4th Specialty Conference on Coastal, Estuary and Offshore Engineering
4e Conférence spécialisée sur l'ingénierie côtière et en milieu maritime

Montréal, Québec
May 29 to June 1, 2013 / *29 mai au 1 juin 2013*

MODELLING COASTAL PROCESSES AT SHIPPAGAN GULLY INLET, NEW BRUNSWICK, CANADA

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Abstract: This paper describes the development, calibration and application of a numerical model of the hydrodynamic and sedimentary processes at a dynamic tidal inlet known as Shippagan Gully, located on the Gulf of St-Lawrence near Le Goulet, New Brunswick. The new model has been developed to provide guidance concerning the response of the inlet mouth to various potential interventions aimed at increasing navigation safety. The new model is based on coupling the most recent CMS-Flow and CMS-Wave models developed by the US Army Corps of Engineers. The coupled model is capable of simulating the depth-averaged currents generated within Shippagan Gully and along the neighbouring coastline due to the effects of tides, winds and waves; the transport of non-cohesive sediments; and the resulting changes in seabed morphology. The development of the model and the steps taken to calibrate and validate it against field measurements are described. The application of the model to predict the coastal processes and the response of the inlet mouth to several storms is described and discussed. The influences of storm direction and storm surge on coastal processes is presented and discussed. The research described herein will contribute to an improved understanding of the hydrodynamics and sedimentary processes at strongly ebb-dominated tidal inlets in general and Shippagan Gully in particular.

1 Introduction

Shippagan Gully is a narrow channel at the mouth of a highly dynamic tidal inlet located on the Gulf of Saint Lawrence near Le Goulet, New Brunswick, Canada (see Figure 1). It is a particularly interesting and complex tidal inlet due to the fact that its tidal lagoon bisects the Acadian peninsula and is open to the sea at two locations where there is an appreciable phase lag in the tidal cycle. Due to the nature of this phase lag in tidal forcing, the ebb flows through Shippagan Gully, which routinely exceed 2 m/s, are roughly twice as strong as the flood flows. As a consequence of this imbalance, the hydrodynamic and sedimentary processes at the inlet, and the morphological features produced by these processes, tend to be strongly dominated by the ebb flows.

For many years Shippagan Gully has served as an important navigation channel, providing boaters from communities in the Acadian Peninsula and the Baie des Chaleurs with direct access to the open waters of the Gulf of St-Lawrence. The fishing industry, a very important element of the local economy, relies on safe navigation through the inlet. Attempts to control and stabilize the inlet date back to 1882, when two 300 m long jetties were initially constructed. Various additional human interventions, including dredging, additional structures and modifications to existing structures have been implemented over the intervening years while attempting to stabilize the inlet and establish a safe and maintenance-free navigation channel. The current configuration of structures (see Figure 1) includes a short ~25m long damaged jetty on the east side of the inlet mouth, a 325m long jetty on the west side, and a 600m long curved vertical training wall extending northwards from the tip of the west jetty. The harbour of Le Goulet is formed between the west jetty and the curved training wall.

Figure 1. Shippagan Gully is located on the Acadian Peninsula near Le Goulet, New Brunswick.

Over the last few decades, significant volumes of sediment have accumulated within the inlet mouth due to natural processes. A detailed history for Shippagan Gully was developed by Logan *et al.* (2012) from local knowledge and analysis of available data, including aerial photographs, documentation of past coastal works and a complete dredging record (1882 to present time). From this analysis it was determined that approximately 2100 m^3 of sediment is deposited within the confines of Shippagan Gully (not including the ebb shoal complex) in a typical year. Moreover, the navigation channel passing through the inlet has become narrower and has migrated westward, closer to the curved training wall. Today the inlet mouth (and the navigation channel) is less than ~75m wide at its narrowest point, where it is constricted by a large sand spit that has formed on the eastern side of the inlet mouth. These changes make it more difficult and riskier for fishing vessels to pass safely through the inlet on their way to and from the Gulf of St-Lawrence. Many of the larger vessels which once relied on the inlet for safe and sheltered passage to and from the Gulf can no longer safely navigate the constricted channel. These vessels must now circumnavigate the Acadian Peninsula, thus considerably lengthening their journey and forcing passage through the rough waters off Miscou Point.

