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Verification and Comparison of Two Commonly Used Numerical Modeling Systems in Hydrodynamic Simulation at a Dual-Inlet System, West-Central Florida

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Verification and Comparison of Two Commonly Used Numerical Modeling Systems in Hydrodynamic Simulation at a Dual-Inlet System, West-Central Florida

by

Ming Xie

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science
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ABSTRACT

Numerical modeling systems are very important tools to study tidal inlets. In order to test its capability and accuracy of solving multi-inlet system problems, this study selected two widely used numerical modeling systems: Coastal Modeling System (CMS) and Delft3D Modeling Package. The hydrodynamics modules of the two modeling systems were tested at John’s Pass and Blind Pass, Florida, a dual-inlets system, based on a similar modeling scheme. Detailed bathymetric surveys and hydraulic measurements were conducted to collect water depths, tide conditions, wave and current velocities as the input data as well as verification data for the models.

A comparison study was conducted by comparing computed hydrodynamic results from both models with the extensive field measurement data. Results show that both of the modeling systems yield better prediction for water levels than for current velocity. Furthermore, under the similar modeling scheme, Delft3D was able to capture the measured tidal phase lag between the ocean boundary and the coastal inlet, therefore gave better water level prediction than the CMS model. However, the CMS yielded current velocities that are closer to the measured values than the DELFT3D model. CMS has a more user-friendly Graphic User’s Interface (GUI) for input data preprocessing and plotting and visualization of output data. Delft3D has faster calculation speed.
INTRODUCTION

Tidal inlets, as described by FitzGerald (1993), are gaps in the shoreline (often associated with barrier islands) where water flows through during flood and ebb tides, creating a connection between the ocean and back bays or lagoons. Tidal inlets located between the coastal ocean and barrier-island back bays serve as a transitional pathway between the two different environments. As a consequence, tidal inlets are influenced by wave and tide conditions of the ocean environment, and typically have various morphologic features ranging from deep channels to shallow shoals (Wang et al., 2011). Driven by complicated hydrodynamic, meteorological and morphological factors, tidal inlets are one of the most dynamic zones along the coasts. More than 80% of the erosion along Florida coast can be directly linked to tidal inlets (Dean, 1988). Humans have utilized tidal inlets as navigation channels for hundreds of years. By applying anthropogenic activities, such as beach nourishment, inlet stabilization, and jetty and bridge construction, the nature of tidal inlet systems has become more complicated. As a consequence, an in-depth and quantitative understanding and prediction of tidal inlet systems plays an important role in coastal management.

With the growth of computational technology, mathematical modeling has become a powerful tool for the study of inlet systems. Many different hydrodynamic modeling codes have been developed and improved to a stable and mature status, and widely used for both academic study and practical applications. Despite the fact that several widely-used models have been
utilized and tested at numerous coastal inlets, a modeler typically uses only one model in one case, thus, comparisons between different models haven’t been accomplished or well-documented. Furthermore, most models are designed for ideal single-inlet systems. Thus, their capacity and accuracy for calculating and predicting the response of multiple-inlet systems needs to be further examined.

In this study, John’s Pass and Blind Pass, a dual-inlets system, is chosen for the comparison study to test the models’ capacity of solving multiple-inlets problems. The two inlets are six kilometers apart and connected by Boca Ciega Bay. Intensive bathymetric surveys and hydraulic measurements were conducted in the inlet channel, Boca Siega Bay and adjacent beaches to acquire precise input, calibration and verification data for the models. Two widely used models, CMS (Coastal Modeling System), Delft3D are examined in this study. Their performance and results from the hydrodynamic modules (tidal flows and waves) are compared using the same study area, input parameters and modeling scheme. Specifically, the objectives of this study are to 1) examine the models’ capability and accuracy, especially for resolving multiple-inlets problems; 2) making a comparison of two widely-used hydraulic portions of the models, by comparing their computation results with the extensive field datasets.
CMS (Coastal Modeling System) Model Review

Coastal Modeling System (CMS), is developed and supported by the US Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory’s (CHL) Coastal Inlets Research Program (CIRP). Originated as a 1D hydrodynamic model for a class project, CMS has developed into an integrated coastal inlet modeling software package for simulating tides, currents, waves, sediment transport and morphology changes. With the growth of the modeling functions, Surface Water Modeling System (SMS), a graphical interface, was created to provide a user friendly platform for model grid construction, data pre-processing, visualizing results and exporting to other software tools.

The CMS consists of two modules, CMS-Flow and CMS-Wave. CMS-Flow calculates the depth-averaged flow field, including water elevation and current velocity, and the sediment transport, salinity transport and morphology change induced by the flow and wave field. CMS-Wave is a spectral wave transformation model that simulates the wave motions (shoaling, breaking, refraction and reflection) and output wave parameters including wave height and wave period. Wave-breaking parameters, including wave-height dissipation and radiation stress, are calculated. The two modules can work independently or interactively by exchanging information and results in a steering run (shown in Figure 1). CMS has been used in over 80 projects within
the U.S. and more internationally (Reed et al. 2011). Numerous researchers and engineers have adopted CMS as the preferred tool in academic studies and inlet management projects (Beck and Kraus, 2011, Connell and Zarillo, 2011, Sanchez and Wu, 2011, Dabees and Moore, 2011, Wang et al., 2011).

Some recent model enhancements, including the improvement of wave adjusted boundary condition, an additional implicit solver and the introducing of quad-tree grid, or telescoping grid structure (Reed et al. 2011), further improve the capability, reliability and computational speed of the CMS model. All of the three improvements mentioned here were utilized in this study.

Figure 1. CMS framework and its components (from Alejandro et al. 2012)
**Delft3D Model Review**

Delft3D is a modeling package developed by WL|Delft Hydraulics in close cooperation with Delft University of Technology. Based on a quasi-3D modeling approach, Delft3D allows users to simulate hydrodynamic processes, transport of water-borne constituents (e.g., salinity and heat), wave propagation and morphological changes (Lesser et al. 2004).

