NOAA Technical Report NOS CS 23

THE ST. JOHNS RIVER OPERATIONAL FORECAST SYSTEM (SJROFS) AND ITS SKILL ASSESSMENT

Silver Spring, Maryland
March 2006

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Coast Survey Development Laboratory

Office of Coast Survey
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

The Office of Coast Survey (CS) is the Nation's only official chartmaker. As the oldest United States scientific organization, dating from 1807, this office has a long history. Today it promotes safe navigation by managing the National Oceanic and Atmospheric Administration's (NOAA) nautical chart and oceanographic data collection and information programs.

There are four components of CS:

The Coast Survey Development Laboratory develops new and efficient techniques to accomplish Coast Survey missions and to produce new and improved products and services for the maritime community and other coastal users.

The Marine Chart Division collects marine navigational data to construct and maintain nautical charts, Coast Pilots, and related marine products for the United States.

The Hydrographic Surveys Division directs programs for ship and shore-based hydrographic survey units and conducts general hydrographic survey operations.

The Navigation Services Division is the focal point for Coast Survey customer service activities, concentrating predominantly on charting issues, fast-response hydrographic surveys and Coast Pilot updates.

NOAA Technical Report NOS CS 23

THE ST. JOHNS RIVER OPERATIONAL FORECAST SYSTEM (SJROFS) AND ITS SKILL ASSESSMENT

Aijun Zhang
Edwards Myers
Frank Aikman III

March 2006

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
Carlos Gutierrez, Secretary

National Oceanic and Atmospheric Administration
Conrad C. Lautenbacher, Jr., VADM USN (Ret.), Under Secretary

National Ocean Service
John H. Dunnigan, Assistant Administrator

Office of Coast Survey
Captain Roger L. Parsons, NOAA

Coast Survey Development Laboratory
Mary Erickson

NOTICE

Mention of a commercial company or product does not constitute an endorsement by NOAA. Use for publicity or advertising purposes of information from this publication concerning proprietary products or the tests of such products is not authorized.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

An experimental model-based nowcast/forecast system for the St. Johns River (SJROFS) has been implemented in NOAA's Coast Survey Development Laboratory (CSDL). This hydrodynamic model system uses the Environmental Fluid Dynamics Code (EFDC) circulation model to make hourly nowcasts and 36 hour forecasts four times a day of water levels, currents, salinity, and temperature. The nowcast/forecast system is run under the standardized Coastal Ocean Modeling Framework (COMF) that NOS is implementing for operational forecast systems.

A standard suite of NOS skill assessment statistics which includes Central Frequency (CF), Negative and Positive Outlier Frequency (NOF and POF), Maximum Duration of Negative and Positive Outlier (MDNO and MDPO), and the Worst Outlier Frequency (WOF) were computed for four model scenarios: 1) astronomical tidal simulation, 2) hindcast simulation, 3) semi-operational nowcast simulation, and 4) semi-operational forecast simulation. A forecast method comparison is presented between the model forecast and persistence forecast which is based upon the observed persisted residual value and astronomical tidal prediction. For each scenario, the modeled and observed time series of water levels and currents were compared at eight water level stations, which are Mayport, Main Street Bridge, Long Branch, Buckman, Red Bay Point, Racy Point, Palatka, and Buffalo Bluff, and at the three current stations of J2 (Mayport Basin Entrance), J5 (Dames Point Bridge), and J6 (Trout River). Time series of astronomical tide and hindcast simulations were created for the year of 1998, and the time series of semi-operational nowcast and forecast simulations were created for the year of 2003.

The skill assessment statistics for water levels pass the criteria for each of the four scenarios at the eight stations. Therefore, the model's water level nowcasts and forecasts are of sufficient accuracy to recommend that the SJROFS be made operational. Most of CF, NOF, POF, MDNO, and MDPO for water currents either pass or are close to the criteria for the astronomical tidal and hindcast simulations. However, model nowcasts and forecasts of water currents are less satisfactory than those from the hindcast simulation, and are incapable of meeting the criteria for the test period. The astronomical tidal current predictions might be used as a worthy operational product, especially for the period of no storm surge events.

The skill assessment results for each scenario are summarized as follows:

<u>Astronomical Tidal Simulation:</u>

1) Water Level

The modeled tidal constituents are in very close agreement with the observed values. The amplitude errors of M_2 range from 0.6 cm to 2.6 cm with the maximum error of 2.6 cm at Buffalo Bluff, and M_2 phase errors range from -1.9 to 12.7 degrees (-4 to 26 minutes) with the largest deviation of 26 minutes at Buffalo Bluff. The RMS errors vary from 2.7 at Mayport to 6.9 cm at Buffalo Bluff. CF, NOF, POF, MDNO, MDPO, and WOF all pass the criteria for the entire time series, and amplitudes of high and low water for all of the 8 stations. CF fails at some stations for time of high and low water.

2) Currents

For the dominant M_2 constituent, the modeled amplitudes are smaller than the observed values at all of the three stations, and the differences are -12.5, -19.8, and -8.9 cm/s at J2, J5, and J6 respectively. The phase differences between the modeled and observed values are -0.3, -1.5, and -7.8 degrees at J2, J5, and J6 respectively. CF, NOF, POF, MDNO, and MDPO all pass the criteria for current speed time series, amplitudes of maximum flood and ebb currents at J2 and J6, but fail to pass the criteria at J5. CF, NOF, POF, MDNO, and MDPO all passed the criteria for current direction at the three stations.

Hindcast

1) Water Level

The RMS errors vary from 6.2 cm at Mayport to 10.7 cm at Buffalo Bluff. CF, NOF, POF, MDNO, MDPO, and WOF all pass the criteria for 6-minute water level time series, amplitudes of high and low water except Buffalo Bluff which is directly connected to the sponge boundary area.

2) Current

RMS errors of the current speeds are 17.6, 12.8, and 14.2 cm/s at J2, J5, and J6, respectively. CF, NOF, POF, MDNO, and MDPO pass the criteria for current speeds, and amplitudes of maximum flood and ebb currents at J5 and J6 stations, but CF fails at J2 with values of greater than 84%. CF also fails for the time of the maximum flood and ebb currents at the all three stations. CF, NOF, POF, MDNO, and MDPO pass the criteria for current direction at the three stations. The differences of mean current directions are 13, 8, and 9 degrees at J2, J5, and J6, respectively.

Semi-Operational Nowcast

1) Water Level

The RMS errors at the 8 stations range from 3.7 cm at Buckman Bridge to 14.6 cm at Buffalo Bluff. CF, NOF, POF, MDNO, MDPO, and WOF all pass the criteria for 6-minute entire time series, amplitudes of high and low water except Buffalo Bluff.

2) Current

At J2, the RMS errors of the current speeds and directions are 30.6 cm/s and 46 degrees. MDNO and MDPO pass the criteria, but CF and POF fail to pass the criteria for the current speeds. CF, NOF, POF, MDPO, and MDPO pass the criteria for the directions of maximum ebb currents, However, CF, NOF, POF, MDPO, and MDPO fail to pass the criteria for the current directions. At J5, CF, NOF, POF, MDPO, and MDPO pass the criteria for the maximum ebb current speeds, but fail to pass the criteria for the other tests. CF, NOF, POF, MDPO, and MDPO pass the criteria for current directions. At J6, NOF, POF, MDNO, and MDPO pass the criteria for the current speeds, the maximum flood and ebb current speeds, and all tests of current direction. CF fails to pass the criteria for some tests.

<u>Semi-Operational Forecast</u>

1) WaterLevel

RMS errors out to 24 hours are less than 10 cm at all stations. CF, NOF, POF, MDNO, MDPO, and WOF all pass the criteria for entire time series, amplitudes of high and low water except Buffalo Bluff.

2) Currents

At J2, for current speeds, the values of CF range from 69% to 71.4%, and POF are all greater than 10% throughout 24 forecast hours. NOF, MDNO, and MNPO pass the criteria for all forecast hours. For current directions, CF range from 54% to 58% throughout 24 forecast hours. Most of NOF, CF, and POF fail to pass the criteria.

At J5, NOF, MDNO, and MDPO pass the criteria for current speeds, the maximum flood and ebb current speeds, but CF fails for some tests. CF, NOF, POF, MDNO, and MDPO pass the criteria for the directions of the maximum flood and ebb currents. However, CF and POF fail to pass the criteria for current directions.

At J6, the current speed RMS errors range from 26 cm/s to 23.2 cm/s. NOF, POF, MDNO, and MDPO pass the criteria for the current speeds, the maximum flood and ebb current speeds. CF fails to pass the criteria for some tests. For the current direction, the RMS errors range from 15 degrees to 16 degrees, most of CF, NOF, POF, MDNO, and MDPO fail to pass the criteria.

The results of the forecast method comparison show that the astronomical tidal water level prediction fails to meet the criteria since non-tidal water level information is missing; and the persisted water level forecasts pass the criteria at all stations. Astronomical tidal current predictions pass the criteria for both current speed and direction. Persisted current forecasts pass the criteria for current speeds, but fail for current direction at the 3 stations.

1. INTRODUCTION

Over half of the U.S. population lives within 50 miles of the coast, and coastal areas serve as centers of commerce for tourism, transportation, recreation, fishing and other activities. Coastal storms can therefore cause substantial costs to this infrastructure, which is inextricably linked to the U.S. economy. The Coastal Storms Program (CSP) is a nationwide effort led by NOAA to help coastal communities better prepare for and respond to the hazards that might occur during storm events, and lessen the impacts of storms on coastal communities. The first pilot project of the CSP was in the St. Johns River, where various NOAA offices worked with the northeast Florida community to develop products and tools that would help them address planning, mitigation, and response strategies for storm events. One of these tools is a three-dimensional hydrodynamic model that can provide forecasts of water levels, currents, salinity and temperature throughout the lower river estuary. The Coast Survey Development Laboratory (CSDL) of the National Ocean Service (NOS) is leading the development of this forecast circulation model for eventual operational implementation in the Center for Operational Oceanographic Products and Services (CO-OPS).

In meeting with local stakeholders during the initial phase of this pilot project, CSDL identified a well-calibrated hydrodynamic modeling application that had been developed by the St. Johns River Water Management District (SJRWMD) for the St. Johns River (Sucsy and Morris, 2001). This modeling application was set up to simulate circulation conditions in the St. Johns River during a hindcast period of 1995-1998. CSDL therefore coordinated with the SJRWMD to transfer the model to NOAA for implementation in an operational nowcast/forecast system. While the model parameterizations (e.g. friction, boundary types, external forcing implementation, etc.) remain the same between the SJWMD hindcast and the NOS nowcasts/forecasts, the operational framework supporting the latter provides the structure to systematically make routine simulations that can be quality controlled to provide consistent, accurate results that meet NOS performance criteria.

The operational framework for implementation of coastal ocean models in NOS is referred to as the Coastal Ocean Modeling Framewok (COMF). The first component of COMF is a standard file format for output of the model results. The SJRWMD model application used the Environmental Fluid Dynamics Code (EFDC) (Hamrick, 1992a; 1992b), and therefore the initial step in porting their model into COMF was to adjust the output into the COARDS-compliant netCDF format that NOS supports. Another component of COMF is the use of standard scripts to access real-time data and forecasts used as input to the nowcast/forecast model simulations. The EFDC simulations were set up to perform hourly nowcasts (a simulation over the previous one hour up until the present time) and four forecasts (extending 36 hours into the future) per day using these standard COMF scripts.

With these components of COMF in place for the St. Johns River model, the final step in the transition to operational implementation is to quality assess the performance of a model application against standard NOS skill assessment criteria (Hess et al., 2003). A software tool (Zhang et al., in preparation) was developed to perform this skill assessment with models in the COMF environment, and the St. Johns River model results were subsequently analyzed using this tool for different simulation scenarios (tides only, hindcasts, operational nowcasts and forecasts). Skill assessment score tables were compiled for each location where observations were available using the software package, and these tables will help guide the best approach for transitioning the model to an operational environment.

Section 2 of this report focuses on an overview of the St. Johns River Operational Forecast System (SJROFS) with a brief description of EFDC, the model grid for this application, the input files, installation of SJROFS using the Concurrent Versioning System (CVS), and system interruption and recovery procedures. Section 3 describes the model run scenarios for the astronomical tide simulation, a model hindcast simulation, and semi-operational nowcast/forecast simulations. A summary of the NOS skill assessment criteria and available observations in the St. Johns River are summarized in Section 4. Lastly, the performance of the model is reviewed based upon skill assessment criteria relating to water levels and currents in Sections 5 and 6, respectively. Section 7 presents a summary of the SJROFS skill assessment.

2. MODEL SYSTEM OVERVIEW

2.1 EFDC Hydrodynamic Model

The physics of the EFDC model and many aspects of the computational scheme are equivalent to the widely used Blumberg-Mellor model (Blumberg & Mellor, 1987). The EFDC model solves the three-dimensional, vertically hydrostatic, free surface, turbulent averaged equations of motions for a variable density fluid. The model uses a stretched or sigma vertical coordinate and Cartesian or curvilinear, orthogonal horizontal coordinates. Dynamically coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved. The two turbulence parameter transport equations implement the Mellor-Yamada level 2.5 turbulence closure scheme (Mellor & Yamada, 1982) as modified by Galperin et al (1988). An optional bottom boundary layer submodel allows for wave-current boundary layer interaction using an externally specified high frequency surface gravity wave field. The numerical scheme employed in EFDC to solve the equations of motion are summarized in Hamrick, 1992a; 1992b.

The EFDC model application to the lower St. Johns River uses external forcing by water level, ocean salinity, wind, and fresh water discharges entering the model domain. The model calculates water levels, velocity in three components, salinity, and temperature. The EFDC had been well calibrated for a simulation of the lower St. Johns River for 1995-1998 by the SJRWMD. To build upon this existing resource, the SJRWMD shared this model application with CSDL for development of an operational nowcast/forecast system for the St. Johns River. While many of the model parameterizations (e.g. friction, boundary types, external forcing implementation, etc.) remain the same between the SJWMD hindcast model system and the NOS operational nowcast/forecast model system, the wetting/drying function is deactivated in the NOS operational nowcast/forecast system.

2.2 Model Grid

An orthogonal, boundary-fitted, structured grid extending upstream from the Atlantic Ocean near Mayport to Buffalo Bluff (Figure 1) was created by the SJRWMD for their hindcast simulation. The model area contains a 188 km^2 portion of the Atlantic coastal shelf for mixing of the discharged river water with ocean waters. The upstream model boundary contains a 32 km^2 sponge to reduce artificial wave-reflection of the progressive tidal wave passing through the upstream boundary. The boundary-fitted model grid is based on a transformed 188 x 105 rectangular computational grid containing 2,210 water cells. Horizontal cell sizes, irrespective of direction, range from 81–2,040 m. The model grid generally does not extend up the tributaries to the head of tide, and the model application does not allow for flooding and drying of grid cells. There are six stretched, sigma vertical layers.

Principal bathymetric data for the model were obtained from a river survey performed by the U.S. Army Engineer Research and Development Center (ERDC) in 1993. Additional bathymetric data included a 1993 survey of Mill Cove and the approach to the river entrance by the U.S. Army Corps. Of Engineer (USACE), a 1995 survey of the Cedar and Ortega Rivers by Morgan and Eklund, Inc., and various NOS's surveys of smaller tidal tributaries and the adjacent Atlantic Shelf. All bathymetric data were converted to meters relative to the North Atlantic Vertical Datum of 1988 (NAVD88). The shoreline data were obtained from two sources: (a) a digitized version of the St. Johns River shoreline from USGS 7.5 minute quad maps at 1:24000 scale, and (b) 1995 digital orthorectified quarter quad (DOQ) images obtained from the National Aerial Photography Program.

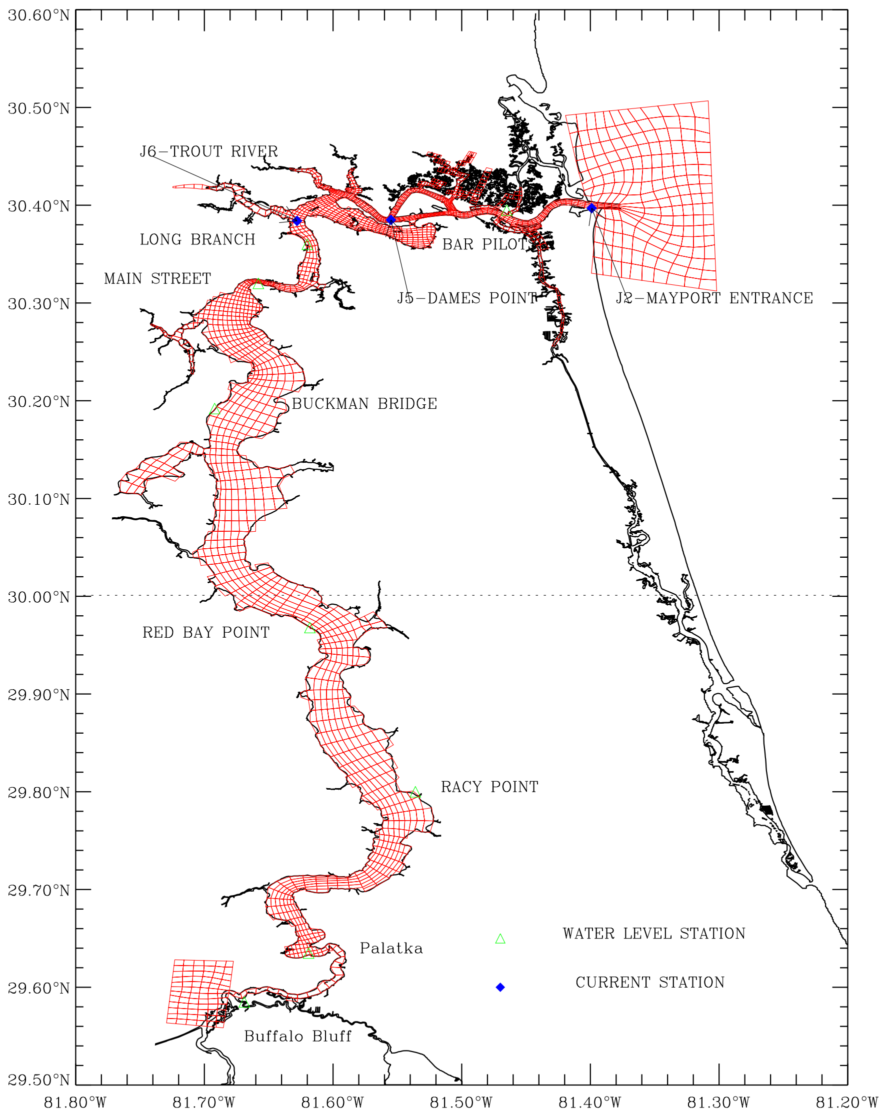

Figure 1. Boundary-fitted model grid of the lower St. Johns River and observation locations which are used in skill assessment.

2.3. EFDC Input Files

The master input file, efdc.inp, is required for all model runs. The information in efdc.inp provides model runtime control parameters, output control, and physical information describing the model domain and external forcing functions. Many options in the code are activated by integer switches. The options are normally activated by specifying nonzero integer values. Setting switches to zero deactivates the option. A more detailed explanation about the efdc.inp file can be found in the User's Manual for EFDC (Tetra Tech, Inc., 2002).

Additional input files required in order to run the EFDC model are listed below:

File Name	Comments
aser.inp	Atmospheric time-series data. Required for all model runs for which atmospheric conditions are needed (i.e., when NASER=1 on card image 14).
cell.inp	Horizontal cell type identifier file. Required for all model runs.
celllt.inp	Horizontal cell type identifier file for saving mean mass transport. Required for all model runs.
dxdy.inp	Horizontal grid spacing or metrics, depth, bottom elevation, bottom roughness and vegetation classes for either Cartesian or curvilinear orthogonal horizontal grids. Required if ISCLO=1 or if ISCLO=0 and (LC-LVC) .GT. 2 on card image 9 of file efdc.inp.
lxly.inp	Horizontal cell center coordinates and cell orientations for either Cartesian or curvilinear-orthogonal grids. Required if ISCLO=1 or if ISCLO=0 and (LC-LVC) .GT. 2 on card image 9 of file efdc.inp.
pser.inp	Open boundary water surface elevation time series file. Required if NPSER .GE.1 on card image 16 of file efdc.inp.
qser.inp	Volumetric source-sink time series file. Required if NQSER .GE.1 on card image 23 of file efdc.inp.
restart.inp	Restart file for restarting a simulation. Required if ISRESTI =1 on card image 2 of file efdc.inp.
salt.inp	Initial salinity distribution for cold start, salinity stratified flow simulations. Required if ISTOPT = 1 on line 2, card image 6 of file efdc.inp.
show.inp	Controlling screen print of conditions in a specified cell during simulation runs. Required if ISHOW > 1 on card image 2 of file efdc.inp.

sser.inp	Salinity time series file for open boundary. Required if NSSER .GE.1 on card image 22 of file efdc.inp.

tser.inp	Temperature time series file for open boundary. Required if NTSER .GE.1 on card image 22 of file efdc.inp.

wser.inp	Wind time series file for surface forcing. Required if NWSER > 0.

The input files listed above can be classified into four groups as shown below.

(1) Horizontal grid specification files: cell.inp, celllt.inp, dxdy.inp, gcellmap.inp, lxly.inp

(2) General data and run control files: efdc.inp, show.inp

(3) Initialization and restart files: salt.inp, restart.inp

(4) Time series forcing and boundary condition files: aser.inp, pser.inp, qser.inp, sser.inp, tser.inp,wser.inp

2.4. Installation Using CVS System

CVS is a software which coordinates many developers working on the same project. This software package keeps all the programs in a directory structure, which allows control over multiple versions. The St. Johns River Operational Forecast System (SJROFS) has been committed to the CVS system, so users/developers can install a version of SJROFS using the CVS system on the user’s local computer. The preferred approach is to run SJROFS from the user's local directory, where all COMF related directories and programs are stored. For instance, if the user runs SJROFS from his/her local directory:

```
/comf/development/COMF_user/
```

Under this directory, there are such directories as ohms, opds, oqcs, and oqctools. All model related files will be located under ohms directory, and all model outputs should be saved in a user's local directory such as,

/comf/development/COMF_user/ohms/SJROFS/archive.

