA25281P	12.35	12.26	0.15	0.19	0.14
JDA25282P	12.17	12.11	0.11	0.15	0.1
JDA25284P	12.32	12.19	0.12	0.16	0.16
JDA25285P	12.55	12.31	0.13	0.23	0.29
Concentration					
JDA25281P	36.43	38.69	0.3	0.26	2.27
JDA25282P	36.37	38.9	0.42	0.3	2.6
JDA25284P	37.72	39.28	0.82	0.27	1.8
JDA25285P	36.7	39.32	0.92	0.25	2.81
Gas Pressure					
JDA25281P	942.69	1000.67	9.64	8.71	58.33
JDA25282P	937.38	1002.73	10.38	10	67.28
JDA25284P	975.01	1014.31	20.8	9.3	46.3
JDA25285P	953.68	1018.23	22.09	8.87	70.13
% Saturation					
JDA25281P	125.54	133.21	1.34	1.17	7.72
JDA25282P	124.82	133.48	1.43	1.35	8.92
JDA25284P	129.83	135.03	2.79	1.23	6.13
JDA25285P	127	135.55	2.95	1.21	9.29

Table 30. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 252.8 for the Spring 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA25281P	100	0	0	0
JDA25282P	100	0	0	0
JDA25284P	100	48.19	59.59	60.1
JDA25285P	100	0	10.36	11.4

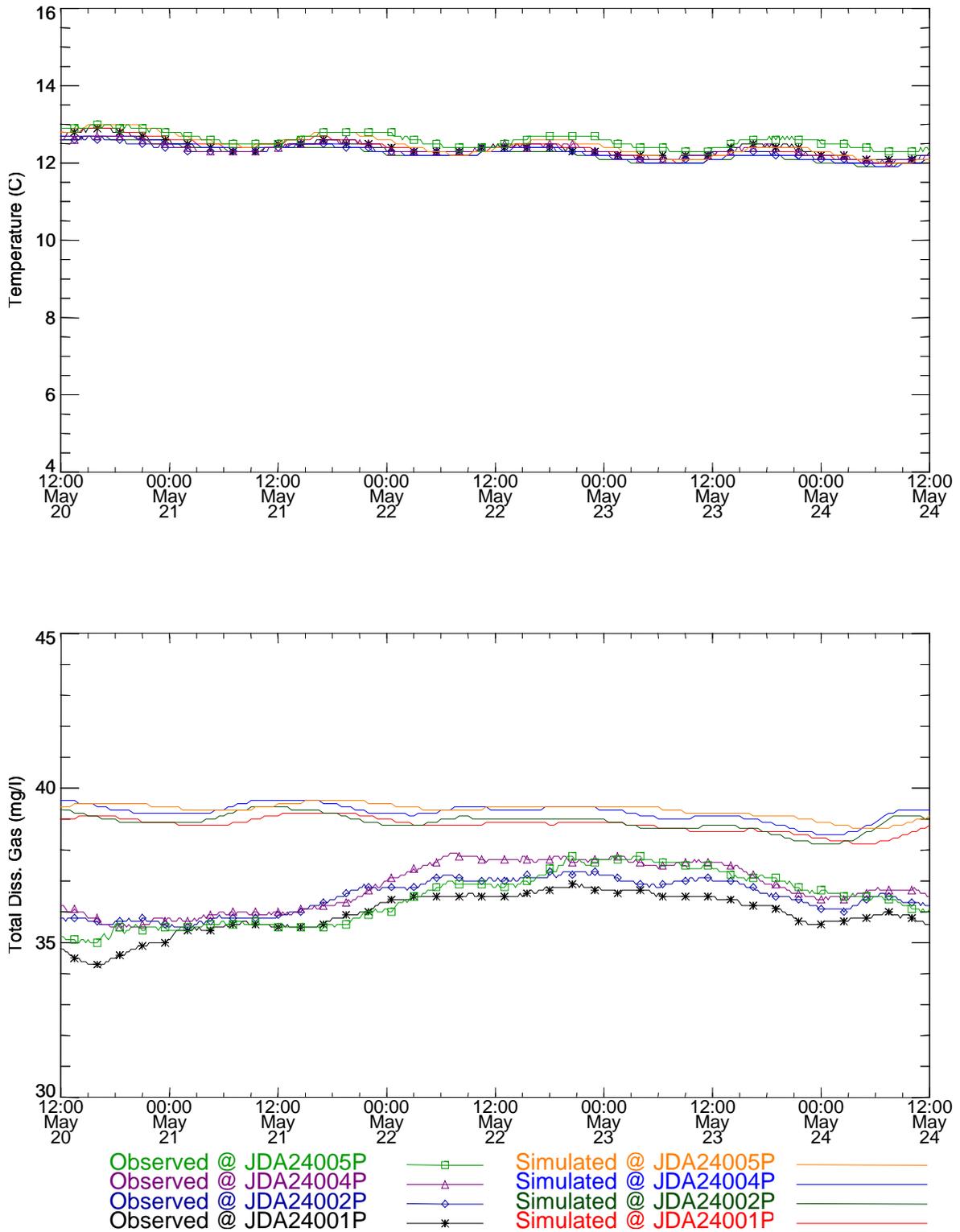


Figure 129. Temperature and total dissolved gas time series near Columbia River Mile 240.0 for the Spring 1997 study (TM-BC).

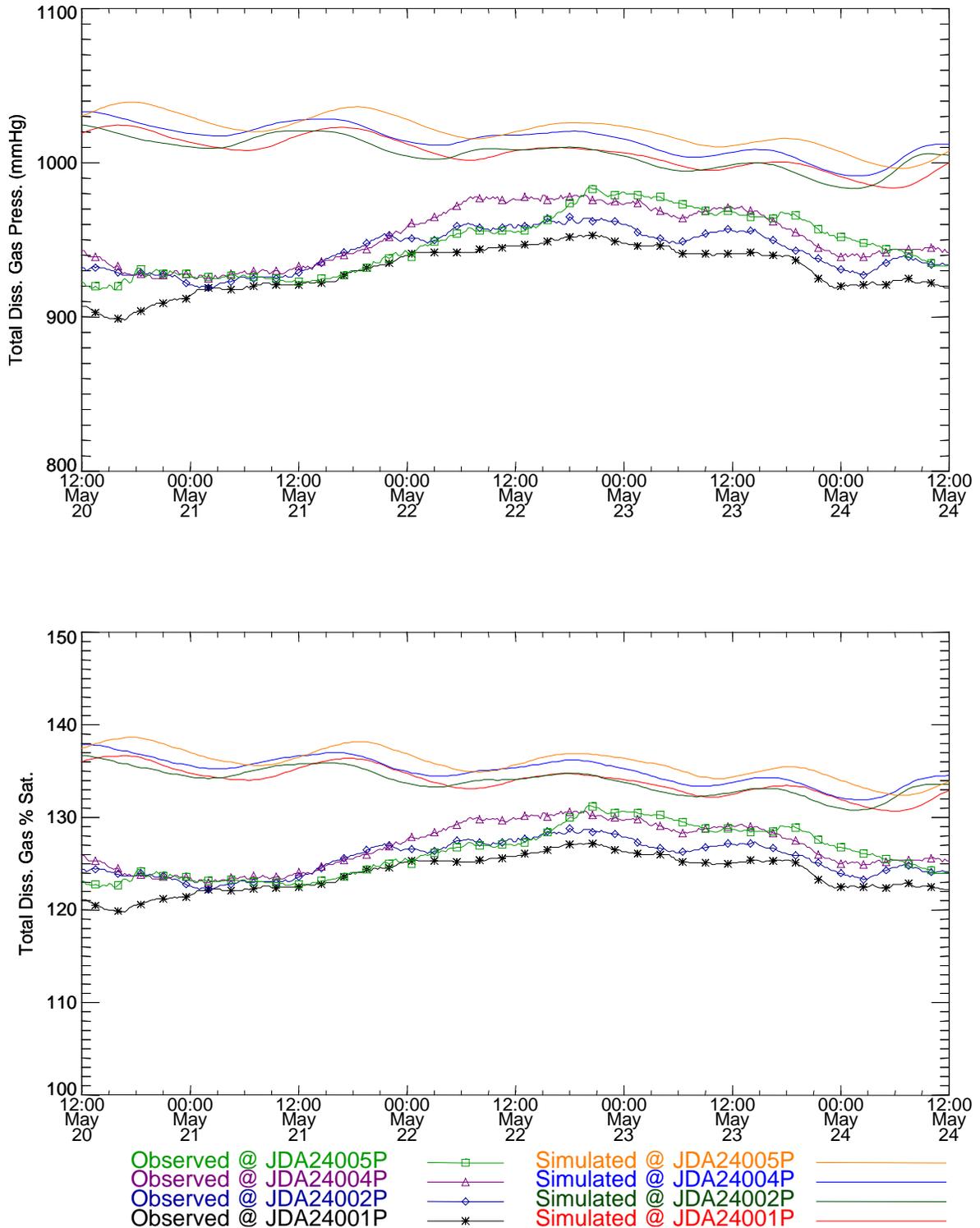


Figure 130. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 240.0 for the Spring 1997 study (TM-BC).

Table 31. Statistical summary of measurements and simulations at river mile 240.0 during Spring 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA24001P	12.38	12.38	0.2	0.24	0.09
JDA24002P	12.3	12.25	0.16	0.2	0.1
JDA24004P	12.36	12.28	0.18	0.22	0.12
JDA24005P	12.59	12.46	0.19	0.27	0.17
Concentration					
JDA24001P	35.94	38.81	0.66	0.25	2.97
JDA24002P	36.48	38.9	0.56	0.28	2.51
JDA24004P	36.8	39.21	0.77	0.27	2.56
JDA24005P	36.44	39.29	0.83	0.23	3
Gas Pressure					
JDA24001P	930.74	1006.48	14.61	10.78	78.48
JDA24002P	943.04	1005.98	13.52	10.13	65.59
JDA24004P	952.21	1014.61	18.47	10.23	66.56
JDA24005P	947.69	1020.68	19.48	10.94	77.36
% Saturation					
JDA24001P	123.93	133.98	1.95	1.55	10.42
JDA24002P	125.58	133.92	1.83	1.4	8.7
JDA24004P	126.8	135.06	2.47	1.44	8.82
JDA24005P	126.19	135.88	2.61	1.59	10.27

Table 32. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 240.0 for the Spring 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA24001P	100	0	0	0
JDA24002P	100	0	0	0
JDA24004P	100	0	7.77	7.77
JDA24005P	100	0	0	0

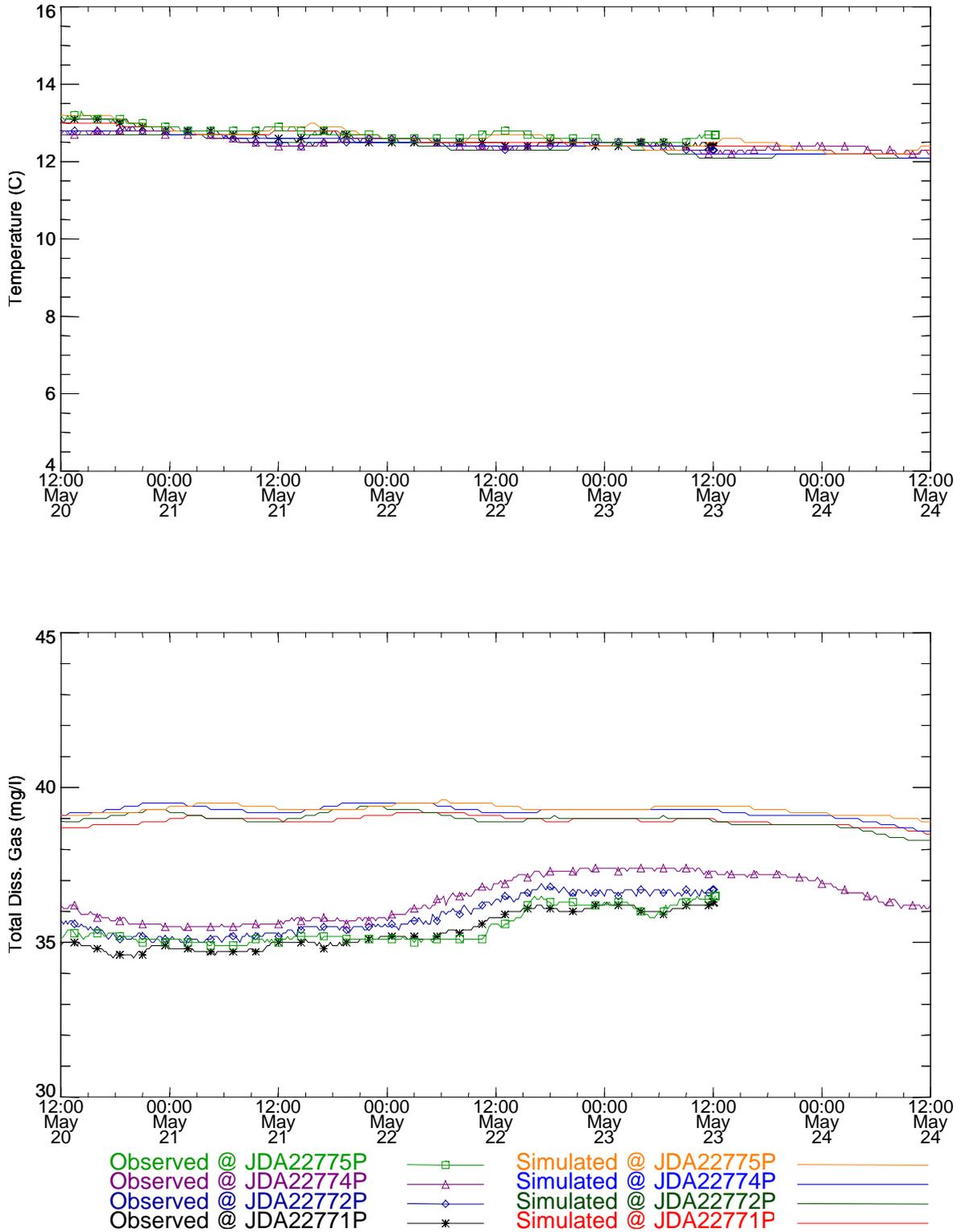


Figure 131. Temperature and total dissolved gas time series near Columbia River Mile 227.7 for the Spring 1997 study (TM-BC).

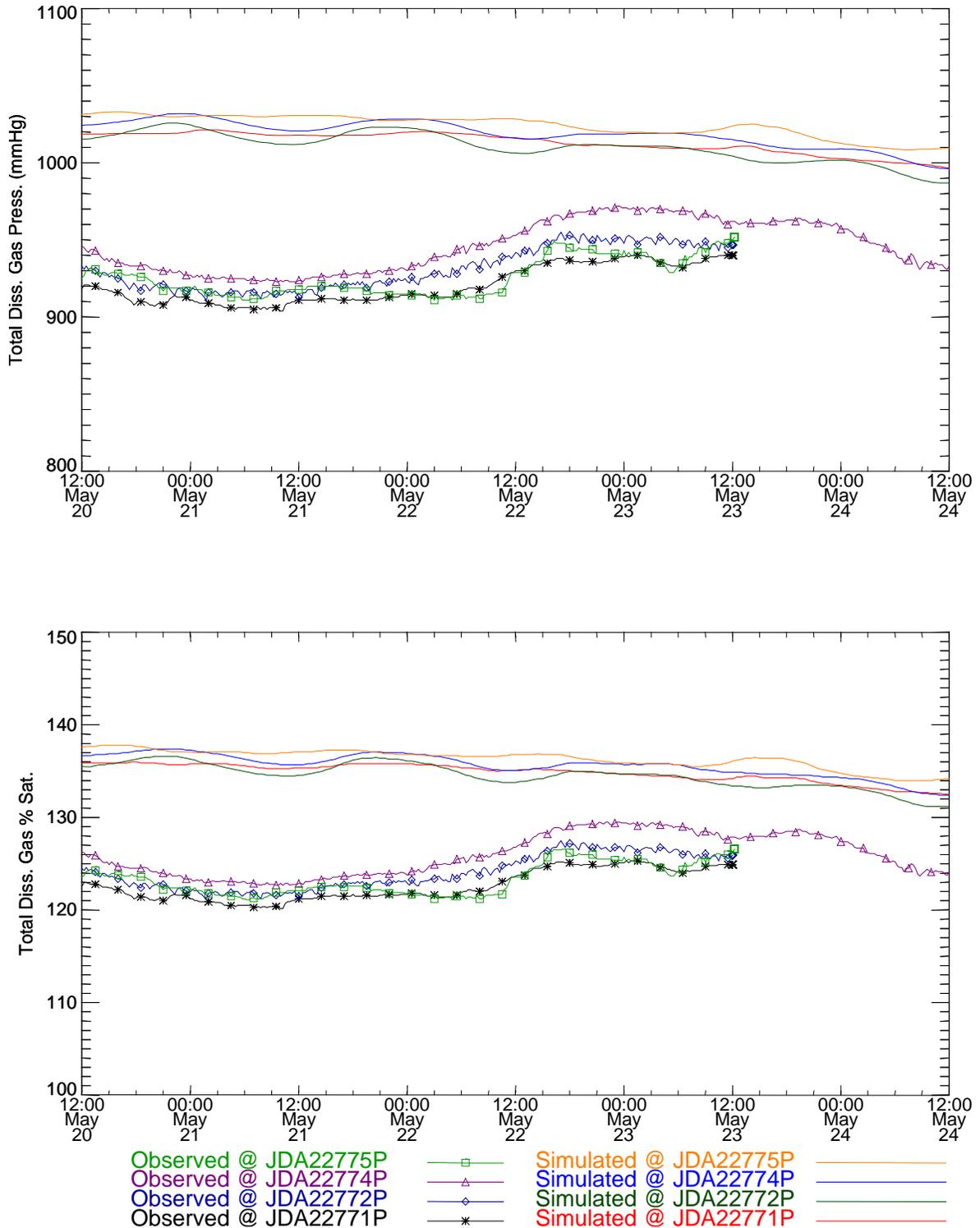


Figure 132. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 227.7 for the Spring 1997 study (TM-BC).

Table 33. Statistical summary of measurements and simulations at river mile 227.7 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA22771P	12.57	12.55	0.21	0.24	0.11
JDA22772P	12.49	12.38	0.17	0.2	0.12
JDA22774P	12.48	12.44	0.17	0.21	0.11
JDA22775P	12.73	12.61	0.16	0.27	0.22
Concentration					
JDA22771P	35.58	38.93	0.65	0.15	3.42
JDA22772P	36.05	38.97	0.65	0.23	3.03
JDA22774P	36.45	39.24	0.71	0.2	2.9
JDA22775P	35.72	39.31	0.64	0.14	3.66
Gas Pressure					
JDA22771P	925.38	1013.13	13.41	6.83	89.9
JDA22772P	935.22	1010.65	13.56	9.49	78.41
JDA22774P	945.73	1018.88	16.54	8.64	76.27
JDA22775P	932.19	1024.19	15.41	7.17	94.49
% Saturation					
JDA22771P	123.16	134.87	1.74	0.97	11.98
JDA22772P	124.49	134.54	1.79	1.35	10.43
JDA22774P	125.93	135.63	2.25	1.22	10.12
JDA22775P	124.1	136.34	2.04	1.02	12.57

Table 34. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 227.7 for the Spring 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA22771P	100	0	0	0
JDA22772P	100	0	0	0
JDA22774P	100	0	0	0
JDA22775P	100	0	0	0

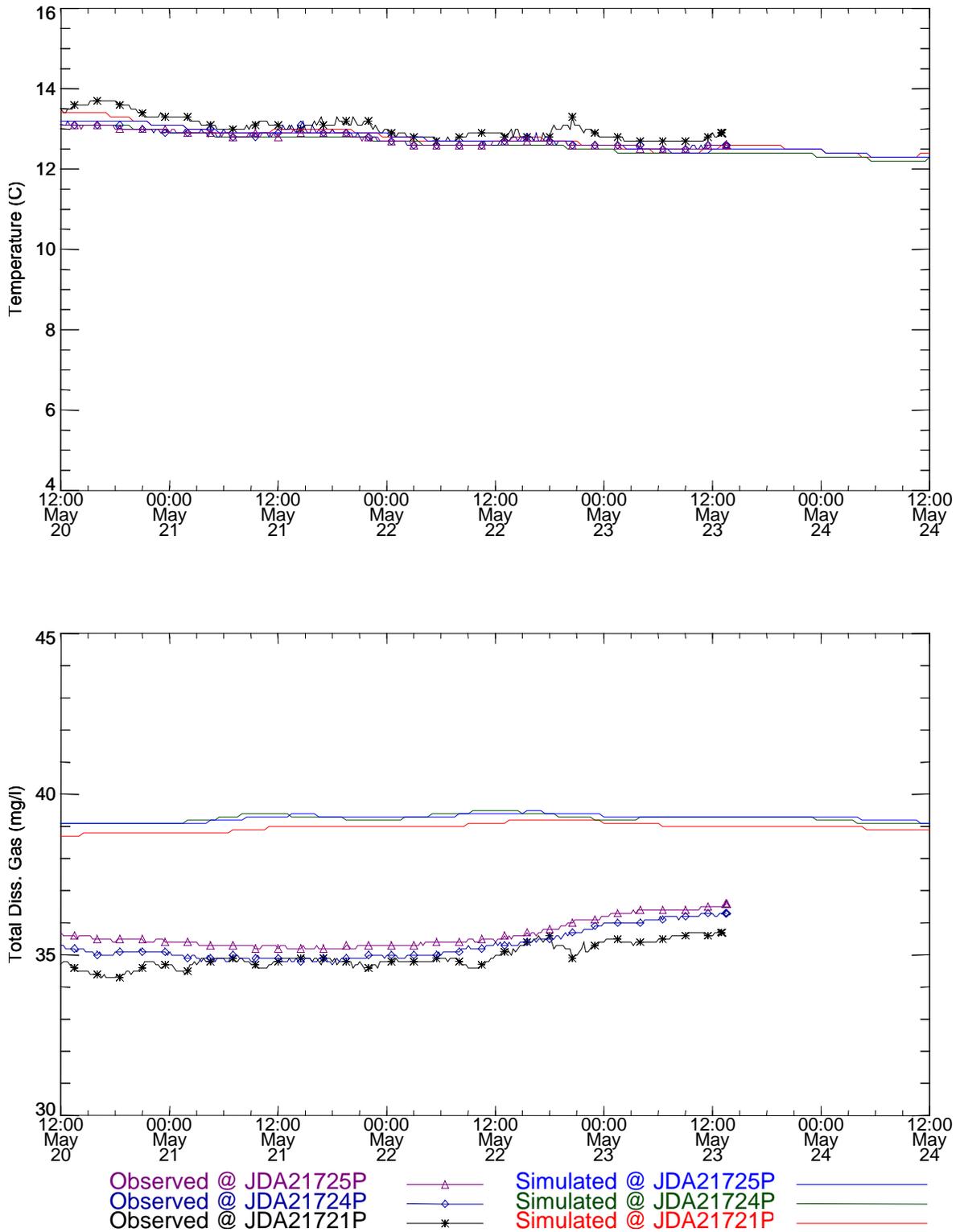


Figure 133. Temperature and total dissolved gas time series near Columbia River Mile 217.2 for the Spring 1997 study (TM-BC).

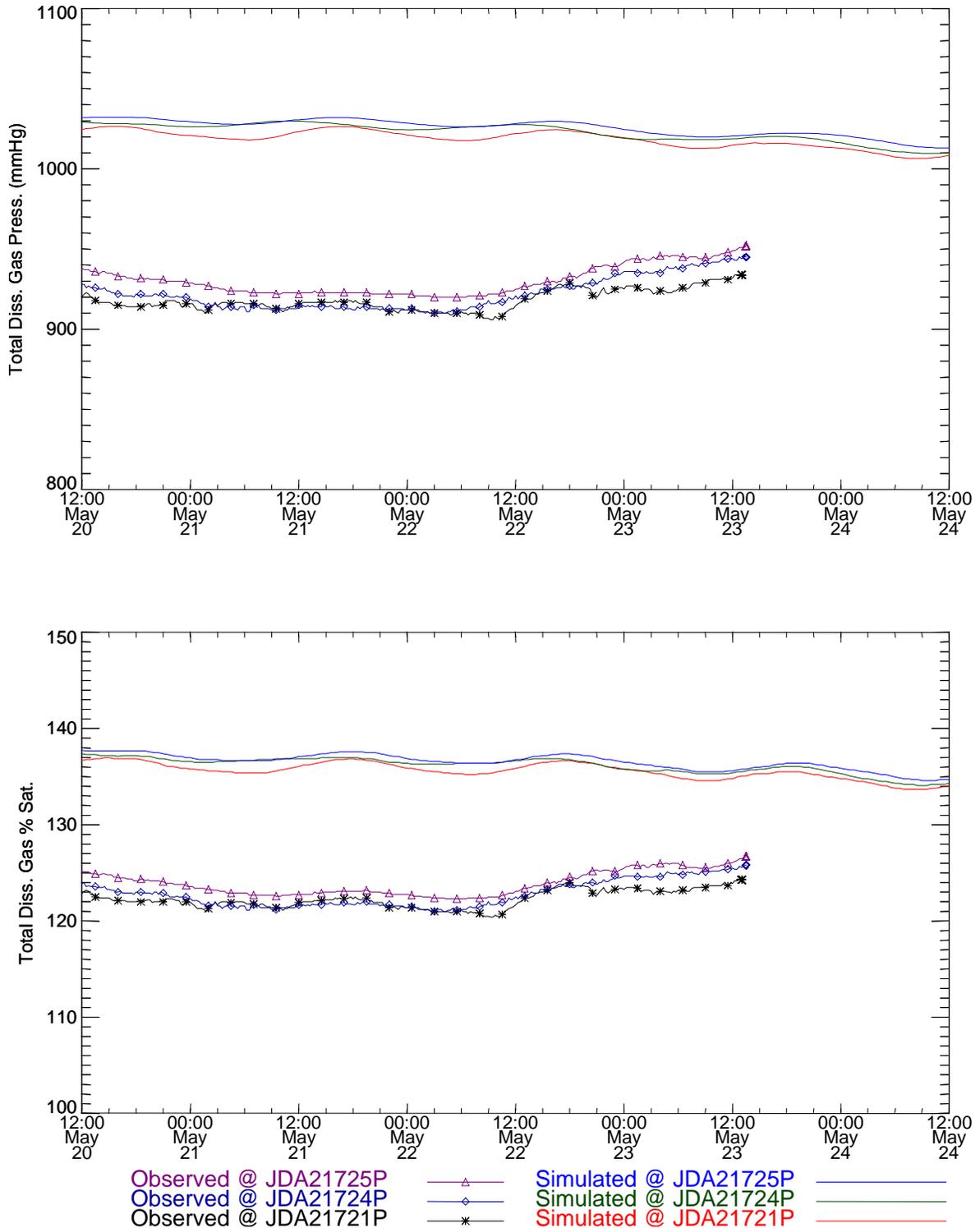


Figure 134. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 217.2 for the Spring 1997 study (TM-BC).

Table 35. Statistical summary of measurements and simulations at river mile 217.2 during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA21721P	13	12.75	0.25	0.3	0.3
JDA21724P	12.74	12.62	0.18	0.26	0.17
JDA21725P	12.73	12.72	0.17	0.27	0.13
Concentration					
JDA21721P	35.13	38.98	0.45	0.12	3.87
JDA21724P	35.53	39.26	0.59	0.12	3.78
JDA21725P	35.86	39.27	0.55	0.1	3.46
Gas Pressure					
JDA21721P	921.89	1018.7	8.87	5.4	97.7
JDA21724P	927.39	1022.84	13.11	5.7	97.18
JDA21725P	935.37	1025.74	12.11	5.24	91.89
% Saturation					
JDA21721P	122.75	135.61	1.19	0.86	12.98
JDA21724P	123.49	136.16	1.75	0.84	12.91
JDA21725P	124.54	136.55	1.61	0.82	12.21

Table 36. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 217.2 for the Spring 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA21721P	100	0	0	0
JDA21724P	100	0	0	0
JDA21725P	100	0	0	0

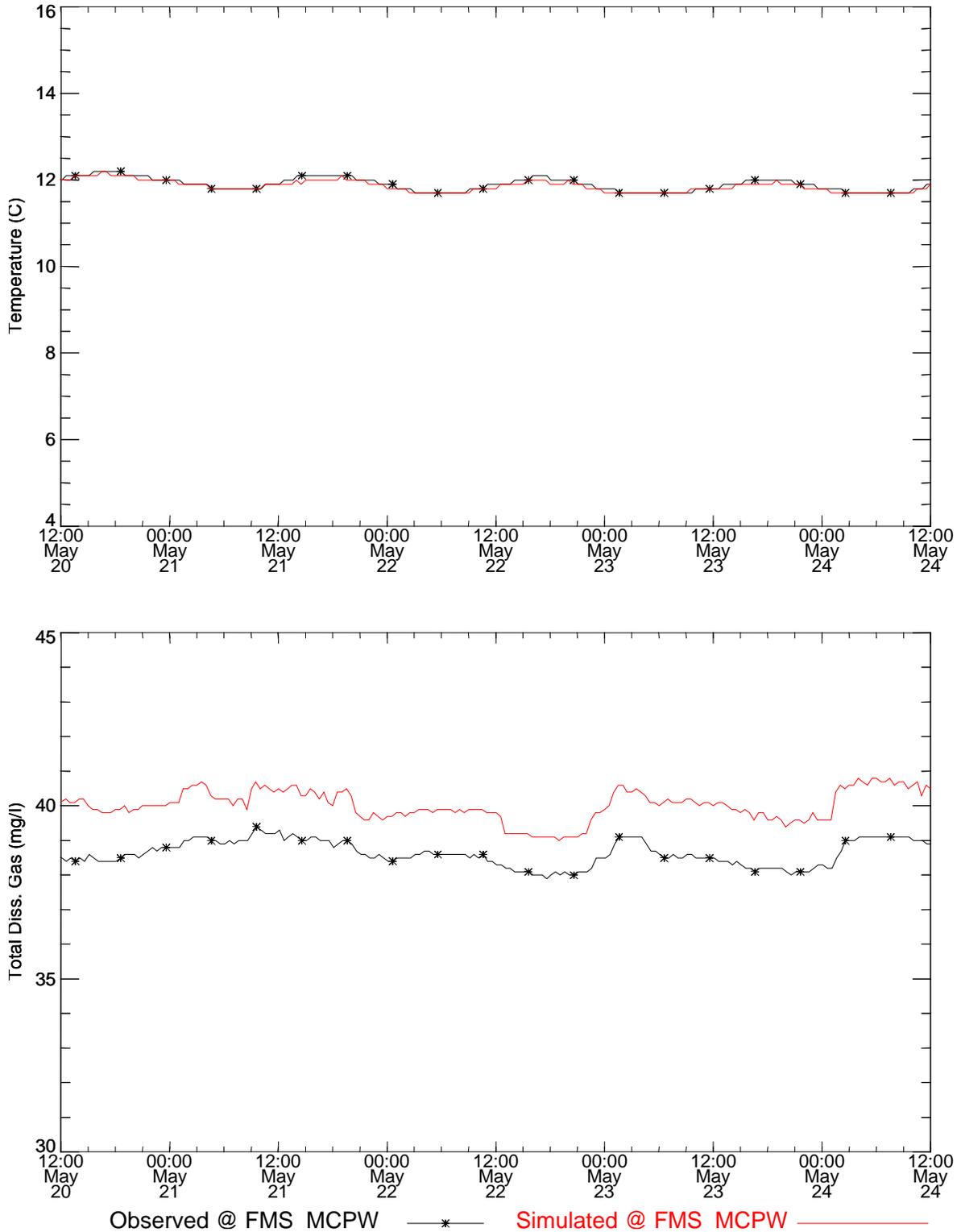


Figure 135. Temperature and total dissolved gas time series near fixed monitor MCPW for the Spring 1997 study (TM-BC).

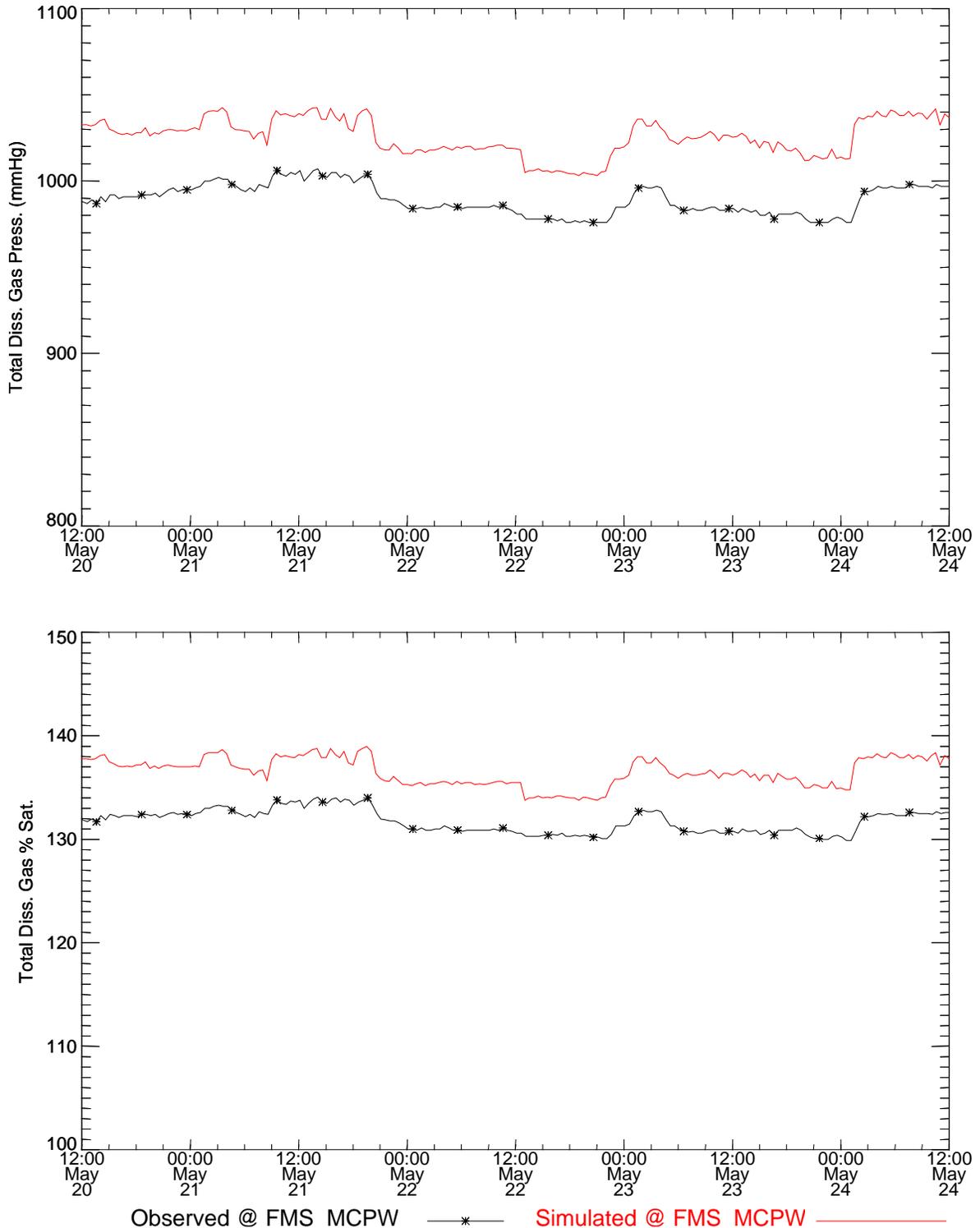


Figure 136. Total dissolved gas pressure and saturation time series comparisons near fixed monitor MCPW for the Spring 1997 study (TM-BC).

Table 37. Statistical summary of measurements and simulations at fixed monitor MCPW during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature FMS_MCPW	11.89	11.86	0.15	0.13	0.06
Concentration FMS_MCPW	38.63	40.01	0.36	0.44	1.4
Gas Pressure FMS_MCPW	989.26	1025.58	8.64	10.64	36.67
% Saturation FMS_MCPW	131.73	136.53	1.12	1.36	4.85

Table 38. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor MCPW for the Spring 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_MCPW	100	2.59	65.8	65.8

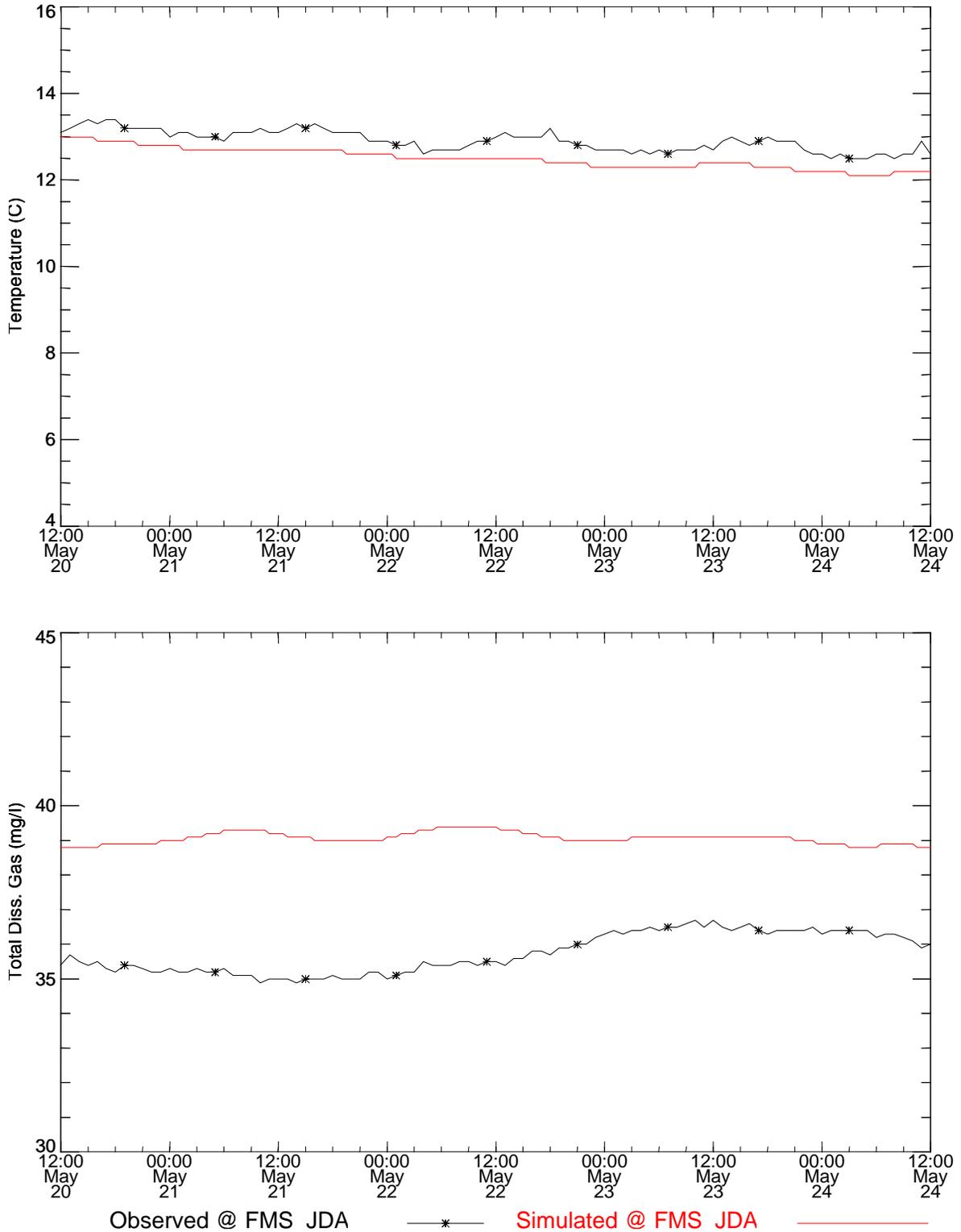


Figure 137. Temperature and total dissolved gas time series near fixed monitor JDA for the Spring 1997 study (TM-BC).

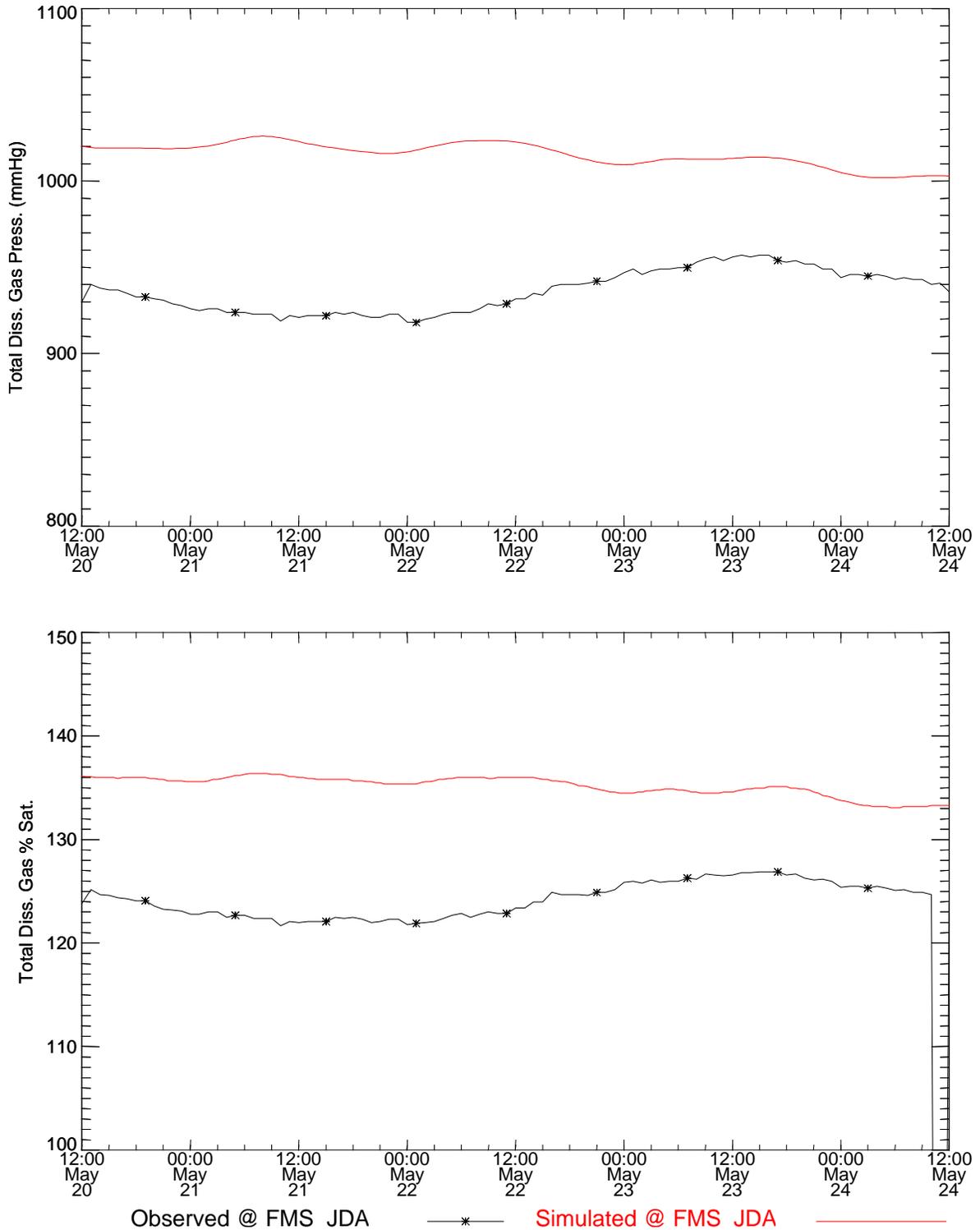


Figure 138. Total dissolved gas pressure and saturation time series comparisons near fixed monitor JDA for the Spring 1997 study (TM-BC).

Table 39. Statistical summary of measurements and simulations at fixed monitor JDA during Spring 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_JDA	12.91	12.5	0.24	0.24	0.43
Concentration					
FMS_JDA	35.74	39.07	0.57	0.17	3.39
Gas Pressure					
FMS_JDA	936.25	1015.55	11.97	6.67	81.15
% Saturation					
FMS_JDA	122.91	135.19	10.99	0.92	16.41

Table 40. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor JDA for the Spring 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_JDA	100	0	0	0

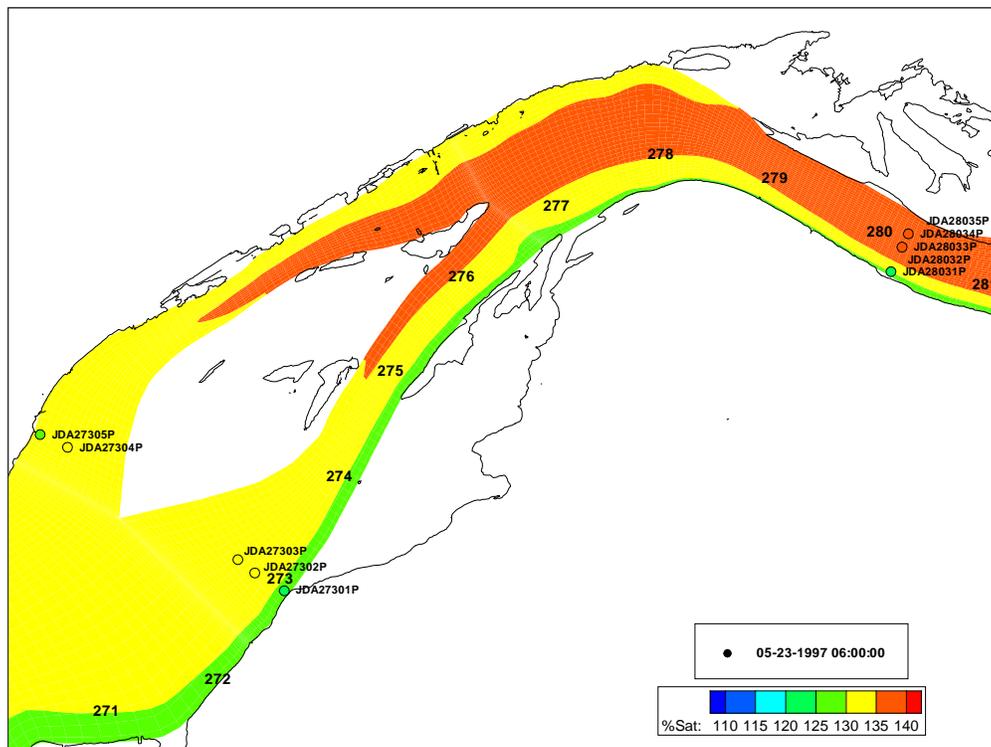


Figure 139. Spatial distribution of dissolved gas near Columbia river mile 277 during the Spring 1997 study period.

Boundary Conditions using Temporary Monitored Field Data with Air/Water Gas Exchange Option Activated

Using the temporary monitor boundary conditions, predicted dissolved gas saturations were overestimated in the lower portions of the John Day pool, as shown above. This may be due to gas exchange with the atmosphere. The simulation was performed again using the model's gas exchange option. Comparisons between the measurements and simulations using gas exchange option are shown in the figures below. Statistics on comparisons between measured and simulated temperatures and total dissolved gas are also presented.