The Delft3D modeling package consists of a number of cooperating modules acting as stand-alone programs that communicate via files. Delft3D-FLOW, which is the hydrodynamic calculation and simulation module, is the core of Delft3D modeling package. The Delft3D-FLOW module calculates non-steady flow and transport resulting from a large number of processes, for example, tide, wind, wave, salinity and temperature gradient, air pressure change, etc. This provides Delft3D-FLOW the capability of handling a wide range of modeling situations (river, wetland, estuarine, coastal inlet, etc.). The wave module in the Delft3D modeling package is calculated by Delft3D-WAVE, which is based on SWAN models (Booji et al. 1999). In a flow and wave steering run, the wave parameter, mainly the radiation stress, calculated from Delft3D-WAVE is used as input for Delft3D-FLOW to compute long-shore current and wave-driven sediment transport. Delft3D has also been applied to numerous projects at tidal inlet and estuary areas all over the world (Hu et al, 2009, Chanudet et al, 2012, Harcourt-Baldwin and Diedericks, 2006, Brown et al, 2014, Elias et al, 2006).
STUDY AREA

John’s Pass and Blind Pass are located in west-central Florida, Pinellas County. As shown in Figure 2, the study area includes the barrier island chain, from north to south, of Sand Key, Treasure Island and Long Key. John’s Pass is the more northerly inlet between Sand Key and Treasure Island, and Blind Pass is to the south between Treasure Island and Long Key. The two inlets are connected by Boca Ciega Bay, forming the dual-inlets system in this study. John’s Pass is the larger of the two inlets, of which the narrowest part of the main channel is about 170 meters wide. The inlet mouth opens to southwest direction. There are three natural islands behind the inlet entrance. Small channels are between the islands and extend into the back bay. Blind Pass is the smaller one of the two inlets. The inlet mouth also opens to southwest direction. But after the short inlet mouth (about 100 meters), the channel becomes narrow and turns northwest direction. The inlet mouth is about 100 meters wide and the narrowest part of the Blind Pass main channel is 70 meters wide. Due to the different sizes of the two inlets, John’s Pass plays a more significant role in terms of tidal prism in this dual-inlet system. According to the previous research, John’s Pass captures roughly 80% of the total tidal prism of the two inlets (Wang et al., 2012), and has a relatively large ebb delta.
Figure 2. Study Area: The dual-inlet system of John’s Pass and Blind Pass

Opened by a hurricane in 1848, John’s Pass was a natural inlet until 1926, when hard engineering structures were introduced into the Boca Ciega Bay area. Bridges, causeways and jetties were built in the channel and along the coast around the inlets. Artificial islands were constructed in the back bay, and the water surface area of Boca Ciega Bay decreased by 30%~40% by the 1970s. After that, most modifications were soft engineering within the area of the inlets, including dredging and beach renourishment. As a result of the opening of John’s Pass and subsequent capture of most of the tidal prism, Blind Pass became unstable and started to migrate southward continuously (Figure 3) until it was artificially stabilized in 1937. Blind Pass is one of the most heavily structured tidal inlets along the west-central Florida coasts (Davis and Bernard, 2003). Although the construction stopped the migration, it didn’t solve all the problems.
Longshore sediment transport deposited in the northern part of the inlet and filled in the channel. Dredging only keeps the channel open for couple years. As a result, there has been a cycle of filling and dredging since 1960s.

Figure 3. Blind Pass Migration (from Davis, 2003)
METHODOLOGY

Data Collection

Numerous field surveys were conducted to collect detailed data for input to the models. The data surveys can be generally classified as two types: bathymetric surveys and hydrodynamic measurements. Bathymetric surveys, including ship-mounted single-beam/multi-beam echo sounder surveys, beach profile surveys, offshore bathymetry surveys, shoreline surveys and external bathymetry resources (for example, Coastal Relief Model from NOAA), provided the models with detailed bathymetry data for grid construction and bathymetry interpolation. A series of wave and tide gauges were deployed at the models’ domain boundary, tidal inlet channels and key back bay locations to collect hydrodynamic data for model input data, verification and calibration of the model results.

Inlet channel, ebb delta, and back bay bathymetry was surveyed with a ship-mounted echo sounder synchronized with a Trimble RTK GPS (Real-Time Kinematic Global Positioning System). Two types of echo sounder were used in the study: single-beam, which has a downward looking angle of 2.8 degrees, and multi-beam, which has a downward looking angle as wide as 120 degrees. Thus, with the pitch-and-roll compensation module built in, the multi-beam echo sounder is able to acquire precise and detailed bathymetry swaths while the ship is moving. The single-beam echo sounder, however, acquires a single, narrow survey line under the same
conditions. John’s Pass and Blind Pass inlet channels and ebb deltas were surveyed in great detail and precision with multi-beam echo sounder. The acquired bathymetric data were processed with PDS2000 software. Flood shoal and back bay bathymetry data is a combination of single-beam survey data collected in 2008 and multi-beam surveys conducted in July, 2014. Single-beam surveys were also used for offshore surveys of beach profiles. HYPACK software was used to manage and process the single-beam survey data.

Beach profile surveys were conducted to get nearshore bathymetry. The location of the survey lines are referenced to the bench marks established by US Army Corps of Engineers and Florida Department of Natural Resources every 1000 feet (300 m) along the coast. The survey lines were set on the bench marks and extended offshore perpendicular to the. The dry beach and nearshore beach profile surveys were acquired with a Topcon Electronic Total Station GTS-240, and the offshore portion of the survey was surveyed with a ship-mounted single-beam echo sounder. The near shore beach profile survey conducted with the Total Station extended to a water depth of approximately 3 meters, so that the survey point overlapped with the echo sounder surveys. This method serves both as quality control for each survey and also allows for the tidal correction of the ship mounted survey.

The shoreline was also surveyed to determine the land boundary for numerical models. The survey was conducted using an RTK-GPS system mounted to a 4-wheeler all-terrain vehicle (ATV) driving along the shoreline, recording location points every 2 meters. Dune line and high-high-water-line are measured in the shoreline survey. Location points were processed and plotted in ArcGIS software.
For the hydrodynamic measurements, numerous gauges were deployed in the field areas covered by the model domain (Figure 4). One Teledyne RD Instruments (TRDI) WorkHorse Sentinel Acoustic Doppler Current Profiler (ADCP) was deployed 7 kilometers away from the coast, collecting the input water elevation and wave forcing parameters for the model. Another two Sentinel ADCPs were deployed in each inlet channel to collect water level and current velocity data, which served as the verification and calibration data for the models. Two TRDI Channel Master Horizontal ADCPs were also deployed, one in each inlet to collect cross channel current profiles. A SonTek Triton ADV Directional Wave Gauge was installed 300 meters offshore in the middle of Treasure Island, to collect verification data for the wave models. Six In-Situ AquaTroll gauges were placed in the inlet channels and back bay providing detailed data for water level verifications. The measured water levels in the back bay also serve as input boundary conditions for the flow models. The flow field through the inlet channels and over parts of the ebb shoals and flood shoals was surveyed and mapped with a ship-mounted TRDI WorkHorse Monitor ADCP. The deployment time of hydrodynamic gauge is also shown in Figure 4. Considering the power and physical memory of the gauges, some of them were retrieved and redeployed for a couple times. The gap in the data is covered with external data, for example, water level data from NOAA’s National Buoy Data Center (NBDC) and wave data from U.S. Army corps of Engineers Research and Development Center, Coastal and Hydraulics Laboratory’s Wave Information Studies (WIS). The external data also helps to verified the measured data. The processed hydrodynamic data was able to cover the modeling duration from July 6th, 2014 till September 15th, 2014.
Figure 4. Hydrodynamic measurement sites