Several steps are involved in order to install SJROFS in the user's local directory:

step 1) Checkout the SJROFS from the CVS repository. Download SJROFS to the user's local directory by running the following commands (in the **shell** environment):

```
export CVS_RSH=ssh
export CVSROOT=dsofs1.nos-tcn.noaa.gov:/comf/CVSPROJECTS
cd /comf/development/COMF_user/ohms
cvs co SJROFS
```

A new directory "SJROFS" will be created, which includes some subdirectories.

step 2) Set correct environment variables by modifying the following file called "setenvironmentvariables_XX.sh" (Gross, et al., in preparation) in directory,oqcs.

And then run the following commands:

```
source /comf/development/COMF_user/oqcs/setenvironmentvariables_sjrofs.sh
export MODELDIR=$COMFDIR/ohms/SJROFS
```

step 3) Create empty archive directories

```
cd $MODELDIR
mkdir archive
mkdir $COMFDIR/ohms/SJROFS/archive/hotstart
mkdir $COMFDIR/ohms/SJROFS/archive/CORMSFLAGS
mkdir $COMFDIR/ohms/SJROFS/archive/modelinput
mkdir $COMFDIR/ohms/SJROFS/archive/netcdf
```

step 4) Recompile fortran programs as needed:

```
cd $MODELDIR/sorc
COMPILE_SJROFS.sh
```

step 5) Make sure all control files for IDL graphics are in $MODELDIR/info. There should not be problems if the user downloads SJROFS from CVS because all control files are stored there.
plot_field_sjrofs.ctl
plot_timeseries_cu_sjrofs.ctl
plot_timeseries_wl_sjrofs.ctl

step 6) Run SJROFS

cd $MODELDIR/scripts
MAIN_SJROFS_COLDSTART.sh

MAIN_SJROFS_COLDSTART.sh will run a nowcast simulations for 30 days to your computer current system time (call "time_nowcastend") from initial model setup conditions. This run will generate restart files for an operational nowcast run. After completing this warm-up run, operational nowcasts and forecasts can be conducted by turning on the crontab job,

```
crontab SJROFS.crn
```

Thereafter, SJROFS will run automatically, and will provide hourly nowcasts and 36-hour forecasts at 5, 11, 17 and 23 hours (UTC).

2.5. System Interruption and Recovery Procedure

In the event of a hardware failure or computer system crash, the disk system should be reconstructed to as recent a state as possible. Because the system requires a restart file for the nowcast run, there are two approaches to recover SJROFS. The first option is to make a cold start by performing step 6 described in Section 2.4. The second approach is to make a hot start model run. If the user wants to restart SJROFS from a specific past time (e.g., 03/10/2005 00:00), the two files called "200503100000_SJROFS_hotstartout" and "200503100000_SJROFS_hotstartout_wlmayp" in the directory of $ARCHIVE/hotstart/200503 have to be manually copied to $MODELDIR/init using the following commands:

```
cp $ARCHIVE/hotstart/200503/200503100000_SJROFS_hotstartout $MODELDIR/init/hotstart.dat
cp $ARCHIVE/hotstart/200503/200503100000_SJROFS_hotstartout_wlmayp $MODELDIR/init/wlmaypold.dat
```

SJROFS will then operate normally by switching on the crontab job. SJROFS will run nowcast simulations from that specific time to the present nowcast time, and restart files will be generated for the next cycle's nowcast (or forecast) run. Since real-time river discharge and salinity data from the USGS web site can only be accessed over the previous 31 days, SJROFS cannot run nowcast simulations longer than 31 days before the current time using this approach. In this case, the cold start approach could be used to recover SJROFS.

3. MODEL RUN SCENARIO DEFINITION

In order to evaluate the performance of the SROFS model under a range of conditions, the NOS skill assessment criteria are applied to four model simulation scenarios. These include a simulation of just the tides, a hindcast simulation, the nowcast simulations and the forecast simulations. Each is discussed in more detail below.

3.1. Astronomical Tides Only Simulation

For the astronomical tides only simulation, water levels along the open ocean boundary are forced using the accepted CO-OPS constituents from Mayport modified with a 5% increase in tidal amplitudes and a phase shift of -10 minutes. There are no river discharge inflows and surface forcings. The salinity and temperature are held constant.

3.2. Model Hindcast Simulation

To facilitate the transition of the EFDC hindcast simulation developed by the SJRWMD into an operational nowcast/forecast model, we first transferred their input files and codes to CSDL. Their hindcast simulation was then reproduced to ensure that all appropriate files were transferred correctly to the CSDL computer environment.

For the hindcast simulation, the ocean boundary of the grid is forced with a superposition of the observed subtidal water levels at Mayport (shown in Figure 1) and predicted tides. The former are determined by 30-hour low-pass filtering of observations, and the latter are based on tidal harmonics available at Mayport with a slight adjustment (approximately 5% increase in tidal amplitudes) for matching the model with observations. Salinity is also specified along the ocean boundary as a linear transition from 35 psu at the surface to 36 psu at the bottom.

At the upstream boundary, the SJRWMD uses a sponge condition (as seen in Figure 1 by the rectangular region at the upstream end) to control reflection of the tides back into the model domain. The main flow of the St. Johns River was forced at the upstream boundary using data collected by the USGS gauge at Buffalo Bluff. Salinity is also specified at Buffalo Bluff using conductivity data collected by the USGS gauge. Freshwater discharge from 61 other tributaries was specified in the SJRWMD model. These values were estimated from a GIS-based hydrologic model that uses rainfall-runoff ratios that are dependent on land-use and soil types.

Wind forcing was provided from a Jacksonville Naval Air Station wind sensor and was specified throughout the grid as spatially constant and temporally varying. A spatially constant rainfall was likewise applied throughout the domain using a composite of 8 rainfall stations. River evaporation was determined based on daily pan evaporation data in Gainesville multiplied by a pan correction factor.

3.3. Semi-Operational Nowcast/Forecast Simulation

For the nowcasts, water levels along the open ocean boundary are determined using a slight correction factor of 1.05 applied to real-time water level data at the Mayport, Florida NOAA water level gauge. Salinity along the open ocean boundary is set equal to the hindcast values of 35 psu at the surface and 36 psu at the bottom. Wind data available from the NOAA Mayport station is applied to all the grid cells in the model. Finally, real-time river discharges along six of the main tributaries entering the St. Johns River are downloaded from the USGS as lateral inflows to the model. The nowcasts are run every hour.

Thirty-six hour forecasts are made with the model four times a day. Along the open ocean boundary, water levels are specified as a superposition of the tide predictions from Mayport and the subtidal water level forecasts at Fernandina Beach, Florida. The latter are made available by the National Weather Service (NWS) as output from their Extratropical Storm Surge Model. River discharges are currently persisted from the latest observations from the same six USGS gauges used in the nowcasts. Forecasts of surface wind and air pressure from the North American Mesoscale (NAM) model are interpolated onto the EFDC model grid as surface forcing.

4. SKILL ASSESSMENT STATISTICS AND DATA

4.1 Skill Assessment Statistics

Skill assessment is an objective measurement of the performance of a model when systematically compared with observations. NOS skill assessment criteria were created for evaluating the performance of circulation models (Hess et al., 2003), and a software package was subsequently developed to compute these criteria using standard file formats output from the models (Zhang et al., in preparation). The software can compute the skill assessment scores automatically using files containing observations, predictions, and nowcast/forecast model results. A standard suite of skill assessment statistics is defined in Table 1 (Hess et al., 2003). The target frequencies of the associated statistics are,

CF(X) ≥90%, POF(2X) ≤1%, NOF(2X) ≤1%, WOF(2X) ≤0.5%
MDPO(2X) ≤ L, MDNO(2X) ≤ L

Table 1. Skill Assessment Statistics (from Hess et al., 2003)

Variable	Explanation
Error	The error is defined as the predicted value, p, minus the reference (observed or astronomical tide value, r : $e_i = p_i - r_i$.
SM	Series Mean. The mean value of a series y. Calculated as $\overline{y} = \frac{1}{N}\sum_{i=1}^{N} y_i$.
RMSE	Root Mean Square Error. Calculated as $RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N} e_i^2}$.
SD	Standard Deviation. Calculated as $SD = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N} (e_i - \overline{e})^2}$
CF(X)	Central Frequency. Fraction (percentage) of errors that lie within the limits ±X.
POF(X)	Positive Outlier Frequency. Fraction (percentage) of errors that are greater than X.
NOF(X)	Negative Outlier Frequency. Fraction (percentage) of errors that are less than -X.
MDPO(X)	Maximum Duration of Positive Outliers. A positive outlier event is two or more consecutive occurrences of an error greater than X. MDPO is the length of time (based on the number of consecutive occurrences) of the longest event.
MDNO(X)	Maximum Duration of Negative Outliers. A negative outlier event is two or more consecutive occurrences of an error less than -X. MDNO is the length of time (based on the number of consecutive occurrences) of the longest event.
WOF(X)	Worst Case Outlier Frequency. Fraction (percentage) of errors that, given an error of magnitude exceeding X, either (1) the simulated value of water level is greater than the astronomical tide and the observed value is less than the astronomical tide, or (2) the simulated value of water level is less than the astronomical tide and the observed value is greater than the astronomical tide.

There are three types of data sets (Table 2): Group 1, a time series of values at uniform time intervals; Group 2, a set of values representing the consecutive occurrences of an event (such as high water or slack water); and Group 3, a set of values representing a forecast valid at a given projection time. The acceptable error limits (X) and maximum duration limits (L) for the associated variable applied to the SJROFS are presented in Table 3.

Table 2. Data series groups and the variables in each. Note that upper case letters indicate a prediction series (e.g., H), and lower case letters (e.g., h) indicate a reference series (observation or astronomical prediction). Slack water is defined as a current speed less than ½ knot. The direction is computed only for current speeds greater than ½ knot (from Hess et al., 2003).

Group	Variable	Symbol
Group 1	Water level	H, h
(Time Series)	Current speed	U, u
	Current direction	D,d
	Salinity	S, s
	Water temperature	T,t
Group 2	Amplitude of high water	AHW,ahw
(Values at a Tidal Stage)	Amplitude of low water	ALW,ahw
	Time of high water	THW,thw
	Time of low water	TLW,tlw
	Amplitude of maximum flood current	AFC,afc
	Amplitude of maximum ebb current	AEC,aec
	Time of maximum flood current	TFC,tfc
	Time of maximum ebb current	TEC,tec
	Direction of current at maximum flood	DFC,dfc
	Direction of current at maximum ebb	DEC,dec
	Time of start of current slack before flood	TSF,tsf
	Time of end of current slack before flood	TEF, tef
	Time of start of current slack before ebb	TSE, tse
	Time of end of current slack before ebb	TEE, tee
Group 3	Water level at forecast projection time of nn hrs	Hnn, hnn
(Values from a Forecast)	Current speed at forecast projection time of nn hrs	Unn, unn
	Current direction at forecast projection time of nn hrs	Dnn, dnn
	Salinity at forecast projection time of nn hrs	Snn, snn
	Water temperature at forecast projection time of nn hrs	Tnn, tnn

Table 3. Acceptance error limits (X) and the maximum duration limits (L)

variables	X	L (hours)
H, Hnn, AHW,ALW	15 cm	24
THW, TLW	0.5 hours	25
U, Unn, AFC, AEC	0.26 m/s	24
TFC, TEC	0.5 hours	25
TSF, TEF, TSE, TEE	0.25 hours	25
D, Dnn,	22.5 degrees	24
DFC, DEC	22.5 degrees	25

4.2 Data

For SJROFS, skill assessment scores were computed at 8 locations for water levels (Table 4) and at 3 locations for currents (Table 5) where the observations are available in both 1998 and 2003 (see Figure 1 for the locations). For the skill assessment of the astronomical tide and hindcast simulations, water level observations during 1998 were obtained from the SJWMD. The ADCP current meter data were obtained from CO-OPS (Bourgerie, 1999). For the skill assessment of the nowcast and forecast simulations, the verified water level observations at the 8 stations were obtained from CO-OPS. The water current meter data for 2003 were obtained from a more recent CO-OPS survey that included the same three ADCP deployment locations. The accepted harmonic constants for tidal water levels at the 8 water level stations derived by CO-OPS were used to make water level tidal predictions and were also used in comparisons with the modeled harmonic constants obtained through harmonic analysis of water level time series from the astronomical tide simulation. Harmonic constants of the water currents were obtained by harmonically-analyzing the ADCP data time series and were used to make tidal current predictions.

Table 4. Water level stations used in the skill assessment

Station ID	Name	Latitude	Longitude	Period pf record
8720218	Bar Pilots Dock	30.395	-81.465	01/02/ - 12/31/1998 01/02 - 12/31/2003
8720226	Main St. Bridge	30.320	-81.658	01/02/ - 12/31/1998 06/13 - 12/31/2003
8720242	Long Branch	30.360	-81.620	07/01/ - 12/31/1998 01/02 - 03/28/2003
8720357	Buckman	30.192	-81.692	06/25/ - 12/31/1998 05/08 - 12/31/2003
8720503	Red Bay Point	30.968	-81.618	01/02/ - 06/22/1998 01/02 - 12/31/2003
8720625	Racy Point	29.800	-81.536	08/10/ - 12/31/1998 04/29 - 08/01/2003
8720774	Palatka	29.635	-81.619	01/02/ - 06/12/1998 08/17 - 12/31/2003
8720767	Buffalo Bluff	29.585	-81.669	06/29/ - 12/31/1998 09/04 - 12/31/2003

Table 5. Current stations used in skill assessment

Station ID	Name	Latitude	Longitude	Period pf record
J2	Mayport Basin Entrance	30.397	-81.399	06/03 - 07/21/1998 07/28 - 10/07/2003
J5	Dames Point Bridge	30.385	-81.555	07/23 - 08/15/1998 05/23 - 07/23/2003
J6	Trout River	30.384	-81.628	07/22 - 09/16/1998 05/23 - 07/23/2003

5. RESULTS FOR WATER LEVEL SKILL ASSESSMENT

Skill assessment statistics were calculated for each model scenario (astronomical tides only, hindcast, nowcast and forecast) and for a model-independent persisted forecast. The NOS skill assessment software was used to automatically generate skill assessment tables for each of the stations mentioned in Section 4.2. Tables of observed and modeled tidal harmonic constants were also generated using a least squares harmonic analysis algorithm in the skill assessment software. The results of the skill assessment for each scenario are presented below.

Astronomical Tide Only

The astronomical tidal simulation was made for the entire year of 1998, and water level time series were saved in six minute intervals at locations where observations were available. The model was forced with water level ocean boundary conditions derived from the tidal predictions at Mayport by forcing the amplitudes of four lower frequency constituents (MM, SSA, SA, and MSF) to be zero. At Mayport, the amplitudes of the four constituents are 2.5, 7.7, 11.5, and 3.9 cm, respectively. This is done because the four lower frequency constituents are zero for the CO-OPS accepted tidal constituents at Buckman Bridge, Main Street Bridge, Racy Point, and Red Bay Point, and because the limitation of only performing a one-year simulation. The harmonic constants derived from the simulated water level time series are compared with the CO-OPS accepted harmonic constants in Appendix A.

Due to the close proximity of the Mayport station to the model ocean boundary, the simulated tidal constituents at this station are in close agreement with the observed values, with amplitude error being 1.3 cm and the phase error being 1.9 degrees (4 minutes) for the M_2 constituent. At the other seven stations, the M_2 amplitude error ranges from 0.6 to 2.6 cm (maximum error of 2.6 cm at Buffalo Bluff), and the M_2 phase error ranges from -1.9 to 12.7 degrees (-4 to 26 minutes; largest deviation of 26 minutes at Buffalo Bluff). It is noted that the simulated tides at Buffalo Bluff are affected by the sponge boundary condition directly upstream of Buffalo Bluff. The simulated amplitudes and phases for the other constituents match the observed values well, as shown in Appendix A.

The standard suite of statistics was computed for comparing the simulated and predicted tidal water level time series and are presented in Appendix B (Scenario: Tidal Simulation Only). The RMS errors vary from 2.7 cm at Mayport to 6.9 cm at Buffalo Bluff. CF, NOF, POF, MDNO, MDPO, and WOF all pass the criteria for the entire time series, as do the amplitudes of high and low water. CF fails at some stations for the times of high and low water.

Hindcast

A detailed comparison of EFDC model results with observations in the Lower St. Johns River were presented in Sucsy et al (2001). Their (SJRWMD) EFDC hindcast simulation was transferred to CSDL and rerun for the entire year of 1998 using all the input files from SJWMD. The model simulated water level time series were compared with the observations from SJRWMD at the eight water level stations. The standard suite of statistics for this simulation are presented in Appendix B (Scenario: Hindcast). The results show that the RMS errors vary from 6.2 cm at Mayport to 10.7 cm at Buffalo Bluff. The CF, NOF, POF, MDNO, MDPO, and WOF all pass the criteria for the 6-minute water level time series, as well as the amplitudes of high/low water at all of the stations except Buffalo Bluff, which is directly connected to and affected by the sponge boundary condition.

Semi-Operational Nowcast/Forecast

Semi-operational nowcasts and forecasts were made during the year of 2003, and the results from these simulations were concatenated into continuous time series for analysis using the skill assessment software. The vertical reference datum is a common issue for total water level comparisons of model simulations and observations. The model simulation has a single well defined mean sea level datum that is equal to zero (the sea surface with no slope). The mean sea level reported with the observations is a local value calculated from data which is generally not the same as the value of model mean sea level because of fresh water effects, meteorological forcing, and baroclinic effects. Mean values of the simulated and observed water levels were calculated based on one-year long nowcast time series and verified water level observations referenced to mean sea level from CO-OPS during 2003 at the eight water level stations (Table 6). The mean water level differences between the model and observations will produce more than 10 cm differences in water level skill assessment statistics within St. Johns River except at Mayport. Since the mean water level differences are almost constant for each station, these mean value difference corrections are applied to the corresponding model time series for the semi-operational nowcasts and forecasts before computing skill assessment statistics.

Tables in Appendix B (SCENARIO: Semi-Operational Nowcast) show the skill assessment statistics for the semi-operational nowcast. The RMS errors at the eight water level stations range from 3.7 cm at Buckman Bridge to 14.6 cm at Buffalo Bluff. CF, NOF, POF, MDNO, MDPO, and WOF all pass the criteria for the 6-minute entire time series. The amplitudes of high/low water also pass the skill assessment criteria, except at Buffalo Bluff.

For the semi-operational forecasts, the RMS errors out to 24 hours are less than 10 cm at all stations. CF, NOF, POF, MDNO, MDPO, and WOF all pass the criteria throughout the 24 forecasts hours. The amplitudes and times of high and low water also pass the criteria, with the exception of CF at Mayport and Buffalo Bluff (CF >80% at both stations).

Forecast Method Comparison

The semi-operational forecast model results are compared with both the astronomical tide predictions and persistence forecasts. A persistence forecast is constructed by adding an offset value, which is based on an observed offset at one station during some time period before the forecast is made (subtracting the tidal prediction from the observation produces the non-tidal component), to the tidal prediction for the duration of the 24 hour forecast. A persistence forecast can be easily made without running a numerical model if a real-time observation and tide tables are available at a specific station. Within the St. Johns River, 24-hour persistence forecasts are made using the following procedure: (1) For each forecast cycle, an offset between the observation and the tidal prediction at forecast time=0 is calculated. (2) This offset value is then considered to be constant and is superimposed with the tidal predictions to generate 24 hour persistence forecasts of the cycle. Therefore, a persisted forecast is defined as the tidal prediction plus an offset, where the offset is equal to observation minus tide prediction at forecast time=0.

A suite of statistics for persistence forecasts is presented in Appendix B (Scenario: Persistence forecast). The persistence forecasts passed the skill assessment criteria and were generally better than the model forecasts at all of the eight water level stations. The reasons might be that: (1) there were rarely storm surge events in 2003; (2) astronomical tides predominate the water level variations in the Lower St. John River; (3) the errors in total water level forecasts were partly caused by the errors in the astronomical tidal simulation. It is expected that better forecasts should be obtained by the model forecasts during storm surge events.

The semi-operational forecasts were also compared with astronomical tidal predictions. The results show that the astronomical tidal prediction failed to pass the skill assessment criteria because of the inability to produce non-tidal water level variations via this method.

Table 6. Means of the simulated and observed water level (in centimeters)

Station ID	Name	Observed Mean	Modeled Mean	Difference
8720218	Bar Pilots Duck	-0.7	0.0	0.7
8720226	Main St. Bridge	-0.09	11.0	11.09
8720242	Long Branch	0.14	11.1	10.9
8720357	Buckman	-3.4	17.9	21.3
8720503	Red Bay Point	-3.0	18.6	21.6
8720625	Racy Point	-3.3	19.3	22.6
8720774	Palatka	-3.4	20.7	24.1
8720767	Buffalo Bluff	3.1	25.6	22.5

6. SKILL ASSESSMENT OF WATER CURRENTS

Skill assessment for the currents were made at three locations where ACDP surveys were conducted by CO-OPS in 1998 and 2003. The observations of water currents at a depth of about 4 m below the Mean Lower Low Water (MLLW) were compared with the model results at the second vertical sigma layer from the surface (about 3.3 m at J2, 3 m at J5, and 3.3 m at J6). The current observations were filtered using a 3-hour low-pass Fourier filter to eliminate high frequency variance in the ADCP measurements before being compared with model results. Figure 2 shows sample current speed time series comparisons of observations, tidal predictions, modeled tide-only simulations, and hindcast simulations in 1998 for the three ADCP locations. Figure 3 presents a portion of the current speed time series of the observations, tidal predictions, and model semi-operational nowcast and forecast simulations in 2003. Figures 2 and 3 demonstrate that the tidal current predictions match the observations very well at these stations. The astronomical tidal constituents account for about 95% of the total variance, with the M_2 constituent comprising more than 90% of the total variance alone, at the J2, J5, and J6 stations. The observed velocity scatter diagram is presented in Figure 4. It shows that the currents at J2 in 1998 are different from those in 2003. For example, maximum flood currents are not well defined during the 2003 survey. These differences are attributed to the ADCP location in 2003 being located 105 m eastward of the location in 1998 (out of the mouth of St. Johns River entrance). The flood directions for the 1998 data at all three stations are also different from those in 2003. These changes might be caused by bathymetric and hydrodynamic changes around the stations. In addition, the ADCP measurements may not have been long enough (the time lengths of ADCP data are 48, 22, and 52 days at J2, J5, and J6, respectively), thus the observed harmonic constants obtained directly from the observations and skill assessment results generated based on the ADCP measurements may exhibit bias, and cannot completely represent the accuracy of the model simulation.

