Appendix A
Hydrodynamic Model Descriptions

Appendix A. Hydrodynamic Model Descriptions

The following provides descriptions of the Gulf Coast Shelf Model (GCSM) and Charlotte Harbor/St. Joseph Sound hydrodynamic model, including data sources used for boundary conditions, initial conditions, and calibration. Calibration statistics are provided which are based on comparison of model output to observed data, for water surface elevation, salinity, and temperature. The discussion of the GCSM is modified from Janicki Environmental (2003, 2008).

A.1. Gulf Coast Shelf Model

The large-scale Gulf Coast Shelf Model (GCSM) domain extends from the mouth of Tampa Bay to Cape San Blas (Figure A-1). The GCSM contains 2155 horizontal cells, with 10 layers in the vertical. The model grid cells are approximately rectangular, with dimensions of about six km by four km, with some variation.

The data used for the model include: bathymetry, freshwater inflows, rainfall, meteorology (wind speed, wind direction, solar radiation, dry bulb air temperature, wet bulb air temperature, atmospheric pressure, relative humidity, evaporation, and cloud cover), salinity, water temperature, and water surface elevation. These data can be divided into two groups, data used as forcing functions for the model (bathymetry, boundary conditions, and atmospheric data) and data used for calibration of the model. A summary of all data is presented below that includes source, data format, units, frequency of measurements, period of record, and whether the data are used for boundary conditions or calibration.

A.1.1 Bathymetry

Bathymetric data for the GCSM were derived from the National Geodetic Data Center (NGDC) Coastal Relief Model. The Coastal Relief Model uses the restructured National Ocean Service (NOS) Hydrographic Database combined with the U.S. Geological Survey DEM grids to assemble a gridded database of coastal zone elevations. For areas where NOS coverage does not exist, bathymetric contours from the International Bathymetric Chart of the Caribbean Sea and Gulf of Mexico (IBCCA) were used. Depth information was extracted from the NGDC CD Volume 3 as point data in text format with associated latitude and longitude. Units are in meters and the datum is Mean Sea Level (MSL). The data were converted into an ARC-GIS shape file and trimmed to the model domain (Figure A-1).

A.1.2. Freshwater Inflows

Freshwater inflows were obtained from the USGS, SWFWMD, and NWFWMD for the coastal area bordering the GCSM domain. USGS data were received as daily streamflow (cfs) data in tab-delimited text files. As expected, the freshwater inflows are dominated by the Apalachicola and Suwannee rivers in the northern and middle portions of the model domain. Together, these two rivers represent approximately 75% of the gaged freshwater inflows to the model domain. Discharge estimates for the Weeki Wachee River were obtained from SWFWMD (M. Heyl, pers. comm.). Discharge data for Wakulla Spring were obtained from NWFWMD in text format with a frequency of 3 hours. Daily medians were calculated and all data were converted to SAS datasets. The station name, period of record, and median daily flow for 2000-2002 are provided in Table A-1. The Aucilla River flow data are from a regression developed for this study. The locations of the USGS gages and Wakulla Spring are presented in Figure A-2. Data gaps were filled by an appropriate method based on the number of missing records.

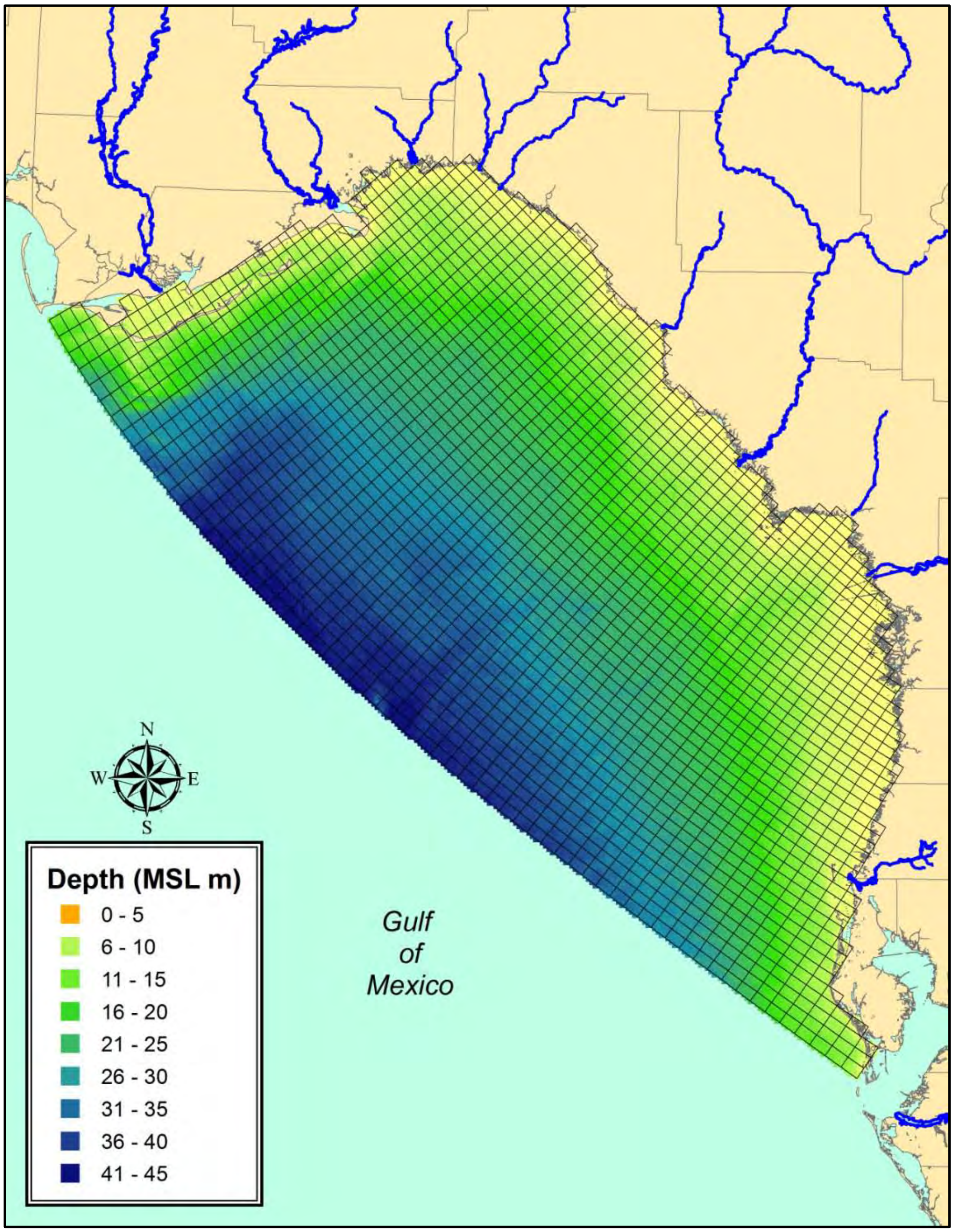


Figure A-1. Model domain for the large-scale Gulf Coast Shelf Model with bathymetry.

Table A-1. Period of record, frequency, and daily flow (2000-2002) for river and spring discharge stations.

Station Name	Period	Median flow (cfs)
Curlew Creek at County Road 1 Near Ozona FL	8/9/1999 to Present	6
Bee Branch at 15th Street at Palm Harbor FL	6/30/2000 to Present	1
Hollin Creek near Tarpon Springs FL	6/26/1981 to Present	1
Anclote River Near Elfers FL	6/1/1946 to Present	4
Pithlachascotee River Near New Port Richey FL	4/1/1963 to Present	1
Weeki Wachee River Near Weeki Wachee Springs FL	11/14/2000 to Present	123
Chassahowitzka River Near Homosassa FL	10/15/1999 to Present	53
Homosassa Springs at Homosassa Springs FL	10/18/1995 to Present	83
Crystal River near Crystal River FL	3/1/1964 to 9/30/1977	963
Withlacoochee River at Inglis Dam Near Dunnellon FL	10/1/1969 to Present	70
Withlacoochee River Bypass Channel Near Inglis FL	1/1/1970 to Present	515
Waccasassa River near Gulf Hammock FL	4/1/1963 to Present	112
Suwannee River above Gopher River Near Suwannee FL	6/24/1999 to Present	4020
Steinhatchee River Near Cross City FL	3/1/1950 to Present	19
Fenholloway River Near Perry FL	8/10/1977 to Present	89
Econfina River Near Perry FL	2/1/1950 to Present	26
Aucilla River Near Mouth near Nutall Rise FL	5/4/2001 to Present	869
St. Marks River Near Newport FL	10/1/1956 to Present	441
Wakulla Spring Near Tallahassee FL	5/9/1997 to Present	264
Sopchoppy River near Sopchoppy FL	6/1/1964 to Present	39
Ochlockonee River Near Smith Creek FL	8/7/1996 to Present	647
New River Near Sumatra FL	12/11/1996 to Present	80
Apalachicola River Near Sumatra FL	10/1/1977 to Present	10300

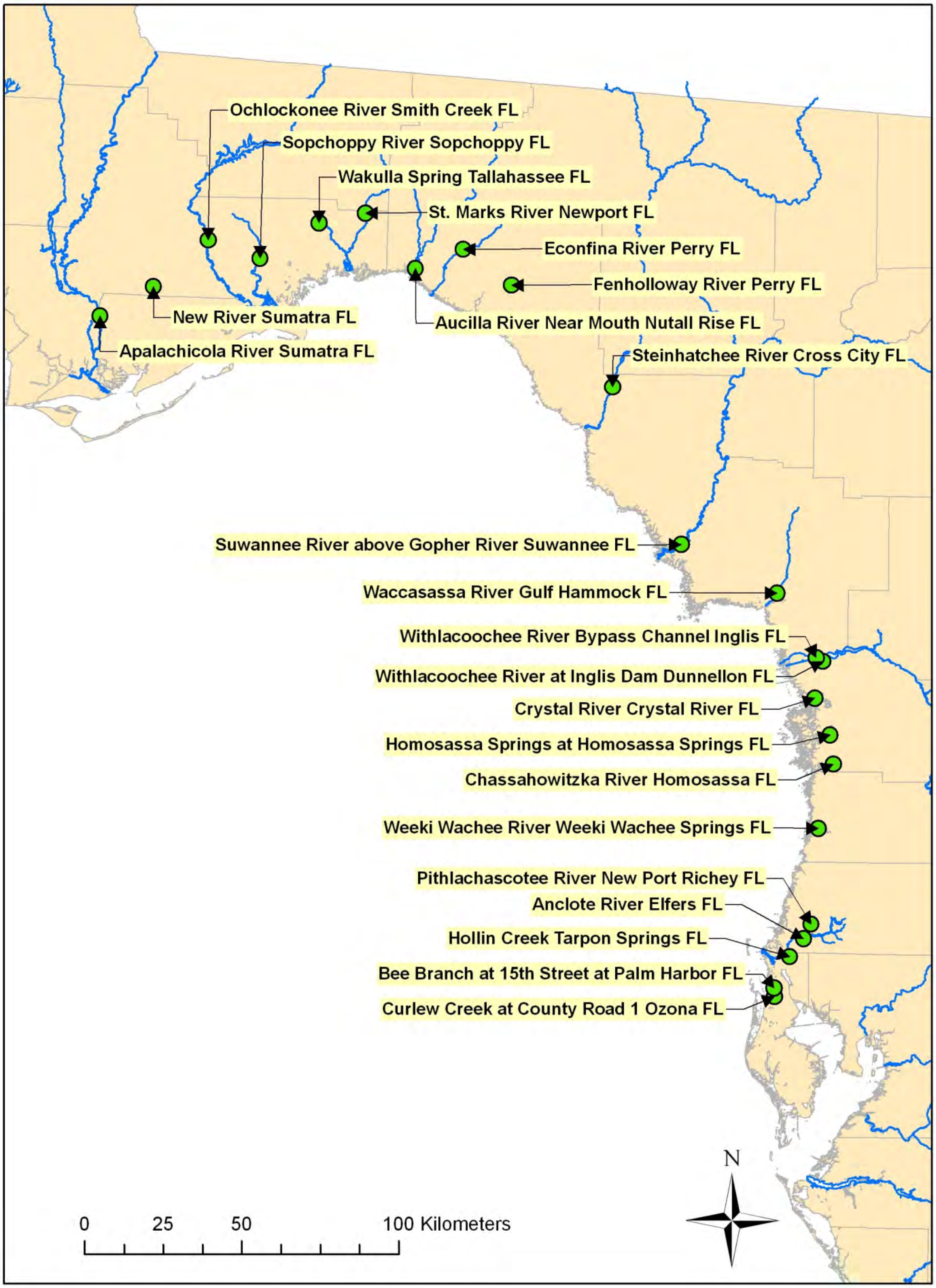


Figure A-2. River and spring discharge station locations.

A.1.3. Atmospheric Data

The locations of stations used for atmospheric forcing data are shown in Figure A-3. These data include wind, solar radiation, rainfall, and other meteorological parameters such as cloud cover, relative humidity, atmospheric pressure, and dry/wet bulb air temperatures.

Figure A-3. Locations of atmospheric data stations.

The stations used for wind-forcing are presented in Table A-2. Hourly wind speed (m/s) and direction were obtained from NOAA/NDBC stations and 6 minute data were obtained from the Coastal Ocean Monitoring and Prediction System (COMPS) maintained by the University of South Florida (USF). One measurement per hour was used from the COMPS data. Both the COMPS and NOAA/NDBC datasets were obtained as space-delimited text files and converted to SAS datasets.

Table A-2. Stations, period of record, and frequency for wind speed and direction.

Station Name	Period	Frequency
Pensacola South Buoy	1/1/1996 to Present	Hourly
Keaton Beach	1/1/1996 to Present	Hourly
West Tampa Buoy	1/1/1994 to Present	Hourly
Cape San Blas	1/1/1984 to Present	Hourly
Homossassa	3/31/1999 to Present	6 Min
Egmont Key	1/7/1999 to Present	6 Min

Hourly solar radiation data for Dover, Ocklawaha, and Hastings were obtained from the Florida Automated Weather Network (FAWN) at the University of Florida (Table A-3). The solar radiation data were obtained as space-delimited text files in units of watts/m^2 and converted to a SAS dataset.

Table A-3. Stations, period of record, and frequency for solar radiation.

Station Name	Period	Frequency
Dover	5/5/1998 to Present	Hourly
Ocklawaha	12/19/1998 to Present	Hourly
Hastings	8/4/1999 to Present	Hourly

Data for daily precipitation (in inches) (Table A-4) and meteorology (Table A-5) were obtained from NOAA's National Climatic Data Center (NCDC). Data were received as comma-delimited text files. A descriptive cloud cover parameter was converted to % sky cover based on NWS guidelines, air temperatures were reported in °C, relative humidity was reported as a percentage, and atmospheric pressure was reported in millibars. All data files were converted to SAS datasets.

Table A-4. Stations, period of record, and frequency for daily precipitation.

Station Name	Period	Frequency
Weeki Wachee	11/1/1969 to Present	Daily
Usher Tower	7/1/1956 to Present	Daily
Apalachicola Municipal Airport	4/1/1931 to Present	Daily

Table A-5. Stations, period of record, and frequency for meteorological data (cloud cover, relative humidity, dry bulb temperature, wet bulb temperature, and atmospheric pressure).

Station Name	Period	Frequency
Tallahassee Regional Airport	5/1/1942 to Present	Hourly
Gainesville Regional Airport	11/1/1943 to Present	Hourly
Tampa International Airport	8/1/1940 to Present	Hourly

A.1.4. Boundary Condition and Calibration Data

Boundary condition and calibration data are necessary for water surface elevation, water temperature, and salinity. The following describes the data utilized for the GCSM.

A.1.4.1. Water Surface Elevation

Boundary condition water surface elevations are necessary for the entire offshore boundary of the model domain. Observed water surface elevation data off the shelf in the Gulf of Mexico are sparse. Therefore, predicted water surface elevations were obtained from the Eastcoast 2001 tidal constituent database (Mukai, 2001) to define the offshore boundary conditions for the large-scale model. Eastcoast 2001 was developed by the University of North Carolina for the Army Corps of Engineers. The tidal constituents have been calibrated to over 100 water level observation stations (Figure A-4) throughout the Gulf of Mexico and the U.S. east coast. The Eastcoast 2001 grid has a spatial resolution that varies from 1-4 km near the coast to 25 km out at sea. Amplitude and phase for the dominant tidal constituents were used to predict water level at the offshore boundary of the model at approximately 25 km intervals.

The input file for Eastcoast 2001 requires a list of latitude/longitude pairs in its model domain. The output file lists the amplitude in meters (MSL) and phase in degrees for each tidal frequency. The tidal oscillation for each frequency is then summed up to obtain hourly tidal elevation at several points along the large-model offshore boundary.

For calibration of the GCSM, observed water surface elevation data were obtained from the Center for Operational Oceanographic Products and Services (CO-OPS) maintained by NOAA's National Ocean Service (Table A-6). CO-OPS data were received as space-delimited text files with water level in meters MLLW. Hourly data values were used for comparison of the model output to observed data from Clearwater Beach and Cedar Key (Figure A-5). Additional water surface elevation data were available from the COMPS monitoring, but were not utilized for calibration. The COMPS data were processed and reviewed for each site obtained, and for various reasons were disqualified as being inappropriate for calibration purposes.

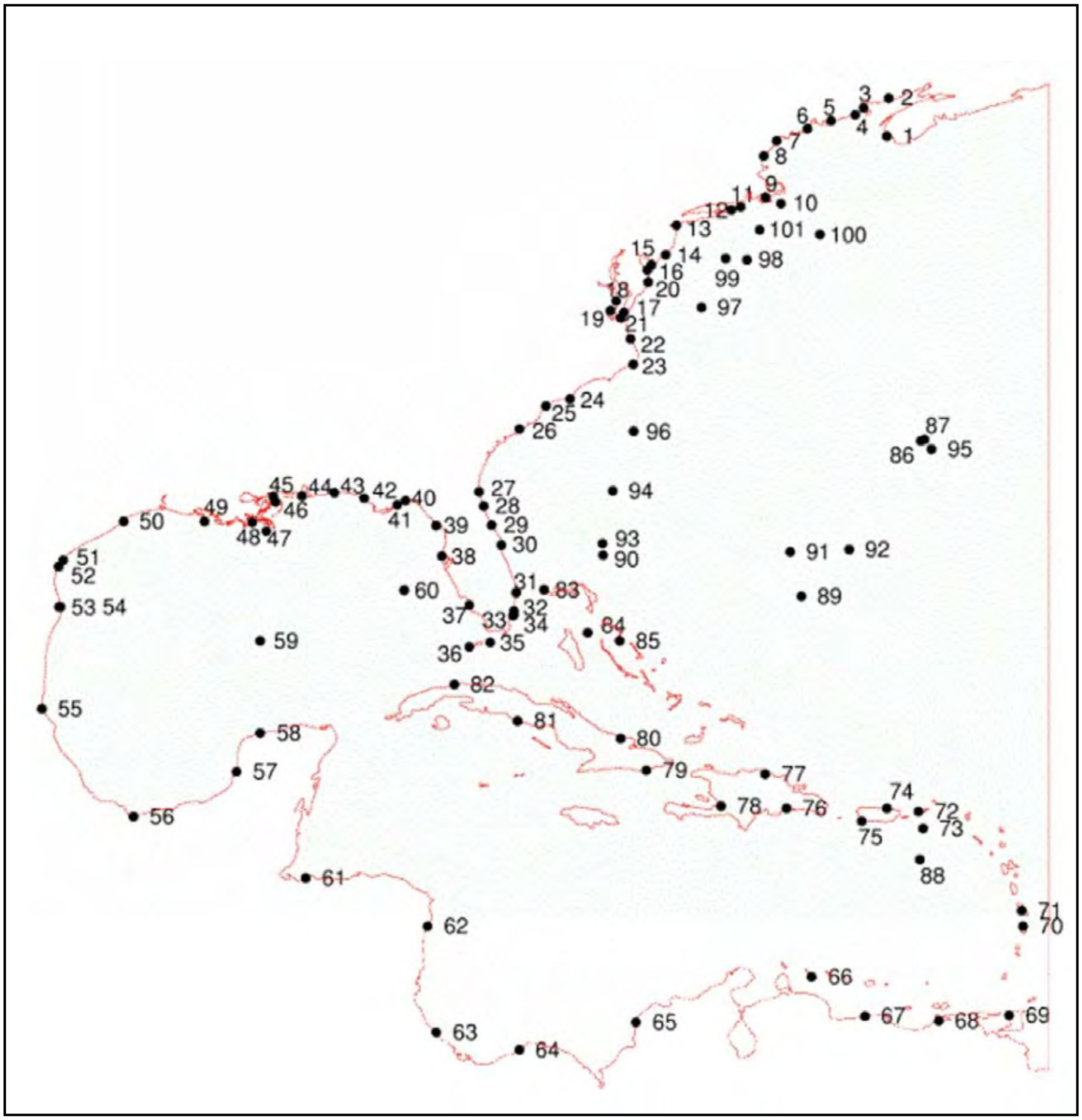


Figure A-4. Eastcoast 2001 calibration points.

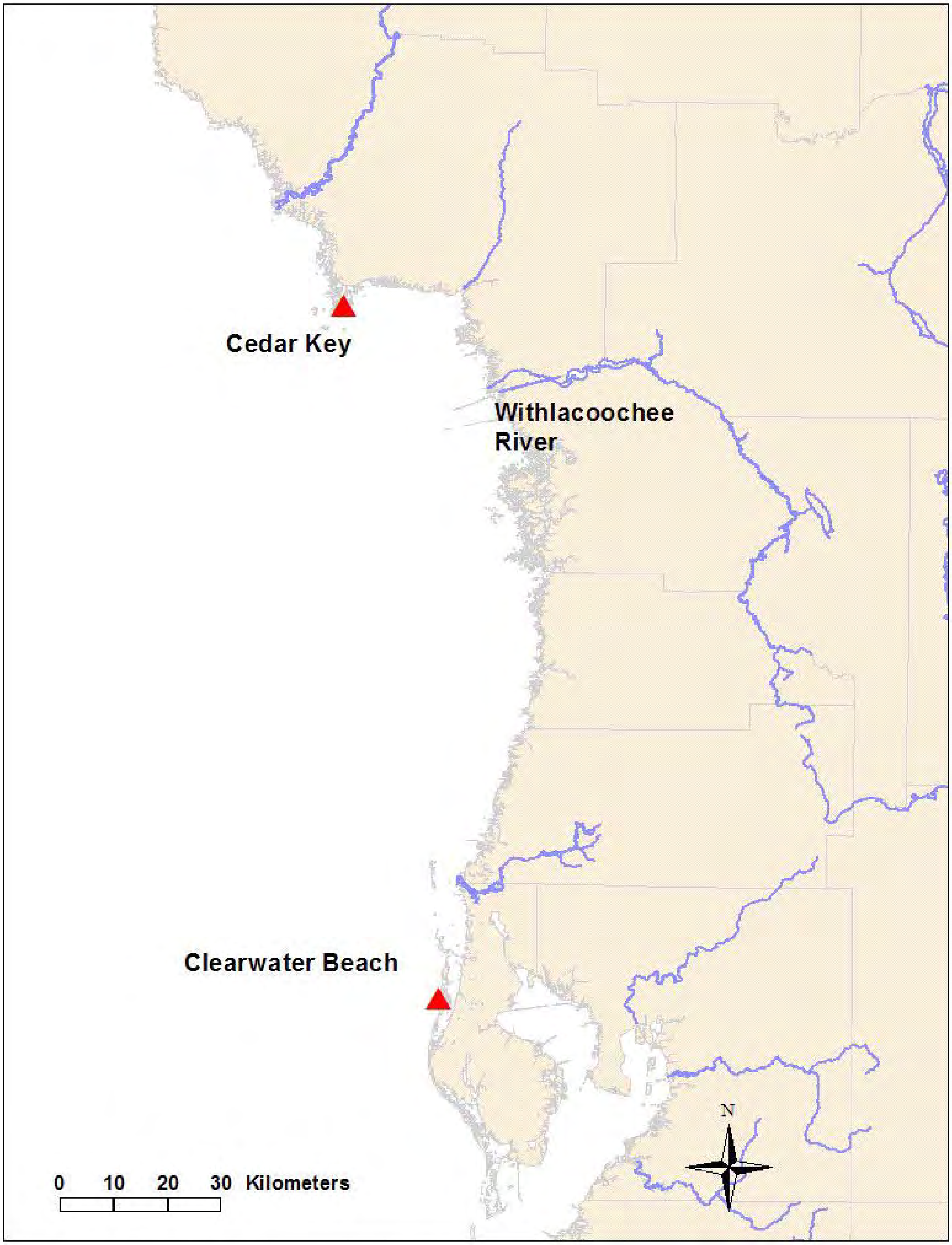


Figure A-5. Locations of water surface elevation calibration points.