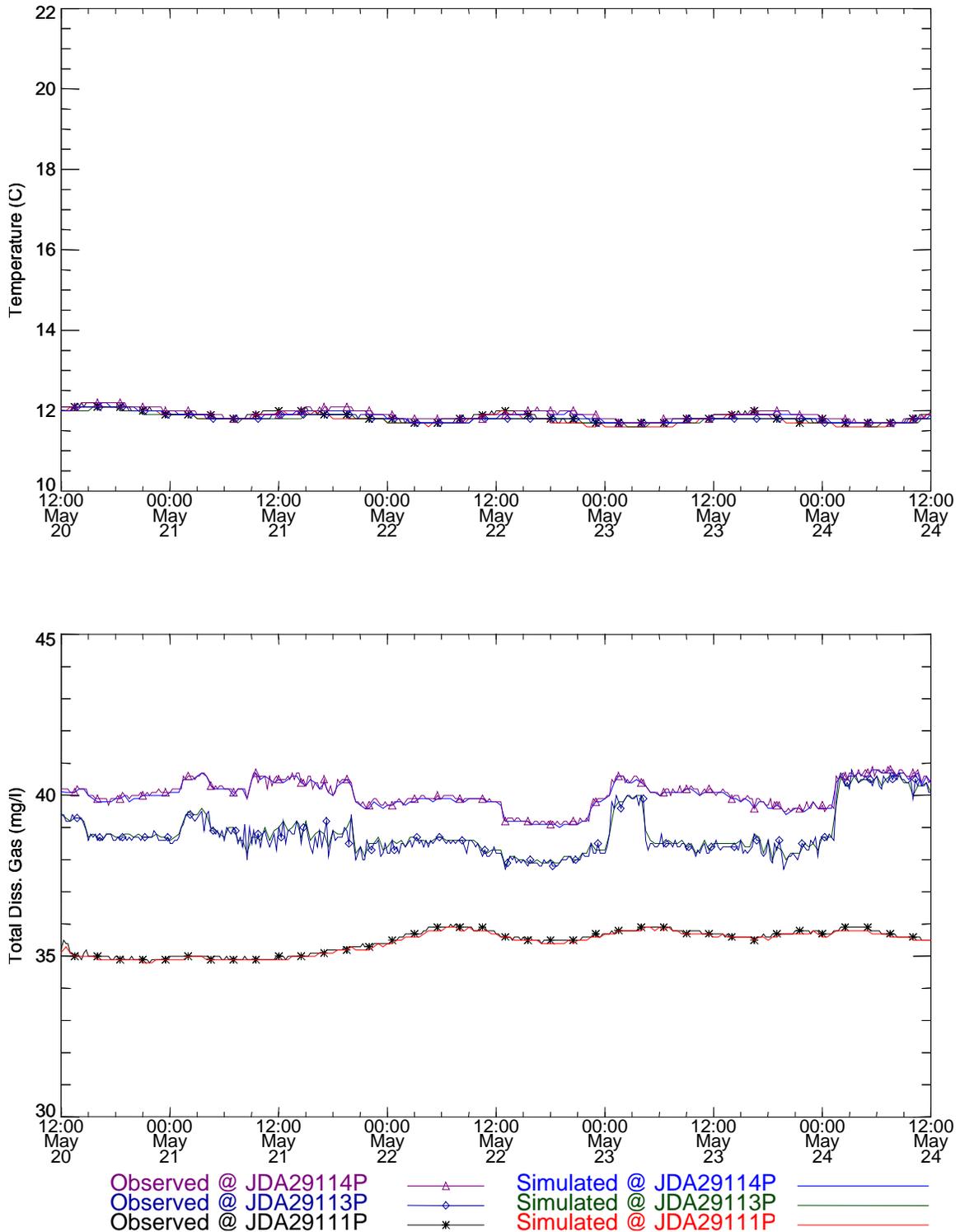


Figure 140. Temperature and total dissolved gas time series near Columbia River Mile 291.1 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

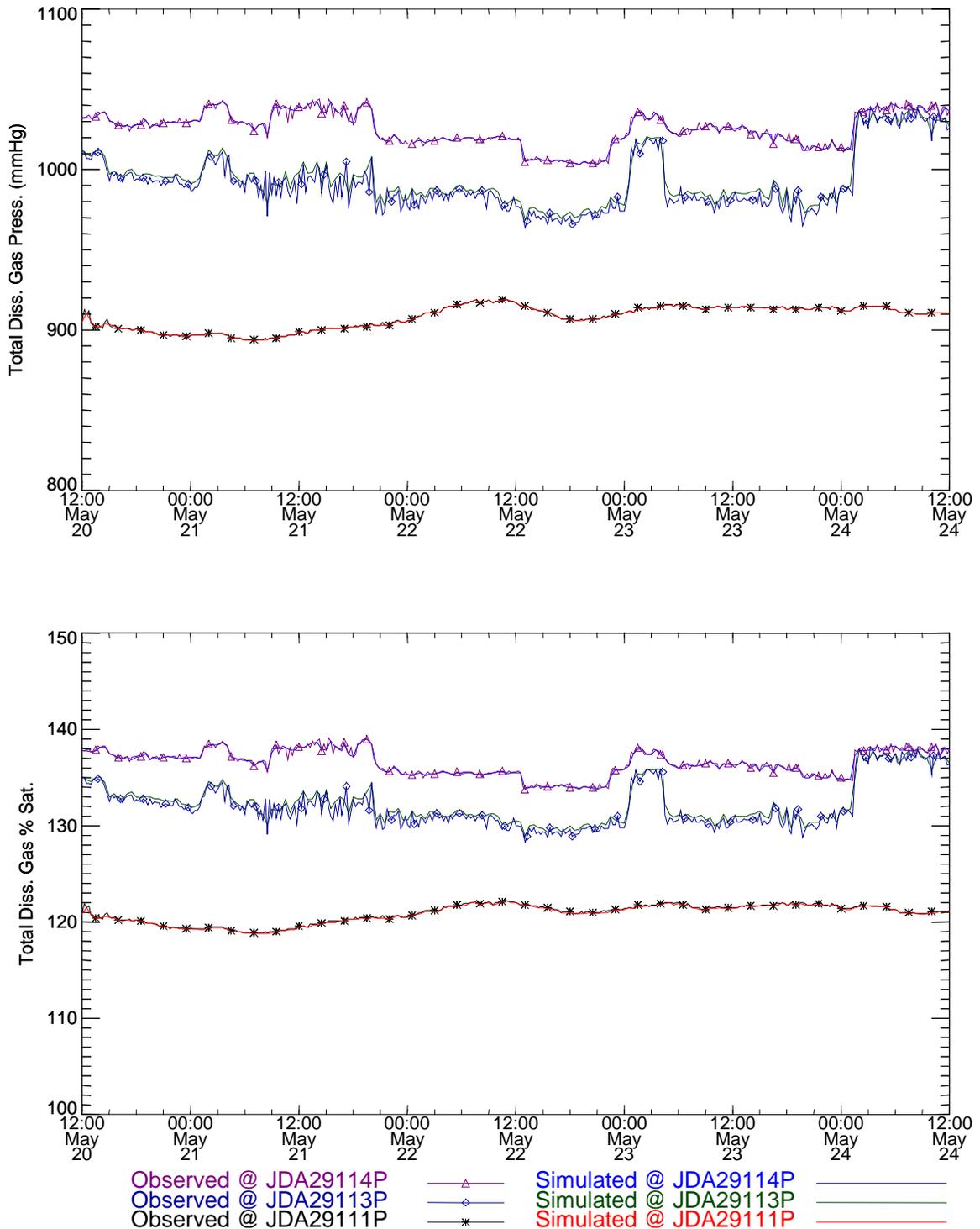


Figure 141. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 291.1 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Table 41. Statistical summary of measurements and simulations at river mile 291.1 during Spring 1997 pool study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA29111P	11.85	11.8	0.13	0.14	0.07
JDA29113P	11.82	11.79	0.11	0.11	0.05
JDA29114P	11.91	11.86	0.14	0.13	0.08
Concentration					
JDA29111P	35.46	35.41	0.36	0.35	0.07
JDA29113P	38.77	38.84	0.73	0.7	0.1
JDA29114P	40.06	40.01	0.44	0.44	0.07
Gas Pressure					
JDA29111P	907.89	907.8	7.3	7.28	0.22
JDA29113P	991.32	994.38	18.24	17.2	3.47
JDA29114P	1025.64	1025.54	10.73	10.61	0.56
% Saturation					
JDA29111P	120.89	120.84	0.95	0.95	0.07
JDA29113P	132	132.38	2.37	2.23	0.43
JDA29114P	136.57	136.52	1.37	1.35	0.1

Table 42. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 291.1 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA29111P	100	100	100	100
JDA29113P	100	100	100	100
JDA29114P	100	100	100	100

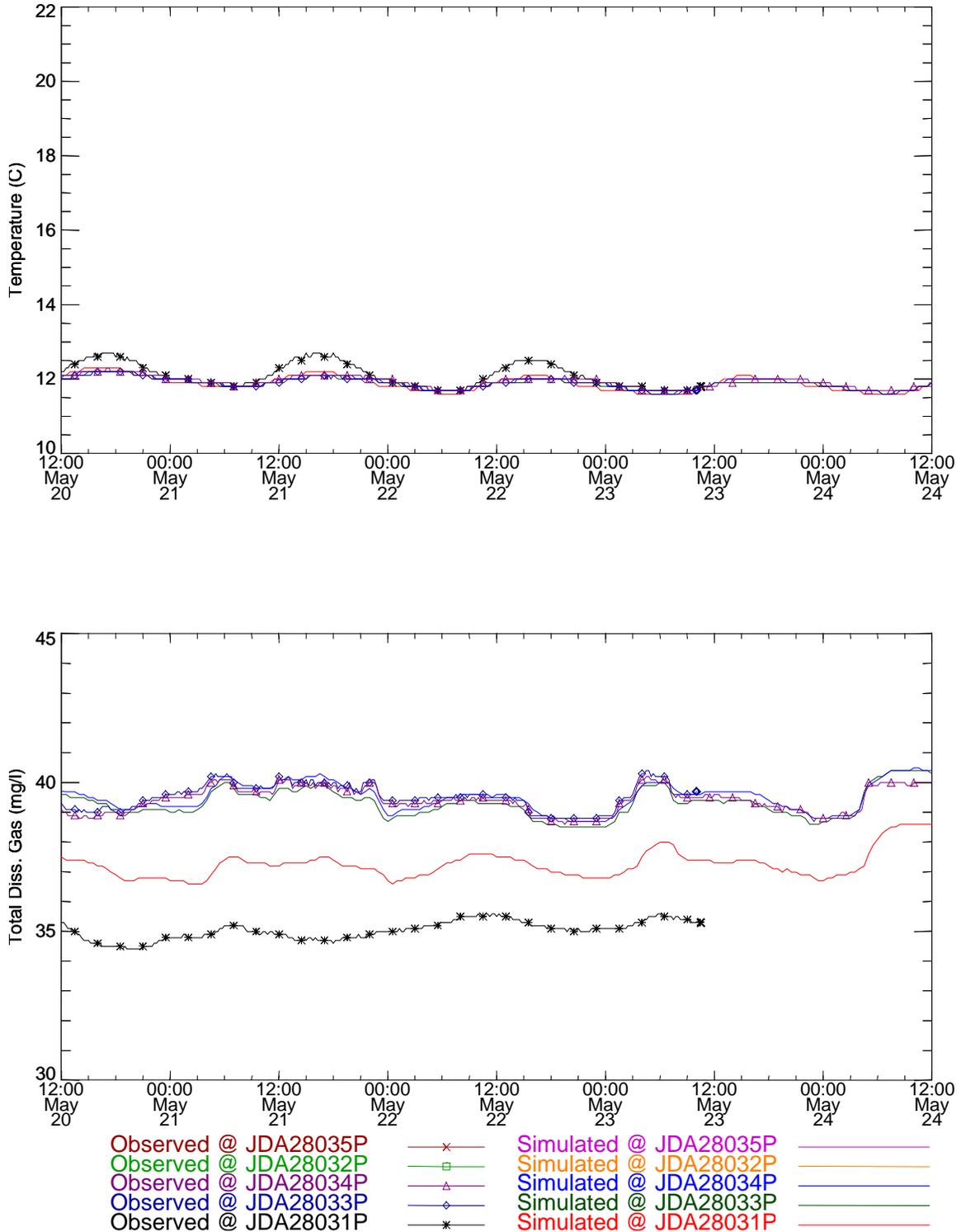


Figure 142. Temperature and total dissolved gas time series near Columbia River Mile 280.3 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

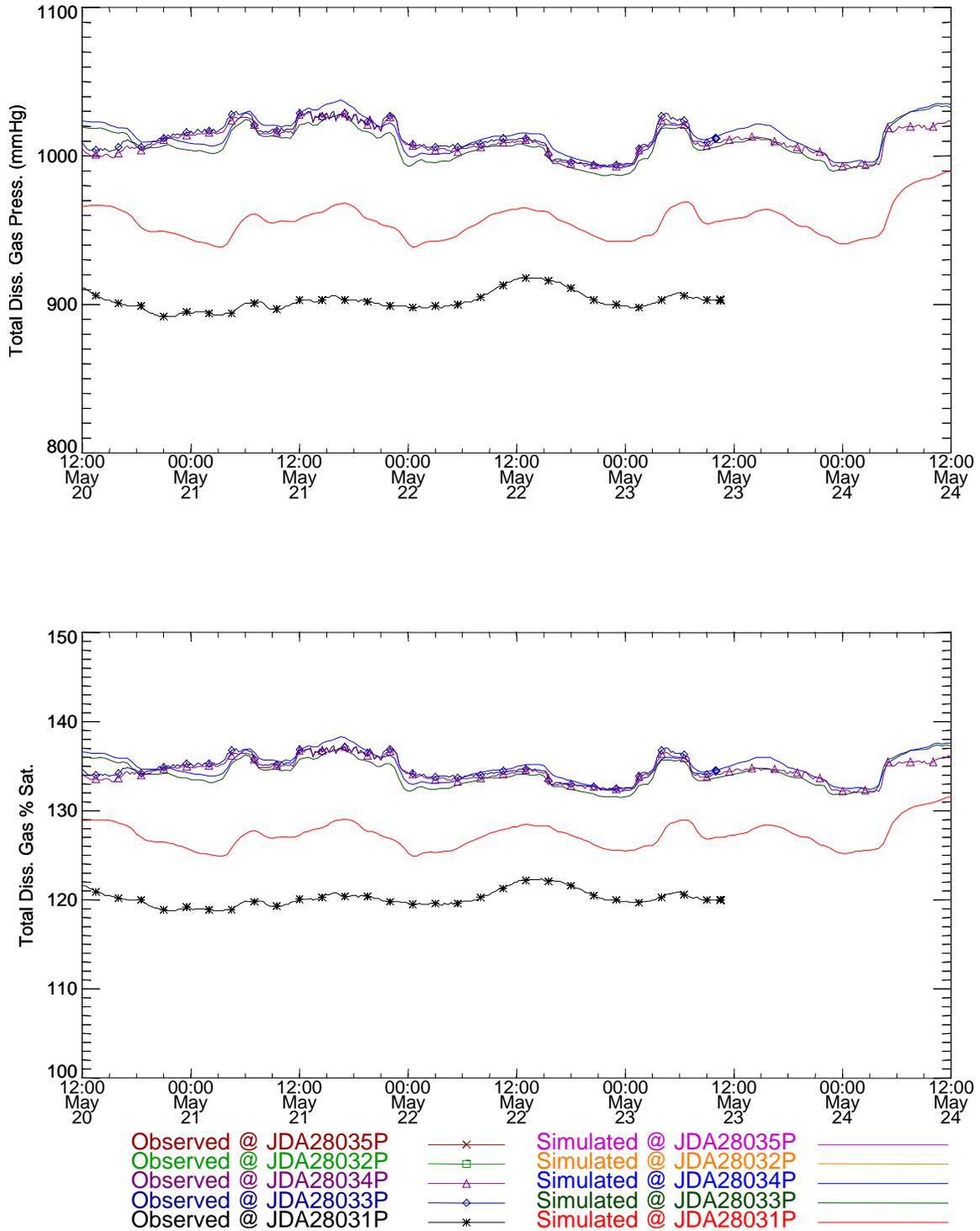


Figure 143. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 280.3 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Table 43. Statistical summary of measurements and simulations at river mile 280.3 during Spring 1997 pool study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA28031P	12.03	11.88	0.31	0.2	0.23
JDA28033P	11.86	11.88	0.16	0.15	0.08
JDA28034P	11.93	11.9	0.15	0.16	0.06
Concentration					
JDA28031P	35.11	37.25	0.29	0.46	2.19
JDA28033P	39.58	39.31	0.37	0.48	0.47
JDA28034P	39.42	39.51	0.43	0.47	0.25
Gas Pressure					
JDA28031P	902.54	956.07	5.45	11.19	54.46
JDA28033P	1012.36	1008.09	8.67	11.86	10.17
JDA28034P	1010.1	1013.81	10.11	11.69	7.25
% Saturation					
JDA28031P	120.13	127.27	0.76	1.47	7.26
JDA28033P	134.75	134.2	1.13	1.54	1.32
JDA28034P	134.5	134.96	1.3	1.53	0.95

Table 44. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 280.3 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA28031P	100	0	1.04	0
JDA28033P	100	98.45	100	100
JDA28034P	100	100	100	100

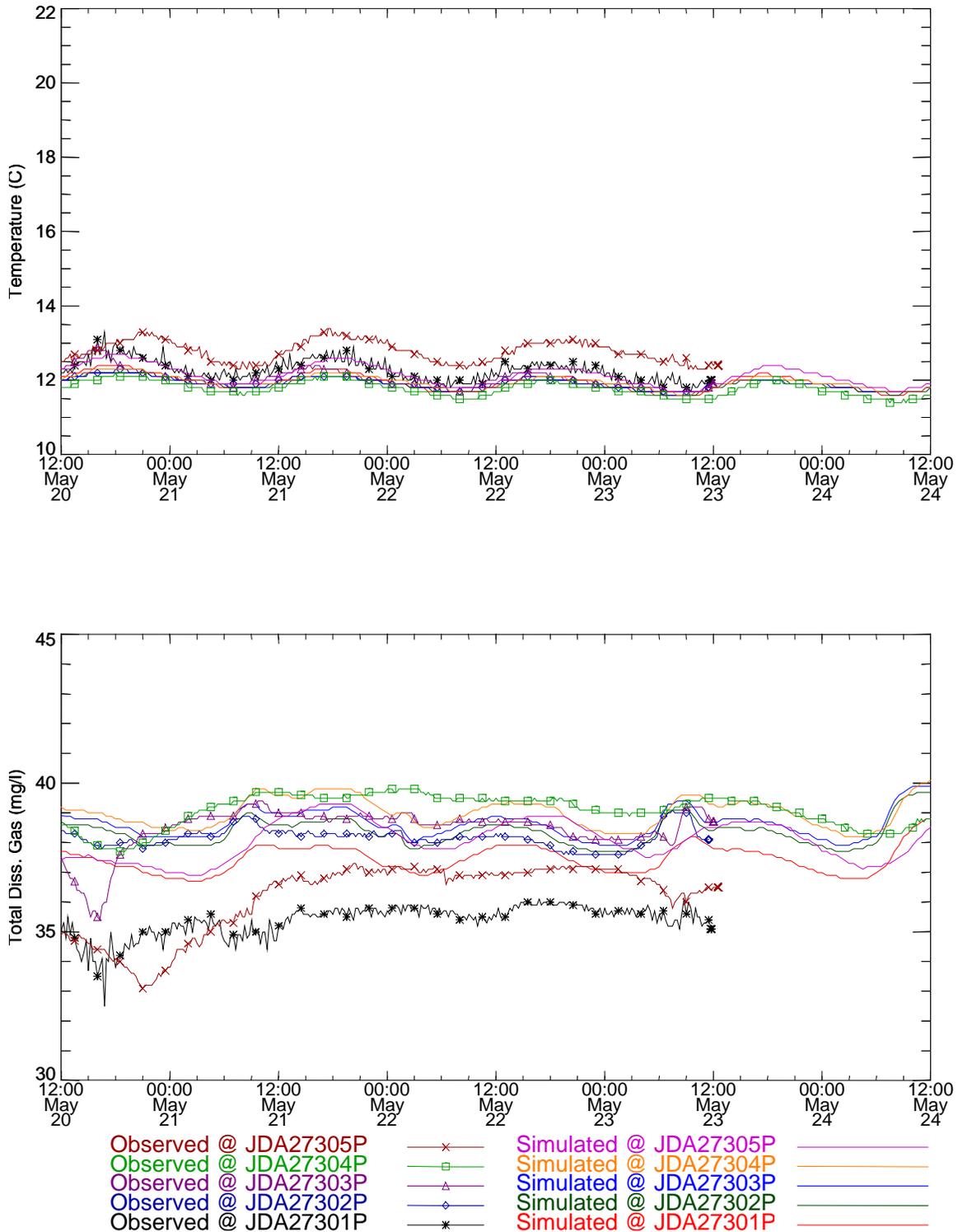


Figure 144. Temperature and total dissolved gas time series near Columbia River Mile 273.0 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

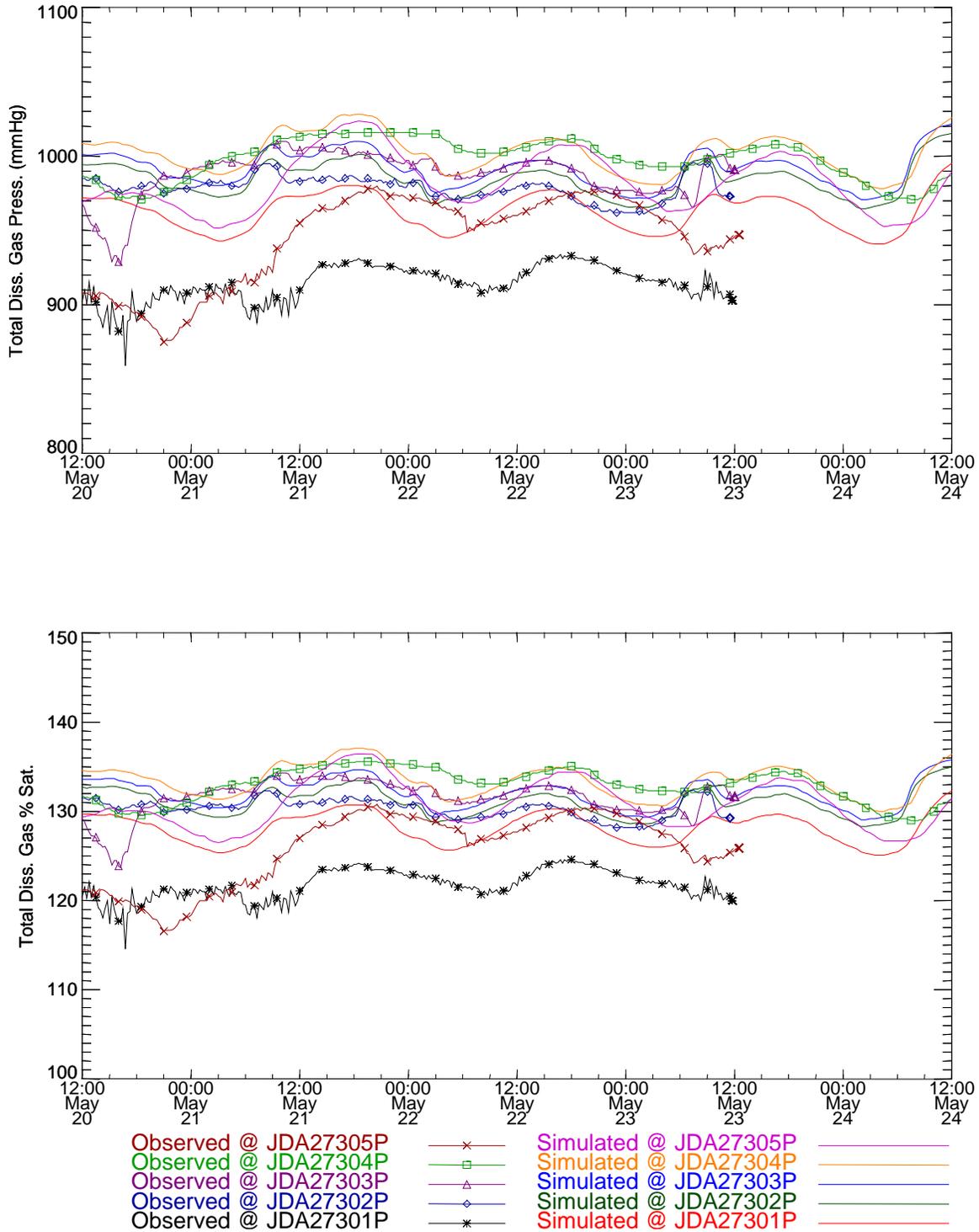


Figure 145. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 270.3 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Table 45. Statistical summary of measurements and simulations at river mile 273.0 during Spring 1997 pool study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA27301P	12.2	11.95	0.27	0.22	0.3
JDA27302P	11.92	11.89	0.15	0.16	0.09
JDA27303P	12.01	11.9	0.23	0.16	0.18
JDA27304P	11.78	11.95	0.19	0.18	0.19
JDA27305P	12.69	12.13	0.3	0.27	0.6
Concentration					
JDA27301P	35.31	37.44	0.47	0.45	2.22
JDA27302P	38.15	38.35	0.29	0.46	0.43
JDA27303P	38.51	38.62	0.65	0.47	0.76
JDA27304P	39.08	39.01	0.55	0.49	0.56
JDA27305P	36.24	38.07	1.05	0.67	1.99
Gas Pressure					
JDA27301P	911.36	962.25	11.23	12.52	53.27
JDA27302P	977.25	984.1	7.4	11.6	11.86
JDA27303P	988.63	991.32	14.07	12.01	17.6
JDA27304P	997.96	1002.12	13.96	13.12	14.68
JDA27305P	945	982.24	26.56	19.17	43.12
% Saturation					
JDA27301P	121.31	128.09	1.59	1.73	7.12
JDA27302P	130.08	131	1.01	1.57	1.6
JDA27303P	131.59	131.97	1.8	1.62	2.34
JDA27304P	132.89	133.4	1.88	1.81	1.94
JDA27305P	125.79	130.76	3.55	2.66	5.76

Table 46. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 273.0 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA27301P	100	0.52	24.87	24.87
JDA27302P	100	95.34	97.41	97.41
JDA27303P	100	88.6	94.3	94.3
JDA27304P	100	90.16	98.96	99.48
JDA27305P	100	20.21	52.33	51.81

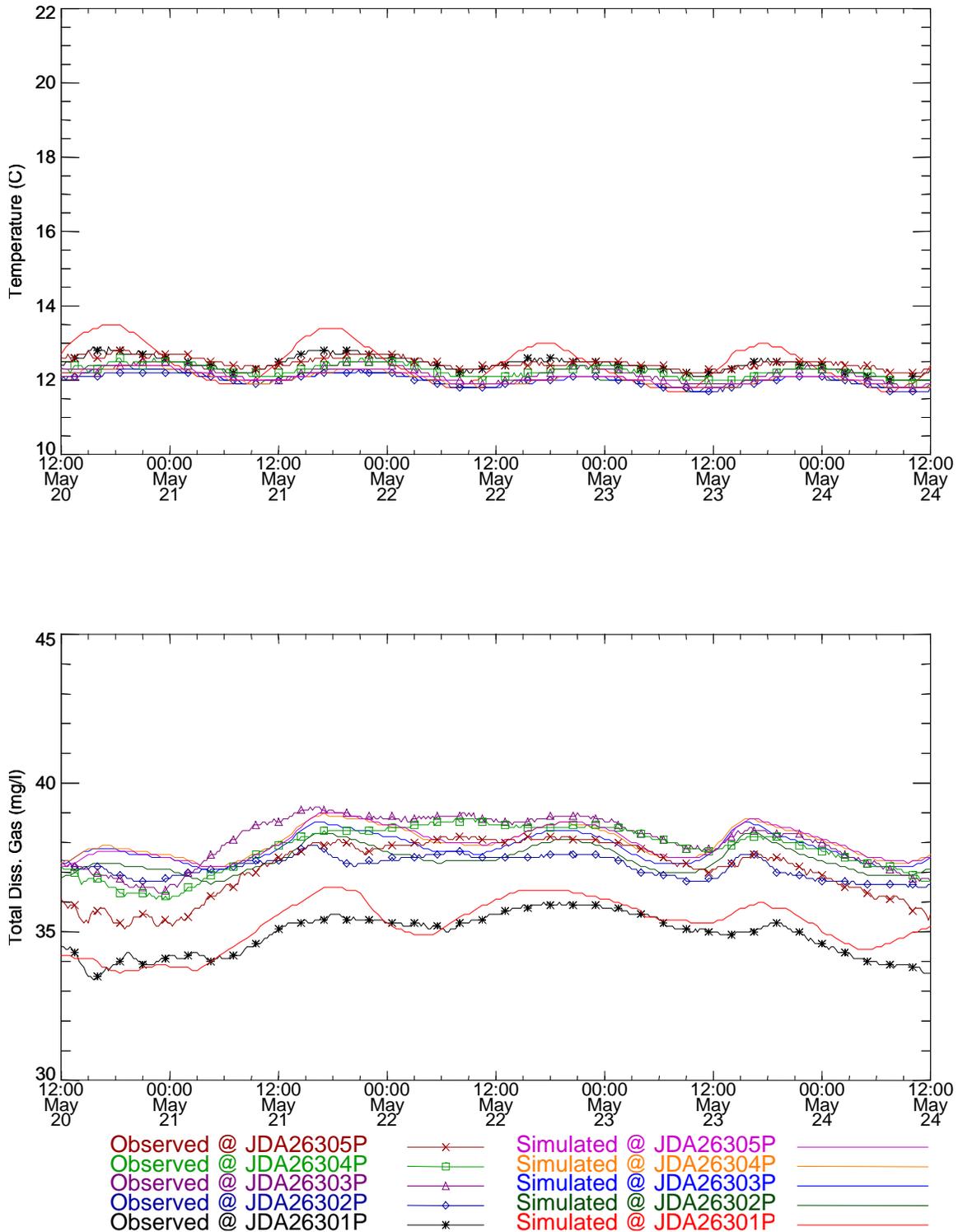


Figure 146. Temperature and total dissolved gas time series near Columbia River Mile 263.0 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

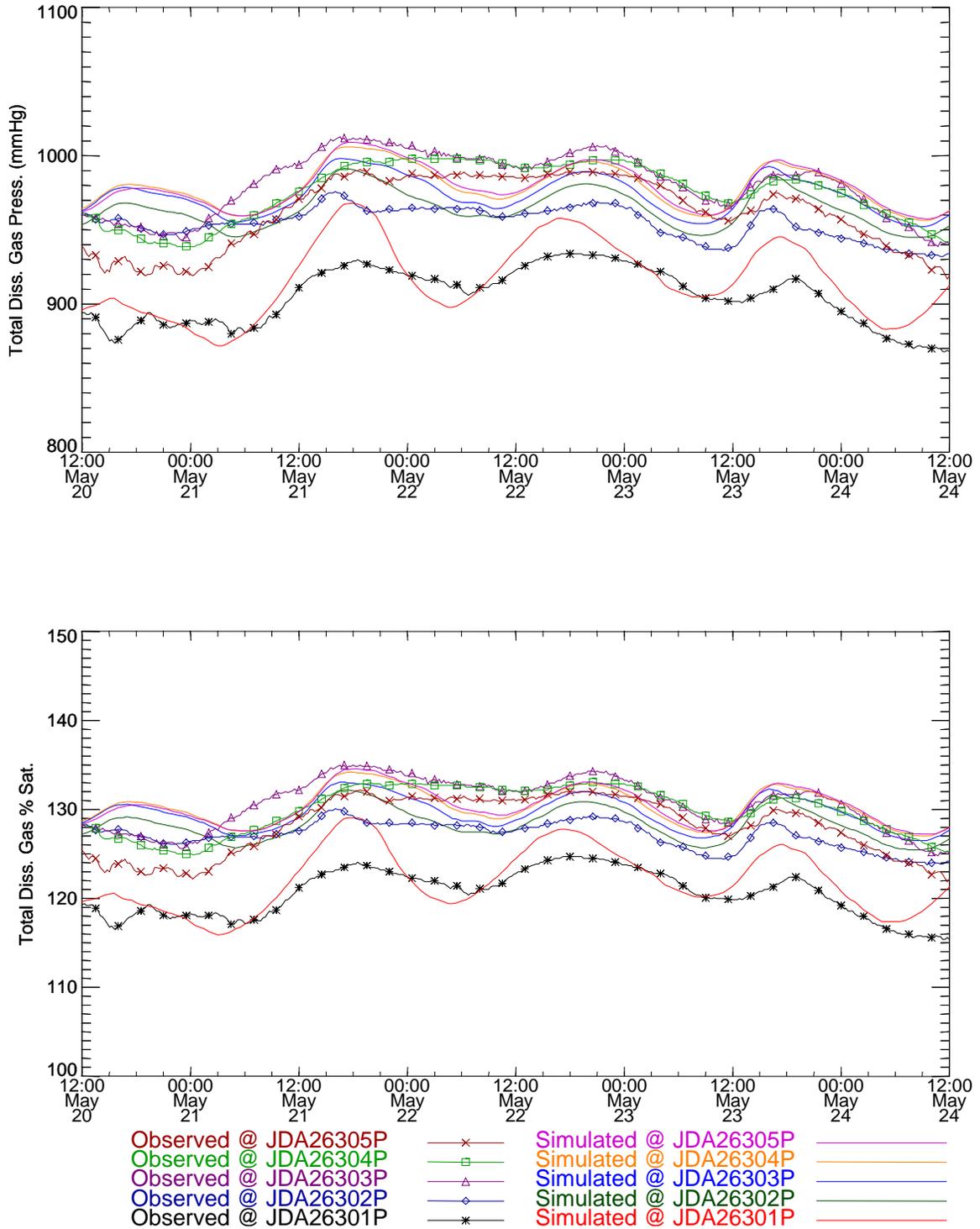


Figure 147. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 263.0 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Table 47. Statistical summary of measurements and simulations at river mile 263.0 during Spring 1997 pool study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA26301P	12.44	12.46	0.21	0.53	0.36
JDA26302P	11.99	12.05	0.16	0.18	0.1
JDA26303P	12.17	12.02	0.2	0.17	0.18
JDA26304P	12.26	12.05	0.16	0.18	0.22
JDA26305P	12.47	12.08	0.15	0.18	0.4
Concentration					
JDA26301P	34.9	35.24	0.7	0.85	0.54
JDA26302P	37.18	37.44	0.37	0.45	0.43
JDA26303P	38.1	37.81	0.81	0.45	0.7
JDA26304P	37.79	38.01	0.77	0.49	0.62
JDA26305P	37.12	38.01	0.96	0.52	1.13
Gas Pressure					
JDA26301P	905.35	916.42	19	25.5	18.16
JDA26302P	954.76	964.28	10.61	12.62	12.83
JDA26303P	981.73	973.25	20.99	12.71	18.46
JDA26304P	975.63	978.9	19.41	13.84	15.94
JDA26305P	962.69	979.58	23.98	14.33	24.66
% Saturation					
JDA26301P	120.56	121.99	2.61	3.5	2.39
JDA26302P	127.14	128.36	1.52	1.83	1.68
JDA26303P	130.73	129.56	2.84	1.83	2.48
JDA26304P	129.92	130.31	2.62	1.98	2.11
JDA26305P	128.19	130.4	3.23	2.04	3.26

Table 48. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 263.0 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA26301P	100	96.89	96.37	95.85
JDA26302P	100	100	100	100
JDA26303P	100	83.42	100	100
JDA26304P	100	90.16	99.48	99.48
JDA26305P	100	57.51	86.01	86.01

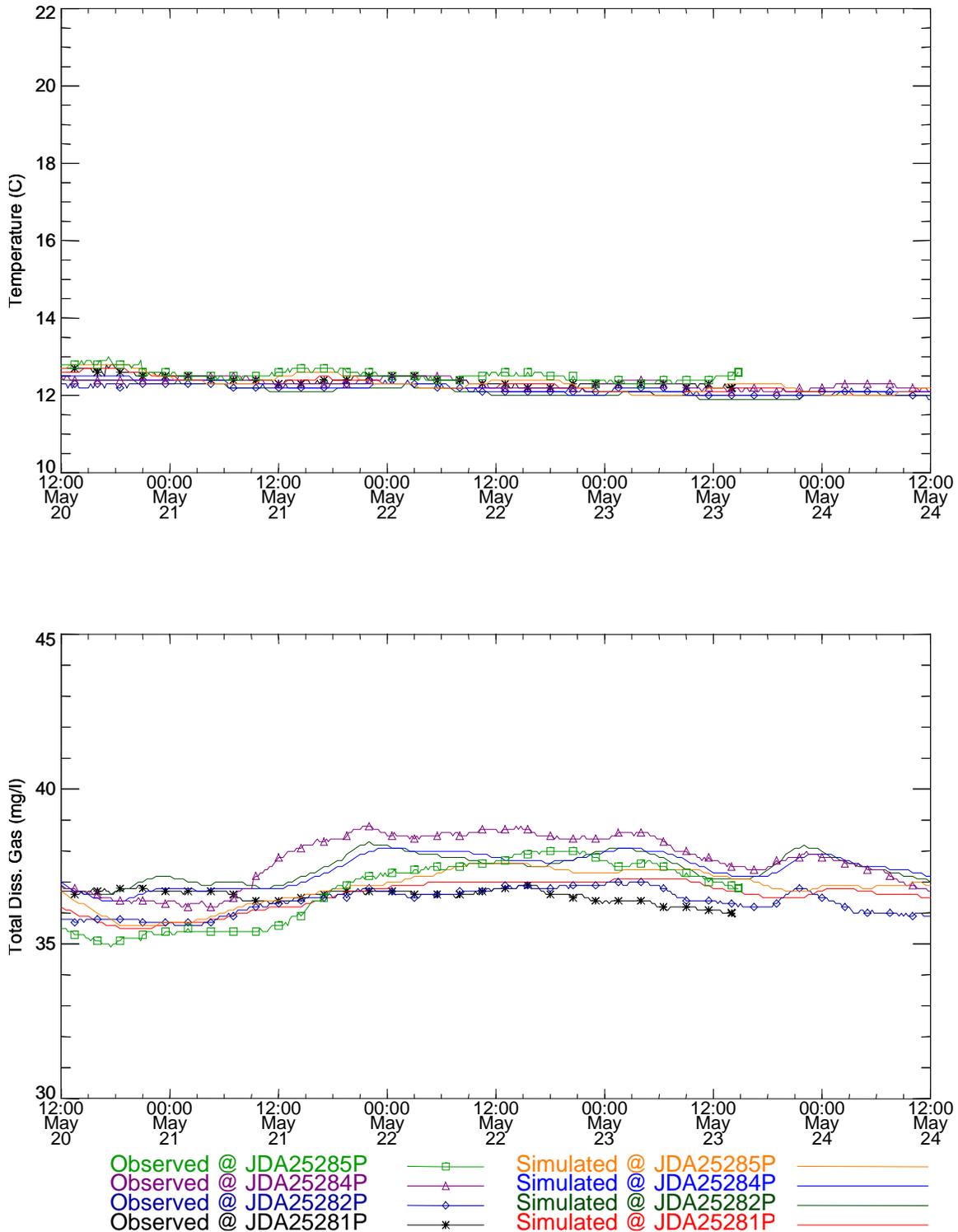


Figure 148. Temperature and total dissolved gas time series near Columbia River Mile 252.8 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

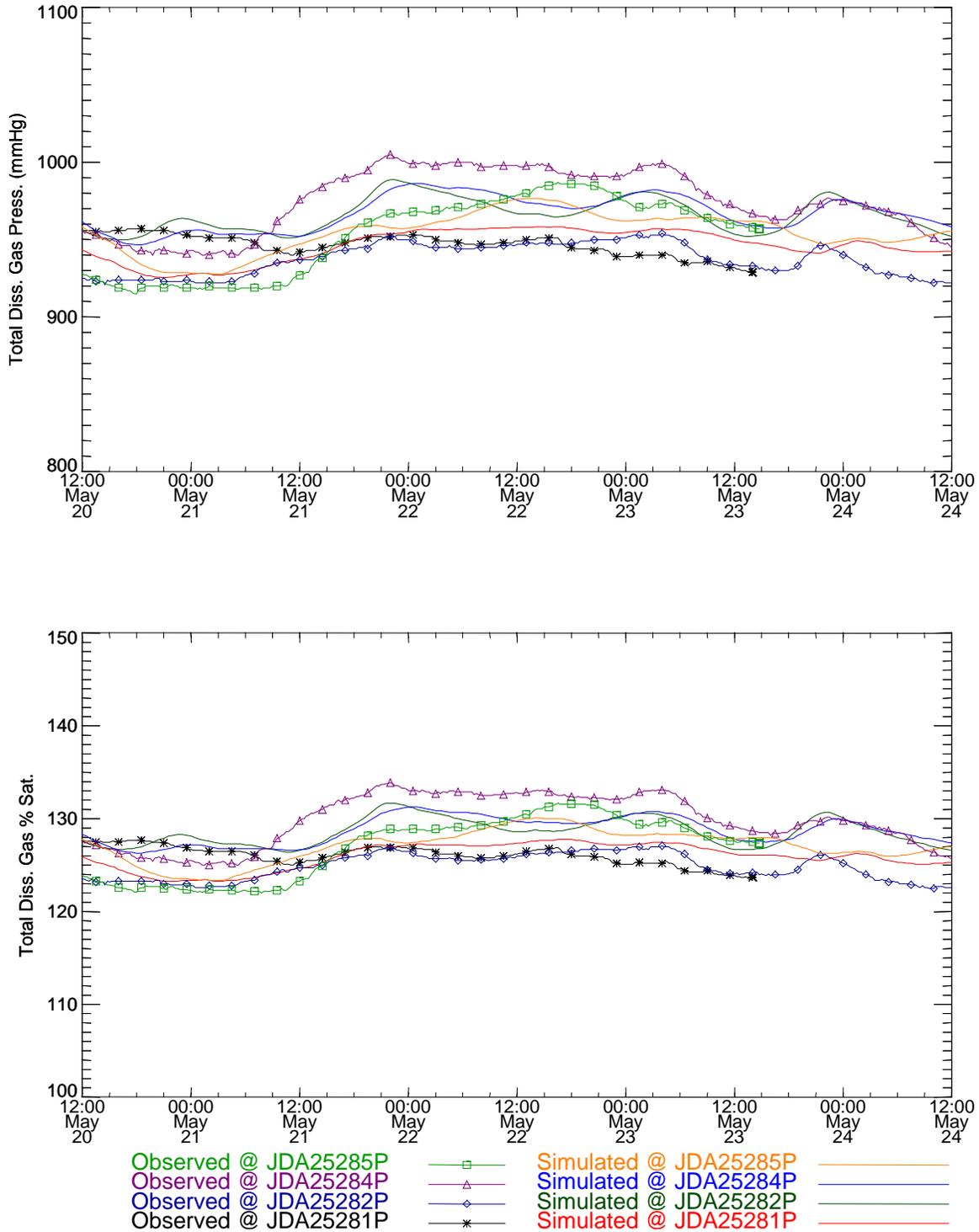


Figure 149. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 252.8 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Table 49. Statistical summary of measurements and simulations at river mile 252.8 during Spring 1997 pool study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA25281P	12.35	12.26	0.15	0.19	0.14
JDA25282P	12.17	12.11	0.11	0.15	0.1
JDA25284P	12.32	12.19	0.12	0.16	0.16
JDA25285P	12.55	12.31	0.13	0.23	0.29
Concentration					
JDA25281P	36.43	36.55	0.3	0.5	0.65
JDA25282P	36.37	37.45	0.42	0.45	1.12
JDA25284P	37.72	37.42	0.82	0.51	0.55
JDA25285P	36.7	36.83	0.92	0.59	0.44
Gas Pressure					
JDA25281P	942.69	946.02	9.64	10.39	15.79
JDA25282P	937.38	965.94	10.38	10.74	29.44
JDA25284P	975.01	966.96	20.8	11.35	14.74
JDA25285P	953.68	954.5	22.09	13.09	11.9
% Saturation					
JDA25281P	125.54	125.93	1.34	1.39	2.09
JDA25282P	124.82	128.59	1.43	1.46	3.89
JDA25284P	129.83	128.72	2.79	1.5	1.99
JDA25285P	127	127.06	2.95	1.76	1.59

Table 50. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 252.8 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA25281P	100	93.26	100	100
JDA25282P	100	47.67	91.19	92.23
JDA25284P	100	95.85	100	100
JDA25285P	100	97.93	100	100

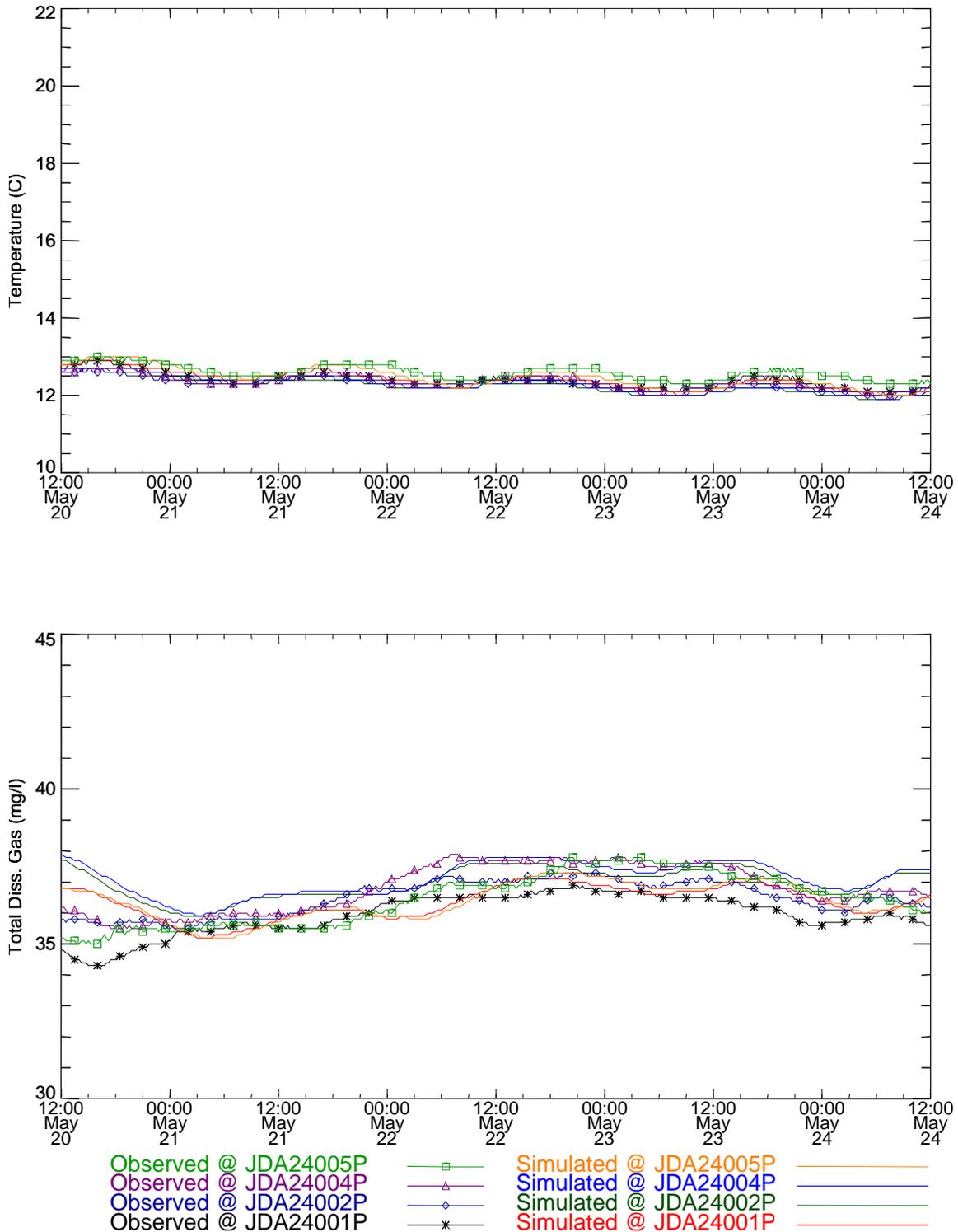


Figure 150. Temperature and total dissolved gas time series near Columbia River Mile 240.0 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

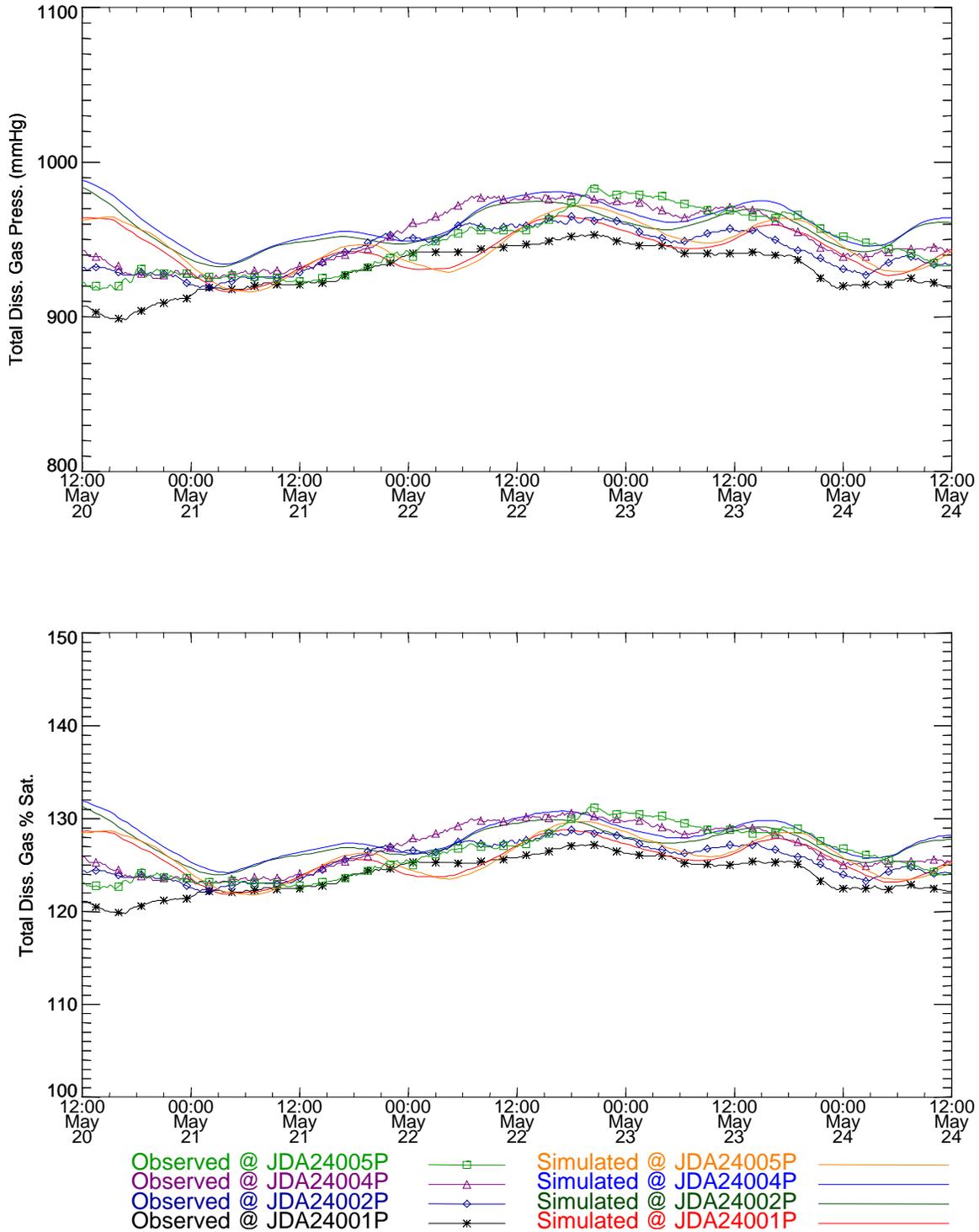


Figure 151. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 240.0 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Table 51. Statistical summary of measurements and simulations at river mile 240.0 during Spring 1997 pool study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA24001P	12.38	12.38	0.2	0.24	0.09
JDA24002P	12.3	12.25	0.16	0.2	0.1
JDA24004P	12.36	12.28	0.18	0.22	0.12
JDA24005P	12.59	12.46	0.19	0.27	0.17
Concentration					
JDA24001P	35.94	36.34	0.66	0.53	0.75
JDA24002P	36.48	36.97	0.56	0.5	0.63
JDA24004P	36.8	37.1	0.77	0.54	0.6
JDA24005P	36.44	36.39	0.83	0.59	0.59
Gas Pressure					
JDA24001P	930.74	943.21	14.61	13.44	20.44
JDA24002P	943.04	956.67	13.52	11.95	17.27
JDA24004P	952.21	960.7	18.47	13.09	16.43
JDA24005P	947.69	946.14	19.48	15.2	16.6
% Saturation					
JDA24001P	123.93	125.56	1.95	1.92	2.7
JDA24002P	125.58	127.35	1.83	1.66	2.27
JDA24004P	126.8	127.89	2.47	1.82	2.17
JDA24005P	126.19	125.95	2.61	2.16	2.21

Table 52. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 240.0 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA24001P	100	90.16	91.71	91.71
JDA24002P	100	92.23	94.82	94.82
JDA24004P	100	90.67	93.26	93.26
JDA24005P	100	93.78	95.34	95.34