The research discussed in this paper has been conducted as part of a multi-year study commissioned by Public Works and Government Services Canada (PWGSC) with funding from Fisheries and Oceans Canada (DFO). Logan *et al.* (2012) present results from Phase 1 of this multi-year research effort. The purpose of the present Phase 2 study is to develop an improved numerical model capable of simulating the complex and dynamic coastal processes at Shippagan Gully, and then apply the new model to help assess the effectiveness of alternative strategies for establishing a navigation channel that is safer and requires minimal maintenance. For enhanced navigation safety, the channel should ideally be straight, at least 110 m wide and at least 4 m deep at all times. The current paper builds on the foundation established in Phase 1, and presents new results from the studies' second phase.

2 Field Investigations

Several field investigations have been conducted at the site to collect data to support the modelling effort. PWGSC has conducted hydrographic surveys of the navigation channel on an annual basis over the past decades. This data has been used to define the bathymetry along the channel and quantify the changes over various time periods. A team from the University of Ottawa and the National Research Council (NRC) visited the site in August 2010 and collected sediment samples and velocity data using an electromagnetic current meter. Researchers with the University of Ottawa returned to the site in June 2012, collecting additional sediment samples and acquiring velocity data within the inlet mouth using an Acoustic Doppler Current Profiler (ADCP). The firm GEMTEC was retained by PWGSC to collect additional sediment samples from the seabed in 10 different locations, including the navigation channel and the ebb shoal.

Figure 2 presents a summary of the data on sediment grain size that has been obtained from the various field investigations. The beaches NE and SW of the inlet are comprised of non-cohesive sediments with D_{50} ranging from 0.17 up to ~18 mm. The field data suggest that the ebb shoal contains a wide range of sands and fine gravels, with grain sizes ranging from 0.15 to ~10 mm. Within the inlet mouth, where peak velocities regularly exceed 2 m/s, the navigation channel is evidently armoured with a blend of coarse sand and gravel with particle sizes ranging from 1 mm up to 85 mm.

The velocity data acquired in August 2010 has previously been described by Logan *et al.* (2012). In June 2012, an ADCP and a GPS system were fitted to a small boat and used to obtain velocity measurements along several transects within the inlet mouth (see Figure 3). The raw velocity data was subsequently processed to produce estimates of the depth-averaged velocity (magnitude and direction) along each transect. This survey spanned ebb tide, flood tide and slack tide.

Sample	D_{50} (mm)	D_{35} (mm)	D_{90} (mm)
A	7.00	0.65	18.00
B	0.34	0.26	0.45
C	12.00	6.00	18.00
D	0.34	0.30	0.60
E	0.55	0.40	2.50
F	1.90	0.90	9.00
G	0.20	0.17	0.26
H	0.25	0.20	0.30
I	0.20	0.17	0.50
J	0.43	0.37	15.00
K	0.35	0.27	0.42
L	0.45	0.37	0.42
M	24.80	15.00	52.00
N	0.38	0.34	0.47
O	4.00	0.60	60.00
P	0.37	0.34	0.48
Q	6.00	2.00	50.00
R	52.80	40.00	90.00
S	0.28	0.25	0.40
T	1.20	0.20	40.00
U	0.33	0.28	0.45

Figure 2. Summary of grain sizes from field investigations.