Table A-6. Water surface elevation calibration stations.		
Station Name	**Period**	**Frequency**
Clearwater Beach	1/1/1996 to Present	Hourly
Cedar Key	1/1/1997 to Present	Hourly

A.1.4.2. Temperature and Salinity

Boundary condition temperature and salinity were needed for the offshore boundary of the GCSM. Few data points exist in the open Gulf of Mexico, however. Daily snap-shots of salinity and temperature from the Navy Coastal Ocean Model (NCOM) were utilized to define boundary conditions within the Gulf of Mexico where data are sparse. A snapshot of salinity for January 1, 2002 is presented in Figure A-6. A snap-shot of temperature for January 1, 2002 is presented in Figure A-7. These daily salinity and temperature fields are from the 1/8° NCOM grid which is maintained by the Naval Research Laboratory (NRL). Boundary conditions and calibration points for NCOM are derived from the Modular Ocean Data Assimilation System (MODAS) which incorporates an extensive amount of in-situ and satellite-derived observation data.

An image was obtained for each day for temperature and salinity. Temperature and salinity were derived from each image to estimate values at the offshore model boundary.

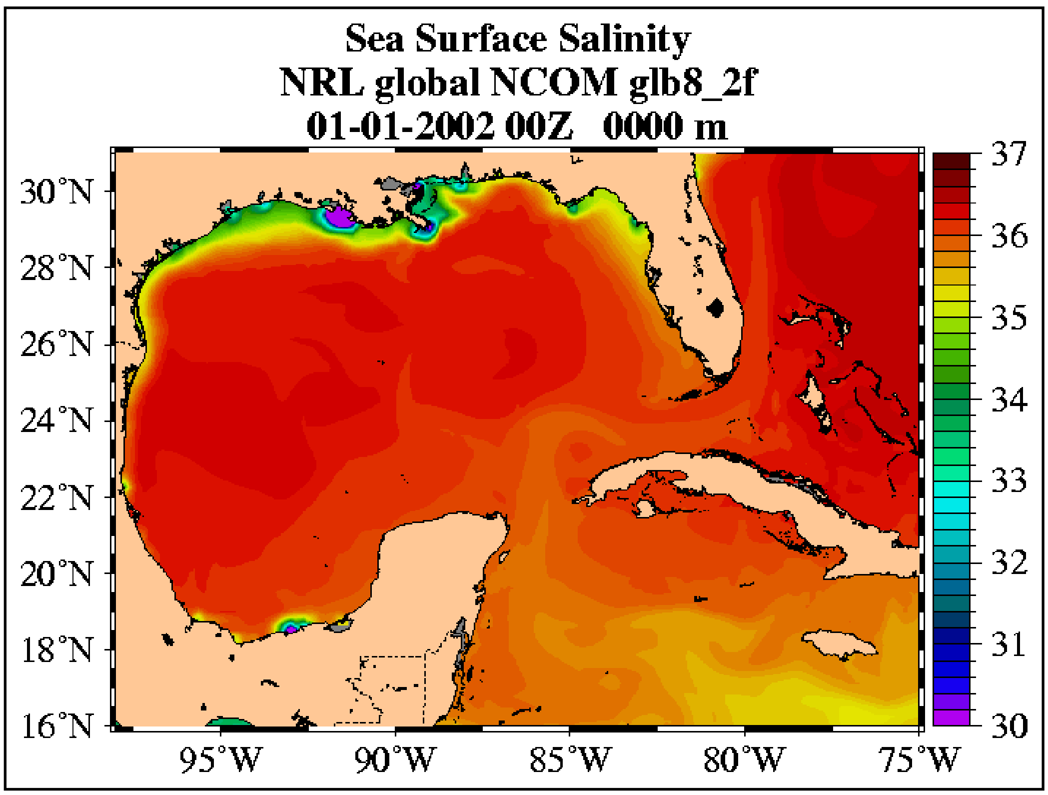


Figure A-6. NCOM derived sea surface salinity snapshot.

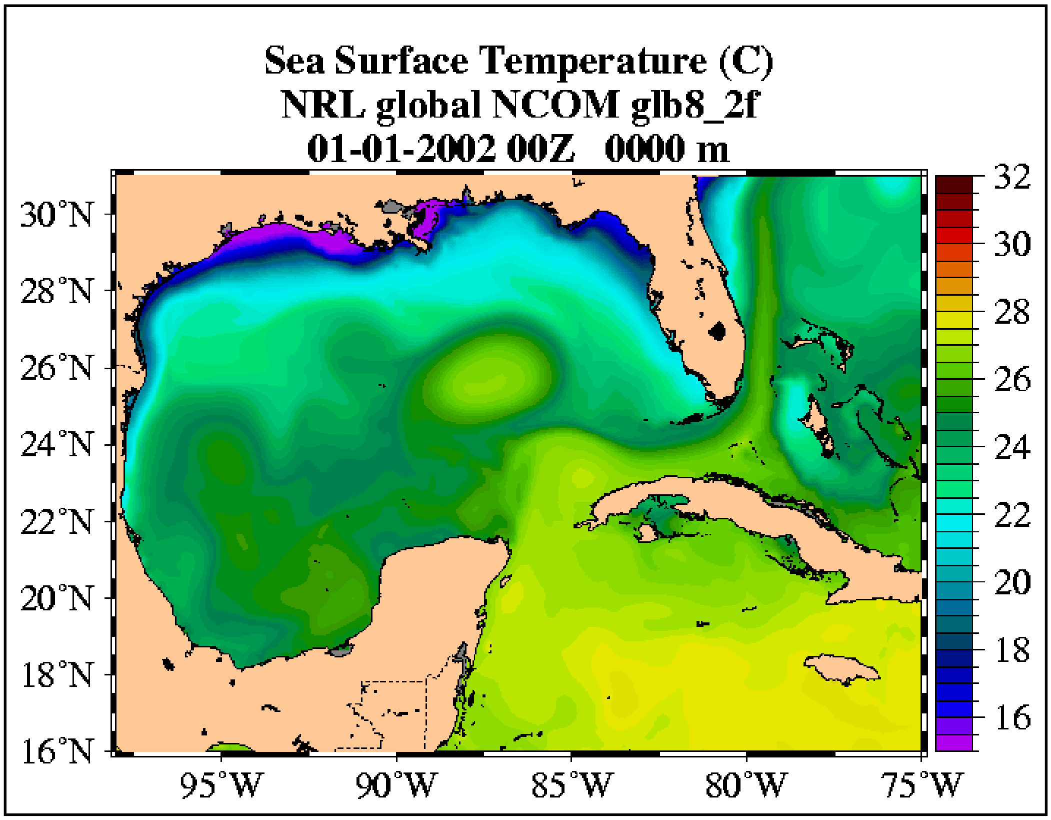


Figure A-7. NCOM derived sea surface temperature snapshot.

For calibration of the GCSM, observed surface salinity (ppt) and surface temperature (°C) data were available from Project COAST covering the time period 2000-2002. COAST data were obtained from the Southwest Florida Water Management District (SWFWMD) as an Excel File. These data were used as calibration points for temperature and salinity for the GCSM. Figure A-8 shows the locations of all the COAST stations used in the calibration.

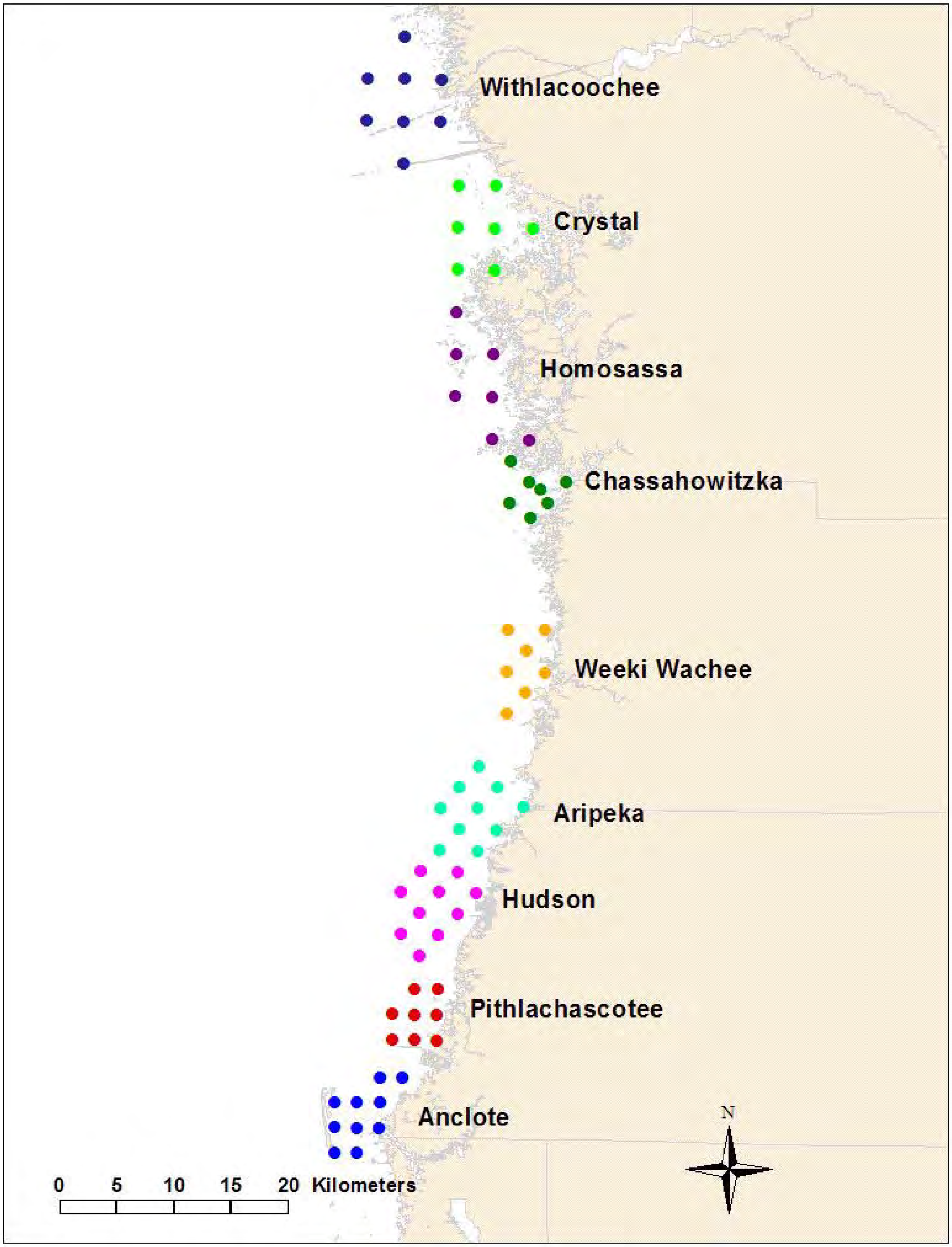


Figure A-8. Project COAST stations used in calibration of GCSM.

A.2. Clearwater Harbor/St. Joseph Sound Model

The fine-scale Clearwater Harbor/St. Joseph Sound hydrodynamic model domain extends from north of Anclote Key south into Boca Ciega Bay (Figure A-9), with the Gulf of Mexico to the west. The observed data used for the model include: bathymetry, freshwater inflows, and meteorology (wind speed, wind direction, dry bulb air temperature, wet bulb air temperature, atmospheric pressure, rainfall, relative humidity, evaporation, solar radiation, and cloud cover). These data can be divided into two groups, data used as forcing functions for the model (boundary conditions and atmospheric data) and data used for calibration of the model. Model output from the large-scale GCSM is used for the boundary conditions of water surface elevation, salinity, and water temperature at the seaward boundary of the Clearwater Harbor/St. Joseph Sound model grid.

The Clearwater Harbor/St. Joseph Sound model grid contains 11.639 horizontal cells, and three vertical layers. The surface and bottom vertical layers within each horizontal grid cell are each one-quarter of the water column, with the middle cell making up the other half of the water column. Cell dimensions range from 48 m to 186 m in the x-direction (east-west) and from 131 m to 601 m in the y-direction (north-south). Larger cells are in the offshore area and south of the study area, in Boca Ciega Bay, with smaller cells in the St. Joseph Sound and Clearwater Harbor North and South segments.

A.2.1. Bathymetry

Bathymetric data for the Clearwater Harbor/St. Joseph Sound model domain were based on depth-sounding data contained within the US Geological Survey's Florida Shelf Habitat (FLaSH) Point dataset (Robbins et al., 2007) and are reported referenced to the Mean Lower Low Water (MLLW) vertical datum. The bathymetry is provided in Figure A-10.

A.2.2. Freshwater Inflows

Freshwater inflows were obtained from the hydrologic loading estimates developed as part of the loading analysis. Anclote River flows upstream of the USGS Elfers gage were included in these loadings. The locations of the freshwater inputs to the model domain are provided in Figure A-9.

A.2.3. Atmospheric Data

The Tampa site (Figure A-3) used for the GCSM was used for the Clearwater Harbor/St. Joseph Sound model for meteorological and solar radiation data. Rainfall was utilized from the Tarpon Springs NWS site. The West Tampa Buoy was used for wind data (Figure A-3).

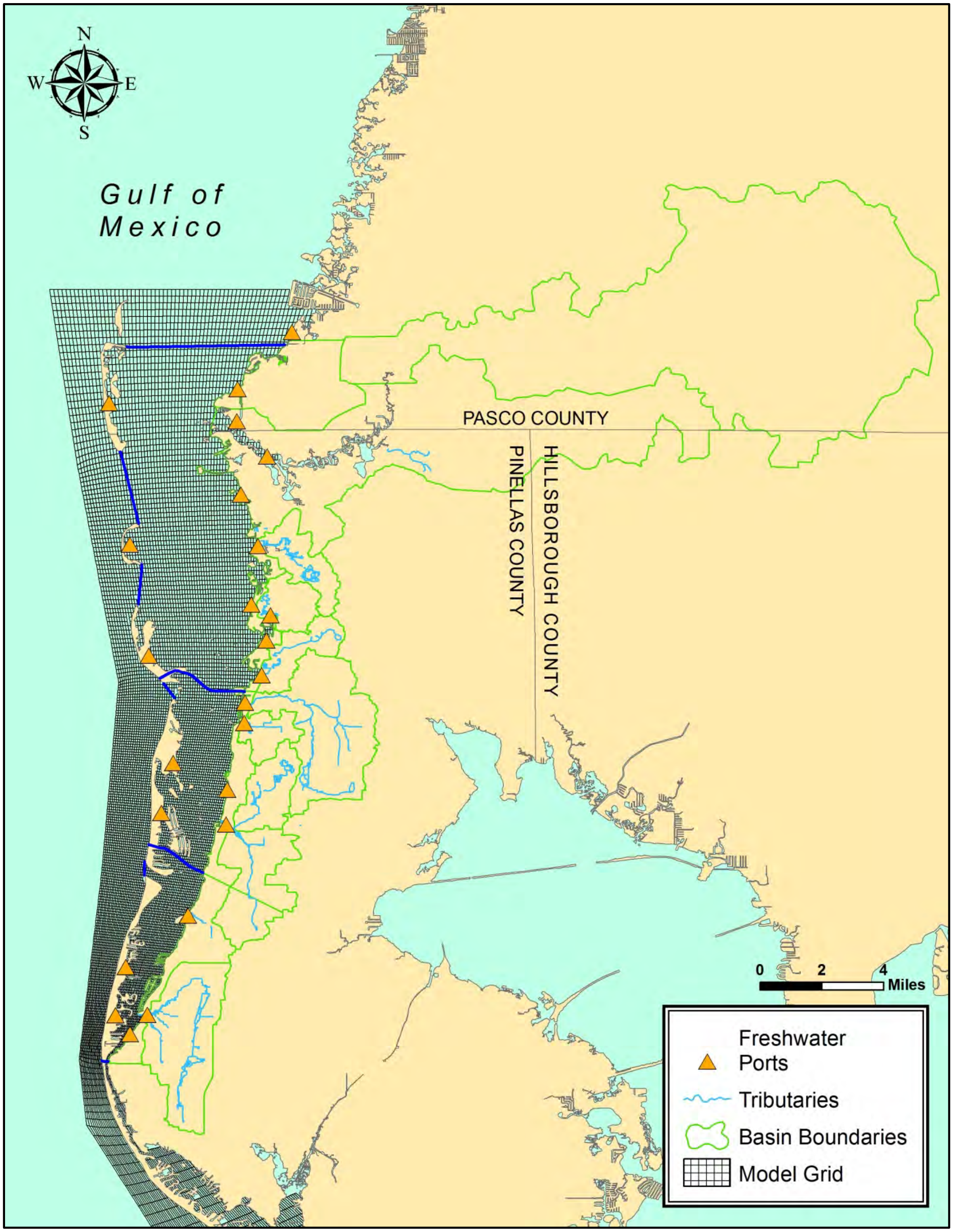


Figure A-9. Clearwater Harbor/St. Joseph Sound model grid and points of watershed freshwater input.

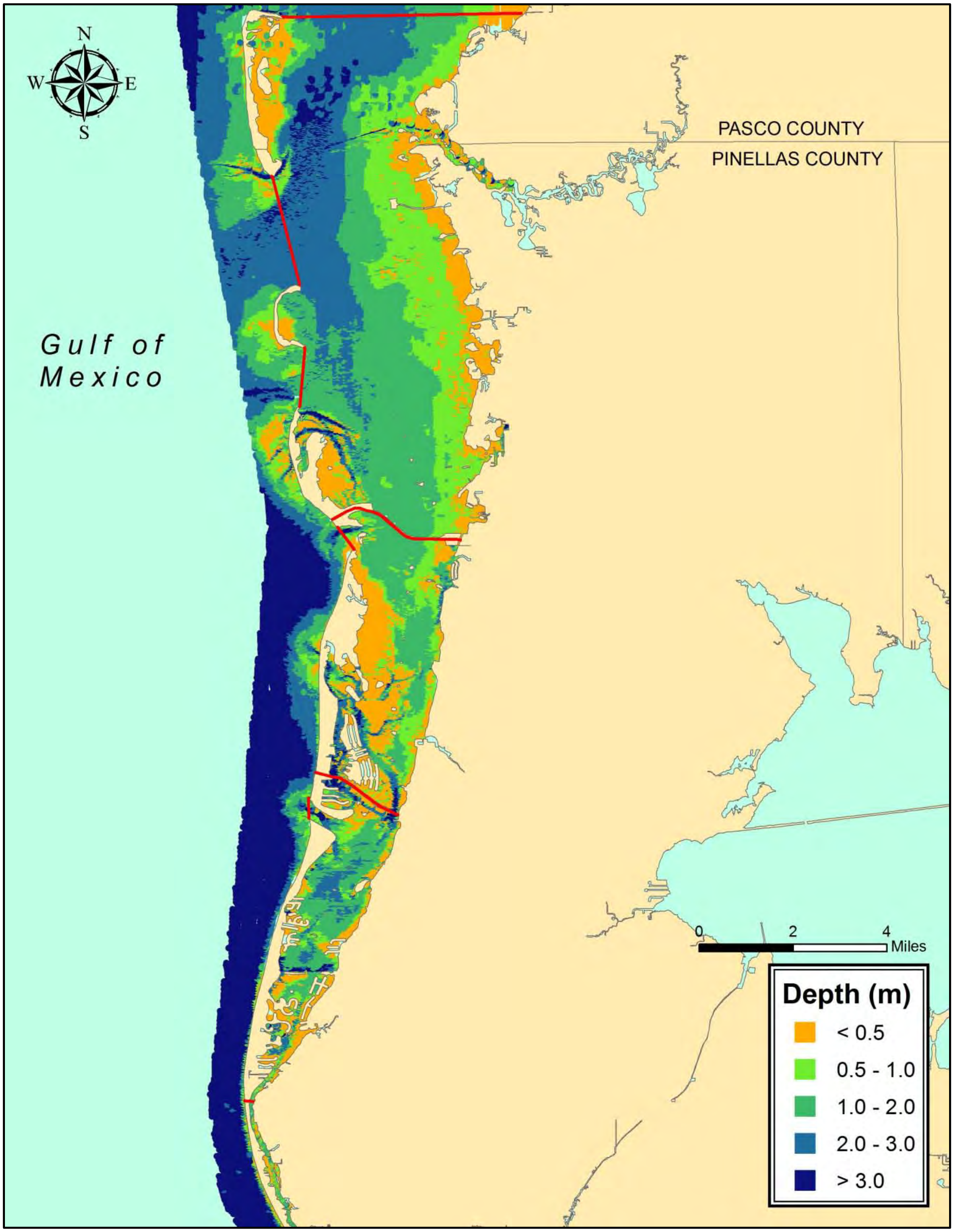


Figure A-10. Bathymetry in Clearwater Harbor/St. Joseph Sound model domain (m MLLW).

A.2.4. Boundary Condition and Calibration Data

Boundary conditions of water surface elevation, salinity, and temperature are derived from the output from the GCSM. Values from the appropriate GCSM cells are used to force the Clearwater Harbor/St. Joseph Sound model on the western, northern, and southern boundaries.

Temperature and salinity data from PCDEM sampling for November-December of the years preceding the selected years were used to derive initial conditions. The PCDEM sites were also used as calibration points for the model. Figure A-11 shows the locations of the water quality monitoring sites within the model domain, along with the location of the Clearwater Beach water surface elevation gage.

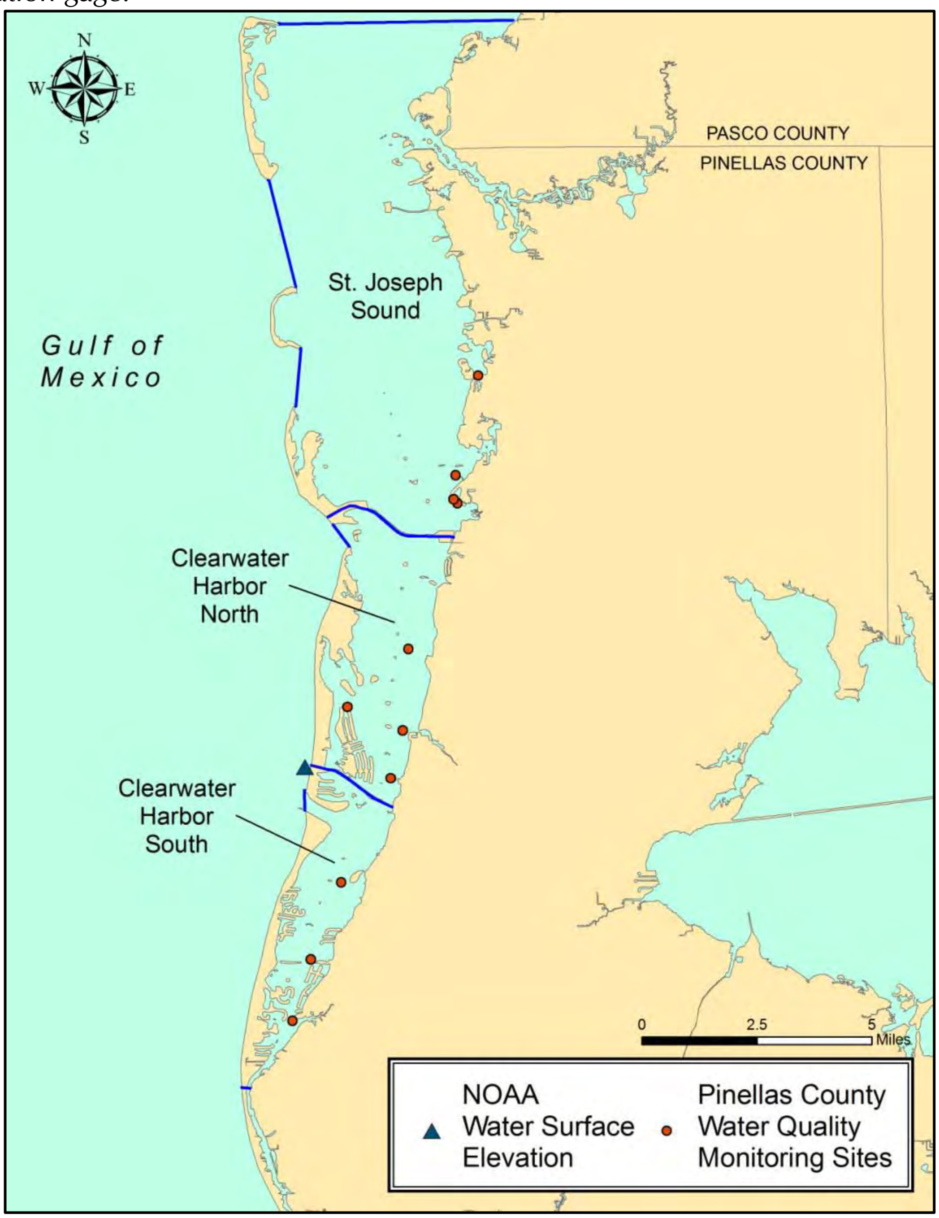


Figure A-11. Locations of PCDEM water quality monitoring sites and Clearwater Beach tidal gage used for calibration.