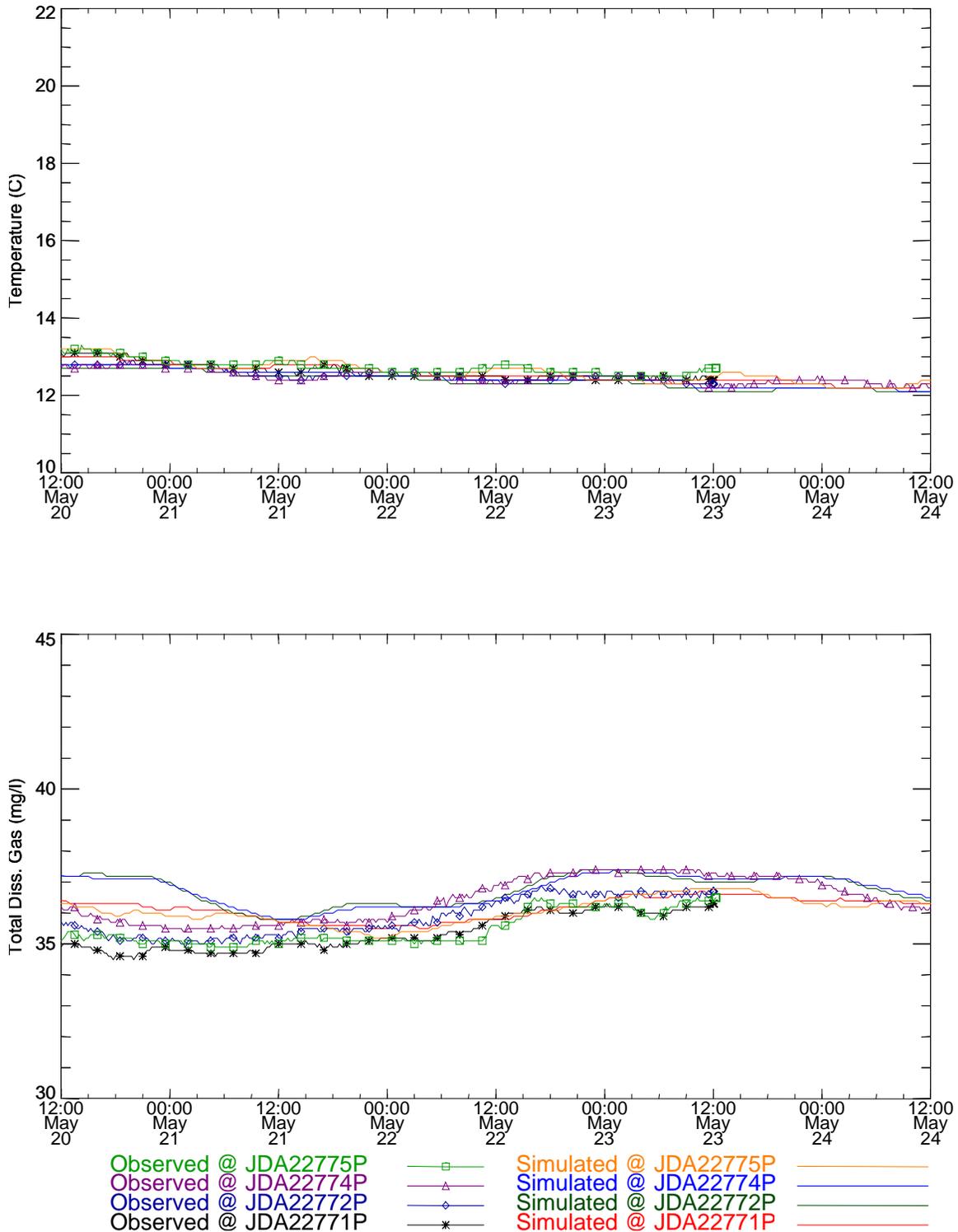


Figure 152. Temperature and total dissolved gas time series near Columbia River Mile 227.7 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

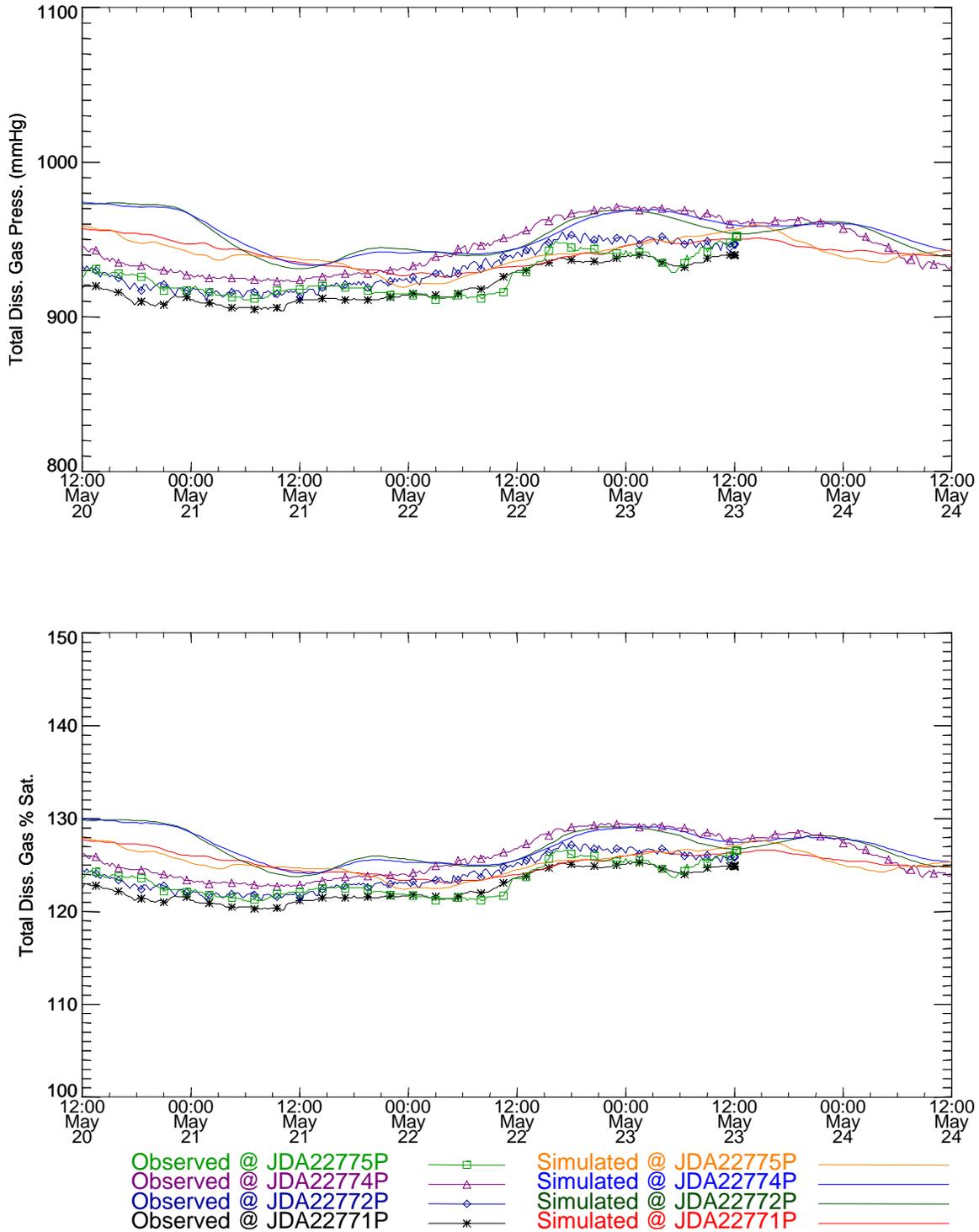


Figure 153. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 227.7 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Table 53. Statistical summary of measurements and simulations at river mile 227.7 during Spring 1997 pool study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA22771P	12.57	12.55	0.21	0.24	0.11
JDA22772P	12.49	12.38	0.17	0.2	0.12
JDA22774P	12.48	12.44	0.17	0.21	0.11
JDA22775P	12.73	12.61	0.16	0.27	0.22
Concentration					
JDA22771P	35.58	36.14	0.65	0.36	0.76
JDA22772P	36.05	36.74	0.65	0.49	0.9
JDA22774P	36.45	36.74	0.71	0.49	0.62
JDA22775P	35.72	36.08	0.64	0.43	0.55
Gas Pressure					
JDA22771P	925.38	941.39	13.41	8.33	21.08
JDA22772P	935.22	953.4	13.56	12.46	23.67
JDA22774P	945.73	954.34	16.54	11.99	17.16
JDA22775P	932.19	941.08	15.41	9.83	15.77
% Saturation					
JDA22771P	123.16	125.32	1.74	1.17	2.8
JDA22772P	124.49	126.91	1.79	1.77	3.15
JDA22774P	125.93	127.04	2.25	1.69	2.27
JDA22775P	124.1	125.27	2.04	1.37	2.08

Table 54. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 227.7 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA22771P	100	76.68	90.67	90.67
JDA22772P	100	81.35	83.94	84.46
JDA22774P	100	85.49	93.26	92.23
JDA22775P	100	95.85	100	100

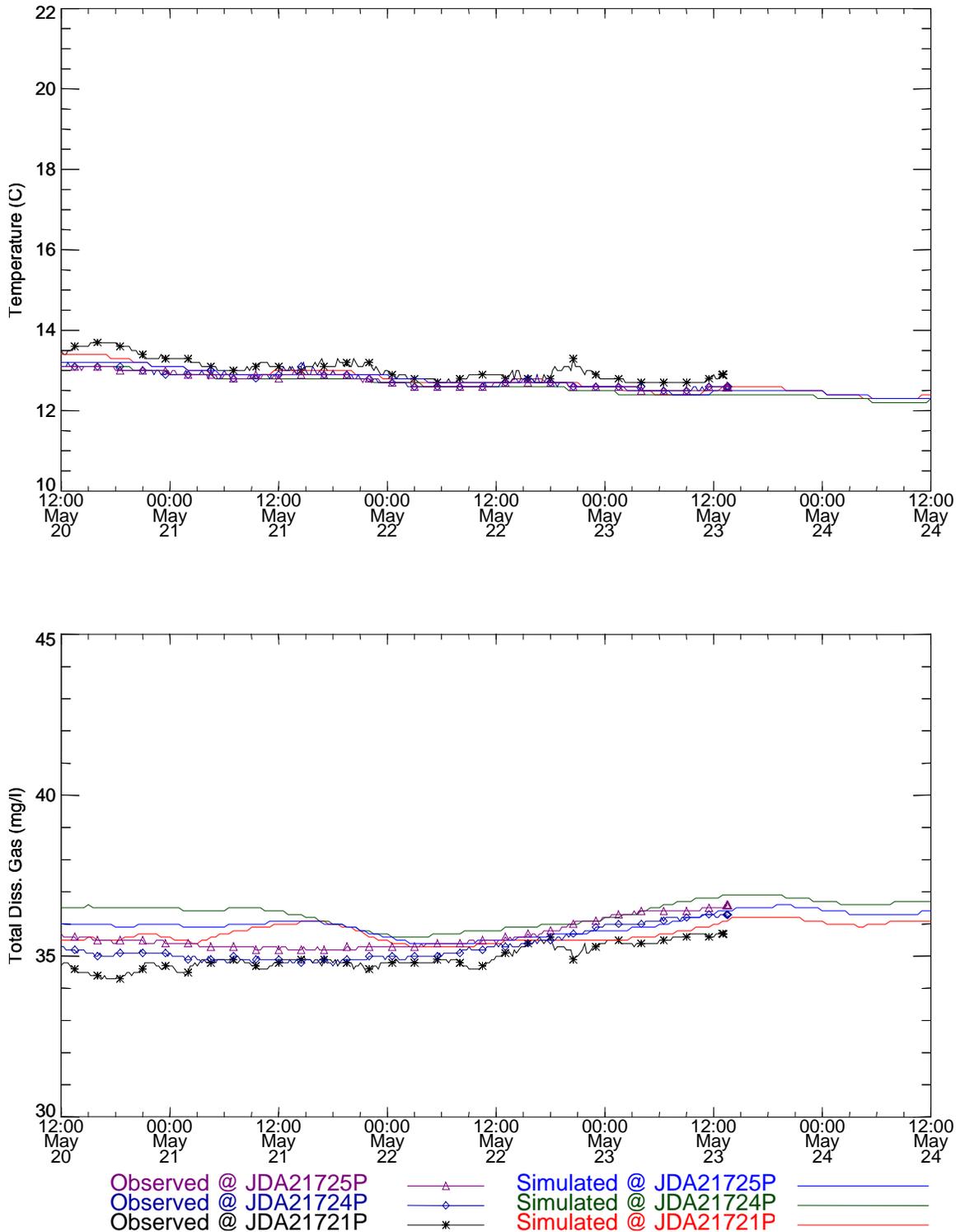


Figure 154. Temperature and total dissolved gas time series near Columbia River Mile 217.2 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

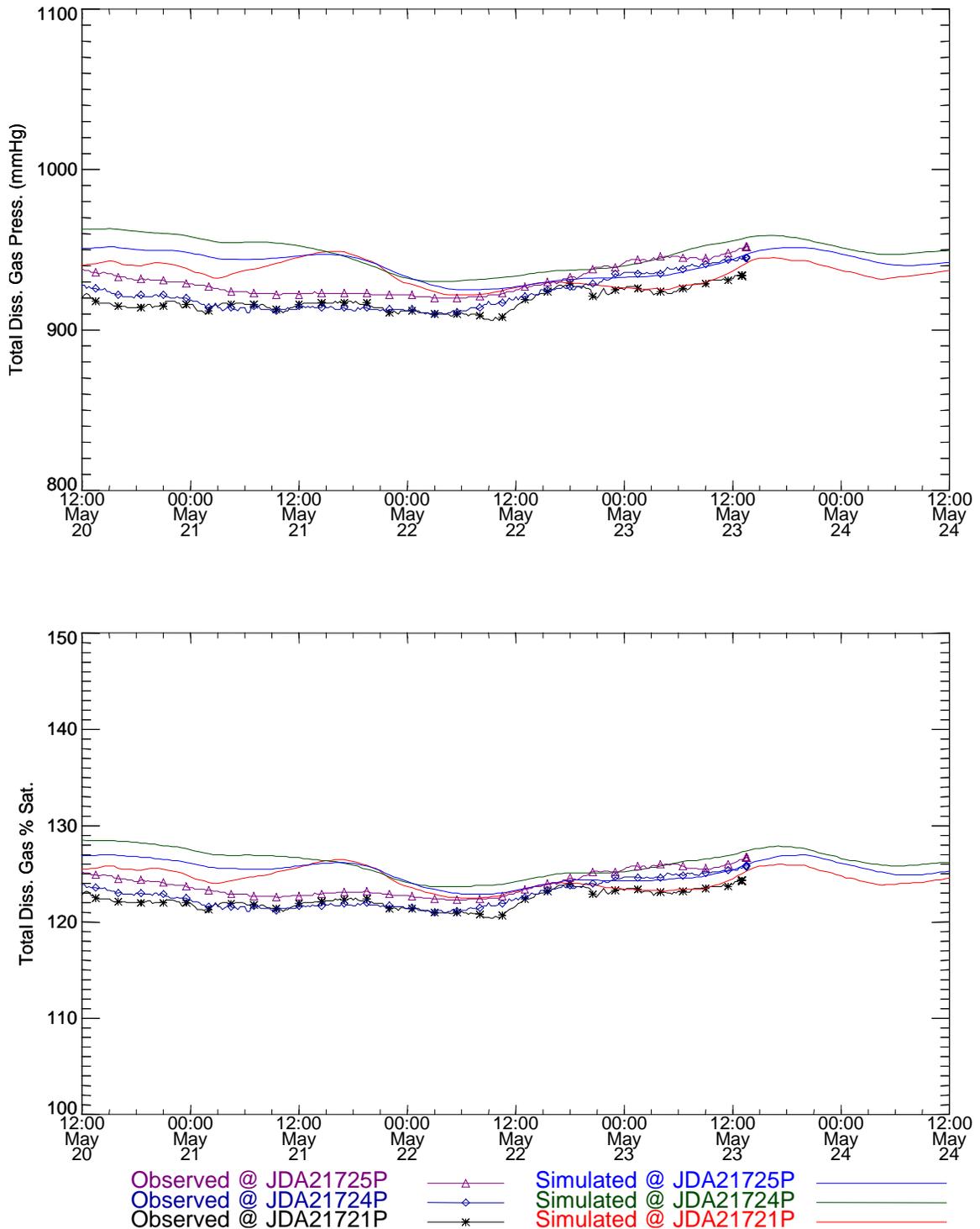


Figure 155. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 217.2 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Table 55. Statistical summary of measurements and simulations at river mile 217.2 during Spring 1997 pool study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA21721P	13	12.75	0.25	0.3	0.3
JDA21724P	12.74	12.62	0.18	0.26	0.17
JDA21725P	12.73	12.72	0.17	0.27	0.13
Concentration					
JDA21721P	35.13	35.73	0.45	0.29	0.71
JDA21724P	35.53	36.33	0.59	0.38	0.93
JDA21725P	35.86	35.98	0.55	0.33	0.43
Gas Pressure					
JDA21721P	921.89	934.95	8.87	7.52	16.89
JDA21724P	927.39	947.71	13.11	9.96	24.53
JDA21725P	935.37	940.65	12.11	8.28	13.34
% Saturation					
JDA21721P	122.75	124.46	1.19	1.08	2.24
JDA21724P	123.49	126.16	1.75	1.37	3.25
JDA21725P	124.54	125.22	1.61	1.17	1.78

Table 56. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 217.2 for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA21721P	100	80.31	100	100
JDA21724P	100	67.36	78.24	78.76
JDA21725P	100	100	100	100

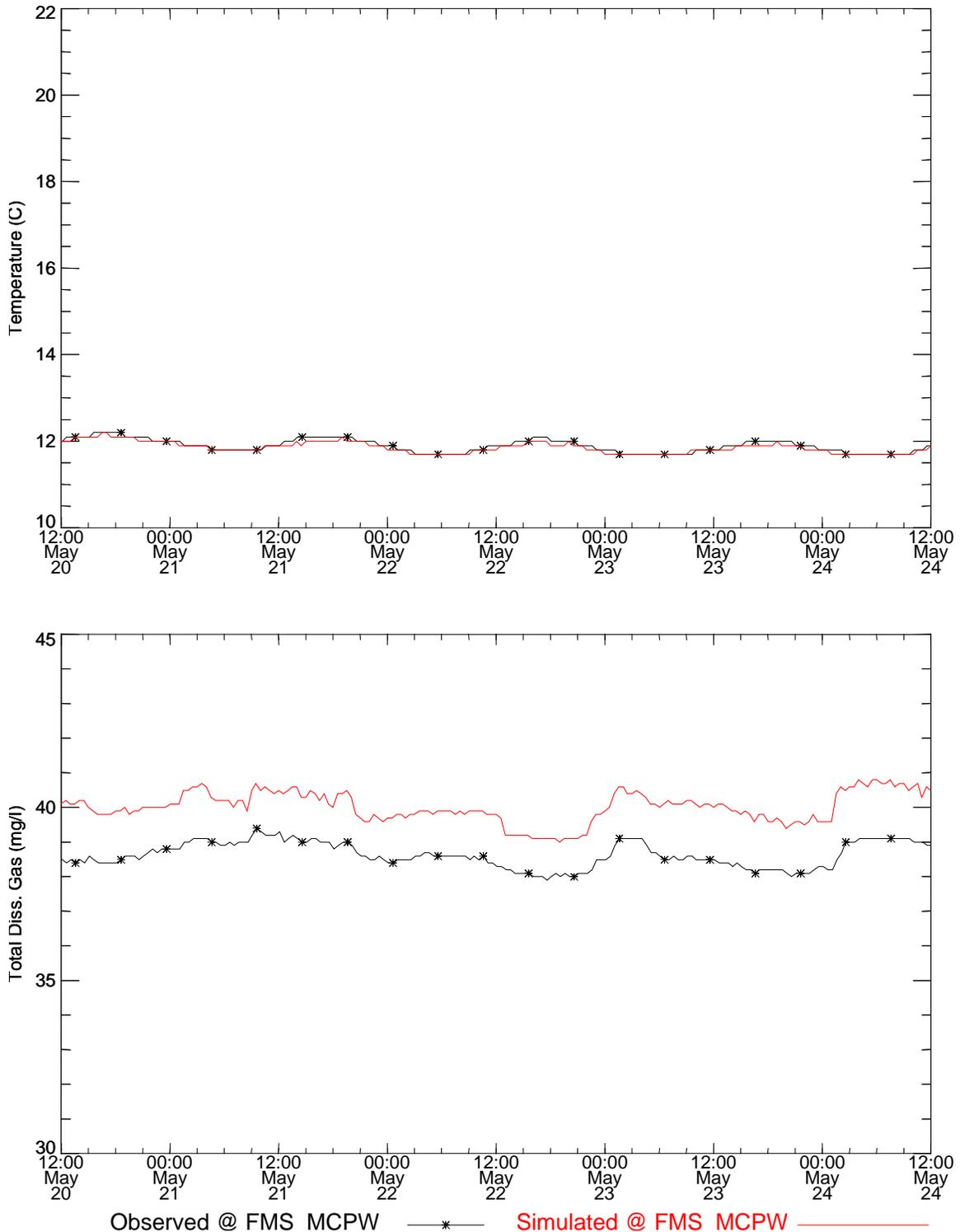


Figure 156. Temperature and total dissolved gas time series at fixed monitor MCPW for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

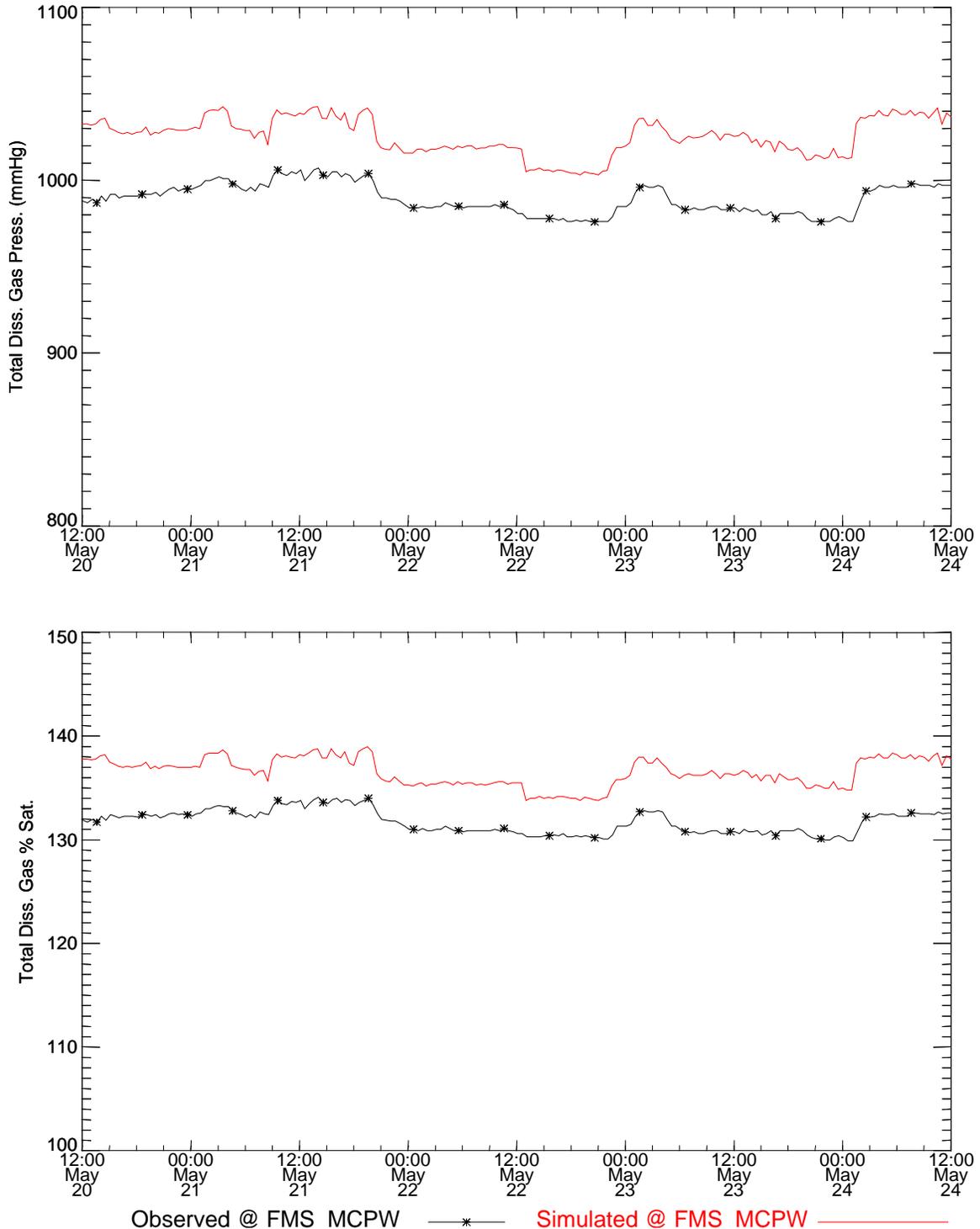


Figure 157. Total dissolved gas pressure and saturation time series comparisons at fixed monitor MCPW for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Table 57. Statistical summary of measurements and simulations at fixed monitor MCPW during Spring 1997 pool study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_MCPW	11.89	11.86	0.15	0.13	0.06
Concentration					
FMS_MCPW	38.63	40.01	0.36	0.44	1.4
Gas Pressure					
FMS_MCPW	989.26	1025.56	8.64	10.64	36.65
% Saturation					
FMS_MCPW	131.73	136.52	1.12	1.36	4.84

Table 58. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor MCPW for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_MCPW	100	2.59	66.32	65.8

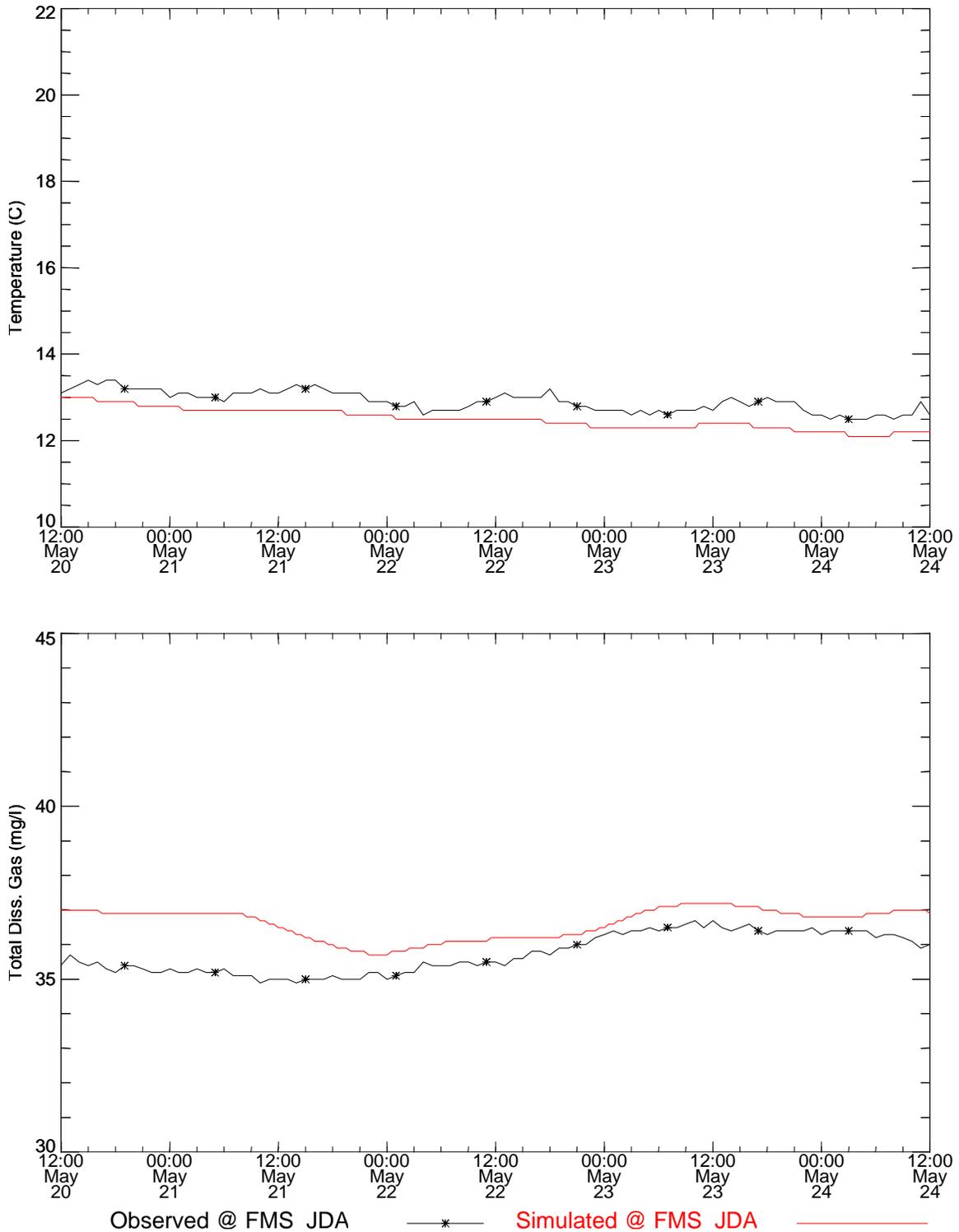


Figure 158. Temperature and total dissolved gas time series at fixed monitor JDA for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

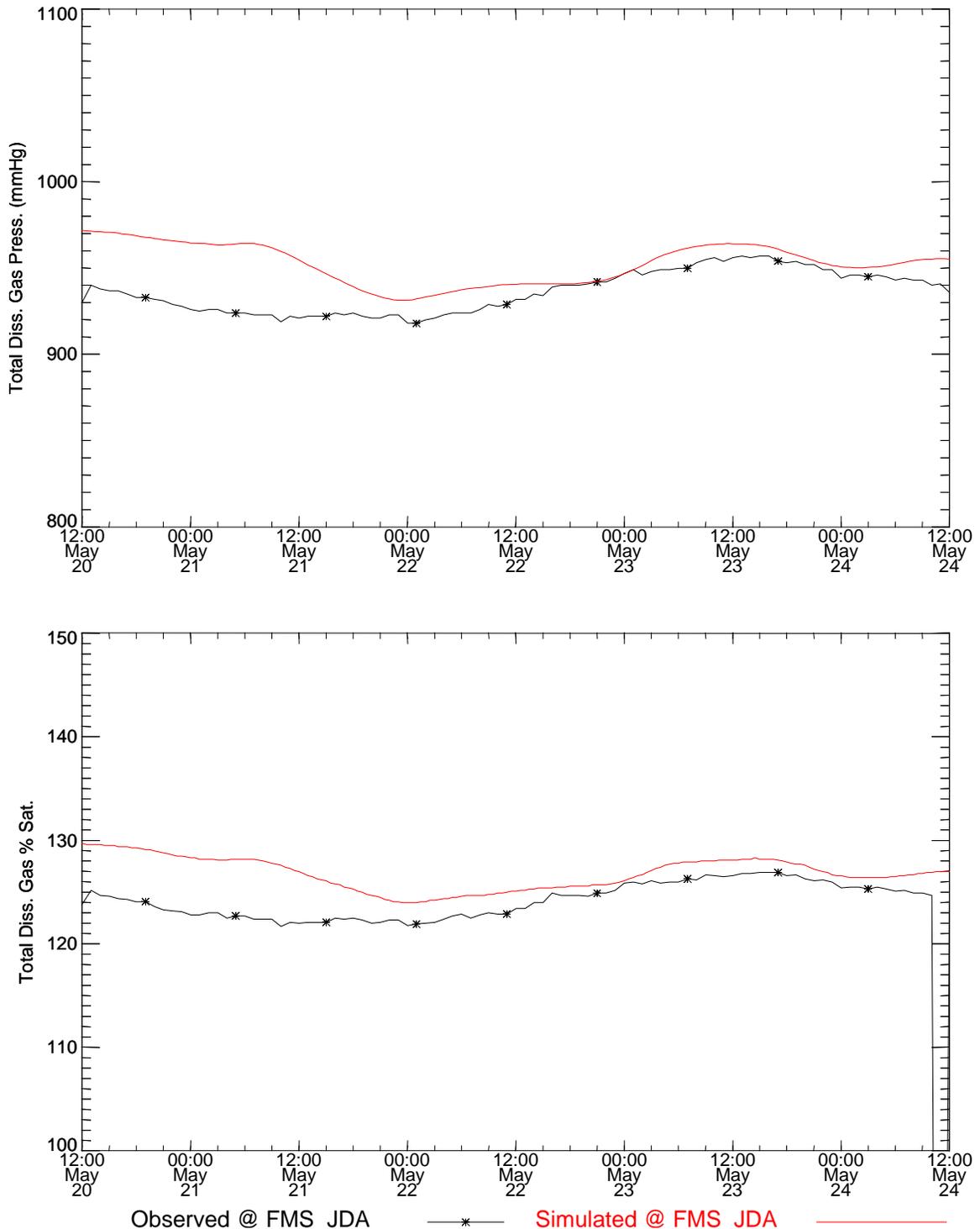


Figure 159. Total dissolved gas pressure and saturation time series comparisons at fixed monitor JDA for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Table 59. Statistical summary of measurements and simulations at fixed monitor JDA during Spring 1997 pool study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_JDA	12.91	12.5	0.24	0.24	0.43
Concentration					
FMS_JDA	35.74	36.62	0.57	0.44	1.01
Gas Pressure					
FMS_JDA	936.25	952.54	11.97	11.55	21.05
% Saturation					
FMS_JDA	122.91	126.8	10.99	1.55	11.7

Table 60. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor JDA for the Spring 1997 study (TM-BC-GASX) with the air/water gas exchange option activated.

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_JDA	100	68.39	89.64	77.2

1.4.2 Summer 1997 Simulation

Boundary Conditions using McNary Sourcing Function and Forebay FMS Data

Comparisons between the measurements and simulations using an upstream boundary condition developed from the empirical project gas sourcing function and the forebay FMS are shown in the figures below. Statistics on comparisons between measured and simulated temperatures and total dissolved gas are also presented. The case is denoted as TM-BC in the figure and table captions.

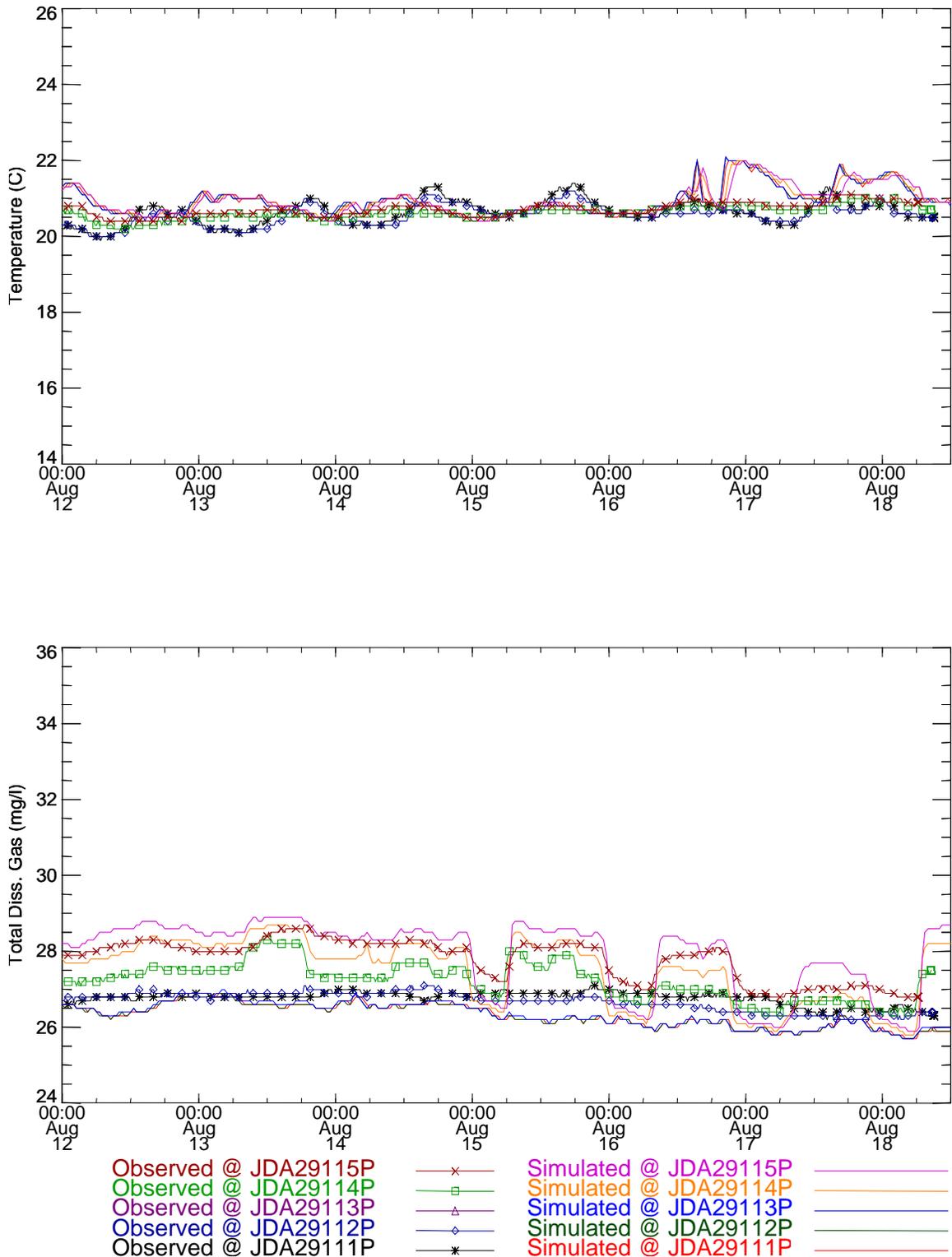


Figure 160. Temperature and total dissolved gas time series near Columbia River Mile 291.1 for the Summer 1997 study (FMS-BC).

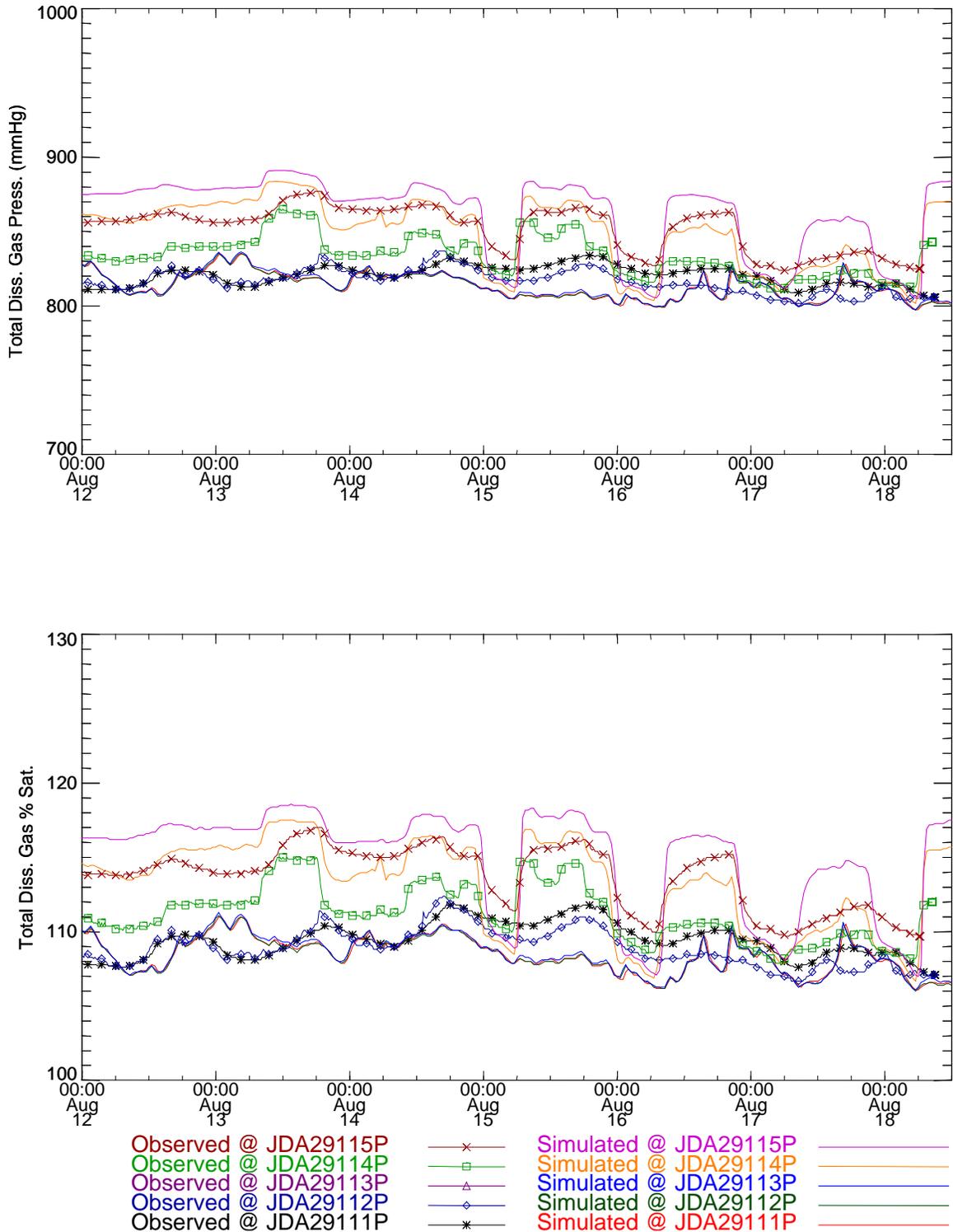


Figure 161. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 291.1 for the Summer 1997 study (FMS-BC).

Table 61. Statistical summary of measurements and simulations at river mile 291.1 during Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA29111P	20.63	20.94	0.31	0.38	0.59
JDA29112P	20.56	20.93	0.26	0.38	0.6
JDA29113P	20.4	20.94	0	0.38	0.66
JDA29114P	20.62	20.94	0.17	0.38	0.43
JDA29115P	20.71	20.94	0.17	0.38	0.35
Concentration					
JDA29111P	26.78	26.32	0.17	0.31	0.54
JDA29112P	26.68	26.32	0.25	0.31	0.41
JDA29113P	27.5	26.34	0	0.32	1.2
JDA29114P	27.22	27.49	0.49	0.84	0.5
JDA29115P	27.78	27.91	0.55	0.93	0.53
Gas Pressure					
JDA29111P	820.62	813.53	6.67	8.65	13.17
JDA29112P	816.61	813.42	7.9	8.68	10.52
JDA29113P	839	814.08	0	8.88	26.45
JDA29114P	833.83	848.83	13.43	22.79	19.45
JDA29115P	851.96	861.69	15.45	25.51	17.54
% Saturation					
JDA29111P	109.45	108.46	1.18	1.18	1.78
JDA29112P	108.91	108.45	1.27	1.18	1.42
JDA29113P	111.3	108.54	0	1.2	3.01
JDA29114P	111.21	113.17	1.88	3.04	2.56
JDA29115P	113.63	114.89	2.12	3.4	2.31

Table 62. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 291.1 for the Summer 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA29111P	90.54	100	100	100
JDA29112P	90.7	100	100	100
JDA29113P	85.81	41.92	94.29	98.69
JDA29114P	96.57	100	100	100
JDA29115P	99.02	98.53	98.69	98.69

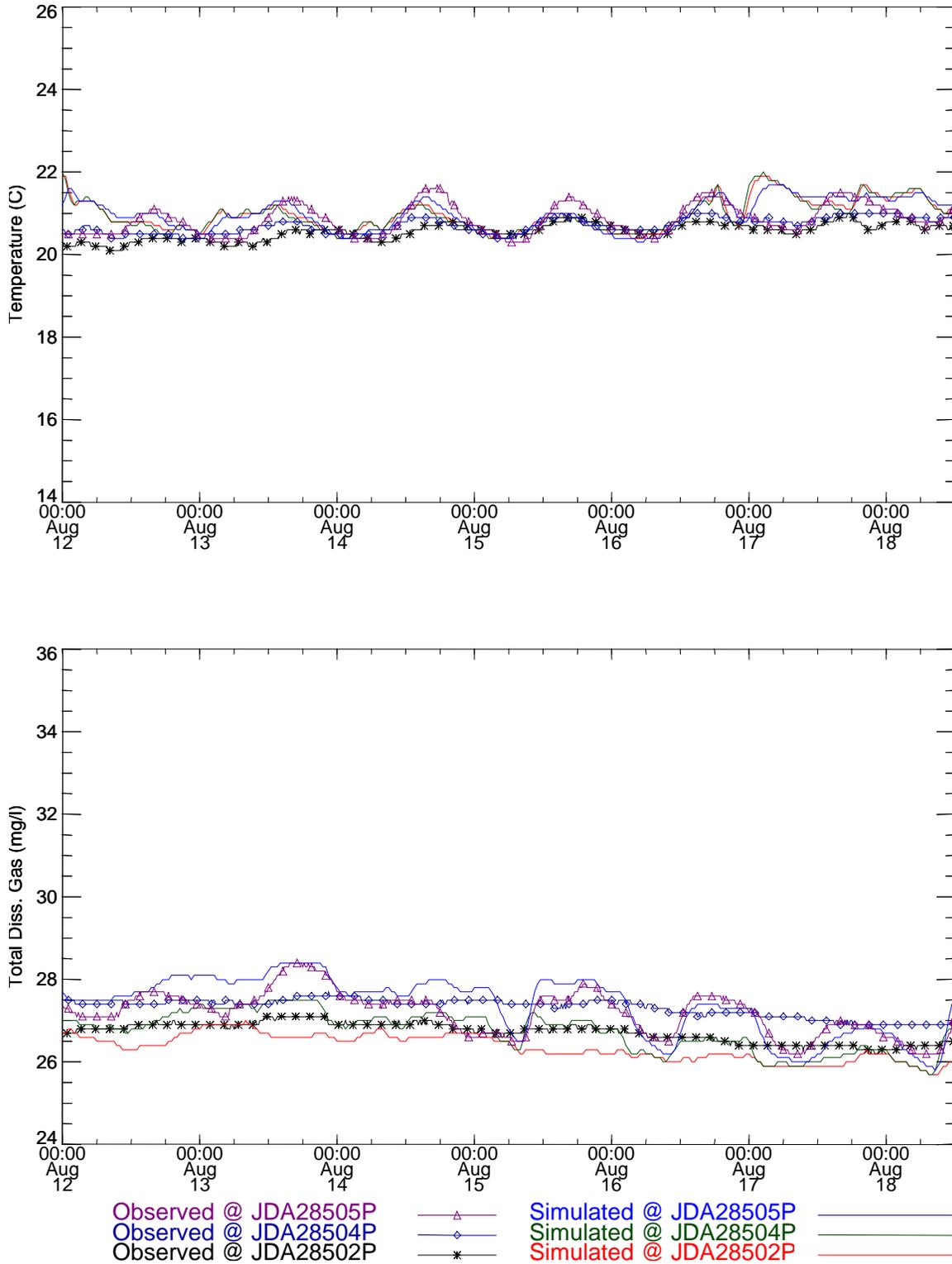


Figure 162. Temperature and total dissolved gas time series near Columbia River Mile 285.0 for the Summer 1997 study (FMS-BC).

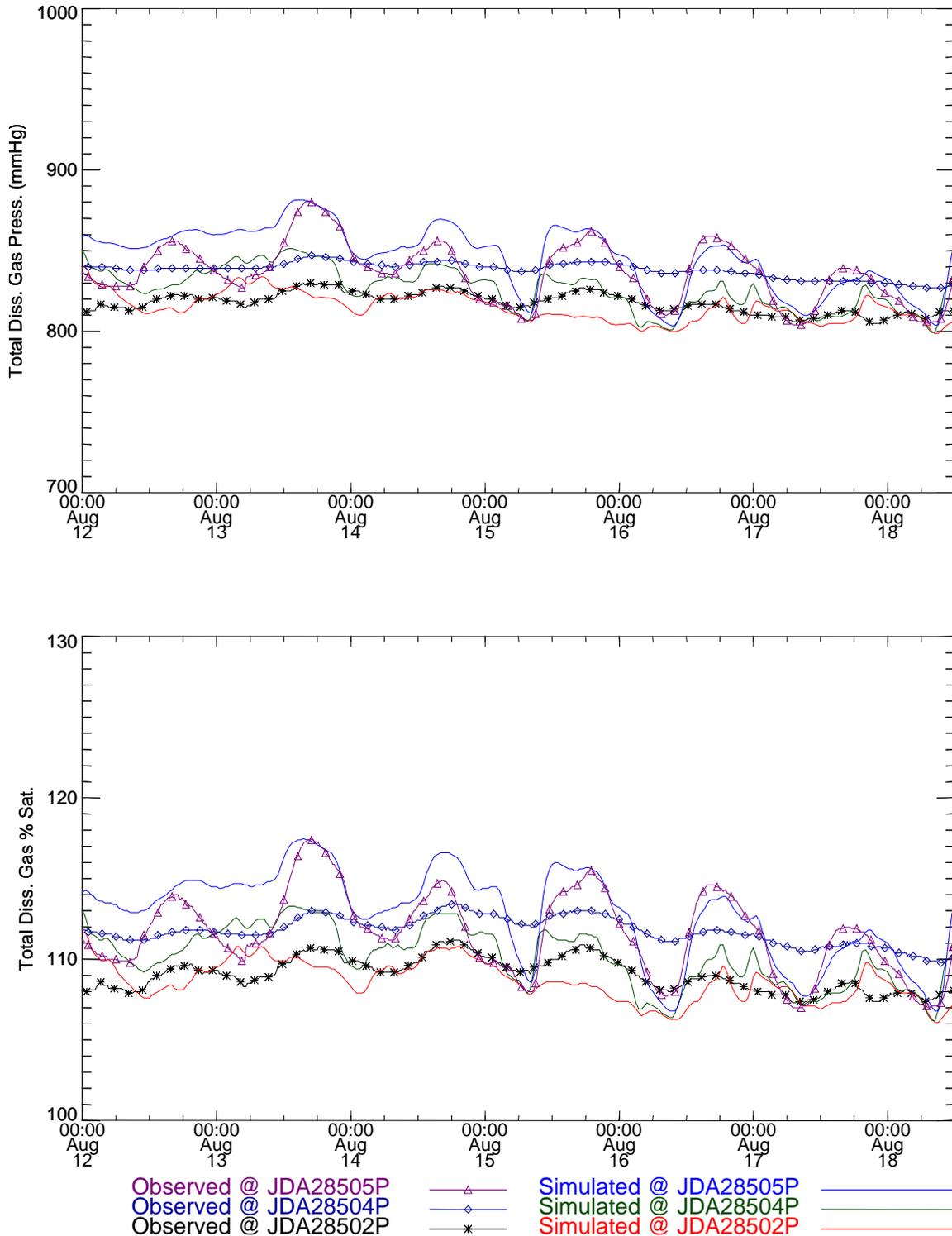


Figure 163. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 285.0 for the Summer 1997 study (FMS-BC).