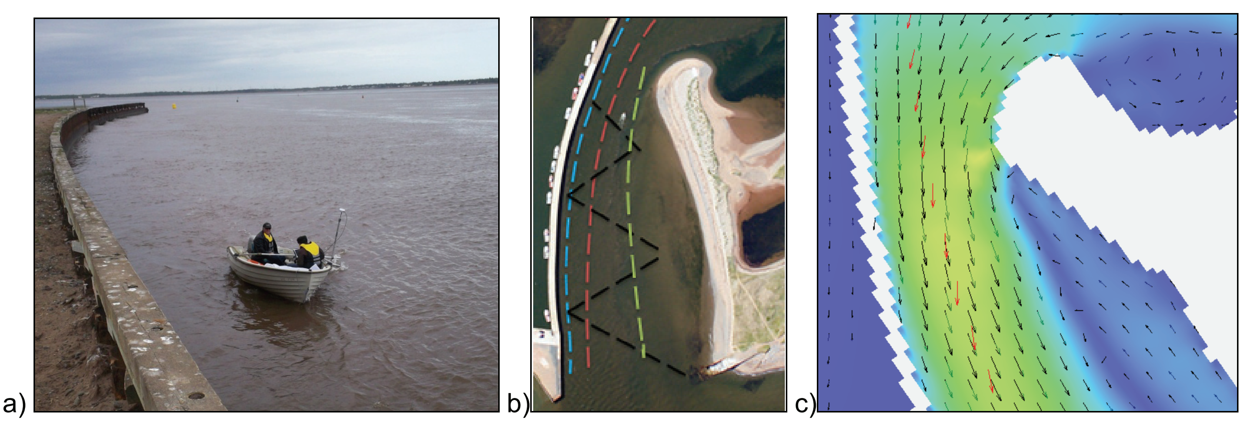

Figure 3. Velocity survey with boat-mounted ADCP: a) equipment; b) transects; c) depth-averaged velocity vectors during ebb tide (red=measured, black=modelled).

3 Numerical Model Set-up

The Coastal Modeling System (CMS) is an integrated suite of numerical models developed by the Coastal Inlets Research Program (CIRP) of the United States Army Corps of Engineers (USACE) for simulating flow, waves, sediment transport, and morphology change in coastal areas (Sanchez *et al*., 2012). The system is designed for practical applications in navigation channel performance and sediment management for coastal inlets and adjacent beaches. In this study the numerical models CMS-Flow and CMS-Wave were applied in a coupled manner to simulate the wave and tidal hydrodynamics, sediment transport and morphology change at Shippagan Gully.

CMS-Flow is a coupled hydrodynamic and sediment transport model capable of simulating depth-averaged circulation, salinity and sediment transport due to tides, wind and waves. The hydrodynamic model solves the conservative form of the shallow water equations and includes terms for the Coriolis force, wind stress, wave stress, bottom stress, vegetation flow drag, bottom friction, and turbulent diffusion. Three different sediment transport models are available in CMS: a sediment mass balance model, an equilibrium advection-diffusion model, and non-equilibrium advection-diffusion model. The salinity transport is simulated with the standard advection diffusion model and includes evaporation and precipitation. All equations are solved using the Finite Volume Method on a non-uniform (telescoping) Cartesian grid. CMS-Flow is suitable for simulating hydrodynamics and sediment transport over a wide range of time scales extending from hours to years (Buttolph *et al.,* 2006).

CMS-Wave is a spectral wave transformation model that solves the steady-state wave-action balance equation on a non-uniform Cartesian grid. It considers wind wave generation and growth, diffraction, reflection, dissipation due to bottom friction, whitecapping and breaking, wave-wave and wave-current interactions, wave runup, wave setup, and wave transmission through structures (Lin *et al*., 2008).

The CMS-Flow and CMS-Wave models were coupled through a steering module, which exchanges information back and forth between the two models at specified time intervals (see Figure 4). For example, information on water levels, currents and bathymetry is transferred from CMS-Flow to CMS-Wave, while information on radiation stresses (which force wave-induced currents) is transferred from CMS-Wave to CMS-Flow. Such coupling is essential for modelling a highly dynamic coastal inlet such as Shippagan Gully, where coastal processes result from complex interactions between tide-driven flows and nearshore waves. Both models operate on a finite difference grid with variable grid spacing, such that areas of interest can be modelled at a higher resolution without greatly sacrificing computation time. For this study, the grid spacing for the hydrodynamic model (CMS-Flow) varied from 80 m at the offshore boundary to 4 m at the inlet mouth (see Figure 5). The resolution of the wave model (CMS-Wave) varied in a similar manner.

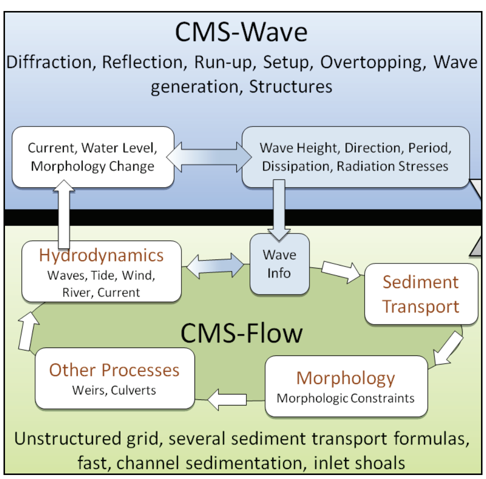

Figure 4. Coupling between CMS-Flow and CMS-Wave models (Sanchez *et al*., 2012).