A.3. Calibration

The following subsections provide discussion of the calibrations of both the GCSM and the Clearwater Harbor/St. Joseph Sound hydrodynamic models.

A.3.1. Gulf Coast Shelf Model

The primary forcing functions affecting salinity in the nearshore region is the quantity of freshwater entering the system and the supply of higher salinity water from the Gulf. Gaged flows from the USGS stations and estimated spring flows for the Weeki Wachee (from the SWFWMD) and from Wakulla Springs (from the NWFWMD) provide the minimum amount of freshwater entering the system from the watershed of the model domain. However, large areas of ungaged watershed remain, and no accounting exists of numerous springs along the coast and submarine springs in the nearshore environment. Some means of estimating the ungaged watershed and unmeasured spring flow is necessary for simulation of spatial and temporal salinity patterns observed. A methodology was developed in consultation with Southwest Florida Water Management District staff as part of the previously mentioned Withlacoochee River modeling project (Janicki Environmental, 2003; 2008). The estimation of ungaged freshwater input provided the best fit to observed salinity values.

A.3.1.1. Elevation

As discussed previously, observed elevations for Cedar Key and Clearwater Beach, from the CO-OPS program, were obtained for comparison with predicted water surface elevations from the GCSM. The model utilized the Eastcoast 2001 tidal constituent database to define the offshore boundary conditions for the large-scale model. A statistical summary of the comparison between model and observed water surface elevations is provided in Table A-7, for the period March-September 2002. Here r^2 is the coefficient of determination, RMSE is the root mean square error, ME is the mean error, and AME is the absolute mean error.

Table A-7. Statistical summary of comparison of hourly predicted and observed water surface elevation, GCSM.

Statistic	Clearwater Beach	Cedar Key
r^2	0.89	0.87
RMSE (m)	0.09	0.14
ME (m)	0.02	-0.02
AME (m)	0.07	0.11

The comparison shows good agreement between predicted and observed hourly water surface elevations, with the AME of 11 cm or less, and the ME of 2 cm at Clearwater Beach and -2 cm at Cedar Key indicating only small differences between predicted and observed values over the time period.

A.3.1.2. Salinity and Temperature

Observed salinity and temperature values from the COAST sites from Anclote to the Withlacoochee (Figure A-8) were compared to predicted salinity and temperature. For this comparison, the instantaneous measurements of surface salinity and temperature at the COAST sites were plotted as time series along with the hourly model output for the surface. The model output is representative of the entire grid cell, which covers an area of approximately 24 km^2. It is possible that several COAST sites fall within a given cell. To get a better understanding of the comparison of predicted values over a large area to observed values representative of specific points, the predicted salinity and temperature for a given cell are compared to the data from one or more COAST sites.

The COAST sites selected for comparison to a given cell are either within the cell or nearby. A single COAST site may be used for comparison to more than one grid cell. Table A-8 provides a listing of the COAST sites compared with each model grid cell.

Table A-9 provides a salinity calibration summary over all cells shown in Table A-8, for the same period as for elevation. The COAST data were typically collected between 10 AM and 3 PM. The mean predicted salinity for the period 10 AM - 3 PM of each day for a given grid cell was compared to the COAST salinity data collected on that day. Dry season salinities are predicted well by the model for most grid cells. Wet season predictions and observations show more variability, and the model sometimes underpredicts salinity. This is most notably so in those cells adjacent to land. Over all cells, the model does well, with a root mean square error (RMSE is the) of 3.4 ppt, a mean error (ME) of -0.3 ppt, an absolute mean error (AME) of 2.8 ppt, and a relative error (RE) of 10%.

Table A-8. COAST sites compared to GCSM grid cells.

Grid Cell (i,j)	COAST Sites	Grid Cell (i,j)	COAST Sites
(26,10)	AN-4,5,6,7	(41,13)	WE-10
(27,10)	AN-1,2,3,4	(44,14)	CH-5,6,7,8,9
(27,11)	AN-3,8	(45,14)	CH-7,10
(28,10)	AN-2,9,10	(45,15)	CH-10, HO-9
(29,10)	AN-10, PI-8,10	(46,15)	HO-7,8,9
(30,10)	PI-4,6	(46,16)	HO-2,6,7
(30,11)	PI-5,6	(47,16)	HO-2,3
(31,10)	PI-6,7	(47,17)	HO-1,2
(31,11)	PI-6, HU-8,10	(48,17)	HO-1, CR-8
(32,11)	HU-6,8,9,10	(49,17)	CR-8,9
(33,11)	HU-4,6	(50,17)	CR-6,9
(33,12)	HU-1,3	(50,18)	CR-5,6
(34,11)	HU-2, AR-6	(50,20)	WI-10
(34,12)	AR-6	(51,17)	CR-6,7
(35,11)	AR-4,7	(51,18)	CR-2,6
(35,12)	AR-4,10	(51,20)	WI-8,9
(36,11)	AR-1,2,5	(51,21)	WI-4,7,8
(36,12)	AR-2,9	(52,20)	WI-5,9
(37,12)	AR-1,8	(52,21)	WI-1,4,5
(39,12)	WE-7,8,9	(53,20)	WI-6
(40,12)	WE-6,7,9	(53,21)	WI-1
(41,12)	WE-5,6		

Table A-9. Salinity calibration statistics for all cells, GCSM.				
Grid Cell	**RMSE (ppt)**	**ME (ppt)**	**AME (ppt)**	**RE (%)**
All Cells	3.6	-0.3	2.8	10

An additional analysis was completed to quantify the relationship between predicted and observed salinity. This analysis was completed for both dry season (March-June) and wet season (July-September). Using the daily predicted mean salinity for 10 AM – 3 PM as described above, the proportion of predictions within 3 ppt of the observations, and within 5 ppt of the observations, were calculated. The results of this analysis are provided in Table A-10.

Table A-10. Proportion of predicted salinity values within 3 ppt and 5 ppt of observations, GCSM.				
Season	**Within 3 ppt**	**Proportion (%)**	**Within 5 ppt**	**Proportion (%)**
Dry (Mar-Jun)	279/396	70%	359/396	91%
Wet (Jul-Sep)	169/297	57%	232/297	78%
All	448/693	65%	591/693	85%

Predictions are better during the dry season, but this is not surprising given the spatial variability in salinity seen during the wet season and the relative low spatial resolution of the GCSM.

A similar analysis was completed for temperature. Table A-11 provides the temperature calibration summary over all cells. As for salinity, the mean predicted temperature for the period 10 AM - 3 PM of each day for a given grid cell was compared to the COAST temperature data collected on that day. Wet season temperatures are predicted well by the model for all grids, when the air temperatures are more stable. Dry season predictions and observations show more variability. Over all cells, the model does well, with a root mean square error (RMSE) of 2.0 °C, a mean error (ME) of -1.2 °C, an absolute mean error (AME) of 1.6 °C, and a relative error (RE) of 6%.

Table A-11. Temperature calibration statistics for all cells, GCSM.				
Grid Cell	**RMSE (°C)**	**ME (°C)**	**AME (°C)**	**RE (%)**
All Cells	2.0	-1.2	1.6	6

As for salinity, an additional analysis was completed to quantify the relationship between predicted and observed temperature. This analysis was completed for both dry season (March-June) and wet season (July-September). Using the daily predicted mean temperature for 10 AM – 3 PM as described above, the proportion of predictions within 3 °C of the observations, and within 5 °C of the observations, were calculated. The results of this analysis are provided in Table A-12.

Table A-12. Proportion of predicted temperature values within 3 °C and 5 °C of observations, GCSM.				
Season	**Within 3 °C**	**Proportion (%)**	**Within 5 °C**	**Proportion (%)**
Dry (Mar-Jun)	318/396	80%	389/396	98%
Wet (Jul-Sep)	290/297	98%	297/297	100%
All	608/693	88%	686/693	99%

The model predictions are within 3 ºC 88% of the time, and within 5 ºC 99% of the time, over the cells listed in Table A-8. Predictions are better during the wet season, but this is not surprising given the temporal variability in temperature seen during the dry (colder) season.

A.3.2. Clearwater Harbor/St. Joseph Sound Hydrodynamic Model

The Clearwater Harbor/St. Joseph Sound hydrodynamic model receives freshwater inflow at the locations provided in Figure A-9. Offshore boundary conditions of elevation, salinity, and temperature are provided by the GCSM, at the western, northern, and southern boundaries. Calibration of the model was to the tidal gage at Clearwater Beach, and to the surface salinity and temperature observations at Pinellas County water quality monitoring sites within the model domain (Figure A-11).

A.3.2.1. Elevation

Time series plots of predicted and observed water surface elevation at the Clearwater Beach site are provided below, for hourly values by month for both 1997 (a wet year) and 1999 (a dry year). A statistical summary of the comparison between predicted and observed water level is provided in Table A-13 for each year. Here r^2 is the coefficient of determination, RMSE is the root mean square error, ME is the mean error, and AME is the absolute mean error.

Table A-13. Statistical summary of comparison of hourly predicted and observed water surface elevation, Clearwater Harbor/St. Joseph Sound hydrodynamic model.

Statistic	1997	1999
r^2	0.79	0.78
RMSE (m)	0.13	0.13
ME (m)	-0.04	0.01
AME (m)	0.10	0.10

The comparison shows good agreement between predicted and observed hourly water surface elevations, with the AME of 10 cm, and the MEs of -4 and 1 cm indicating slight overprediction of water surface elevation during the wet year (1997) and slight underprediction during the dry year (1999) compared to observed values over the time period. Time series plots of the predicted and observed elevations and Clearwater Beach are provided for each month of the wet year (Figures A-12 through A-17) and dry year (Figures A-18 through A-23).

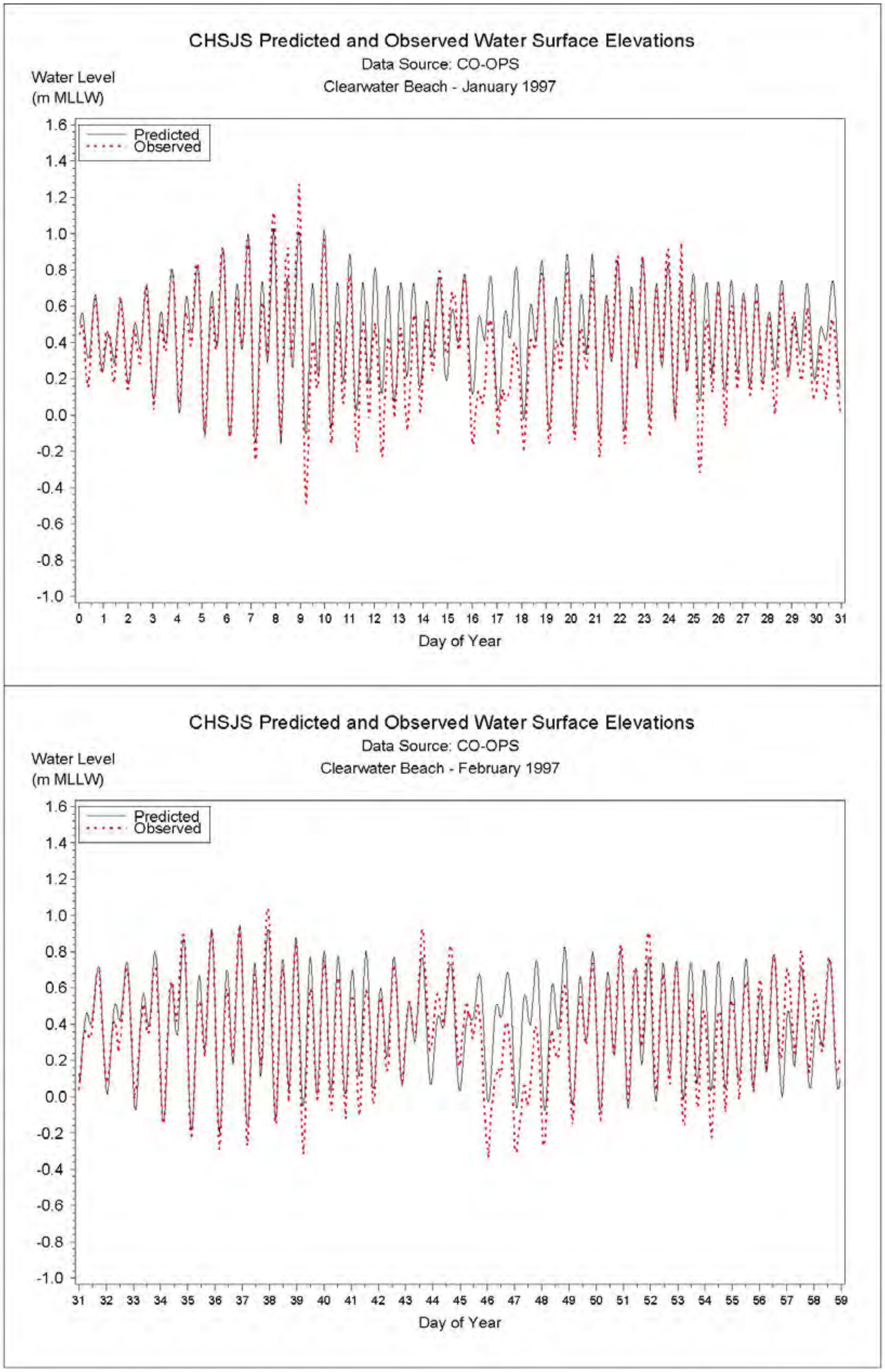


Figure A-12. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, January and February 1997, wet year.

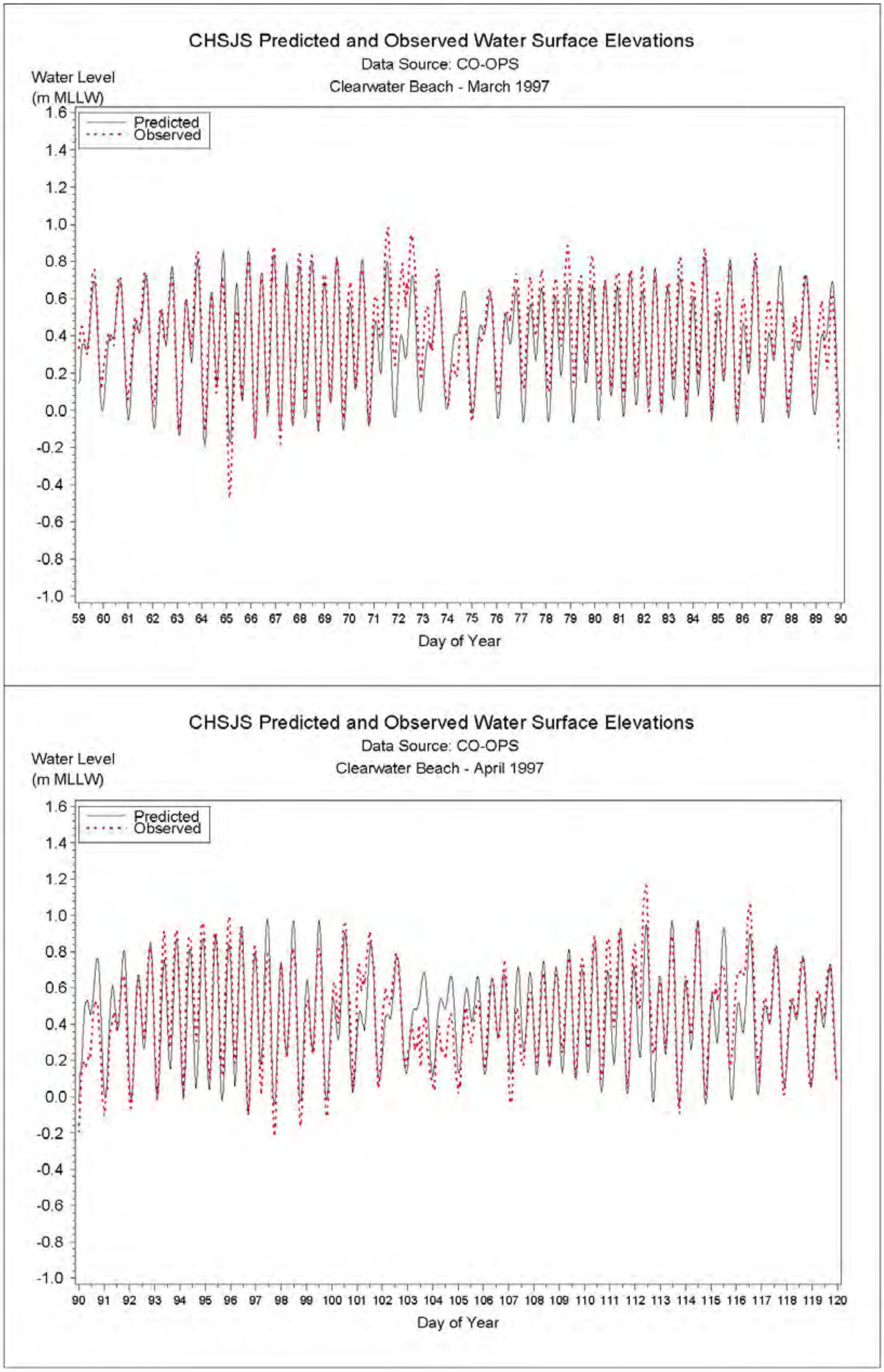


Figure A-13. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, March and April 1997, wet year.

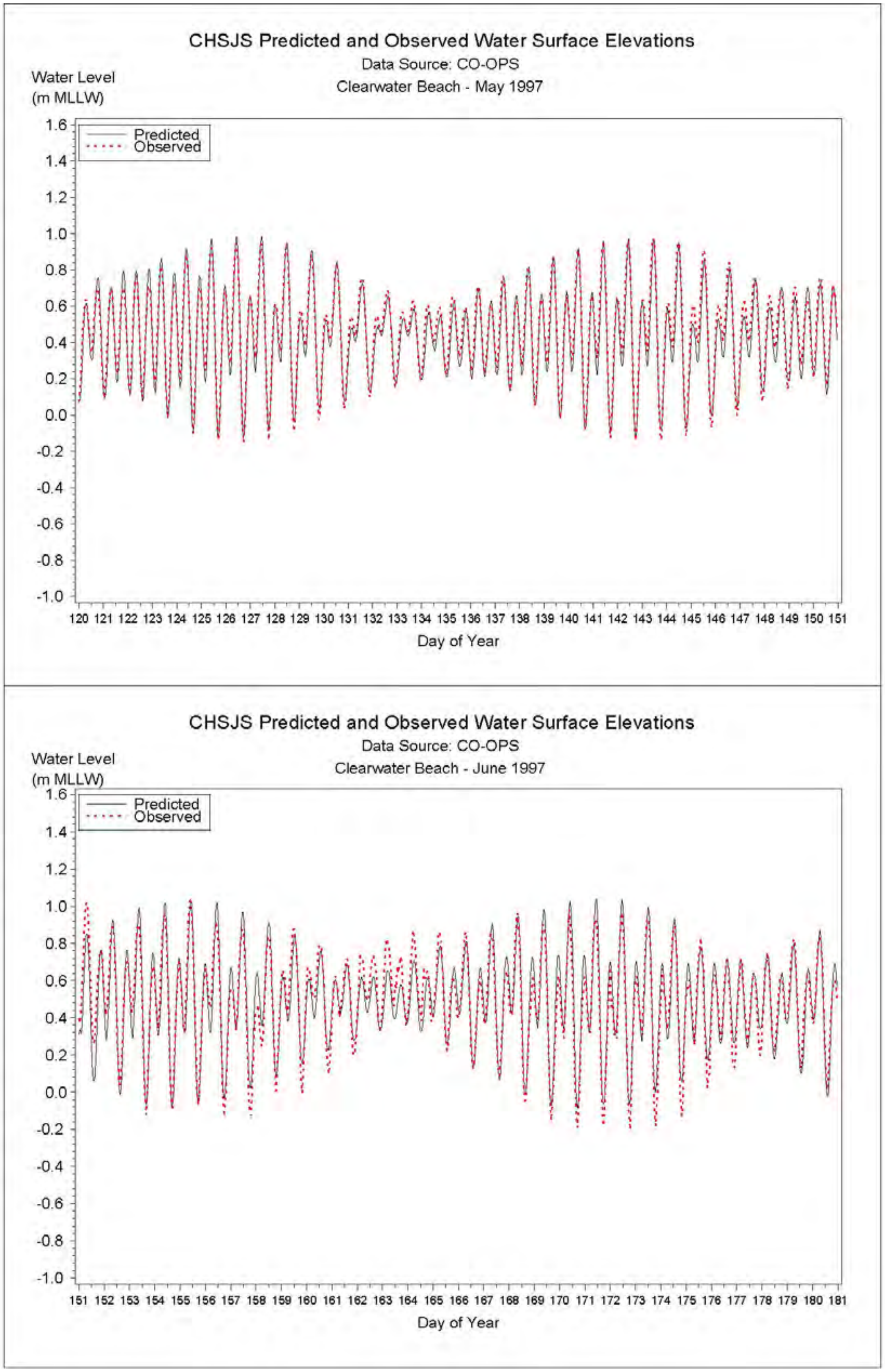


Figure A-14. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, May and June 1997, wet year.

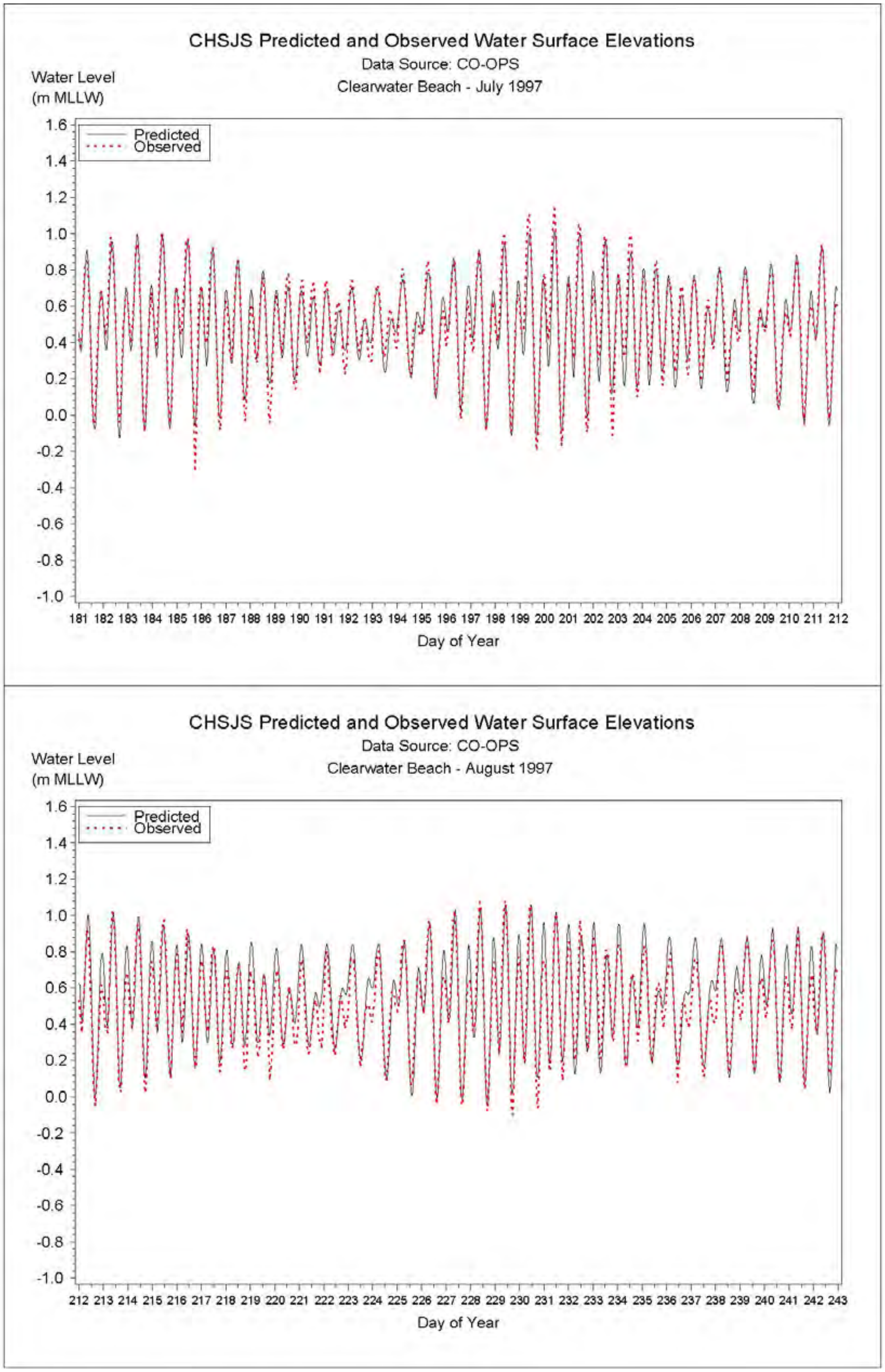


Figure A-15. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, July and August 1997, wet year.