Table 63. Statistical summary of measurements and simulations at river mile 285.0 during Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA28502P	20.56	20.96	0.2	0.37	0.56
JDA28504P	20.7	20.95	0.19	0.37	0.39
JDA28505P	20.86	20.98	0.36	0.37	0.38
Concentration					
JDA28502P	26.72	26.36	0.23	0.31	0.41
JDA28504P	27.32	26.73	0.22	0.48	0.68
JDA28505P	27.19	27.38	0.53	0.7	0.42
Gas Pressure					
JDA28502P	817.75	814.96	6.28	8.85	9.34
JDA28504P	838.03	826.27	4.83	13.02	15.68
JDA28505P	836.61	846.04	18.15	19.82	14.92
% Saturation					
JDA28502P	109.06	108.64	1.03	1.22	1.26
JDA28504P	111.76	110.15	0.85	1.8	2.12
JDA28505P	111.57	112.79	2.51	2.74	1.96

Table 64. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 2285.0 for the Summer 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA28502P	92.96	100	100	100
JDA28504P	97.6	85.6	100	100
JDA28505P	98.72	97.28	100	100

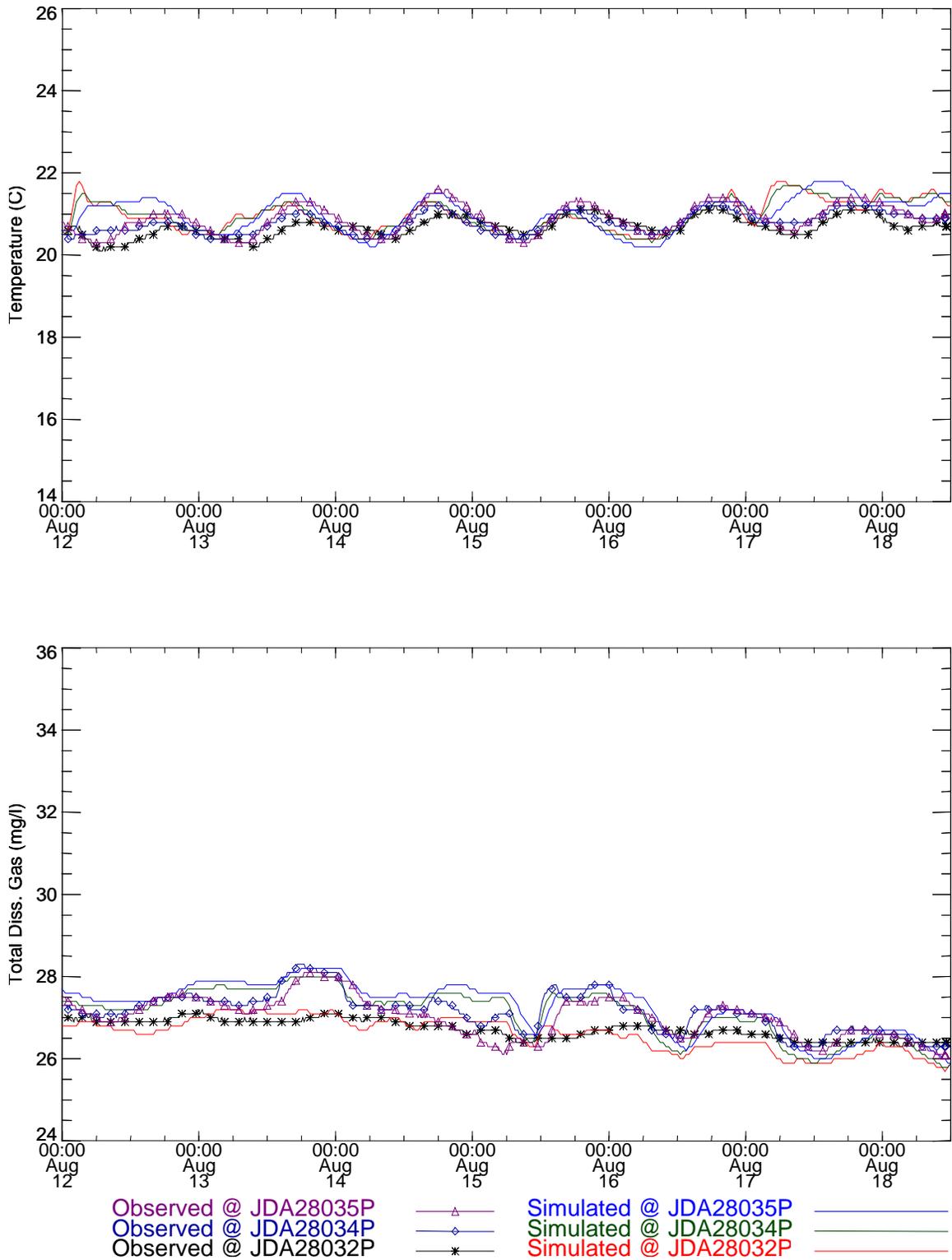


Figure 164. Temperature and total dissolved gas time series near Columbia River Mile 280.3 for the Summer 1997 study (FMS-BC).

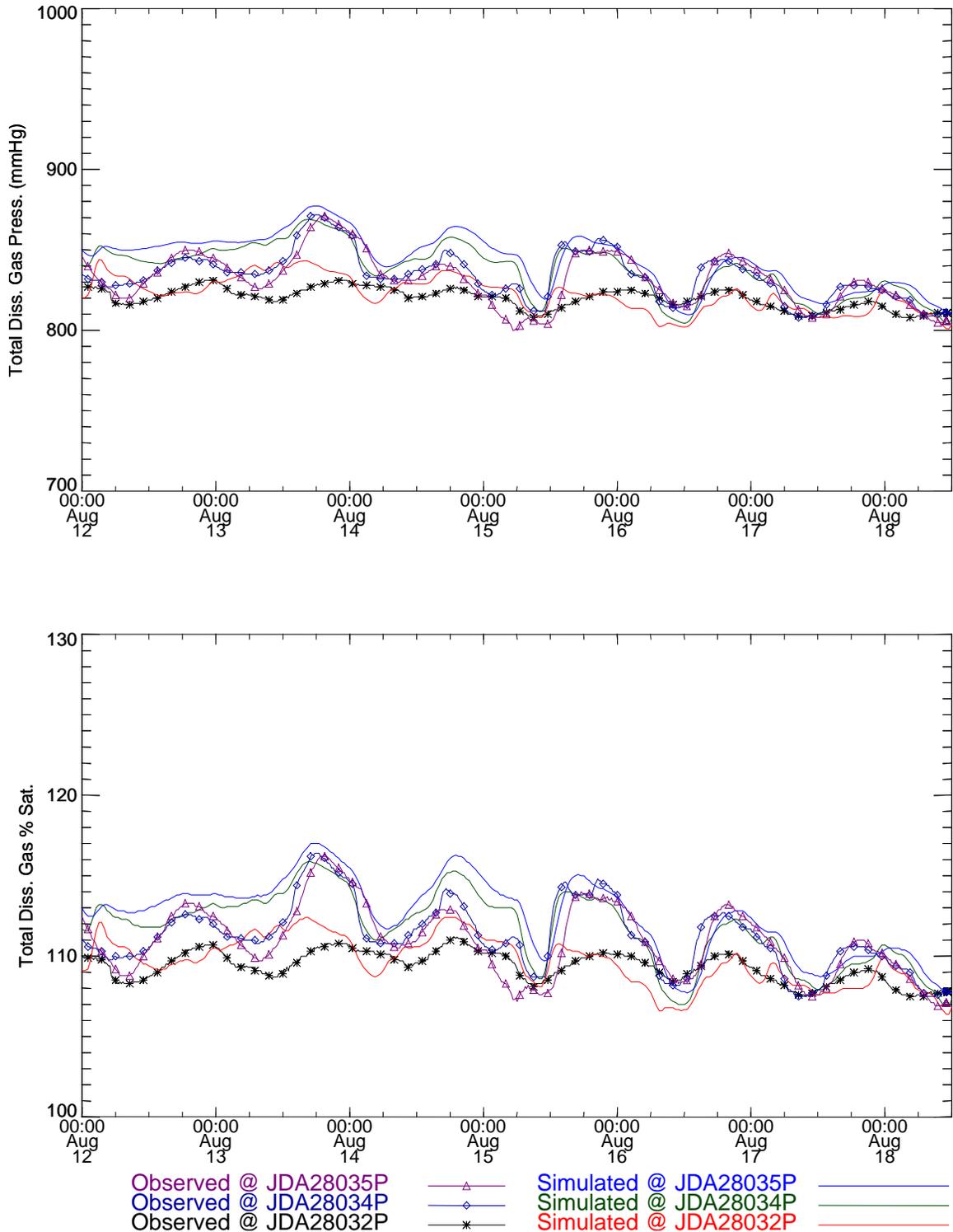


Figure 165. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 280.3 for the Summer 1997 study (FMS-BC).

Table 65. Statistical summary of measurements and simulations at river mile 280.3 during Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA28032P	20.69	20.96	0.24	0.37	0.51
JDA28034P	20.78	20.97	0.25	0.36	0.34
JDA28035P	20.89	20.99	0.34	0.42	0.36
Concentration					
JDA28032P	26.73	26.61	0.23	0.4	0.29
JDA28034P	27.15	27.12	0.47	0.58	0.26
JDA28035P	27.02	27.29	0.49	0.6	0.47
Gas Pressure					
JDA28032P	820.03	822.78	6.29	10.73	9.45
JDA28034P	834.09	838.19	14.56	15.89	9.73
JDA28035P	831.9	843.84	15.91	16.62	16.91
% Saturation					
JDA28032P	109.36	109.69	0.94	1.51	1.25
JDA28034P	111.24	111.75	2.07	2.22	1.28
JDA28035P	110.94	112.5	2.16	2.32	2.23

Table 66. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 280.3 for the Summer 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA28032P	92.6	100	100	100
JDA28034P	100	100	100	100
JDA28035P	100	93.09	97.11	96.95

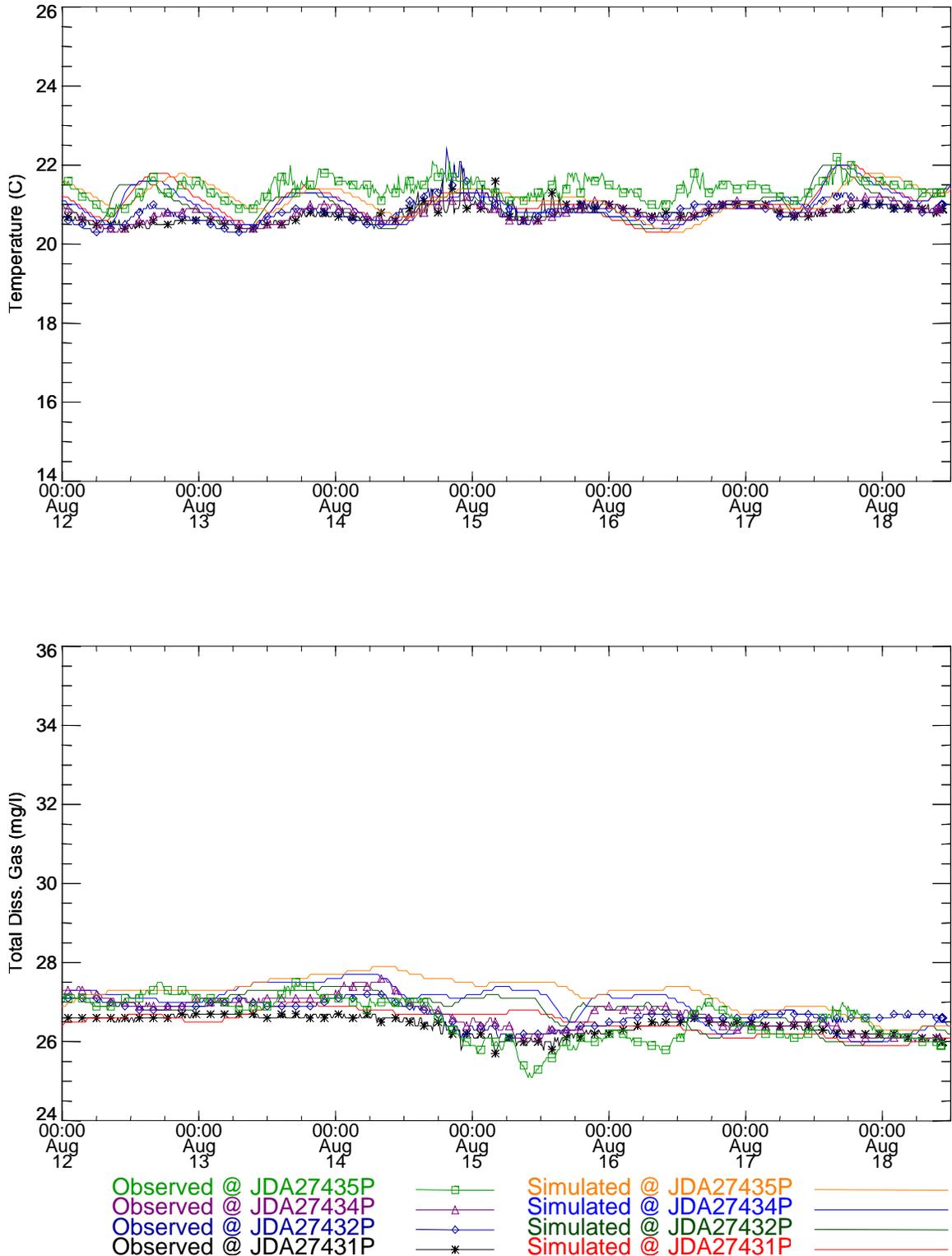


Figure 166. Temperature and total dissolved gas time series near Columbia River Mile 274.3 for the Summer 1997 study (FMS-BC).

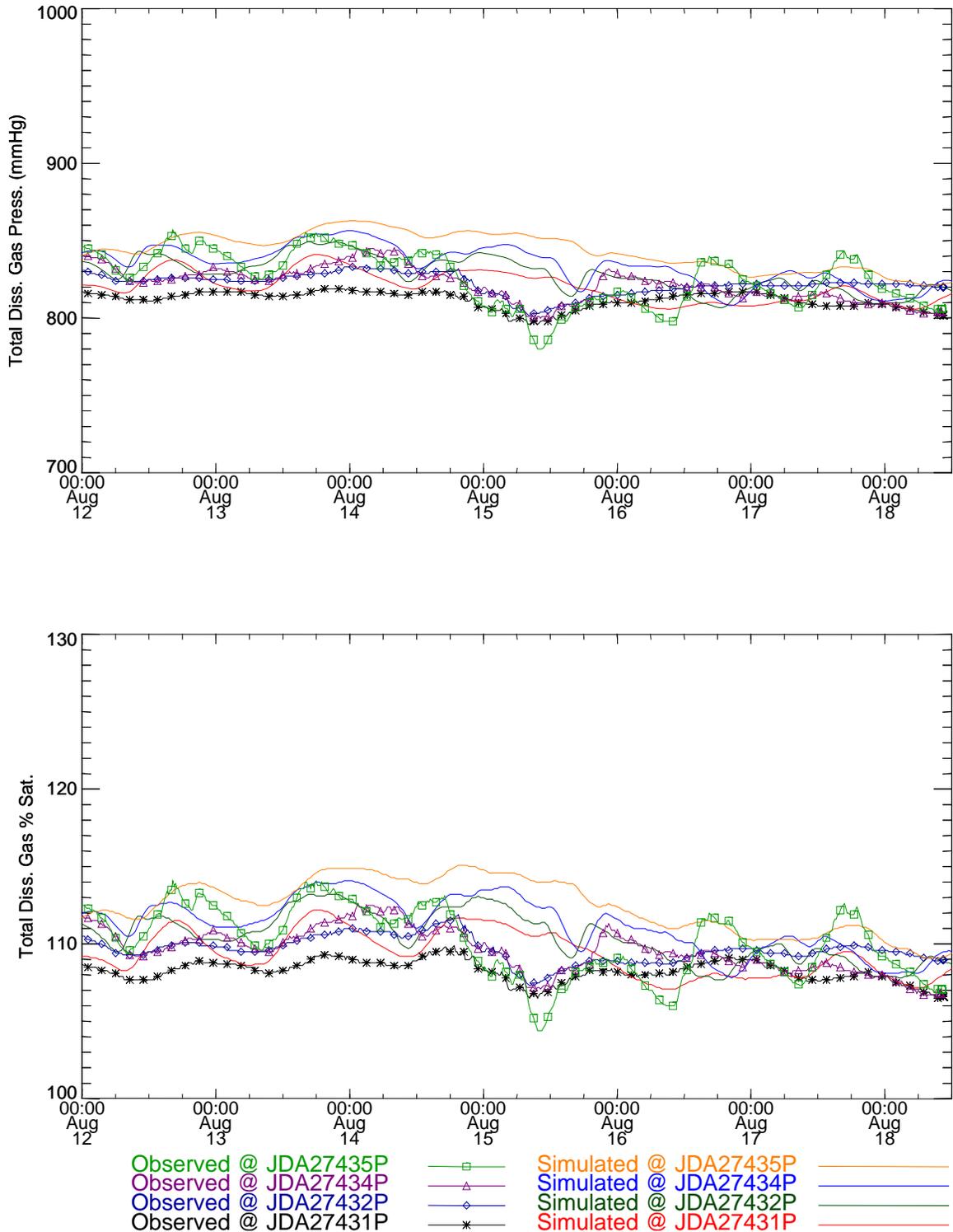


Figure 167. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 274.3 for the Summer 1997 study (FMS-BC).

Table 67. Statistical summary of measurements and simulations at river mile 274.3 during Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA27431P	20.76	21.04	0.21	0.39	0.51
JDA27432P	20.84	20.98	0.3	0.37	0.36
JDA27434P	20.81	20.99	0.21	0.36	0.37
JDA27435P	21.39	21.13	0.26	0.35	0.45
Concentration					
JDA27431P	26.41	26.49	0.23	0.3	0.32
JDA27432P	26.72	26.8	0.28	0.41	0.41
JDA27434P	26.73	26.99	0.41	0.46	0.4
JDA27435P	26.56	27.23	0.54	0.41	0.89
Gas Pressure					
JDA27431P	811.87	820.37	5.41	9.75	13.58
JDA27432P	822.1	828.63	6.76	11.23	12.76
JDA27434P	821.86	834.52	11.03	12.59	16.12
JDA27435P	825.68	843.95	17.25	11.76	24.83
% Saturation					
JDA27431P	108.27	109.37	0.68	1.45	1.79
JDA27432P	109.63	110.47	0.83	1.57	1.69
JDA27434P	109.6	111.26	1.41	1.73	2.12
JDA27435P	110.11	112.52	2.23	1.71	3.29

Table 68. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 274.3 for the Summer 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA27431P	92.57	100	100	100
JDA27432P	99.84	99.68	100	100
JDA27434P	99.03	95.8	96.45	96.45
JDA27435P	97.58	73.18	86.43	86.27

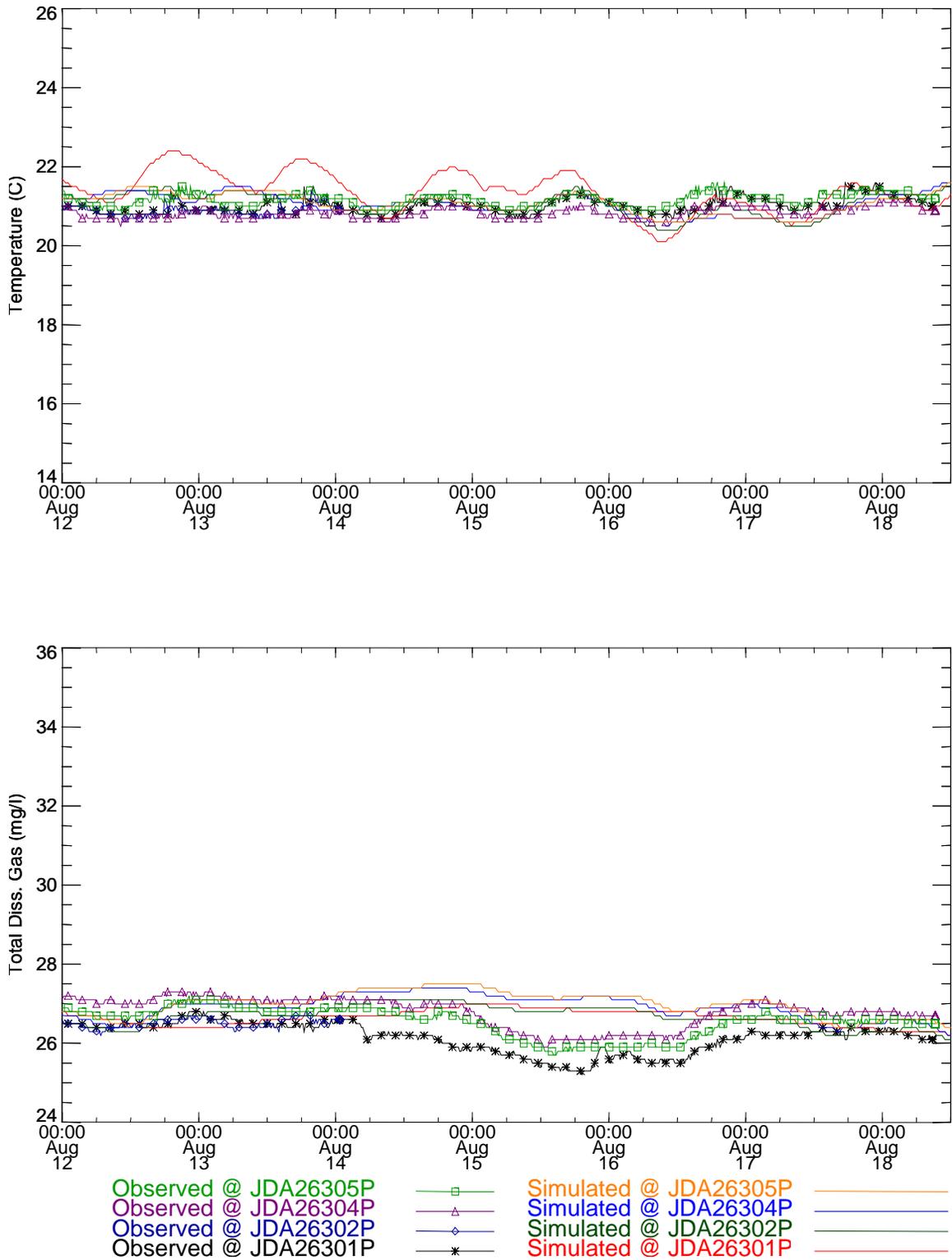


Figure 168. Temperature and total dissolved gas time series near Columbia River Mile 263.0 for the Summer 1997 study (FMS-BC).

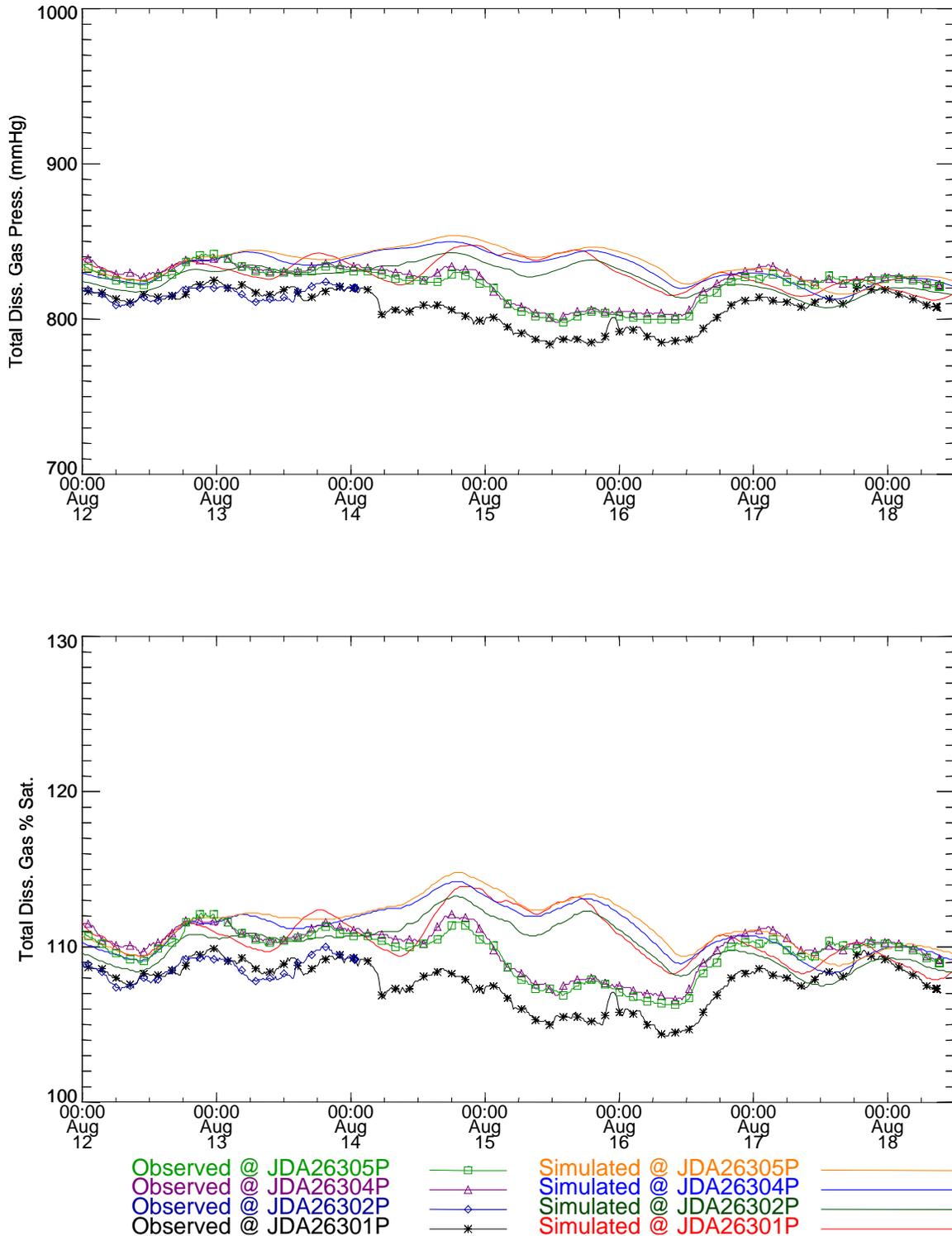


Figure 169. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 263.0 for the Summer 1997 study (FMS-BC).

Table 69. Statistical summary of measurements and simulations at river mile 263.0 during Summer 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA26301P	21.01	21.36	0.2	0.51	0.62
JDA26302P	20.89	21.05	0.07	0.29	0.34
JDA26304P	20.83	21.04	0.14	0.26	0.36
JDA26305P	21.17	21.06	0.16	0.26	0.31
Concentration					
JDA26301P	26.15	26.65	0.38	0.2	0.74
JDA26302P	26.57	26.69	0.08	0.26	0.28
JDA26304P	26.8	26.92	0.38	0.3	0.51
JDA26305P	26.54	27.01	0.37	0.31	0.68
Gas Pressure					
JDA26301P	807.32	829.89	11.69	9.12	27.53
JDA26302P	818.85	826.33	2.93	8.77	11.75
JDA26304P	824.23	833.47	11.54	9.54	17.31
JDA26305P	821.7	836.15	11.64	9.73	20.97
% Saturation					
JDA26301P	107.67	110.65	1.44	1.49	3.65
JDA26302P	109.02	110.17	0.49	1.4	1.8
JDA26304P	109.92	111.12	1.47	1.49	2.3
JDA26305P	109.59	111.49	1.49	1.53	2.79

Table 70. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 263.0 for the Summer 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA26301P	89.05	74.67	81.21	81.21
JDA26302P	100	100	100	100
JDA26304P	100	95.92	94.61	93.79
JDA26305P	100	80.39	87.75	87.25

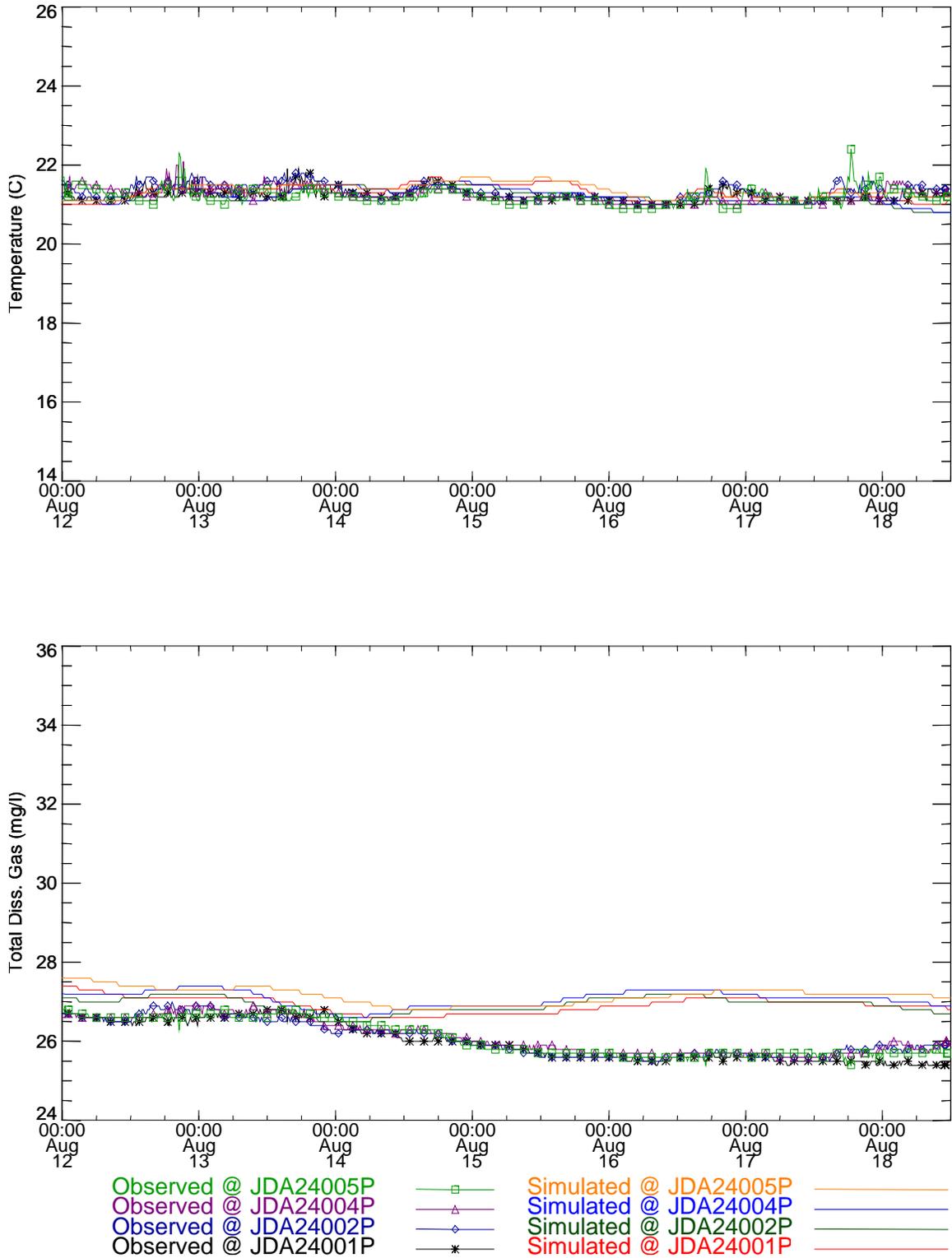


Figure 170. Temperature and total dissolved gas time series near Columbia River Mile 240.0 for the Summer 1997 study (FMS-BC).

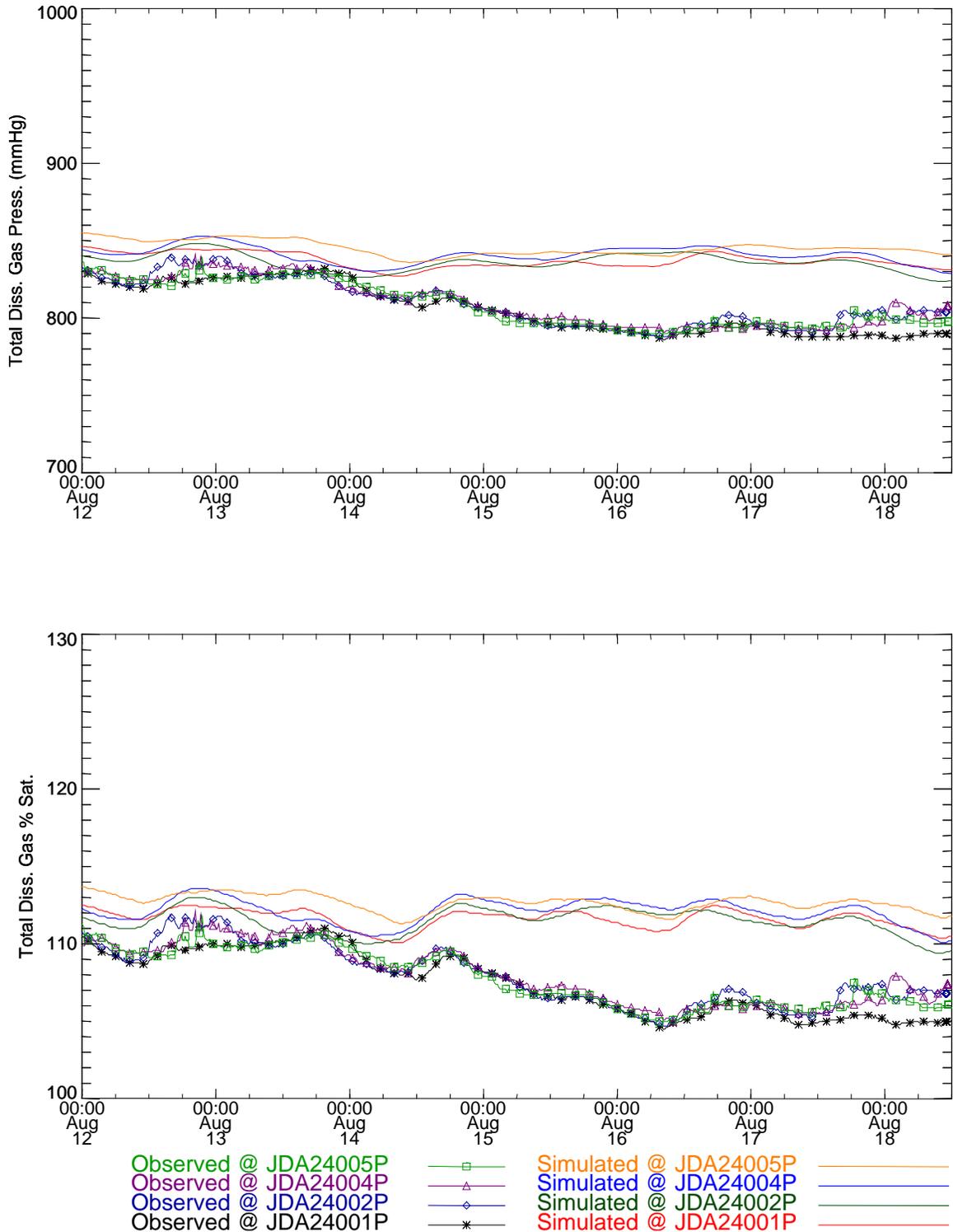


Figure 171. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 240.0 for the Summer 1997 study (FMS-BC).

Table 71. Statistical summary of measurements and simulations at river mile 240.0 during Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA24001P	21.23	21.29	0.16	0.2	0.2
JDA24002P	21.33	21.21	0.2	0.18	0.26
JDA24004P	21.24	21.23	0.18	0.18	0.24
JDA24005P	21.2	21.36	0.2	0.18	0.31
Concentration					
JDA24001P	25.99	26.93	0.49	0.2	1.05
JDA24002P	26.06	26.93	0.44	0.2	1
JDA24004P	26.12	27.08	0.44	0.2	1.07
JDA24005P	26.08	27.16	0.45	0.2	1.16
Gas Pressure					
JDA24001P	805.89	837.38	15.81	4.8	34.63
JDA24002P	809.58	836.24	15.19	5.66	30.86
JDA24004P	810.03	840.96	15.11	5.43	34.58
JDA24005P	808.29	845.28	14.52	4.77	38.94
% Saturation					
JDA24001P	107.47	111.64	2.06	0.61	4.58
JDA24002P	107.97	111.48	1.94	0.83	4.08
JDA24004P	108.02	112.11	1.93	0.79	4.58
JDA24005P	107.79	112.69	1.85	0.54	5.16

Table 72. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 240.0 for the Summer 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA24001P	100	55.07	52.98	52.82
JDA24002P	100	58.62	69.24	69.24
JDA24004P	100	55.56	60.71	60.23
JDA24005P	99.84	47.83	47.5	46.22

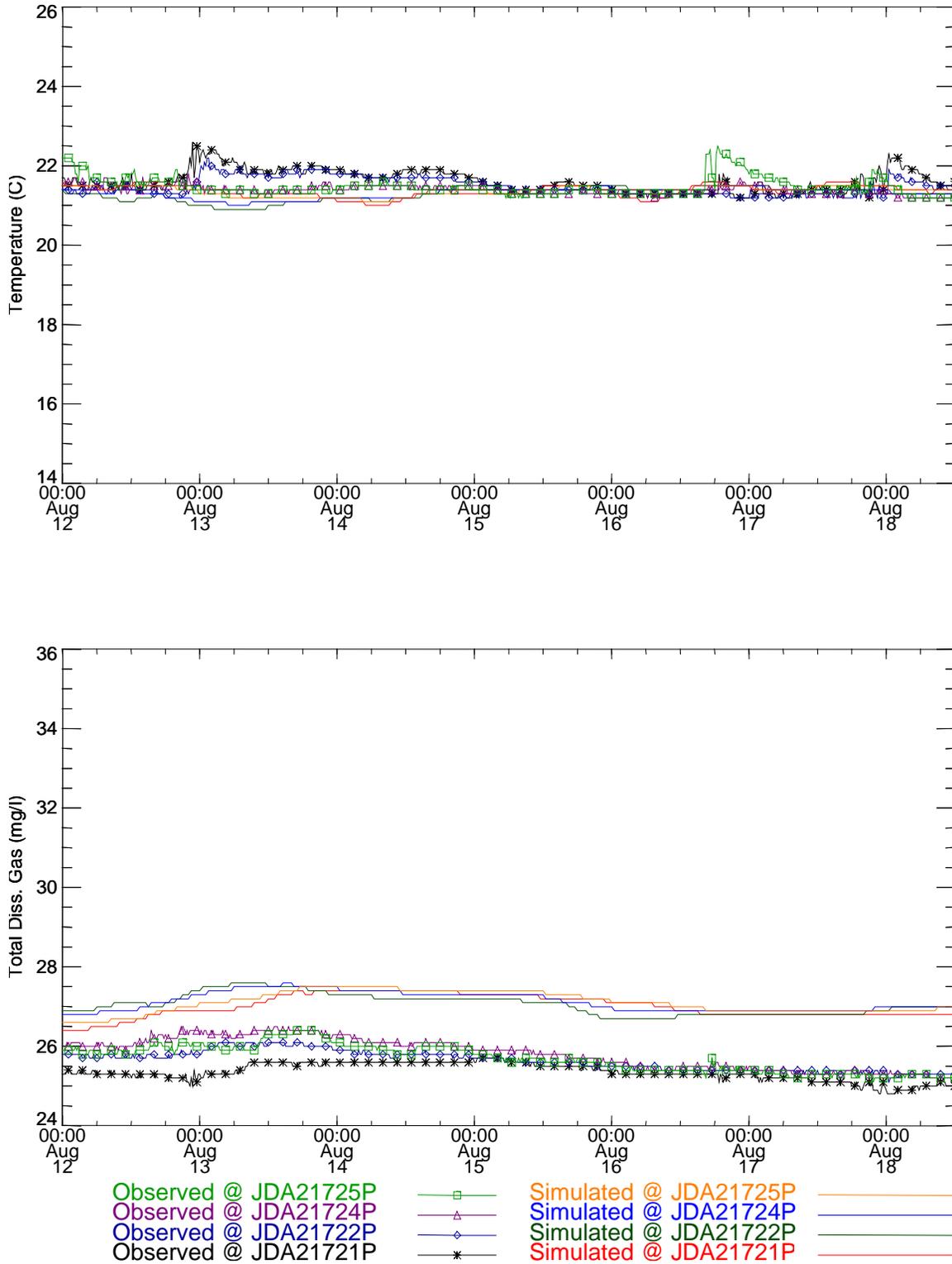


Figure 172. Temperature and total dissolved gas time series near Columbia River Mile 217.2 for the Summer 1997 study (FMS-BC).

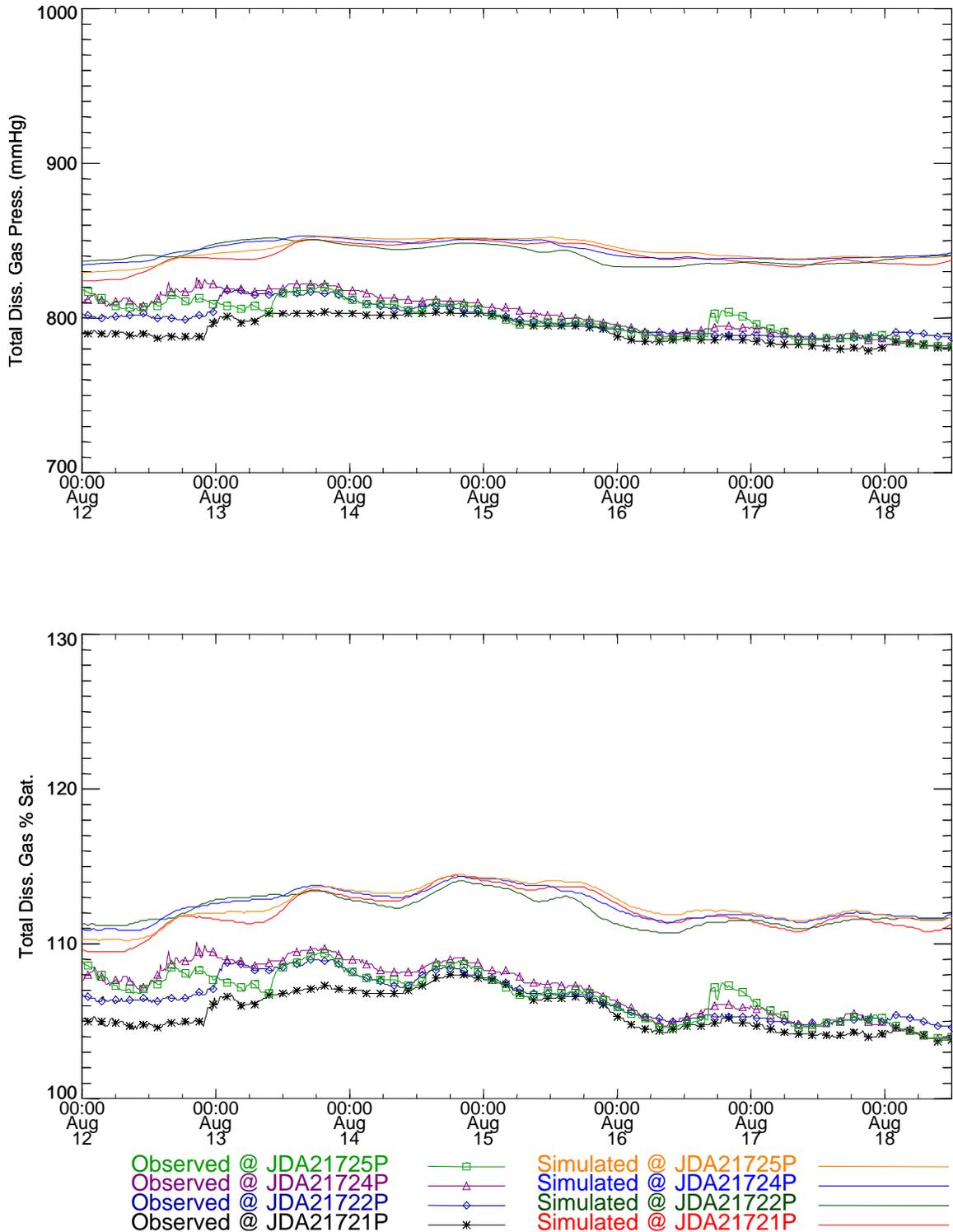


Figure 173. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 271.2 for the Summer 1997 study (FMS-BC).

Table 73. Statistical summary of measurements and simulations at river mile 217.2 during Summer 1997 pool study.

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA21721P	21.61	21.37	0.28	0.15	0.42
JDA21722P	21.5	21.28	0.22	0.16	0.41
JDA21724P	21.4	21.32	0.11	0.13	0.2
JDA21725P	21.48	21.37	0.24	0.12	0.25
Concentration					
JDA21721P	25.36	27.01	0.22	0.28	1.67
JDA21722P	25.64	27.06	0.24	0.26	1.43
JDA21724P	25.82	27.13	0.39	0.23	1.33
JDA21725P	25.69	27.11	0.34	0.27	1.45
Gas Pressure					
JDA21721P	792.2	840.77	8.17	7.29	48.93
JDA21722P	799.15	841.31	9.82	5.87	42.49
JDA21724P	803.24	843.82	12.76	5.66	41.81
JDA21725P	800.4	843.83	10.73	6.56	44.83
% Saturation					
JDA21721P	105.65	112.09	1.26	1.26	6.49
JDA21722P	106.57	112.16	1.36	0.94	5.63
JDA21724P	107.12	112.49	1.74	0.99	5.54
JDA21725P	106.74	112.5	1.48	1.15	5.94

Table 74. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 217.2 for the Summer 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA21721P	99.84	0.96	8.32	8.48
JDA21722P	99.2	0	27.84	28.96
JDA21724P	100	16.96	41.12	40.32
JDA21725P	100	17.12	30.24	30.24

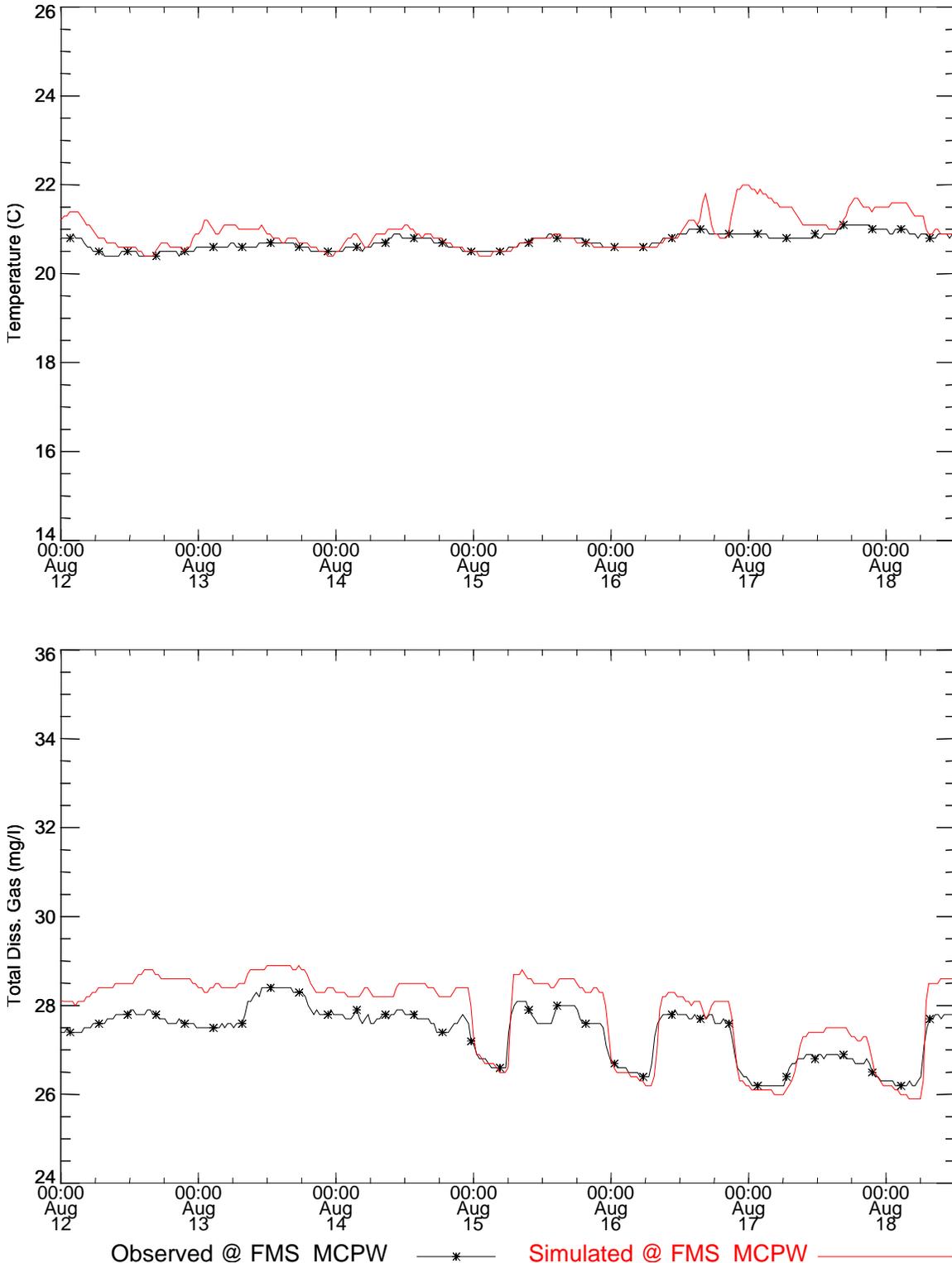


Figure 174. Temperature and total dissolved gas time series near fixed monitor MCPW for the Summer 1997 study (FMS-BC).