Tidal Simulation Only

The observed harmonic constants of the currents derived from the ADCP time series were compared with the modeled harmonic constants derived from one-year of tide-only simulations (see Tables C.1-C.3 in Appendix C). The principle current directions of the modeled and observed currents are very close, with differences between the modeled and observed values of 14, 2, and 2 degrees at J2, J5, and J6, respectively. For the dominant M_2 constituent, the modeled amplitudes are smaller than the observed values at all three stations with differences of -12.5, -19.8, and -8.9 cm/s at J2, J5, and J6, respectively. The phase differences between the modeled and observed currents are -0.3, -1.5, and -7.8 degrees at J2, J5, and J6, respectively. For the second largest constituent, N_2, amplitude differences are 2.5, -3.4, and -1.6 cm/s at J2, J5, and J6, respectively, and phase differences between the model and observed values are -0.2 (J2), -4.3 (J5), and -3.4 degrees (J6).

The tide-only model simulation was compared with the tidal current prediction using the observed harmonic constants. The skill assessment score tables listed in Appendix D

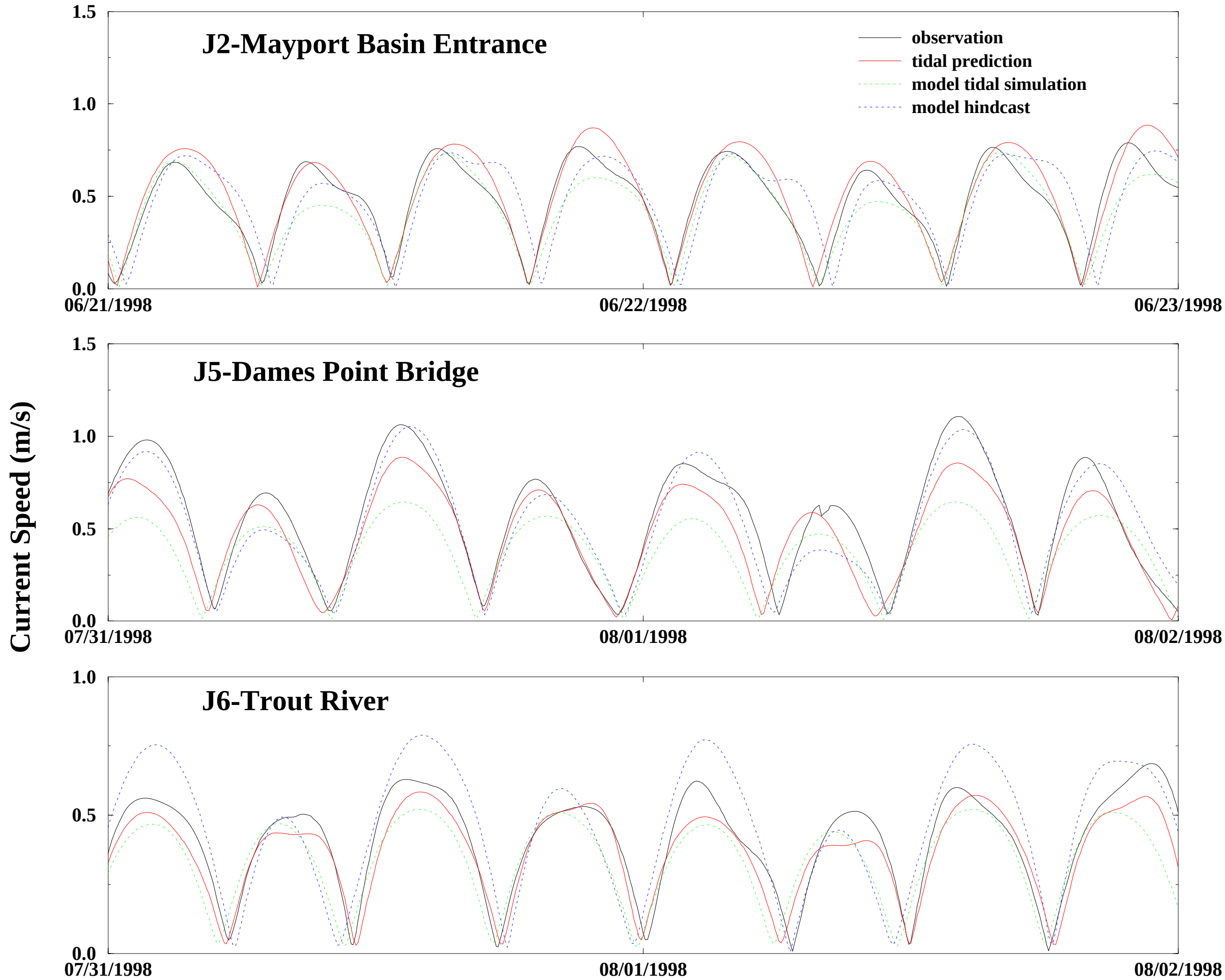

Figure 2. Observed (filtered), tidal predicted, model tide-only simulated, and hindcast simulated current speed time series in 1998 at the J2, J5, and J6 stations.

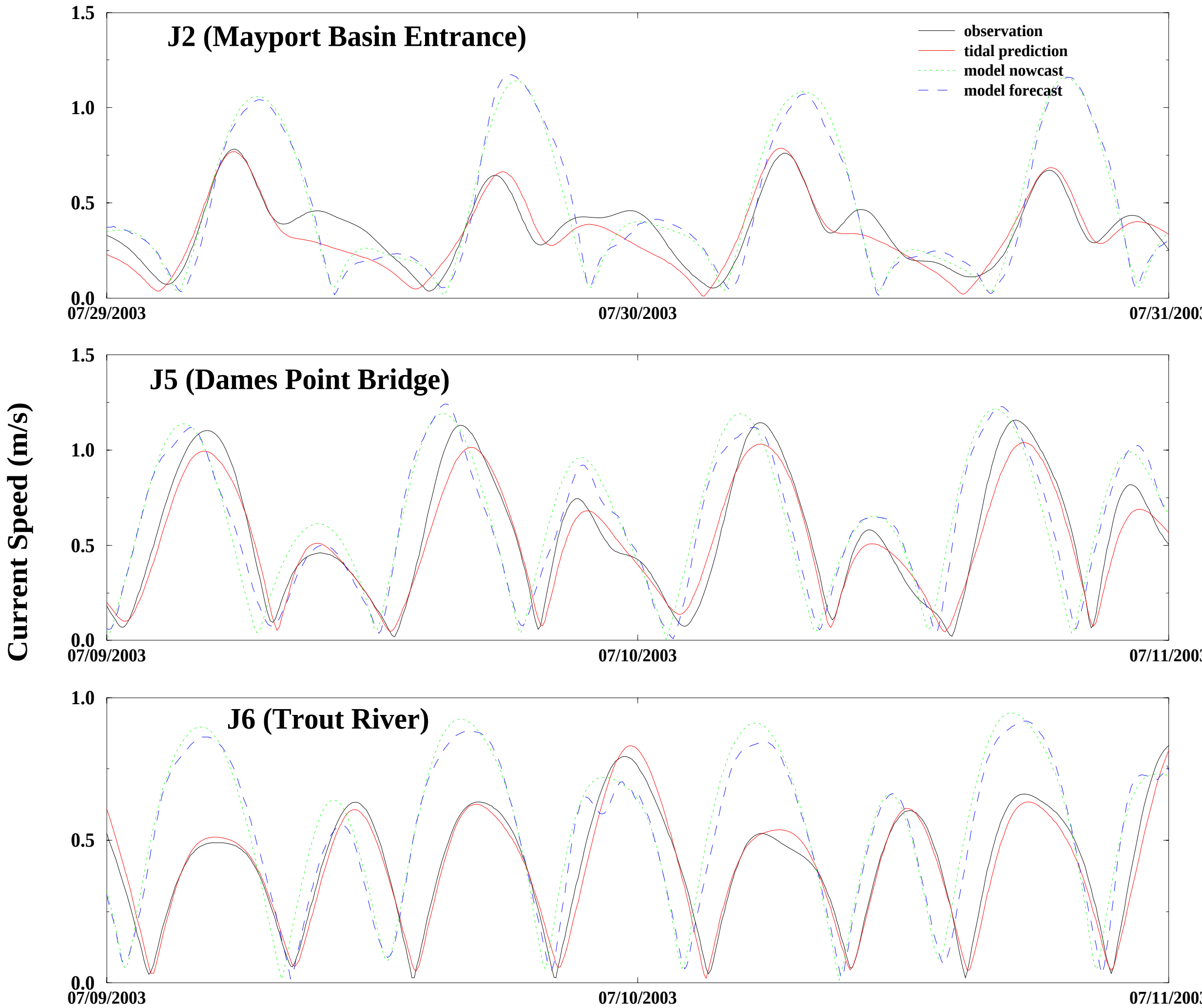

Figure 3. Observed (filtered), tidal predicted, model nowcast, and model forecast current speed time series in 2003 at the J2, J5, and J6 stations.

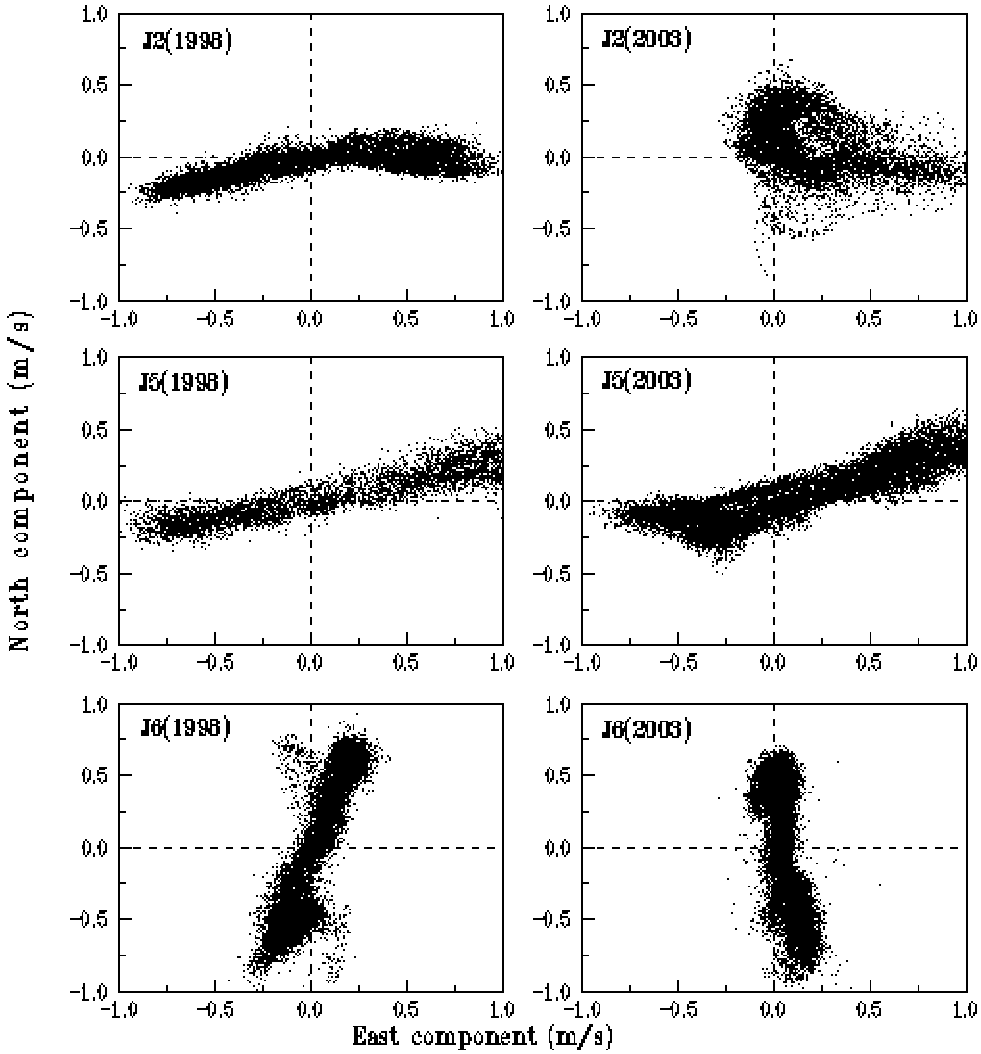

Figure 4. Velocity scatter diagrams for J2, J5, and J6 in 1998 (left panel) and 2003 (right panel).

show the results from these comparisons. At J2 (Mayport basin entrance), the modeled and observed mean velocity values are 36.7 cm/s and 44.6 cm/s, and the RMS error between the simulated and observed current speeds is 11.7 cm/s. The CF, NOF, POF, MDNO, and MDPO statistics all pass the criteria for the entire 6-minute current speed time series, and the amplitudes of maximum flood and ebb currents. CF, NOF, POF, MDNO, MDPO all pass the criteria, but CF fails for the times of maximum flood and ebb currents (74.2 for TFC and 72.3 for TEC), and the start and end times of slack currents before flood (77.0 for TSF and 79.3 for TEF).

At J5 (Dames Point Bridge), Figure 2 shows that the tide-only simulated currents are smaller than the tidal current predictions during the maximum flood and ebb currents (the modeled and observed mean current speeds are 46.3 cm/s and 59.1 cm/s respectively). The RMS error of the current speeds at J5 is 18 cm/s. CF fails to pass the criteria for the

6-minute time series of current speeds, and the amplitudes of maximum flood and ebb currents. CF fails the criteria for the time of maximum flood currents, and the start time of slack currents before flood. NOF, POF, MDNO, and MDPO all pass the criteria for each of the tests.

At J6 (Trout River Cut), Figure 2 shows that the amplitudes of the maximum flood and ebb currents are close. The simulated and observed mean current speeds are 39 and 44 cm/s, and the RMS error between them is 10 cm/s. NOF, CF, and MDNO fail the criteria for the time of the maximum flood currents (TFC) and the start time of current slack before ebb (TSE). CF, NOF, POF, MDNO, and MDPO all pass the criteria for all the other tests.

CF, NOF, POF, MDNO, and MDPO (Scenario: Tidal simulation only in Tables E.1-E.3) all pass the criteria at the three stations for the current direction. The RMS errors of the current directions are 13.6, 6.3, and 6.9 degrees, and the differences of mean current directions are 12, 4, and 3 degrees at J2, J5, and J6, respectively.

Hindcast Simulation

The observed ADCP time series were compared with the hindcast simulations for 1998 at the three locations. Time series in Figure 2 shows that the simulated and observed amplitudes of maximum flood and ebb currents are very close at J2 and J5 stations, and the simulated amplitudes of maximum ebb currents are larger than the observed values at J6 station. The skill assessment score tables (Scenario: Hindcast in Tables D.1-D.3) show that the mean speed differences are 1.6 cm/s, -0.8 cm/s, and 5.3 cm/s, and the RMS errors of current speeds are 17.6 cm/s, 12.8 cm/s, and 14.2 cm/s at J2, J5, and J6, respectively. For the current speeds, CF, NOF, POF, MDNO, and MDPO all passed the criteria for the amplitudes of maximum flood and ebb currents at J5 and J6 stations, but CF fails at J2 station (a value greater than 84%). CF fails to pass the criteria for the time of the maximum flood and ebb currents at all three stations. CF also fails to pass the criteria for the time of current slack at J2 station.

CF, NOF, POF, MDNO, and MDPO all pass the criteria (Scenario: Hindcast in Tables E.1-E.3) for current direction at the three stations. The RMS errors for the direction of the currents are 15, 10.8, and 13.8 degrees, and the differences of mean current directions are 13, 8, and 9 degrees at J2, J5, and J6, respectively.

Semi-Operational Nowcast

The simulated speeds and directions of the currents from the semi-operational nowcasts were compared with the ADCP measurements taken by CO-OPS in 2003 at the three locations. Figure 3 shows that the maximum flood currents are not well defined in the ADCP observations at J2, but they exist in the model nowcast time series with small values (less than 0.4 cm/s). This might be caused by the coarse model grid resolution not being able to resolve such local bathymetric and hydrodynamic features. Skill assessment results for this scenario are listed in Tables D.1 – D.3 for current speeds and Tables E.1-E.3 for current directions (Scenario: Semi-Operational Nowcast).

For J2, the mean velocity of 47.6 cm/s for the model nowcast is greater than the observed value of 32.8 cm/s. The RMS error for the entire 6-minute time series of current speeds is 30.6 cm/s. CF and POF fail to pass the skill assessment criteria, but MDNO and MDPO pass the criteria for all tests. The maximum ebb current speeds of the nowcast are much greater than the observed values with the RMS error being 42.7 cm/s. The time of the maximum ebb currents and slack currents in the nowcasts falls about 50 minutes behind those of the observations (the RMS error is 0.82 hours). For the directions of the currents, the mean directions of the nowcasted and observed currents are 134.8 and 105 degrees, respectively (the RMS error is 46 degrees). CF, NOF, POF, MDPO, and MDPO fail to pass the criteria for the entire 6-minutes time series of the current directions. CF, NOF, POF, MDPO, and MDPO pass the criteria for the directions of the maximum ebb currents.

For J5, the mean velocities of the model nowcasts and observations are 58.1 and 49.8 cm/s, and the RMS error is 24.9 cm/s. A CF value of 67.7% fails to pass the criteria for the entire 6-minute time series of currents. The maximum flood current speeds of the nowcasts are greater than the observed values with an RMS error of 22.9 cm/s, and the maximum ebb current speeds of the nowcasts are close to the observed values with an RMS error of 9.7 cm/s. The time of the maximum ebb currents and slack currents precedes the observations by about 50 minutes (RMS errors are about 0.8 hours), and the time of the maximum flood currents almost coincides with that of the observations with an RMS error of 0.49 hours. CF, NOF, POF, MDPO, and MDPO pass the criteria for the maximum ebb current speeds, but fail to pass the criteria for the other tests. For current direction, the mean directions are 162 and 150 degrees for the model nowcasted and observed currents, respectively. CF, NOF, POF, MDPO, and MDPO pass the criteria for all tests.

For J6, the mean velocities of the model nowcasts and observations are 52.5 and 39.1 cm/s, and the RMS error is 25.8 cm/s. CF fails to pass the criteria with a value of 61%, and NOF, POF, MDNO, and MDPO pass the criteria for the entire 6-minute time series of current speeds. CF, NOF, POF, MDPO, and MDPO pass the criteria for the maximum flood current speeds with an RMS error of 8 cm/s. CF fails to pass the criteria, but NOF, POF, MDNO, and MDPO do pass the criteria for the maximum ebb current speeds with an RMS error of 34 cm/s. The RMS error of the time of the maximum flood currents is about 0.9 hours, and the RMS error of the time of the maximum ebb currents is 0.64 hours. The RMS errors range from 0.47 to 1.23 hours, and CF fails to pass the criteria for the time of slack currents. For current direction, mean current directions are 90 and 120 degrees for the model nowcasts and observations, respectively; CF fails to pass the criteria for the entire 6-minute time series of current directions and the directions of the maximum flood current speed, CF does pass the criteria for the directions of the maximum ebb current speed. NOF, POF, MDPO, and MDPO pass the criteria for all tests.

Semi-Operational Forecast

Figure 3 shows that the semi-operational forecasts of current speed are similar to those of the model nowcasts at all of the three stations. Skill assessment results are listed in Tables D.1 – D.3 for current speeds and Tables E.1-E.3 for current directions (Scenario: Semi-Operational Forecast).

For J2, the RMS errors of the current speed range from 29.6 cm/s at forecast hour 0 to 32 cm/s at forecast hour 24. CF ranges from 69% to 71.4% throughout the 24 forecast hours, but it does not significantly degrade with time. POF is greater than 10% for all forecast hours. NOF, MDNO, and MNPO pass the criteria for all forecast hours. The maximum ebb current speeds of the model forecasts are greater than the observations with an RMS error of 44.4 cm/s. The time of the modeled maximum ebb currents occur about 0.83 hours before the observations. CF and POF fail to pass the criteria for all the tests. For current direction, RMS errors range from 27 to 29 degrees, and CF ranges from 54% to 58% throughout the 24 forecast hours. Most of the NOF, CF, and POF fail to pass the criteria.

For J5, RMS errors of current speed range from 21.8 cm/s at forecast hour 6 to 25.4 cm/s at forecast hour 0, and CF ranges from 68% (forecast hour 0) to 75.9% (forecast hour 6) throughout the 24 forecast hours, and does not significantly degrade over time. NOF, MDNO, and MDPO pass the criteria for the current speed forecasts throughout the 24 forecast hours. The RMS error of the maximum flood current speeds is 24.4 cm/s and the RMS error of the maximum ebb current speeds is 10.8 cm/s. The CF of the maximum flood current speeds fails to pass the criteria with a value of 63.6%. The CF of the maximum ebb current speeds passes the criteria with a value of 97.3%. NOF, POF, MDNO, and MDPO pass the criteria for both the maximum flood and ebb current speeds. The RMS errors of the time of the maximum flood and ebb current speeds are 0.5 hours and 0.69 hours, respectively, and the CF of them fails to pass the criteria (71% and 45.5%). Most of CF, NOF, POF, MDNO, and MDPO fail to pass the criteria for the start and end time of slack currents before flood and ebb. For current direction, the RMS errors range from 9.4 degrees (forecast hour 6) to 14.2 degrees (forecast hour 0), CF ranges from 30.3% (hour 0) to 32.4% (hour 6), and POF ranges from 63.1% (hour 0) to 64.3 (hour 6) throughout the 24 forecast hours. CF, NOF, POF, MDNO, and MDPO pass the criteria for the directions of the maximum flood and ebb currents.