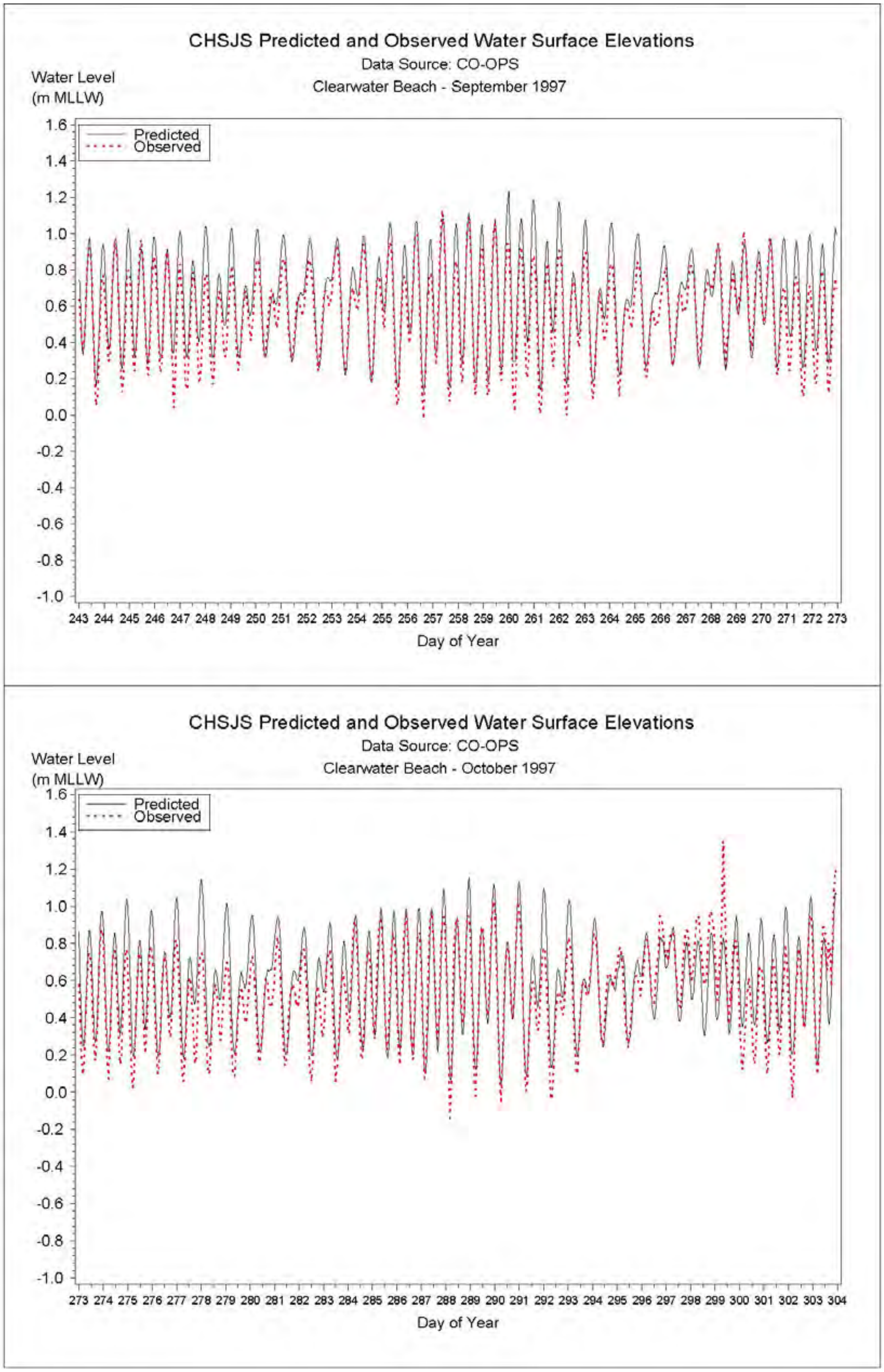


Figure A-16. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, September and October 1997, wet year.

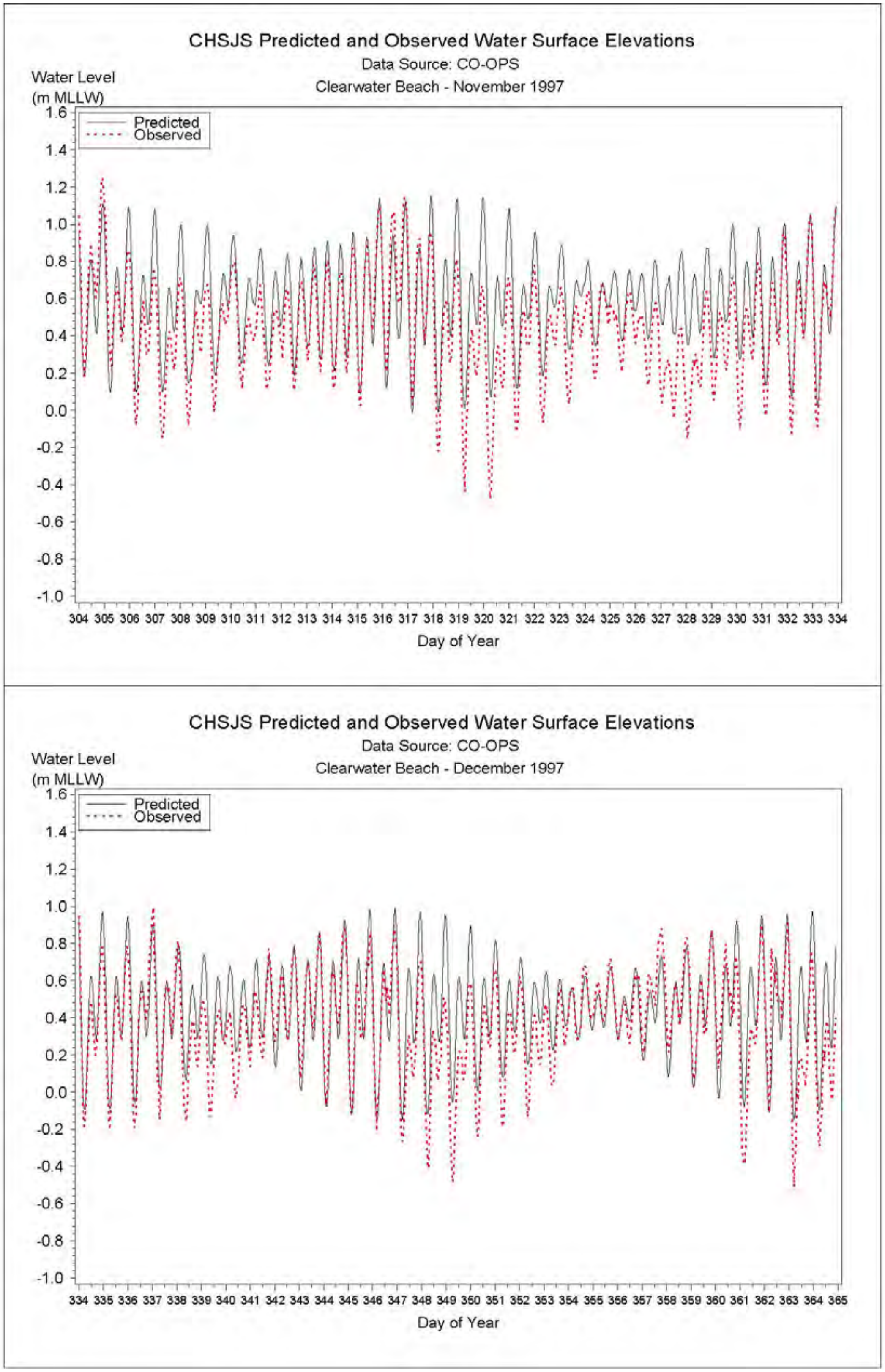


Figure A-17. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, November and December 1997, wet year.

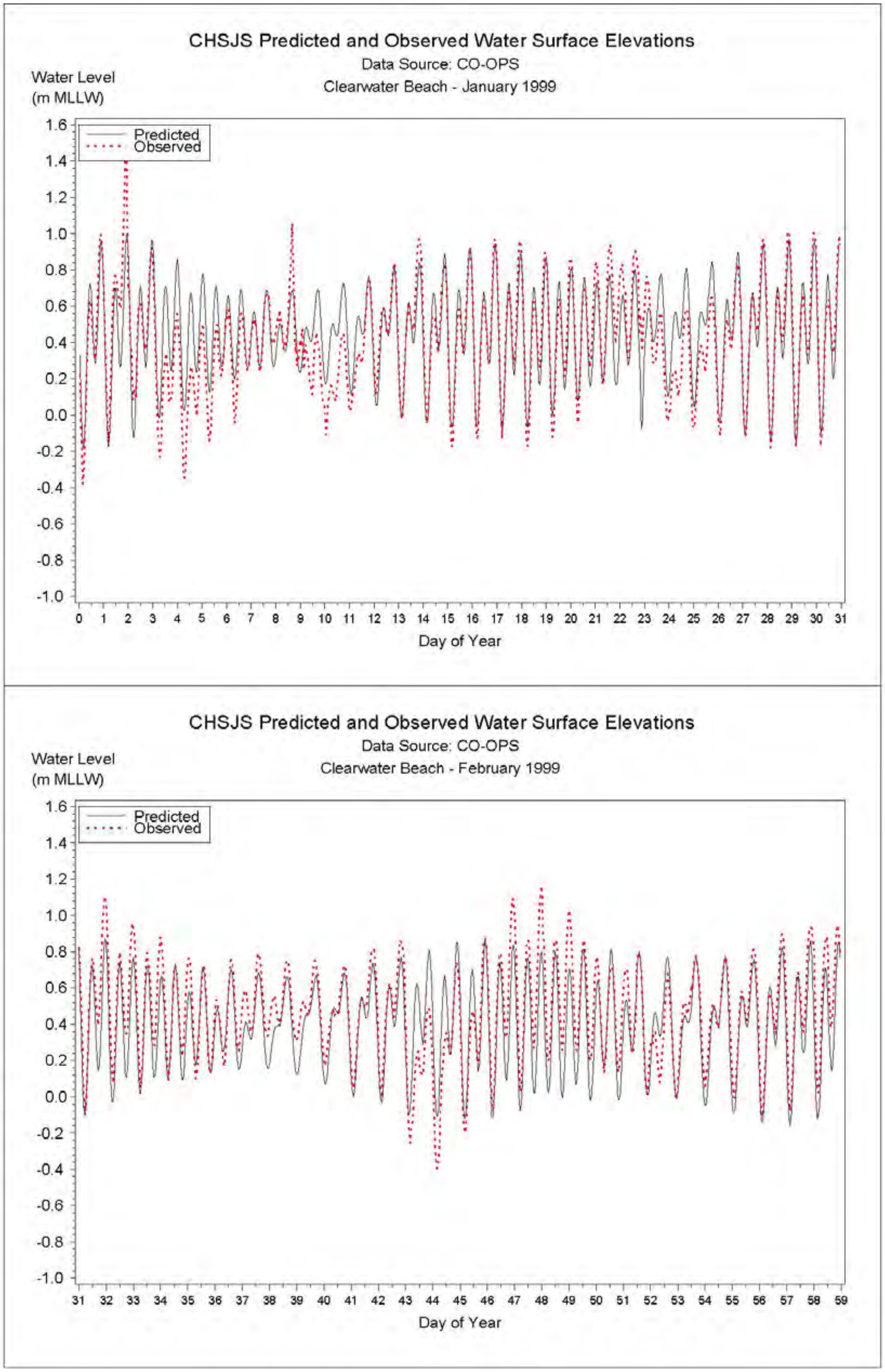


Figure A-18. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, January and February 1999, dry year.

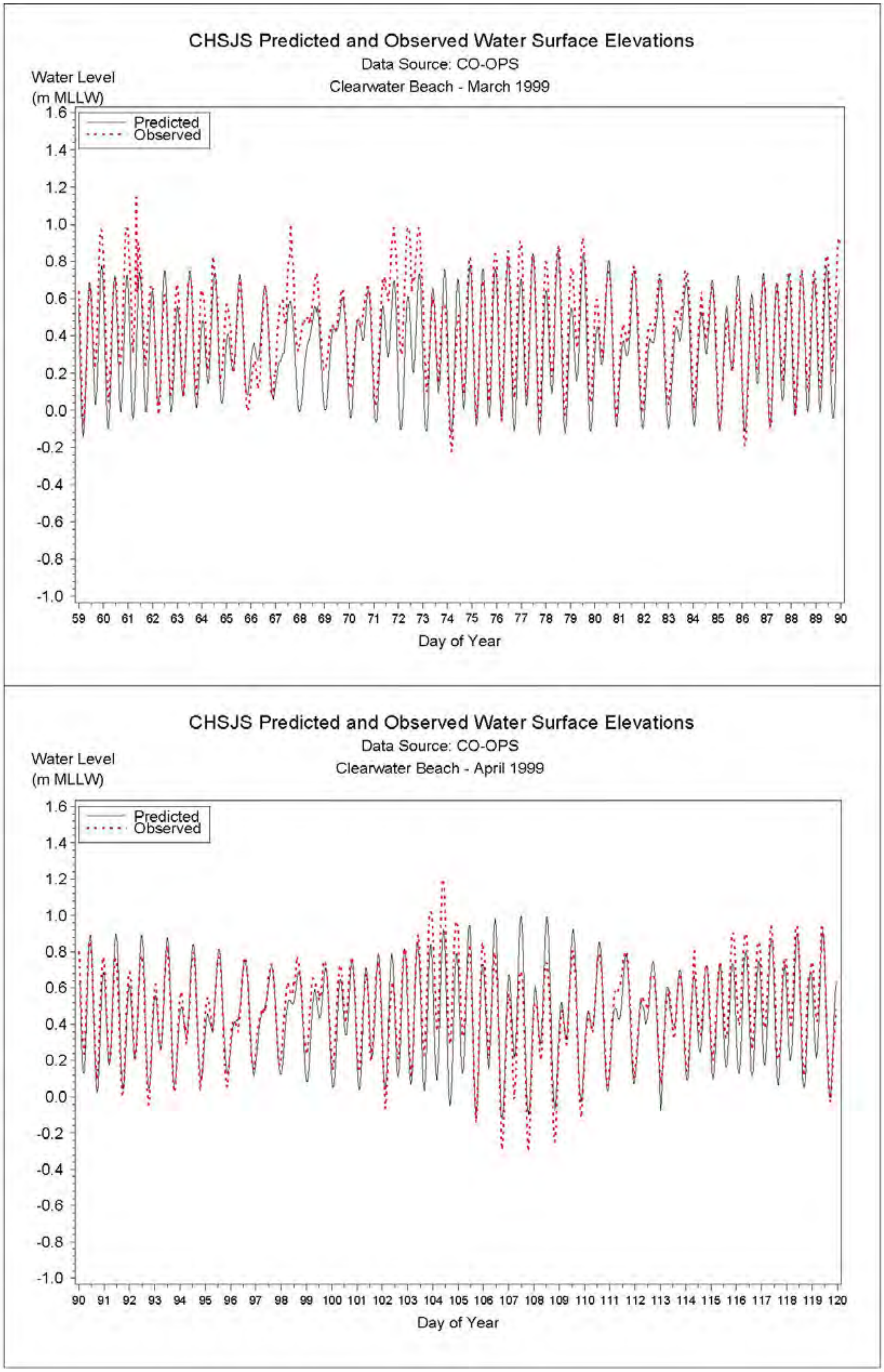


Figure A-19. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, March and April 1999, dry year.

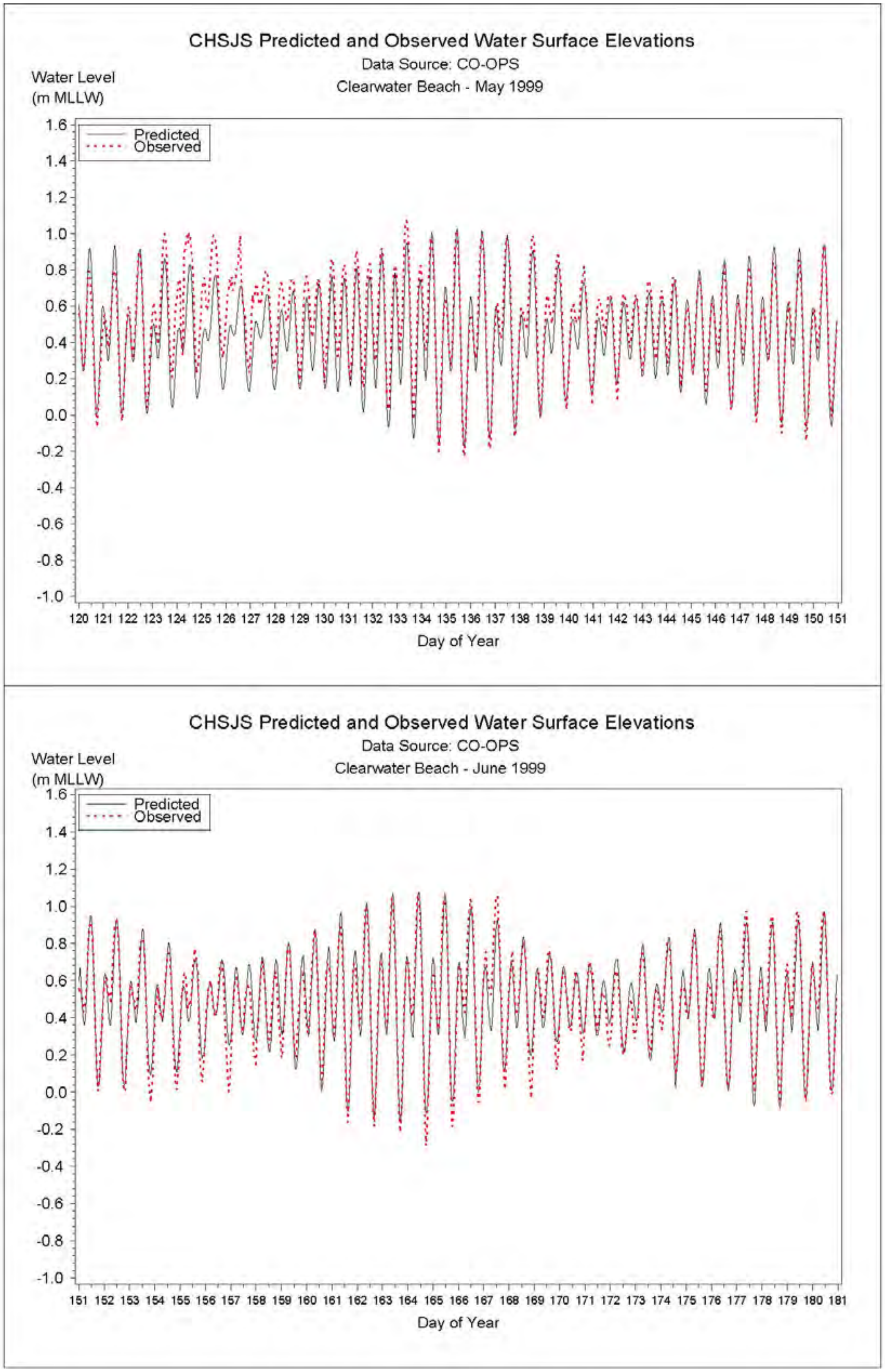


Figure A-20. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, May and June 1999, dry year.

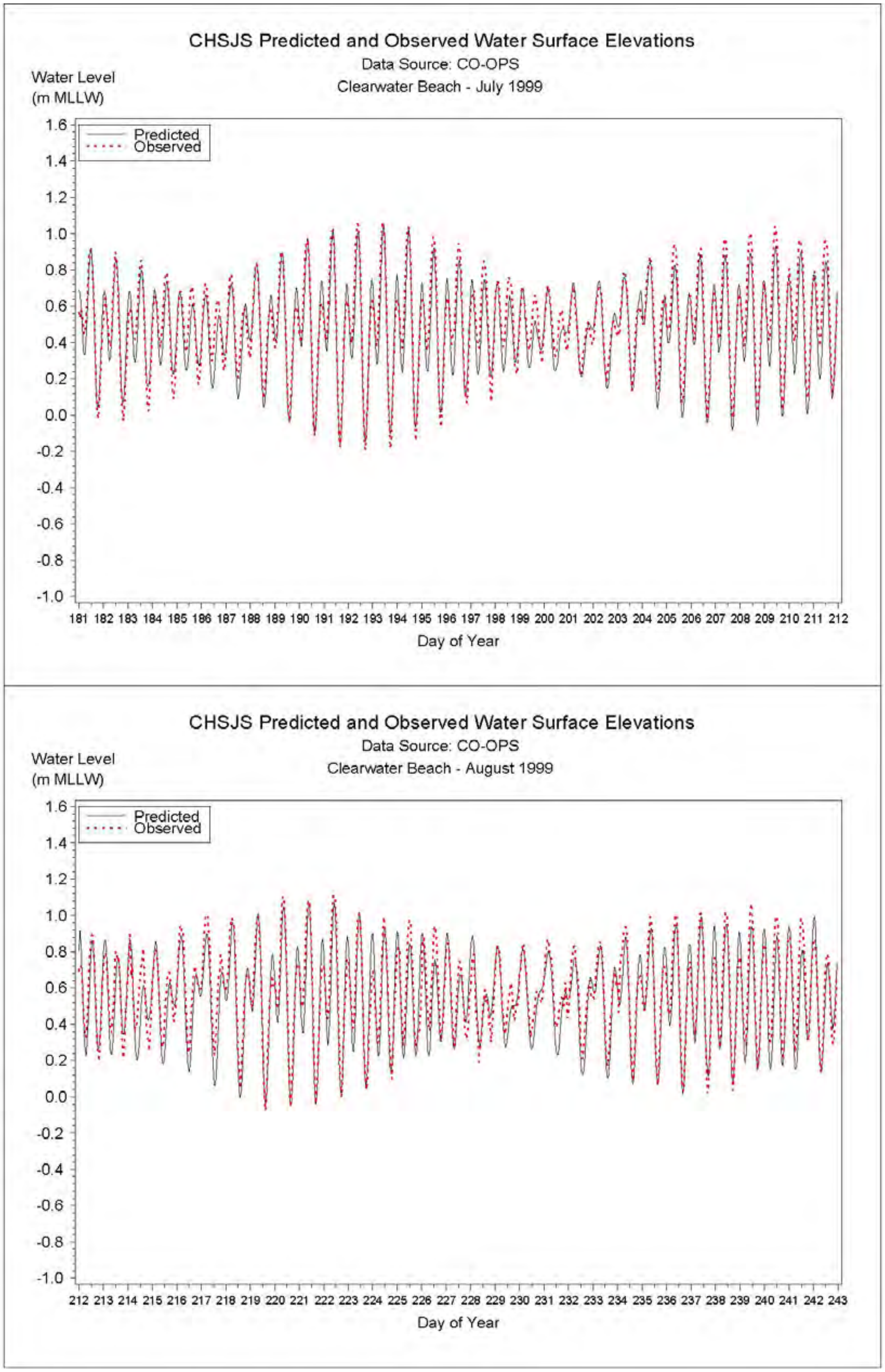


Figure A-21. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, July and August 1999, dry year.