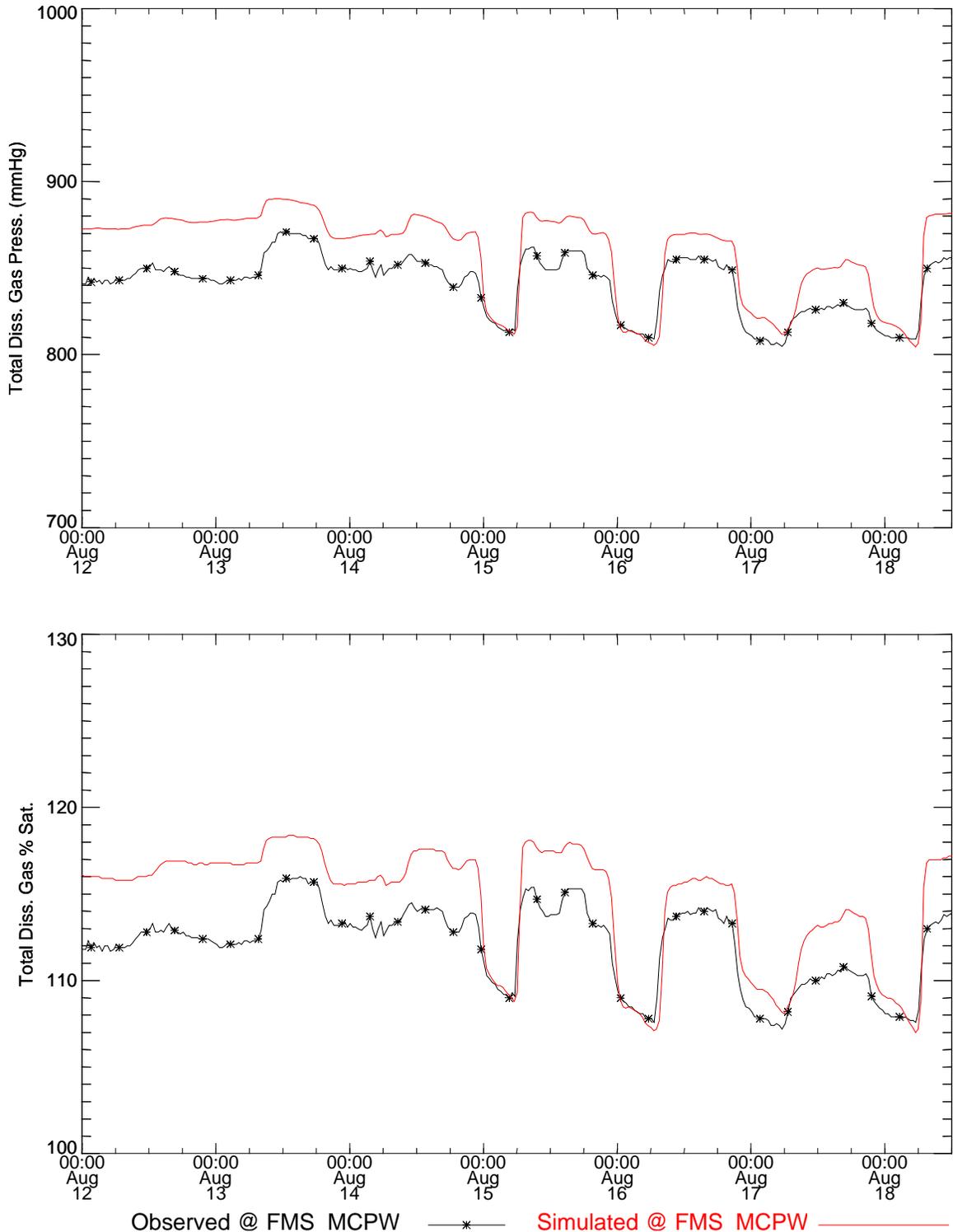


Figure 175. Total dissolved gas pressure and saturation time series comparisons near fixed monitor for the Summer 1997 study (FMS-BC).

Table 75. Statistical summary of measurements and simulations at fixed monitor MCPW during Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature FMS_MCPW	20.72	20.94	0.18	0.37	0.35
Concentration FMS_MCPW	27.39	27.86	0.6	0.91	0.6
Gas Pressure FMS_MCPW	840.55	859.83	17.19	24.9	22.15
% Saturation FMS_MCPW	112.09	114.63	2.31	3.31	2.92

Table 76. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor MCPW for the Summer 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_MCPW	99.04	100	100	100

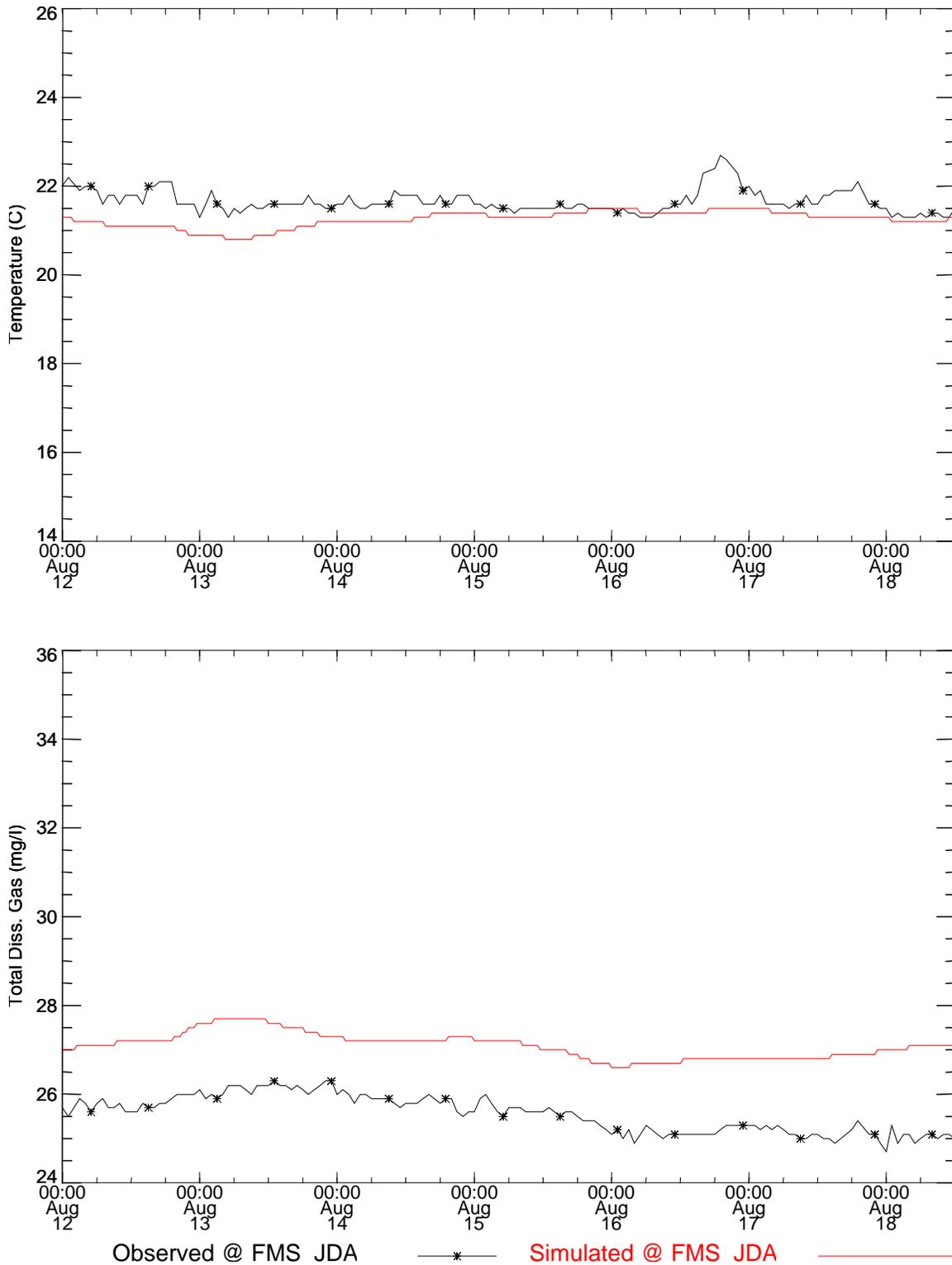


Figure 176. Temperature and total dissolved gas time series near fixed monitor JDA for the Summer 1997 study (FMS-BC).

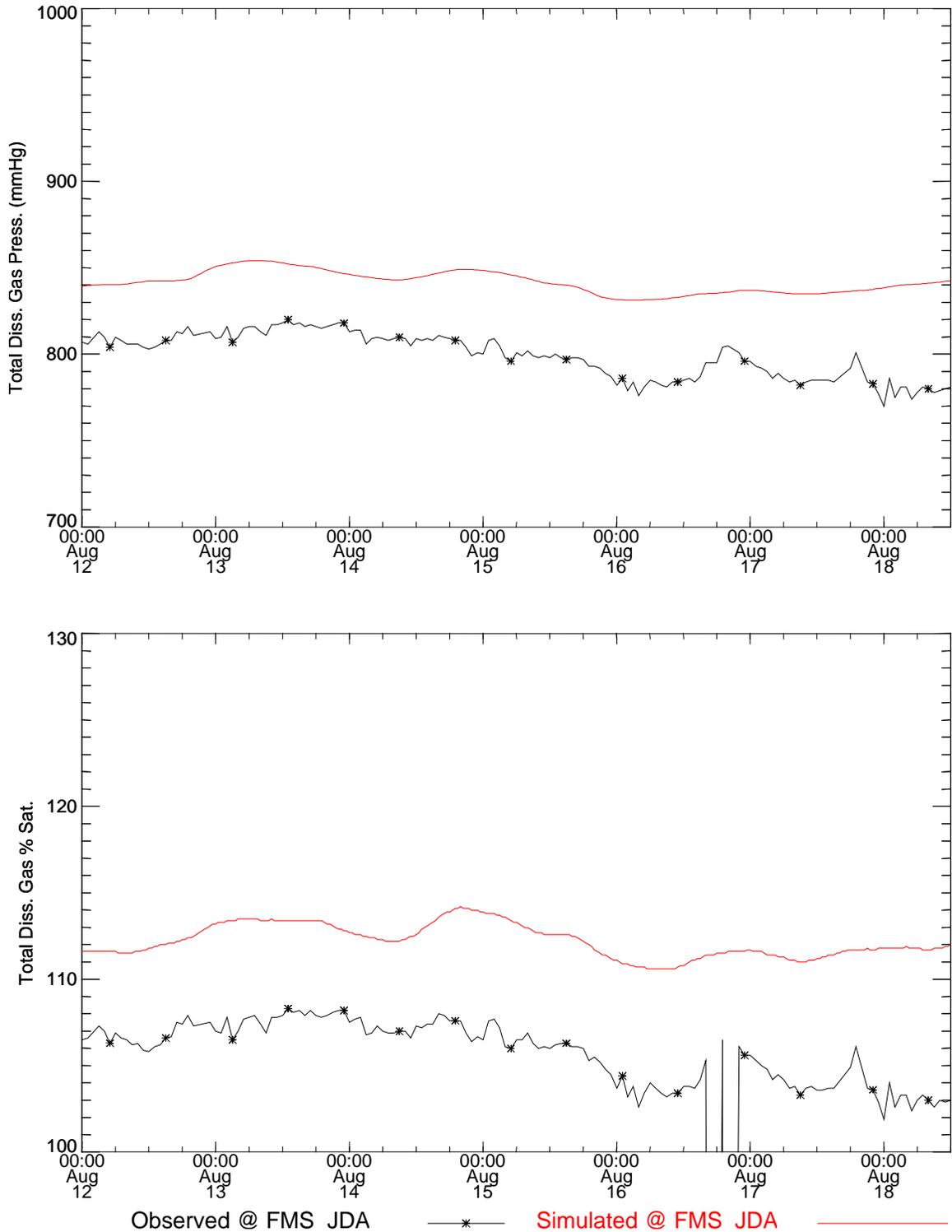


Figure 177. Total dissolved gas pressure and saturation time series comparisons near fixed monitor JDA for the Summer 1997 study (FMS-BC).

Table 77. Statistical summary of measurements and simulations at fixed monitor JDA for the Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature FMS_JDA	21.66	21.25	0.26	0.18	0.5
Concentration FMS_JDA	25.56	27.09	0.41	0.28	1.55
Gas Pressure FMS_JDA	799.18	841.72	12.72	6.28	43.44
% Saturation FMS_JDA	103.79	112.21	12.28	0.95	14.74

Table 78. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor JDA for the Summer 1997 study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_JDA	98.4	0.96	35.78	10.22

Boundary Conditions using Temporary Monitored Field Data

Comparisons between the measurements and simulations using an upstream boundary condition developed from water temperatures and TDG pressures measured by temporary monitors are shown in the figures below. Statistics on comparisons between measured and simulated temperatures and total dissolved gas are also presented. The case is denoted as TM-BC in the figure and table captions.

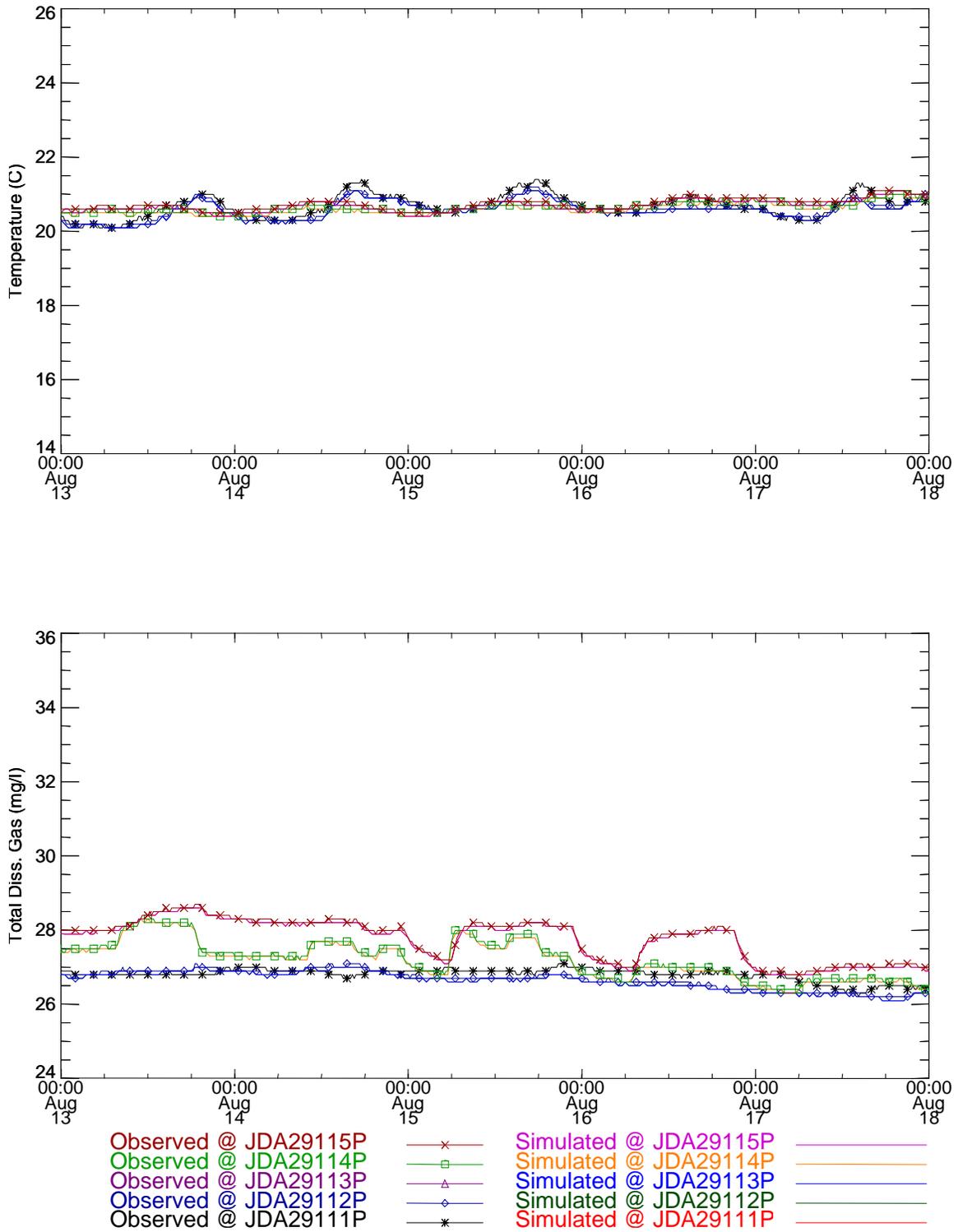


Figure 178. Temperature and total dissolved gas time series near Columbia River Mile 291.1 for the Summer 1997 study (TM-BC).

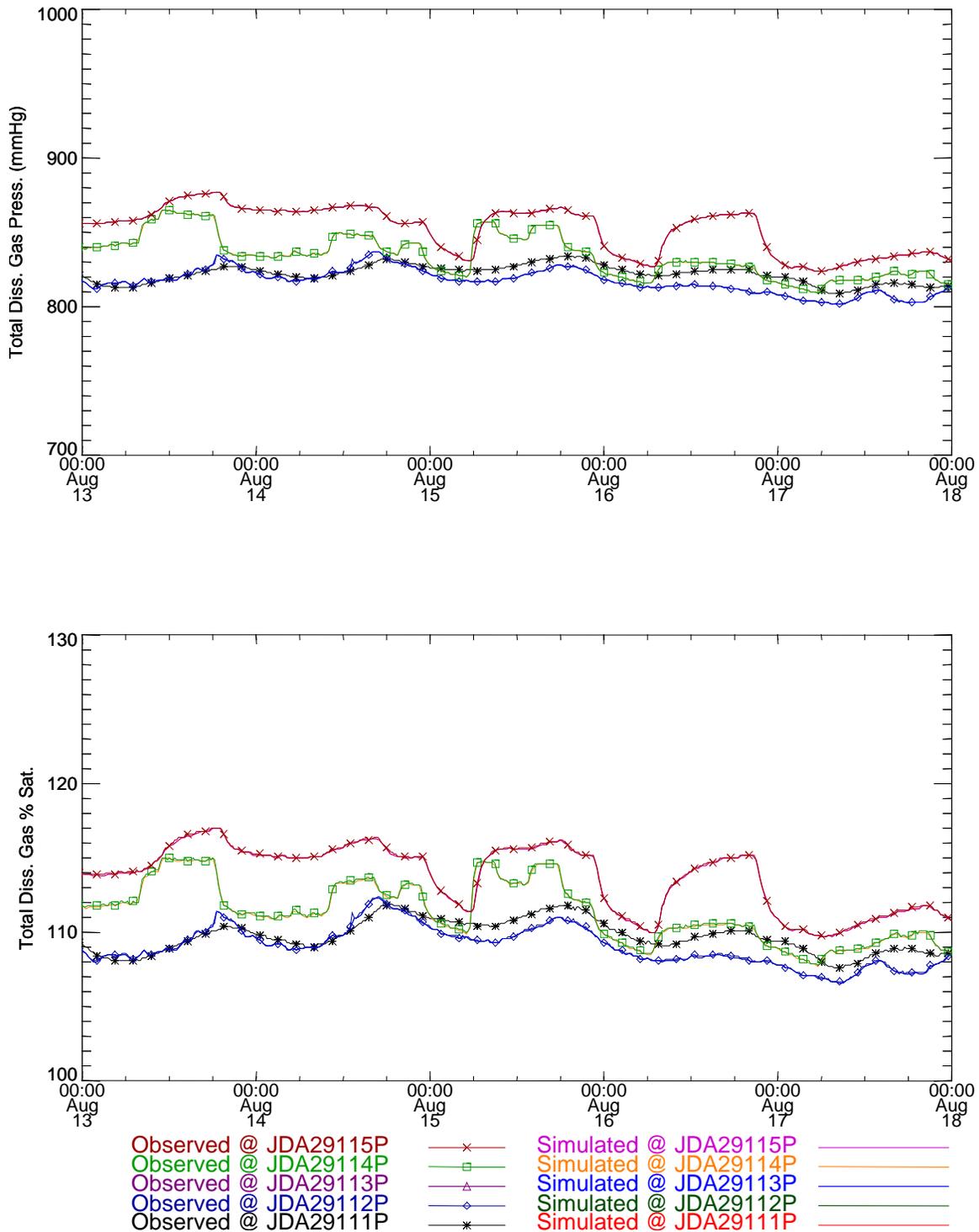


Figure 179. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 291.1 for the Summer 1997 study (TM-BC).

Table 79. Statistical summary of measurements and simulations at river mile 291.1 during the Summer 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA29111P	20.68	20.68	0.3	0.16	0.3
JDA29112P	20.6	20.56	0.25	0.25	0.06
JDA29113P	20.4	20.56	0	0.25	0.3
JDA29114P	20.65	20.6	0.14	0.15	0.07
JDA29115P	20.74	20.68	0.16	0.16	0.07
Concentration					
JDA29111P	26.8	27.74	0.17	0.55	1.05
JDA29112P	26.68	26.63	0.25	0.25	0.07
JDA29113P	27.5	26.63	0	0.25	0.91
JDA29114P	27.22	27.18	0.52	0.51	0.07
JDA29115P	27.78	27.74	0.54	0.55	0.07
Gas Pressure					
JDA29111P	822.05	852.4	6.12	15.61	33.24
JDA29112P	817.19	817.14	8.14	8.13	0.1
JDA29113P	839	817.14	0	8.13	23.32
JDA29114P	834.38	834.34	14.37	14.36	0.12
JDA29115P	852.45	852.4	15.61	15.61	0.12
% Saturation					
JDA29111P	109.73	113.74	1.1	2.15	4.4
JDA29112P	109.07	109.04	1.3	1.3	0.06
JDA29113P	111.3	109.04	0	1.3	2.61
JDA29114P	111.37	111.32	2	2	0.07
JDA29115P	113.78	113.74	2.15	2.15	0.07

Table 80. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 291.1 for the Summer 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
JDA29111P	100	45.23	65.98	64.32
JDA29112P	100	100	100	100
JDA29113P	100	74.27	100	100
JDA29114P	100	100	100	100
JDA29115P	100	100	100	100

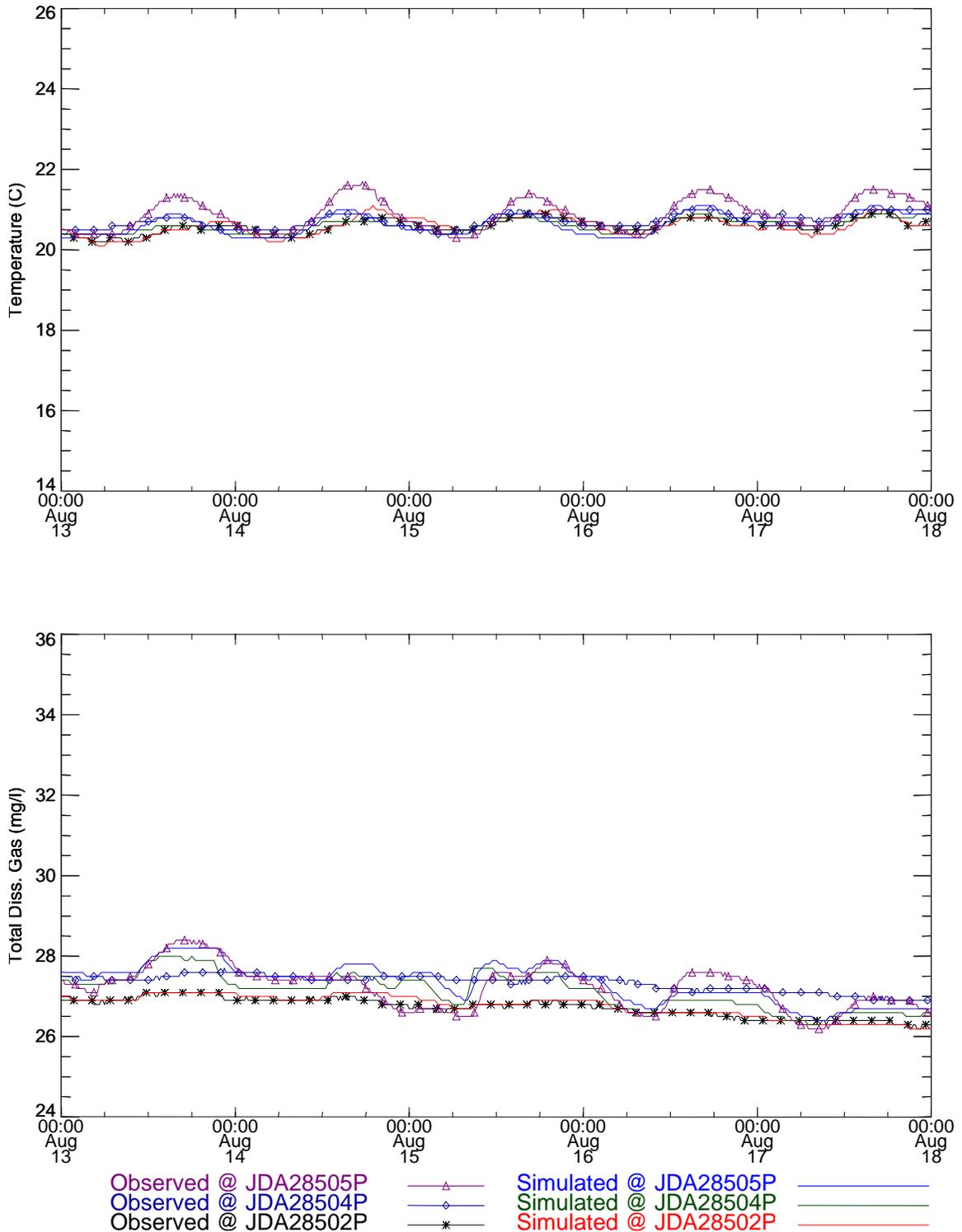


Figure 180. Temperature and total dissolved gas time series near Columbia River Mile 285.0 for the Summer 1997 study (TM-BC).

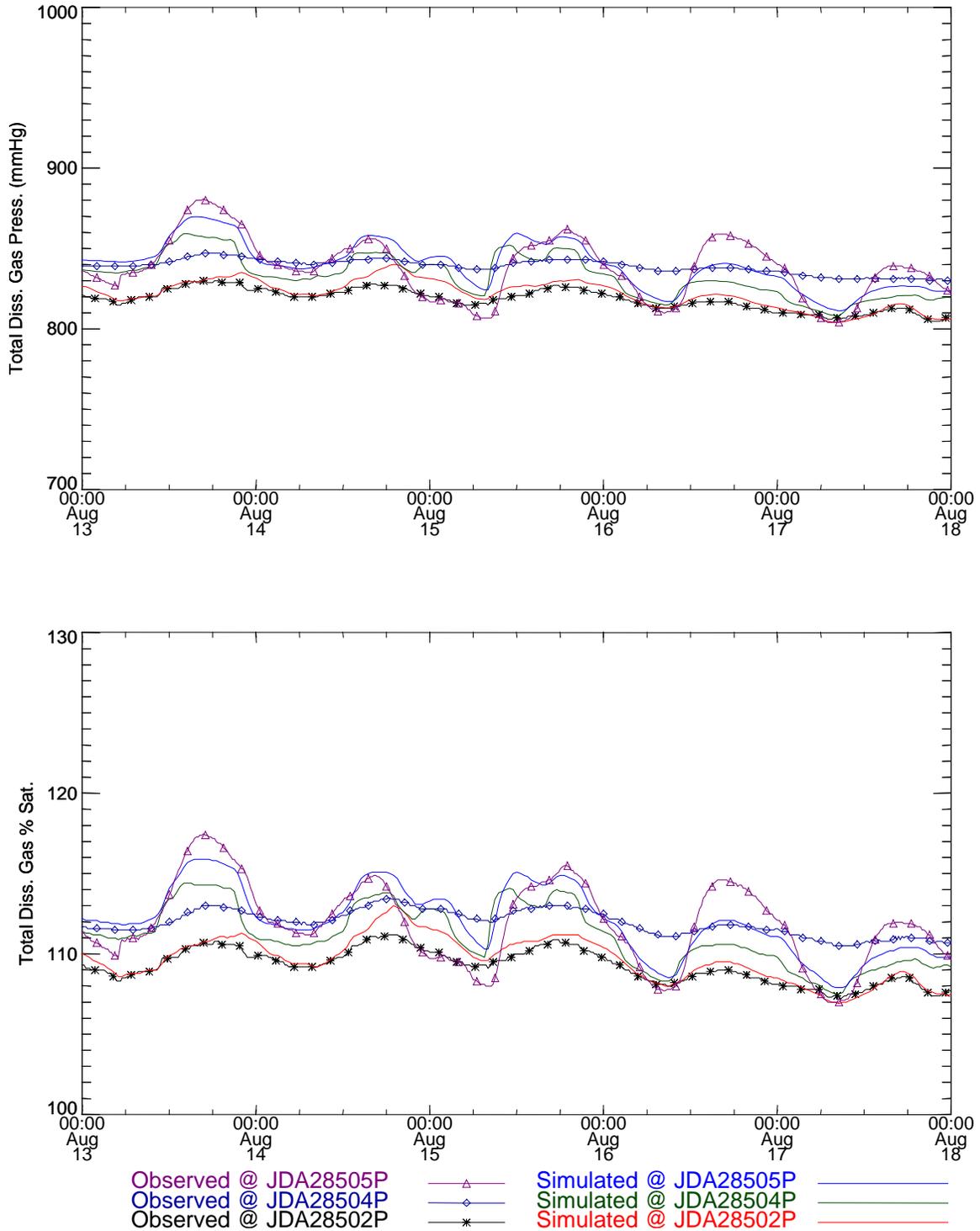


Figure 181. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 285.0 for the Summer 1997 study (TM-BC).

Table 81. Statistical summary of measurements and simulations at river mile 285.0 during Summer 1997 pool study (TM-BC)

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA28502P	20.6	20.59	0.18	0.22	0.1
JDA28504P	20.72	20.6	0.18	0.16	0.14
JDA28505P	20.89	20.64	0.38	0.25	0.32
Concentration					
JDA28502P	26.72	26.76	0.24	0.28	0.1
JDA28504P	27.34	27.13	0.2	0.44	0.38
JDA28505P	27.23	27.34	0.52	0.48	0.34
Gas Pressure					
JDA28502P	818.43	821.75	6.57	8.67	4.74
JDA28504P	838.82	832.76	4.42	12.89	11.17
JDA28505P	838.22	839.83	18.49	14.41	10.88
% Saturation					
JDA28502P	109.24	109.65	1.05	1.39	0.61
JDA28504P	111.96	111.11	0.78	1.87	1.51
JDA28505P	111.88	112.06	2.53	2.08	1.45

Table 82. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 285.0 for the Summer 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA28502P	100	100	100	100
JDA28504P	100	100	100	100
JDA28505P	100	100	100	100

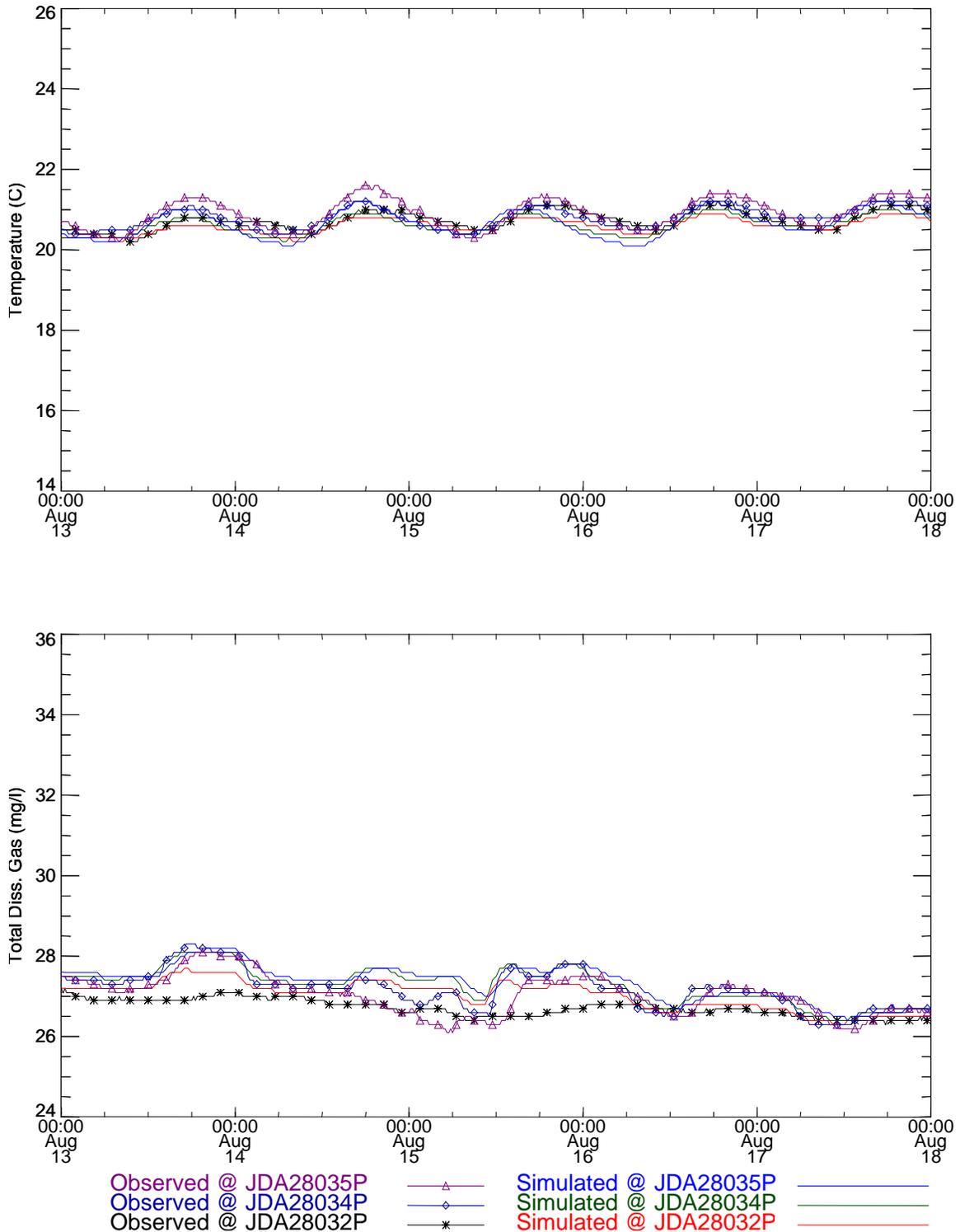


Figure 182. Temperature and total dissolved gas time series near Columbia River Mile 280.3 for the Summer 1997 study (TM-BC).

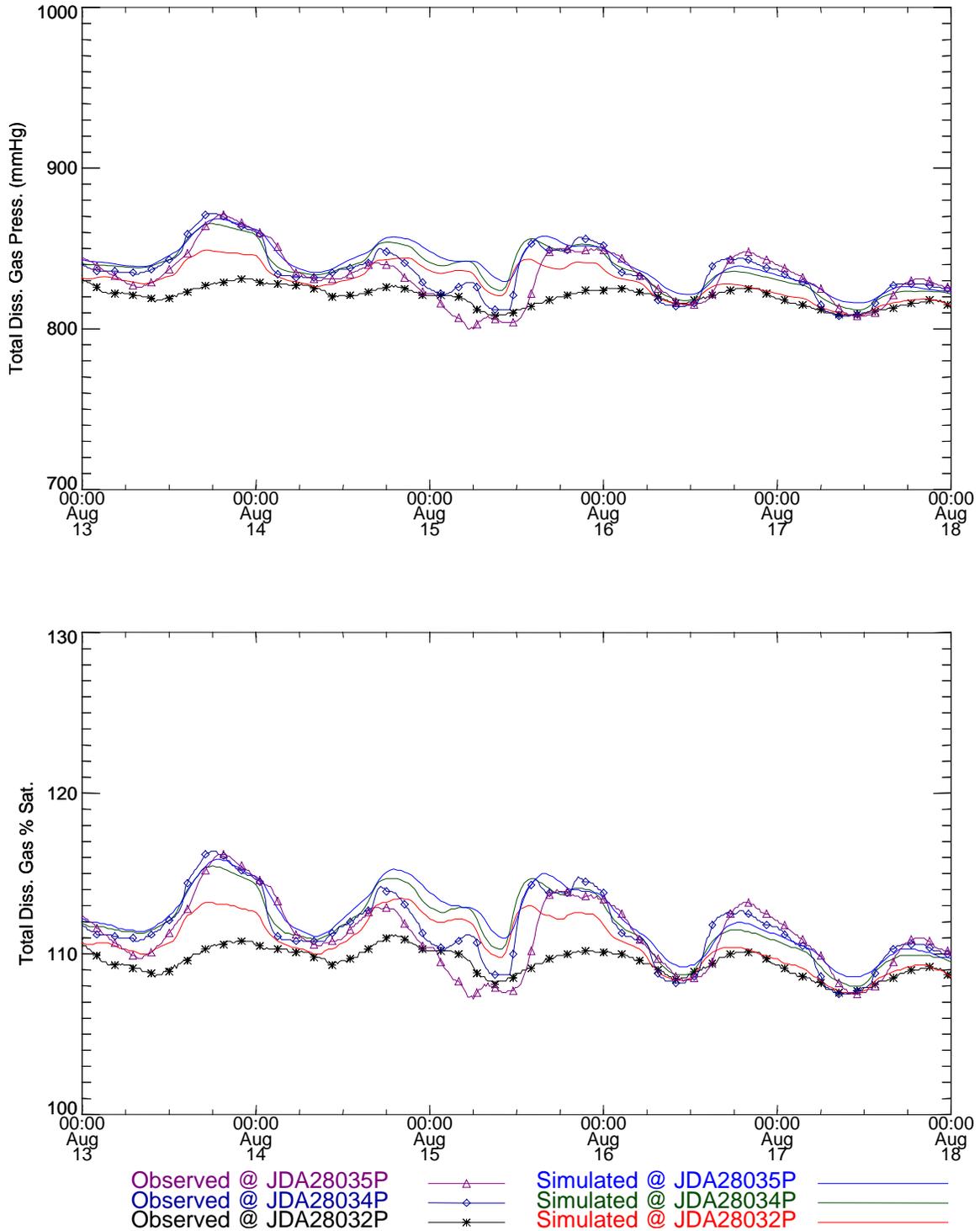


Figure 183. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 280.3 for the Summer 1997 study (TM-BC).

Table 83. Statistical summary of measurements and simulations at river mile 280.3 during Summer 1997 pool study (USBC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA28032P	20.73	20.6	0.24	0.18	0.18
JDA28034P	20.8	20.62	0.26	0.23	0.2
JDA28035P	20.92	20.66	0.36	0.33	0.31
Concentration					
JDA28032P	26.71	27.03	0.21	0.35	0.4
JDA28034P	27.19	27.28	0.48	0.45	0.21
JDA28035P	27.04	27.35	0.49	0.44	0.46
Gas Pressure					
JDA28032P	820.29	829.64	5.79	10.56	12.22
JDA28034P	835.57	837.54	15.06	13.26	6.7
JDA28035P	832.76	840.22	16.29	13.1	13.78
% Saturation					
JDA28032P	109.48	110.7	0.85	1.61	1.61
JDA28034P	111.53	111.75	2.1	1.94	0.88
JDA28035P	111.15	112.11	2.17	1.93	1.82

Table 84. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 280.3 for the Summer 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA28032P	100	100	100	100
JDA28034P	100	100	100	100
JDA28035P	100	94.19	98.34	98.34

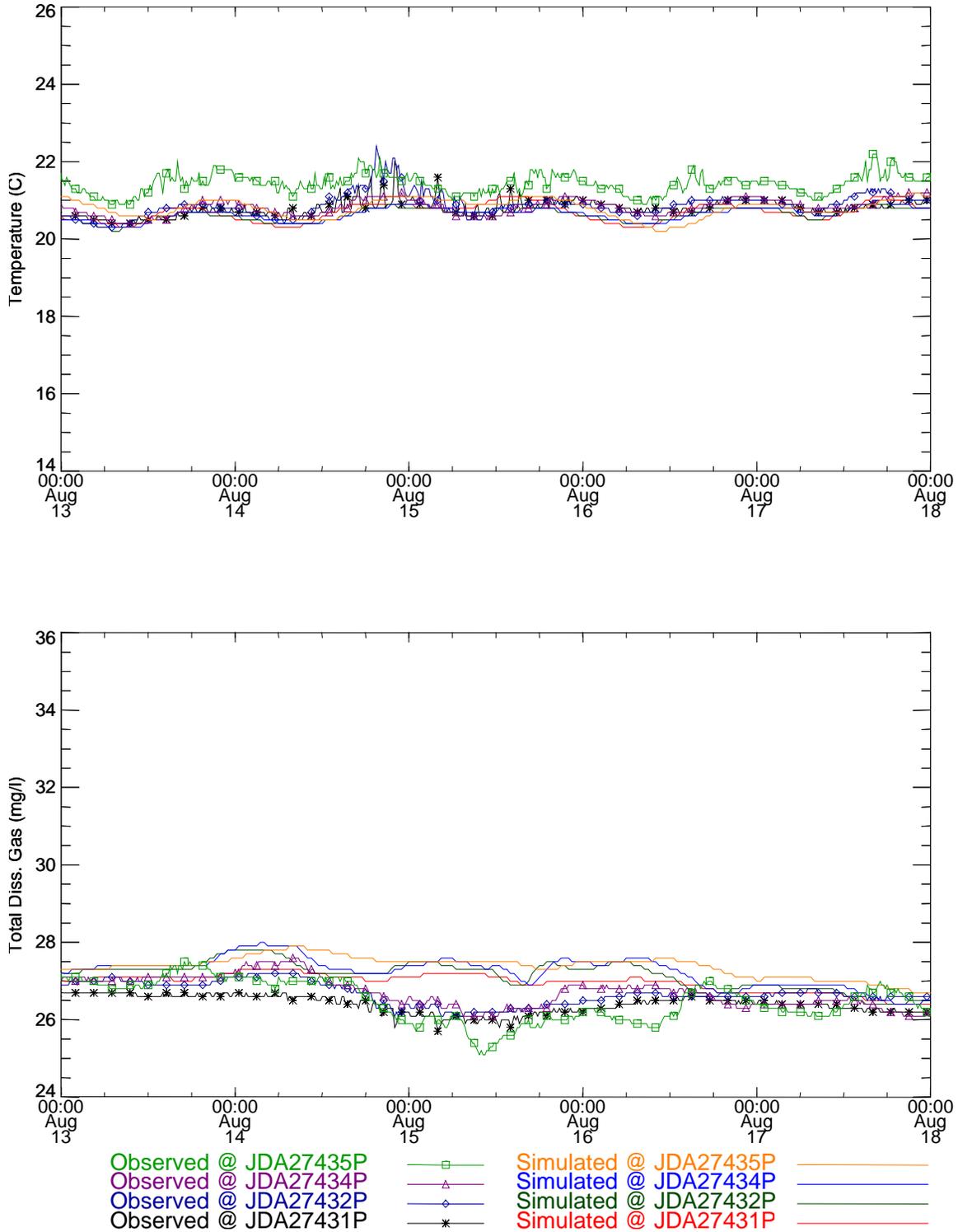


Figure 184. Temperature and total dissolved gas time series near Columbia River Mile 274.3 for the Summer 1997 study (TM-BC).

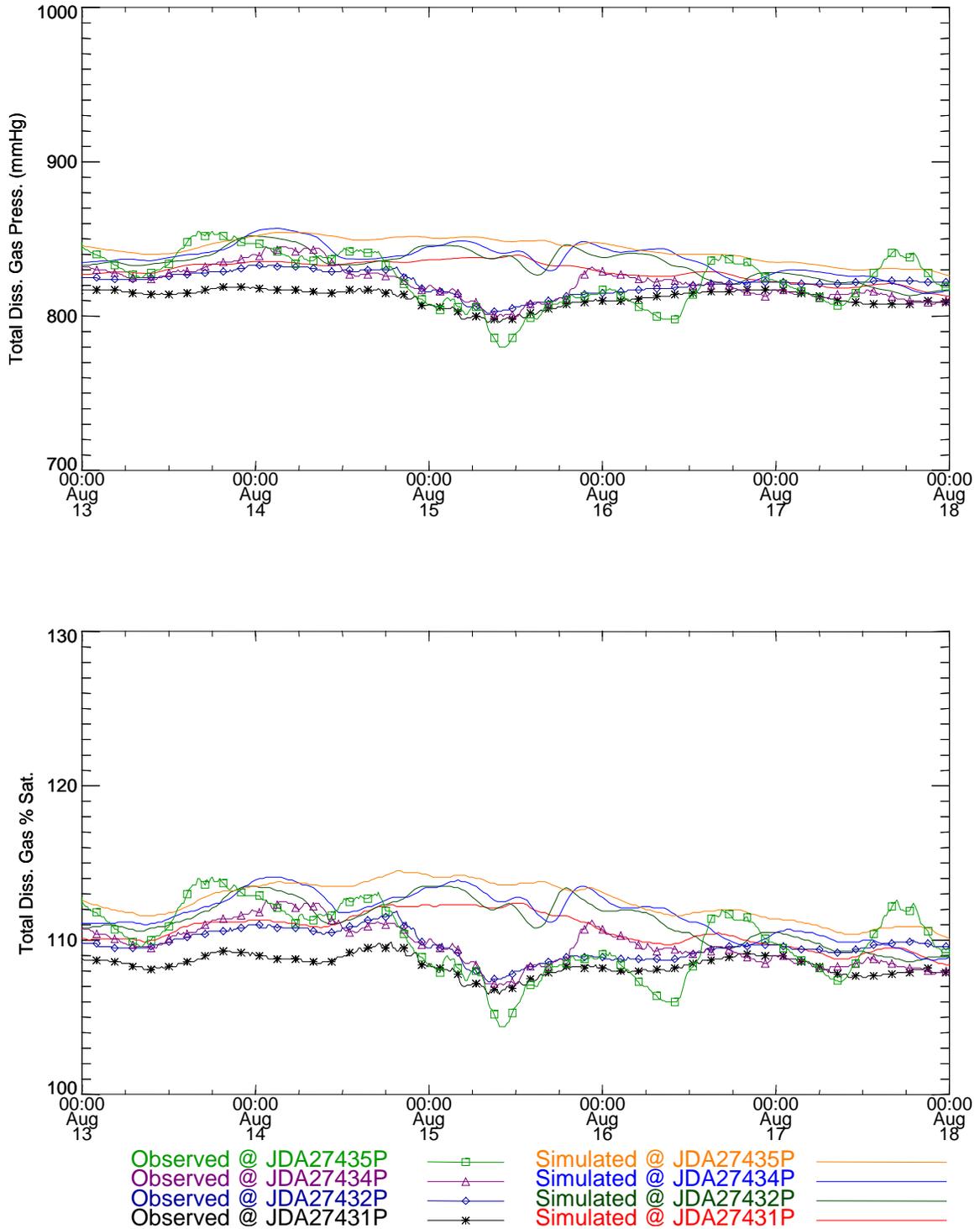


Figure 185. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 274.3 for the Summer 1997 study (TM-BC).

Table 85. Statistical summary of measurements and simulations at river mile 274.3 during Summer 1997 pool study (TM-BC)

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA27431P	20.8	20.69	0.21	0.23	0.25
JDA27432P	20.88	20.63	0.31	0.17	0.32
JDA27434P	20.83	20.65	0.2	0.17	0.23
JDA27435P	21.42	20.8	0.26	0.24	0.68
Concentration					
JDA27431P	26.4	26.96	0.23	0.24	0.64
JDA27432P	26.68	27.16	0.29	0.36	0.62
JDA27434P	26.72	27.25	0.39	0.38	0.61
JDA27435P	26.49	27.38	0.53	0.27	1.06
Gas Pressure					
JDA27431P	811.98	829.29	5.6	6.54	19.63
JDA27432P	821.44	833.99	7.42	9.79	17.25
JDA27434P	821.83	837.21	10.73	10.06	18.04
JDA27435P	823.94	843.38	17.3	7.62	26.93
% Saturation					
JDA27431P	108.38	110.65	0.65	1.1	2.59
JDA27432P	109.63	111.28	0.92	1.43	2.28
JDA27434P	109.69	111.71	1.34	1.42	2.38
JDA27435P	109.97	112.53	2.24	1.22	3.57

Table 86. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 274.3 for the Summer 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA27431P	99.59	89.63	92.95	92.53
JDA27432P	98.34	86.72	100	100
JDA27434P	100	92.53	93.78	93.78
JDA27435P	91.7	63.9	79.25	79.67

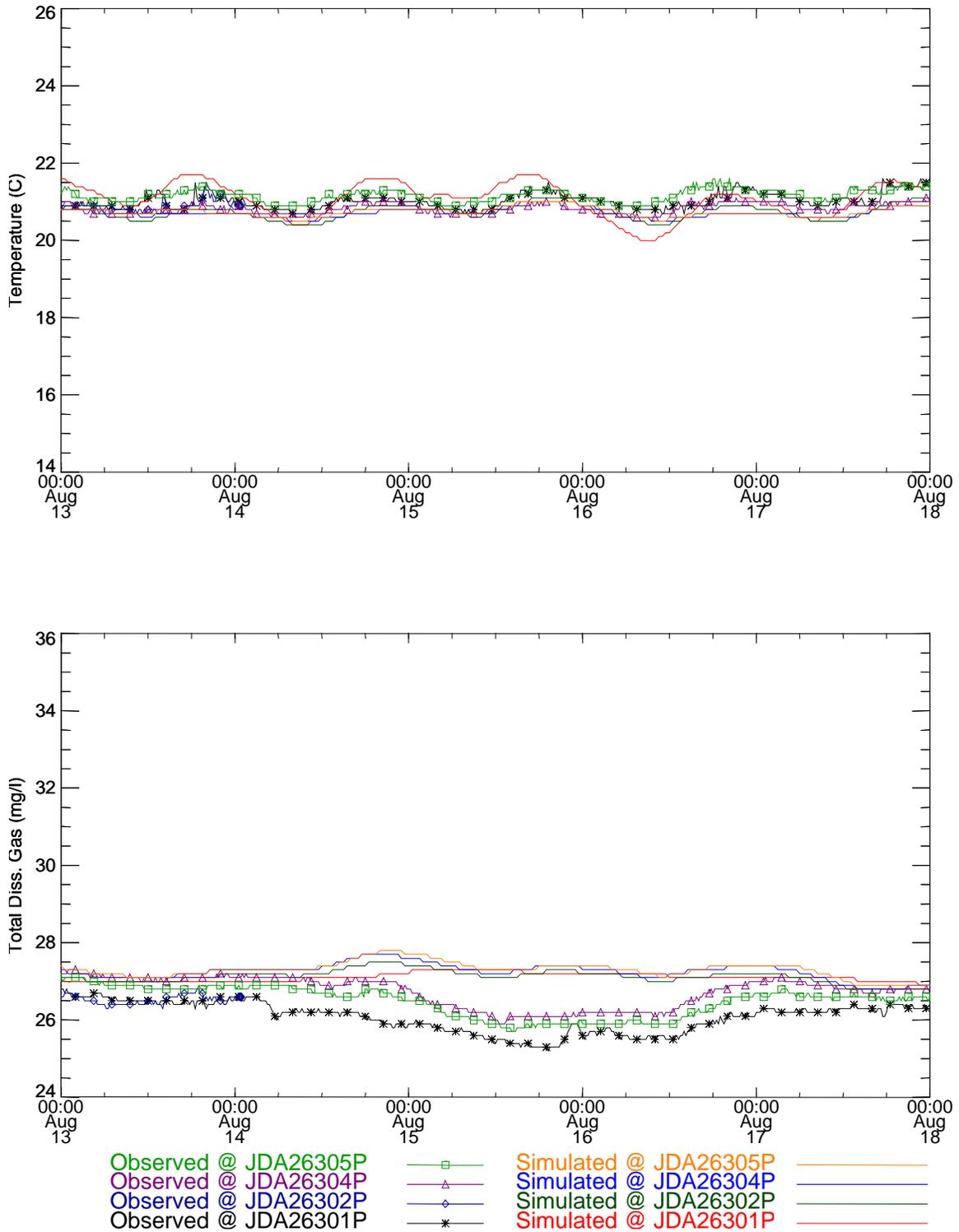


Figure 186. Temperature and total dissolved gas time series near Columbia River Mile 263.0 for the Summer 1997 study (TM-BC).