Numerical Modeling Schemes

Two commonly used models, CMS and Delft3D, are compared in this study. The domain of both models (Figure 5) is set as a rectangular area between 82.68°–82.88° W and 27.68°–27.88° N measuring 11100 meters across-shore and 17800 meters along shore, including John’s Pass, Blind Pass and most of Boca Ciega Bay. The north boundary of the model is North Park Boulevard, and the south boundary of the model is located at Corey Causeway. Ebb deltas, channels of the two inlets and the beach profiles were surveyed in July, 2014. Back bay bathymetry consists of July, 2014, survey data and some data collected in 2008. Landward boundaries of the model are defined with shoreline survey data and from aerial photos. Offshore
bathymetry beyond the offshore profile survey, terminated at approximately 1 km from shoreline, was obtained from NOAA Coastal Relief Model.

The model domain’s southwest offshore boundary is set 7 kilometers from the shore line, which is a reasonable distance for waves to propagate into the model and practical for deploying measurement gauges. The north offshore boundary is 8 kilometers north of John’s Pass and the south boundary is 4 kilometers south of Blind Pass. Hydrodynamic input data for the model are water levels and wave parameters collected by the offshore ADCP gauge at the west boundary of
the model domain during July, 2014, to August, 2014. Two other ADCPs collected water levels and current velocities in John’s Pass and Blind Pass channel for model calibration.

The CMS Model for this study has two different types of grid for the CMS-FLOW module and CMS-WAVE module, respectively. The gridding system for CMS-FLOW is Quad-tree, also referred to as telescoping grid. In this type of grid, cell dimensions are large at the offshore boundary and split into four equal smaller cells when they approach the refinement points (Figure 6). The telescoping grid structure helps reduce the number of cells and keeps all the cells the same square shape. As shown in Figure 7, John’s Pass and Blind Pass inlet channels are covered in fine resolution with grid cell sizes of 10 meters square. Ebb delta, near-shore, and back bay areas are gridded with 20 meter square cells. The largest cell size at the ocean boundary is 320 m square.

Figure 6. Quad-tree Gridding System.
Figure 7. CMS-FLOW grid, zoomed in at John’s Pass and Blind Pass inlets

CMS-WAVE grid, shown in Figure 8, uses the traditional refined Cartesian Grid Structure because a telescoping grid option was not available for the CMS-WAVE module. Refine points are set along the shoreline and over the ebb shoals, especially at the mouth of the inlets, to ensure good spatial resolution along the coast. The smallest cells at the refine points are 10×10 meters and the largest cells further offshore are 320×320 meters. The cell sizes are increased in the offshore direction using a cell dimension multiplier of 1.1.
Delft3D-FLOW and Delft3D-WAVE share the same general grid shown in Figure 9. Delft3D uses a curvilinear grid structure, which allows the user to build grid lines with curves. In this study, however, cells are mostly rectangular to match the grid used in the CMS model. The cell size in Delft3D grid is relatively uniform. In the channel it is about 15×15 meters and the...
offshore cell is about $50 \times 50$ meters. Delft3D does not support adding boundary conditions within the modeling domain, so some of the land cells were removed from the grid to set boundary conditions in back bay areas. The revised grid with boundary conditions is shown in Figure 10.

**Figure 9.** Delft3D general grid, zoomed in at John’s Pass and Blind Pass inlets
The CMS-FLOW model considers the north, south and west offshore boundaries as one uniform water level boundary. Delft3D-FLOW, however, regards the three boundaries as separate boundaries. Although it is not recommended to set all the three offshore boundaries as the same water level boundary because it would make the model unstable, the boundaries are still set like that under the following conditions: 1) there is unexpected strong flow at the parallel boundaries using a Neumann/Riemann boundary; 2) the modeling domain is small and the
uniform water level boundaries are realistic and applicable for the model domain; 3) the uniform water boundaries would be consistent with the boundary settings in CMS-FLOW, so that the results from CMS-FLOW and Delft3D-FLOW are compared under the same modeling scheme. CMS-WAVE model does not have a fixed linear boundary. Waves are calculated from the southwest corner of the model domain as the default setting, which fits the condition of this study. In Delft3D-WAVE, the wave boundary is set as the west boundary of the modeling domain. The water level and wave parameter measurements from offshore gauges are applied in the models’ boundary input.

In addition to the gridding setup, other parameters could have a critical influence on the model results and execution times, for example time step discretization and friction coefficient values. The friction coefficient was treated as a calibration variable and the setup and calibration of friction coefficient values are discussed in the Sensitivity Test section. The selected time step is very important to the execution time: a smaller time step means longer execution time for the same simulation period. If the simulation period is longer than one month, it could take days for model to finish the run if a time step of less than one minute is selected. Considering the efficiency of model, we would want larger time step. However, it would make the model unstable when the time step is too big. There are two different possible calculation modules in CMS-FLOW: the implicit module and explicit module. The explicit module requires a smaller time step for stability, which is usually less than 1 second. The implicit module can use larger time steps without becoming unstable. To improve model execution efficiency, the implicit module is selected in this study. In a number of sensitivity tests for time step length for both CMS and Delft3D, the results are identical between each test. The models give error warnings or
crash when the implicit time step is larger than 3 minutes. A time step of 3 minutes was used for both models.
RESULTS AND DISCUSSION

Bathymetric Survey Results

Bathymetric survey data served as the bathymetric background of the model. A general map of bathymetric survey point coverage is shown in Figure 11. As mentioned before, it includes echo sounder survey, beach profile survey, shoreline survey and bathymetric data from NOAA’s Coastal Relief Model.