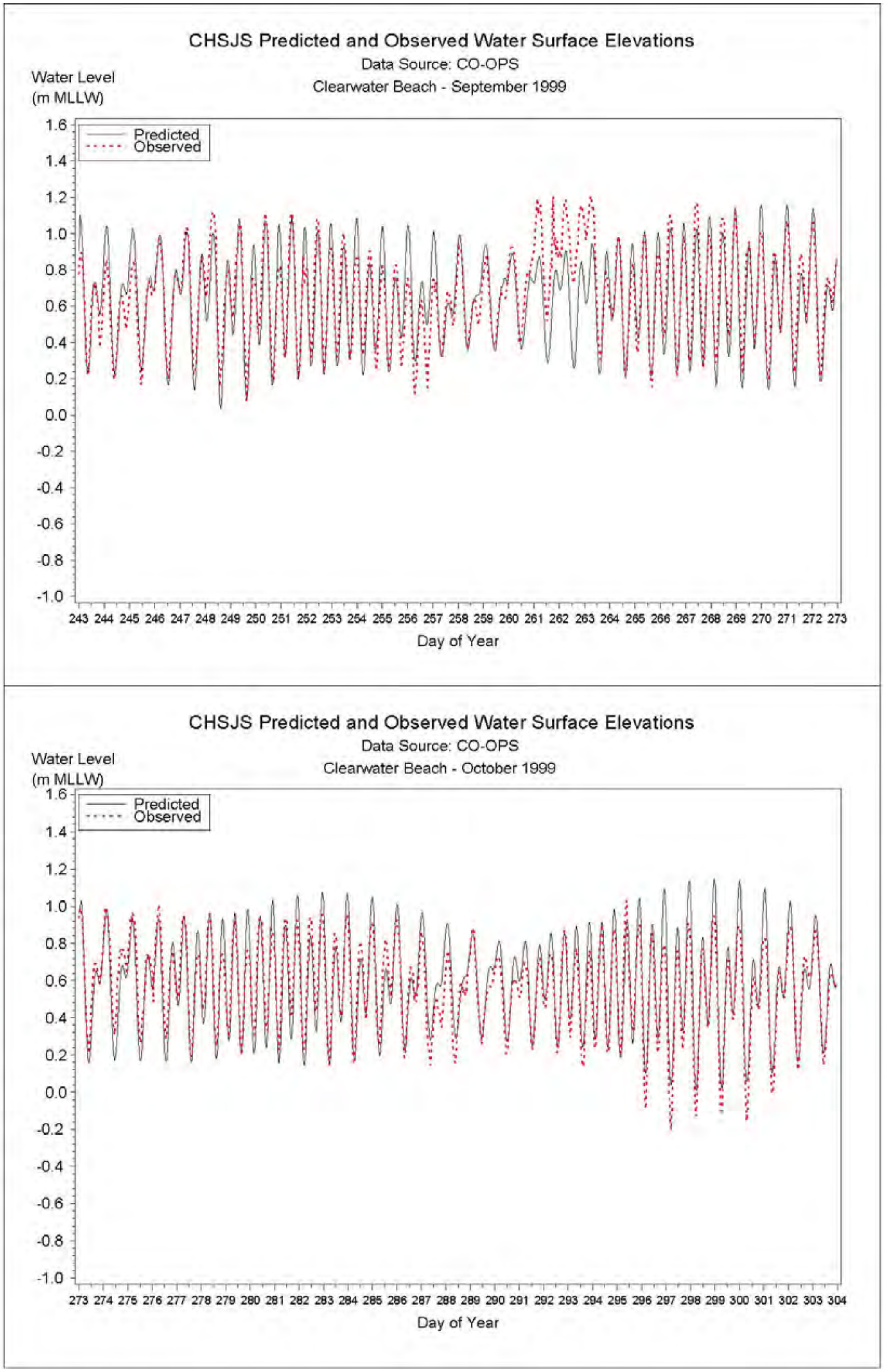


Figure A-22. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, September and October 1999, dry year.

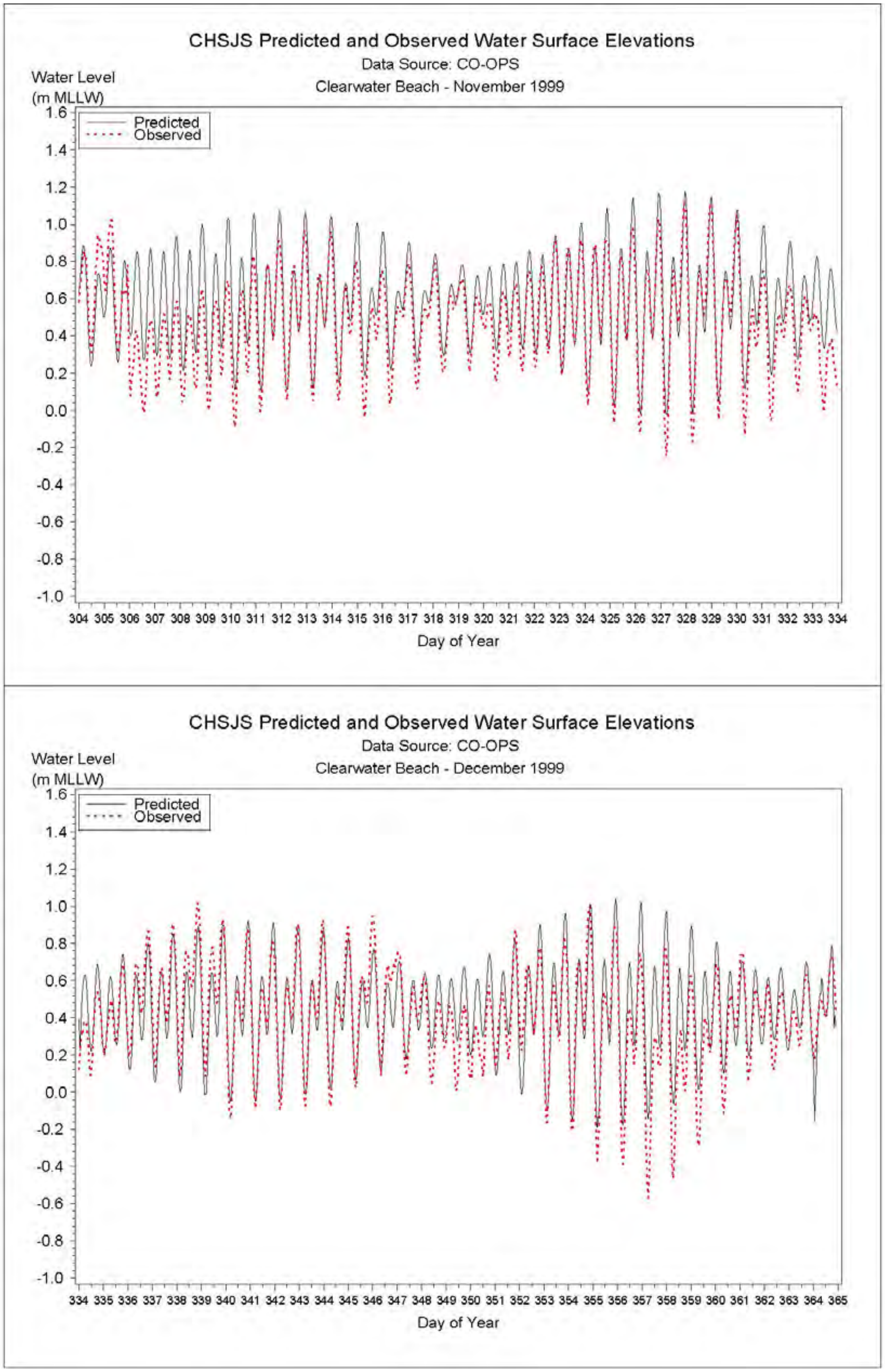


Figure A-23. Time series comparisons of hourly predicted and observed elevations at Clearwater Beach tide gage, November and December 1999, dry year.

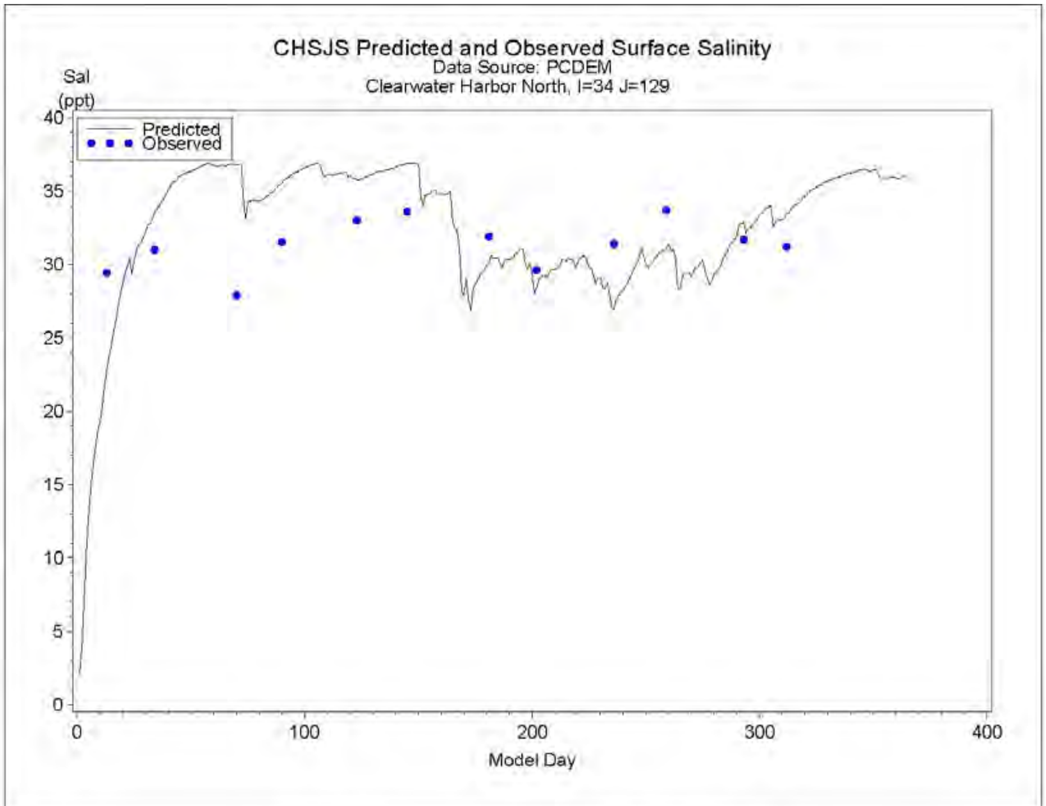
A.3.2.2 Salinity and Temperature

Time series plots of predicted and observed salinity and temperature at the PCDEM monitoring sites are provided below, for three grid cells in Clearwater Harbor South, four grid cells in Clearwater Harbor North, and two grid cells in St. Joseph Sound. Data for one additional site and grid cell were available for St. Joseph Sound, at site S-07-04, but as this site is likely influenced by the nearby Wall Springs, and no hydrologic loadings due specifically to the spring were included in the freshwater inflows, the predicted values here are not representative of expected conditions given the proximity of the spring. A statistical summary of the comparison between predicted and observed salinity and temperature is provided in Table A-14 for each year. Here r^2 is the coefficient of determination, RMSE is the root mean square error, ME is the mean error, and AME is the absolute mean error.

Table A-14. Statistical summary of comparison of predicted and observed surface salinity and temperature at PCDEM water quality monitoring sites, Clearwater Harbor/St. Joseph Sound hydrodynamic model. The parenthetical statistics for 1999 salinity are those resulting from exclusion of three observations in March 1999 where salinity was less than 15 ppt.

	1997 (Wet Year)		**1999 (Dry Year)**	
Statistic	**Salinity**	**Temperature**	**Salinity**	**Temperature**
RMSE (m)	4.6	1.8	7.9 (3.1)	2.1
ME (m)	1.2	0.8	-2.4 (-0.5)	0.4
AME (m)	3.4	1.7	4.5 (2.9)	1.7

The comparison shows good agreement between predicted and observed salinity and temperature indicate very good agreement between predicted and observed values. During March 1999, three salinity observations were less than 15 ppt in Clearwater Harbor North, with one less than 10 ppt, one less than 15 ppt, and one less than 1 ppt. The model did not recreate these low salinities. Removing these three observations from the comparison statistics, the comparison between observed and predicted salinities during 1999 is even better. The salinity MEs of 1.2 ppt (1997) and -2.4 ppt (1999) indicate slight underprediction of salinity during the wet year (1997) and slight overprediction during the dry year (1999) compared to observed values over the time period. Similarly, the temperature MEs of 0.8 (1997) and 0.4 (1999) indicate very good agreement between predicted and observed temperatures. Time series plots of the predicted and observed salinities at each grid cell are provided for dry year (Figures A-24 through A-32) and wet year (Figures A-33 through A-41).



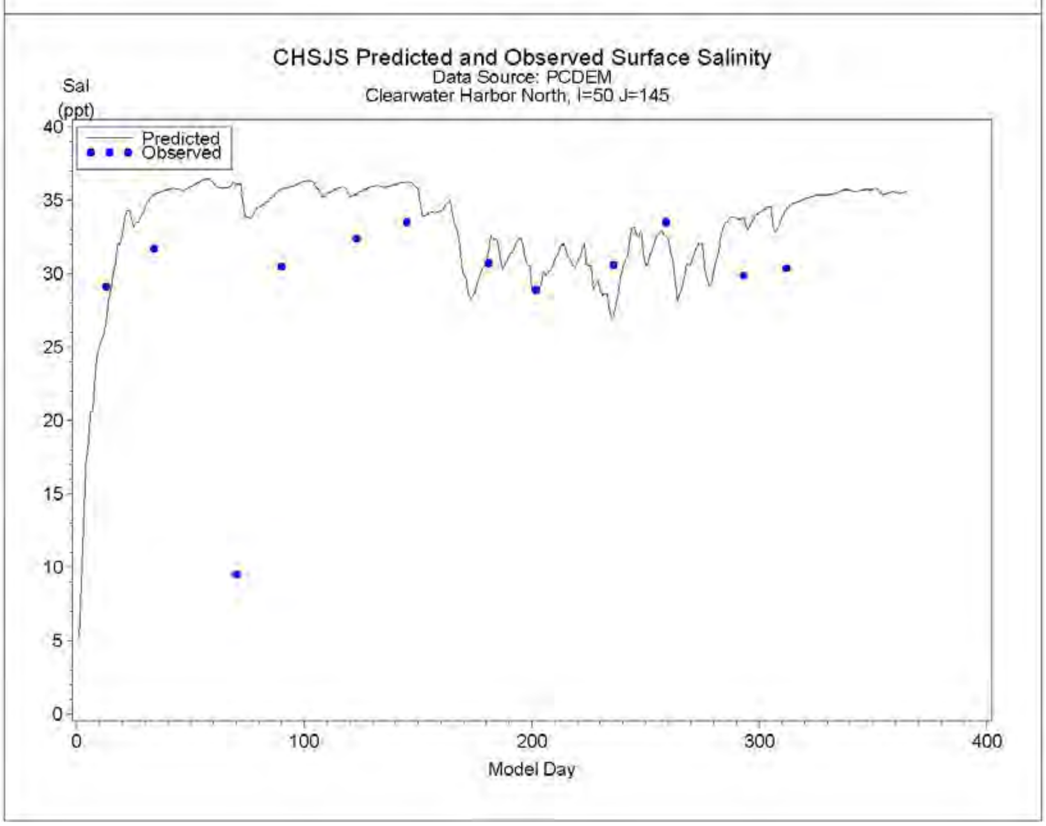
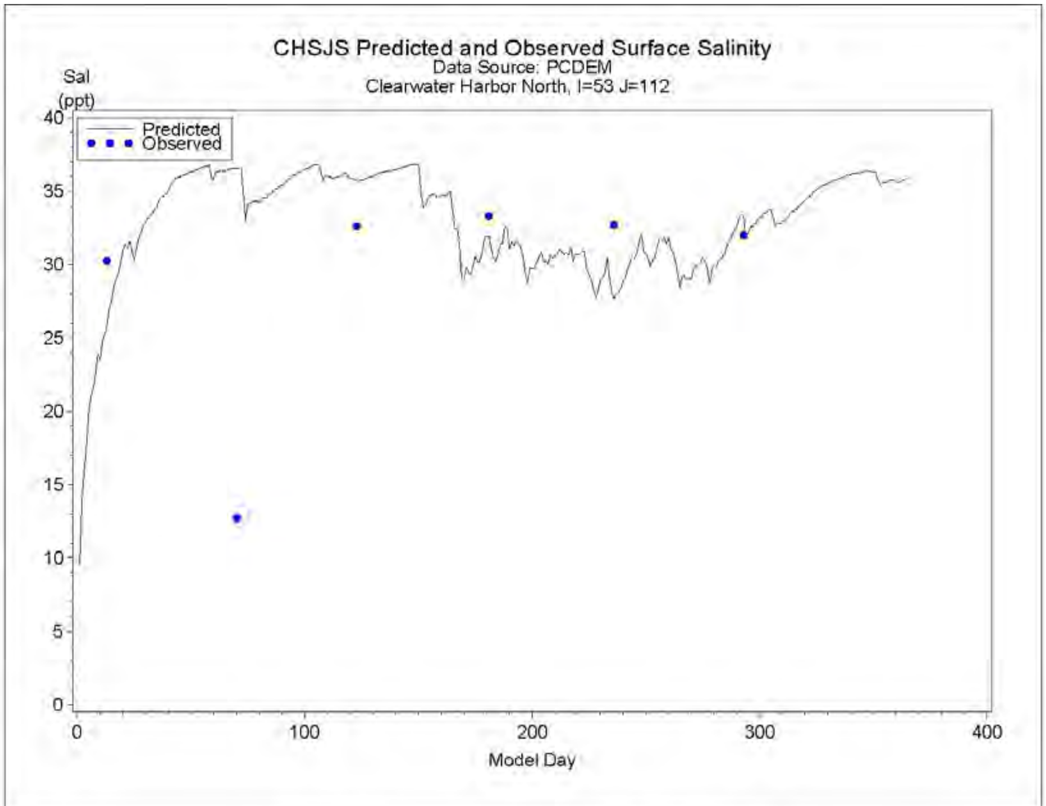


Figure A-24. Time series comparisons of daily predicted and observed salinity at PCDEM sites, 1999, dry year.



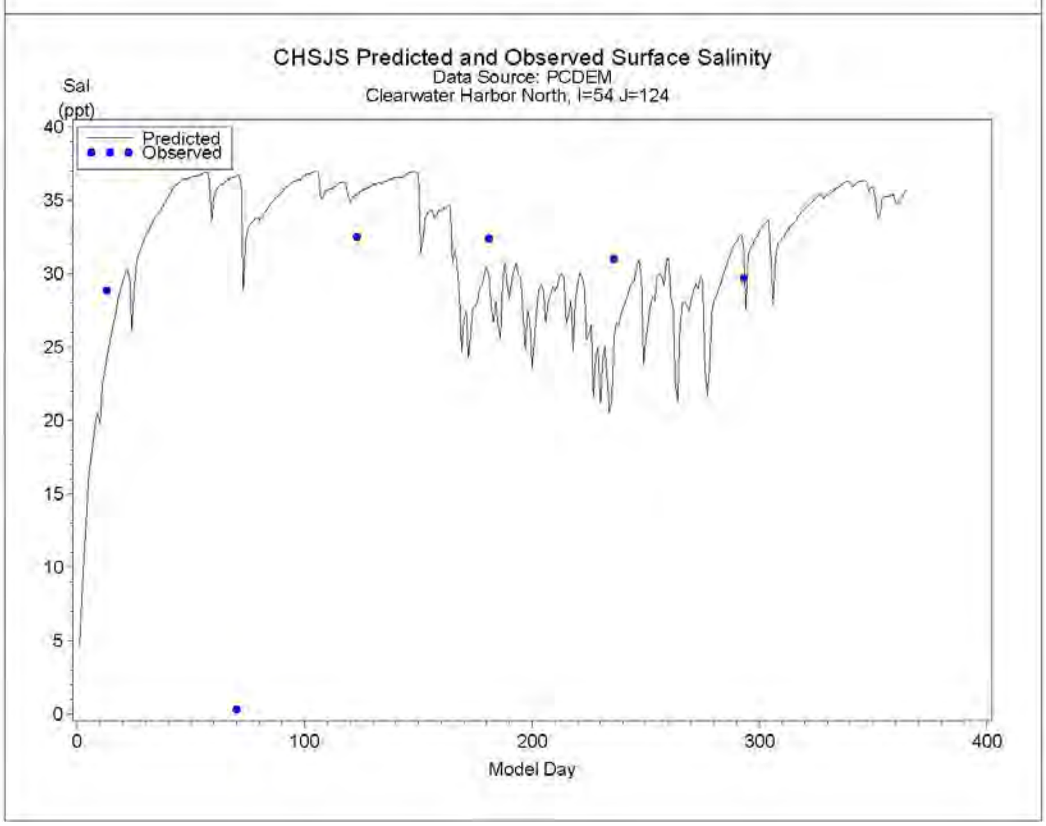


Figure A-25. Time series comparisons of daily predicted and observed salinity at PCDEM sites, 1999, dry year.

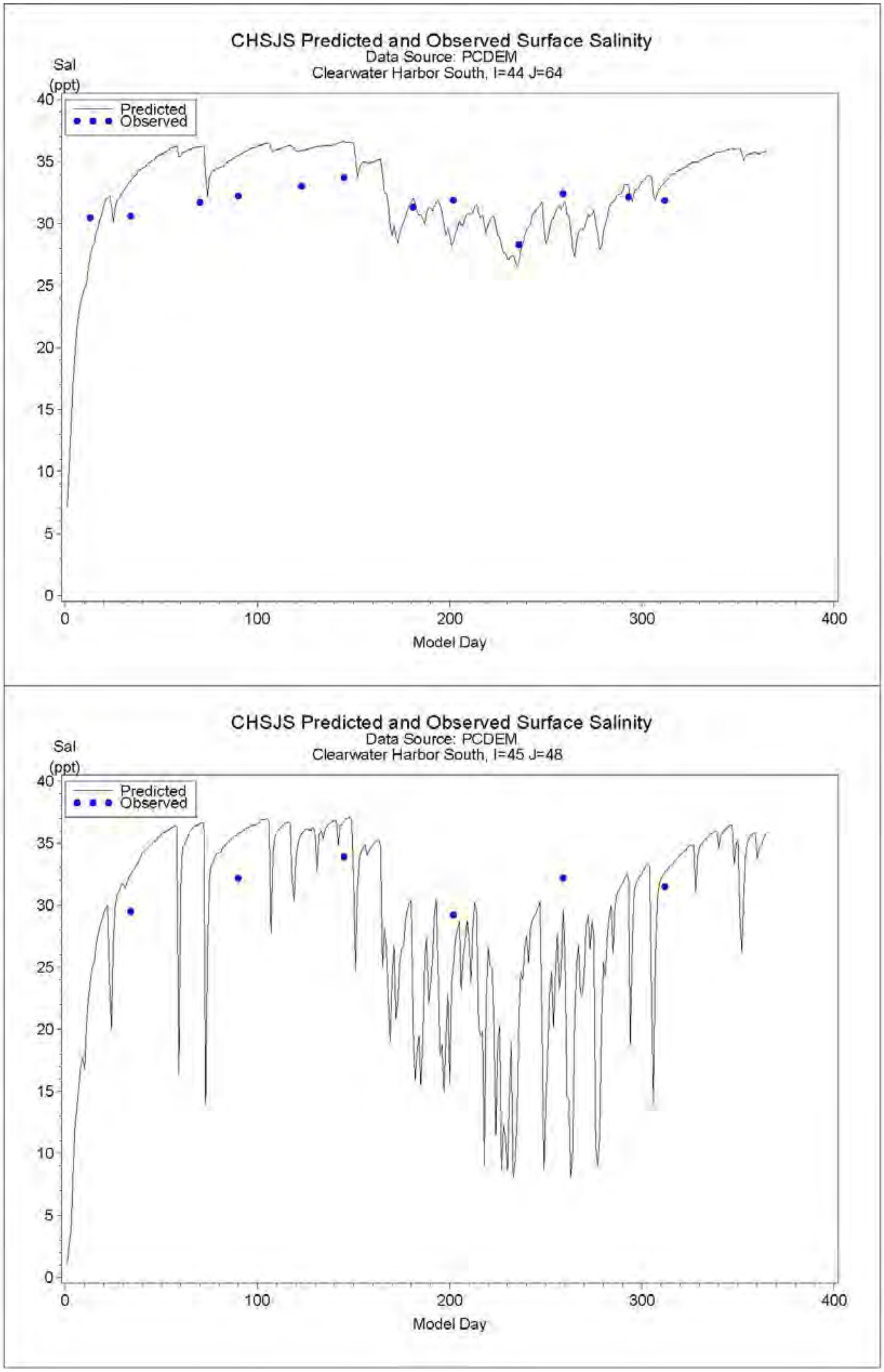


Figure A-26. Time series comparisons of daily predicted and observed salinity at PCDEM sites, 1999, dry year.