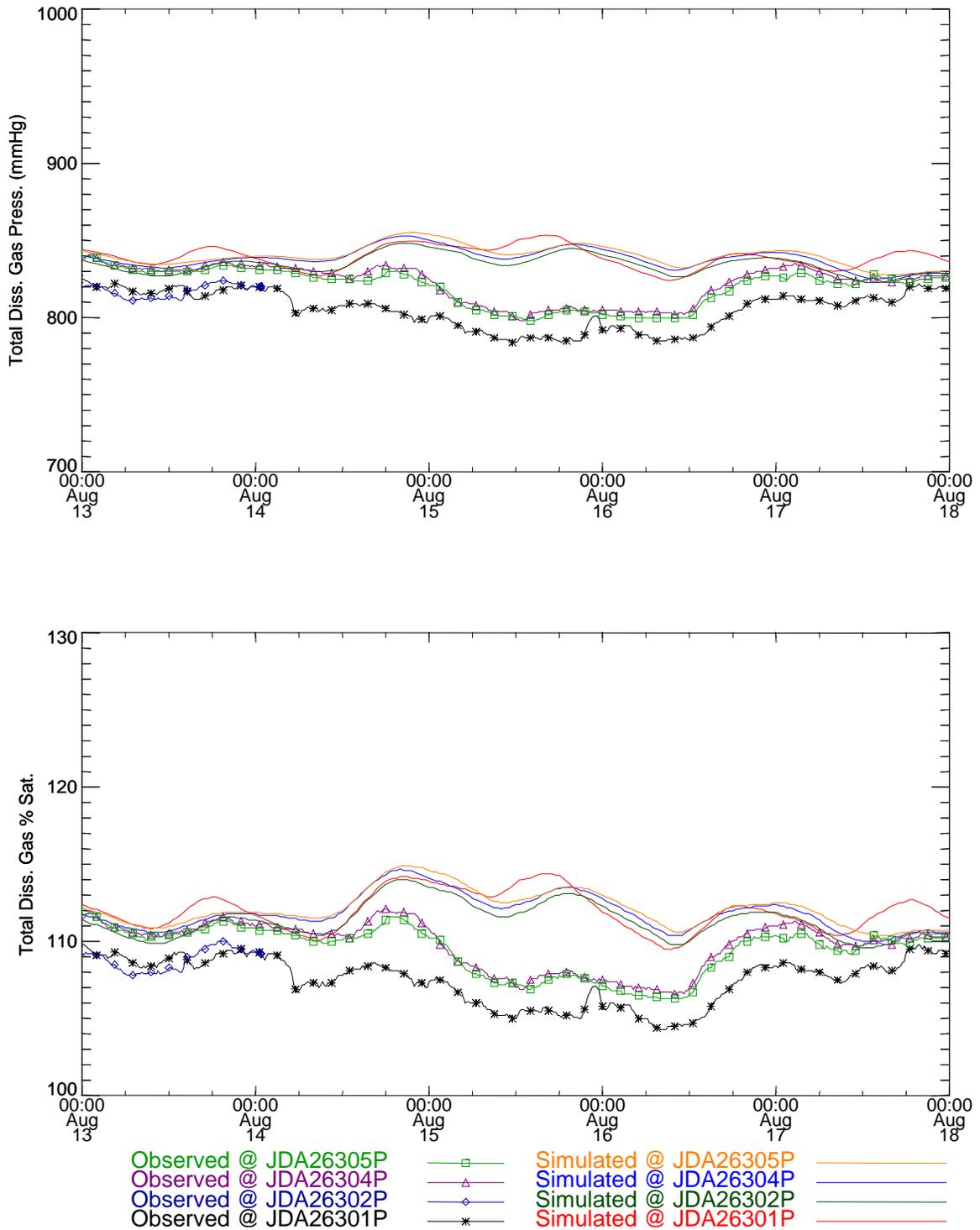


Figure 187. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 263.0 for the Summer 1997 study (TM-BC).

Table 87. Statistical summary of measurements and simulations at river mile 263.0 during Summer 1997 pool study (TM-BC)

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA26301P	21.02	21.07	0.2	0.43	0.38
JDA26302P	20.9	20.73	0.06	0.19	0.25
JDA26304P	20.83	20.72	0.13	0.13	0.17
JDA26305P	21.16	20.74	0.16	0.12	0.45
Concentration					
JDA26301P	26.07	27.11	0.39	0.11	1.14
JDA26302P	26.59	27.13	0.06	0.17	0.57
JDA26304P	26.74	27.25	0.39	0.21	0.68
JDA26305P	26.48	27.3	0.39	0.2	0.94
Gas Pressure					
JDA26301P	805.18	839.3	12.16	7.09	37.13
JDA26302P	819.45	834.67	2.23	6.26	16.36
JDA26304P	822.35	838.44	12.07	6.5	21.49
JDA26305P	819.85	840.3	12.09	6.52	25.15
% Saturation					
JDA26301P	107.47	111.99	1.53	1.26	4.93
JDA26302P	109.12	111.37	0.36	1.14	2.49
JDA26304P	109.76	111.87	1.57	1.16	2.85
JDA26305P	109.43	112.12	1.56	1.16	3.33

Table 88. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 263.0 for the Summer 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA26301P	100	59.75	59.75	61
JDA26302P	100	100	100	100
JDA26304P	100	82.16	88.8	88.8
JDA26305P	100	61.83	77.59	77.59

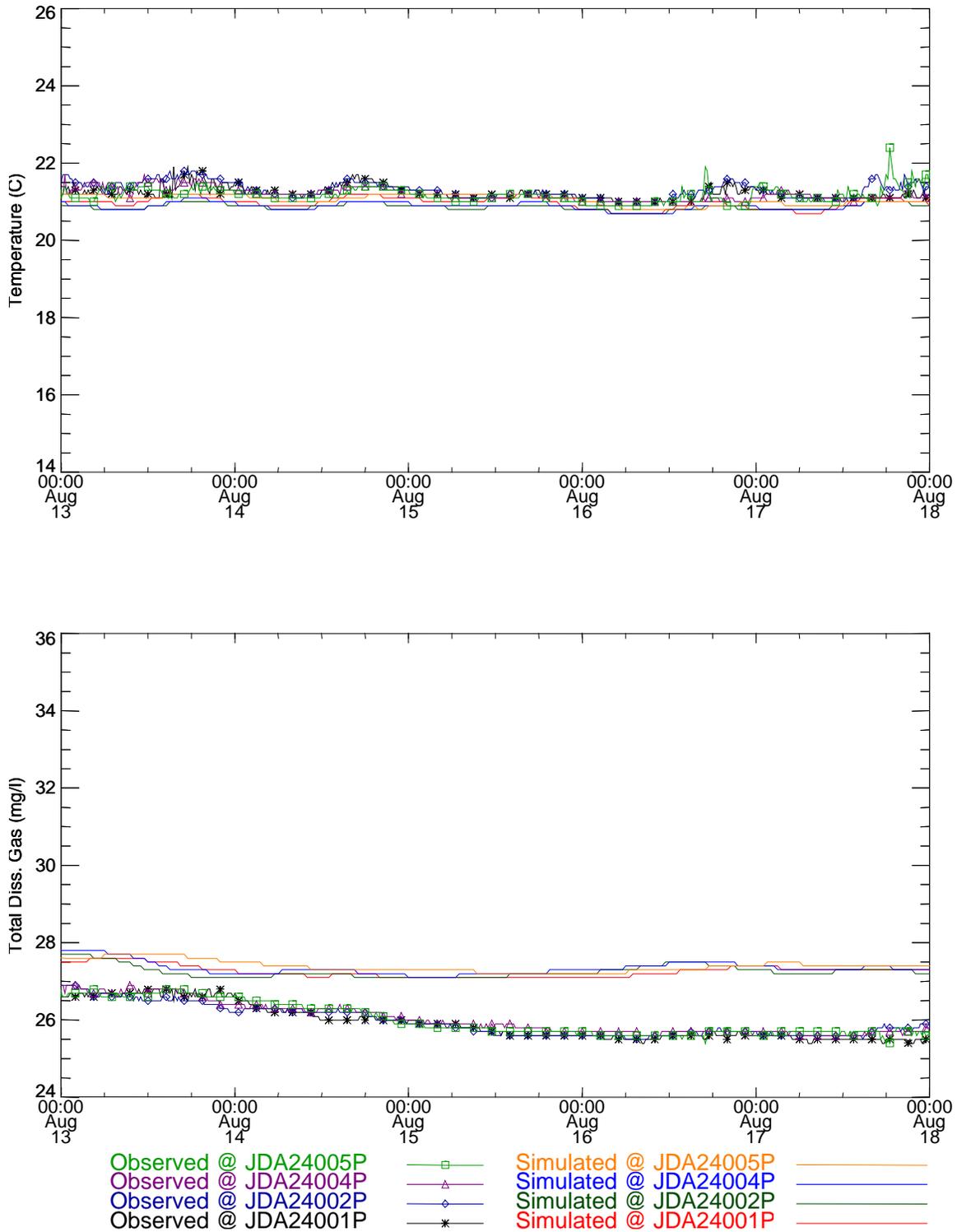


Figure 188. Temperature and total dissolved gas time series near Columbia River Mile 240.0 for the Summer 1997 study (TM-BC).

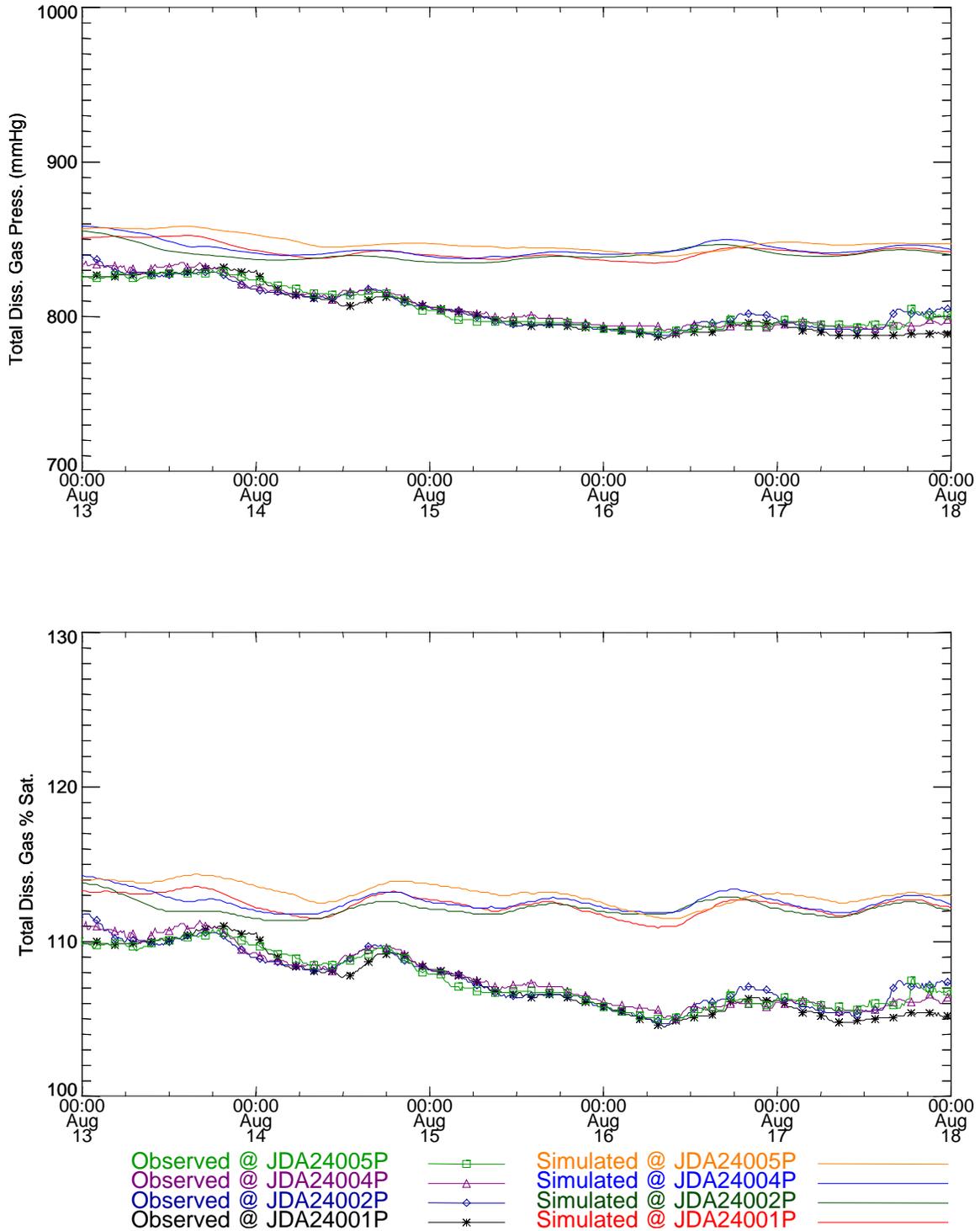


Figure 189. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 240.0 for the Summer 1997 study (TM-BC).

Table 89. Statistical summary of measurements and simulations at river mile 240.0 during Summer 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA24001P	21.23	20.97	0.17	0.14	0.3
JDA24002P	21.31	20.87	0.21	0.08	0.47
JDA24004P	21.2	20.89	0.16	0.1	0.34
JDA24005P	21.17	21.06	0.2	0.13	0.23
Concentration					
JDA24001P	25.93	27.26	0.45	0.15	1.39
JDA24002P	25.96	27.26	0.39	0.16	1.36
JDA24004P	26.03	27.34	0.41	0.17	1.36
JDA24005P	26.01	27.39	0.43	0.15	1.43
Gas Pressure					
JDA24001P	803.93	842.22	15.11	4.88	40.22
JDA24002P	806.15	840.67	13.82	4.38	36.86
JDA24004P	806.78	843.87	14.36	4.79	39.29
JDA24005P	805.56	847.81	13.52	5.18	43.29
% Saturation					
JDA24001P	107.3	112.37	2	0.64	5.33
JDA24002P	107.6	112.17	1.81	0.49	4.88
JDA24004P	107.68	112.59	1.89	0.56	5.2
JDA24005P	107.52	113.12	1.77	0.69	5.74

Table 90. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 240.0 for the Summer 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA24001P	100	30.29	46.89	46.89
JDA24002P	100	36.51	49.38	49.79
JDA24004P	100	34.02	46.89	46.89
JDA24005P	99.17	29.05	37.34	37.34

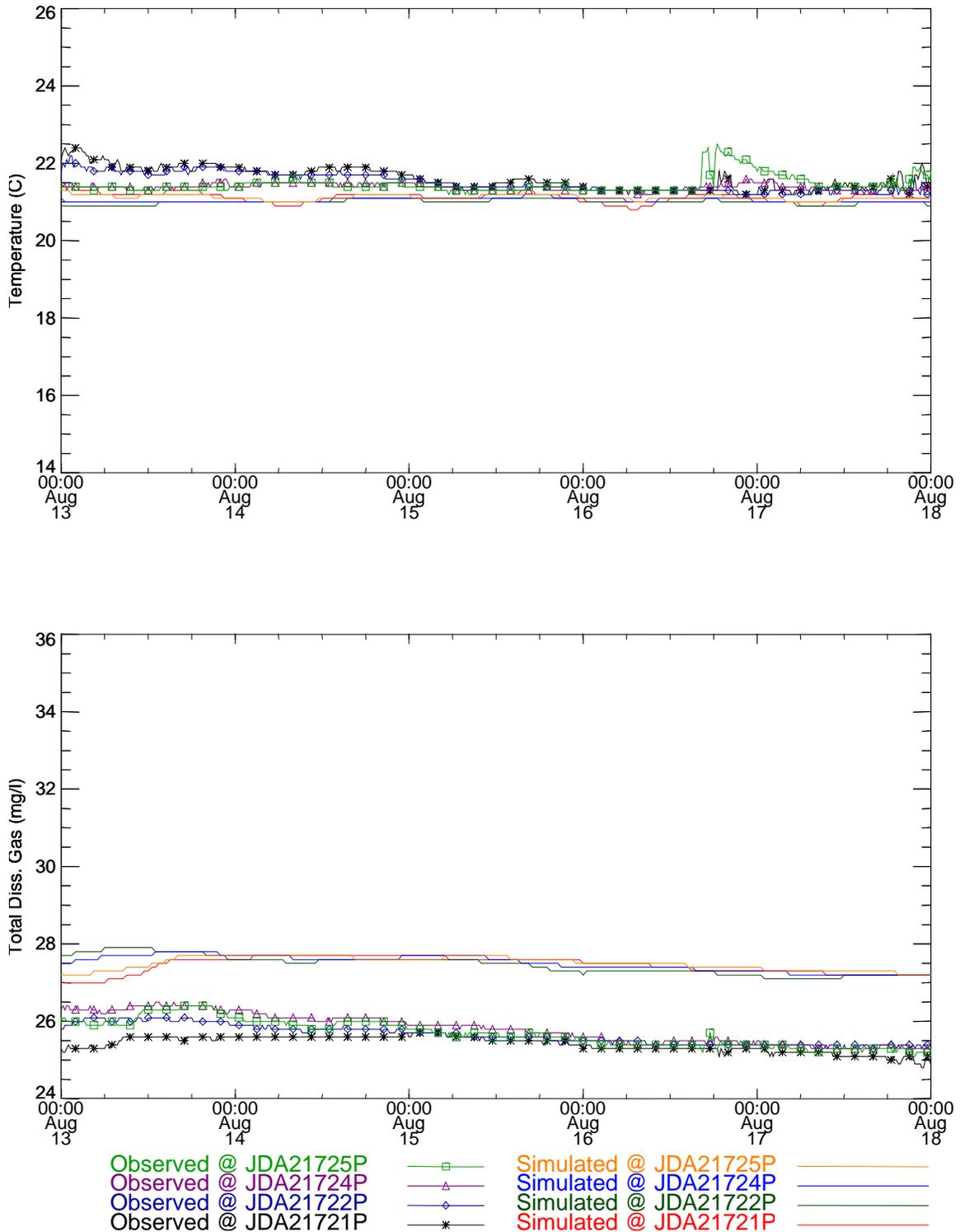


Figure 190. Temperature and total dissolved gas time series near Columbia River Mile 217.2 for the Summer 1997 study (TM-BC).

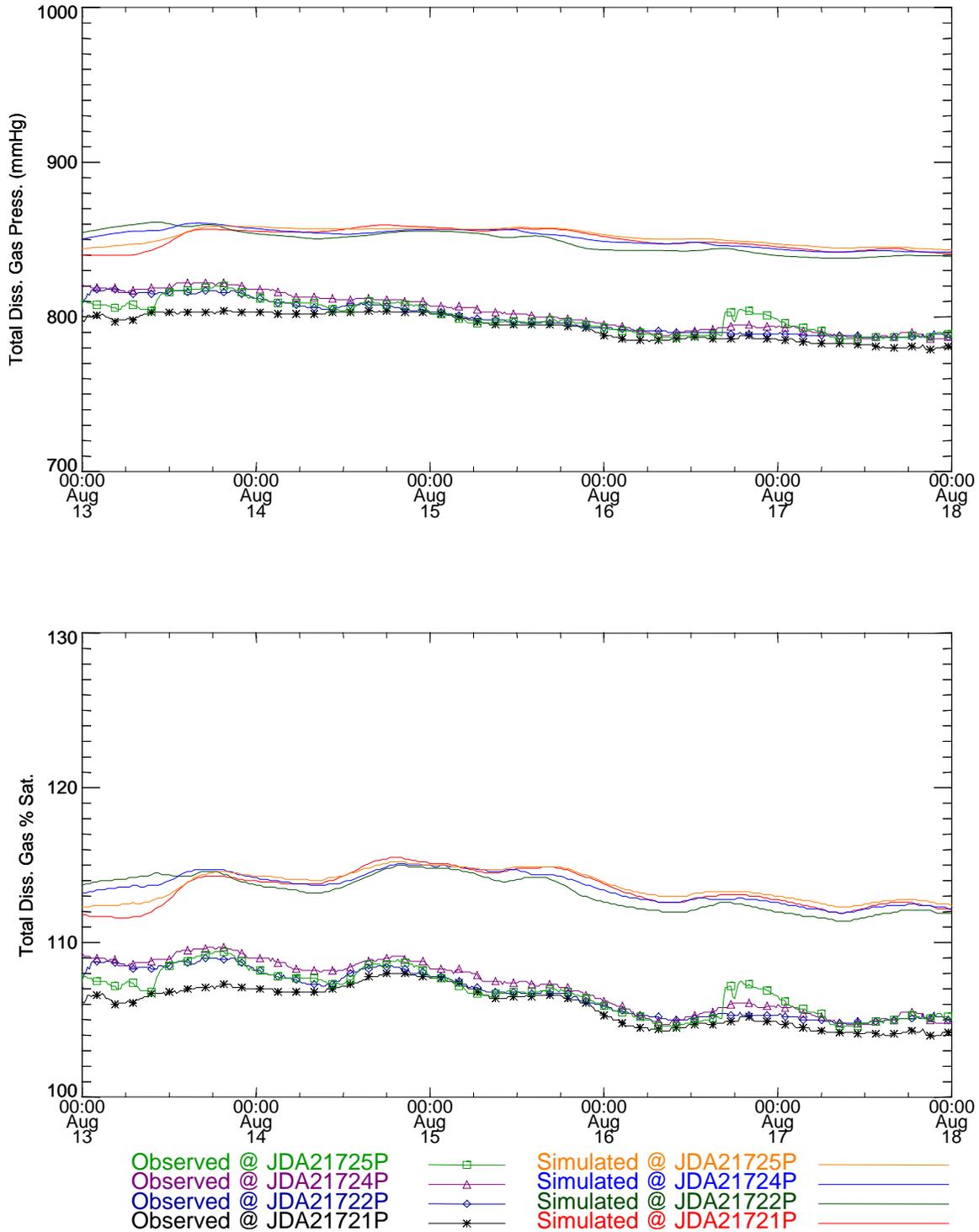


Figure 191. Total dissolved gas pressure and saturation time series comparisons near Columbia River Mile 217.2 for the Summer 1997 study (TM-BC).

Table 91. Statistical summary of measurements and simulations at river mile 217.2 during Summer 1997 pool study (TM-BC)

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
JDA21721P	21.6	21.12	0.29	0.12	0.54
JDA21722P	21.51	21	0.24	0.06	0.57
JDA21724P	21.39	21.05	0.09	0.06	0.36
JDA21725P	21.46	21.12	0.22	0.07	0.41
Concentration					
JDA21721P	25.41	27.45	0.2	0.21	2.05
JDA21722P	25.65	27.46	0.25	0.24	1.81
JDA21724P	25.81	27.5	0.38	0.2	1.7
JDA21725P	25.69	27.5	0.34	0.17	1.83
Gas Pressure					
JDA21721P	793.68	850.46	8.55	6.34	57.16
JDA21722P	799.73	848.79	10.7	7.31	49.3
JDA21724P	802.98	851.14	12.03	5.85	48.73
JDA21725P	800.07	852.14	9.93	5.22	52.73
% Saturation					
JDA21721P	105.94	113.48	1.28	1.13	7.59
JDA21722P	106.74	113.25	1.45	1.1	6.55
JDA21724P	107.18	113.57	1.65	0.95	6.47
JDA21725P	106.79	113.7	1.39	0.95	7

Table 92. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at river mile 217.2 for the Summer 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
JDA21721P	99.17	0	0	0
JDA21722P	98.34	0	0.41	0
JDA21724P	100	0	12.03	13.28
JDA21725P	97.1	0	7.05	7.05

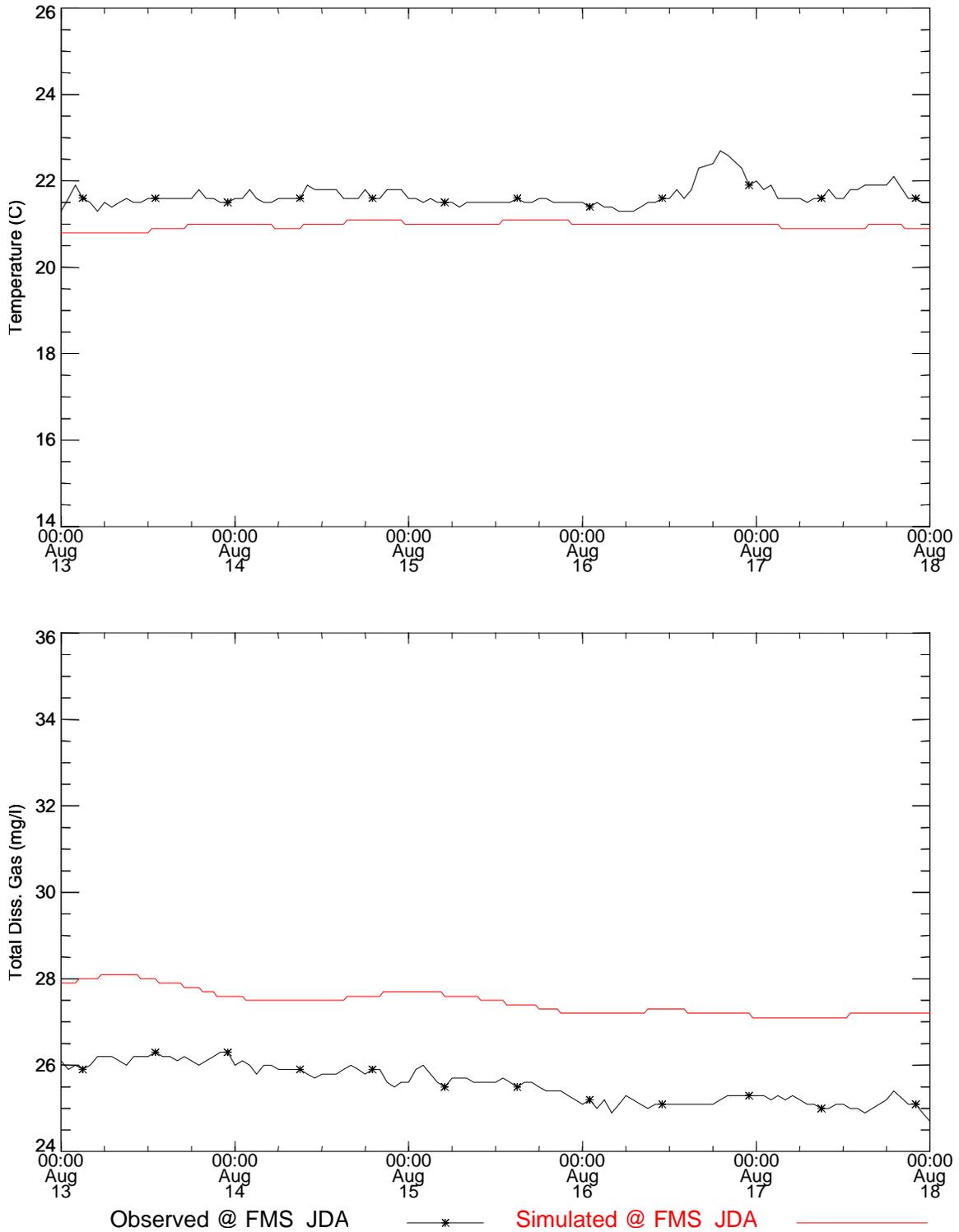


Figure 192. Temperature and total dissolved gas time series near fixed monitor JDA for the Summer 1997 study (TM-BC).

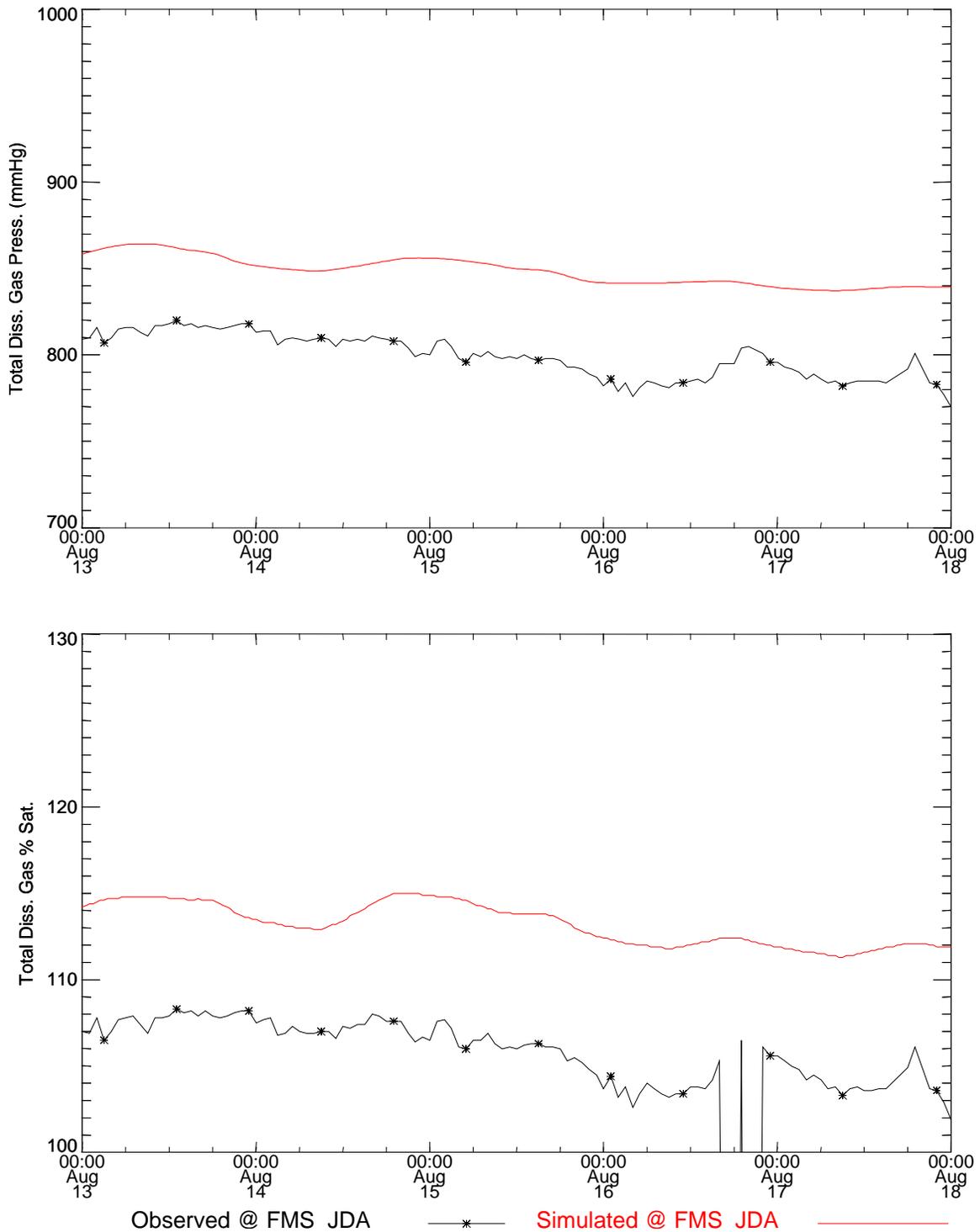


Figure 193. Total dissolved gas pressure and saturation time series comparisons near fixed monitor JDA for the Summer 1997 study (TM-BC).

Table 93. Statistical summary of measurements and simulations at fixed monitor JDA for the Summer 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_JDA	21.66	20.97	0.25	0.08	0.73
Concentration					
FMS_JDA	25.56	27.46	0.42	0.29	1.91
Gas Pressure					
FMS_JDA	799.28	848.49	12.24	8.25	49.7
% Saturation					
FMS_JDA	103.27	113.21	13.91	1.2	16.9

Table 94. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor JDA for the Summer 1997 study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_JDA	92.95	0	5.81	0

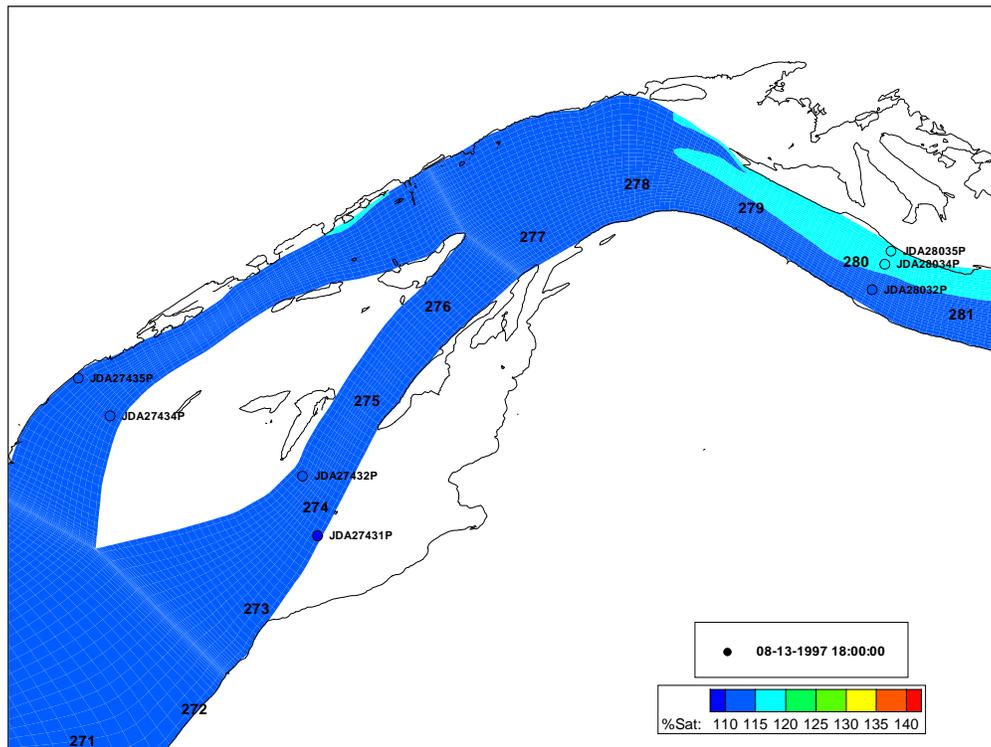


Figure 194. Spatial distribution of dissolved gas near Columbia river mile 277 during the Summer 1997 study period.

2 References

Richmond, M.C., W.A. Perkins, and T.D. Scheibe. 1998. *Two-Dimensional Hydrodynamic, Water Quality, and Fish Exposure Modeling of the Columbia and Snake Rivers. Part 1: Summary and Model Formulation*. Draft Final Report submitted to U.S. Army Corps of Engineers, Walla Walla District. Battelle Pacific Northwest Division, Richland, Washington.

Schneider, M.L., and S.C. Wilhelms, 1997. *Total Dissolved Gas Production at Spillways on the Snake and Lower Columbia Rivers*. Memorandum for Record, CEWES-HS-L, U.S. Army Corps of Engineers, Available (limited access): limnos.wes.army.mil
Directory: /data3/dgas/Documents/reports/ File: dgasprod.exe.

Steinbrenner J.P., and J.R. Chawner, 1995. *The GRIDGEN Version 9 Multiple Block Grid Generation Software*. MDA Engineering, Inc., Arlington, Texas.

U.S. Geological Survey (USGS), 1995. *Metadata for 1-degree Digital Elevation Models*. [online report]. Available Online URL: <http://nsdi.usgs.gov/> File: nsdi/wais/maps/dem1deg.HTML.

Appendix A. John Day Pool Data Sources

A.1 Bathymetry

Bathymetric data for the Columbia River was gathered from the various sources shown in Table 95. The primary source was John Day pool survey, during which elevations were measured at a relatively fine spacing over the entire pool, except in the restricted areas below Lower Granite dam and above John Day dam. Using the Arc/Info® GIS software system, the data was converted to a consistent coordinate system and datum, and combined to build a triangular irregular network (TIN), which represented the river bottom and shore as a three-dimensional surface. The resulting surface for John Day pool is shown in Figure 195. Once the surface was produced, it was “sampled” at the necessary grid locations to produce the bathymetry required by the hydrodynamic model grid.

Table 95. Columbia River bathymetry data sets used to create the John Day pool bathymetric surface. Listed Figure numbers refers to the map which shows the survey location(s).

Bathymetric Data Set	Source	Survey Date	Approximate Rivermile	
			Start	End
John Day Pool Survey (Figure 196 and Figure 197)	George Kalli (Portland)	unknown	216.5	292.5
McNary Pool Survey, (Columbia River,)	Gary Slack (Walla Walla)	1997	293.5	335.5
McNary Dam Tailrace Surveys (Figure 196)	Gregg Bertrand (Portland)	unknown	290.3	292.5
McNary Dam Forebay (Figure 196)	Gary Slack (Walla Walla)	1997	292.5	293.5
John Day Tailrace Survey (Figure 197)	Gregg Bertrand (Portland)	unknown	213.5	216.4
John Day Forebay Surveys (Figure 197)	Gregg Bertrand (Portland)	unknown	216.5	226.0
Digitized NOAA Navigation Charts (Figure 196 and Figure 197)	Battelle	unknown	various	various

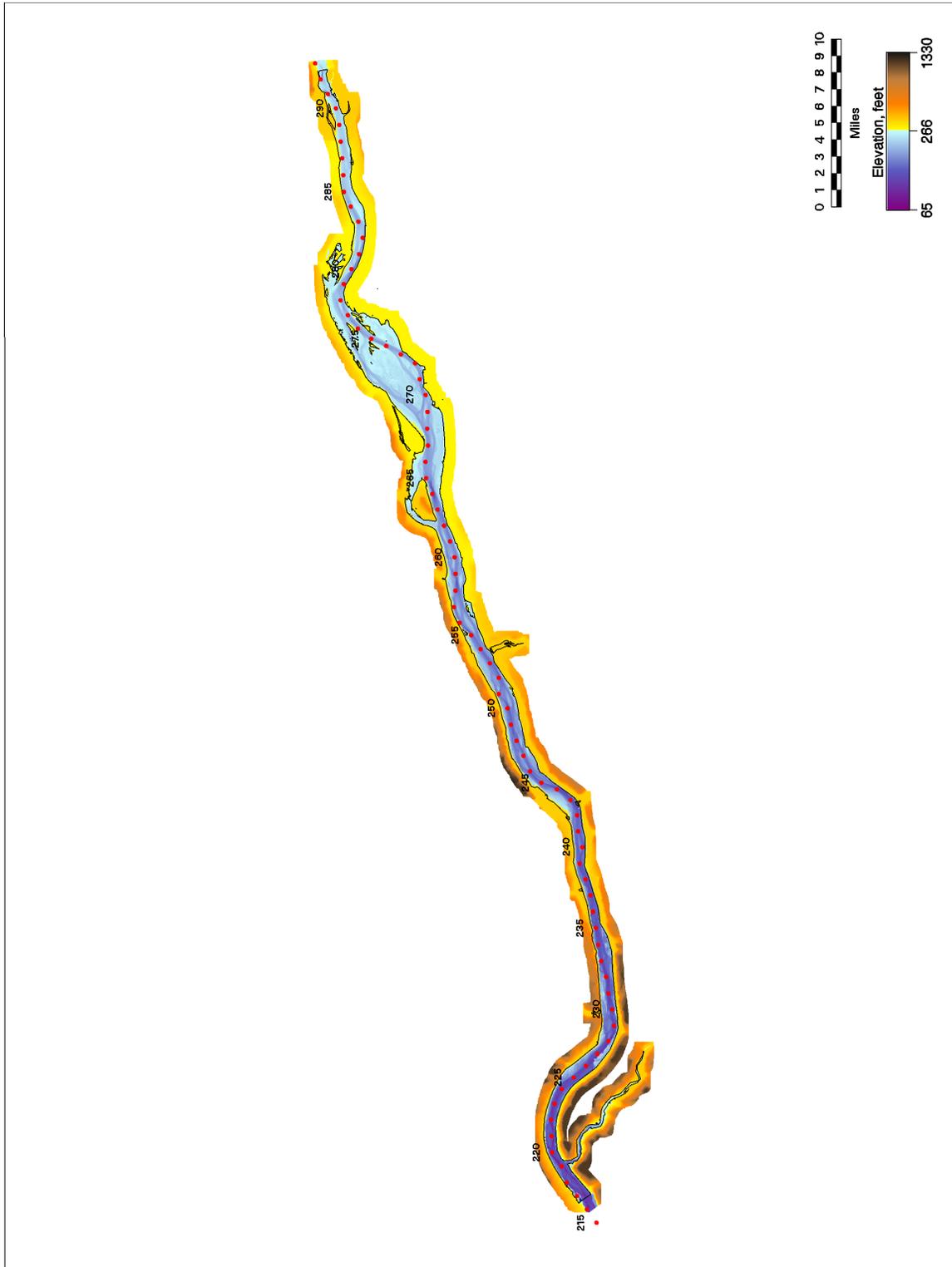


Figure 195. Color representation of John Day pool bathymetric surface.

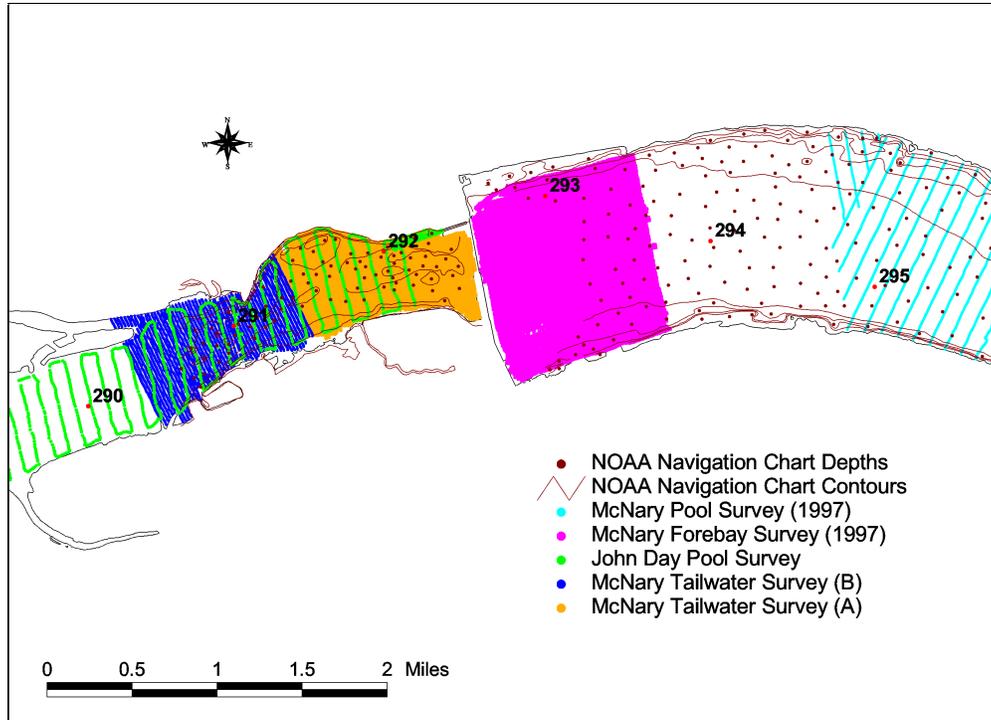


Figure 196. Bathymetric data near McNary dam.

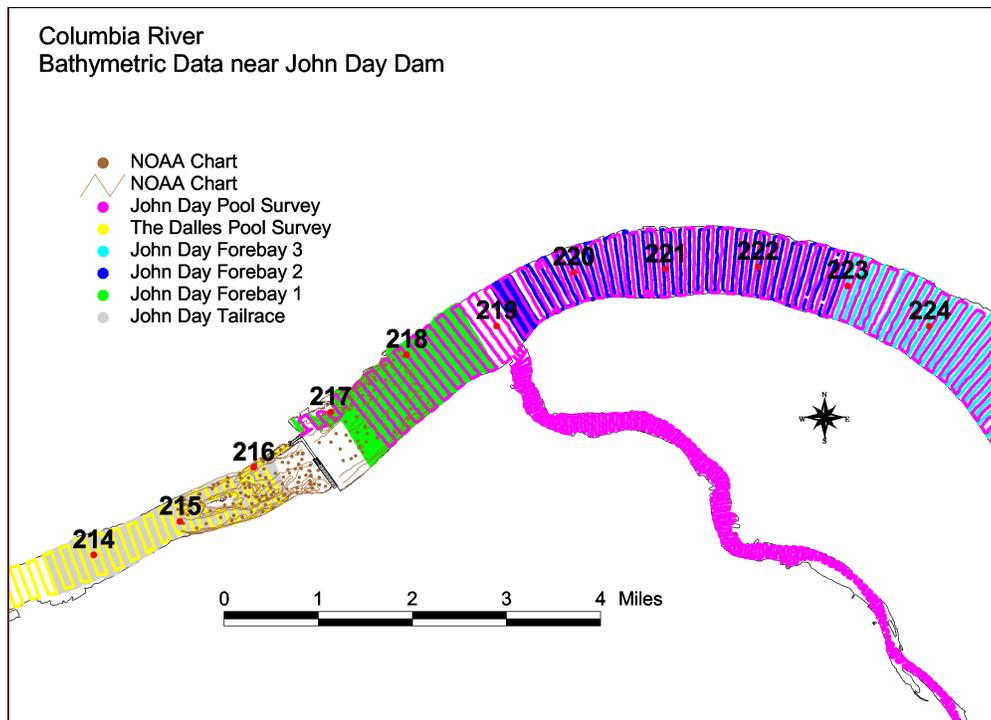


Figure 197. Bathymetric data near John Day dam.

A.2 Calibration/Verification Data Sources

A.2.1 Dissolved Gas Measurements

Dissolved gas measurements were available from two sources: permanent fixed monitors and dissolved gas pool studies which used temporary monitors. Fixed monitor stations (FMS) in John Day pool area are shown in Figure 198. The water quality data recorded by the FMS included total dissolved gas (TDG) pressure, barometric pressure, and temperature, and was obtained from the DGAS team ftp server,

`limnos.wes.army.mil`, in the file

`/data3/dgas/database/FMS_data/FMS_data.zip`, dated August 25, 1998.

Fixed monitor data was used to establish temperature and TDG concentration in powerhouse flow at the Lower Granite dam model boundary.

The dissolved gas pool studies performed in John Day Pool to date are shown in Table 96 and their durations are shown graphically in Figure 199. During these studies water temperature and TDG pressures were measured at several locations within John Day pool. These periods were used for model calibration and verification and are discussed individually below. The water quality data gathered during these studies was obtained from the DGAS team ftp server, `limnos.wes.army.mil`, in the file `/data3/dgas/database/field_data/field_data.zip`, dated August 25, 1998.

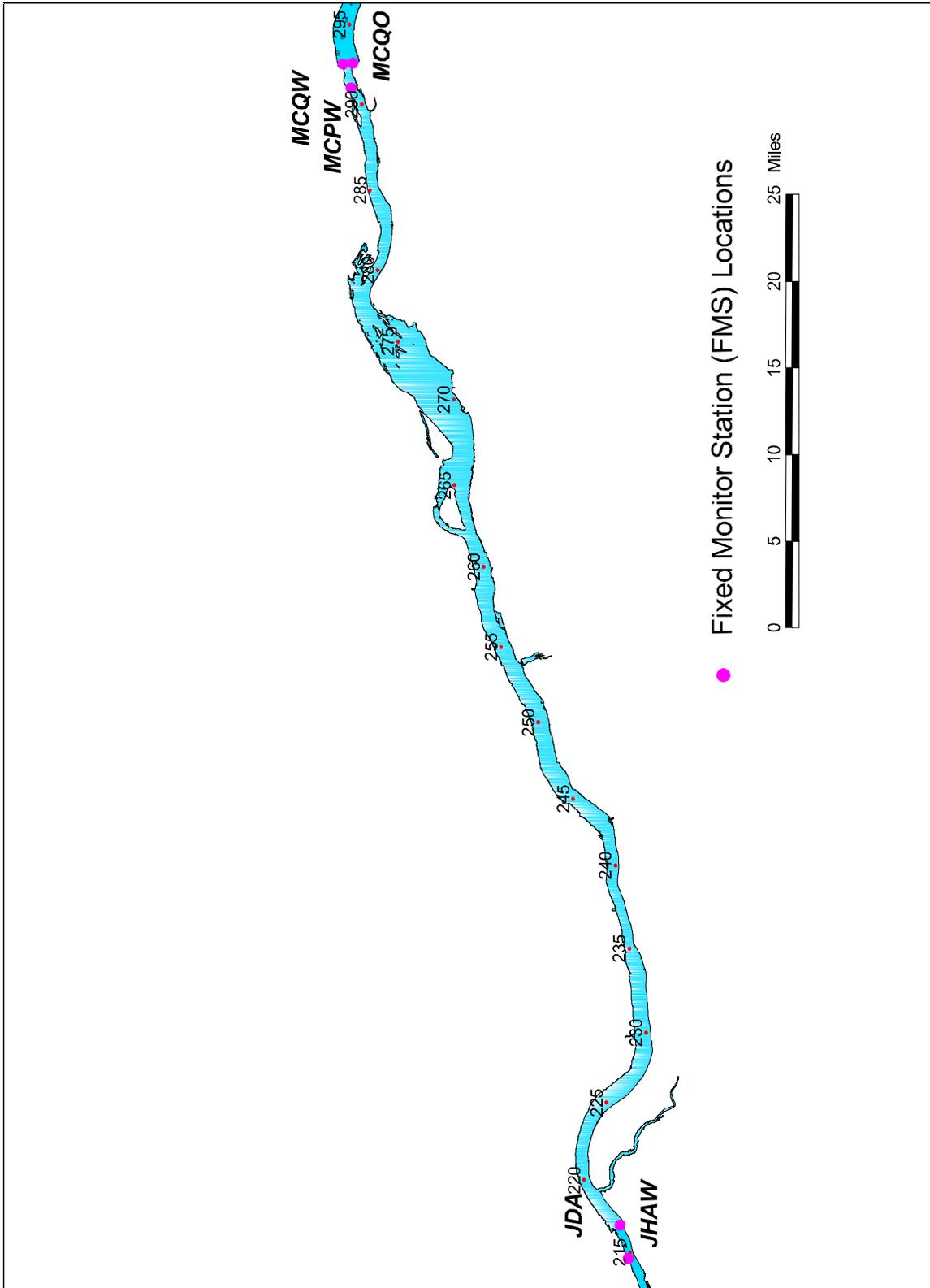


Figure 198. FMS locations in and around John Day pool.

Table 96. Dates of dissolved gas field studies in John Day pool.