Figure 11. General map of bathymetric survey points.
Echo sounder surveys conducted by this study can provide the most detail, so it was applied in inlet channel, ebb delta and back bay, which require the highest bathymetric resolution due to the complicated bathymetry variations. John’s Pass and Blind Pass ebb delta are surveyed with multi-beam echo sounder with 10 meters survey-line intervals to ensure the survey quality. Back bay survey data are combination of multi-beam and single beam survey data, which is roughly 25 meters survey-line interval on the flood shoal, 200-meter spaced crossing lines elsewhere and covering every small channel and canal (Figure 12).

![Figure 12. Bathymetric survey points. Red are the survey lines in back bay.](image)

Figure 13 shows a depth contour figure of the bathymetry of the two inlets and part of the back bay from echo sounder survey. Results show that at John’s Pass the middle of the inlet is over 8 meters deep; at Blind Pass, the south of the inlet is about 7 meters deep and the north of the inlet is only 2 meters deep. The bathymetric survey results at Blind Pass correspond with the
deposition happened in north Blind Pass inlet. On the bay side of John’s Pass there are generally three small channels, about 5 to 6 meters deep. One of them goes north direction and the other two go east direction. The two channels that go east direction turn southward in the back bay and connected with Blind Pass. The depth of two channels is about 3 to 4 meters and the rest of the back bay is about 2 to 3 meters deep.

**Figure 13.** Bathymetry contour map of the two inlets and back bay

Beach profile surveys are included to provide accurate near shore morphology. Beach profiles are surveyed along the entire Sand Key, Treasure Island, and Long Key. Profile data
from south Sand Key, Entire Treasure Island, and north Long Key (R98 to R159) is used as bathymetry input in the model (Figure 14).

Figure 14. Beach profile data included in the modeling domain
Figure 15 shows an example of beach profile survey data at R133, middle Treasure Island. The red line is the survey results from total station conducted at June 13th, 2014, and the brown line is the survey results from single beam echo sounder also conducted during June, 2014. The total station survey covers from dry beach till 3 meter deep water, and the survey line is about 300 meter long. The echo sounder survey starts from 250 meter from the bench marker, of which the water depth is about of 1.5 meter, and extends 1250 meters from the bench marker. The two surveys have a 50 meter overlap and match well. As shown in the results the elevation dropped very fast from 2 meters to -4 meter in a distance of 100 meters, and then stayed about 4 to 5 meters at the near shore area.

![Figure 15. Beach profile survey results at R133.](image)

Shoreline surveys cover the entire Sand Key, Treasure Island, Long Key, to help model define the land boundary. The results were post-processed and plotted in ArcGIS. An example of
processed shoreline data at north John’s Pass is shown in Figure 16. The survey covers both of the dune-line and spring-high-water-line. They all match with the base map. The spring-high-water-line is accepted at ocean-and-land boundary. Some of the area that is not accessible for ATV 4 Wheeler is manually digitized from base map. The finalized land boundaries are set as part of the bathymetric file in CMS model to help identify land cells and ocean cells, and build land boundary file in Delft3D for visualization purpose (Figure 17).

Figure 16. Processed shoreline data at north John’s Pass
Figure 17. Delft3D land boundary, illustrated as brown lines on the base map.

Hydrodynamic Survey Results

Water elevation variations were measured at the ocean boundary, in the inlet channels and in the back bay. As shown in Figure 18, the water levels at the ocean boundary have generally similar amplitude and phase as those in the inlet channel. However, there is a half an
hour to one hour tidal phase lag between the ocean boundary and the inlet channel during flood, and a shorter phase lag (about 20 minute) during ebb (Figure 19).

![Graph](image1.png)

**Figure 18.** Water level measurement at the offshore boundary and John’s Pass

![Graph](image2.png)

**Figure 19.** Detailed measurement of water level at offshore boundary and John’s Pass

The back bay water level measurements at various locations also illustrate a 20 minute tidal phase lag compared with the inlet channel, especially during flooding tide (Figure 20 & 21).
Meanwhile, the magnitude of tidal range in the back bay is also 5 to 10 centimeters smaller than that in the inlet channel. This indicates a considerable friction that creates the tidal phase lag when the tides flow through the channels into the back bay.

**Figure 20.** Water level measurement at offshore boundary, John’s Pass and back bay

**Figure 21.** Detailed measurement of water level at offshore boundary, John’s Pass and back bay
As mentioned in the previous sections, current measurements were conducted in three
different ways. Sentinel ADCP in John’s Pass and Blind Pass are taking directional current
velocity in fixed locations; Monitor ADCP surveys the tidal channels, flood shoal, and ebb shoal
at Blind Pass and John’s Pass to map the flow field; Channel Master (horizontal ADCP) is
deployed in John’s Pass and Blind Pass channel to survey the flow pattern in the inlet channel.

Sentinel ADCP measurements in John’s Pass give a peak velocity of about 1.3 m/s during
the survey period (Figure 22). The ebb flow is generally higher than the flood flow through the
main channel. Blind Pass Sentinel ADCP measurements (Figure 23) show a similar ebb and
flood pattern, while the peak ebb velocity is about 0.6 m/s and the peak flood velocity is about
0.4 m/s, which is smaller than that of John’s Pass. All the Sentinel ADCP current curves are
about 90° out of phase compared with the measured tide water level curve (Figure 24), as
expected.

Figure 22. John’s Pass current measurements. Positive as ebbing and negative as flooding.
Figure 23. John’s Pass current measurements. Positive as ebbing and negative as flooding.

Figure 24. Comparison between tide and current velocity measurements

The flow field of John’s Pass during ebbing and flooding was surveyed and mapped with a ship-mounted Monitor ADCP. The plotted results show that during the ebb, current flow from the back bay starts to become higher when entering the narrow inlet channel, and current velocity is about 0.8 m/s to 0.9 m/s in the middle of the inlet, and 0.3 m/s to 0.5 m/s at the edge. So the current velocity relatively higher in the middle of the inlet channel than that along the edge.
After it leaves the inlet and enters the ebbing shoal area, the current does not dissipate quickly and the ebb jet extends as far as 1 kilometer offshore (Figure 25). During the flood, current flow coming from offshore is relatively weak until it reaches the entrance of the inlet. The strongest flow is at the narrowest part of the inlet. The current velocity in the middle is over 1 m/s, stronger than that in the edge, which is about 0.4 m/s. After it enters the back bay, the flood currents diverge into different small channels and dissipate (Figure 26).