For J6, RMS errors of the current speed range from 26 cm/s at forecast hour 0 to 23.2 cm/s at forecast hour 6, and CF ranges from 62% (forecast hour 0) to 65% (forecast hour 6) throughout the 24 forecast hours without significantly degrading over time. NOF, POF, MDNO, and MDPO pass the criteria for the current speed forecasts throughout the 24 forecast hours. CF, NOF, POF, MDNO, and MDPO pass the criteria for the maximum flood current speeds with an RMS error of 7.6 cm/s and CF value of 99%. NOF, POF, MDNO, and MDPO pass the criteria and CF fails for the maximum ebb current speeds with a RMS error of 32.8 cm/s and CF value of 5.2%. CF fails to pass the criteria for time of the maximum flood and ebb current speeds, and start and end time of the slack currents. For the current direction, the RMS errors range from 15 degrees to 16 degrees, CF ranges from 35.4% to 35.8%, and POF ranges from 57.9% to 58.3% throughout the 24 forecast hours. CF, NOF, POF, MDNO, and MDPO pass the criteria for direction of the maximum ebb currents. NOF, POF, MDNO, and MDPO pass the criteria, but CF fails for the direction of the maximum flood currents.

Forecast Method Comparison

Currents from the persistence forecasts and tidal predictions were compared with the observations, and the results are presented in Appendix D for current speeds and in Appendix E for current directions. The results show that, for persistence forecasts, CF, NOF, POF, MDNO, and MDPO pass the criteria for current speeds throughout the 24 forecast hours at all the three stations. They also pass the criteria for the maximum flood and ebb current speeds at each of the three stations. CF, NOF, POF, MDNO, and MDPO fail to pass the criteria for current direction forecasts throughout the 24 forecast hours at all three stations. The persistence forecast performs better than the semi-operational current speed forecasts in estimating current speeds. However, the semi-operational forecasts provide better results than the persistence forecasts for the current direction. For the tidal current predictions, CF, NOF, POF, MDNO, and MDPO pass the criteria for both the current speeds and directions at the three stations. The reasons might include: (1) the astronomical tidal constituents account for more than 95% of the total variance at J2, J5, and J6. Therefore, both the tidal current prediction and the persistence forecast which is based on tidal current prediction can capture most of the signal in the current observations; (2) there were rarely storm events in the St. Johns River during the ADCP survey time period of 2003.

7. CONCLUSIONS

As part of the Coastal Storms Program (CSP), NOS has implemented an application of the EFDC circulation model in the St. Johns River to perform operational hourly nowcasts and 36-hour forecasts. The application was integrated into the Coastal Ocean Modeling Framework (COMF) that NOS has implemented for operational coastal and estuarine systems. The model results were compared with the observations at eight water level stations and 3 water current stations using the NOS standard skill assessment software. The skill assessment for this application focused on the performance of the model in simulating water levels and currents in four model run scenarios. These include an astronomical tide simulation, a model hindcast, a semi-operational nowcast, and a semi-operational forecast.

The skill assessment results indicate that most statistical parameters of water levels pass the NOS skill assessment criteria for the four model run scenarios at the eight stations, and amplitudes and epochs of the dominant M_2 constituent from the model tide-only simulation are very close to the observed values at all stations.

Most of CF, NOF, POF, MDNO, and MDPO either pass or are close to the criteria for all tests at the three current stations for tide-only simulation and model hindcast simulations. However, most of CF, NOF, POF, MDNO, and MDPO fail to pass the criteria for the semi-operational nowcast and forecast simulations at the three current stations. The semi-operational current nowcasts are less satisfactory than those from the hindcast simulation. This might be attributed to a couple of different reasons. First, river discharge inflows were specified at 61 locations throughout the entire St. Johns River, and there were more than 10 locations from Mayport to Jacksonville where ADCP measurements were conducted in 1998 and 2003. River discharges are specified at only 6 locations for the semi-operational nowcast and forecast, all of which are upstream of Jacksonville and the locations of the NOS ADCP survey. As river discharges have an important impact on the currents, this may explain why the hindcast currents performed better than the nowcast/foreast results. Another factor for the discrepancy may be that the same bathymetric data were used in both the hindcast simulation of 1998 and the semi-operational nowcast and forecast of 2003. However, between 1998 and 2003 bathymetric and hydrodynamic changes may have occurred near the stations which could potentially affect the current pattern. Therefore, specifying more river discharge inputs and updating the bathymetric and hydrodynamic changes might improve the current nowcasts and forecasts. The tidal current prediction and persistence current forecast, which is based on the tidal current prediction, are better than the model current forecast since tidal current dominate the signal in lower St. Johns River.

Based on the skill assessment results for the model hindcast and the semi-operational nowcast/forecast described above, the following issues should be useful to further improve water current forecasts of the SJROFS: (1) sensitivity tests about impacts of river discharges on current and salinity simulations. Climatological river discharge data may be used for the locations where real time river discharge data is not available for the semi-operational nowcast/forecast simulation. (2)Real time salinity and temperature data are needed to evaluate the salinity and water temperature from the semi-operational run.

ACKNOWLEDGMENTS

We thank the St. Johns River Water Management District (SJRWMD) for providing the calibrated EFDC model to CSDL for implementation in a real-time nowcast/forecast system. We are grateful to Dr. John Hamrick, of Tetra Tech, Inc., for providing guidance in implementing SJROFS. We are also grateful to CO-OPS for providing ADCP measurements for comparison.

REFERENCES

Blumberg, A. F., and G. L. Mellor, 1987. A description of a three-dimensional coastal ocean circulation model. In: *Three-Dimensional Coastal Ocean Models, Coastal and Estuarine Science,* Vol. 4. (Heaps, N. S., ed.) American Geophysical Union, pp. 1-19.

Bourgerie, R., 1999. Currents in the St. Johns River, Florida Spring and Summer of 1998. NOAA Technical Report, NOS CO-OPS 025.

Galperin, B., L. H. Kantha, S. Hassid, and A. Rosati, 1988. A quasi-equilibrium turbulent energy model for geophysical flows. *J. Atmos. Sci.*, **45**, 55-62.

Gross, T. F., H. Lin, M. Vercent, and Z. Bronder, 2006. Coastal Ocean Modeling Framework:COMF. NOAA Technical Report, in prepareation.

Hamrick, J.M., 1992a, A three-dimensional environmental fluid dynamics compute code: Theoretical and computational aspects. *Special Rept. 317*. The College of William and Mary, Virginia Inst. of Marine Sciences, Virginia.

Hamrick, J.M., 1992b, Estuarine environmental impact assessment using a three-dimensional circulation and transport model. In *Estuarine and Coastal Modeling, Proceedings of the 2nd International Conference*, ASCE, New York.

Hess, K.W., Gross, T.F., Schmalz, R.A., Kelley, J.G.W., Aikman III, F., Wei, E., Vincent, M.S. (2003). "NOS Standards for Evaluating Operational Nowcast and Forecast Hydrodynamic Model Systems." NOAA Technical Report, NOS CS 17.

Mellor, G. L., and T. Yamada, 1982. Development of a turbulence closure model for geophysical fluid problems. *Rev. Geophys. Space Phys.*, **20**, 851-875.

Sucsy, P.V. and F.W. Morris, 2001, Calibration of a Three-dimensional Circulation and Mixing Model of the Lower St. Johns River, *St. Johns River Water Management District*, Palatka, Florida.

Tetra Tech, Inc., 2002. User's Manual for Environmental Fluid Dynamics Code (EFDC). A report for the U.S. Environmental Protection Agency.

Zhang, A., Hess, K.W., Wei, E. and Myers, E.P. (2005). "Implementation of Model Skill Assessment Software for Water Level and Currents." NOAA Technical Report, in preparation.

APPENDICES:

In the Appendice tables, water level units are in meters, water current units are in meters/second, phase (epoch) units are in degrees referenced to UTC (GMT), time is in hours.

APPENDIX A. Comparison of Water Level Harmonic Constants

Table A.1. Mayport: Bar Pilots

Observation:CO-OPS Accepted Harmonic Constants
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are degrees, referenced to UTC(GMT)

		Observed		Modeled		Difference	
N	Constituent	Amplitude	Epoch	Amplitude	Epoch	Amplitude	Epoch
1	M(2)	0.676	25.3	0.663	23.4	-0.013	-1.9
2	S(2)	0.105	48.3	0.100	48.0	-0.005	-0.3
3	N(2)	0.157	7.3	0.151	5.9	-0.006	-1.4
4	K(1)	0.084	202.5	0.078	199.7	-0.006	-2.8
5	M(4)	0.033	159.4	0.040	160.8	0.007	1.4
6	O(1)	0.058	210.9	0.052	216.8	-0.006	5.9
7	M(6)	0.009	196.0	0.010	199.2	0.001	3.2
8	MK(3)	0.008	20.4	0.010	7.6	0.002	-12.8
9	S(4)	0.005	290.7	0.004	285.9	-0.001	-4.8
10	MN(4)	0.013	156.0	0.017	152.7	0.004	-3.3
11	NU(2)	0.032	2.7	0.031	1.1	-0.001	-1.6
12	S(6)	0.000	0.0	0.000	0.0	0.000	0.0
13	MU(2)	0.012	31.2	0.010	41.8	-0.002	10.6
14	2N(2)	0.019	354.6	0.018	353.8	-0.001	-0.8
15	OO(1)	0.004	212.6	0.003	198.7	-0.001	-13.9
16	LAMDA(2)	0.009	47.8	0.010	41.1	0.001	-6.7
17	S(1)	0.011	158.3	0.011	158.4	0.000	0.1
18	M(1)	0.003	221.2	0.003	207.1	0.000	-14.1
19	J(1)	0.005	210.2	0.004	208.0	-0.001	-2.2
20	MM	0.000	230.4	0.002	207.3	0.000	0.0
21	SSA	0.000	55.4	0.000	0.0	0.000	0.0
22	SA	0.000	190.2	0.000	0.0	0.000	0.0
23	MSF	0.000	202.7	0.002	189.7	0.000	0.0
24	MF	0.000	0.0	0.000	0.0	0.000	0.0
25	RHO(1)	0.002	214.5	0.002	216.4	0.000	1.9
26	Q(1)	0.011	209.5	0.010	217.0	-0.001	7.5
27	T(2)	0.010	22.1	0.009	21.8	-0.001	-0.3
28	R(2)	0.005	291.8	0.005	291.2	0.000	-0.6
29	2Q(1)	0.002	219.2	0.002	226.7	0.000	7.5
30	P(1)	0.029	202.2	0.028	202.2	-0.001	0.0
31	2SM(2)	0.003	60.1	0.003	66.4	0.000	6.3
32	M(3)	0.006	186.4	0.005	177.2	-0.001	-9.2
33	L(2)	0.041	31.4	0.045	16.9	0.004	-14.5
34	2MK3(3)	0.008	44.0	0.010	34.3	0.002	-9.7
35	K(2)	0.028	48.2	0.026	41.6	-0.002	-6.6
36	M(8)	0.003	4.2	0.004	7.9	0.001	3.7
37	MS(4)	0.013	175.8	0.015	177.8	0.002	2.0

Table A.2. Main Street Bridge

Observation:CO-OPS Accepted Harmonic Constants
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are in degrees, referenced to UTC (GMT)

		Observed		Modeled		Difference	
N	Constituent	Amplitude	Epoch	Amplitude	Epoch	Amplitude	Epoch
1	M(2)	0.279	74.9	0.257	64.9	-0.022	-10.0
2	S(2)	0.036	103.8	0.034	95.4	-0.002	-8.4
3	N(2)	0.057	62.6	0.053	50.2	-0.004	-12.4
4	K(1)	0.029	246.3	0.025	238.4	-0.004	-7.9
5	M(4)	0.020	353.2	0.016	324.0	-0.004	-29.2
6	O(1)	0.021	256.7	0.017	258.1	-0.004	1.4
7	M(6)	0.014	12.6	0.020	346.7	0.006	25.9
8	MK(3)	0.010	124.0	0.007	92.3	-0.003	-31.7
9	S(4)	0.000	0.0	0.002	38.0	0.000	0.0
10	MN(4)	0.009	341.9	0.007	319.3	-0.002	-22.6
11	NU(2)	0.011	56.4	0.012	42.7	0.001	-13.7
12	S(6)	0.000	0.0	0.000	0.0	0.000	0.0
13	MU(2)	0.006	168.7	0.005	155.3	-0.001	-13.4
14	2N(2)	0.004	60.9	0.005	39.9	0.001	-21.0
15	OO(1)	0.001	235.7	0.001	235.5	0.000	-0.2
16	LAMDA(2)	0.008	94.4	0.006	72.2	-0.002	-22.2
17	S(1)	0.008	219.6	0.003	196.8	-0.005	-22.8
18	M(1)	0.002	251.4	0.001	281.2	-0.001	29.8
19	J(1)	0.002	241.0	0.001	242.9	-0.001	1.9
20	MM	0.000	0.0	0.010	23.0	0.000	0.0
21	SSA	0.000	0.0	0.001	39.6	0.000	0.0
22	SA	0.000	0.0	0.000	318.6	0.000	0.0
23	MSF	0.000	0.0	0.008	46.5	0.000	0.0
24	MF	0.000	0.0	0.004	45.9	0.000	0.0
25	RHO(1)	0.001	261.2	0.001	270.2	0.000	9.0
26	Q(1)	0.004	261.0	0.003	260.8	-0.001	-0.2
27	T(2)	0.005	64.8	0.003	68.6	-0.002	3.8
28	R(2)	0.000	105.1	0.002	334.9	0.000	0.0
29	2Q(1)	0.001	267.1	0.000	264.3	-0.001	-2.8
30	P(1)	0.010	239.4	0.009	239.6	-0.001	0.2
31	2SM(2)	0.000	0.0	0.000	143.5	0.000	0.0
32	M(3)	0.000	0.0	0.003	227.4	0.000	0.0
33	L(2)	0.030	71.5	0.025	58.7	-0.005	-12.8
34	2MK3(3)	0.010	124.7	0.008	99.0	-0.002	-25.7
35	K(2)	0.010	106.9	0.009	87.5	-0.001	-19.4
36	M(8)	0.000	0.0	0.002	249.3	0.000	0.0
37	MS(4)	0.004	6.4	0.003	340.2	-0.001	26.2

Table A.3. Long Branch

Observation:CO-OPS Accepted Harmonic Constants
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are in degrees, referenced to UTC (GMT)

		Observed		Modeled		Difference	
N	Constituent	Amplitude	Epoch	Amplitude	Epoch	Amplitude	Epoch
1	M(2)	0.379	64.3	0.363	54.6	-0.016	-9.7
2	S(2)	0.053	95.2	0.050	84.9	-0.003	-10.3
3	N(2)	0.078	49.7	0.077	39.7	-0.001	-10.0
4	K(1)	0.042	230.4	0.038	222.6	-0.004	-7.8
5	M(4)	0.015	41.9	0.006	45.8	-0.009	3.9
6	O(1)	0.030	240.2	0.027	237.3	-0.003	-2.9
7	M(6)	0.021	334.3	0.028	312.4	0.007	-21.9
8	MK(3)	0.008	110.7	0.004	69.1	-0.004	-41.6
9	S(4)	0.003	33.8	0.002	25.3	-0.001	-8.5
10	MN(4)	0.008	10.5	0.005	19.5	-0.003	9.0
11	NU(2)	0.016	40.7	0.017	31.7	0.001	-9.0
12	S(6)	0.000	0.0	0.000	0.0	0.000	0.0
13	MU(2)	0.008	155.2	0.007	132.0	-0.001	-23.2
14	2N(2)	0.008	63.2	0.007	29.8	-0.001	-33.4
15	OO(1)	0.003	264.8	0.001	220.3	-0.002	-44.5
16	LAMDA(2)	0.012	78.0	0.008	61.4	-0.004	-16.6
17	S(1)	0.006	198.6	0.005	183.8	-0.001	-14.8
18	M(1)	0.002	252.3	0.001	238.8	-0.001	-13.5
19	J(1)	0.002	244.3	0.001	229.0	-0.001	-15.3
20	MM	0.000	344.9	0.013	23.0	0.000	0.0
21	SSA	0.000	27.9	0.001	39.0	0.000	0.0
22	SA	0.000	159.5	0.000	319.2	0.000	0.0
23	MSF	0.000	321.0	0.011	36.4	0.000	0.0
24	MF	0.000	308.0	0.005	41.5	0.000	0.0
25	RHO(1)	0.001	235.9	0.001	252.4	0.000	16.5
26	Q(1)	0.005	231.4	0.005	235.3	0.000	3.9
27	T(2)	0.008	51.8	0.005	57.3	-0.003	5.5
28	R(2)	0.001	243.9	0.002	325.5	0.001	81.6
29	2Q(1)	0.001	13.1	0.001	247.0	0.000	126.1
30	P(1)	0.014	227.6	0.013	226.7	-0.001	-0.9
31	2SM(2)	0.001	54.6	0.001	116.5	0.000	61.9
32	M(3)	0.001	288.3	0.004	226.8	0.003	-61.5
33	L(2)	0.050	67.6	0.034	46.1	-0.016	-21.5
34	2MK3(3)	0.008	109.6	0.007	76.1	-0.001	-33.5
35	K(2)	0.015	96.9	0.013	76.2	-0.002	-20.7
36	M(8)	0.003	42.6	0.001	328.3	-0.002	74.3
37	MS(4)	0.002	74.6	0.002	143.8	0.000	69.2

Table A.4. Buckman Bridge

Observation:CO-OPS Accepted Harmonic Constants
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are in degrees, referenced to UTC (GMT)

		Observed		Modeled		Difference	
N	Constituent	Amplitude	Epoch	Amplitude	Epoch	Amplitude	Epoch
1	M(2)	0.140	109.4	0.131	104.7	-0.009	-4.7
2	S(2)	0.017	137.4	0.016	135.6	-0.001	-1.8
3	N(2)	0.027	98.7	0.026	90.4	-0.001	-8.3
4	K(1)	0.021	280.1	0.017	274.3	-0.004	-5.8
5	M(4)	0.009	188.0	0.007	187.3	-0.002	-0.7
6	O(1)	0.018	282.3	0.013	286.0	-0.005	3.7
7	M(6)	0.010	116.5	0.012	85.5	0.002	-31.0
8	MK(3)	0.003	178.3	0.002	136.9	-0.001	-41.4
9	S(4)	0.001	106.7	0.001	118.8	0.000	12.1
10	MN(4)	0.003	168.6	0.003	156.7	0.000	-11.9
11	NU(2)	0.006	91.5	0.006	82.7	0.000	-8.8
12	S(6)	0.000	0.0	0.000	0.0	0.000	0.0
13	MU(2)	0.003	218.6	0.003	214.3	0.000	-4.3
14	2N(2)	0.003	63.2	0.002	78.1	-0.001	14.9
15	OO(1)	0.000	0.0	0.001	273.2	0.000	0.0
16	LAMDA(2)	0.005	124.2	0.003	114.1	-0.002	-10.1
17	S(1)	0.005	230.1	0.002	237.4	-0.003	7.3
18	M(1)	0.002	34.2	0.000	326.2	-0.002	68.0
19	J(1)	0.001	205.6	0.000	231.3	-0.001	25.7
20	MM	0.000	0.0	0.017	24.4	0.000	0.0
21	SSA	0.000	0.0	0.002	40.5	0.000	0.0
22	SA	0.000	0.0	0.001	318.1	0.000	0.0
23	MSF	0.000	0.0	0.014	40.4	0.000	0.0
24	MF	0.000	0.0	0.006	41.8	0.000	0.0
25	RHO(1)	0.000	0.0	0.001	306.3	0.000	0.0
26	Q(1)	0.003	286.5	0.002	284.1	-0.001	-2.4
27	T(2)	0.002	107.4	0.002	107.3	0.000	-0.1
28	R(2)	0.002	359.5	0.001	12.8	-0.001	13.3
29	2Q(1)	0.001	252.0	0.000	301.5	-0.001	49.5
30	P(1)	0.005	276.1	0.006	279.7	0.001	3.6
31	2SM(2)	0.001	280.5	0.000	0.0	-0.001	79.5
32	M(3)	0.001	277.6	0.002	286.3	0.001	8.7
33	L(2)	0.009	98.7	0.014	101.1	0.005	2.4
34	2MK3(3)	0.005	164.6	0.004	143.6	-0.001	-21.0
35	K(2)	0.005	139.7	0.005	127.2	0.000	-12.5
36	M(8)	0.001	153.1	0.001	134.8	0.000	-18.3
37	MS(4)	0.002	246.5	0.002	236.5	0.000	-10.0

Table A.5. Red Bay Point

Observation:CO-OPS Accepted Harmonic Constants
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are in degrees, referenced to UTC (GMT)