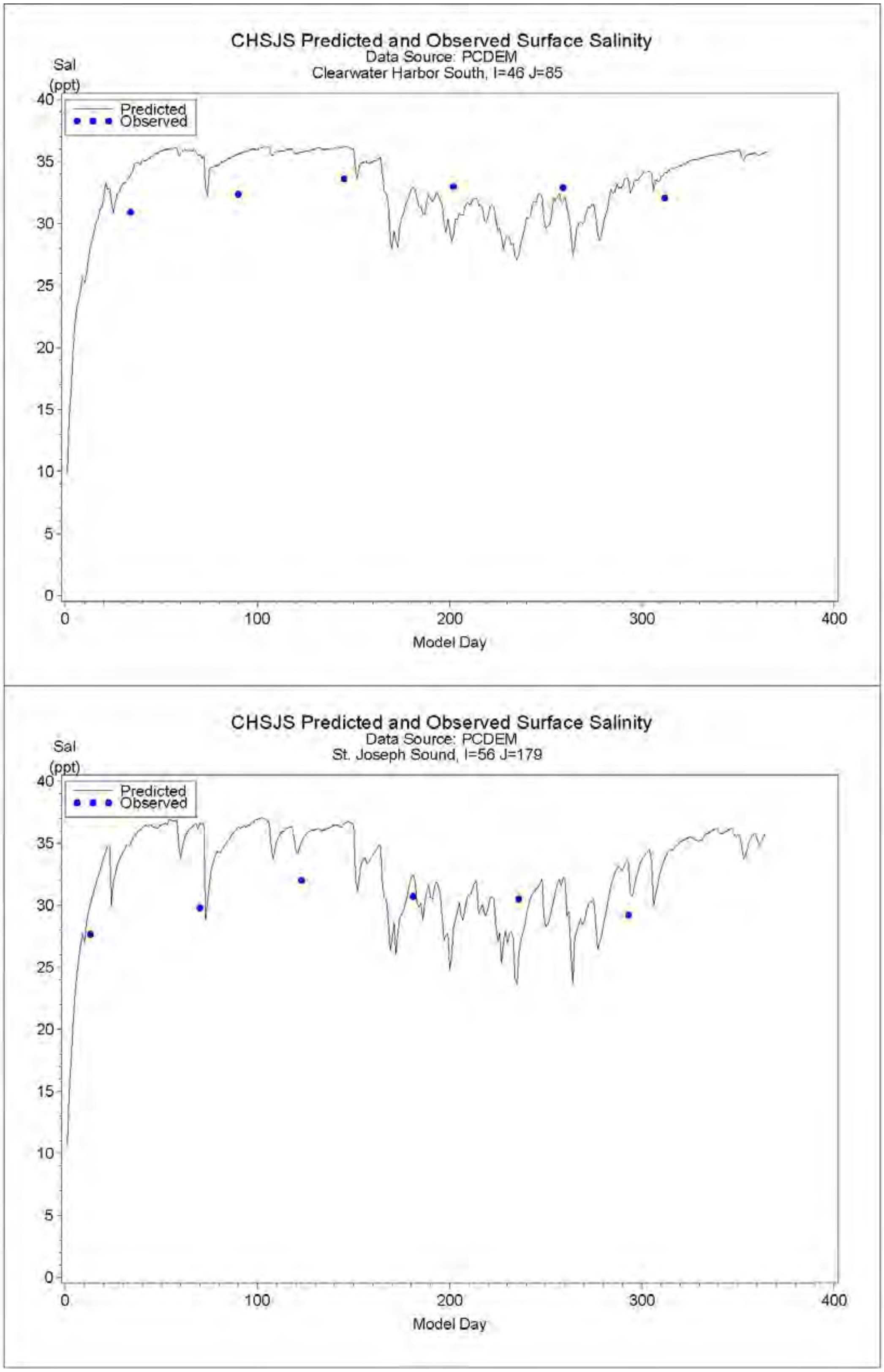
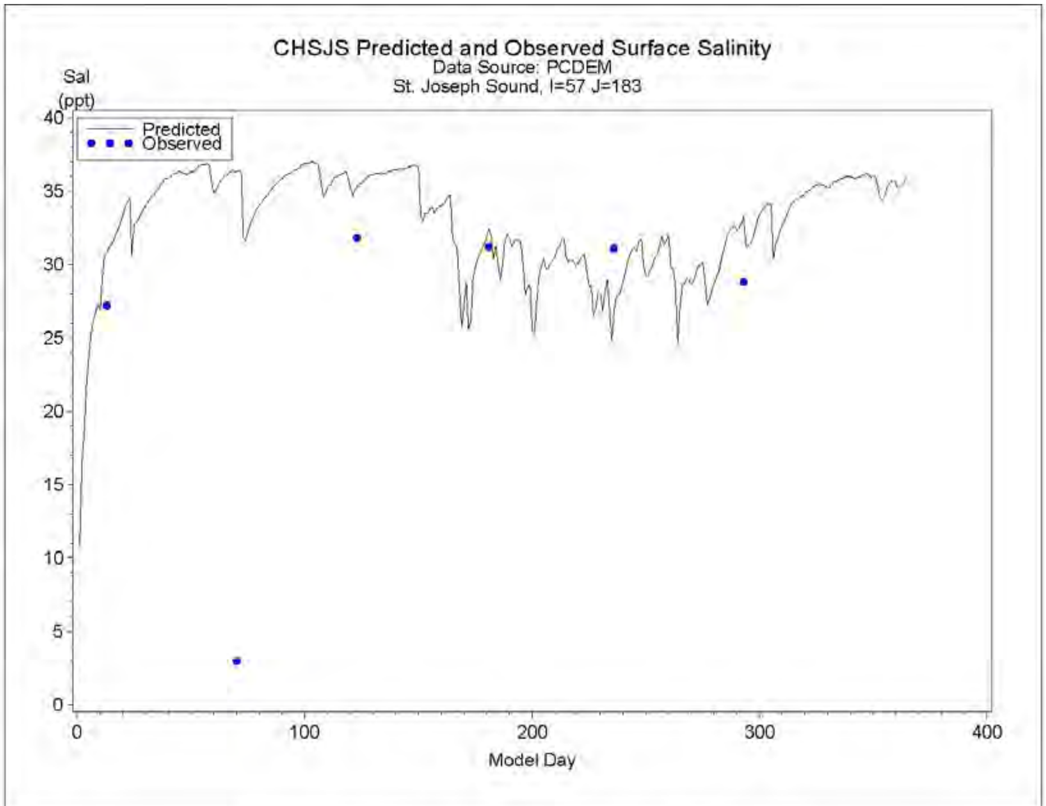


Figure A-27. Time series comparisons of daily predicted and observed salinity at PCDEM sites, 1999, dry year.



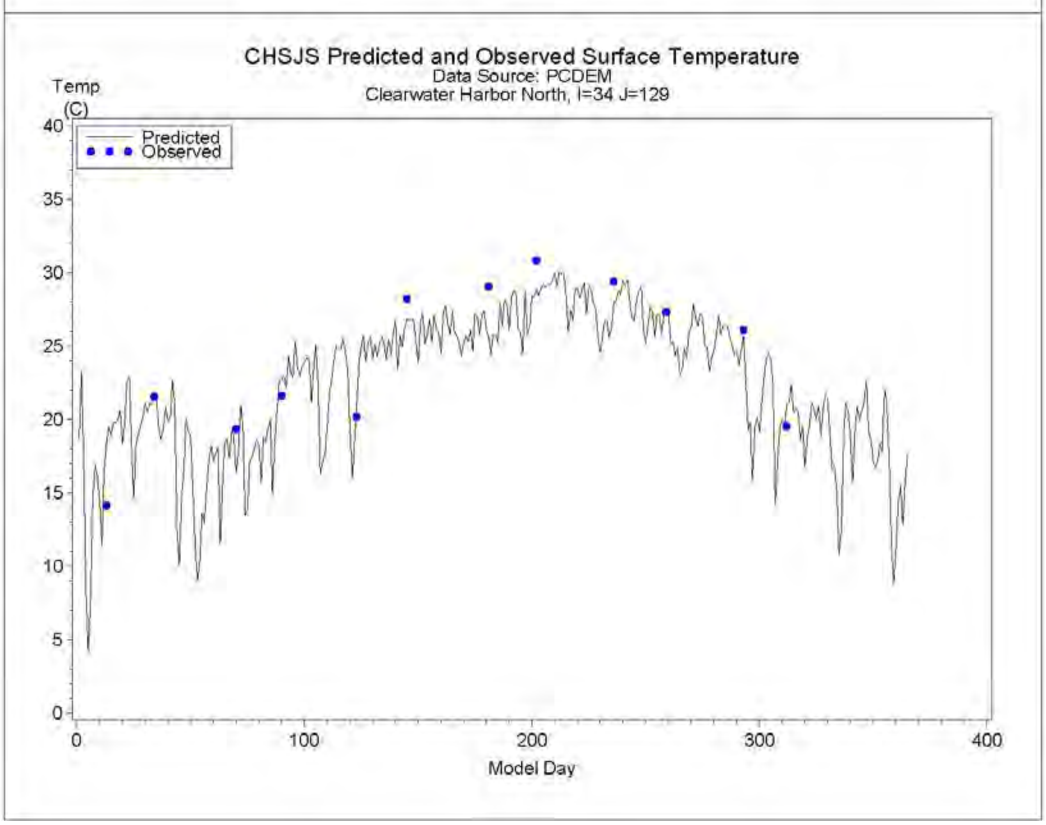


Figure A-28. Time series comparisons of daily predicted and observed salinity and temperature at PCDEM sites, 1999, dry year.

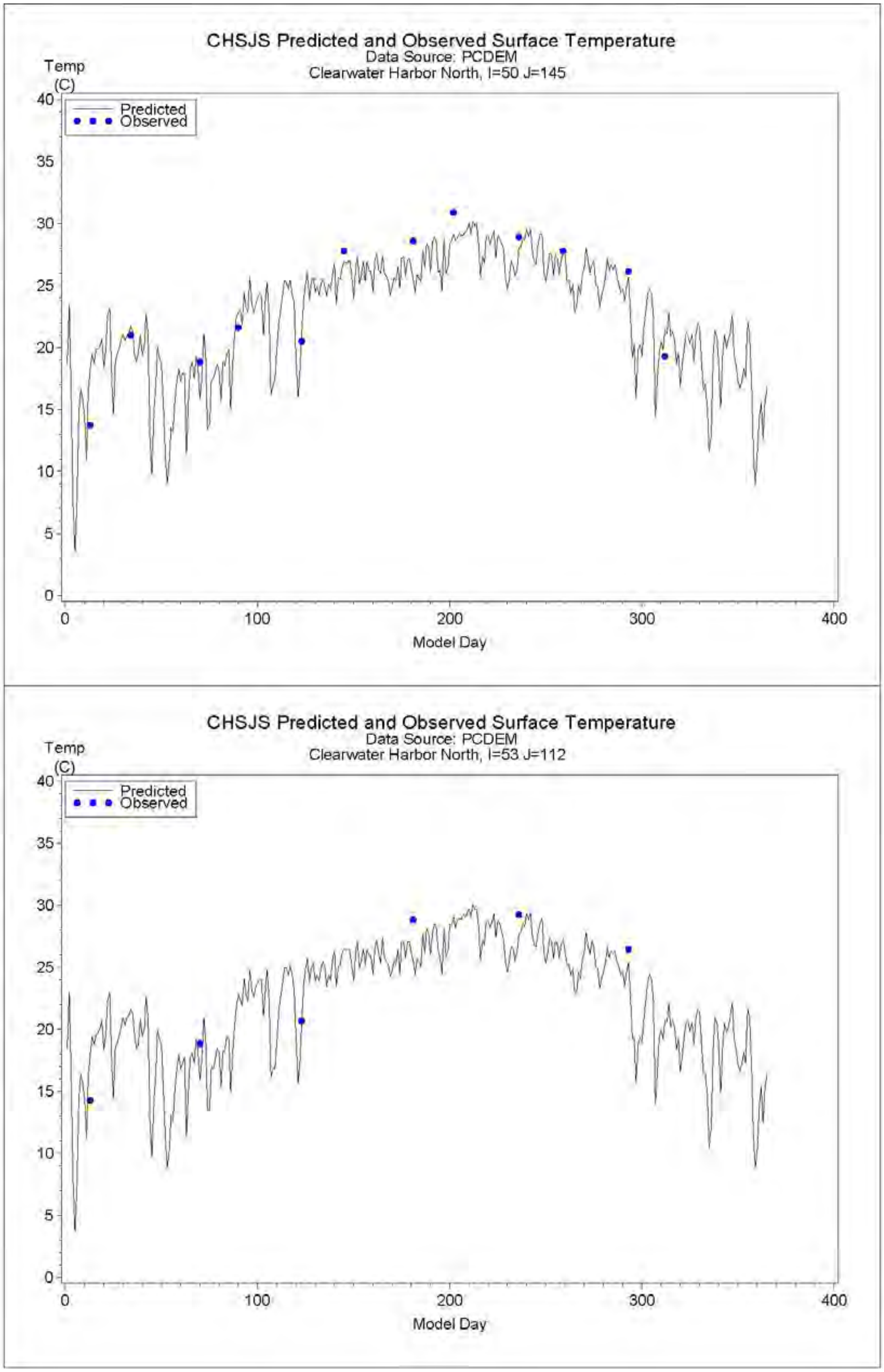
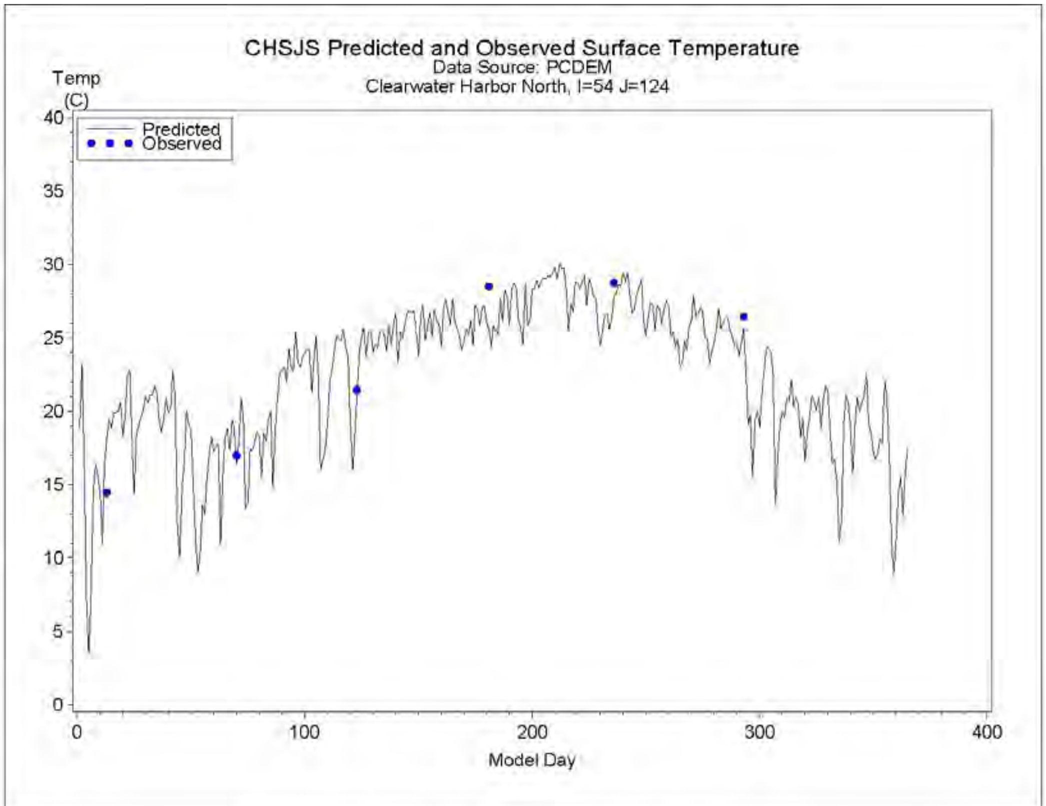


Figure A-29. Time series comparisons of daily predicted and observed temperature at PCDEM sites, 1999, dry year.



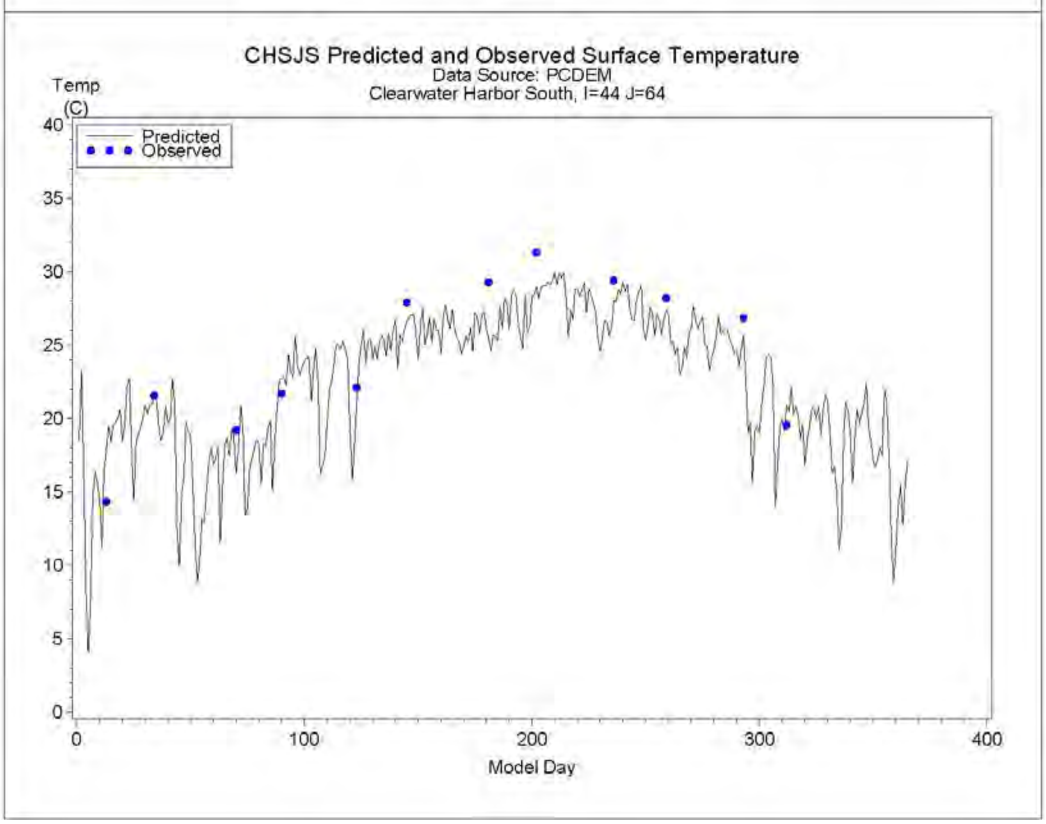
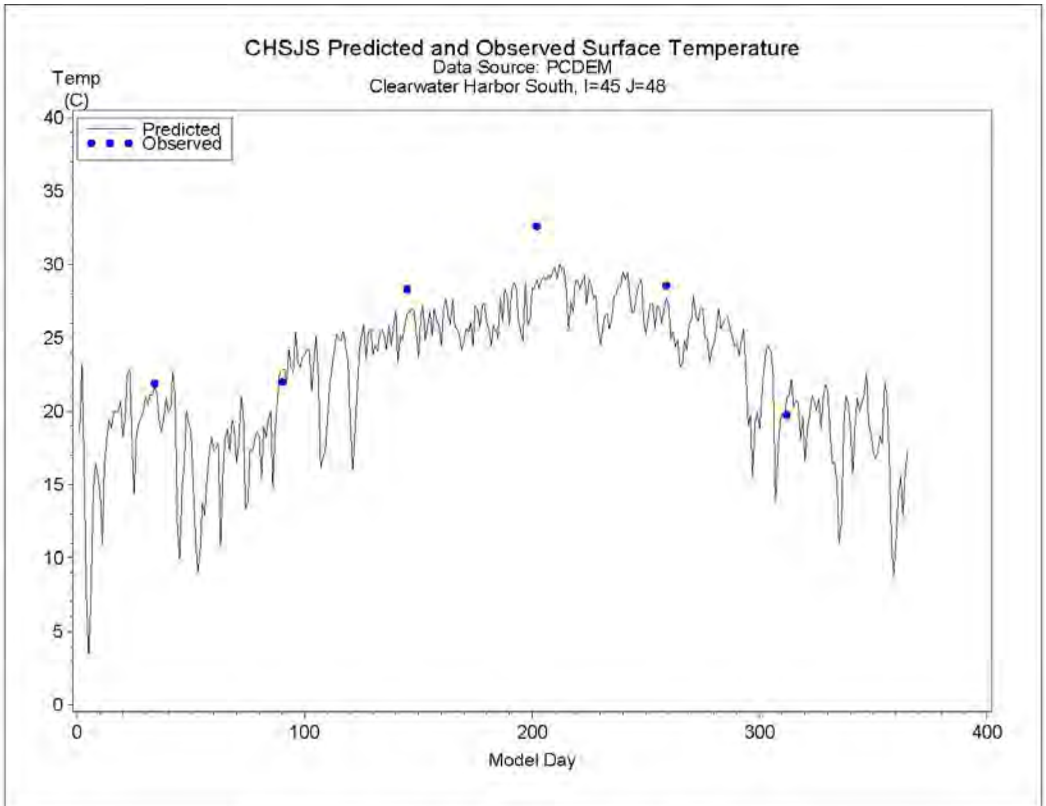


Figure A-30. Time series comparisons of daily predicted and observed temperature at PCDEM sites, 1999, dry year.



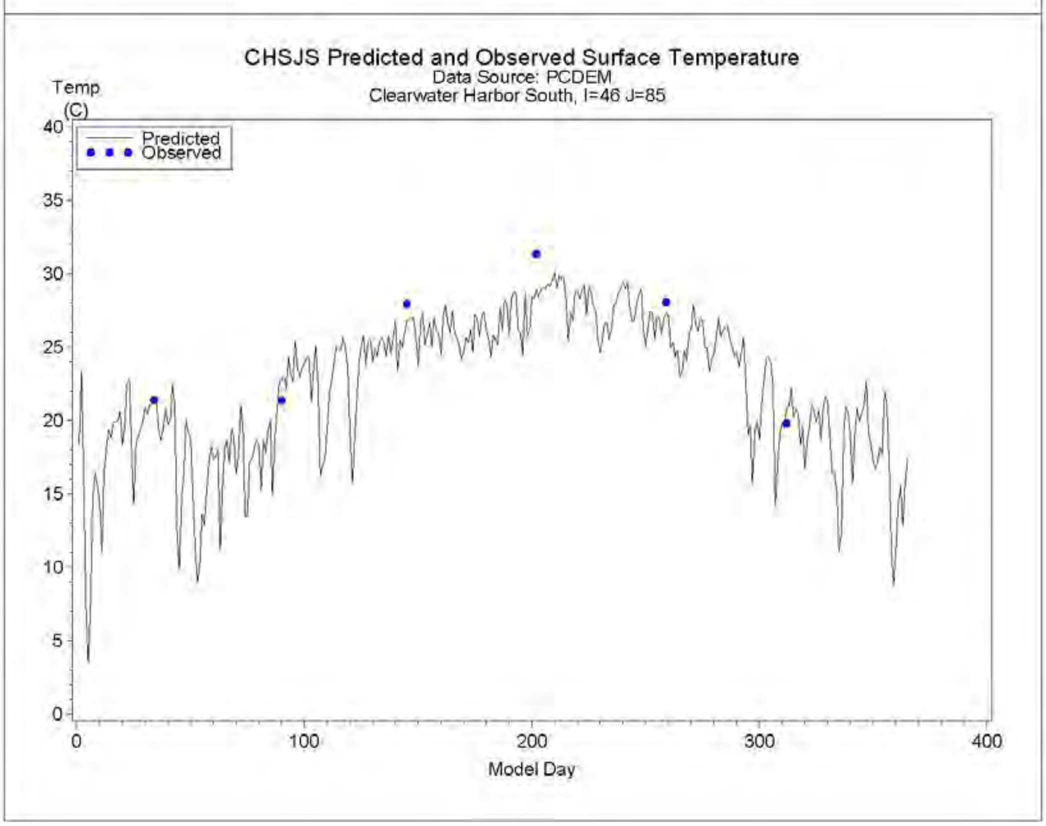


Figure A-31. Time series comparisons of daily predicted and observed temperature at PCDEM sites, 1999, dry year.