**Figure 25.** Measured flow field at John’s Pass during ebbing tide. Note that although the whole survey is conducted during the same ebbing period (red line shown in the upper left), all the points are not surveyed at exact the same time.
Figure 26. Measured flow field at John’s Pass during flooding tide. Note that although the whole survey is conducted during the same flooding period (red line shown in the lower left), all the points are not surveyed at exact the same time.

The third method of current velocity measurement was obtained with a Channel Master horizontal ADCP, which provides flow distribution patterns across channel. The cross-channel flow distribution pattern has a significant influence on erosion and sedimentation patterns in the inlet channel (Wang and Beck, 2012). The locations of the deployed Channel Master ADCP’s are shown in Figure 27. At John’s Pass, the Channel Master was mounted at the southern edge at the narrowest part of the inlet, looking northward to nearly the middle of the channel. At Blind
Pass, the Channel Master is mounted at the east edge where the channel turns northward, looking westward and covering most of the channel.

Figure 27. Detail location of Channel Master side-looking ADCP. Yellow lines are the coverage of Channel Master

The cross channel distribution of current velocity in John’s Pass is different during the flood and ebb (Figure 28). During the flood, current velocity was small at the edge of the inlet and quickly increases, till around 15 meters away from the bank and reaches the peak current velocity points. During the ebbing, the current velocity didn’t reach the peak velocity until 50
meters away from the bank. These results match with the Monitor ADCP survey results shown above. At Blind Pass, the flow pattern during ebbing and flooding are similar (Figure 29). The current velocity distribution is more uniform in the whole channel compared with that of John’s during both flooding and ebbing.

Figure 28. Current velocity distribution across the main channel of John’s Pass.

Figure 29. Current velocity distribution across the main channel of Blind Pass. Some measured bins at the end of the survey line are not accurate.
Wave conditions were measured at the offshore boundary and near shore. A Sentinel ADCP measured and recorded directional waves at the offshore boundary, serving as the input data for the wave modules. Nearshore measurements were obtained with a Triton ADV, recording non-directional wave data, for verification and calibration. The wave conditions used in the model are for the period from August 4\textsuperscript{th}, 2014 to September 11\textsuperscript{th}, 2014. The general trends of measured significant wave height and wave period at the offshore boundary and the near shore station match well in phase. Significant wave height at the offshore boundary is about 100\% higher than that in the near shore (Figure 30). At offshore boundary, the average significant wave height is 0.4 meters, and at the near shore it’s about 0.2 meters. Recorded wave conditions were mild, with significant wave heights generally less than 0.5 meters during the measurement period. Only one wave height event was recorded from August 10\textsuperscript{th} to August 12\textsuperscript{th}. The maximum significant wave height recorded was over 0.8 meter.

Measured offshore wave period is generally the same as that measured near shore (Figure 31). Except for one measurement at offshore on August 9\textsuperscript{th} that is over 15 seconds. All the other measurements are ranging from 4 to 8 seconds during the recording period. The average measured wave period during the measurement period is about 5 seconds. According to linear wave transformation theory, the wave period is constant during the transformation process. The fact that the measured wave periods at offshore and near shore are generally identical match with the linear wave transformation theory.
Figure 30. Measured significant wave heights at offshore boundary and near shore

Figure 31. Measured wave periods at offshore boundary and near shore

The wave direction was only recorded at the offshore boundary. As shown in Figure 32, most of the waves come from 200° to 300° during the measurement period. As mentioned before, CMS-WAVE assumes that waves propagate from the lower left corner of the modeling domain. This measured wave direction matches with this assumption. In Delft3D-WAVE, wave boundary is set at southwest boundary according to this wave direction measurement, which keeps consistency with the wave boundary setup in CMS-WAVE.
Figure 32. Wave direction at offshore ADCP station during August 7\textsuperscript{th}, 2014 to September 11\textsuperscript{th}, 2014.

Sensitivity Test

The goal of a sensitivity analysis is to test the influence of several input parameters to the model results and stability. These parameters are typically calibration variables. The major parameter examined in this sensitivity test is the friction coefficient, because the friction coefficient is one of the most important physical parameters and it plays a significant role in both realistic simulation and mathematical calculation. Friction is the resistance force that drags the current from flowing through the inlet. So a higher friction force is expected to slow down the current flow. An appropriate and realistic friction coefficient is very important for the numerical model to get reliable results.

In CMS-FLOW, there are three different kinds of bottom friction datasets: Manning’s number N, bottom friction coefficient and roughness height. The default setting is Manning’s N
The CMS-FLOW model was tested with Manning’s N = 0.02, 0.025, 0.03 and 0.035. The models crashed or gave warnings when the Manning’s N is < 0.02 and the models failed to give reasonable results, for example, peak velocity less than 0.5 m/s, when the Manning’s N is > 0.035. The calculated water levels and current velocities responded differently to the change of friction coefficient. Shown in Figure 33, the calculated water levels for different values of N are the same, which indicates the friction coefficient has no effect on water level calculation. When the results are zoomed in and the measurement at the boundary is added (Figure 34), the calculated water level is between the measurement from boundary and inlet, which suggests that friction coefficient didn’t help the model to capture the tidal phase between inlet and the offshore boundary.

Figure 33. Comparison between measured and CMS calculated water level with different Manning’s N Number at John’s Pass
The calculated peak current velocity has a negative correlation with Manning’s Number N. As shown in Figure 35, the peak current velocity was higher with the smaller Manning’s Number N. The peak velocity is 0.2 m/s lower than the measurement during ebbing with Manning’s Number N =0.02. When increase the Manning’s Number N to 0.035, the difference increase to 0.4 m/s. The absolute differences between calculation and measurement at each time step were averaged and show in Table 1. The averaged differences have a negative correlation with Manning’s Number N, and the smallest difference is 0.149, which is about 9.9% of the measured peak velocity. According to this result, the smaller friction coefficient within the modeling area brings up the current velocity magnitude, especially during peak flow. And because all the results under-predicts the peak flow velocity, the result from the smallest friction coefficient is closest to the measurement.
Figure 35. Comparison between CMS calculated current velocity with different Manning’s N Number and measured velocity at John’s Pass. Positive as ebbing and negative as flooding.

Table 1. Averaged difference in current velocity between measured and CMS calculation using different Manning’s N Number.