		Observed		Modeled		Difference	
N	Constituent	Amplitude	Epoch	Amplitude	Epoch	Amplitude	Epoch
1	M(2)	0.124	168.9	0.118	157.5	-0.006	-11.4
2	S(2)	0.014	202.3	0.014	188.7	0.000	-13.6
3	N(2)	0.023	155.4	0.022	141.9	-0.001	-13.5
4	K(1)	0.021	302.8	0.018	298.2	-0.003	-4.6
5	M(4)	0.007	247.3	0.007	226.2	0.000	-21.1
6	O(1)	0.018	305.6	0.014	307.4	-0.004	1.8
7	M(6)	0.010	233.8	0.013	193.7	0.003	-40.1
8	MK(3)	0.003	234.8	0.002	202.1	-0.001	-32.7
9	S(4)	0.001	229.8	0.000	191.4	-0.001	-38.4
10	MN(4)	0.002	221.5	0.003	201.9	0.001	-19.6
11	NU(2)	0.006	146.9	0.006	136.1	0.000	-10.8
12	S(6)	0.000	0.0	0.000	0.0	0.000	0.0
13	MU(2)	0.003	298.4	0.003	284.6	0.000	-13.8
14	2N(2)	0.003	114.3	0.002	122.4	-0.001	8.1
15	OO(1)	0.000	0.0	0.001	300.3	0.000	0.0
16	LAMDA(2)	0.004	179.1	0.003	170.7	-0.001	-8.4
17	S(1)	0.005	252.9	0.002	261.6	-0.003	8.7
18	M(1)	0.002	45.5	0.001	358.1	-0.001	47.4
19	J(1)	0.000	0.0	0.000	0.0	0.000	0.0
20	MM	0.000	0.0	0.017	24.7	0.000	0.0
21	SSA	0.000	0.0	0.002	40.9	0.000	0.0
22	SA	0.000	0.0	0.001	317.3	0.000	0.0
23	MSF	0.000	0.0	0.014	41.7	0.000	0.0
24	MF	0.000	0.0	0.006	42.6	0.000	0.0
25	RHO(1)	0.001	297.4	0.001	323.6	0.000	26.2
26	Q(1)	0.003	312.2	0.002	306.7	-0.001	-5.5
27	T(2)	0.002	176.3	0.001	160.4	-0.001	-15.9
28	R(2)	0.000	0.0	0.001	64.9	0.000	0.0
29	2Q(1)	0.001	253.5	0.000	333.8	-0.001	80.3
30	P(1)	0.005	295.8	0.006	304.3	0.001	8.5
31	2SM(2)	0.001	34.9	0.000	0.0	-0.001	-34.9
32	M(3)	0.001	332.1	0.001	342.0	0.000	9.9
33	L(2)	0.009	162.8	0.014	158.9	0.005	-3.9
34	2MK3(3)	0.004	227.0	0.003	205.9	-0.001	-21.1
35	K(2)	0.004	196.4	0.004	181.8	0.000	-14.6
36	M(8)	0.002	317.1	0.002	271.5	0.000	-45.6
37	MS(4)	0.001	300.4	0.002	278.3	0.001	-22.1

Table A.6. Racy Point

Observation:CO-OPS Accepted Harmonic Constants
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are in degrees, referenced to UTC (GMT)

		Observed		Modeled		Difference	
N	Constituent	Amplitude	Epoch	Amplitude	Epoch	Amplitude	Epoch
1	M(2)	0.166	208.6	0.149	198.5	-0.017	-10.1
2	S(2)	0.024	247.5	0.017	234.1	-0.007	-13.4
3	N(2)	0.029	203.9	0.028	183.0	-0.001	-20.9
4	K(1)	0.023	330.3	0.019	315.2	-0.004	-15.1
5	M(4)	0.006	336.8	0.006	341.9	0.000	5.1
6	O(1)	0.013	314.3	0.014	323.0	0.001	8.7
7	M(6)	0.009	330.3	0.011	301.5	0.002	-28.8
8	MK(3)	0.000	0.0	0.002	261.3	0.000	0.0
9	S(4)	0.001	275.8	0.000	280.4	-0.001	4.6
10	MN(4)	0.000	0.0	0.003	312.8	0.000	0.0
11	NU(2)	0.006	204.5	0.007	175.7	0.001	-28.8
12	S(6)	0.001	231.1	0.000	0.0	-0.001	128.9
13	MU(2)	0.004	6.5	0.005	323.5	0.001	43.0
14	2N(2)	0.004	199.2	0.002	160.3	-0.002	-38.9
15	OO(1)	0.001	346.3	0.001	319.8	0.000	-26.5
16	LAMDA(2)	0.001	226.6	0.004	212.1	0.003	-14.5
17	S(1)	0.000	0.0	0.002	278.7	0.000	0.0
18	M(1)	0.001	322.3	0.001	16.1	0.000	53.8
19	J(1)	0.001	338.2	0.000	0.0	-0.001	21.8
20	MM	0.000	0.0	0.017	24.8	0.000	0.0
21	SSA	0.000	0.0	0.002	41.3	0.000	0.0
22	SA	0.000	0.0	0.001	317.0	0.000	0.0
23	MSF	0.000	0.0	0.014	42.7	0.000	0.0
24	MF	0.000	0.0	0.006	43.6	0.000	0.0
25	RHO(1)	0.001	307.4	0.001	334.7	0.000	27.3
26	Q(1)	0.003	306.3	0.002	323.3	-0.001	17.0
27	T(2)	0.001	246.0	0.002	205.7	0.001	-40.3
28	R(2)	0.000	249.1	0.001	108.0	0.000	0.0
29	2Q(1)	0.000	298.4	0.000	358.6	0.000	0.0
30	P(1)	0.008	329.1	0.006	321.7	-0.002	-7.4
31	2SM(2)	0.000	0.0	0.000	0.0	0.000	0.0
32	M(3)	0.000	0.0	0.001	50.7	0.000	0.0
33	L(2)	0.005	213.2	0.019	200.8	0.014	-12.4
34	2MK3(3)	0.000	0.0	0.004	272.0	0.000	0.0
35	K(2)	0.007	250.7	0.005	227.2	-0.002	-23.5
36	M(8)	0.002	86.9	0.003	69.5	0.001	-17.4
37	MS(4)	0.000	0.0	0.001	30.3	0.000	0.0

Table A.7. Palatka

Observation:CO-OPS Accepted Harmonic Constants
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are in degrees, referenced to UTC (GMT)

		Observed		Modeled		Difference	
N	Constituent	Amplitude	Epoch	Amplitude	Epoch	Amplitude	Epoch
1	M(2)	0.192	227.3	0.173	223.3	-0.019	-4.0
2	S(2)	0.021	265.7	0.019	260.2	-0.002	-5.5
3	N(2)	0.032	213.9	0.032	207.4	0.000	-6.5
4	K(1)	0.022	324.7	0.019	327.1	-0.003	2.4
5	M(4)	0.015	37.8	0.015	28.1	0.000	-9.7
6	O(1)	0.016	330.9	0.014	333.8	-0.002	2.9
7	M(6)	0.014	96.7	0.019	52.8	0.005	-43.9
8	MK(3)	0.004	350.7	0.002	313.7	-0.002	-37.0
9	S(4)	0.001	9.6	0.000	12.4	-0.001	2.8
10	MN(4)	0.004	16.3	0.006	6.5	0.002	-9.8
11	NU(2)	0.010	208.1	0.009	199.8	-0.001	-8.3
12	S(6)	0.000	0.0	0.000	0.0	0.000	0.0
13	MU(2)	0.008	344.3	0.006	347.6	-0.002	3.3
14	2N(2)	0.005	168.8	0.002	183.0	-0.003	14.2
15	OO(1)	0.001	266.1	0.001	333.4	0.000	67.3
16	LAMDA(2)	0.006	243.8	0.005	237.3	-0.001	-6.5
17	S(1)	0.004	324.7	0.002	291.0	-0.002	-33.7
18	M(1)	0.002	61.8	0.001	29.5	-0.001	-32.3
19	J(1)	0.001	256.4	0.000	0.0	-0.001	103.6
20	MM	0.000	126.1	0.017	24.9	0.000	0.0
21	SSA	0.000	15.6	0.002	41.5	0.000	0.0
22	SA	0.000	213.2	0.001	317.0	0.000	0.0
23	MSF	0.000	107.3	0.014	43.4	0.000	0.0
24	MF	0.000	104.8	0.006	44.3	0.000	0.0
25	RHO(1)	0.001	290.7	0.001	343.0	0.000	52.3
26	Q(1)	0.003	343.2	0.002	334.7	-0.001	-8.5
27	T(2)	0.003	211.2	0.002	231.6	-0.001	20.4
28	R(2)	0.001	201.6	0.001	133.2	0.000	-68.4
29	2Q(1)	0.001	279.9	0.000	0.0	-0.001	80.1
30	P(1)	0.003	344.0	0.006	333.8	0.003	-10.2
31	2SM(2)	0.002	69.0	0.000	0.0	-0.002	-69.0
32	M(3)	0.002	76.3	0.002	98.4	0.000	22.1
33	L(2)	0.014	229.4	0.022	226.1	0.008	-3.3
34	2MK3(3)	0.007	340.0	0.005	313.9	-0.002	-26.1
35	K(2)	0.006	257.5	0.006	253.6	0.000	-3.9
36	M(8)	0.003	235.2	0.004	231.5	0.001	-3.7
37	MS(4)	0.003	85.3	0.004	77.1	0.001	-8.2

Table A.8. Buffalo Bluff

Observation:CO-OPS Accepted Harmonic Constants
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are in degrees, referenced to UTC (GMT)

		Observed		Modeled		Difference	
N	Constituent	Amplitude	Epoch	Amplitude	Epoch	Amplitude	Epoch
1	M(2)	0.161	242.9	0.135	255.6	-0.026	12.7
2	S(2)	0.017	284.1	0.014	292.7	-0.003	8.6
3	N(2)	0.028	227.3	0.024	239.4	-0.004	12.1
4	K(1)	0.017	333.6	0.017	347.7	0.000	14.1
5	M(4)	0.018	82.5	0.008	57.7	-0.010	-24.8
6	O(1)	0.012	340.4	0.013	353.2	0.001	12.8
7	M(6)	0.015	170.4	0.012	125.7	-0.003	-44.7
8	MK(3)	0.004	13.5	0.002	5.9	-0.002	-7.6
9	S(4)	0.000	0.0	0.000	47.2	0.000	0.0
10	MN(4)	0.005	62.7	0.004	36.4	-0.001	-26.3
11	NU(2)	0.009	225.2	0.007	232.8	-0.002	7.6
12	S(6)	0.001	39.2	0.000	0.0	-0.001	-39.2
13	MU(2)	0.007	355.6	0.005	24.7	-0.002	29.1
14	2N(2)	0.004	189.0	0.001	210.8	-0.003	21.8
15	OO(1)	0.001	283.4	0.000	355.6	-0.001	72.2
16	LAMDA(2)	0.004	261.5	0.004	270.7	0.000	9.2
17	S(1)	0.003	338.8	0.002	311.9	-0.001	-26.9
18	M(1)	0.002	74.6	0.001	55.9	-0.001	-18.7
19	J(1)	0.001	239.7	0.000	162.0	-0.001	-77.7
20	MM	0.000	128.2	0.017	25.2	0.000	0.0
21	SSA	0.000	13.2	0.002	42.4	0.000	0.0
22	SA	0.000	212.6	0.001	316.4	0.000	0.0
23	MSF	0.000	122.0	0.014	45.3	0.000	0.0
24	MF	0.000	113.1	0.006	46.1	0.000	0.0
25	RHO(1)	0.001	343.0	0.001	2.1	0.000	19.1
26	Q(1)	0.002	357.8	0.002	355.0	0.000	-2.8
27	T(2)	0.003	212.6	0.001	264.2	-0.002	51.6
28	R(2)	0.001	195.6	0.001	164.1	0.000	-31.5
29	2Q(1)	0.000	0.0	0.000	0.0	0.000	0.0
30	P(1)	0.003	355.9	0.005	355.0	0.002	-0.9
31	2SM(2)	0.002	87.2	0.000	0.0	-0.002	-87.2
32	M(3)	0.003	101.9	0.002	135.4	-0.001	33.5
33	L(2)	0.012	250.4	0.018	260.3	0.006	9.9
34	2MK3(3)	0.006	4.4	0.004	0.5	-0.002	-3.9
35	K(2)	0.005	270.5	0.004	287.4	-0.001	16.9
36	M(8)	0.004	355.1	0.003	280.8	-0.001	-74.3
37	MS(4)	0.004	132.3	0.002	108.2	-0.002	-24.1

APPENDIX B. Skill Assessment Scores of Water Levels

Table B.1. Mayport

Observed data time period from: / 1/ 2/1998 to /12/31/1998
Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
H			87121	-0.013								
h			87121	0.000								
H-h	15 cm	24h	87121	-0.013	0.027	0.023	0.0	100.0	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	702	-0.032	0.035	0.015	0.0	100.0	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	701	-0.003	0.008	0.008	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	702	0.018	0.065	0.062	0.0	100.0	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	701	-0.111	0.124	0.056	0.0	100.0	0.0	0.0	0.0	
SCENARIO: HINDCAST												
H			87121	-0.141								
h			87121	-0.146								
H-h	15 cm	24h	87121	0.005	0.062	0.061	0.0	98.6	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	702	-0.035	0.056	0.044	0.0	99.9	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	701	0.042	0.063	0.046	0.0	98.4	0.0	0.0	0.0	
THW-thw	0.50h	25h	702	-0.104	0.241	0.218	0.0	94.4	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	701	0.115	0.249	0.221	0.0	95.4	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
H			86651	-0.007								
h			86651	-0.007								
H-h	15 cm	24h	86651	0.000	0.033	0.033	0.0	100.0	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	697	-0.039	0.051	0.033	0.0	100.0	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	698	0.015	0.021	0.015	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	697	0.079	0.142	0.118	0.0	100.0	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	698	0.010	0.077	0.076	0.0	100.0	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
H00-h00	15 cm	24h	1448	-0.001	0.032	0.032	0.0	100.0	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	1448	-0.003	0.099	0.099	0.1	87.6	0.1	0.0	0.0	0.00
H12-h12	15 cm	24h	1448	-0.001	0.083	0.083	0.2	93.6	0.2	0.0	0.0	0.21
H18-h18	15 cm	24h	1448	-0.005	0.110	0.110	0.4	84.1	0.3	0.0	0.0	0.28
H24-h24	15 cm	24h	1448	-0.004	0.104	0.104	0.5	88.7	0.9	0.0	6.0	0.62
HHW-hhw	15 cm	24h	698	-0.013	0.054	0.053	0.0	98.7	0.0			
HLW-hlw	15 cm	24h	699	-0.017	0.053	0.050	0.0	99.1	0.0			
THW-thw	0.50h	25h	698	0.189	0.374	0.322	0.0	81.7	1.4			
TLW-tlw	0.50h	25h	699	0.170	0.366	0.324	0.6	80.8	0.4			
COMPARISON: PERSISTENCE FORECAST												
H00-h00	15 cm	24h	1448	0.000	0.012	0.012	0.0	100.0	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	1448	0.000	0.082	0.082	0.2	93.6	0.1	0.0	0.0	0.07
H12-h12	15 cm	24h	1448	0.000	0.071	0.072	0.2	95.6	0.1	0.0	0.0	0.14
H18-h18	15 cm	24h	1448	0.000	0.104	0.104	0.8	87.0	0.6	6.0	0.0	0.69
H24-h24	15 cm	24h	1448	0.000	0.098	0.098	0.7	89.2	0.8	6.0	6.0	0.90
HHW-hhw	15 cm	24h	698	0.003	0.044	0.044	0.0	99.0	0.0			
HLW-hlw	15 cm	24h	698	-0.005	0.051	0.051	0.0	99.3	0.0			
THW-thw	0.50h	25h	698	-0.059	0.230	0.223	0.7	95.8	0.0			
TLW-tlw	0.50h	25h	698	0.038	0.283	0.281	1.1	91.4	0.6			
COMPARISON: ASTRONOMICAL TIDE ONLY												
H-h	15 cm	24h	87121	0.008	0.145	0.145	1.3	66.8	1.4	9.7	31.9	0.00
HHW-hhw	15 cm	24h	701	0.002	0.125	0.125	0.1	75.9	1.0	0.0	24.8	
HLW-hlw	15 cm	24h	701	0.013	0.156	0.156	2.1	61.3	1.3	37.7	37.1	
THW-thw	0.50h	25h	701	-0.057	0.164	0.154	0.0	99.3	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	701	0.042	0.211	0.207	0.0	96.7	0.1	0.0	0.0	

Table B.2. Main Street Bridge

Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
H			87121	0.013								
h			87121	0.000								
H-h	15 cm	24h	87121	0.013	0.047	0.046	0.0	100.0	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	701	-0.019	0.028	0.021	0.0	100.0	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	701	0.049	0.053	0.018	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	701	0.295	0.628	0.555	1.9	55.2	12.8	0.0	25.1	
TLW-tlw	0.50h	25h	701	-0.003	0.138	0.138	0.0	99.9	0.0	0.0	0.0	
SCENARIO: HINDCAST												
H			87111	-0.032								
h			87111	-0.079								
H-h	15 cm	24h	87111	0.047	0.070	0.051	0.2	98.5	0.2	3.7	4.2	0.23
HHW-hhw	15 cm	24h	677	0.072	0.076	0.023	0.0	99.7	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	693	0.030	0.042	0.029	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	677	-0.352	0.546	0.418	7.2	60.9	0.1	62.4	0.0	
TLW-tlw	0.50h	25h	693	0.082	0.274	0.262	0.1	92.9	0.1	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
H			84306	0.005								
h			84306	0.002								
H-h	15 cm	24h	84306	0.003	0.042	0.042	0.0	99.5	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	658	0.015	0.039	0.036	0.0	99.2	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	677	-0.009	0.042	0.041	0.0	99.4	0.0	0.0	0.0	
THW-thw	0.50h	25h	658	0.088	0.411	0.402	3.0	81.5	1.1	24.7	0.0	
TLW-tlw	0.50h	25h	677	-0.037	0.221	0.218	0.4	96.2	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
H00-h00	15 cm	24h	1408	0.003	0.043	0.043	0.0	99.4	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	1408	0.004	0.055	0.055	0.0	98.5	0.1	0.0	0.0	0.07
H12-h12	15 cm	24h	1408	0.003	0.057	0.057	0.0	98.5	0.2	0.0	0.0	0.21
H18-h18	15 cm	24h	1408	0.001	0.072	0.072	0.0	95.2	0.2	0.0	0.0	0.21
H24-h24	15 cm	24h	1408	0.000	0.076	0.076	0.1	95.1	0.4	0.0	6.0	0.36
HHW-hhw	15 cm	24h	674	0.021	0.045	0.040	0.0	98.7	0.0			
HLW-hlw	15 cm	24h	678	-0.010	0.042	0.041	0.0	99.1	0.0			
THW-thw	0.50h	25h	674	-0.061	0.444	0.440	2.7	74.2	1.0			
TLW-tlw	0.50h	25h	678	-0.040	0.317	0.314	1.0	87.9	0.0			
COMPARISON: PERSISTENCE FORECAST												
H00-h00	15 cm	24h	1408	-0.001	0.005	0.004	0.0	100.0	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	1408	-0.001	0.052	0.052	0.0	99.2	0.0	0.0	0.0	0.00
H12-h12	15 cm	24h	1408	-0.001	0.050	0.050	0.0	98.5	0.1	0.0	0.0	0.07
H18-h18	15 cm	24h	1408	-0.001	0.072	0.072	0.0	96.5	0.3	0.0	6.0	0.28
H24-h24	15 cm	24h	1408	-0.001	0.071	0.071	0.0	96.3	0.2	0.0	6.0	0.21
HHW-hhw	15 cm	24h	665	0.004	0.034	0.034	0.0	100.0	0.0			
HLW-hlw	15 cm	24h	673	0.002	0.032	0.032	0.0	99.9	0.0			
THW-thw	0.50h	25h	665	-0.212	0.579	0.539	8.4	57.4	1.4			
TLW-tlw	0.50h	25h	673	-0.128	0.367	0.345	1.5	83.2	0.1			
COMPARISON: ASTRONOMICAL TIDE ONLY												
H-h	15 cm	24h	84776	-0.002	0.160	0.160	4.2	60.5	0.9	72.2	19.0	0.00
HHW-hhw	15 cm	24h	680	-0.004	0.140	0.140	2.1	69.7	0.1	88.3	0.0	
HLW-hlw	15 cm	24h	682	0.006	0.177	0.177	5.7	52.5	1.6	125.0	37.2	
THW-thw	0.50h	25h	680	-0.274	0.573	0.503	7.5	59.1	0.6	25.2	0.0	
TLW-tlw	0.50h	25h	682	-0.153	0.303	0.263	0.1	89.4	0.0	0.0	0.0	