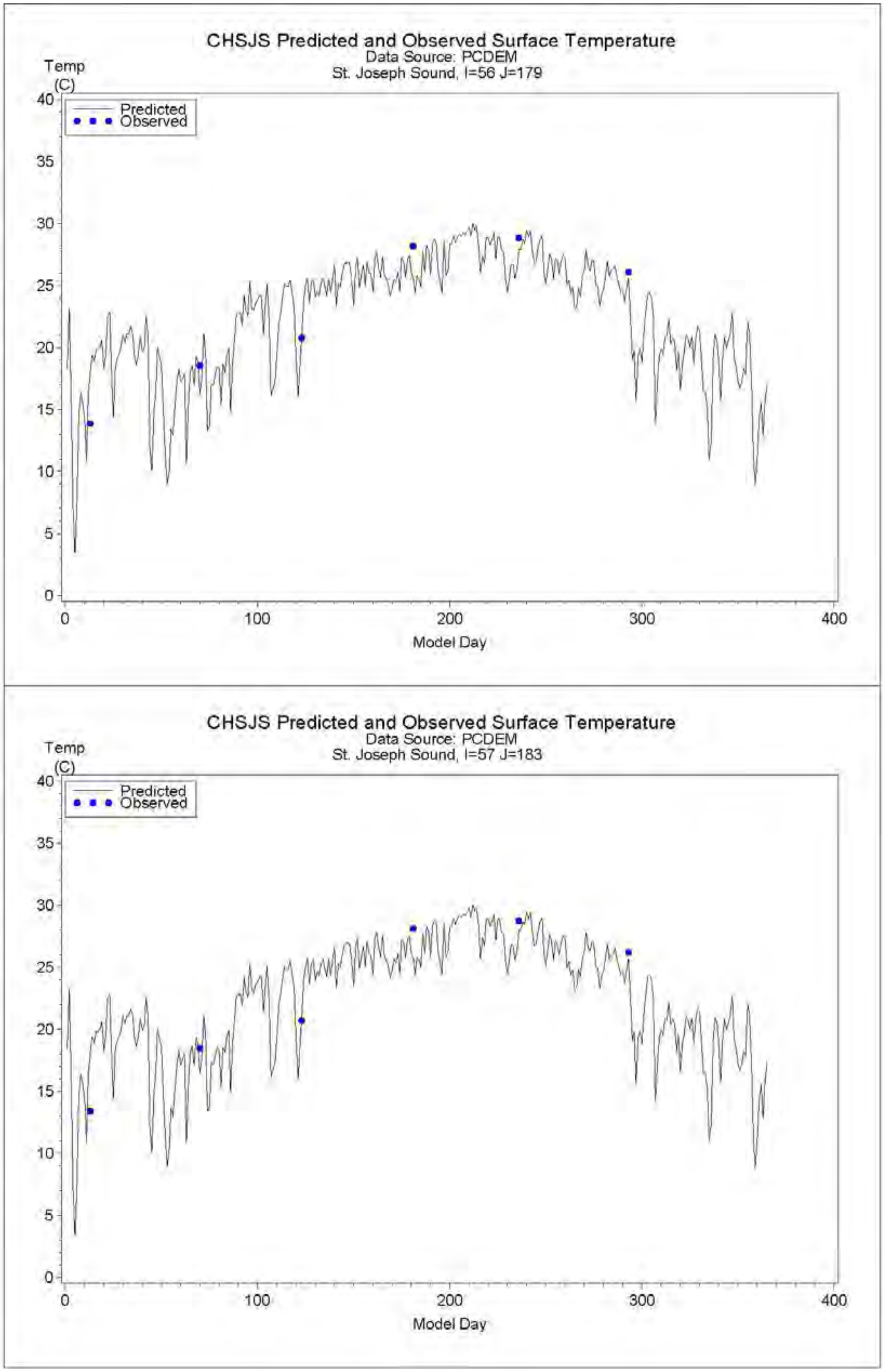
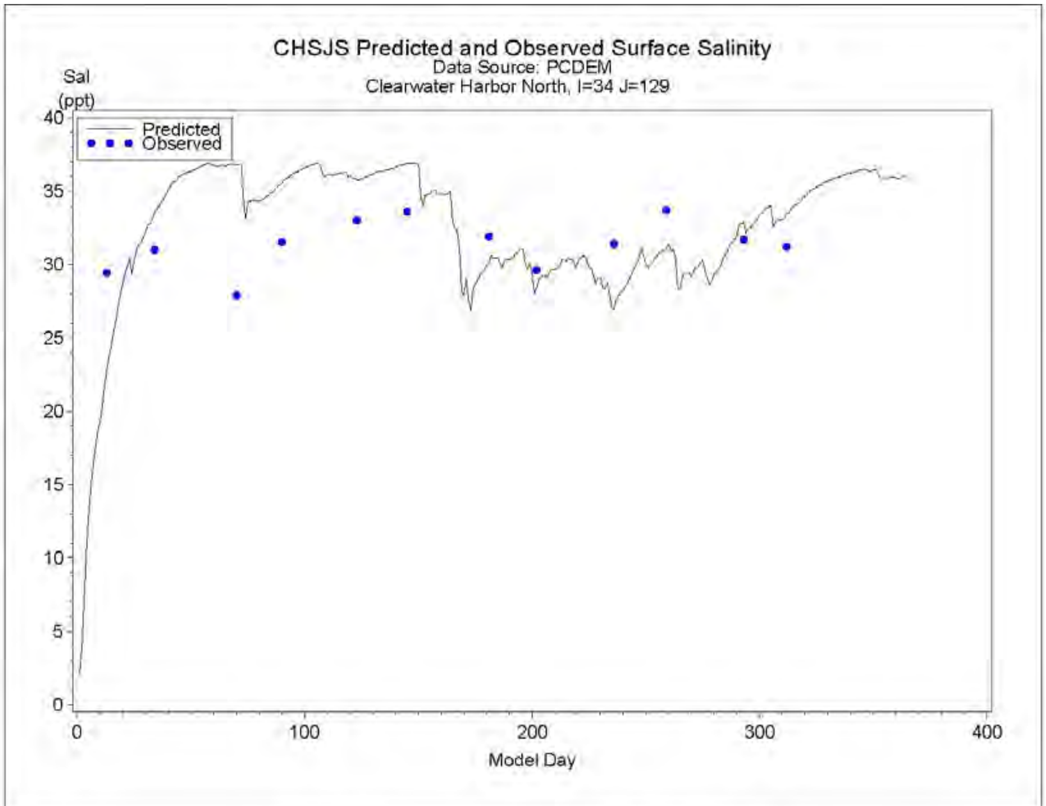


Figure A-32. Time series comparisons of daily predicted and observed temperature at PCDEM sites, 1999, dry year.



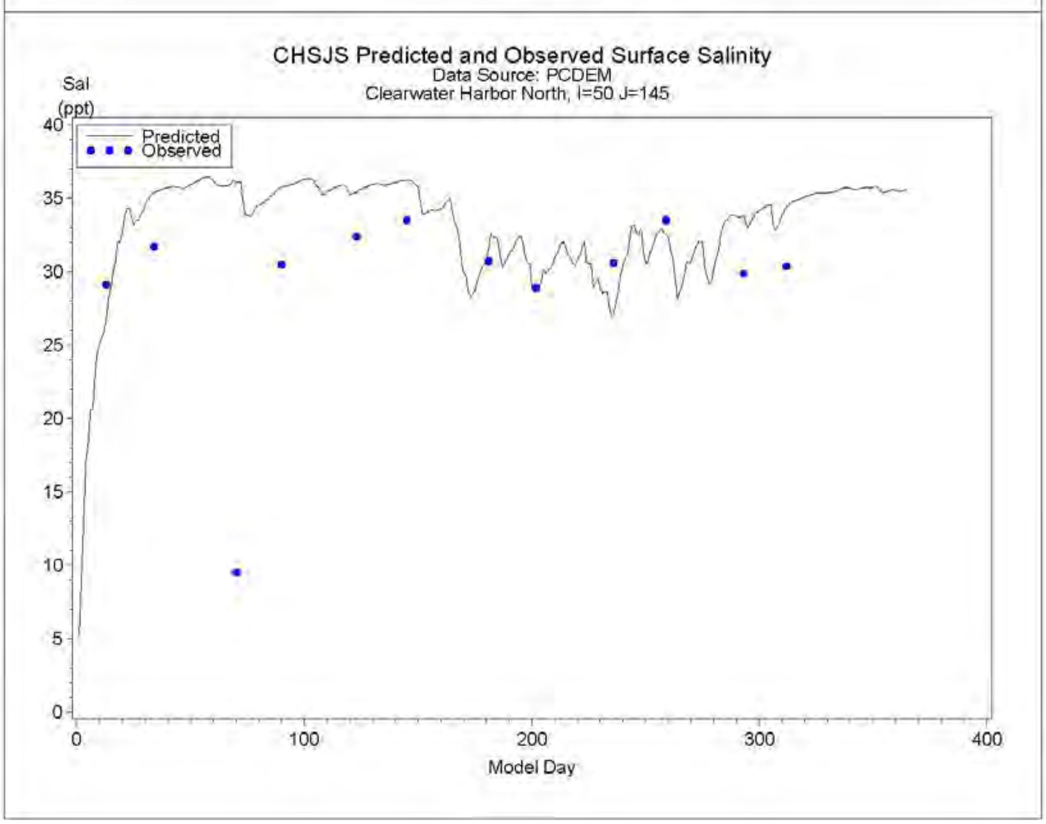
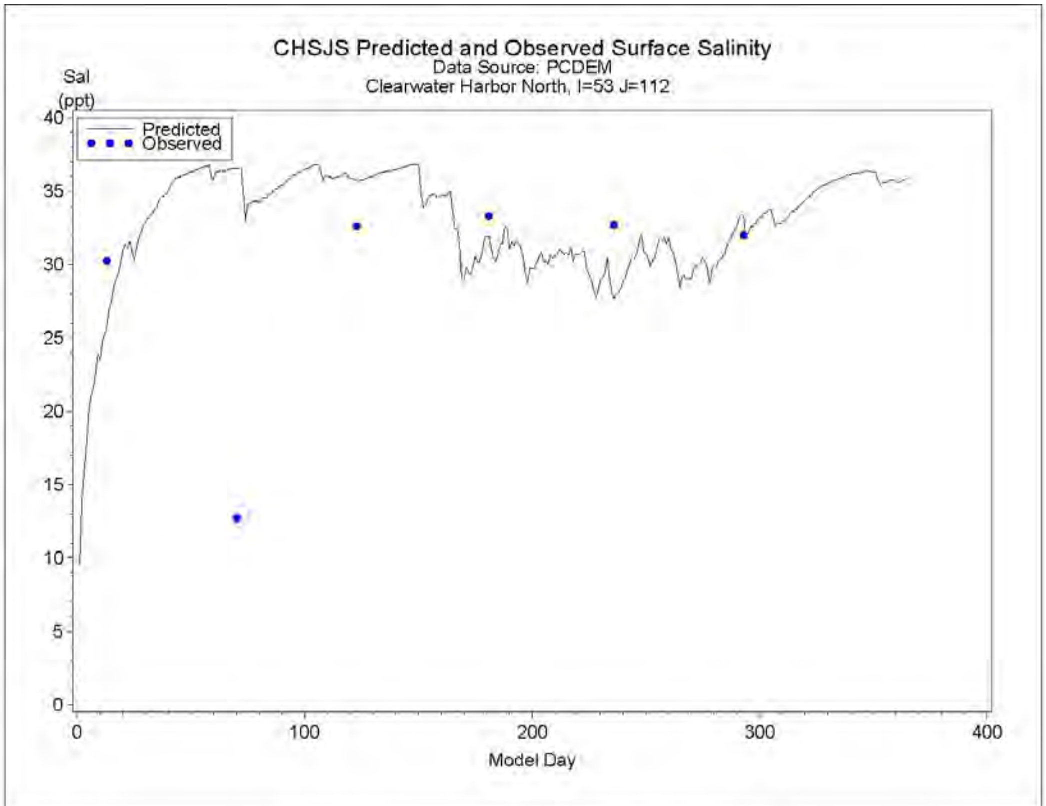


Figure A-33. Time series comparisons of daily predicted and observed salinity at PCDEM sites, 1997, wet year.



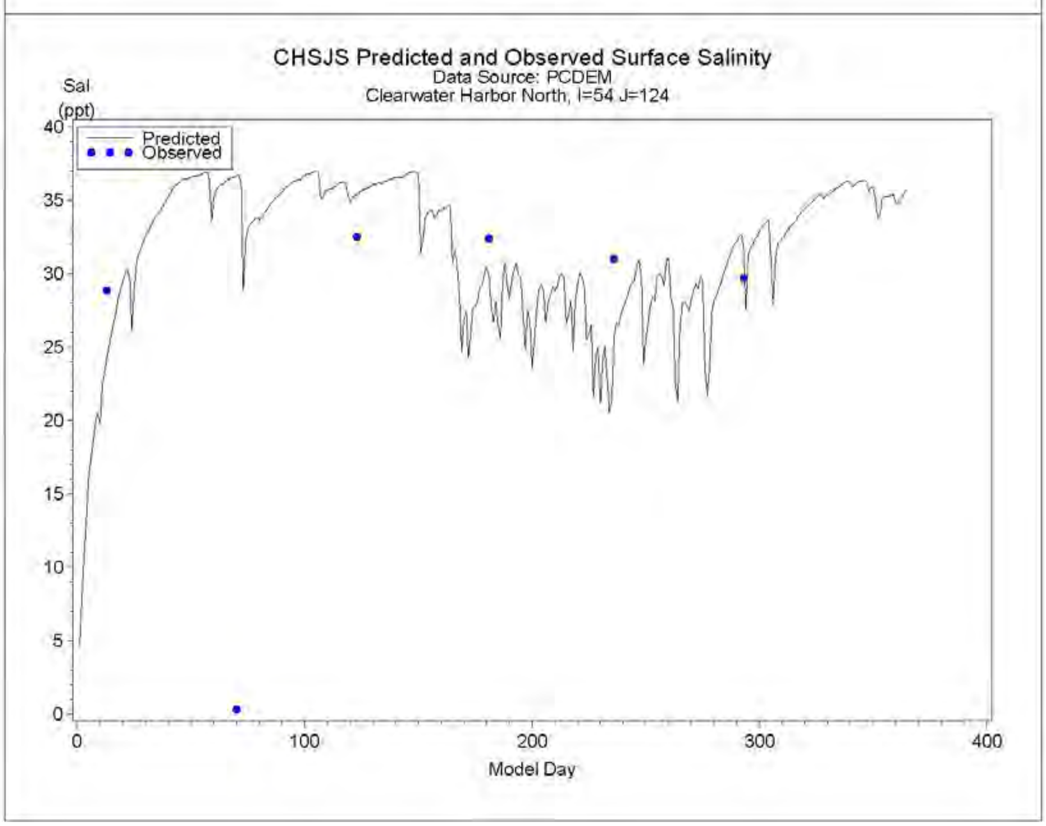
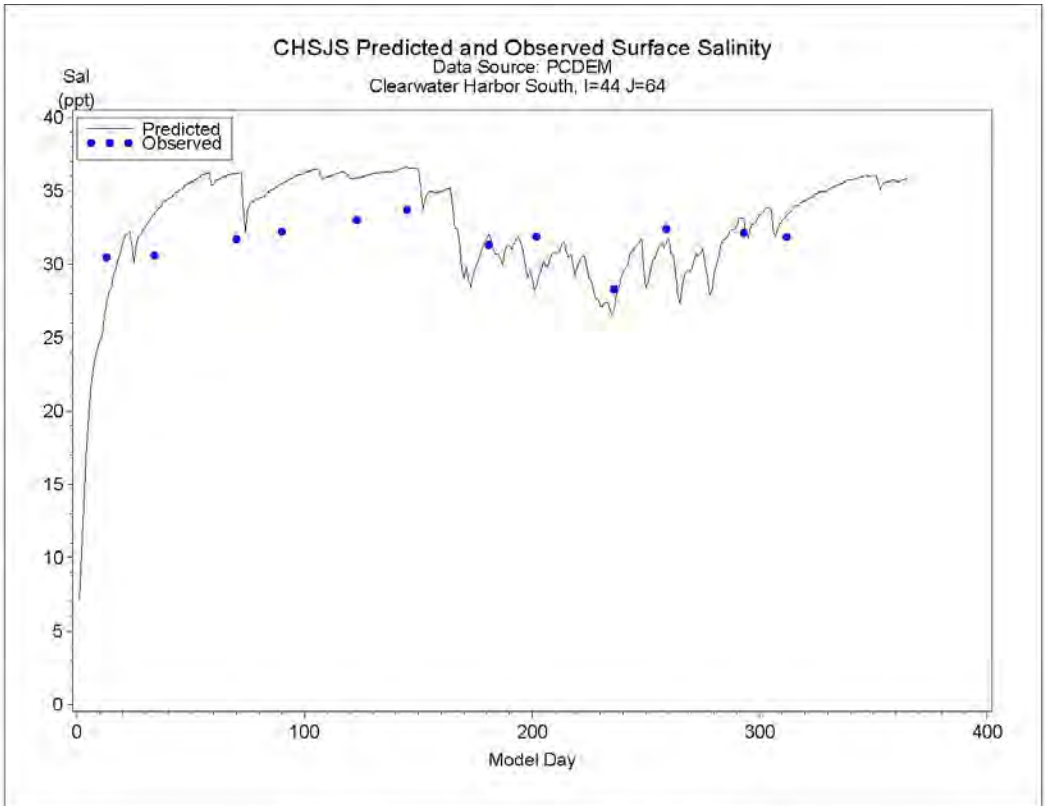


Figure A-34. Time series comparisons of daily predicted and observed salinity at PCDEM sites, 1997, wet year.



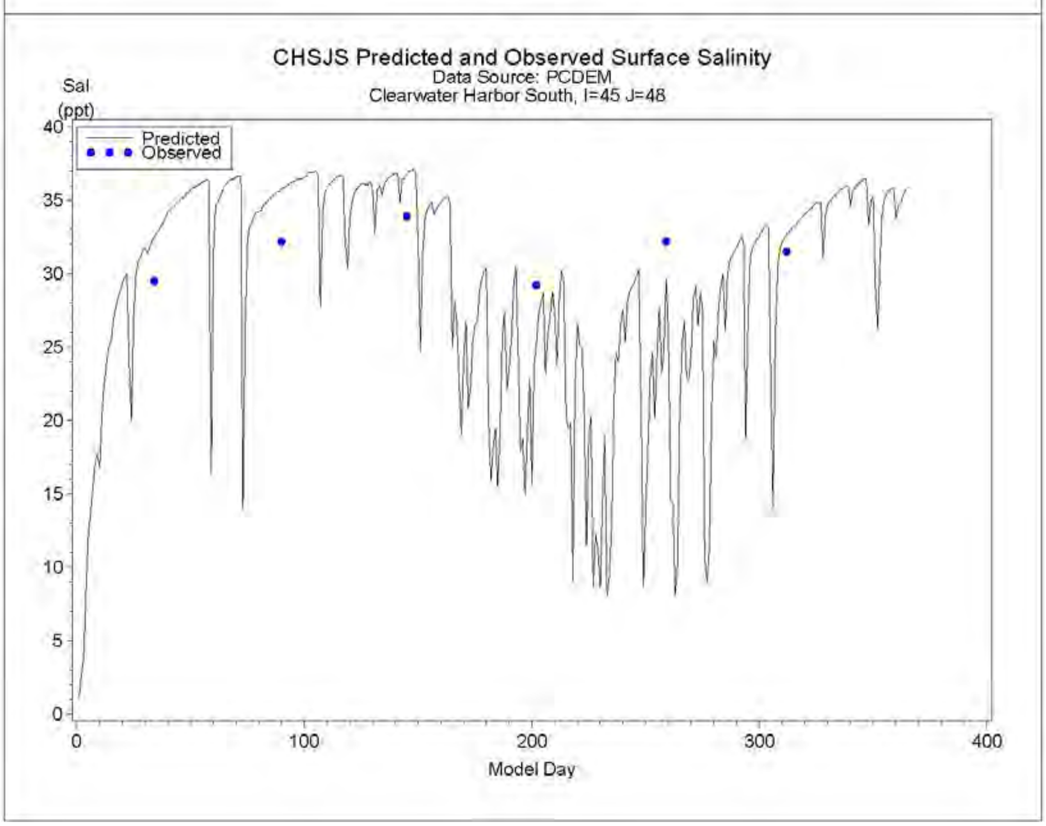


Figure A-35. Time series comparisons of daily predicted and observed salinity at PCDEM sites, 1997, wet year.

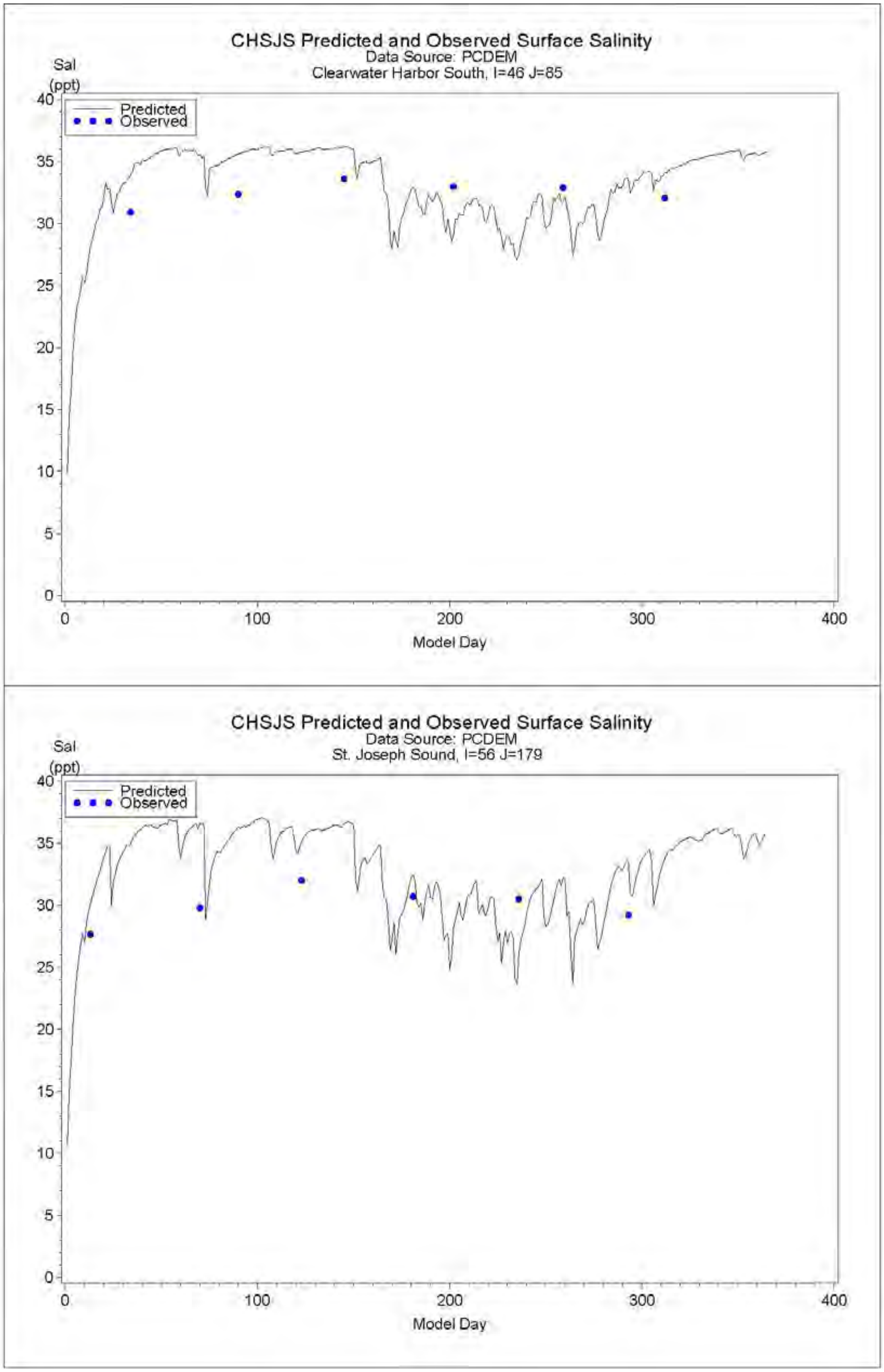


Figure A-36. Time series comparisons of daily predicted and observed salinity at PCDEM sites, 1997, wet year.