<table>
<thead>
<tr>
<th>Manning’s N</th>
<th>Averaged Difference (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.035</td>
<td>0.191</td>
</tr>
<tr>
<td>0.030</td>
<td>0.169</td>
</tr>
<tr>
<td>0.025</td>
<td>0.156</td>
</tr>
<tr>
<td>0.020</td>
<td>0.149</td>
</tr>
</tbody>
</table>

In Delft3D-FLOW, the options for friction coefficients are Chezy’s Number, Manning’s Number and White-Colebrook’s Number. To keep consistency with CMS-FLOW and to be easier for comparison of the results of the two models, the Manning’s Number is chosen in the sensitivity test. The same Manning’s Number as those in CMS-FLOW sensitivity test (= 0.02, 0.025, 0.03, 0.035) were selected in the Delft3D-FLOW sensitivity test. The calculated water level also has no correlation with the change of friction coefficient (Figure 36 & 37), and the current velocity has a negative correlation with Manning’s number (Figure 38). This correlation between friction coefficient, calculated water level and current velocity is similar with that in CMS-FLOW. The averaged absolute difference between Delft3D calculation and measurement...
is shown in Table 2. The smallest averaged difference is 0.176, which is about 11.7% of the peak current velocity.

**Figure 36.** Comparison between measured and Delft3D calculated water level with different Manning’s N Number at John’s Pass

**Figure 37.** Comparison between measured and Delft3D calculated water level with different Manning’s N Number John’s Pass and offshore boundary
Figure 38. Comparison between measured and Delft3D calculated current velocity with different Manning’s N Number at John’s Pass. Positive as ebbing and negative as flooding.

Table 2. Averaged difference in current velocity between measured and Delft3D calculation using different Manning’s N Number and measurement.

<table>
<thead>
<tr>
<th>Manning’s N</th>
<th>Averaged Difference (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>=0.035</td>
<td>0.243</td>
</tr>
<tr>
<td>=0.030</td>
<td>0.216</td>
</tr>
<tr>
<td>=0.025</td>
<td>0.191</td>
</tr>
<tr>
<td>=0.020</td>
<td>0.176</td>
</tr>
</tbody>
</table>

Besides friction coefficients, Delft3D- FLOW is also tested by adjusting the Reflection Parameter, which is an additional parameter in boundary condition setup. The recommended Reflection Parameter is calculated as follows:

$$\alpha = T_d \frac{H}{g}, [s^2]$$

Where $\alpha$ is reflection parameter, $T_d$ is the time it takes for a free surface wave to travel from the left boundary to the right boundary of the model area, $H$ is the water depth (Dletares, 2012). The reflection parameter was tested because it has significant influence on the tidal phase. The calculated water levels respond significantly to different values of the reflection parameterin
the sensitivity tests (Figure 39). The tidal phase lag increases and the tidal range decreases with increasing values of the reflection parameter. The results with higher reflection parameter values also tend to have a smoother water level curve. The calculated current velocity is also affected by the value of the reflection parameter (Figure 40). The current velocity dissipated quickly with increasing values of the reflection parameter. In conclusion, reflection parameter in Delft3D-FLOW provides users an approach to adjust the tidal phase lag between domain boundary and the area of interest.

![Figure 39](image.png)

**Figure 39.** Comparison between Delft3D calculated water level with different Reflection Parameter (RP) and measurement at John’s Pass and offshore boundary.
Figure 40. Comparison between Delft3D calculated current velocity with different Reflection Parameters and measurement at John’s Pass. Positive as ebbing and negative as flooding.

Based on the sensitivity test results, Manning’s Number $N = 0.02$ is selected as the friction coefficient used in production run, because the corresponding results are most close to the measurement in both modeling systems, especially predicted current velocity. The Reflection Parameter in Delft3D are set differently at the west offshore boundary and the parallel boundaries because there different distant to the inlet. At the west offshore boundary the Reflection Parameter is set as 800. And at the north and south boundaries, the Reflection Parameter is set smaller as 1000, because they are farther from the inlet entrance.

CMS Model Results

CMS-FLOW individual run and CMS-FLOW & CMS-WAVE steering runs are examined in this study. The calculated water levels from both the flow-only run and the steering run match the observed data well (Figure 41). The flow-only run and steering run gave identical
calculated water level, which indicates that the CMS-WAVE module has little to no influence on water level calculation in the CMS-FLOW module under mild wave conditions. Note that the calculated water levels (both flow-only run and steering run) is overlap with boundary water level rather than measurement in the inlet when zoomed in detail (Figure 42), which suggests that the CMS model did not capture the tidal phase lag between offshore and inlet. The calculated velocity generally matches the measurement during the flooding, but considerably under-predicts during the ebbing (Figure 43). The flow-only run and wave steering run basically gave identical results. During the ebbing, the predicted peak velocity during the ebbing is about 1 m/s, which is very close to the measured velocity in John’s Pass. While during the flooding, the predicted peak velocity is about 0.7 m/s, much smaller than the measurement current velocity, which could be over 1 m/s.

Figure 41. CMS flow-only and wave-steering model calculated water level in John’s Pass, compared with measurement at John’s Pass
Figure 42. CMS flow-only and wave-steering model calculated water level in John’s Pass, compared with measurement at John’s Pass and offshore boundary, in detail.

Figure 43. CMS flow-only and wave-steering model calculated current velocity at John’s Pass, compared with measurement at John’s Pass. Positive as ebbing and negative as flooding.
The CMS flow-only model calculated flow field of John’s Pass is shown in Figure 44&45. CMS-FLOW is able to capture the general ebb flow and flood flow patterns through the tidal inlet as measured by the ship-mounted ADCP Monitor. As shown in the figure, the ebb flow is usually stronger, and can extent offshore for over 1 kilometer, which matches with the hydraulic survey results from Monitor ADCP. Flood flow is relatively weaker. Current is still strong in the channel, and then flows into different channels and dissipates after it enters the back bay. There are two peak flow points: the narrowest point in the channel and the mouth of the inlet, during both ebbing and flooding. These results match with the hydraulic survey results from Monitor ADCP and Channel Master.

**Figure 44.** An example of CMS flow-only result on August 12th, 2014 at 5:00 pm during a peak ebb flow at John’s Pass
The Blind Pass flow pattern (Figures 46 and 47), is different from that of John’s Pass. Ebb flow is still stronger, and the strongest flow is at the narrowest channel before the flow enters the main inlet. After it enters the main inlet, the flow rushes to the southern edge of the inlet and its direction turns southwest. As a consequence, during the ebbing, the current flows out of inlet along the southern edge of Blind Pass. At the northern edge of the inlet, however, there is small incoming flow entering the inlet and building gyres. This unique ebbing flow pattern causes the deposition on the north edge of the inlet and erosion on the south edge, which is the reason for Blind Pass migration and the refilling process after dredging. The ebb flow in Blind Pass dissipates faster offshore compared with John’s Pass and ebb jet is smaller. The flood flow in Blind Pass is relatively uniform. Current flow enters the entire inlet and the highest velocity is
in the narrow channel where it turns northwest. Note that during the ebbing, the flow is relatively uniform in the narrow channel, and during the flooding the current velocity is relatively stronger in the middle of the channel than that at the edge.