Table B.3. Long Branch

Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
H			87121	0.035								
h			87121	0.000								
H-h	15 cm	24h	87121	0.035	0.067	0.058	0.0	98.4	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	701	0.005	0.034	0.034	0.0	100.0	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	701	0.069	0.072	0.020	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	701	0.128	0.400	0.379	0.0	76.7	0.6	0.0	0.0	
TLW-tlw	0.50h	25h	701	0.052	0.180	0.172	0.0	96.9	0.0	0.0	0.0	
SCENARIO: HINDCAST												
H			65262	-0.012								
h			65262	-0.059								
H-h	15 cm	24h	65262	0.047	0.070	0.052	0.0	96.6	0.0	0.0	0.1	0.00
HHW-hhw	15 cm	24h	520	0.093	0.098	0.033	0.0	95.6	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	525	0.028	0.041	0.030	0.0	99.8	0.0	0.0	0.0	
THW-thw	0.50h	25h	520	-0.497	0.593	0.322	7.3	48.3	0.0	24.9	0.0	
TLW-tlw	0.50h	25h	525	0.030	0.246	0.245	0.2	95.2	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
H			20639	-0.046								
h			20639	-0.060								
H-h	15 cm	24h	20639	0.014	0.054	0.052	0.0	99.2	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	165	0.041	0.059	0.043	0.0	98.8	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	166	-0.007	0.049	0.048	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	165	-0.051	0.267	0.263	0.6	93.9	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	166	-0.066	0.188	0.176	0.0	98.8	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
H00-h00	15 cm	24h	344	0.014	0.058	0.056	0.0	98.8	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	343	0.024	0.075	0.071	0.0	95.3	0.3	0.0	0.0	0.29
H12-h12	15 cm	24h	342	0.023	0.075	0.071	0.0	95.6	0.6	0.0	0.0	0.58
H18-h18	15 cm	24h	341	0.022	0.090	0.088	0.0	89.7	0.6	0.0	0.0	0.59
H24-h24	15 cm	24h	340	0.021	0.092	0.090	0.0	90.9	0.3	0.0	0.0	0.29
HHW-hhw	15 cm	24h	164	0.057	0.075	0.048	0.0	94.5	0.0			
HLW-hlw	15 cm	24h	166	-0.009	0.053	0.052	0.0	100.0	0.0			
THW-thw	0.50h	25h	164	-0.105	0.422	0.410	1.8	76.2	0.0			
TLW-tlw	0.50h	25h	166	-0.104	0.323	0.307	0.6	86.7	0.0			
COMPARISON: PERSISTENCE FORECAST												
H00-h00	15 cm	24h	344	0.000	0.007	0.007	0.0	100.0	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	343	0.000	0.070	0.070	0.0	97.1	0.0	0.0	0.0	0.00
H12-h12	15 cm	24h	342	-0.001	0.061	0.061	0.0	98.2	0.3	0.0	0.0	0.29
H18-h18	15 cm	24h	341	-0.001	0.091	0.091	0.3	92.1	0.6	0.0	6.0	0.88
H24-h24	15 cm	24h	340	-0.002	0.084	0.084	0.0	93.5	0.6	0.0	6.0	0.59
HHW-hhw	15 cm	24h	162	-0.008	0.046	0.046	0.0	100.0	0.0			
HLW-hlw	15 cm	24h	164	0.008	0.042	0.041	0.0	100.0	0.0			
THW-thw	0.50h	25h	162	-0.061	0.458	0.455	1.2	71.6	1.2			
TLW-tlw	0.50h	25h	164	-0.155	0.380	0.348	1.2	81.7	0.6			
COMPARISON: ASTRONOMICAL TIDE ONLY												
H-h	15 cm	24h	20639	-0.085	0.145	0.117	2.0	66.9	0.0	6.1	0.0	0.00
HHW-hhw	15 cm	24h	165	-0.103	0.142	0.099	0.0	63.6	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	166	-0.063	0.141	0.127	1.2	68.1	0.0	0.0	0.0	
THW-thw	0.50h	25h	165	-0.137	0.422	0.400	0.6	77.0	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	166	-0.195	0.348	0.289	0.0	80.7	0.0	0.0	0.0	

Table B.4. Buckman Bridge

Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
H			87121	0.055								
h			87121	0.000								
H-h	15 cm	24h	87121	0.055	0.060	0.024	0.0	100.0	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	701	0.046	0.049	0.017	0.0	100.0	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	699	0.060	0.063	0.021	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	701	0.323	0.395	0.227	0.0	80.6	0.4	0.0	0.0	
TLW-tlw	0.50h	25h	699	0.339	0.549	0.432	0.0	77.1	16.3	0.0	99.1	
SCENARIO: HINDCAST												
H			83893	0.043								
h			83893	-0.026								
H-h	15 cm	24h	83893	0.069	0.079	0.037	0.0	98.5	0.2	0.0	4.3	0.12
HHW-hhw	15 cm	24h	667	0.090	0.093	0.023	0.0	99.1	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	653	0.050	0.058	0.029	0.0	99.4	0.0	0.0	0.0	
THW-thw	0.50h	25h	667	-0.004	0.304	0.304	0.6	88.9	0.0	35.7	0.0	
TLW-tlw	0.50h	25h	653	0.285	0.381	0.252	0.0	81.2	1.4	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
H			56269	0.030								
h			56269	0.025								
H-h	15 cm	24h	56269	0.006	0.037	0.036	0.0	99.2	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	453	0.020	0.037	0.032	0.0	99.3	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	448	-0.008	0.038	0.038	0.0	99.1	0.0	0.0	0.0	
THW-thw	0.50h	25h	453	0.240	0.339	0.240	0.2	86.3	0.7	0.0	0.0	
TLW-tlw	0.50h	25h	448	0.232	0.320	0.220	0.0	89.1	0.9	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
H00-h00	15 cm	24h	941	0.005	0.038	0.037	0.0	99.1	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	942	0.005	0.042	0.041	0.0	99.0	0.0	0.0	0.0	0.00
H12-h12	15 cm	24h	943	0.004	0.048	0.048	0.0	98.7	0.1	0.0	0.0	0.11
H18-h18	15 cm	24h	944	0.003	0.057	0.057	0.0	97.5	0.1	0.0	0.0	0.11
H24-h24	15 cm	24h	945	0.001	0.069	0.069	0.2	96.4	0.3	0.0	6.0	0.42
HHW-hhw	15 cm	24h	454	0.019	0.038	0.032	0.0	99.3	0.0			
HLW-hlw	15 cm	24h	448	-0.004	0.037	0.037	0.0	99.1	0.0			
THW-thw	0.50h	25h	454	0.126	0.383	0.362	0.7	78.2	0.7			
TLW-tlw	0.50h	25h	448	0.259	0.410	0.318	0.7	78.3	1.6			
COMPARISON: PERSISTENCE FORECAST												
H00-h00	15 cm	24h	941	0.000	0.005	0.005	0.0	100.0	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	942	0.000	0.029	0.029	0.0	99.9	0.0	0.0	0.0	0.00
H12-h12	15 cm	24h	943	0.000	0.040	0.040	0.0	99.4	0.0	0.0	0.0	0.00
H18-h18	15 cm	24h	944	0.000	0.053	0.053	0.0	97.8	0.0	0.0	0.0	0.00
H24-h24	15 cm	24h	945	0.000	0.061	0.061	0.0	96.9	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	450	0.005	0.022	0.022	0.0	99.8	0.0			
HLW-hlw	15 cm	24h	431	-0.005	0.019	0.019	0.0	100.0	0.0			
THW-thw	0.50h	25h	450	-0.211	0.459	0.408	4.9	72.4	0.0			
TLW-tlw	0.50h	25h	431	-0.375	0.597	0.465	11.4	58.7	0.2			
COMPARISON: ASTRONOMICAL TIDE ONLY												
H-h	15 cm	24h	56739	-0.024	0.167	0.165	8.5	60.4	0.5	108.3	20.6	0.00
HHW-hhw	15 cm	24h	457	-0.022	0.159	0.157	7.4	64.3	0.7	112.8	24.7	
HLW-hlw	15 cm	24h	440	-0.027	0.171	0.169	9.3	58.2	0.5	125.6	11.4	
THW-thw	0.50h	25h	457	-0.212	0.415	0.357	1.8	75.1	0.0	11.9	0.0	
TLW-tlw	0.50h	25h	440	-0.398	0.608	0.461	10.9	59.3	0.5	25.0	0.0	

Table B.5. Red Bay Point (Shands Bridge)

Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
H			87121	0.056								
h			87121	0.000								
H-h	15 cm	24h	87121	0.056	0.063	0.029	0.0	99.8	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	701	0.055	0.058	0.017	0.0	100.0	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	702	0.052	0.056	0.022	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	701	-0.170	0.246	0.179	0.0	98.1	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	702	-0.263	0.350	0.231	0.0	81.9	0.0	0.0	0.0	
SCENARIO: HINDCAST												
H			78334	0.055								
h			78334	-0.015								
H-h	15 cm	24h	78334	0.070	0.083	0.044	0.0	97.2	0.0	0.0	1.1	0.02
HHW-hhw	15 cm	24h	584	0.083	0.087	0.027	0.0	99.3	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	604	0.052	0.060	0.031	0.0	99.7	0.0	0.0	0.0	
THW-thw	0.50h	25h	584	-0.257	0.416	0.327	2.4	79.5	0.5	37.1	0.0	
TLW-tlw	0.50h	25h	604	-0.094	0.358	0.346	4.1	90.6	0.3	99.3	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
H			54791	0.058								
h			54791	0.039								
H-h	15 cm	24h	54791	0.019	0.045	0.041	0.0	99.2	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	441	0.035	0.050	0.036	0.0	99.3	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	441	0.001	0.043	0.043	0.0	98.9	0.0	0.0	0.0	
THW-thw	0.50h	25h	441	-0.041	0.173	0.168	0.0	98.4	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	441	-0.074	0.155	0.136	0.0	98.6	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
H00-h00	15 cm	24h	917	0.019	0.046	0.041	0.0	99.2	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	918	0.019	0.047	0.043	0.0	99.1	0.0	0.0	0.0	0.00
H12-h12	15 cm	24h	919	0.019	0.054	0.051	0.2	98.8	0.0	0.0	0.0	0.00
H18-h18	15 cm	24h	920	0.018	0.057	0.055	0.1	98.3	0.0	0.0	0.0	0.00
H24-h24	15 cm	24h	921	0.016	0.072	0.070	0.3	96.6	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	442	0.035	0.051	0.037	0.0	99.1	0.0			
HLW-hlw	15 cm	24h	443	0.003	0.043	0.043	0.0	98.9	0.0			
THW-thw	0.50h	25h	442	0.036	0.243	0.241	0.0	93.7	0.0			
TLW-tlw	0.50h	25h	443	0.142	0.236	0.188	0.0	95.0	0.2			
COMPARISON: PERSISTENCE FORECAST												
H00-h00	15 cm	24h	917	0.000	0.004	0.004	0.0	100.0	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	918	0.000	0.031	0.031	0.0	99.9	0.0	0.0	0.0	0.00
H12-h12	15 cm	24h	919	0.000	0.037	0.037	0.0	99.6	0.0	0.0	0.0	0.00
H18-h18	15 cm	24h	920	0.001	0.052	0.052	0.0	98.3	0.0	0.0	0.0	0.00
H24-h24	15 cm	24h	921	0.001	0.058	0.058	0.0	96.4	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	440	0.000	0.020	0.020	0.0	100.0	0.0			
HLW-hlw	15 cm	24h	443	0.001	0.017	0.017	0.0	100.0	0.0			
THW-thw	0.50h	25h	440	-0.087	0.426	0.418	3.2	78.6	0.2			
TLW-tlw	0.50h	25h	443	-0.068	0.373	0.368	2.0	80.8	0.0			
COMPARISON: ASTRONOMICAL TIDE ONLY												
H-h	15 cm	24h	55261	-0.038	0.167	0.163	9.4	63.6	0.0	132.6	0.0	0.00
HHW-hhw	15 cm	24h	444	-0.043	0.164	0.158	9.7	65.8	0.0	137.7	0.0	
HLW-hlw	15 cm	24h	444	-0.032	0.171	0.168	9.9	61.9	0.0	212.9	0.0	
THW-thw	0.50h	25h	444	-0.084	0.376	0.367	0.2	83.1	0.9	0.0	0.0	
TLW-tlw	0.50h	25h	444	-0.059	0.339	0.334	0.5	85.4	0.2	0.0	0.0	

Table B.6. Racy Point

Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
H			87121	0.051								
h			87121	0.000								
H-h	15 cm	24h	87121	0.051	0.057	0.025	0.0	100.0	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	701	0.047	0.049	0.015	0.0	100.0	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	701	0.057	0.059	0.014	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	701	-0.109	0.258	0.234	0.0	93.4	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	701	-0.140	0.283	0.246	0.0	91.3	0.0	0.0	0.0	
SCENARIO: HINDCAST												
H			65923	0.034								
h			65923	-0.015								
H-h	15 cm	24h	65923	0.050	0.060	0.034	0.0	99.7	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	531	0.063	0.071	0.034	0.0	99.4	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	530	0.042	0.053	0.032	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	531	-0.066	0.209	0.198	0.0	96.0	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	530	0.087	0.228	0.211	0.0	96.2	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
H			37815	0.030								
h			37815	0.033								
H-h	15 cm	24h	37815	-0.003	0.041	0.041	0.0	99.5	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	305	0.016	0.039	0.036	0.0	100.0	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	304	-0.014	0.048	0.046	0.0	98.7	0.0	0.0	0.0	
THW-thw	0.50h	25h	305	-0.054	0.204	0.197	0.3	97.7	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	304	-0.010	0.177	0.177	0.0	97.4	0.3	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
H00-h00	15 cm	24h	631	-0.004	0.041	0.041	0.0	99.4	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	631	-0.003	0.043	0.043	0.0	99.4	0.0	0.0	0.0	0.00
H12-h12	15 cm	24h	631	-0.006	0.049	0.049	0.0	98.7	0.0	0.0	0.0	0.00
H18-h18	15 cm	24h	631	-0.008	0.050	0.050	0.0	99.4	0.0	0.0	0.0	0.00
H24-h24	15 cm	24h	631	-0.012	0.062	0.061	0.0	96.7	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	305	0.020	0.042	0.038	0.0	100.0	0.0			
HLW-hlw	15 cm	24h	304	-0.013	0.048	0.046	0.0	98.7	0.0			
THW-thw	0.50h	25h	305	-0.054	0.293	0.288	0.3	90.8	0.0			
TLW-tlw	0.50h	25h	304	0.249	0.327	0.212	0.0	90.5	0.3			
COMPARISON: PERSISTENCE FORECAST												
H00-h00	15 cm	24h	631	-0.026	0.027	0.004	0.0	100.0	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	631	-0.026	0.047	0.039	0.0	99.8	0.0	0.0	0.0	0.00
H12-h12	15 cm	24h	631	-0.026	0.047	0.039	0.0	99.4	0.0	0.0	0.0	0.00
H18-h18	15 cm	24h	631	-0.026	0.059	0.052	0.0	98.4	0.0	0.0	0.0	0.00
H24-h24	15 cm	24h	631	-0.027	0.058	0.052	0.0	97.5	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	304	-0.024	0.037	0.028	0.0	100.0	0.0			
HLW-hlw	15 cm	24h	302	-0.025	0.034	0.023	0.0	100.0	0.0			
THW-thw	0.50h	25h	304	-0.060	0.368	0.364	1.3	84.5	0.3			
TLW-tlw	0.50h	25h	302	-0.164	0.401	0.366	3.6	81.5	0.0			
COMPARISON: ASTRONOMICAL TIDE ONLY												
H-h	15 cm	24h	37815	-0.033	0.180	0.177	12.0	62.7	0.2	156.3	8.5	0.00
HHW-hhw	15 cm	24h	304	-0.034	0.170	0.167	9.5	63.2	0.3	149.4	0.0	
HLW-hlw	15 cm	24h	303	-0.029	0.187	0.185	13.9	62.7	0.0	237.5	0.0	
THW-thw	0.50h	25h	304	-0.065	0.286	0.279	0.0	91.8	0.3	0.0	0.0	
TLW-tlw	0.50h	25h	303	-0.161	0.335	0.294	0.3	86.5	0.0	0.0	0.0	

Table B.7. Palatka

Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
H			87121	0.057								
h			87121	0.000								
H-h	15 cm	24h	87121	0.057	0.065	0.031	0.0	99.7	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	701	0.047	0.049	0.016	0.0	100.0	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	701	0.057	0.062	0.025	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	701	0.260	0.335	0.212	0.0	87.6	0.0	0.0	0.0	
TLW-tlw	0.50h	25h	701	0.104	0.362	0.347	0.0	88.6	4.7	0.0	0.0	
SCENARIO: HINDCAST												
H			78685	0.080								
h			78685	-0.004								
H-h	15 cm	24h	78685	0.084	0.098	0.050	0.1	94.0	0.3	2.4	3.8	0.17
HHW-hhw	15 cm	24h	616	0.096	0.104	0.039	0.0	92.4	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	620	0.065	0.072	0.031	0.0	99.7	0.0	0.0	0.0	
THW-thw	0.50h	25h	616	-0.031	0.467	0.467	3.1	70.3	0.3	25.1	0.0	
TLW-tlw	0.50h	25h	620	0.325	0.421	0.268	0.2	72.9	0.5	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
H			56699	0.067								
h			56699	0.058								
H-h	15 cm	24h	56699	0.009	0.077	0.077	0.8	96.3	0.0	43.3	1.6	0.03
HHW-hhw	15 cm	24h	454	0.020	0.066	0.063	0.7	98.2	0.0	23.6	0.0	
HLW-hlw	15 cm	24h	450	-0.015	0.081	0.080	0.9	94.9	0.0	38.7	0.0	
THW-thw	0.50h	25h	454	0.088	0.386	0.376	0.4	80.0	0.9	0.0	0.0	
TLW-tlw	0.50h	25h	450	0.146	0.273	0.231	0.2	93.8	0.9	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
H00-h00	15 cm	24h	948	0.009	0.078	0.077	0.8	96.4	0.0	36.0	0.0	0.00
H06-h06	15 cm	24h	949	0.009	0.078	0.078	0.8	96.2	0.0	36.0	0.0	0.00
H12-h12	15 cm	24h	950	0.008	0.084	0.084	0.9	95.3	0.1	36.0	0.0	0.21
H18-h18	15 cm	24h	951	0.006	0.083	0.083	1.2	95.5	0.0	42.0	0.0	0.32
H24-h24	15 cm	24h	952	0.005	0.095	0.095	0.9	92.3	0.0	24.0	0.0	0.42
HHW-hhw	15 cm	24h	455	0.023	0.067	0.063	0.7	98.2	0.0			
HLW-hlw	15 cm	24h	449	-0.008	0.080	0.079	0.9	95.5	0.0			
THW-thw	0.50h	25h	455	0.229	0.437	0.373	0.2	73.2	1.5			
TLW-tlw	0.50h	25h	449	0.427	0.503	0.266	0.0	54.1	1.3			
COMPARISON: PERSISTENCE FORECAST												
H00-h00	15 cm	24h	948	-0.030	0.031	0.006	0.0	100.0	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	949	-0.030	0.053	0.043	0.0	99.3	0.0	0.0	0.0	0.00
H12-h12	15 cm	24h	950	-0.030	0.053	0.044	0.0	98.8	0.0	0.0	0.0	0.00
H18-h18	15 cm	24h	951	-0.029	0.066	0.059	0.1	97.6	0.0	0.0	0.0	0.00
H24-h24	15 cm	24h	952	-0.029	0.067	0.061	0.1	97.1	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	452	-0.032	0.047	0.035	0.0	99.3	0.0			
HLW-hlw	15 cm	24h	443	-0.026	0.035	0.023	0.0	99.8	0.0			
THW-thw	0.50h	25h	452	-0.159	0.467	0.440	3.8	71.9	0.7			
TLW-tlw	0.50h	25h	443	-0.306	0.523	0.425	6.3	64.6	0.7			
COMPARISON: ASTRONOMICAL TIDE ONLY												
H-h	15 cm	24h	57169	-0.057	0.187	0.178	12.6	60.1	0.1	158.4	3.1	0.00
HHW-hhw	15 cm	24h	459	-0.062	0.172	0.161	10.2	65.1	0.0	199.1	0.0	
HLW-hlw	15 cm	24h	451	-0.049	0.190	0.184	12.9	58.5	0.0	225.5	0.0	
THW-thw	0.50h	25h	459	-0.172	0.420	0.384	1.3	73.6	0.2	0.0	0.0	
TLW-tlw	0.50h	25h	451	-0.310	0.489	0.379	5.1	69.8	0.7	0.0	0.0	

Table B.8. Buffalo Bluff

Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
H			87121	0.056								
h			87121	0.000								
H-h	15 cm	24h	87121	0.056	0.069	0.040	0.0	99.3	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	629	0.032	0.036	0.015	0.0	100.0	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	643	0.055	0.060	0.024	0.0	100.0	0.0	0.0	0.0	
THW-thw	0.50h	25h	629	0.786	0.857	0.340	0.0	19.2	28.9	0.0	161.1	
TLW-tlw	0.50h	25h	643	0.275	0.557	0.484	0.0	82.3	16.2	0.0	112.9	
SCENARIO: HINDCAST												
H			83392	0.125								
h			83392	0.041								
H-h	15 cm	24h	83392	0.083	0.107	0.068	0.1	84.2	0.1	3.0	2.7	0.17
HHW-hhw	15 cm	24h	573	0.079	0.097	0.056	0.0	89.7	0.0	0.0	0.0	
HLW-hlw	15 cm	24h	646	0.072	0.086	0.048	0.0	95.4	0.0	0.0	0.0	
THW-thw	0.50h	25h	573	0.437	0.746	0.605	2.1	40.8	18.7	24.8	74.6	
TLW-tlw	0.50h	25h	646	0.309	0.449	0.326	0.0	72.3	3.6	0.0	49.9	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
H			27791	0.131								
h			27791	0.161								
H-h	15 cm	24h	27791	-0.030	0.115	0.111	2.1	88.4	0.0	49.9	0.0	2.10
HHW-hhw	15 cm	24h	201	-0.012	0.094	0.093	1.5	93.5	0.0	23.9	0.0	
HLW-hlw	15 cm	24h	216	-0.053	0.123	0.111	2.8	87.0	0.0	49.4	0.0	
THW-thw	0.50h	25h	201	0.312	0.561	0.468	0.0	65.7	10.0	0.0	24.8	
TLW-tlw	0.50h	25h	216	0.114	0.358	0.340	0.0	85.6	3.2	0.0	12.3	
SCENARIO: SEMI-OPERATIONAL FORECAST												
H00-h00	15 cm	24h	467	-0.029	0.115	0.112	2.1	88.2	0.0	54.0	0.0	2.14
H06-h06	15 cm	24h	468	-0.030	0.115	0.112	2.1	88.0	0.0	54.0	0.0	2.14
H12-h12	15 cm	24h	469	-0.028	0.116	0.113	2.1	86.8	0.0	48.0	0.0	2.13
H18-h18	15 cm	24h	470	-0.027	0.125	0.122	2.6	86.2	0.0	42.0	0.0	2.34
H24-h24	15 cm	24h	471	-0.026	0.127	0.125	2.1	84.9	0.0	36.0	0.0	1.91
HHW-hhw	15 cm	24h	193	-0.009	0.096	0.096	1.6	92.2	0.0			
HLW-hlw	15 cm	24h	212	-0.048	0.117	0.107	2.4	88.2	0.0			
THW-thw	0.50h	25h	193	0.379	0.574	0.432	0.5	60.6	10.4			
TLW-tlw	0.50h	25h	212	0.469	0.562	0.310	0.5	50.9	2.4			
COMPARISON: PERSISTENCE FORECAST												
H00-h00	15 cm	24h	467	0.000	0.006	0.006	0.0	100.0	0.0	0.0	0.0	0.00
H06-h06	15 cm	24h	468	0.000	0.050	0.050	0.0	98.9	0.0	0.0	0.0	0.00
H12-h12	15 cm	24h	469	0.001	0.042	0.042	0.0	98.9	0.0	0.0	0.0	0.00
H18-h18	15 cm	24h	470	0.001	0.065	0.065	0.0	97.4	0.0	0.0	0.0	0.00
H24-h24	15 cm	24h	471	0.001	0.063	0.063	0.0	97.0	0.0	0.0	0.0	0.00
HHW-hhw	15 cm	24h	193	0.015	0.036	0.033	0.0	100.0	0.0			
HLW-hlw	15 cm	24h	158	0.000	0.026	0.026	0.0	100.0	0.0			
THW-thw	0.50h	25h	193	-0.490	0.806	0.641	21.2	29.5	2.6			
TLW-tlw	0.50h	25h	158	-0.388	0.632	0.500	13.3	55.1	0.0			
COMPARISON: ASTRONOMICAL TIDE ONLY												
H-h	15 cm	24h	28261	-0.187	0.244	0.157	25.9	39.5	0.0	133.7	0.0	0.00
HHW-hhw	15 cm	24h	201	-0.164	0.215	0.139	16.4	44.8	0.0	99.8	0.0	
HLW-hlw	15 cm	24h	188	-0.191	0.253	0.167	31.4	39.4	0.0	160.2	0.0	
THW-thw	0.50h	25h	201	-0.437	0.778	0.645	20.9	35.8	2.5	97.8	0.0	
TLW-tlw	0.50h	25h	188	-0.407	0.699	0.570	14.9	45.7	2.1	36.5	0.0	