STUDY SET	Start	End
JDA SPR 97	5/16/97 12:00:00 PM	5/30/97 5:15:00 PM
JDA SUM 97	8/6/97 8:00:00 PM	8/18/97 2:15:00 PM

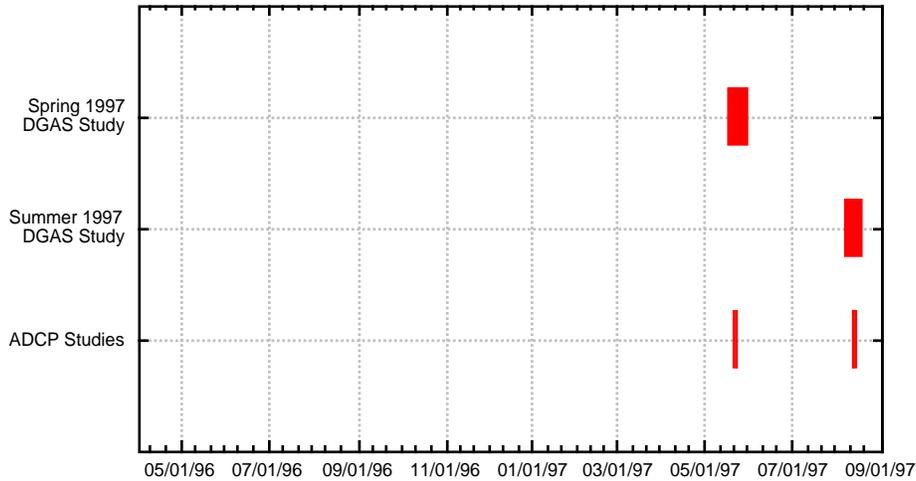


Figure 199. Dates and durations of dissolved gas and ADCP velocity studies in John Day Pool

A.2.2 ADCP Velocity Measurements

As shown in Figure 199, velocity measurements were taken using ADCP (Acoustic Doppler Current Profiler) instruments during both of the dissolved gas pool studies: Spring 1997 and Summer 1997. The ADCP data was obtained from the DGAS team FTP server, `limnos.wes.army.mil`, in the files `/data3/dgas/database/ADCP data/96ADCP.zip` and `/data3/dgas/database/ADCP data/97ADCP.zip`, dated April 10, 1998 and July 15, 1998, respectively. Figure 200 through Figure 207 show the measurements made as small arrows. The measurements were thinned for clarity in those figures: only one arrow in three was drawn.

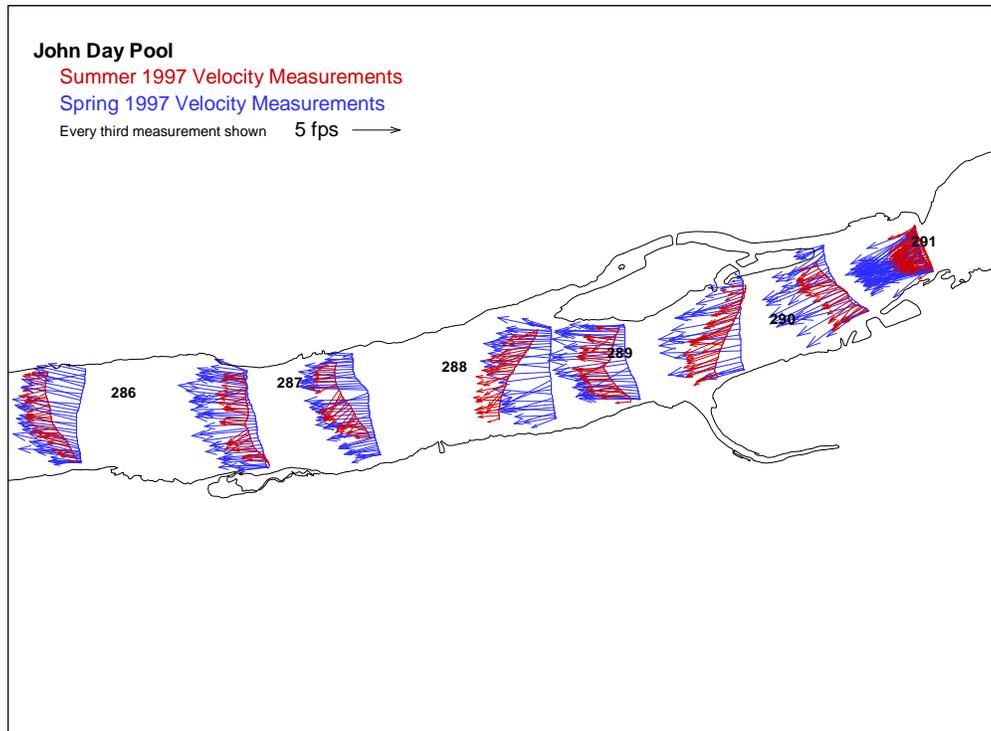


Figure 200. John Day pool ADCP velocity measurements near McNary dam.

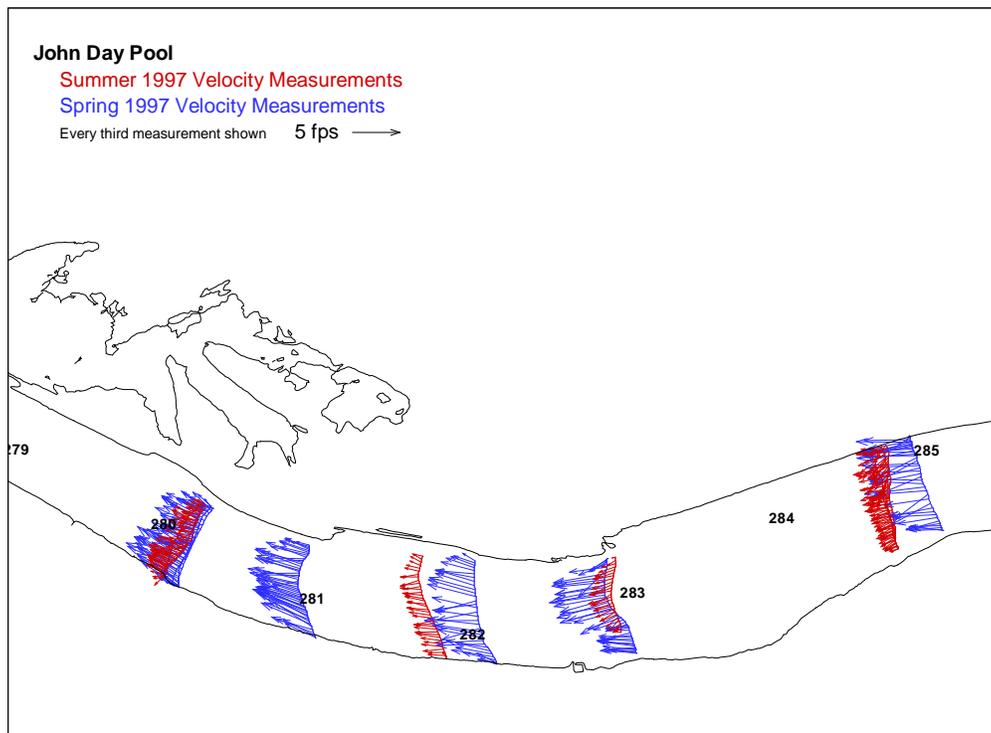


Figure 201. John Day pool ADCP velocity measurements near Irrigon.

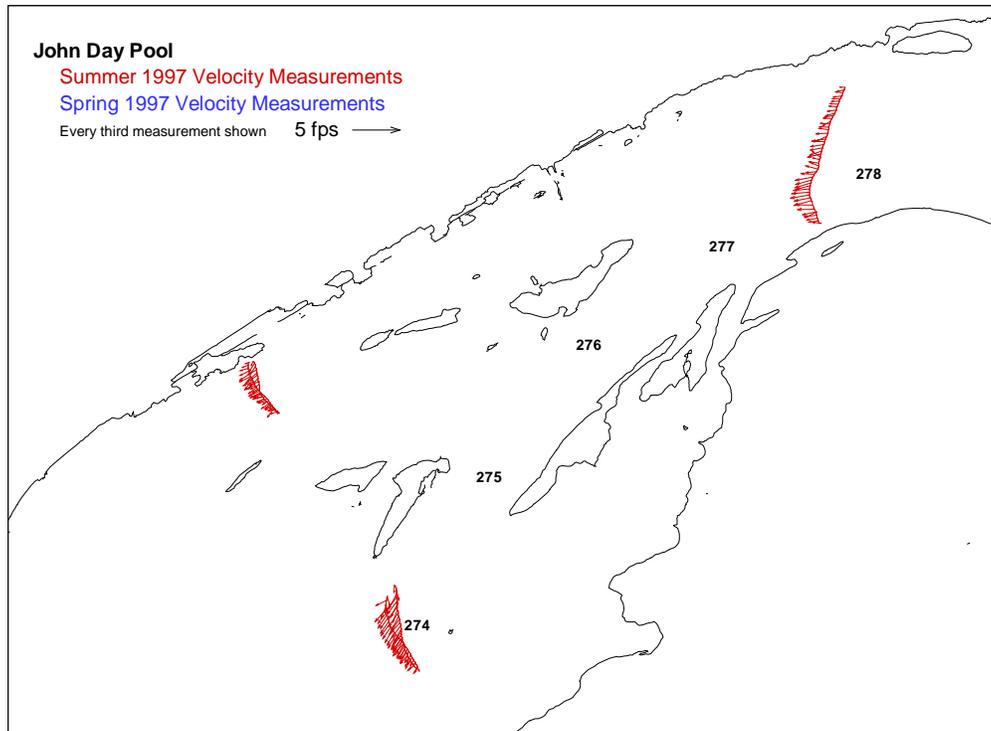


Figure 202. John Day pool ADCP velocity measurements near Blalock Islands.

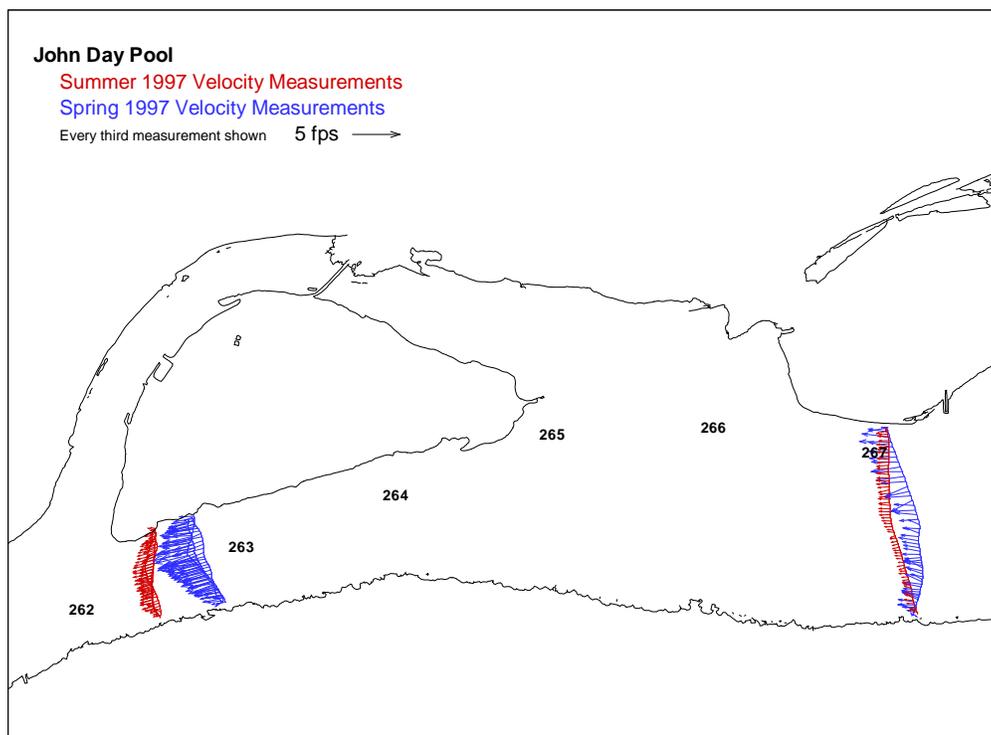


Figure 203. John Day pool ADCP velocity measurements near Crow Butte.

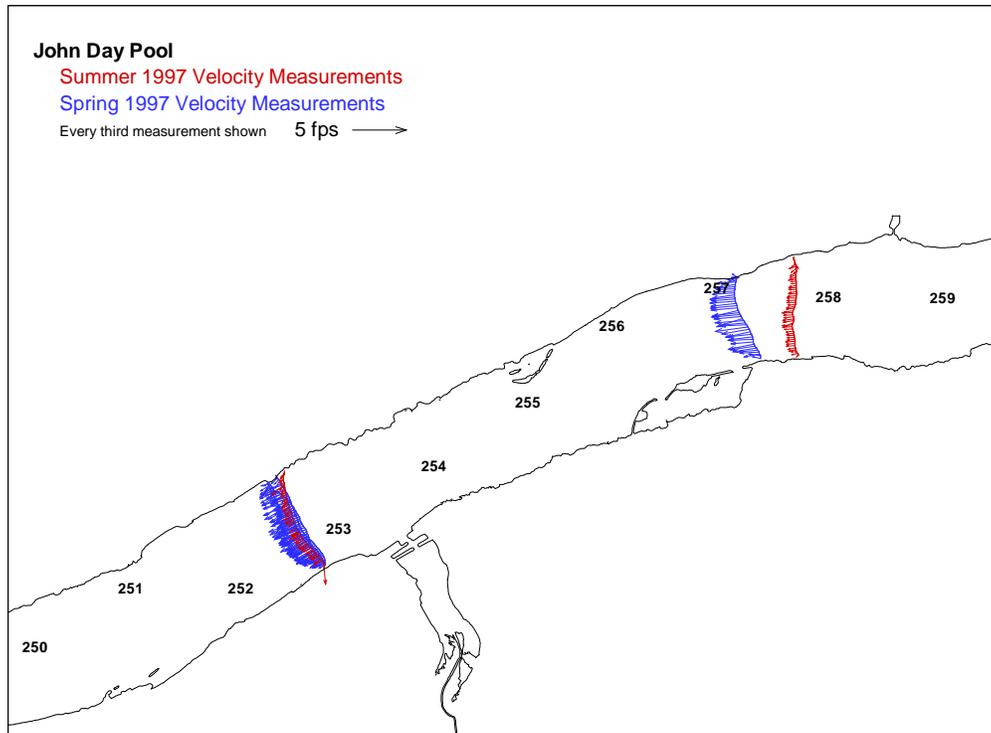


Figure 204. John Day pool ADCP velocity measurements near Willow Creek.

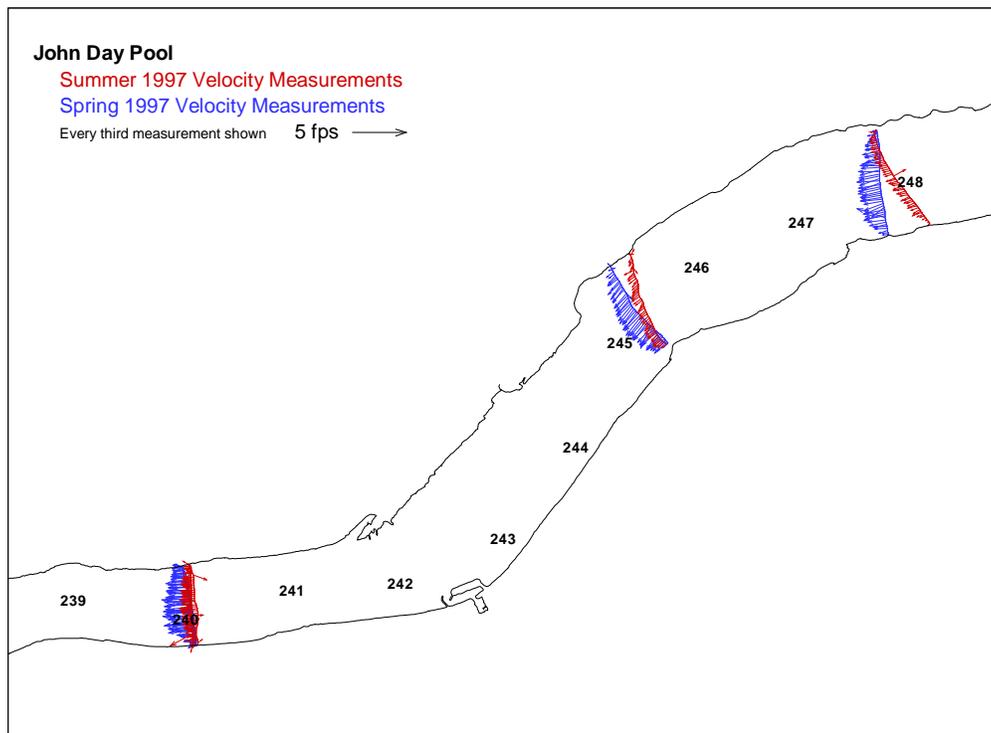


Figure 205. John Day pool ADCP velocity measurements near Arlington.

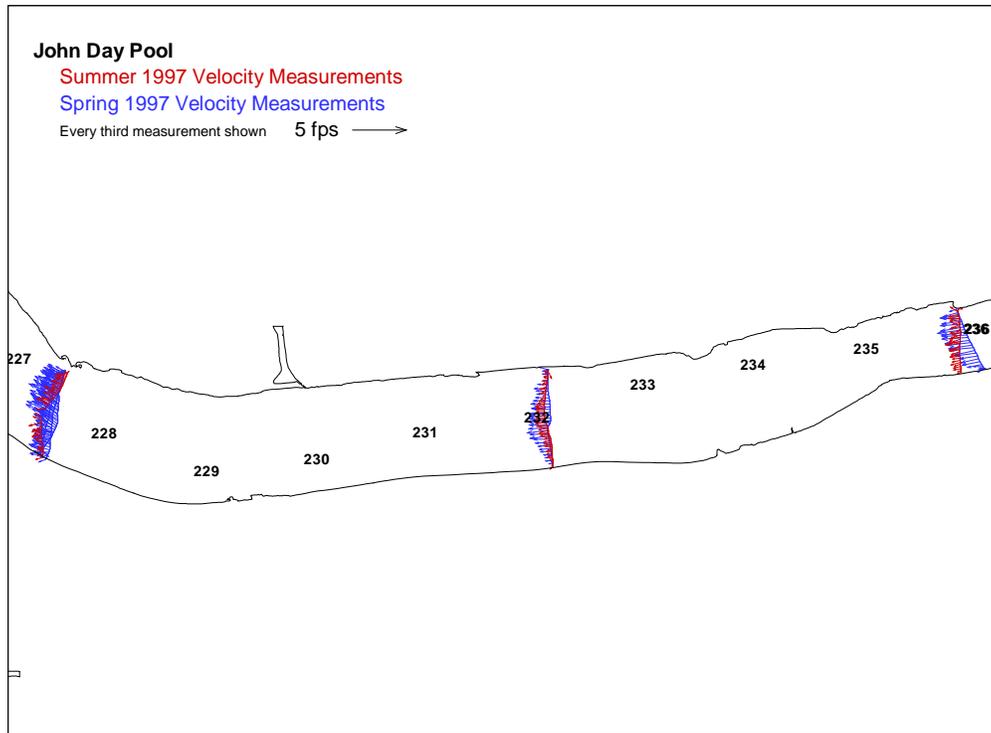


Figure 206. John Day pool ADCP velocity measurements above John Day dam.

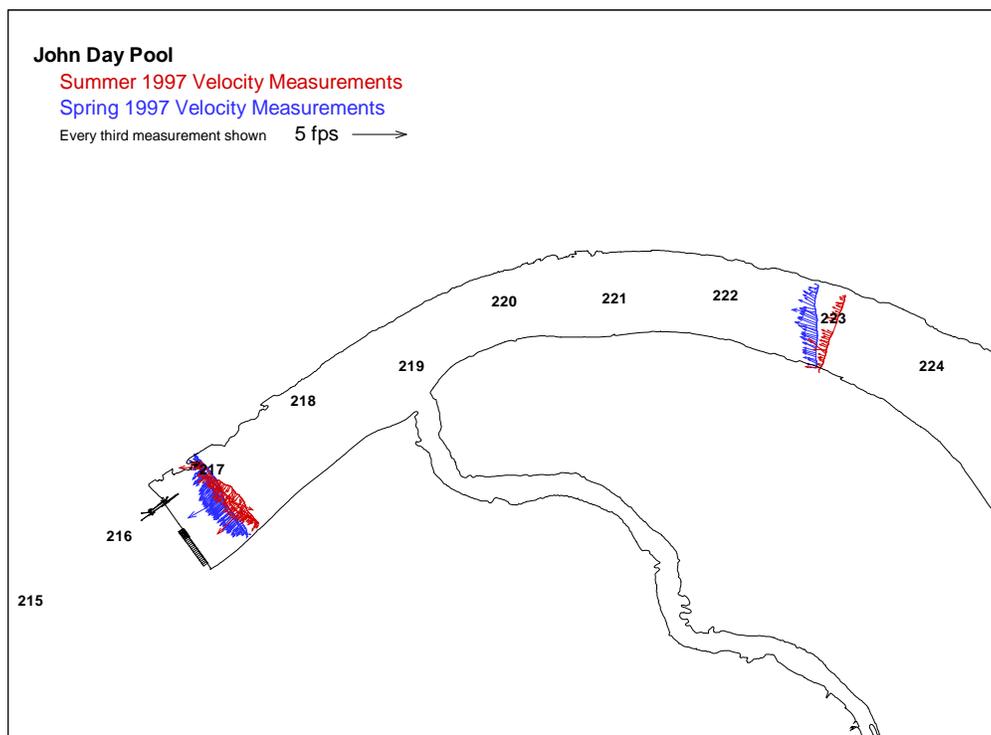


Figure 207. John Day pool ADCP velocity measurements near John Day dam.

A.2.3 Dam Operations Data

Dam operations data was used to establish model boundary conditions. Hourly CHROMS data was obtained from the DGAS team FTP server, limnos.wes.army.mil, in the file /data3/dgas/database/ops_data/ops_data.zip, dated August 25, 1998. The CHROMS operations data provided hourly aggregate spill and powerhouse flows and forebay and tailwater stages.

A.2.4 Weather Data

Weather data was obtained from two DGAS team databases: one containing data from National Weather Service (NWS) stations, the other from WeatherPak instrumentation used for short periods during the pool studies. Both NWS and WeatherPak data was obtained from the DGAS team FTP server, limnos.wes.army.mil, in the file /data3/dgas/database/weather_data/weather_data.zip, dated June 11, 1998.

Appendix B. Spring 1997 John Day Pool Study

B.1 Dissolved Gas Data

The Spring 1997 John Day pool study began on May 16 and ended on May 30. A total of 35 stations were used. These stations, and their records are listed in Table 97. Station locations are shown in Figure 208. TDG pressure was not recorded by stations JDA28035P and JDA28032P.

Table 97. Dissolved gas monitor stations, and their records, used during the Spring 1997 study period.

Station	Record Start	Record End	Temperature Records	Pressure Records
JDA24001P	5/16/97 12:00:00 PM	5/30/97 4:15:00 PM	1362	1362
JDA26301P	5/16/97 12:00:00 PM	5/30/97 9:30:00 AM	1335	1335
JDA25285P	5/16/97 12:00:00 PM	5/23/97 2:45:00 PM	684	684
JDA25284P	5/16/97 12:00:00 PM	5/30/97 3:45:00 PM	1360	1360
JDA25282P	5/16/97 12:00:00 PM	5/30/97 3:45:00 PM	1360	1360
JDA25281P	5/16/97 12:00:00 PM	5/23/97 2:00:00 PM	681	681
JDA24005P	5/16/97 12:00:00 PM	5/30/97 4:30:00 PM	1363	1363
JDA21721P	5/16/97 12:00:00 PM	5/23/97 1:00:00 PM	677	677
JDA24002P	5/16/97 12:00:00 PM	5/30/97 4:45:00 PM	1364	1364
JDA26304P	5/16/97 12:00:00 PM	5/30/97 10:15:00 AM	1338	1338
JDA22775P	5/16/97 12:00:00 PM	5/23/97 12:15:00 PM	674	674
JDA22774P	5/16/97 12:00:00 PM	5/30/97 5:15:00 PM	1366	1366
JDA22772P	5/16/97 12:00:00 PM	5/23/97 12:00:00 PM	673	673
JDA22771P	5/16/97 12:00:00 PM	5/23/97 12:00:00 PM	673	673
JDA21725P	5/16/97 12:00:00 PM	5/23/97 1:30:00 PM	679	679
JDA21724P	5/16/97 12:00:00 PM	5/23/97 1:30:00 PM	679	679
JDA24004P	5/16/97 12:00:00 PM	5/30/97 4:45:00 PM	1364	1364
JDA28031P	5/16/97 12:00:00 PM	5/23/97 10:30:00 AM	667	667
JDA29114P	5/16/97 12:00:00 PM	5/29/97 11:15:00 AM	1246	1246
JDA29113P	5/16/97 12:00:00 PM	5/29/97 11:15:00 AM	1245	1245
JDA29111P	5/16/97 12:00:00 PM	5/29/97 11:30:00 AM	1247	1247
JDA28035P	5/16/97 12:00:00 PM	5/30/97 8:45:00 AM	1332	0
JDA28034P	5/16/97 12:00:00 PM	5/30/97 8:30:00 AM	1331	1331
JDA26302P	5/16/97 12:00:00 PM	5/30/97 10:30:00 AM	1339	1339
JDA28032P	5/16/97 12:00:00 PM	5/30/97 8:15:00 AM	1330	0
JDA26303P	5/16/97 12:00:00 PM	5/30/97 10:30:00 AM	1339	1339
JDA27305P	5/16/97 12:00:00 PM	5/23/97 12:30:00 PM	675	675
JDA27304P	5/16/97 12:00:00 PM	5/30/97 11:45:00 AM	1344	1344
JDA27303P	5/16/97 12:00:00 PM	5/23/97 12:00:00 PM	673	673
JDA27302P	5/16/97 12:00:00 PM	5/23/97 11:30:00 AM	671	671
JDA27301P	5/16/97 12:00:00 PM	5/23/97 11:45:00 AM	672	672
JDA26305P	5/16/97 12:00:00 PM	5/30/97 10:00:00 AM	1337	1337
JDA28033P	5/16/97 12:00:00 PM	5/23/97 10:00:00 AM	665	665
JDADTDP	5/16/97 12:00:00 PM	5/29/97 2:45:00 AM	1212	1212
TDA21585P	5/21/97 3:00:00 PM	5/26/97 7:00:00 AM	449	449

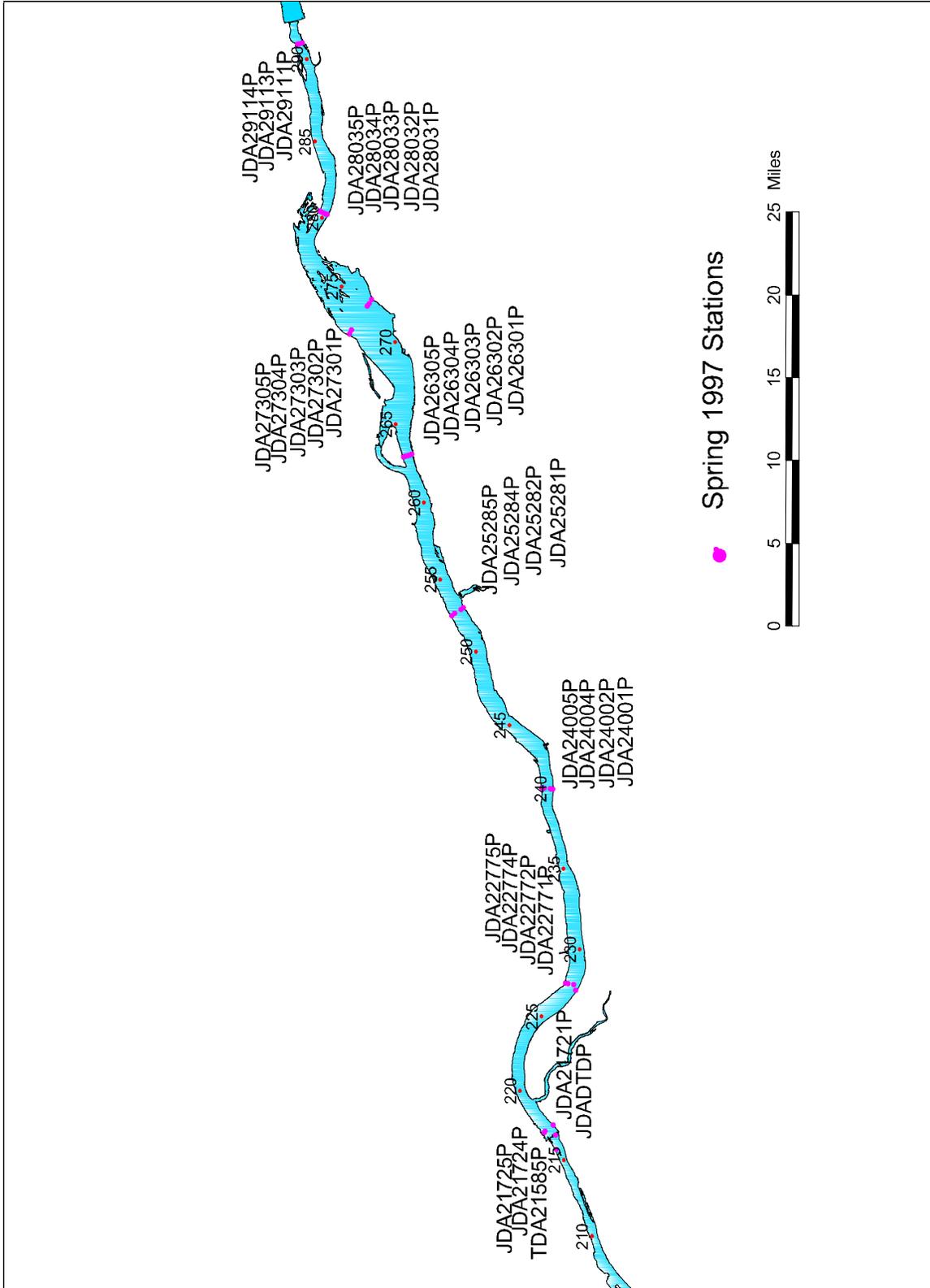


Figure 208. Dissolved gas monitor locations during the Spring 1997 study.

B.2 Velocity Data

Velocity measurements were made along a total of 39 transects during the Spring 1997 study period. The transects are summarized in Table 98. Supplied measurement locations are shown in Figure 209.

Table 98. Summary of ADCP transects made during the Spring 1997 study period.

Date Label	Average		Number of Measurements
	Velocity	Depth	
05-21-1997 09:02:00	5.9	42.9	51
05-21-1997 09:13:00	6.2	48.7	84
05-21-1997 09:21:00	5.9	45.6	68
05-21-1997 09:56:00	5.5	26.3	88
05-21-1997 10:15:00	4.8	22.8	82
05-21-1997 10:34:00	6.5	27.8	94
05-21-1997 10:50:00	5.2	24.0	102
05-21-1997 11:17:00	4.5	25.4	147
05-21-1997 11:43:00	5.0	26.7	136
05-21-1997 12:09:00	5.2	25.6	119
05-21-1997 12:37:00	4.8	32.5	118
05-21-1997 13:13:00	3.8	32.0	136
05-21-1997 13:38:00	4.1	33.0	97
05-21-1997 14:08:00	4.4	39.1	150
05-21-1997 14:29:00	3.9	38.4	54
05-21-1997 14:41:00	3.6	35.4	85
05-21-1997 14:50:00	3.7	36.4	67
05-21-1997 15:54:00	1.9	29.9	169
05-22-1997 07:54:00	1.6	64.7	139
05-22-1997 08:35:00	1.5	60.9	153
05-22-1997 09:18:00	1.7	59.0	143
05-22-1997 09:50:00	1.7	58.7	146
05-22-1997 10:14:00	1.6	58.2	147
05-22-1997 11:03:00	2.0	54.1	125
05-22-1997 11:36:00	2.8	58.5	94
05-22-1997 11:50:00	2.7	53.6	87
05-22-1997 12:04:00	2.8	59.3	90
05-22-1997 13:11:00	1.5	72.5	80
05-22-1997 13:24:00	1.5	71.3	87
05-22-1997 13:38:00	1.5	72.2	94
05-22-1997 14:04:00	1.7	78.8	76
05-22-1997 14:30:00	1.1	77.6	110
05-23-1997 08:40:00	1.2	88.8	138
05-23-1997 09:05:00	1.1	95.4	140
05-23-1997 09:26:00	1.1	91.4	137
05-23-1997 10:10:00	1.3	95.5	112
05-23-1997 10:49:00	1.5	77.2	132
05-23-1997 11:12:00	1.5	75.5	124
05-23-1997 11:33:00	1.5	73.8	130

Figure 209. Locations of ADCP velocity measurements during the Spring 1997 study period.

B.3 McNary Dam Model Boundary

B.3.1 Dam Operations

CHROMS operations data was used to establish the flow at the McNary dam model boundary and stage at the John Day dam model boundary. This data provided hourly spillway flow and powerhouse flow. Hourly total spill and powerhouse flows for the Spring 1997 study period are shown in Figure 210. These flows were uniformly distributed across the corresponding part of the model grid.

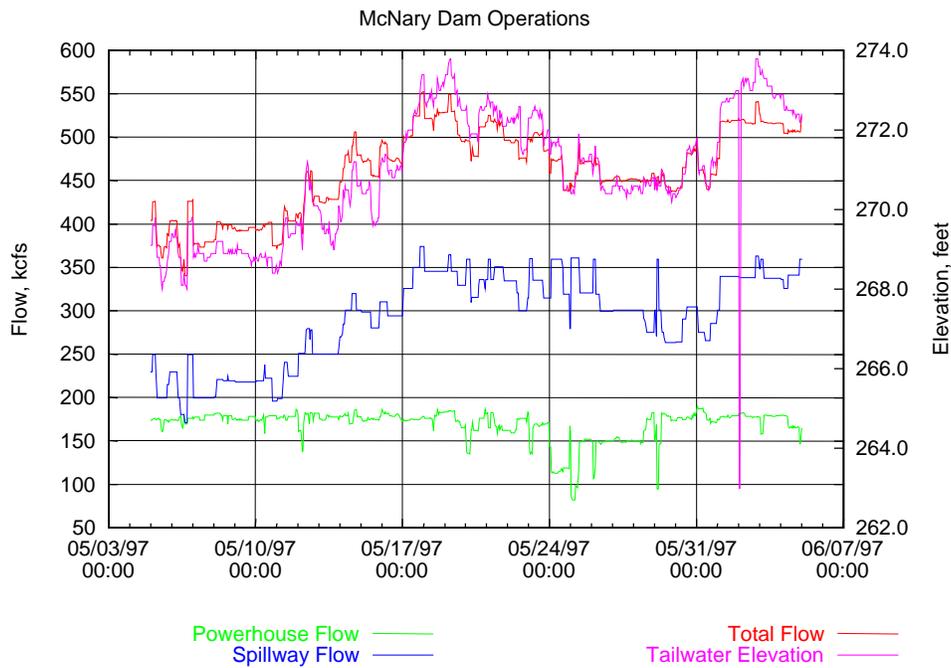


Figure 210. McNary dam operations during the Spring 1997 study.

B.3.2 Water Quality

Initially, data from the permanent fixed monitor located in the McNary dam forebay (station name "MCN") was used to establish temperature at the McNary dam boundary. Station data was taken from the FMS database. Temperature measured by the station (Figure 211) was used for both spillway and powerhouse flow. TDG pressures measured by the station (Figure 212) was used to compute TDG concentrations (Figure 213) for the powerhouse flow. Spillway TDG gas pressures and concentrations (also shown in Figure 212 and Figure 213, respectively) were estimated using the TDG sourcing function for McNary dam.



Figure 211. McNary forebay water temperature during the Spring 1997 study.

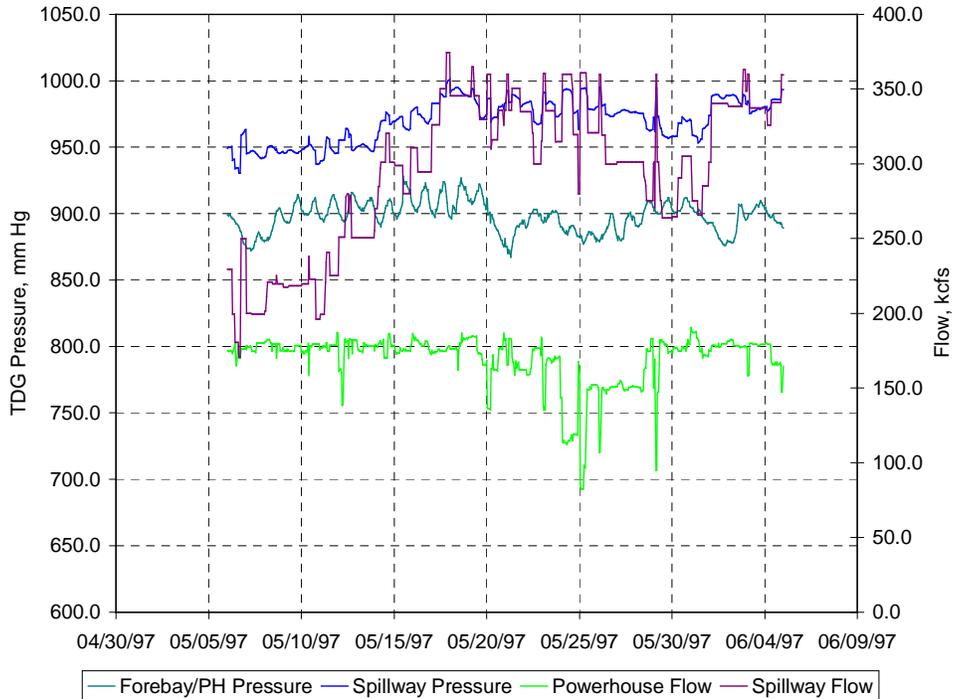


Figure 212. McNary forebay TDG pressure during the Spring 1997 study period.

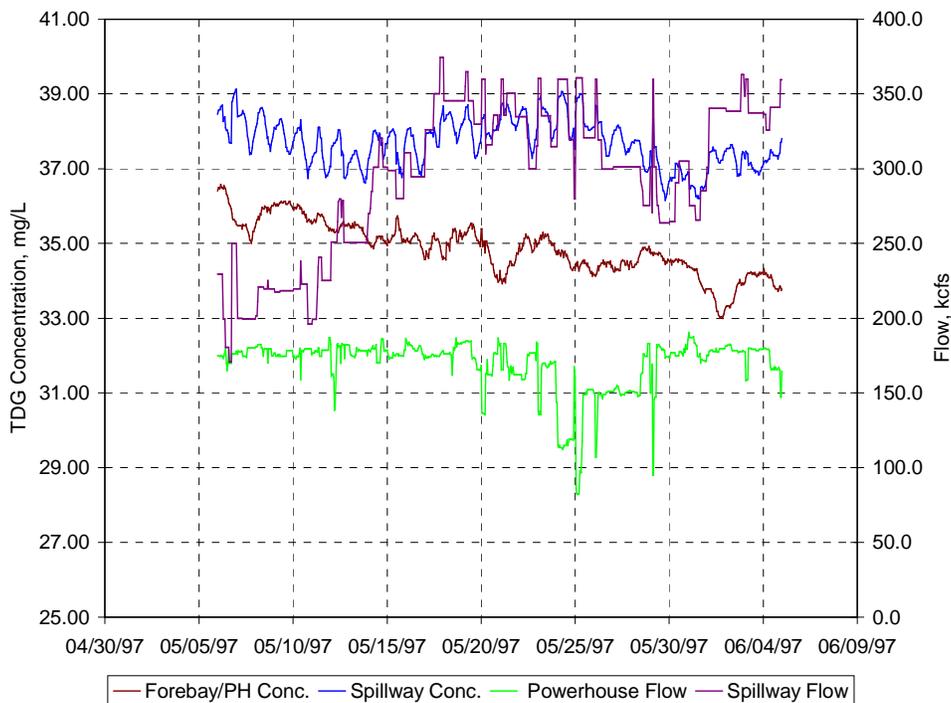


Figure 213. Computed TDG concentration in the McNary forebay during the Spring 1997 study.

McNary dam model boundary temperature and dissolved gas concentrations were also established at the McNary dam boundary using the temporary pool study monitors. Five temporary monitors were located in the McNary tailrace during Summer 1997 study period, as shown in Figure 214. The temperatures and TDG pressures recorded by these monitors are shown in Figure 215 and Figure 216, respectively. TDG concentrations computed from the measured TDG pressures and temperatures are shown in Figure 217. The transport simulation boundary was established at grid row 24 of block 1 (shown in red in Figure 214). Temporary monitor TDG concentrations and temperatures as follows along the model grid:

- JDA29114P: columns 1 to 12;
- JDA29112P: columns 13 to 24; and
- JDA29111P: columns 25 to 29.

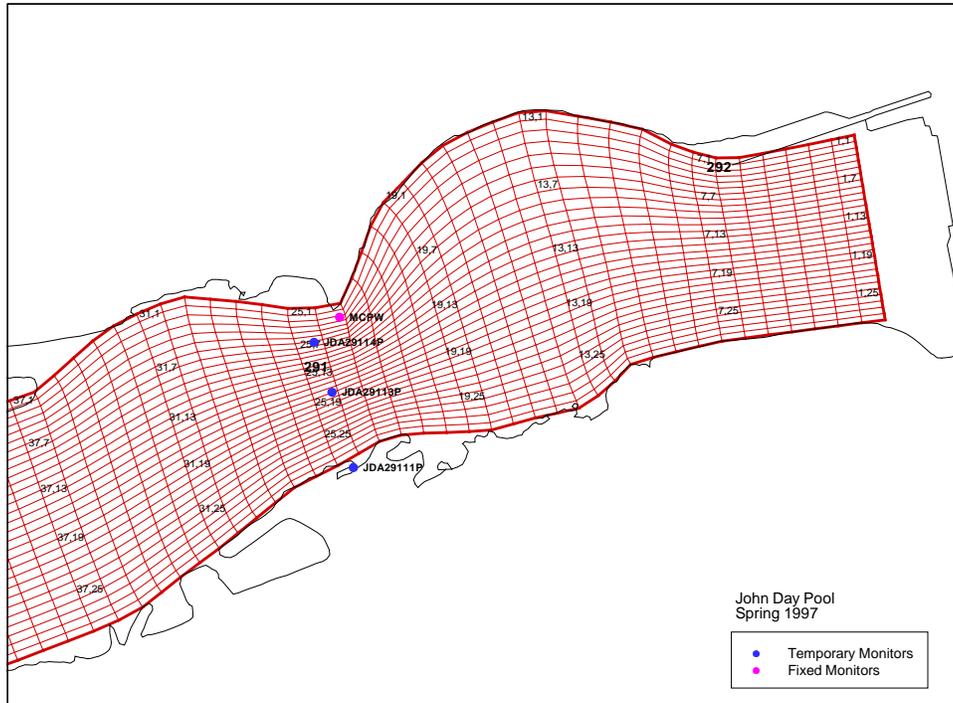


Figure 214. Locations, relative to the model grid, of upstream temporary monitors during the Summer 1997 study period.

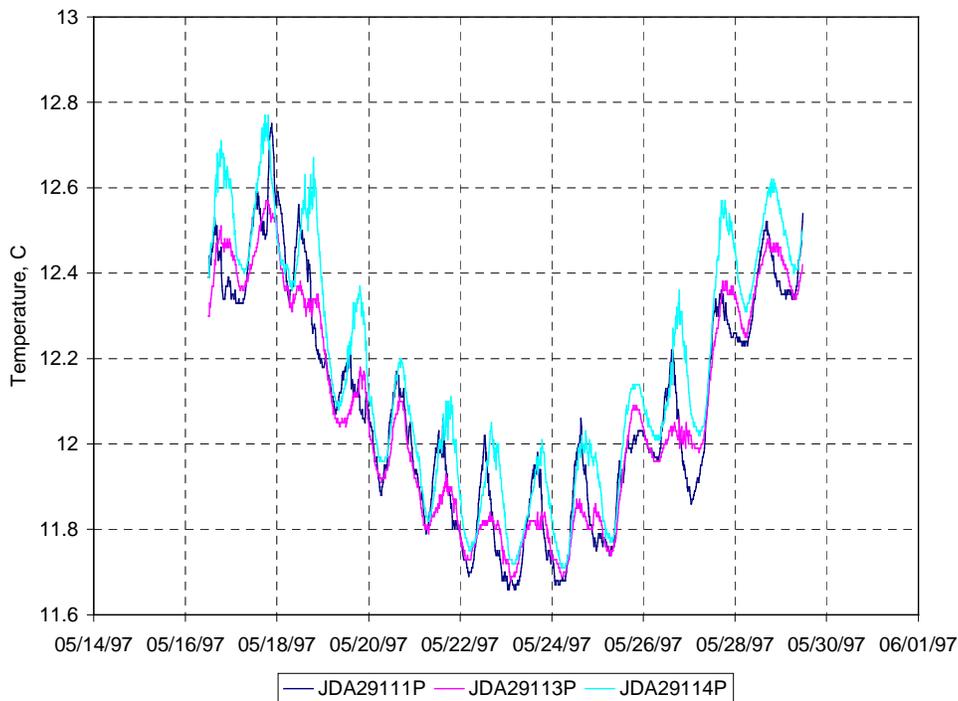


Figure 215. Temperatures measured by temporary monitors near McNary dam during the Spring 1997 study period.

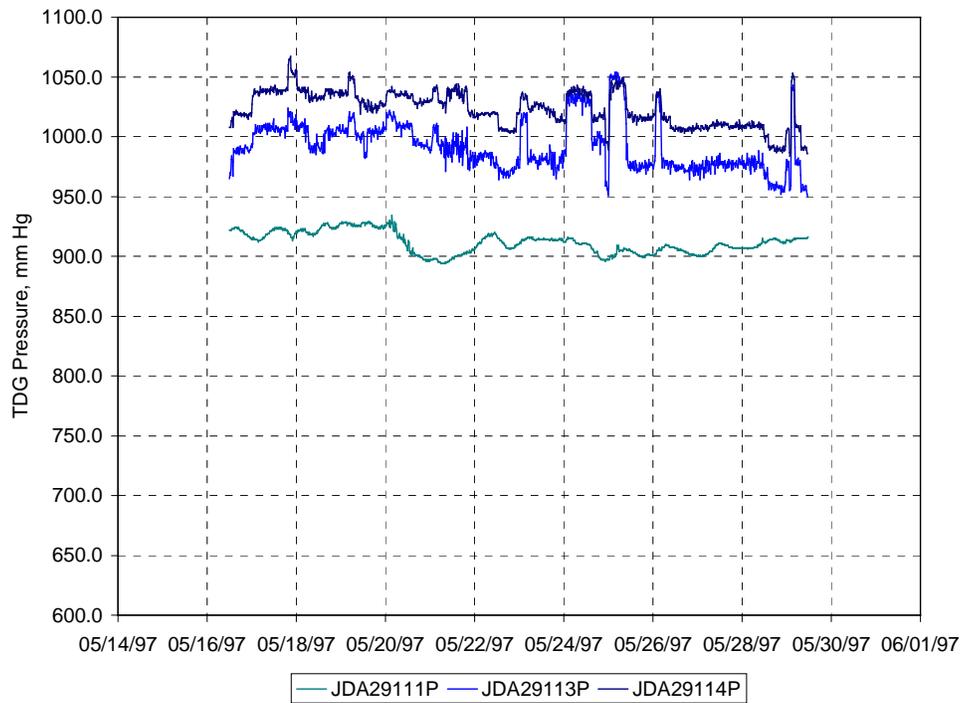


Figure 216. TDG pressures measured by temporary monitors near McNary dam during the Spring 1997 study period.

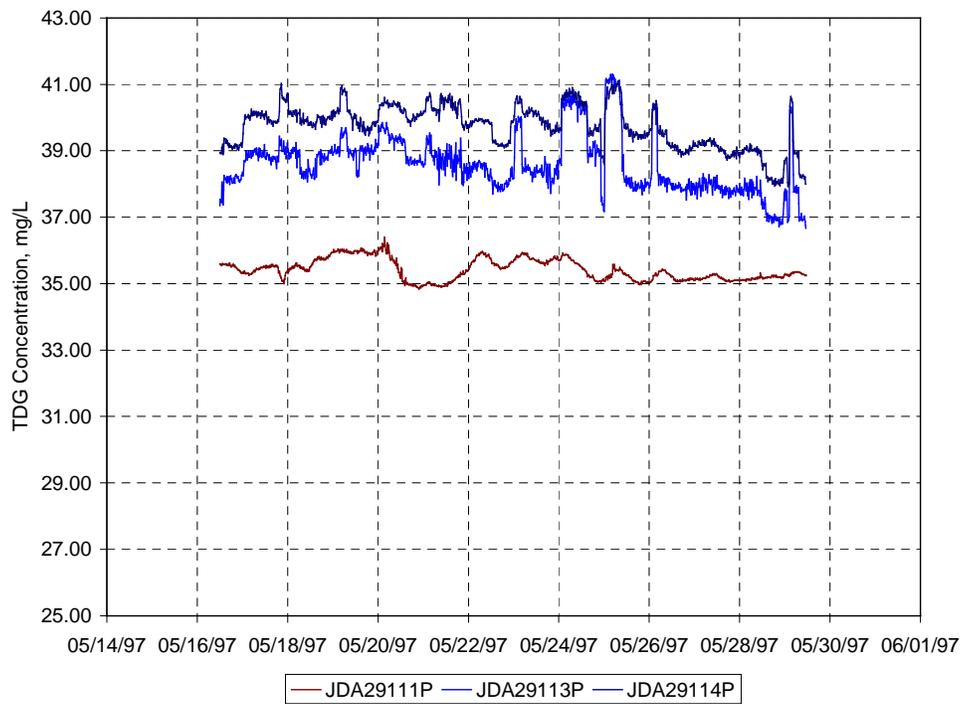


Figure 217. TDG concentrations computed from temporary monitor data near McNary dam during the Spring 1997 study period.

B.4 John Day Dam Boundary Operations

Forebay stage for John Day dam was obtained from hourly CHROMS operations data and is shown in Figure 218.