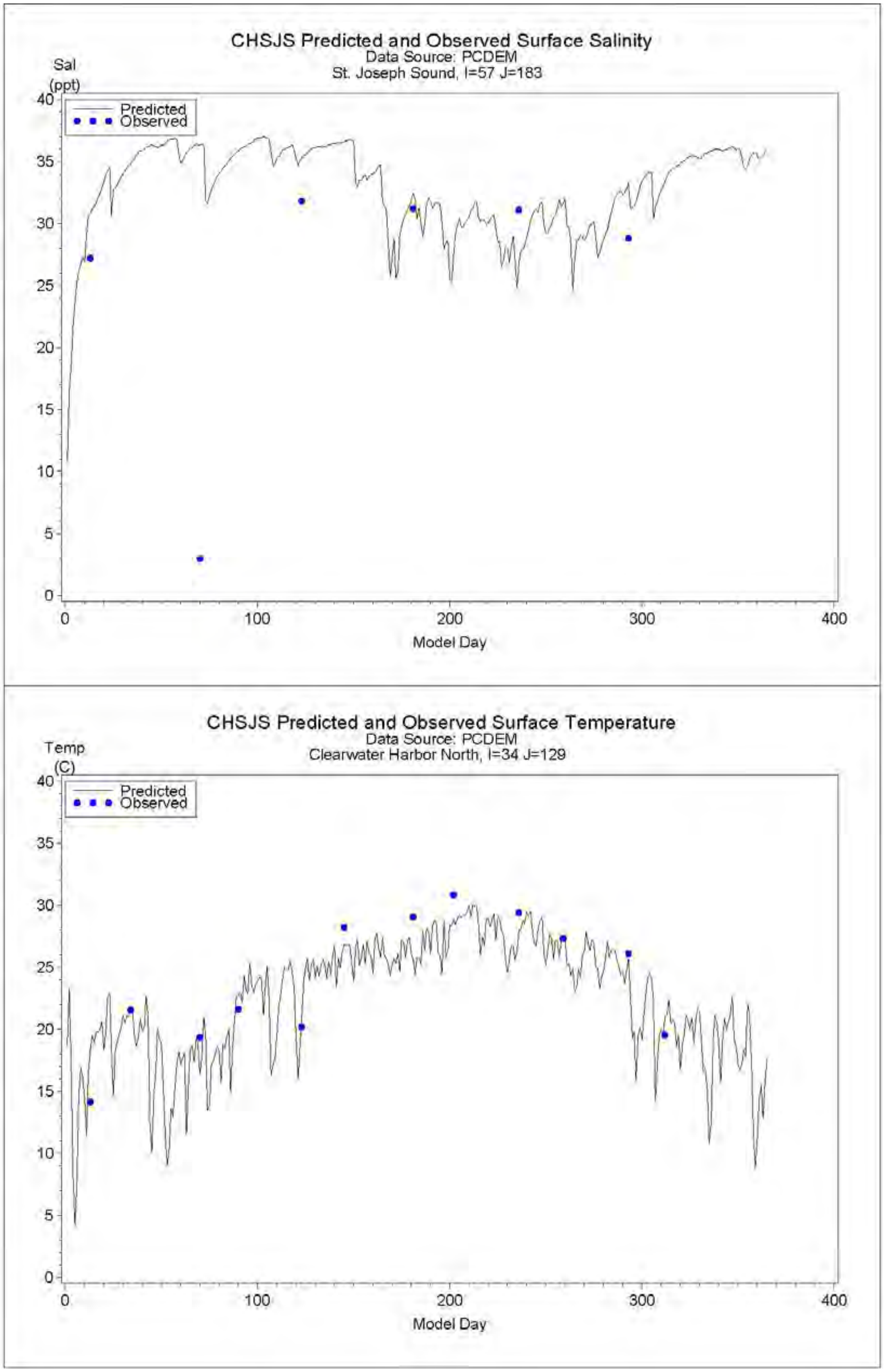
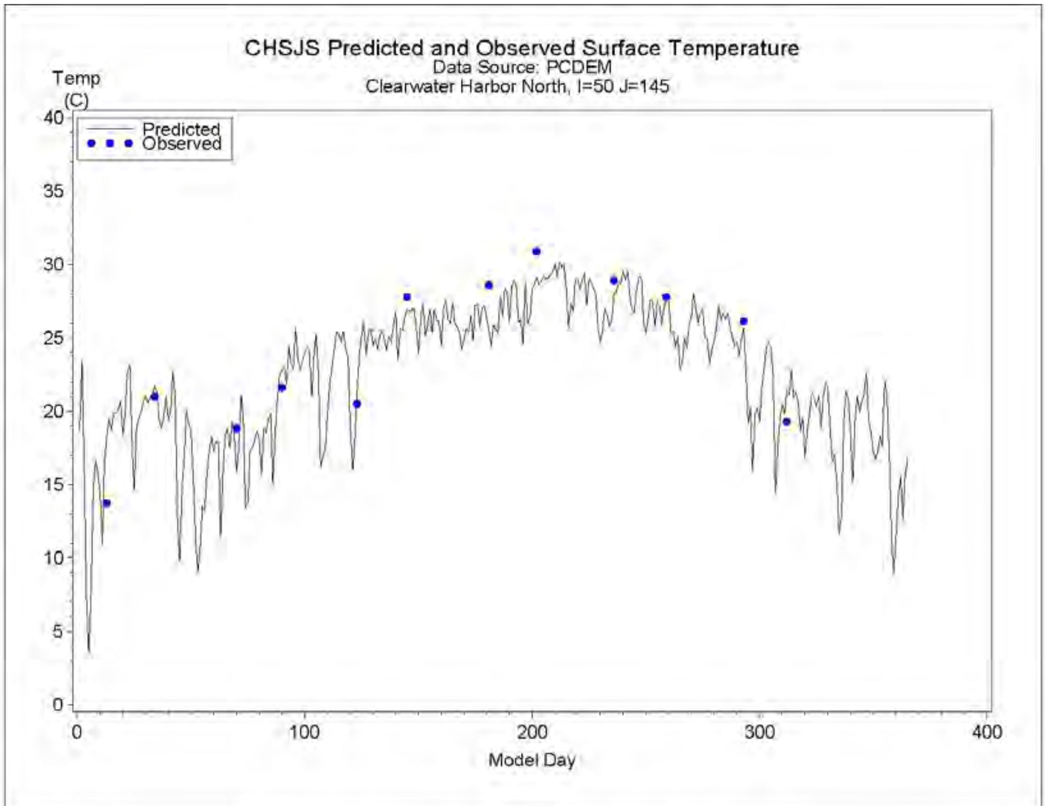


Figure A-37. Time series comparisons of daily predicted and observed salinity and temperature at PCDEM sites, 1997, wet year.



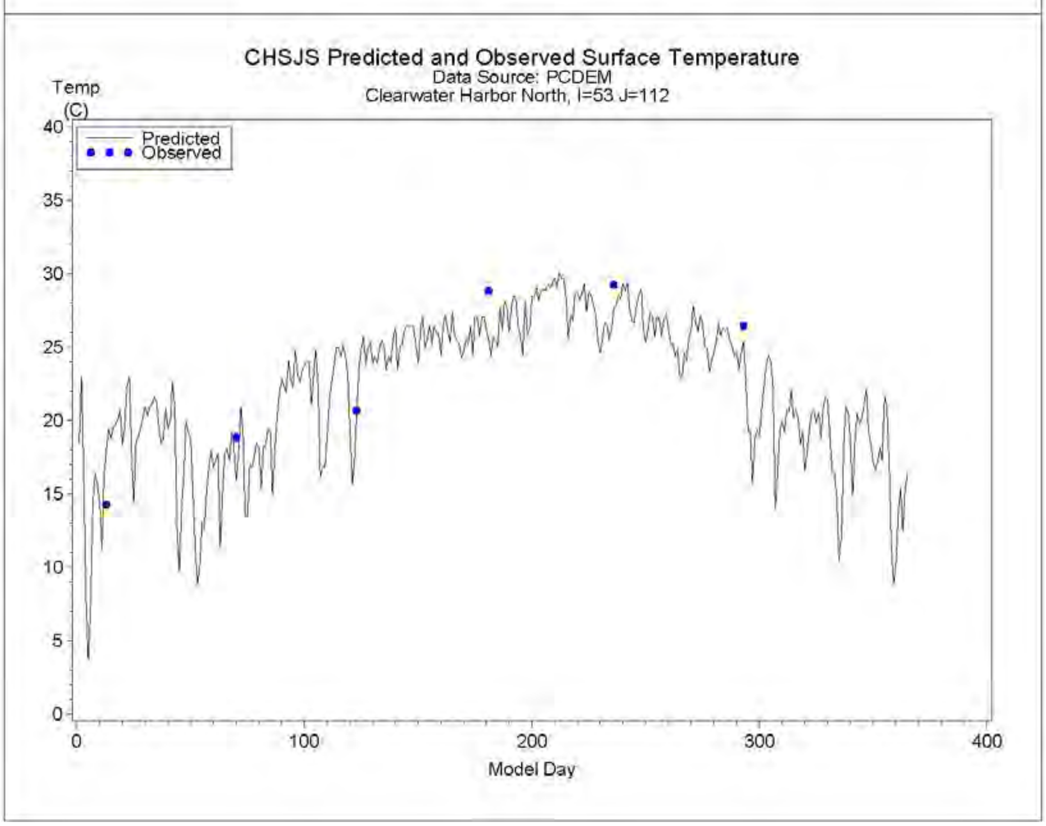
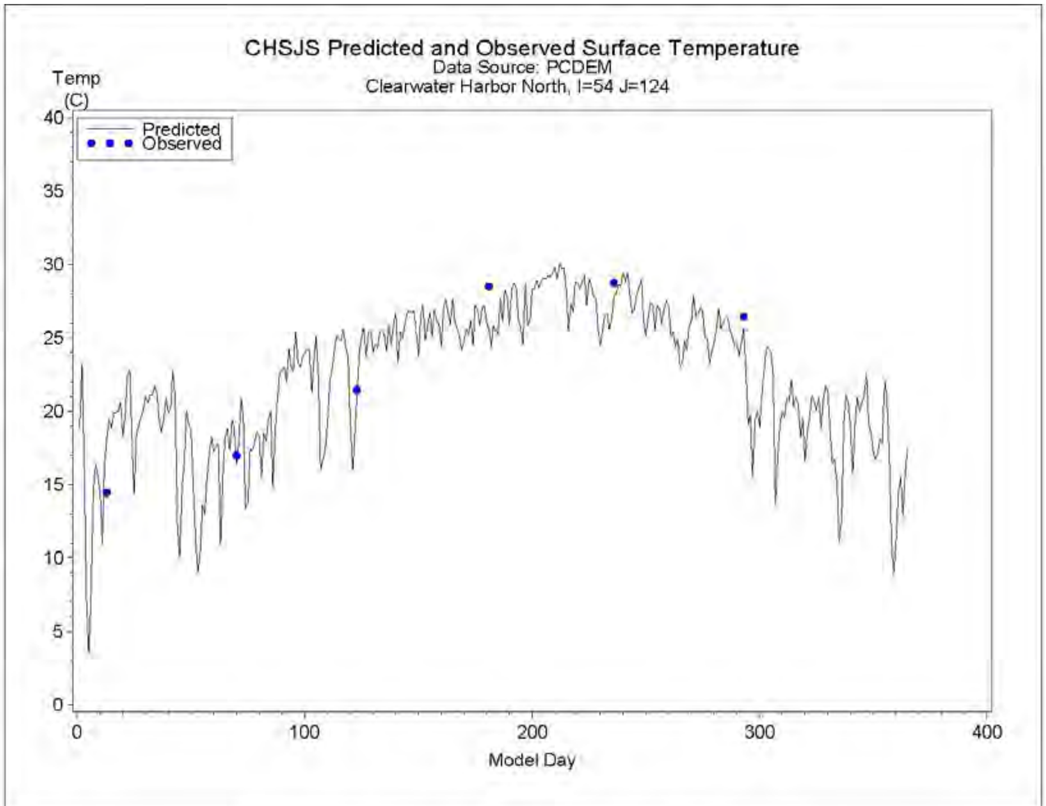


Figure A-38. Time series comparisons of daily predicted and observed temperature at PCDEM sites, 1997, wet year.



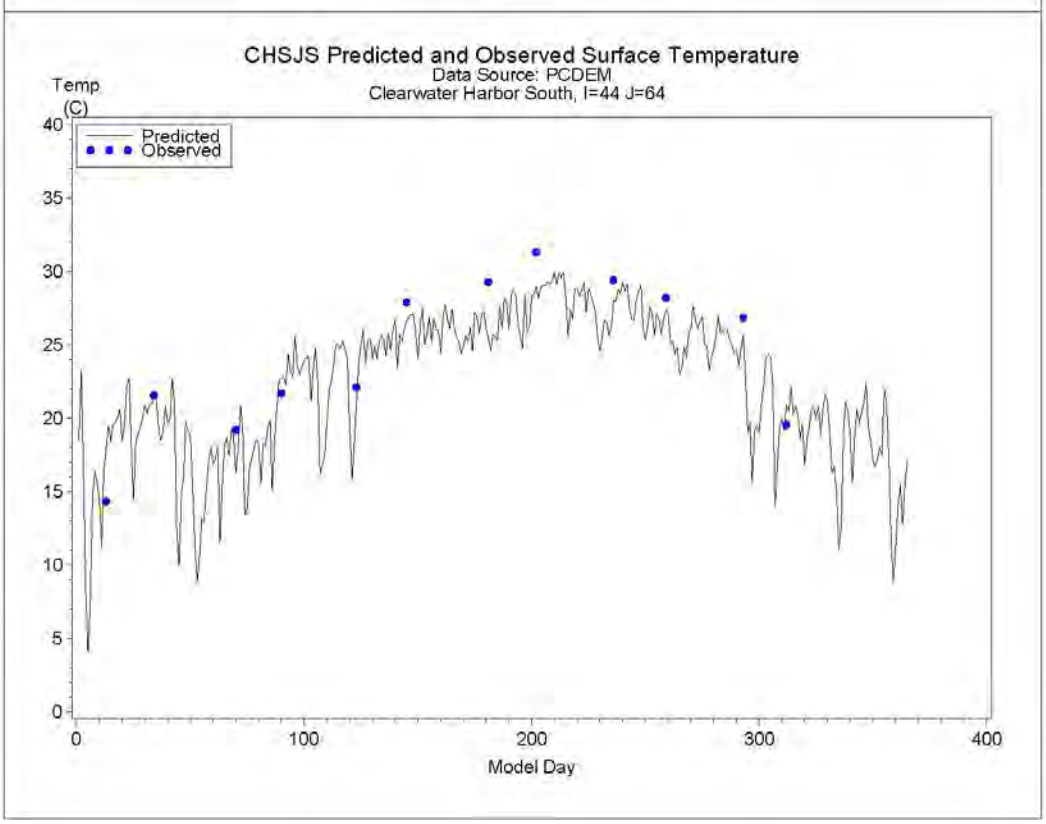


Figure A-39. Time series comparisons of daily predicted and observed temperature at PCDEM sites, 1997, wet year.

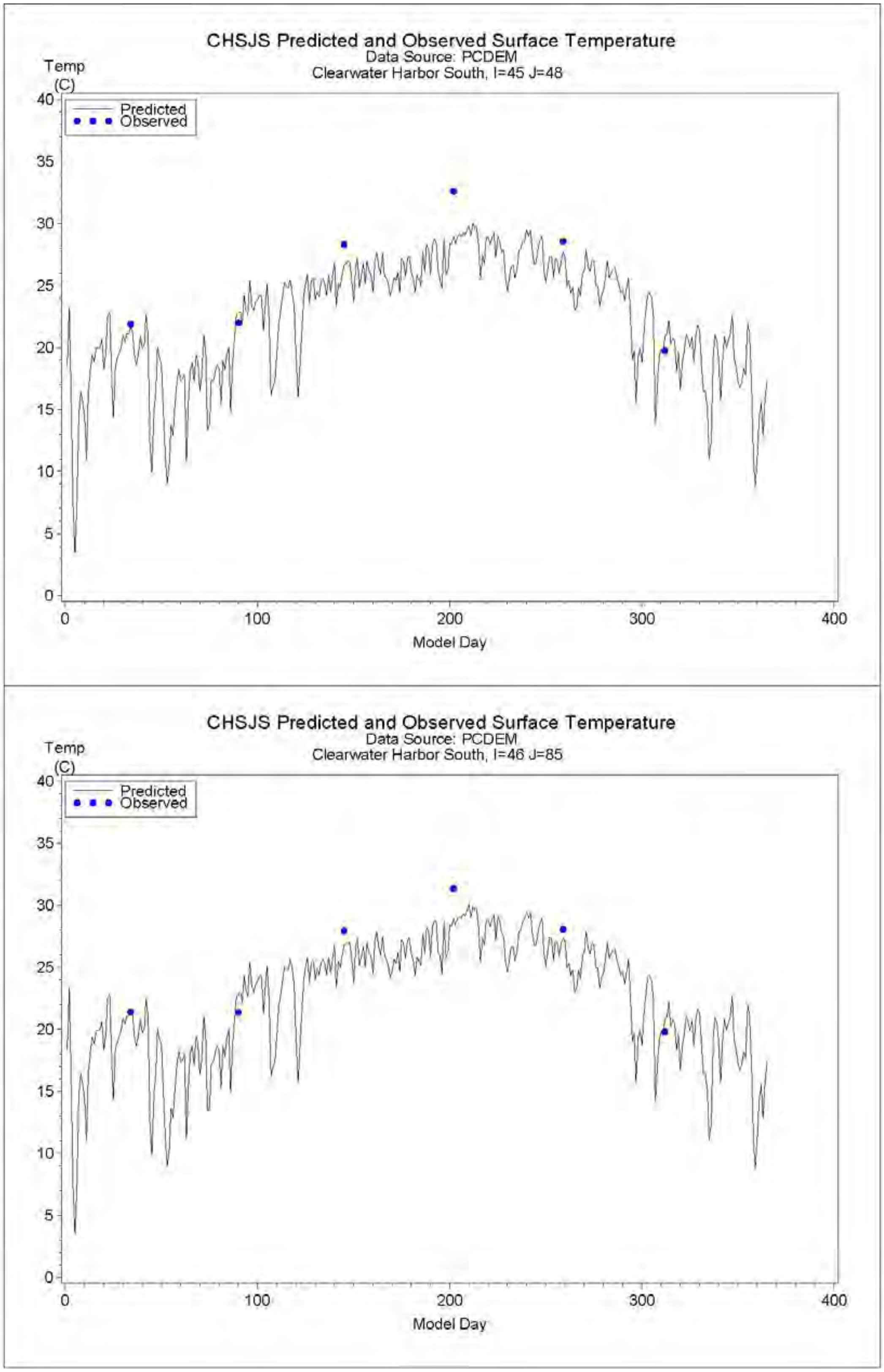


Figure A-40. Time series comparisons of daily predicted and observed temperature at PCDEM sites, 1997, wet year.

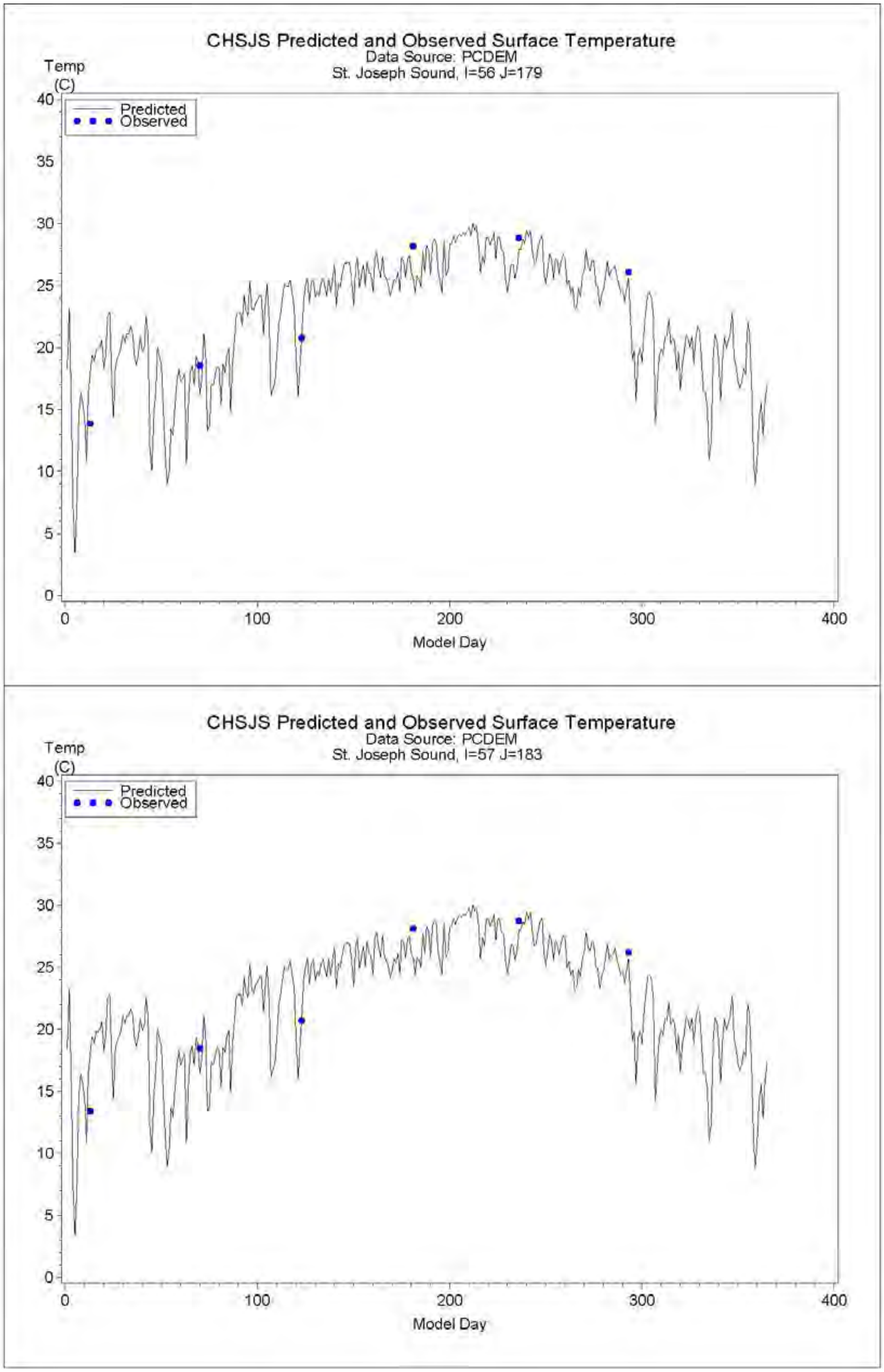


Figure A-41. Time series comparisons of daily predicted and observed temperature at PCDEM sites, 1997, wet year.