APPENDIX C. Comparison of Current Harmonic Constants

Table C.1. Mayport Basin Entrance (J2)

Observation: 29-Day H.A. Beginning 6- 3-1998 at Hour 15.40
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are in degrees, referenced to UTC (GMT)

N	Constituent	Observed(R= 0.02) Amplitude	Observed Epoch	Modeled(R= 0.000) Amplitude	Modeled Epoch	Difference Amplitude	Difference Epoch
CURRENT ALONG PCD		DIR= 82		DIR= 94			
1	M(2)	0.656	178.2	0.531	177.9	-0.125	-0.3
2	S(2)	0.059	174.0	0.076	197.7	0.017	23.7
3	N(2)	0.088	157.7	0.113	157.5	0.025	-0.2
4	K(1)	0.057	333.2	0.050	354.1	-0.007	20.9
5	M(4)	0.019	157.6	0.034	304.7	0.015	147.1
6	O(1)	0.027	1.1	0.034	9.5	0.007	8.4
7	M(6)	0.030	67.2	0.031	41.7	0.001	-25.5
8	MK(3)	0.000	0.0	0.009	176.4	0.000	0.0
9	S(4)	0.009	261.3	0.005	97.8	-0.004	-163.5
10	MN(4)	0.000	0.0	0.011	294.5	0.000	0.0
11	NU(2)	0.017	160.4	0.024	158.2	0.007	-2.2
12	S(6)	0.007	97.4	0.000	0.0	-0.007	-97.4
13	MU(2)	0.000	0.0	0.002	96.2	0.000	0.0
14	2N(2)	0.012	137.2	0.012	139.0	0.000	1.8
15	OO(1)	0.001	305.2	0.002	343.1	0.001	37.9
16	LAMDA(2)	0.005	176.3	0.010	202.7	0.005	26.4
17	S(1)	0.000	0.0	0.007	313.2	0.000	0.0
18	M(1)	0.002	347.1	0.001	81.1	-0.001	94.0
19	J(1)	0.002	319.3	0.002	306.2	0.000	-13.1
20	MM	0.000	0.0	0.008	20.3	0.000	0.0
21	SSA	0.000	0.0	0.002	114.7	0.000	0.0
22	SA	0.000	0.0	0.001	253.5	0.000	0.0
23	MSF	0.000	0.0	0.009	348.5	0.000	0.0
24	MF	0.000	0.0	0.002	70.4	0.000	0.0
25	RHO(1)	0.001	13.1	0.001	26.8	0.000	13.7
26	Q(1)	0.005	14.9	0.005	9.1	0.000	-5.8
27	T(2)	0.003	174.2	0.007	172.5	0.004	-1.7
28	R(2)	0.000	173.9	0.004	84.3	0.000	0.0
29	2Q(1)	0.001	28.8	0.000	0.0	-0.001	-28.8
30	P(1)	0.019	335.3	0.016	355.1	-0.003	19.8
31	2SM(2)	0.000	0.0	0.001	210.4	0.000	0.0
32	M(3)	0.000	0.0	0.006	335.2	0.000	0.0
33	L(2)	0.013	157.7	0.040	184.9	0.027	27.2
34	2MK3(3)	0.000	0.0	0.011	203.4	0.000	0.0
35	K(2)	0.016	173.7	0.020	192.9	0.004	19.2
36	M(8)	0.004	158.7	0.007	167.2	0.003	8.5
37	MS(4)	0.000	0.0	0.012	315.7	0.000	0.0

Table C.2. Dames Point Bridge (J5)

Observation: 15-Day H.A. Beginning 7-23-1998 at Hour 16.00
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are in degrees, referenced to UTC (GMT)

		Observed(R= 0.02)		Modeled(R= 0.000)		Difference	
N	Constituent	Amplitude	Epoch	Amplitude	Epoch	Amplitude	Epoch
CURRENT ALONG PCD		DIR= 76		DIR= 80			
1	M(2)	0.868	224.7	0.670	223.2	-0.198	-1.5
2	S(2)	0.109	260.0	0.087	242.0	-0.022	-18.0
3	N(2)	0.168	205.7	0.134	201.4	-0.034	-4.3
4	K(1)	0.077	5.9	0.075	18.2	-0.002	12.3
5	M(4)	0.071	177.7	0.013	62.0	-0.058	-115.7
6	O(1)	0.020	74.7	0.051	29.8	0.031	-44.9
7	M(6)	0.037	216.6	0.022	120.2	-0.015	-96.4
8	MK(3)	0.000	0.0	0.014	262.3	0.000	0.0
9	S(4)	0.005	287.1	0.004	163.7	-0.001	-123.4
10	MN(4)	0.000	0.0	0.006	82.1	0.000	0.0
11	NU(2)	0.033	208.3	0.031	205.5	-0.002	-2.8
12	S(6)	0.004	348.4	0.000	0.0	-0.004	11.6
13	MU(2)	0.000	0.0	0.010	56.6	0.000	0.0
14	2N(2)	0.022	186.8	0.014	176.9	-0.008	-9.9
15	OO(1)	0.001	297.1	0.002	10.1	0.001	73.0
16	LAMDA(2)	0.006	241.1	0.016	250.0	0.010	8.9
17	S(1)	0.000	0.0	0.010	339.2	0.000	0.0
18	M(1)	0.001	40.3	0.002	104.0	0.001	63.7
19	J(1)	0.002	331.5	0.002	303.0	0.000	-28.5
20	MM	0.000	0.0	0.011	19.8	0.000	0.0
21	SSA	0.000	0.0	0.002	133.6	0.000	0.0
22	SA	0.000	0.0	0.002	277.8	0.000	0.0
23	MSF	0.000	0.0	0.014	348.5	0.000	0.0
24	MF	0.000	0.0	0.003	94.6	0.000	0.0
25	RHO(1)	0.001	104.2	0.002	48.5	0.001	-55.7
26	Q(1)	0.004	109.1	0.008	30.0	0.004	-79.1
27	T(2)	0.006	260.0	0.008	214.3	0.002	-45.7
28	R(2)	0.001	260.0	0.005	124.8	0.004	-135.2
29	2Q(1)	0.001	143.5	0.000	0.0	-0.001	-143.5
30	P(1)	0.026	5.9	0.024	20.6	-0.002	14.7
31	2SM(2)	0.000	0.0	0.001	229.5	0.000	0.0
32	M(3)	0.000	0.0	0.009	28.7	0.000	0.0
33	L(2)	0.024	243.6	0.061	237.1	0.037	-6.5
34	2MK3(3)	0.000	0.0	0.018	274.8	0.000	0.0
35	K(2)	0.030	260.0	0.023	238.1	-0.007	-21.9
36	M(8)	0.017	52.1	0.003	312.0	-0.014	100.1
37	MS(4)	0.000	0.0	0.003	42.8	0.000	0.0

Table C.3. Trout River Cut (J6)

Observation: 29-Day H.A. Beginning 7-22-1998 at Hour 16.40
Model: Least Squares H.A. Beginning 1- 2-1998 at Hour 0.00
Phases are in degrees, referenced to UTC (GMT)

		Observed(R= 0.02)		Modeled(R= 0.005)		Difference	
N	Constituent	Amplitude	Epoch	Amplitude	Epoch	Amplitude	Epoch
CURRENT ALONG PCD		DIR= 15		DIR= 17			
1	M(2)	0.647	252.1	0.558	244.3	-0.089	-7.8
2	S(2)	0.071	272.9	0.066	268.3	-0.005	-4.6
3	N(2)	0.091	222.1	0.107	225.5	0.016	3.4
4	K(1)	0.078	30.9	0.061	28.3	-0.017	-2.6
5	M(4)	0.027	53.1	0.016	314.2	-0.011	98.9
6	O(1)	0.051	43.3	0.042	38.2	-0.009	-5.1
7	M(6)	0.043	210.5	0.018	185.7	-0.025	-24.8
8	MK(3)	0.000	0.0	0.009	286.7	0.000	0.0
9	S(4)	0.004	260.2	0.002	216.2	-0.002	-44.0
10	MN(4)	0.000	0.0	0.007	273.9	0.000	0.0
11	NU(2)	0.018	226.1	0.027	224.8	0.009	-1.3
12	S(6)	0.004	78.7	0.000	0.0	-0.004	-78.7
13	MU(2)	0.000	0.0	0.013	37.6	0.000	0.0
14	2N(2)	0.012	192.1	0.009	201.7	-0.003	9.6
15	OO(1)	0.002	18.4	0.002	24.1	0.000	5.7
16	LAMDA(2)	0.005	261.7	0.015	262.7	0.010	1.0
17	S(1)	0.000	0.0	0.008	349.2	0.000	0.0
18	M(1)	0.004	37.1	0.002	107.0	-0.002	69.9
19	J(1)	0.004	24.7	0.001	293.4	-0.003	91.3
20	MM	0.000	0.0	0.007	22.3	0.000	0.0
21	SSA	0.000	0.0	0.002	155.9	0.000	0.0
22	SA	0.000	0.0	0.002	309.8	0.000	0.0
23	MSF	0.000	0.0	0.010	345.4	0.000	0.0
24	MF	0.000	0.0	0.002	103.7	0.000	0.0
25	RHO(1)	0.002	48.7	0.002	56.1	0.000	7.4
26	Q(1)	0.010	49.5	0.007	38.0	-0.003	-11.5
27	T(2)	0.004	272.1	0.006	245.7	0.002	-26.4
28	R(2)	0.001	273.7	0.003	145.4	0.002	-128.3
29	2Q(1)	0.001	55.7	0.000	0.0	-0.001	-55.7
30	P(1)	0.026	31.8	0.019	33.0	-0.007	1.2
31	2SM(2)	0.000	0.0	0.000	0.0	0.000	0.0
32	M(3)	0.000	0.0	0.007	58.1	0.000	0.0
33	L(2)	0.013	222.1	0.060	253.1	0.047	31.0
34	2MK3(3)	0.000	0.0	0.014	293.0	0.000	0.0
35	K(2)	0.019	274.6	0.019	264.8	0.000	-9.8
36	M(8)	0.014	286.6	0.003	265.8	-0.011	-20.8
37	MS(4)	0.000	0.0	0.006	344.6	0.000	0.0

APPENDIX D. Skill Assessment Scores of Current Speed

Table D.1. Mayport Basin Entrance (J2)

Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
U			87121	0.367								
u			87121	0.446								
U-u	26 cm/s	24h	87121	-0.079	0.117	0.087	0.0	98.6	0.0	0.0	0.0	
AFC-afc	26 cm/s	24h	702	-0.214	0.216	0.034	0.0	90.5	0.0	0.0	0.0	
AEC-aec	26 cm/s	24h	701	-0.056	0.066	0.034	0.0	100.0	0.0	0.0	0.0	
TFC-tfc	0.50h	25h	702	0.025	0.400	0.399	0.0	74.2	0.0	0.0	0.0	
TEC-tec	0.50h	25h	701	-0.348	0.400	0.198	0.0	72.3	0.0	0.0	0.0	
TSF-tsf	0.25h	25h	697	-0.264	0.405	0.306	1.0	77.0	0.0	12.8	0.0	
TEF-tef	0.25h	25h	701	0.210	0.377	0.313	0.0	79.3	0.0	0.0	0.0	
TSE-tse	0.25h	25h	701	-0.057	0.279	0.273	0.6	92.0	0.0	0.0	0.0	
TEE-tee	0.25h	25h	701	0.055	0.264	0.259	0.0	92.6	0.0	0.0	0.0	
SCENARIO: HINDCAST												
U			11512	0.464								
u			11512	0.448								
U-u	26 cm/s	24h	11512	0.016	0.176	0.175	0.0	84.7	0.0	0.0	0.0	
AFC-afc	26 cm/s	24h	75	-0.128	0.158	0.094	0.0	89.3	0.0	0.0	0.0	
AEC-aec	26 cm/s	24h	75	0.098	0.136	0.095	0.0	93.3	0.0	0.0	0.0	
TFC-tfc	0.50h	25h	75	0.348	0.576	0.462	0.0	50.7	4.0	0.0	24.7	
TEC-tec	0.50h	25h	75	0.563	0.684	0.392	0.0	42.7	13.3	0.0	12.7	
TSF-tsf	0.25h	25h	74	0.759	0.809	0.281	0.0	14.9	18.9	0.0	24.7	
TEF-tef	0.25h	25h	75	0.534	0.564	0.183	0.0	41.3	1.3	0.0	0.0	
TSE-tse	0.25h	25h	85	0.178	0.369	0.325	1.2	87.1	1.2	0.0	0.0	
TEE-tee	0.25h	25h	86	0.347	0.437	0.267	0.0	67.4	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
U			9665	0.476								
u			9665	0.328								
U-u	26 cm/s	24h	9665	0.148	0.306	0.268	0.1	68.6	12.4	0.2	3.2	
AEC-aec	26 cm/s	24h	70	0.394	0.427	0.166	0.0	20.0	22.9	0.0	22.1	
TEC-tec	0.50h	25h	70	0.764	0.837	0.343	1.4	8.6	14.3	0.0	13.0	
TSE-tse	0.25h	25h	23	0.023	0.816	0.834	8.7	34.8	21.7	0.0	0.0	
TEE-tee	0.25h	25h	67	0.080	0.355	0.348	0.0	89.6	3.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
U00-u00	26 cm/s	24h	161	0.141	0.296	0.261	0.0	70.2	12.4	0.0	0.0	
U06-u06	26 cm/s	24h	161	0.124	0.296	0.270	0.0	71.4	11.2	0.0	0.0	
U12-u12	26 cm/s	24h	161	0.146	0.314	0.279	0.0	68.9	13.0	0.0	0.0	
U18-u18	26 cm/s	24h	161	0.148	0.308	0.271	0.0	71.4	12.4	0.0	0.0	
U24-u24	26 cm/s	24h	161	0.147	0.320	0.285	0.6	71.4	13.7	0.0	0.0	
AEC-aec	26 cm/s	24h	69	0.414	0.444	0.164	0.0	15.9	24.6	0.0	22.1	
TEC-tec	0.50h	25h	69	0.728	0.831	0.404	1.4	21.7	26.1	0.0	13.2	
TSE-tse	0.25h	25h	15	0.179	1.003	1.022	20.0	33.3	33.3	0.0	0.0	
TEE-tee	0.25h	25h	67	0.357	0.516	0.376	0.0	71.6	7.5	0.0	0.0	

COMPARISON: PERSISTENCE FORECAST

U00-u00	26 cm/s	24h	161	0.005	0.055	0.055	0.0	100.0	0.0	0.0	0.0
U06-u06	26 cm/s	24h	161	0.006	0.148	0.149	0.6	91.3	0.0	0.0	0.0
U12-u12	26 cm/s	24h	161	0.006	0.103	0.103	0.0	98.8	0.0	0.0	0.0
U18-u18	26 cm/s	24h	161	0.006	0.146	0.146	0.0	90.7	0.0	0.0	0.0
U24-u24	26 cm/s	24h	161	0.007	0.124	0.124	0.0	95.0	0.0	0.0	0.0
AEC-aec	26 cm/s	24h	62	0.012	0.118	0.118	0.0	95.2	0.0	0.0	0.0
TEC-tec	0.50h	25h	62	-0.015	0.398	0.401	3.2	79.0	1.6	0.0	0.0
TSE-tse	0.25h	25h	40	0.166	0.817	0.810	10.0	47.5	15.0	0.0	23.9
TEE-tee	0.25h	25h	58	-0.364	0.647	0.540	13.8	58.6	1.7	49.5	0.0

COMPARISON: ASTRONOMICAL TIDE ONLY

U-u	26 cm/s	24h	9665	-0.021	0.101	0.099	0.1	98.2	0.0	0.5	0.0
AEC-aec	26 cm/s	24h	73	-0.034	0.096	0.091	0.0	100.0	0.0	0.0	0.0
TEC-tec	0.50h	25h	73	-0.049	0.370	0.369	2.7	80.8	0.0	0.0	0.0
TSE-tse	0.25h	25h	48	-0.136	0.793	0.789	16.7	37.5	6.3	0.0	0.0
TEE-tee	0.25h	25h	71	-0.033	0.362	0.363	0.0	88.7	1.4	0.0	0.0

Table D.2. Dames Point Bridge (J5)

Observed data time period from: / 7/23/1998 to / 8/15/1998
Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
U			87121	0.463								
u			87121	0.591								
U-u	26 cm/s	24h	87121	-0.128	0.181	0.128	0.0	83.8	0.0	0.0	0.0	
AFC-afc	26 cm/s	24h	700	-0.208	0.227	0.093	0.0	72.4	0.0	0.0	0.0	
AEC-aec	26 cm/s	24h	701	-0.264	0.273	0.066	0.0	54.4	0.0	0.0	0.0	
TFC-tfc	0.50h	25h	700	0.368	0.430	0.222	0.0	69.9	0.0	0.0	0.0	
TEC-tec	0.50h	25h	701	-0.079	0.203	0.187	0.0	98.7	0.0	0.0	0.0	
TSF-tsf	0.25h	25h	698	-0.408	0.484	0.261	0.4	65.5	0.0	0.0	0.0	
TEF-tef	0.25h	25h	700	0.044	0.253	0.249	0.0	94.9	0.0	0.0	0.0	
TSE-tse	0.25h	25h	700	0.154	0.251	0.199	0.0	95.3	0.0	0.0	0.0	
TEE-tee	0.25h	25h	700	0.037	0.190	0.186	0.0	99.6	0.0	0.0	0.0	
SCENARIO: HINDCAST												
U			5418	0.561								
u			5418	0.563								
U-u	26 cm/s	24h	5418	-0.002	0.128	0.128	0.0	94.6	0.0	0.0	0.0	
AFC-afc	26 cm/s	24h	36	0.039	0.137	0.134	0.0	100.0	0.0	0.0	0.0	
AEC-aec	26 cm/s	24h	43	-0.040	0.082	0.073	0.0	97.7	0.0	0.0	0.0	
TFC-tfc	0.50h	25h	36	0.372	0.475	0.299	0.0	50.0	0.0	0.0	0.0	
TEC-tec	0.50h	25h	43	0.267	0.601	0.544	0.0	55.8	11.6	0.0	0.0	
TSF-tsf	0.25h	25h	36	0.119	0.289	0.268	0.0	91.7	0.0	0.0	0.0	
TEF-tef	0.25h	25h	36	0.224	0.346	0.268	0.0	91.7	0.0	0.0	0.0	
TSE-tse	0.25h	25h	39	0.334	0.433	0.280	0.0	71.8	5.1	0.0	0.0	
TEE-tee	0.25h	25h	39	0.227	0.314	0.219	0.0	84.6	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
U			14427	0.581								
u			14427	0.498								
U-u	26 cm/s	24h	14427	0.083	0.249	0.235	1.0	67.7	1.9	1.5	1.4	
AFC-afc	26 cm/s	24h	111	0.183	0.229	0.137	0.0	68.5	0.0	0.0	0.0	
AEC-aec	26 cm/s	24h	110	0.066	0.097	0.072	0.0	99.1	0.0	0.0	0.0	
TFC-tfc	0.50h	25h	111	0.131	0.490	0.474	0.9	79.3	8.1	0.0	24.9	
TEC-tec	0.50h	25h	110	-0.591	0.838	0.597	20.9	24.5	2.7	13.2	0.0	
TSF-tsf	0.25h	25h	114	-0.717	0.860	0.478	24.6	21.1	0.0	87.9	0.0	
TEF-tef	0.25h	25h	115	-0.529	0.706	0.470	6.1	20.9	0.9	24.9	0.0	
TSE-tse	0.25h	25h	116	-0.061	0.465	0.463	0.0	68.1	1.7	0.0	0.0	
TEE-tee	0.25h	25h	116	-0.778	0.889	0.432	34.5	15.5	0.0	137.8	0.0	