Figure 46. An example of CMS flow-only result on August 12th, 2014 at 5:00 pm during a peak ebb flow at Blind Pass
Figure 47. An example of CMS flow-only result on August 11th, 2014 at 9:00 pm during a peak flood flow at Blind Pass

The flow pattern in the vicinity of John’s Pass changed significantly after CMS-WAVE module is steered in. The most apparent difference that wave module adds is the long shore current. The long shore current was mostly going southeast direction along the edge of land boundary. The strength of long shore current has a very close relationship to wave height. Increased wave heights increase the velocity of the long shore current. The strong long shore current meets the inlet flow at the inlet entrance during flood and ebb and forms a unique flow pattern. During the ebbing, the long shore current interacts with ebb jet and forms a large gyre and even changes the direction of ebb jet when the long shore current is strong enough (Figure 48). During the flooding, the strong long shore current forms another peak current velocity point
at the north side of the inlet entrance (Figure 49). After it meets and joins the flood flow, a gyre is formed at the north side of the inlet channel, where the current velocity is relatively weak.

**Figure 48.** An example of CMS flow and wave steering result on during a peak ebb flow with wave condition of $H_s = 1.44$ m, $T_p = 6.24$ s at John’s Pass
The similar interaction between longshore current and inlet current flow also happens in Blind Pass (Figure 50 & 51). As a result of the smaller tidal prism and current flow in Blind Pass, the long shore current has even greater influence on Blind Pass channel. A similar gyre is formed at the north side of the Blind Pass inlet entrance during the flooding like the gyre observed in John’s Pass inlet. The current flow in the ebb jet is affected by the long shore current and turns southward.
Figure 50. CMS flow and wave steering run result at a peak ebb flow with wave condition of $H_s = 1.44$ m, $T_p = 6.24$ s at Blind Pass

Figure 51. CMS flow and wave steering run result at a peak flood flow with wave condition of $H_s = 1.68$ m, $T_p = 6.85$ s at Blind Pass
**Delft3D Model Results**

Delft3D-FLOW individual run and steering run are examined in this study. In both the flow-only run and the wave steering run (Figure 52) the predicted water levels match with the measurement well. The difference from measurement to the calculation is less than 0.05 meter. When zoomed in detail and compared with both offshore and inlet measurement (Figure 53), the predicted water level curve is still in-between measurement at boundary and inlets, but closer to the inlet measurement. This result indicates that although still not 100% accurate, Delft3D reasonably re-produced the tidal phase lag between boundary and inlet.

In terms of predicted current velocity (Figure 54), the flow-only run gave higher peak ebbing current velocity than that in wave steering run. The predicted peak ebbing velocity is about 1 m/s, which is very close to the measurement. But it still under-predicted about 0.2 m/s at the ebb. The flow-only run also accurately calculated the current velocity during flooding, but still had under-predictions (Figure 55). The Delft3D wave steering run gave a peak ebbing velocity smaller than 1 meter, which is an under-prediction by 0.4 m/s. But during flooding, the predicted peak current velocity is about 1.2 m/s, which over-predicted the measured velocity by 0.2 m/s. The results from flow only run and wave steering run are different, which indicates that the wave calculation affect the current velocity calculation in John’s Pass in Delft3D. After the wave module is steered in, the peak velocity during ebbing is smaller while that during flooding get higher.
Figure 52. Delft3D flow-only and wave-steering model calculated water level in John’s Pass, compared with measurement at John’s Pass.

Figure 53. Delft3D flow-only and wave-steering model calculated water level in John’s Pass, compared with measurement at John’s Pass and offshore boundary, in detail.
Figure 54. Delft3D flow-only and wave-steering model calculated current velocity at John’s Pass, compared with measurement at John’s Pass. Positive as ebbing and negative as flooding.

Delft3D flow-only run calculated flow field is plotted as current magnitude contour figure shown below. At John’s Pass during the ebbing, the flow is weak (less than 0.4 m/s) in the back bay. When it gets into the channel, it gets stronger and the velocity can be over 1 m/s in the middle of the inlet. After it passes the inlet, the current velocity didn’t dissipate very fast, the ebb jet extended as far as about 1 kilometer offshore (Figure 55). The flood flow did not get strong until it reached the entrance of the inlet (Figure 56). The flow is stronger in the middle of the inlet than that at the edge of the inlet. The peak current velocity points are at the narrowest part of the channel and the entrance of the inlet. After the flow enters the back bay, it goes into different small channel in the back bay and quickly dissipated.
Figure 55. Delft3D flow-only result on August 12th, 2014 at 5:00 pm during a peak ebb flow at John’s Pass

Figure 56. Delft3D flow-only result on August 11th, 2014 at 9:00 pm during a peak flood flow at John’s Pass
At Blind Pass, Delft3D-FLOW also predicted the unique flow field during the ebbing (Figure 57). There is a “shadow zone” with relatively weaker current flow along the northern edge of the inlet entrance. The current velocity is strongest in the narrow channel and dissipated quickly after turning westward and the ebb jet was not very significant and did not extend very far offshore. During the flooding (Figure 58), the flow is weaker and relatively uniform (without “shadow zone”) in the entrance. The peak current velocity was at the narrow channel after the flow turned northward.

**Figure 57.** Delft3D flow-only result on August 12th, 2014 at 5:00 pm during a peak ebb flow at Blind Pass
Figure 58. Delft3D flow-only result on August 11\textsuperscript{th}, 2014 at 9:00 pm during a peak flood flow at Blind Pass

The wave-steering run by Delft3D also shows similar pattern as CMS steering run. Significant long shore current is observed along the coastline shown as the high velocity area along the shoreline in Figure 59 & 60. The long shore current is about 0.5 m/s to 0.7 m/s during the simulation period in the figure. It also interacts with current flow entering or exiting the inlet during flooding and ebbing. Another peak current velocity point appears at the north edge of the inlet entrance, where long shore current meets with current flow. The long shore current and inlet flow also interact in the inlet and forms gyres shown as the low-current-velocity area at the north of both John’s Pass and Blind Pass. These results also match with plot discussed before from the CMS steering run.
Figure 59. Delft3D flow and wave steering result on during a peak flood flow with wave condition of $H_s = 1.68$ m, $T_p = 6.85$ s at John’s Pass

Figure 60. Delft3D flow and wave steering result on during a peak flood flow with wave condition of $H_s = 1.68$ m, $T_p = 6.85$ s at Blind Pass
Model Comparison

The two modeling systems, CMS and Delft3D are briefly compared in this study in several different aspects, for example, results, running speed, Graphic User’s Interfaces (GUI). The results from two modeling systems are compared in most detail because the reliability and accuracy of the results is of most importance to a numerical modeling system.