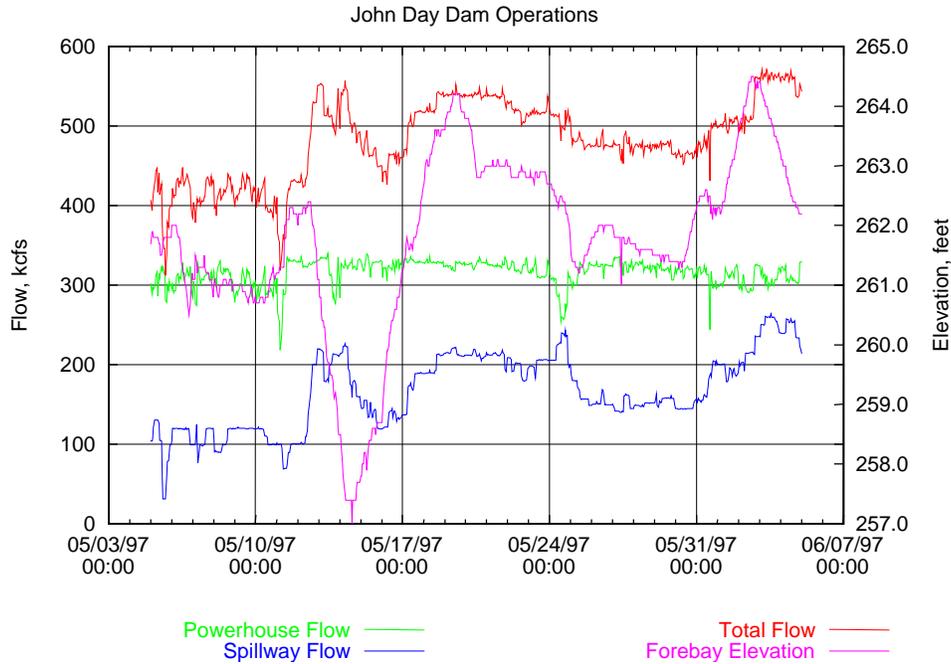


Figure 218. John Day dam operations during the Spring 1997 study period.

B.5 Weather

Atmospheric conditions were considered constant over the entire pool. The Dalles, Oregon, air and dew point temperature (Figure 219) and wind speed (Figure 220) were used from the NWS weather database. Barometric pressure measured by the TDA FMS (also shown in Figure 219) was considered to apply over the entire modeled area. Measured short-wave radiation was available from the WeatherPak database for part the Spring 1997 study. The available radiation data was extended using NWS The Dalles dew point and cloud cover data. Net incoming solar radiation based both on the measured and estimated total solar radiation is shown in Figure 221.

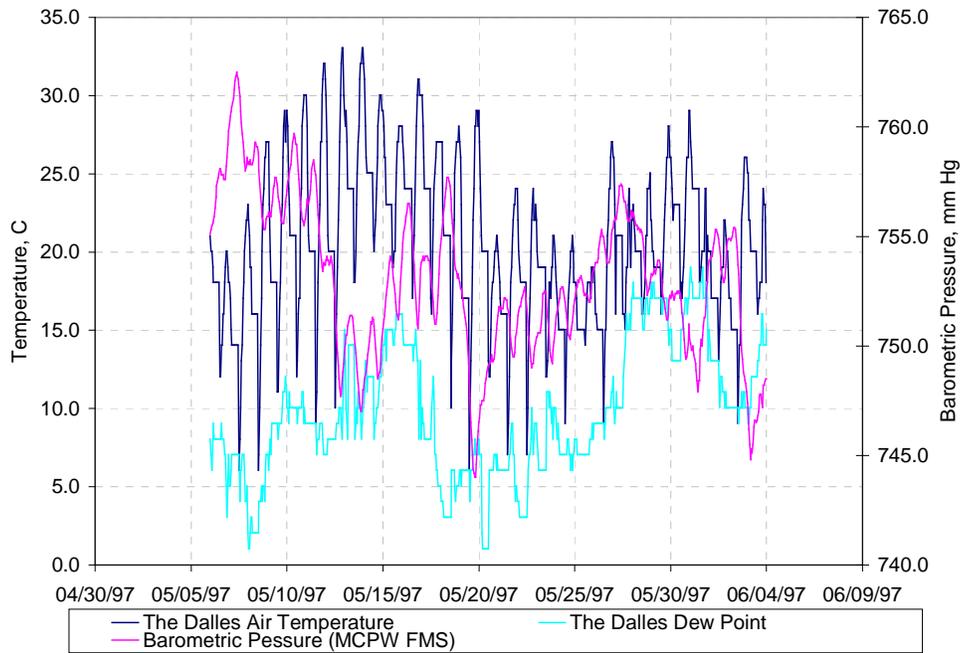


Figure 219. Air temperature, dew point, and barometric pressure used during the Spring 1997 study period.

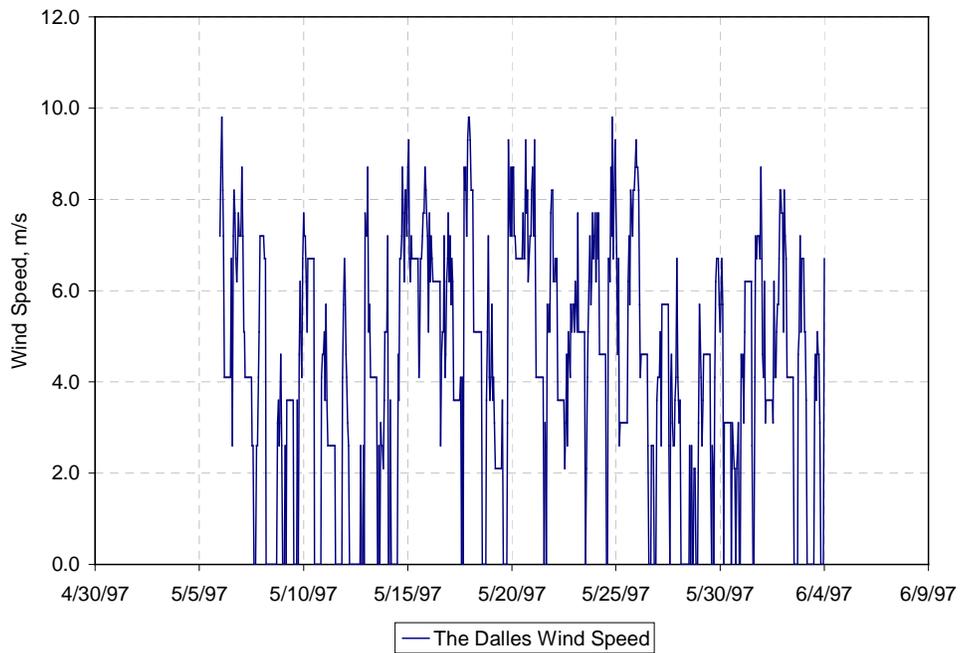


Figure 220. Wind Speed used during the Spring 1997 study period.

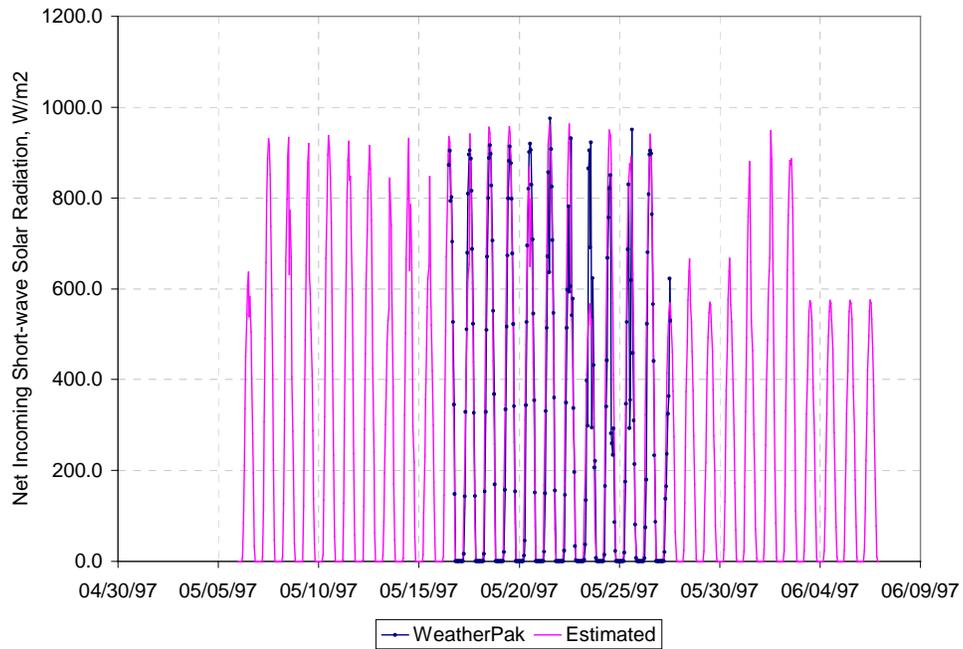


Figure 221. Net incoming short-wave solar radiation based on observed and estimated total radiation during the Spring 1997 study period.

JDA29111P	8/6/97 8:00:00 PM	8/18/97 9:00:00 AM	1109	1109
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Appendix C. Summer 1997 John Day Pool Study

C.1 Dissolved Gas Data

The Summer 1997 John Day pool study began on August 8 and ended on August 18. A total of 29 stations were used. These stations, and their records are listed in Table 99. Station locations are shown in

Table 99. Dissolved gas monitor stations, and their records, used during the Summer 1997 study period.

Station	Record Start	Record End	Temperature Records	Pressure Records
JDA27435P	8/6/97 8:00:00 PM	8/18/97 10:15:00 AM	1114	1114
JDA21722P	8/6/97 8:00:00 PM	8/18/97 1:15:00 PM	1126	1126
JDA21724P	8/6/97 8:00:00 PM	8/18/97 1:30:00 PM	1127	1127
JDA21725P	8/6/97 8:00:00 PM	8/18/97 1:30:00 PM	1127	1127
JDA24001P	8/6/97 8:00:00 PM	8/18/97 11:00:00 AM	1117	1117
JDA24002P	8/6/97 8:00:00 PM	8/18/97 11:00:00 AM	1117	1117
JDA24004P	8/6/97 8:00:00 PM	8/18/97 11:15:00 AM	1118	1118
JDA24005P	8/6/97 8:00:00 PM	8/18/97 11:30:00 AM	1119	1119
JDA26301P	8/6/97 8:00:00 PM	8/18/97 8:45:00 AM	1108	1108
JDA26302P	8/6/97 8:00:00 PM	8/14/97 12:45:00 AM	692	692
JDA26304P	8/6/97 8:00:00 PM	8/18/97 9:15:00 AM	1110	1110
JDA26305P	8/6/97 8:00:00 PM	8/18/97 9:15:00 AM	1110	1110
JDA27431P	8/6/97 8:00:00 PM	8/18/97 10:30:00 AM	1115	1115
JDA21721P	8/6/97 8:00:00 PM	8/18/97 1:15:00 PM	1126	1126
JDA27434P	8/6/97 8:00:00 PM	8/18/97 10:00:00 AM	1113	1113
MCNDTDP	8/6/97 8:00:00 PM	8/18/97 8:00:00 AM	1105	1105
JDA28032P	8/6/97 8:00:00 PM	8/18/97 11:15:00 AM	1118	1118
JDA28034P	8/6/97 8:00:00 PM	8/18/97 11:00:00 AM	1117	1117
JDA28035P	8/6/97 8:00:00 PM	8/18/97 11:00:00 AM	1117	1117
JDA28502P	8/6/97 8:00:00 PM	8/18/97 12:15:00 PM	1122	1093
JDA28504P	8/6/97 8:00:00 PM	8/18/97 12:00:00 PM	1121	1121
JDA28505P	8/6/97 8:00:00 PM	8/18/97 11:45:00 AM	1120	1120
JDA29112P	8/6/97 8:00:00 PM	8/18/97 8:45:00 AM	1108	1108
JDA29113P	8/6/97 8:00:00 PM	8/7/97 8:15:00 AM	50	50
JDA29114P	8/6/97 8:00:00 PM	8/18/97 8:30:00 AM	1107	1107
JDA29115P	8/6/97 8:00:00 PM	8/18/97 6:15:00 AM	1098	1098
JDA27432P	8/6/97 8:00:00 PM	8/18/97 10:30:00 AM	1115	1115
JDADTDP	8/6/97 8:00:00 PM	8/18/97 2:15:00 PM	1130	1130

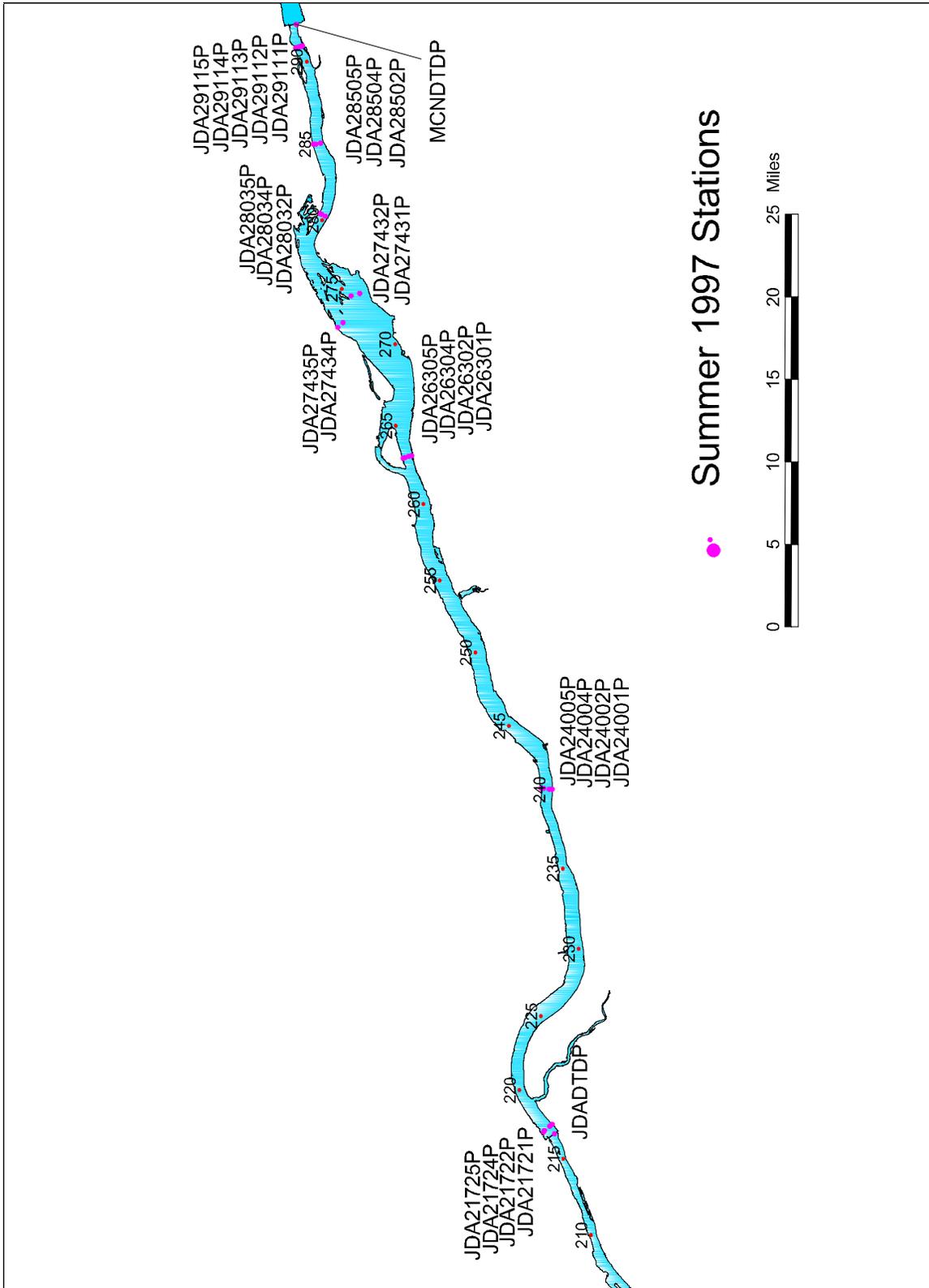


Figure 222. Dissolved gas monitor locations during the Summer 1997 study.

C.2 Velocity Data

Velocity measurements were made along a total of 41 transects during the Summer 1997 study period. The transects are summarized in Table 100. Supplied measurement locations are shown in Figure 223.

Table 100. Summary of ADCP transects made during the Summer 1997 study period.

Date Label	Average		Number of Measurements
	Velocity	Depth	
08-11-1997 09:26:00	2.8	48.1	48
08-11-1997 09:40:00	2.9	50.9	50
08-11-1997 09:49:00	2.7	47.3	48
08-11-1997 10:20:00	3.1	26.5	74
08-11-1997 10:46:00	3.1	23.4	97
08-11-1997 11:12:00	3.0	25.1	90
08-11-1997 11:37:00	2.8	25.3	98
08-11-1997 11:59:00	2.4	27.7	85
08-11-1997 12:26:00	2.3	25.4	102
08-11-1997 12:54:00	2.3	27.7	97
08-11-1997 13:17:00	2.0	28.7	103
08-11-1997 13:36:00	1.9	29.0	105
08-11-1997 13:54:00	1.9	29.0	105
08-11-1997 14:18:00	1.8	39.0	76
08-11-1997 14:41:00	1.9	31.5	106
08-11-1997 15:08:00	1.6	41.8	83
08-11-1997 15:17:00	1.6	40.7	85
08-11-1997 15:31:00	1.6	42.0	86
08-12-1997 09:12:00	1.2	33.9	142
08-12-1997 09:42:00	1.0	34.1	60
08-12-1997 09:53:00	0.9	33.5	61
08-12-1997 10:16:00	1.4	48.7	85
08-12-1997 10:31:00	1.2	42.7	80
08-12-1997 11:10:00	0.9	36.3	186
08-12-1997 11:52:00	1.1	62.7	88
08-12-1997 12:06:00	1.0	62.8	89
08-12-1997 12:21:00	1.1	62.9	87
08-12-1997 12:57:00	0.7	55.5	142
08-12-1997 13:28:00	0.7	58.8	150
08-12-1997 14:03:00	0.6	66.8	158
08-12-1997 14:30:00	0.7	69.4	143
08-13-1997 08:14:00	0.7	78.8	115
08-13-1997 08:32:00	0.7	79.2	116
08-13-1997 08:51:00	0.7	78.8	114
08-13-1997 09:20:00	0.8	89.5	91
08-13-1997 09:49:00	0.6	85.7	139
08-13-1997 10:24:00	0.8	70.2	121
08-13-1997 11:01:00	0.6	93.2	102
08-13-1997 11:35:00	0.6	98.0	127
08-13-1997 11:52:00	0.6	96.9	119
08-13-1997 12:06:00	0.7	97.7	122

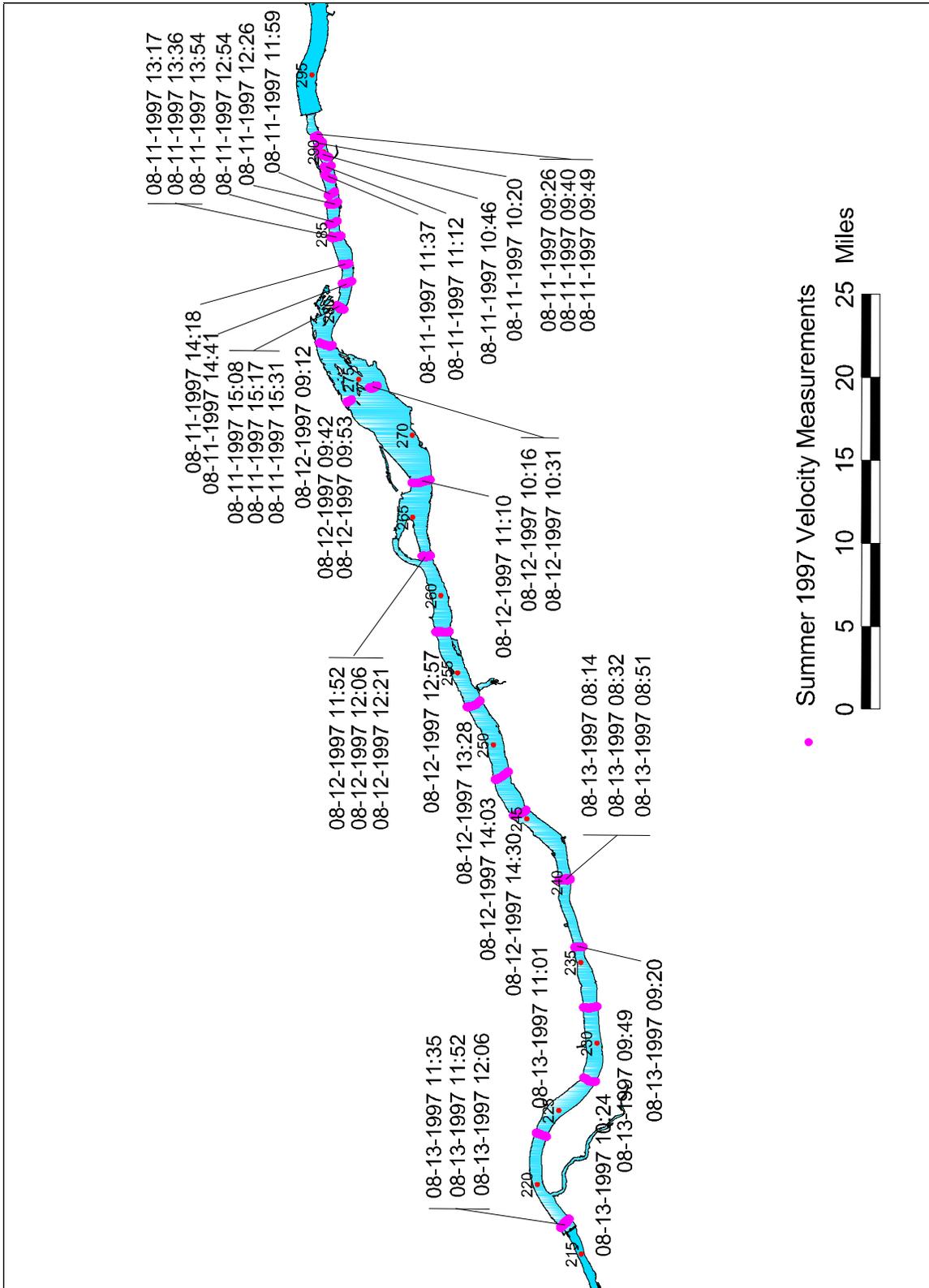


Figure 223. Locations of ADCP velocity measurements during the Summer 1997 study period.

C.3 McNary Dam Model Boundary

C.3.1 Dam Operations

CHROMS operations data was used to establish the flow at the McNary dam model boundary and stage at the John Day dam model boundary. This data provided hourly spillway flow and powerhouse flow. Hourly total spill and powerhouse flows for the Summer 1997 study period are shown in Figure 224. These flows were uniformly distributed across the corresponding part of the model grid.

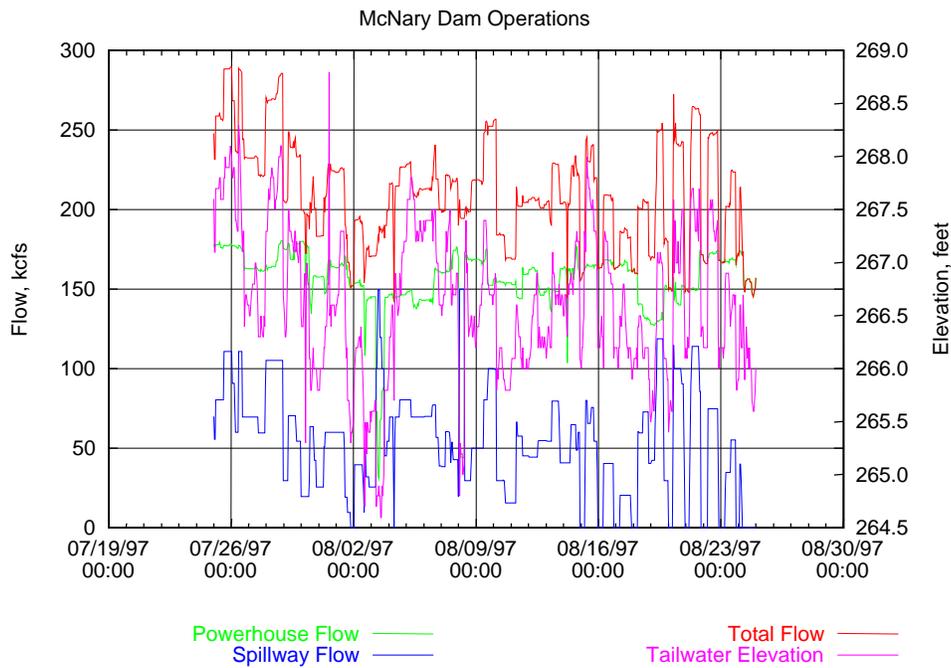


Figure 224. McNary dam operations during the Summer 1997 study.

C.3.2 Water Quality

Initially, data from the permanent fixed monitor located in the McNary dam forebay (station name "MCN") was used to establish temperature at the McNary dam boundary. Station data was taken from the FMS database. Temperature measured by the station (Figure 225) was used for both spillway and powerhouse flow. TDG pressures measured by the station (Figure 226) was used to compute TDG concentrations (Figure 213) for the powerhouse flow. Spillway TDG gas pressures and concentrations (also shown in Figure 226 and Figure 227, respectively) were estimated using the TDG sourcing function for McNary dam.

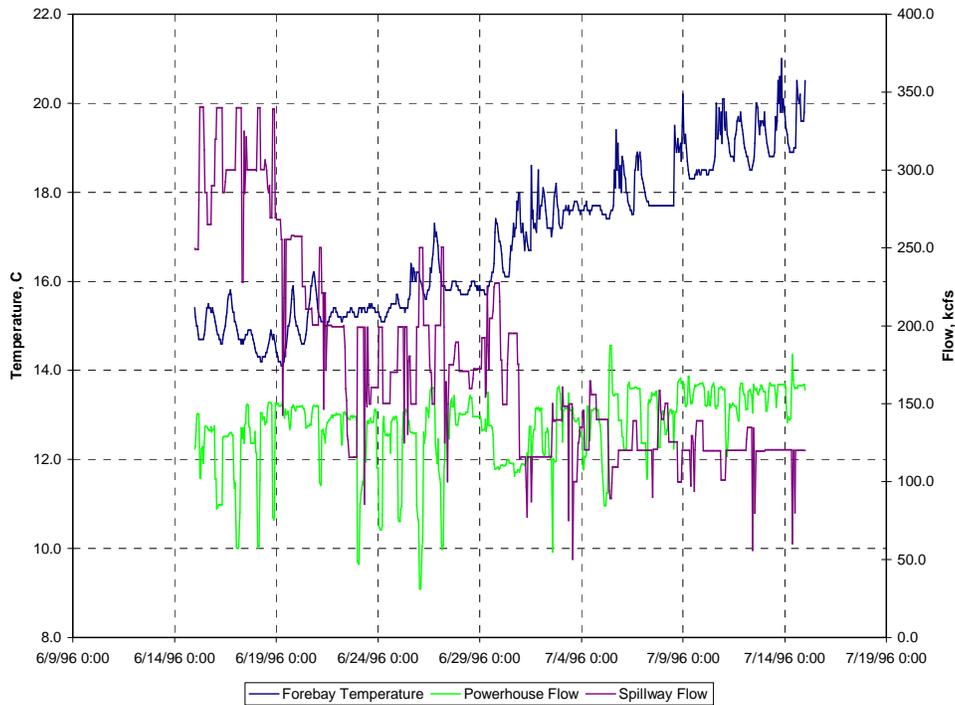


Figure 225. McNary forebay water temperature during the Summer 1997 study.

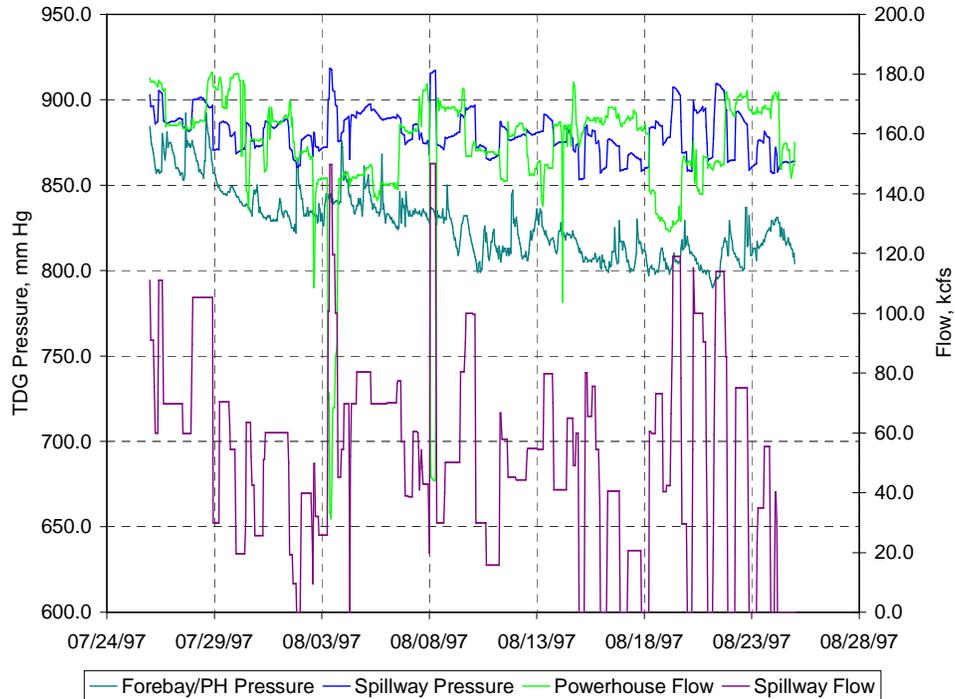


Figure 226. McNary forebay TDG pressure during the Summer 1997 study.

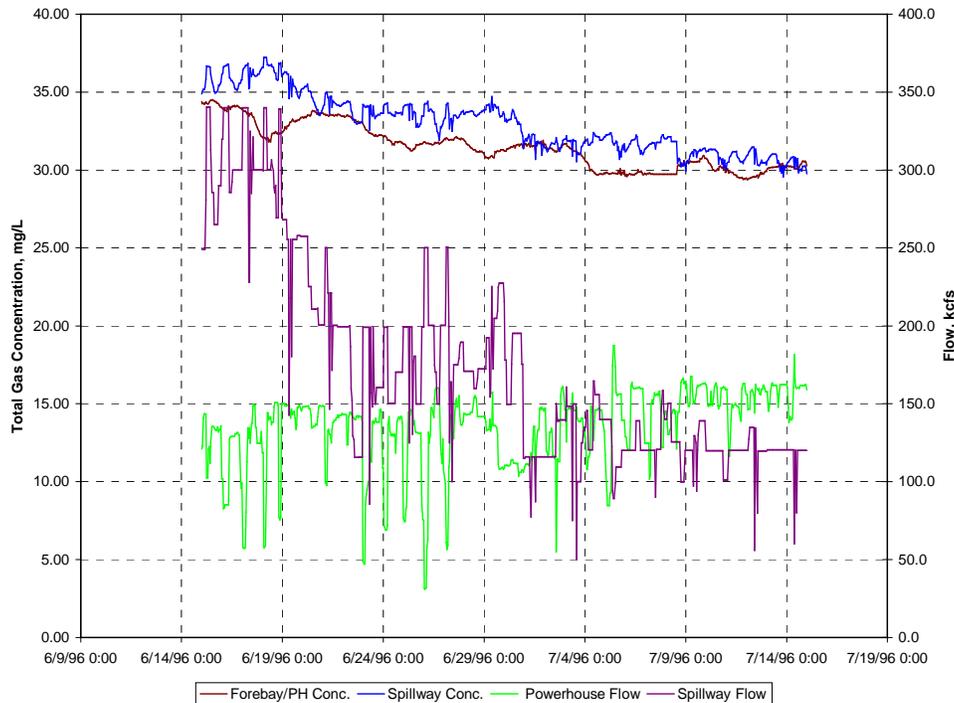


Figure 227. Computed TDG concentration in the McNary forebay during the Summer 1997 study period.

Model boundary temperature and dissolved gas concentrations were also established at the McNary dam boundary using the temporary pool study monitors. Five temporary monitors were located in the McNary tailrace during Summer 1997 study period, as shown in Figure 228 (station JDA291153P was not used for establishing boundary conditions, because of its short record). The temperatures and TDG pressures recorded by these monitors are shown in Figure 229 and Figure 230, respectively. TDG concentrations computed from the measured TDG pressures and temperatures are shown in Figure 231. The transport simulation boundary was established at grid row 26 of block 1 (shown in red in Figure 228). Temporary monitor TDG concentrations and temperatures as follows along the model grid:

- JDA29115P: columns 1 to 3;
- JDA29114P: columns 4 to 17;
- JDA29112P: columns 18 to 27; and
- JDA29111P: columns 28 to 29.

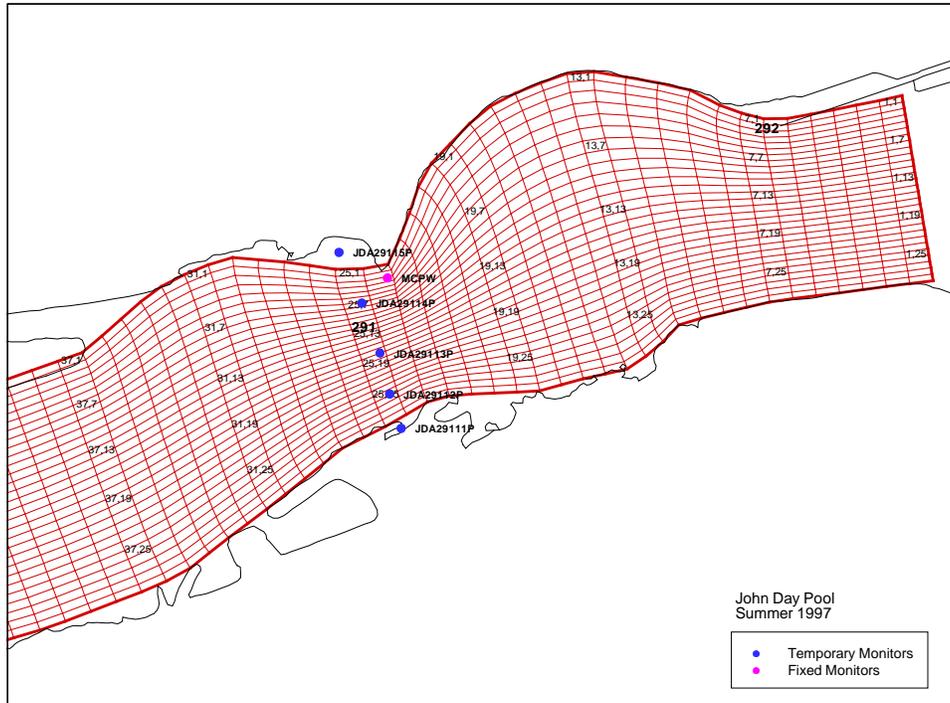


Figure 228. Locations, relative to the model grid, of upstream temporary monitors during the Summer 1997 study period.

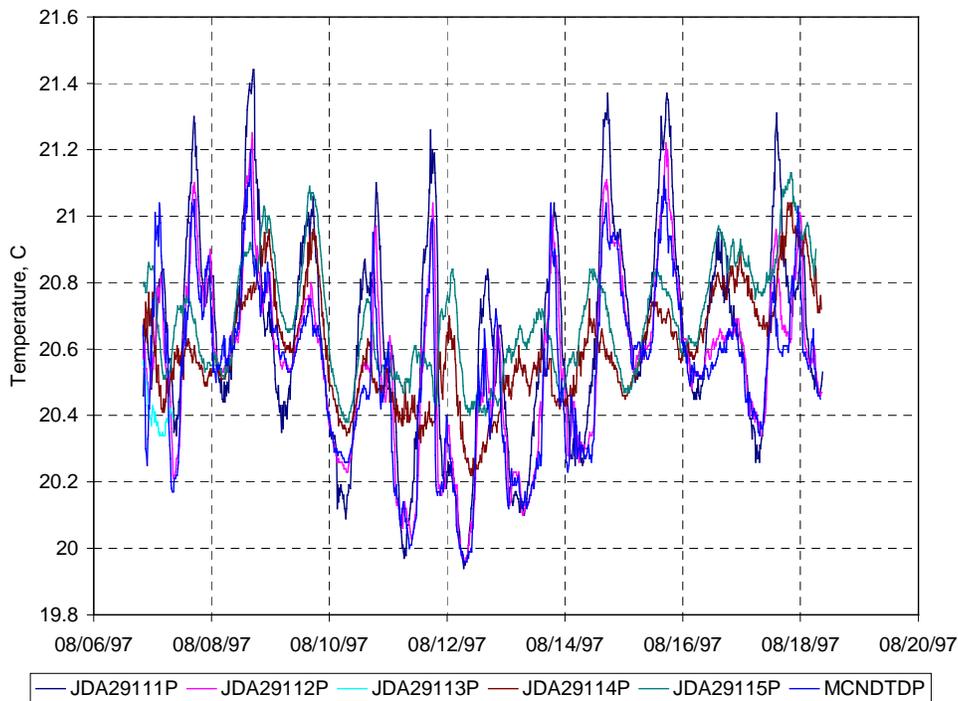


Figure 229. Temperatures measured by temporary monitors near McNary dam during the Summer 1997 study period.

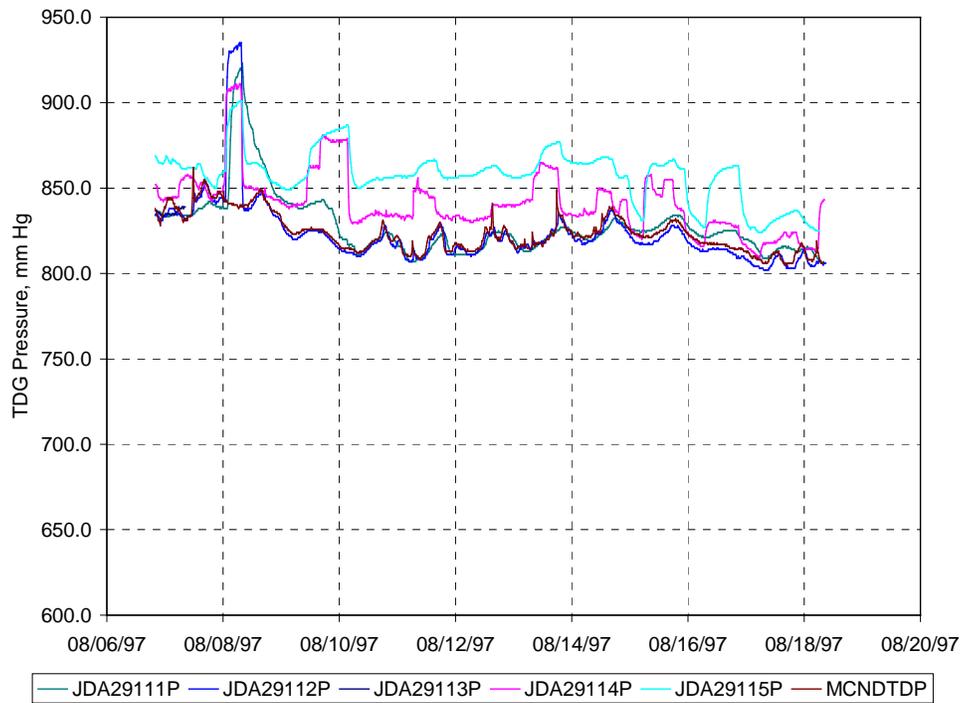


Figure 230. TDG pressures measured by temporary monitors near McNary dam during the Summer 1997 study period.

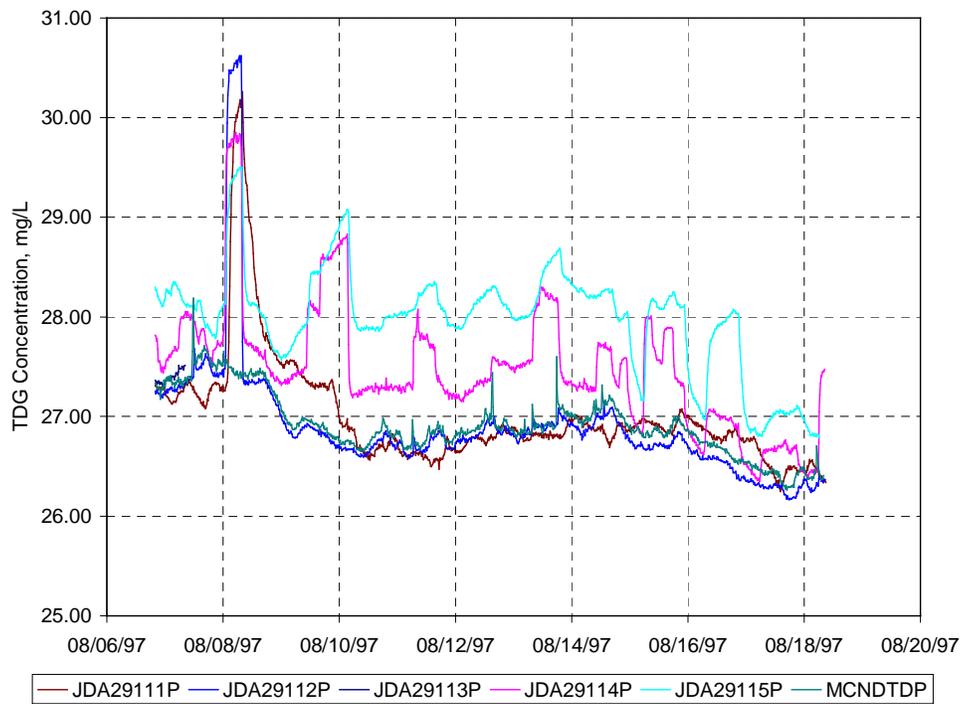


Figure 231. TDG concentrations computed from temporary monitor data near McNary dam during the Summer 1997 study period.

C.4 John Day Dam Boundary Operations

Forebay stage for John Day dam was obtained from hourly CHROMS operations data and is shown in Figure 232.

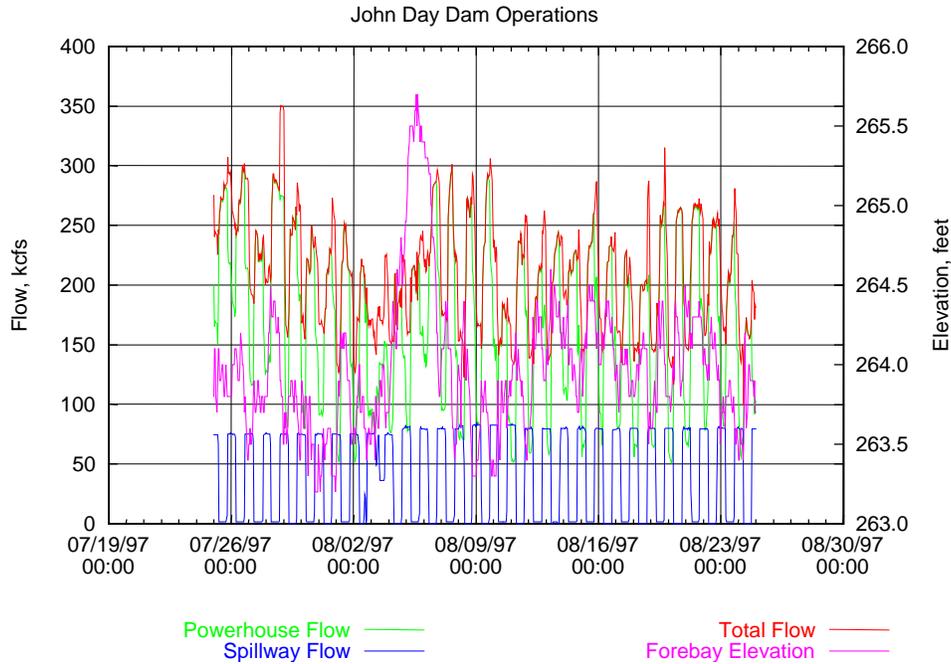


Figure 232. John Day dam operations during the Summer 1997 study period.

C.5 Weather

Atmospheric conditions were considered constant over the entire pool. The Dalles, Oregon, air and dew point temperature (Figure 233) and wind speed (Figure 234) were used from the NWS weather database. Barometric pressure measured by the TDA FMS (also shown in Figure 233) was considered to apply over the entire modeled area. Measured short-wave radiation was available from the WeatherPak database for part the Summer 1997 study. The available radiation data was extended using NWS The Dalles dew point and cloud cover data. Net incoming solar radiation based both on the measured and estimated total solar radiation is shown in Figure 235.

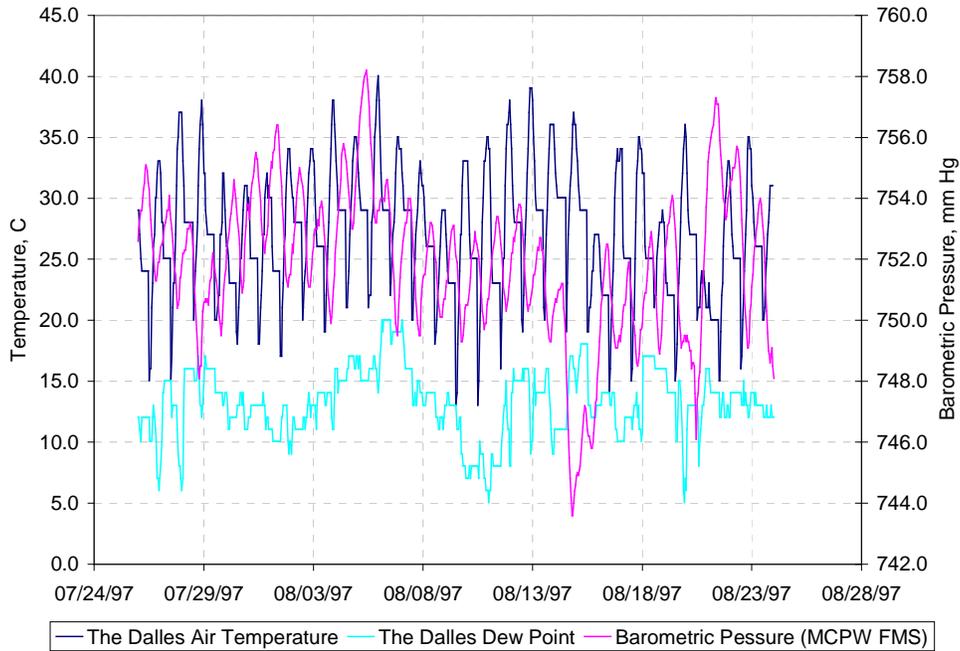


Figure 233. Air temperature, dew point, and barometric pressure used during the Summer 1997 study period.

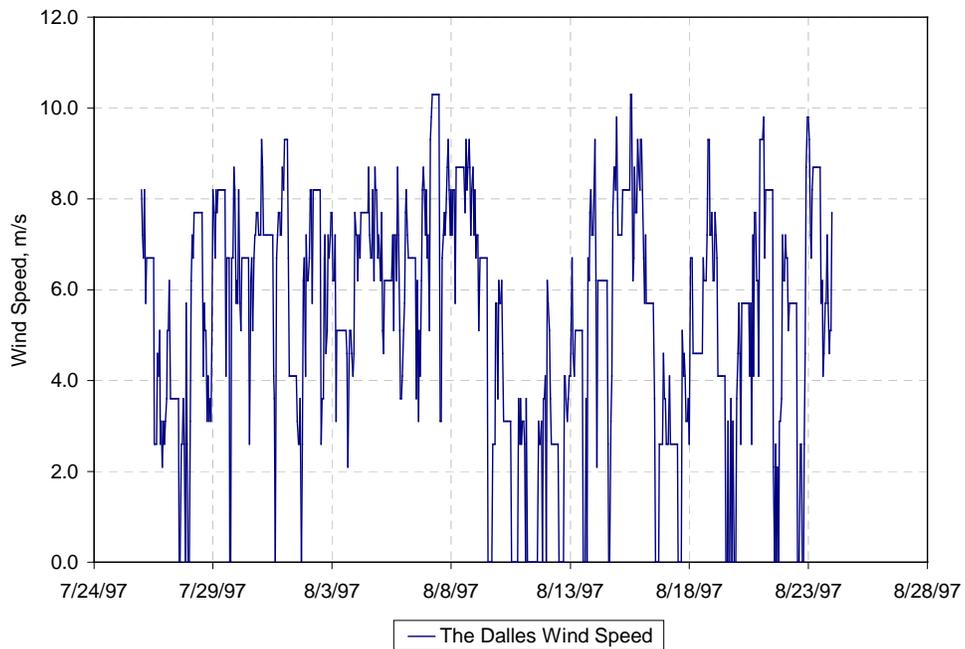


Figure 234. Wind speed used during the Summer 1997 study period.

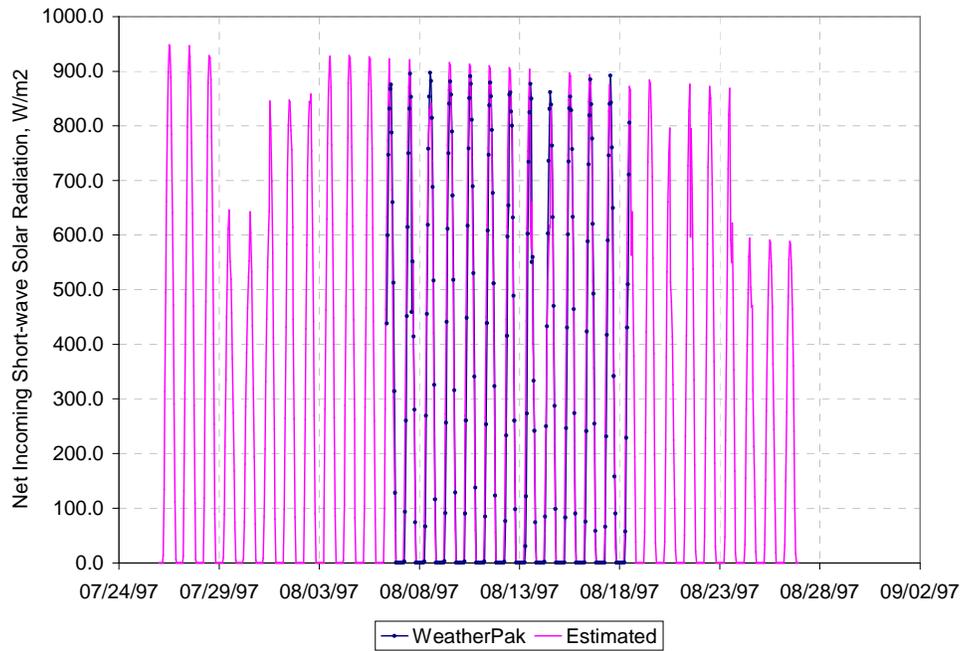


Figure 235. Net incoming short-wave solar radiation based on observed and estimated total radiation during the Summer 1997 study period.