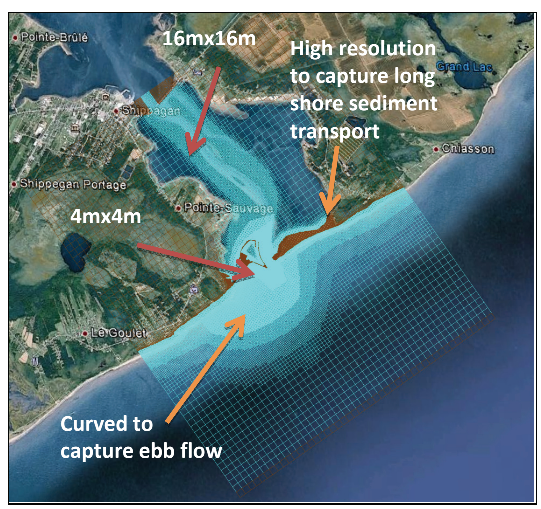

Figure 5. Non-uniform CMS-Flow grid (120,000 cells).

3.1 Boundary Conditions

The coupled model was forced using time-varying water levels applied along three boundaries (NW, SW and NE) and time-varying wave conditions applied along the fourth (SE) boundary. The water level boundary conditions were obtained from a regional model of tidal hydrodynamics around the Acadian Peninsula that was developed for this study, based on the TELEMAC (finite-element) modelling system. Boundary conditions for the regional tide model were developed from tidal constituent data provided by the Canadian Hydrographic Service (CHS). Two offshore boundaries were implemented in order to capture the strong counter-clockwise hydrodynamic circulation present in the Gulf of St. Lawrence which drives longshore currents flowing from north to south along the New Brunswick coastline. This phenomenon is reproduced in the CMS-Flow model by implementing two offshore boundaries, one at each longshore limit of the model domain. These two offshore boundaries have slightly phase-lagged tidal cycles (extracted from the regional TELEMAC-2D model), thus driving flow in the longshore direction from northeast to southwest. An inland water level boundary was placed at the north-western limit of the CMS-Flow model domain, as water levels at this location (within the tidal lagoon) differ greatly from those along the Gulf coast. This is due to the prominent phase lag that exists between tides in the Baie des Chaleurs and the Gulf of St. Lawrence. It is this phase lag that is responsible for the strong imbalance in the strength of the ebb and flood flows through Shippagan Gully inlet, where ebb flows routinely exceed 2m/s while flood flows are typically ~50% slower.

Information on the wave climate at the site was developed from analysis of the MSC50 Atlantic Wave Hindcast produced by Environment Canada (Swail *et al*., 2006). The MSC50 hindcast provides hourly estimates of wave height, period and direction across the entire Gulf of St. Lawrence with 0.1° resolution over the 54 year period from 1954 to 2008. The hindcast has previously been successfully calibrated and validated against available buoy data. Data for a MSC50 hindcast grid point located 5 km offshore Shippagan Gully in a water depth of 16 m was analysed to define the local wave climate. The wave conditions were separated into 30° directional bins and the peak over threshold method was employed to establish extreme wave conditions for each bin, associated with various return periods from 1 year to 25 years. Significant wave heights near Shippagan Gully rarely exceed 3 m, and peak wave periods rarely exceed 12s. The wave climate is dominated by waves approaching from the east (ESE to ENE); however, waves approaching from the south are also common. Storms with Hs ≥ 3 m can approach from the E, SE and S directions.