Both Delft3D and CMS give accurate water level calculation (Figure 61). To examine the results in detail, as shown in the zoomed-in figure (Figure 62), Delft3D calculated water level have a 40 minutes phase lag with the boundary water level. CMS calculated water level has an only 20 minutes phase lag with the boundary water level. Considering the measured 1 hour tidal phase lag, Delft3D is giving better calculation on water level. The calculated averaged absolute difference between calculated water level (both Delft3D and CMS) and measured water level also shows that Delft3D gives more accurate water level calculation by 0.016 meters (Table 3).

Figure 61. Comparison between Delft3D, CMS calculated water level and measurement at John’s Pass
Figure 62. Comparison between Delft3D, CMS calculated water level, measurement at John’s Pass and offshore boundary, in detail.

Table 3. Averaged difference in water level between calculation and measurement.

<table>
<thead>
<tr>
<th></th>
<th>CMS</th>
<th>Delft3D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Averaged Difference (m)</td>
<td>0.046</td>
<td>0.028</td>
</tr>
</tbody>
</table>

The calculated current velocity from both CMS and Delft3D illustrates greater differences as compared to measurement data (Figure 63). CMS under-predicted the ebb flow, but its calculated current velocity curve matches with the measurement well; Delft3D gives higher peak velocity in flooding flow, but it still under-predicted the ebb flow and the flood flow. As discussed before in the Sensitivity Test, by decreasing the friction coefficient, both models gave more accurate calculation on current velocity (Table 4). In each of the tests, results from CMS has smaller averaged absolute differences to the observed data compared with Delft3D. In the production run, when Manning’s Number N is set as 0.02, the absolute different in current velocity between calculation and measurement is about 0.15 m/s by CMS, and about 0.18 m/s in
Delft3D. Generally speaking, by looking at the averaged absolute difference, CMS gives closer simulation in current velocity.

![Figure 63. Comparison between Delft3D, CMS calculated current and measurement at John’s Pass. Positive as ebbing and negative as flooding.](image)

<table>
<thead>
<tr>
<th>Manning’s Number</th>
<th>0.035</th>
<th>0.030</th>
<th>0.025</th>
<th>0.020</th>
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</thead>
<tbody>
<tr>
<td>Models</td>
<td>CMS (m/s)</td>
<td>0.191</td>
<td>0.169</td>
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<td>Delft3D (m/s)</td>
<td>0.243</td>
<td>0.216</td>
<td>0.191</td>
<td>0.176</td>
</tr>
</tbody>
</table>

Besides the simulated results, there are also several different aspects that model users may be interested in, for example, Graphic User’s Interface (GUI), computation speed, etc. As mentioned above, CMS is built in an integrated GUI named SMS. SMS is well-designed and
able to undertake tasks from input data pre-processing, model simulation, to output data post-process. SMS provides users with a good visualization of the working area and makes it easy to modify parameters within the model domain. The Delft3D GUI is relatively simple. However, the pre-processing module is not as powerful as SMS. SMS has an integrated coordinate converting module, which would provide great convenience to the users when the input bathymetry files are not in the same coordinate datum (this is a common situation). Delft3D GUI doesn’t have similar module, so all the space-various files need to be converted into same coordinate system before being entered into the model. In terms of boundary condition input, SMS supports importing from ASCII files, or just copying and pasting in the boundary condition setting window. In Delft3D, however, the boundary files are first generated as blank ASCII files. Users need to go into the generated boundary condition files and edit with ASCII editing tools. The post-processing and plotting module of Delft3D is built on Matlab QUICKPLOT module, which means it would be difficult for users to check the results if they don’t have Matlab installed. Furthermore, the SMS post-processing tools are more powerful than MatlabQUICKPLOT. SMS supports plotting magnitude contour figures combined with directional vector plots. While in QUICKPLOT, these two types of plot have to be plotted separately. SMS has an integrated movie making tools that is able to generate time series results into AVI formatting video files, or even Google Earth File. Although QUICKPLOT is also capable to make time series movies, it doesn’t have a recording function. So the users will need to find another screen recording software to output the movie. In conclusion, SMS is a well-designed and users-friendly GUI that users don’t need to seek for any other software to setup CMS model, start simulation and view results. When users work with Delft3D GUI, it could be
more complicated fixing the input data and users may need to find other software to view the output files.

The simulation speed of a modeling system depends on many parameters, for example, model domain, number of cell, simulation length, boundary condition, hardware condition, etc. In this study, a steering run for one month at 1 minute time step takes about 26 hours for CMS to finish. Under the same hardware condition and modeling scheme, Delft3D finishes the same task in 20 hours. After increasing the time step into 3 minute, CMS steering run for one month in the same model domain takes about 20 hours, and Delft3D takes about 15 hours. So generally speaking, Delft3D has a faster simulation speed under the same condition compared with CMS.
CONCLUSION

As an important approach to study and understand tidal inlet system, numerical modeling proved its efficiency and accuracy in simulating a dual-inlets system. Both of the two widely used numerical modeling system tested in this study realistically reproduced the hydrodynamic processes in the greater tidal inlet area under measured boundary conditions. The flow and wave module in both models steered successfully and were able to generate wave-induced hydraulic processes reasonably, for example, longshore current. Specifically, their predictions on water level are more accurate than those on current velocity.

Under the modeling scheme of this study, Delft3D-FLOW makes more accurate simulation in water level and CMS-FLOW makes more accurate simulation in current velocity. Both models yielded results that matched the measured data reasonably well. Delft3D-FLOW provided user with Reflection Parameter, which is a coefficient that could adjust the tidal phase lag. CMS has a relatively more user-friendly graphic interface for grid setup and post processes. Delft3D is relatively faster in simulation speed in this study.
REFERENCES