SCENARIO: SEMI-OPERATIONAL FORECAST											
U00-u00	26 cm/s	24h	241	0.087	0.254	0.239	0.8	68.0	2.1	0.0	0.0
U06-u06	26 cm/s	24h	241	0.078	0.218	0.204	0.4	75.9	0.8	0.0	0.0
U12-u12	26 cm/s	24h	241	0.093	0.243	0.225	0.4	70.1	2.9	0.0	0.0
U18-u18	26 cm/s	24h	241	0.080	0.232	0.218	0.4	73.4	0.4	0.0	0.0
U24-u24	26 cm/s	24h	241	0.089	0.243	0.227	0.8	72.6	2.9	0.0	6.0
AFC-afc	26 cm/s	24h	107	0.185	0.244	0.160	0.0	63.6	0.0	0.0	0.0
AEC-aec	26 cm/s	24h	112	0.068	0.108	0.084	0.0	97.3	0.0	0.0	0.0
TFC-tfc	0.50h	25h	107	0.229	0.511	0.459	0.9	71.0	5.6	0.0	62.2
TEC-tec	0.50h	25h	112	-0.368	0.686	0.581	11.6	45.5	5.4	12.4	12.7
TSF-tsf	0.25h	25h	114	-0.502	0.721	0.520	13.2	30.7	0.0	38.0	0.0
TEF-tef	0.25h	25h	114	-0.377	0.642	0.522	4.4	32.5	1.8	0.0	0.0
TSE-tse	0.25h	25h	115	0.062	0.490	0.488	0.9	71.3	5.2	0.0	12.5
TEE-tee	0.25h	25h	115	-0.553	0.714	0.455	7.0	27.8	0.0	0.0	0.0
COMPARISON: PERSISTENCE FORECAST											
U00-u00	26 cm/s	24h	241	0.007	0.071	0.071	0.0	99.6	0.0	0.0	0.0
U06-u06	26 cm/s	24h	241	0.008	0.161	0.161	0.4	91.3	0.8	0.0	0.0
U12-u12	26 cm/s	24h	241	0.008	0.154	0.154	0.0	92.1	0.8	0.0	0.0
U18-u18	26 cm/s	24h	241	0.008	0.160	0.161	0.0	92.1	0.8	0.0	0.0
U24-u24	26 cm/s	24h	241	0.008	0.153	0.153	0.0	90.9	0.8	0.0	0.0
AFC-afc	26 cm/s	24h	104	-0.037	0.158	0.154	0.0	90.4	0.0	0.0	0.0
AEC-aec	26 cm/s	24h	109	-0.003	0.143	0.144	0.0	91.7	0.0	0.0	0.0
TFC-tfc	0.50h	25h	104	0.227	0.509	0.458	1.0	71.2	5.8	0.0	37.7
TEC-tec	0.50h	25h	109	0.156	0.560	0.541	0.9	65.1	6.4	0.0	12.7
TSF-tsf	0.25h	25h	104	0.007	0.495	0.497	0.0	70.2	4.8	0.0	37.9
TEF-tef	0.25h	25h	102	0.169	0.478	0.449	0.0	72.5	4.9	0.0	12.3
TSE-tse	0.25h	25h	92	0.012	0.668	0.671	7.6	45.7	5.4	12.3	0.0
TEE-tee	0.25h	25h	102	0.079	0.469	0.465	0.0	65.7	2.9	0.0	24.8
COMPARISON: ASTRONOMICAL TIDE ONLY											
U-u	26 cm/s	24h	14427	-0.003	0.121	0.120	0.1	95.2	0.1	0.8	0.5
AFC-afc	26 cm/s	24h	107	-0.039	0.106	0.098	0.0	99.1	0.0	0.0	0.0
AEC-aec	26 cm/s	24h	112	-0.007	0.106	0.107	0.0	98.2	0.0	0.0	0.0
TFC-tfc	0.50h	25h	107	0.250	0.500	0.435	0.9	72.9	5.6	0.0	37.7
TEC-tec	0.50h	25h	112	0.144	0.544	0.527	0.0	64.3	5.4	0.0	12.7
TSF-tsf	0.25h	25h	115	0.100	0.466	0.457	0.9	80.9	7.8	0.0	37.7
TEF-tef	0.25h	25h	113	0.162	0.431	0.401	0.0	85.0	7.1	0.0	37.8
TSE-tse	0.25h	25h	115	0.158	0.445	0.418	0.0	79.1	4.3	0.0	0.0
TEE-tee	0.25h	25h	115	0.048	0.389	0.388	0.0	84.3	2.6	0.0	12.0

Table D.3. Trout River Cut (J6)

Observed data time period from: / 7/22/1998 to / 9/16/1998
Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
U			87121	0.390								
u			87121	0.443								
U-u	26 cm/s	24h	87121	-0.053	0.100	0.085	0.0	99.3	0.0	0.0	0.0	
AFC-afc	26 cm/s	24h	662	-0.073	0.095	0.060	0.0	100.0	0.0	0.0	0.0	
AEC-aec	26 cm/s	24h	701	-0.082	0.089	0.036	0.0	100.0	0.0	0.0	0.0	
TFC-tfc	0.50h	25h	662	-0.574	0.688	0.380	10.9	34.1	0.0	161.5	0.0	
TEC-tec	0.50h	25h	701	-0.070	0.175	0.160	0.0	99.4	0.0	0.0	0.0	
TSF-tsf	0.25h	25h	670	-0.212	0.302	0.215	0.1	91.9	0.0	0.0	0.0	
TEF-tef	0.25h	25h	675	-0.084	0.290	0.277	0.0	91.3	0.0	0.0	0.0	
TSE-tse	0.25h	25h	675	-0.534	0.585	0.238	1.3	43.4	0.0	24.9	0.0	
TEE-tee	0.25h	25h	675	-0.168	0.292	0.238	0.0	92.9	0.0	0.0	0.0	
SCENARIO: HINDCAST												
U			13419	0.505								
u			13419	0.452								
U-u	26 cm/s	24h	13419	0.052	0.142	0.133	0.0	97.0	0.0	0.0	0.0	
AFC-afc	26 cm/s	24h	84	0.037	0.107	0.101	0.0	98.8	0.0	0.0	0.0	
AEC-aec	26 cm/s	24h	106	0.165	0.172	0.047	0.0	97.2	0.0	0.0	0.0	
TFC-tfc	0.50h	25h	84	-0.761	0.902	0.488	34.5	23.8	0.0	37.6	0.0	
TEC-tec	0.50h	25h	106	0.325	0.575	0.476	0.0	45.3	4.7	0.0	0.0	
TSF-tsf	0.25h	25h	93	0.413	0.480	0.245	0.0	63.4	1.1	0.0	0.0	
TEF-tef	0.25h	25h	93	0.212	0.273	0.172	0.0	97.8	0.0	0.0	0.0	
TSE-tse	0.25h	25h	98	-0.471	0.519	0.219	2.0	56.1	0.0	0.0	0.0	
TEE-tee	0.25h	25h	98	-0.221	0.277	0.167	0.0	98.0	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
U			14409	0.525								
u			14409	0.391								
U-u	26 cm/s	24h	14409	0.134	0.258	0.221	0.0	61.0	0.7	0.0	0.9	
AFC-afc	26 cm/s	24h	111	0.022	0.080	0.078	0.0	99.1	0.0	0.0	0.0	
AEC-aec	26 cm/s	24h	115	0.338	0.340	0.039	0.0	1.7	0.0	0.0	0.0	
TFC-tfc	0.50h	25h	111	-0.795	0.897	0.418	31.5	17.1	0.0	37.5	0.0	
TEC-tec	0.50h	25h	115	-0.438	0.646	0.477	7.0	36.5	0.9	13.0	0.0	
TSF-tsf	0.25h	25h	115	-0.029	0.474	0.475	0.0	78.3	4.3	0.0	0.0	
TEF-tef	0.25h	25h	115	-0.580	0.688	0.371	3.5	21.7	0.0	0.0	0.0	
TSE-tse	0.25h	25h	116	-0.796	0.901	0.424	37.9	16.4	0.0	87.0	0.0	
TEE-tee	0.25h	25h	108	-1.168	1.230	0.387	83.3	16.7	0.0	633.0	0.0	

SCENARIO: SEMI-OPERATIONAL FORECAST											
U00-u00	26 cm/s	24h	240	0.136	0.260	0.222	0.0	62.1	1.3	0.0	0.0
U06-u06	26 cm/s	24h	240	0.133	0.232	0.191	0.0	65.0	0.0	0.0	0.0
U12-u12	26 cm/s	24h	240	0.134	0.250	0.211	0.0	63.3	0.8	0.0	0.0
U18-u18	26 cm/s	24h	240	0.135	0.237	0.196	0.0	65.4	0.0	0.0	0.0
U24-u24	26 cm/s	24h	240	0.135	0.247	0.207	0.0	63.8	0.8	0.0	0.0
AFC-afc	26 cm/s	24h	101	0.022	0.076	0.073	0.0	99.0	0.0	0.0	0.0
AEC-aec	26 cm/s	24h	115	0.325	0.328	0.042	0.0	5.2	0.0	0.0	0.0
TFC-tfc	0.50h	25h	101	-0.571	0.734	0.463	20.8	45.5	0.0	12.3	0.0
TEC-tec	0.50h	25h	115	-0.148	0.564	0.547	7.0	60.9	3.5	12.9	0.0
TSF-tsf	0.25h	25h	111	0.133	0.508	0.492	0.0	82.0	10.8	0.0	49.4
TEF-tef	0.25h	25h	113	-0.364	0.557	0.423	0.0	42.5	0.0	0.0	0.0
TSE-tse	0.25h	25h	115	-0.689	0.824	0.453	23.5	18.3	0.0	49.5	0.0
TEE-tee	0.25h	25h	110	-1.014	1.091	0.403	74.5	16.4	0.0	224.4	0.0
COMPARISON: PERSISTENCE FORECAST											
U00-u00	26 cm/s	24h	240	0.001	0.051	0.051	0.0	100.0	0.0	0.0	0.0
U06-u06	26 cm/s	24h	240	0.001	0.103	0.103	0.0	97.5	0.4	0.0	0.0
U12-u12	26 cm/s	24h	240	0.001	0.105	0.106	0.0	97.1	0.4	0.0	0.0
U18-u18	26 cm/s	24h	240	0.002	0.102	0.102	0.0	97.1	0.0	0.0	0.0
U24-u24	26 cm/s	24h	240	0.002	0.103	0.103	0.0	97.5	0.0	0.0	0.0
AFC-afc	26 cm/s	24h	113	0.002	0.106	0.106	0.0	98.2	0.0	0.0	0.0
AEC-aec	26 cm/s	24h	104	0.005	0.095	0.095	0.0	98.1	0.0	0.0	0.0
TFC-tfc	0.50h	25h	113	0.121	0.397	0.379	0.0	80.5	2.7	0.0	37.2
TEC-tec	0.50h	25h	104	0.273	0.557	0.487	0.0	61.5	5.8	0.0	12.8
TSF-tsf	0.25h	25h	100	-0.058	0.471	0.470	2.0	74.0	2.0	0.0	0.0
TEF-tef	0.25h	25h	104	0.107	0.409	0.397	0.0	79.8	2.9	0.0	0.0
TSE-tse	0.25h	25h	102	0.035	0.401	0.402	0.0	79.4	2.0	0.0	11.7
TEE-tee	0.25h	25h	102	0.091	0.395	0.386	1.0	83.3	2.0	0.0	0.0
COMPARISON: ASTRONOMICAL TIDE ONLY											
U-u	26 cm/s	24h	14409	-0.004	0.076	0.076	0.0	98.8	0.0	0.0	0.0
AFC-afc	26 cm/s	24h	116	-0.006	0.054	0.053	0.0	100.0	0.0	0.0	0.0
AEC-aec	26 cm/s	24h	111	0.001	0.038	0.038	0.0	100.0	0.0	0.0	0.0
TFC-tfc	0.50h	25h	116	0.098	0.370	0.358	0.0	82.8	3.4	0.0	37.2
TEC-tec	0.50h	25h	111	0.271	0.550	0.481	0.0	58.6	7.2	0.0	12.8
TSF-tsf	0.25h	25h	113	0.064	0.409	0.405	0.0	85.0	5.3	0.0	13.4
TEF-tef	0.25h	25h	115	0.130	0.376	0.355	0.0	87.8	3.5	0.0	0.0
TSE-tse	0.25h	25h	115	0.099	0.359	0.347	0.0	85.2	2.6	0.0	11.3
TEE-tee	0.25h	25h	115	0.122	0.345	0.325	0.0	87.0	2.6	0.0	11.5

APPENDIX E. Skill Assessment Scores of Current Direction

Table E.1. Mayport Basin Entrance (J2)

Observed data time period from: / 6/ 3/1998 to / 7/21/1998
Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
D			87121	179.482								
d			87121	167.451								
D-d	22.5 dg	24h	87121	12.031	13.651	6.451	0.0	98.4	0.0	0.0	0.0	
DFC-dfc	22.5 dg	24h	702	17.390	17.450	1.451	0.0	100.0	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	701	6.908	7.279	2.296	0.0	100.0	0.0	0.0	0.0	
SCENARIO: HINDCAST												
D			11512	178.071								
d			11512	165.367								
D-d	22.5 dg	24h	11512	12.705	15.115	8.190	0.0	91.3	0.0	0.0	0.0	
DFC-dfc	22.5 dg	24h	75	19.274	19.514	3.076	0.0	85.3	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	75	6.919	8.345	4.698	0.0	100.0	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
D			9665	192.372								
d			9665	136.018								
D-d	22.5 dg	24h	9665	9.430	31.800	30.371	2.7	77.8	11.9	2.9	3.6	
DEC-dec	22.5 dg	24h	72	9.253	13.395	9.753	0.0	97.2	1.4	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
D00-d00	22.5 dg	24h	161	7.734	27.211	26.170	9.3	58.4	32.3	0.0	0.0	
D06-d06	22.5 dg	24h	161	8.777	29.013	27.740	9.3	57.1	33.5	0.0	0.0	
D12-d12	22.5 dg	24h	161	7.595	29.007	28.082	13.7	54.0	31.1	12.0	0.0	
D18-d18	22.5 dg	24h	161	7.417	28.516	27.620	14.9	54.7	29.8	12.0	0.0	
D24-d24	22.5 dg	24h	161	7.549	28.738	27.815	13.0	55.3	31.1	12.0	0.0	
DEC-dec	22.5 dg	24h	69	9.276	12.939	9.087	0.0	98.6	1.4	0.0	0.0	
COMPARISON: PERSISTENCE FORECAST												
D00-d00	22.5 dg	24h	161	0.067	4.246	4.258	23.0	49.7	24.8	18.0	6.0	
D06-d06	22.5 dg	24h	161	-0.538	14.082	14.116	28.6	50.9	19.3	6.0	12.0	
D12-d12	22.5 dg	24h	161	-0.005	9.854	9.885	22.4	54.0	22.4	12.0	6.0	
D18-d18	22.5 dg	24h	161	-1.369	14.037	14.014	32.3	50.9	16.8	6.0	18.0	
D24-d24	22.5 dg	24h	161	0.017	7.812	7.837	23.6	51.6	23.6	12.0	18.0	
DEC-dec	22.5 dg	24h	73	-3.500	10.183	9.629	0.0	97.3	0.0	0.0	0.0	
COMPARISON: ASTRONOMICAL TIDE ONLY												
D-d	22.5 dg	24h	9665	-0.996	10.601	10.555	0.4	93.7	0.0	0.9	0.0	
DEC-dec	22.5 dg	24h	73	-0.981	6.937	6.915	0.0	98.6	0.0	0.0	0.0	

Table E.2. Dames Point Bridge (J5)

Observed data time period from: / 7/23/1998 to / 8/15/1998
Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
D			87121	163.937								
d			87121	159.375								
D-d	22.5 dg	24h	87121	4.562	6.346	4.412	0.0	100.0	0.0	0.0	0.0	
DFC-dfc	22.5 dg	24h	700	2.359	3.478	2.558	0.0	100.0	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	701	7.300	7.749	2.602	0.0	100.0	0.0	0.0	0.0	
SCENARIO: HINDCAST												
D			5418	160.431								
d			5418	152.316								
D-d	22.5 dg	24h	5418	8.116	10.839	7.186	0.0	97.6	0.0	0.0	0.0	
DFC-dfc	22.5 dg	24h	36	7.514	8.085	3.029	0.0	100.0	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	43	10.196	12.045	6.489	0.0	100.0	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
D			14427	166.018								
d			14427	153.047								
D-d	22.5 dg	24h	14427	7.472	14.332	12.231	0.3	93.4	0.4	0.3	1.0	
DFC-dfc	22.5 dg	24h	111	7.009	11.511	9.173	0.0	91.9	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	110	17.278	17.859	4.540	0.0	88.2	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
D00-d00	22.5 dg	24h	241	8.045	16.329	14.239	5.8	30.3	63.1	6.0	132.0	
D06-d06	22.5 dg	24h	241	8.891	12.937	9.417	2.5	32.4	64.3	0.0	108.0	
D12-d12	22.5 dg	24h	241	8.126	16.095	13.922	5.0	32.4	62.2	0.0	108.0	
D18-d18	22.5 dg	24h	241	8.165	16.035	13.829	4.1	31.5	62.2	0.0	126.0	
D24-d24	22.5 dg	24h	241	8.171	16.123	13.928	5.8	31.1	62.2	0.0	108.0	
DFC-dfc	22.5 dg	24h	107	8.593	13.424	10.362	0.0	90.7	0.9	0.0	0.0	
DEC-dec	22.5 dg	24h	112	16.778	17.392	4.601	0.0	89.3	0.0	0.0	0.0	
COMPARISON: PERSISTENCE FORECAST												
D00-d00	22.5 dg	24h	241	-0.054	5.468	5.479	34.4	25.7	34.9	30.0	42.0	
D06-d06	22.5 dg	24h	241	3.959	22.557	22.253	28.2	32.0	36.5	42.0	66.0	
D12-d12	22.5 dg	24h	241	-0.413	7.599	7.603	34.0	31.5	32.0	30.0	24.0	
D18-d18	22.5 dg	24h	241	3.540	26.251	26.066	27.8	31.5	39.0	42.0	54.0	
D24-d24	22.5 dg	24h	241	-0.886	11.771	11.762	34.4	30.7	32.8	30.0	30.0	
DFC-dfc	22.5 dg	24h	103	-1.029	11.575	11.586	0.0	95.1	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	112	0.566	6.749	6.756	0.0	100.0	0.0	0.0	0.0	
COMPARISON: ASTRONOMICAL TIDE ONLY												
D-d	22.5 dg	24h	14427	0.805	7.281	7.236	0.0	99.4	0.1	0.0	0.5	
DFC-dfc	22.5 dg	24h	107	-0.579	8.470	8.490	0.0	97.2	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	112	0.376	4.699	4.705	0.0	100.0	0.0	0.0	0.0	

Table E.3. Trout River Cut (J6)

Observed data time period from: / 7/22/1998 to / 9/16/1998
Data gap is filled using SVD method
Data are filtered using 3.0 Hour Fourier Filter

VARIABLE	X	N	IMAX	SM	RMSE	SD	NOF	CF	POF	MDNO	MDPO	WOF
CRITERION	-	-	-	-	-	-	<1%	>90%	<1%	<N	<N	<.5%
SCENARIO: TIDAL SIMULATION ONLY												
D			87121	100.023								
d			87121	97.751								
D-d	22.5 dg	24h	87121	2.273	6.918	6.534	0.0	100.0	0.0	0.0	0.0	
DFC-dfc	22.5 dg	24h	662	8.932	9.076	1.612	0.0	100.0	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	701	-0.624	3.563	3.511	0.0	100.0	0.0	0.0	0.0	
SCENARIO: HINDCAST												
D			13419	91.686								
d			13419	102.383								
D-d	22.5 dg	24h	13419	-3.378	13.822	13.403	0.3	97.5	0.0	3.2	0.0	
DFC-dfc	22.5 dg	24h	84	7.164	9.113	5.666	0.0	96.4	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	106	-5.564	8.576	6.557	0.0	99.1	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL NOWCAST												
D			14409	94.352								
d			14409	122.403								
D-d	22.5 dg	24h	14409	9.513	15.448	12.171	0.0	76.9	0.0	0.0	0.0	
DFC-dfc	22.5 dg	24h	111	33.062	33.256	3.603	0.0	0.9	0.9	0.0	0.0	
DEC-dec	22.5 dg	24h	115	7.471	8.371	3.792	0.0	100.0	0.0	0.0	0.0	
SCENARIO: SEMI-OPERATIONAL FORECAST												
D00-d00	22.5 dg	24h	240	9.351	15.445	12.318	5.8	35.4	57.9	0.0	108.0	
D06-d06	22.5 dg	24h	240	10.125	16.369	12.889	5.8	35.0	57.9	0.0	102.0	
D12-d12	22.5 dg	24h	240	9.421	15.492	12.324	4.6	35.8	57.9	0.0	102.0	
D18-d18	22.5 dg	24h	240	9.940	16.152	12.757	5.4	35.4	58.3	0.0	102.0	
D24-d24	22.5 dg	24h	240	9.588	15.648	12.393	4.6	36.7	57.5	0.0	102.0	
DFC-dfc	22.5 dg	24h	101	32.931	33.166	3.957	0.0	1.0	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	115	6.892	7.874	3.824	0.0	100.0	0.0	0.0	0.0	
COMPARISON: PERSISTENCE FORECAST												
D00-d00	22.5 dg	24h	240	-0.403	4.651	4.643	31.7	33.3	30.4	24.0	24.0	
D06-d06	22.5 dg	24h	240	-0.969	16.468	16.474	35.8	31.3	30.8	48.0	42.0	
D12-d12	22.5 dg	24h	240	0.406	7.701	7.707	33.3	35.0	30.4	42.0	12.0	
D18-d18	22.5 dg	24h	240	-0.849	17.084	17.099	32.9	34.6	30.0	30.0	24.0	
D24-d24	22.5 dg	24h	240	-0.023	6.335	6.349	33.3	34.2	31.3	48.0	18.0	
DFC-dfc	22.5 dg	24h	116	-0.401	5.929	5.941	0.0	100.0	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	110	-1.103	7.295	7.245	0.0	98.2	0.0	0.0	0.0	
COMPARISON: ASTRONOMICAL TIDE ONLY												
D-d	22.5 dg	24h	14409	-0.323	3.617	3.603	0.0	100.0	0.0	0.0	0.0	
DFC-dfc	22.5 dg	24h	116	-0.128	3.252	3.264	0.0	100.0	0.0	0.0	0.0	
DEC-dec	22.5 dg	24h	111	-1.508	3.555	3.233	0.0	100.0	0.0	0.0	0.0	