4 Model Calibration and Validation

4.1 Calibration of Hydrodynamics

The hydrodynamic model (CMS- Flow) was calibrated so that it was able to replicate with reasonable precision the flow conditions (levels and current speeds) observed during a field investigation conducted in August 2010. The calibration involved making adjustments to the bottom friction factor used in different parts of the model domain to minimize the overall error between the model's predictions and the velocities observed during the site visit. For this purpose the model was driven using boundary conditions that approximated conditions during the field investigation as closely as possible. The depth-averaged velocities predicted by the numerical model were compared to the measured velocities on a point-by-point basis, taking care to ensure that the locations and times were always in close agreement. The bottom roughness in different parts of the model domain was adjusted to minimize the overall error between the measured and modelled velocities as much as possible. In the end, an RMS error of 20 cm/s was achieved.

4.2 Validation of Hydrodynamics

Following successful calibration of the CMS-Flow model to observations from August 2010, a validation analysis was undertaken to verify that the model was able to correctly predict hydrodynamic flows for other time periods with reasonable precision. The calibrated numerical model was used to predict hydrodynamics at Shippagan Gully inlet for June 14, 2012, when an ADCP velocity survey was undertaken. The calibrated CMS-Flow model was configured to replicate the 2012 bathymetry and forced using estimated boundary conditions (water level fluctuations) from June 13, 2012 to June 15, 2012.

These tidal boundary conditions were obtained from the regional Telemac-2D model of tidal flows around the Acadian Peninsula. The effect of waves was not included in the validation modelling.

The depth-averaged velocities from the numerical simulation where compared to the velocity vectors derived from the ADCP data recorded at the site. As before, an RMS error statistic was calculated to quantify the quality of the agreement between the measured and modelled velocities for each transect. An RMS error of 0.101 was obtained for the longitudinal transect near the curved training wall, while an RMS error of 0.136 was obtained for the longitudinal transect along the center of the navigation channel. For the transect on the north-eastern side of the inlet, the RMS error was 0.234. These results are considered to be acceptable, given that the errors are similar to those obtained during model calibration. These results demonstrate that the CMS-Flow model can be relied on to predict the main features of the depth-averaged tidal flows through the inlet with reasonable precision. However, some details such as eddies and flow patterns during slack tide may not be accurately modelled.

4.3 Morphologic Calibration

The sedimentary processes in the model were also calibrated to measurements from the site. The sedimentary processes were initially tuned to provide a reasonable simulation of the morphology change observed at the inlet over the two year period from 2004 – 2006. An estimate of the actual change in the bed elevation was derived by differencing two bathymetric surveys conducted in 2004 and 2006. Over this period, the depth of the navigation channel remained fairly constant, but the channel slowly grew narrower and migrated slightly towards the western curved training wall. As in the Phase 1 study, when predicting long-term behaviour, the model was forced using simplified tidal boundary conditions and a statistical representation of the annual wave climate. The tidal fluctuations and wave conditions that actually occurred at the site from 2004 to 2006 were not modelled. Instead, a representative 14-day tidal signal was developed for each boundary, and the tidal signals were repeated 52 times over the 2-year simulation. Similarly, a time history of wave conditions (wave spectra approaching from different directions) that approximated the annual wave climate was synthesised and applied along the offshore boundary. Towards the end of the morphology calibration process, a six year period from 2004 to 2010 was also considered. Again, an estimate of the change in seabed elevation at the inlet over this period was obtained by differencing bathymetric survey data gathered in 2004 and 2010.

The model's simulation of sedimentary processes was tuned by manipulating two different aspects of the model: the initial map defining the size of sediments on the seabed over the model domain; and the following three calibration parameters governing the rate of sediment transport: the bed load scaling factor, the suspended load scaling factor and the bed slope coefficient. Changing these parameters affects the rate of erosion, transport and deposition predicted by the model.

The CMS-Flow model used in this study was able to simultaneously reproduce the mobilization, transport and deposition of multiple sediment sizes. The initial sediment properties at any location were specified in terms of the D_{30}, D_{50} and D_{90} values, representing the 30^{th}, 50^{th} and 90^{th} percentiles of the cumulative grain size distribution. These sediment properties had a strong influence on the tendency for sediments to be mobilized and transported, and hence on the temporal changes in seabed elevation. Creating a map of initial sediment properties that was consistent with field investigations and led to reasonable estimates of morphology change was the main challenge in calibrating the numerical model. The sedimentary processes and resulting morphology changes were found to be strongly influenced by the bottom sediment properties specified at each location. In general, erosion could be reduced by increasing the initial bed grain size in that location, and conversely, erosion could be increased by reducing the initial bed grain size, as one might expect. An initial map of bed sediment size (D_{50}) was created based on the maximum velocity contours and information on bed sediment grain sizes obtained from field investigations. Larger grain sizes were generally specified in locations with stronger peak velocities. The initial D_{50} map was modified numerous times in order to improve the agreement between the observed and modelled morphology change. The D_{50} map that was eventually adopted is shown in Figure 6. Medium sands with D_{50} = 0.45 mm were assumed over most of the computational domain away from the inlet, which is generally consistent with sediment samples collected at the site. The seabed over a large portion of the inlet mouth was assumed to be armoured with coarse sediments (D_{50}>20 mm). The largest sediments (D_{50}~50 mm) were co-located with the strongest currents in the central part of the navigation channel. Sediments with D_{50}~25 mm were assumed over a portion of the ebb shoal where the flood jet emerges from the inlet mouth. A gradual transition was assumed between the gravels in the inlet and the sands elsewhere. Near the inlet mouth, the assumed spatial variation of D_{50} is similar to the spatial variation in maximum velocity (see Figure 7). It is important to recognize that the spatial variation of initial bed sediment properties assumed in the numerical modelling is very likely an approximation of actual conditions. Any differences between these assumptions and reality will degrade the realism of any numerical estimates of morphology change.

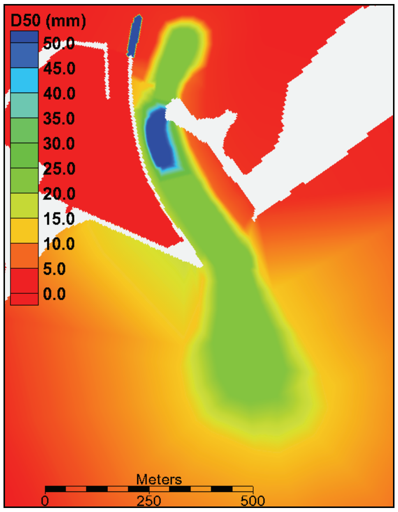

Figure 6. Assumed spatial variation of bottom sediment median grain size D50 (mm).

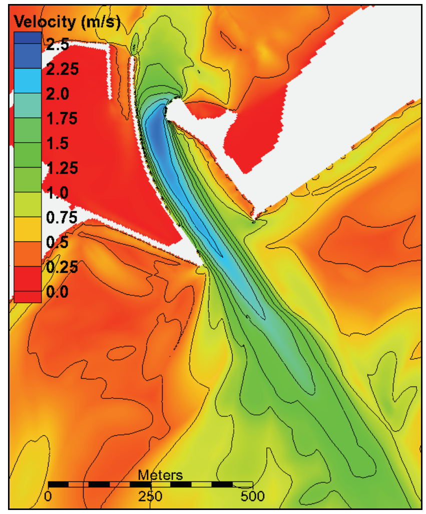

Figure 7. Spatial variation of modelled maximum depth-averaged velocity (m/s).

The measured and modelled changes in seabed elevation over the six years from 2004-2010 are compared in Figure 8. The measured change could only be derived for the area covered by both hydrographic surveys (focused on the navigation channel); and this area represents a small sub-set of the computational domain. Any assessment of model performance is necessarily restricted to this small area. On the whole, the model is able to predict the correct erosional and depositional trends in the correct places within the inlet. The magnitudes of the measured and modelled changes are also similar in most places within the inlet. It should however be noted that the model is unable to predict the re-shaping of the ebb shoal that occurred between the bathymetric surveys conducted in 2004 and 2010, nor is it able to predict the deposition observed at the north-western tip of the sand spit that has formed on the eastern side of the inlet mouth.

Based on these and other similar results for the 2004-2006 period, it was concluded that the model is able to simulate general patterns and trends within the inlet reasonably well, but it cannot be relied on to reliably predict fine details of the flow or the sediment transport, nor provide accurate detailed predictions of morphology change over long durations. Higher precision remains elusive for several reasons:

- The boundary conditions used to force the model were simplified representations of the actual conditions.
- Some potentially important processes, such as storm surge and ice runup were not included in the numerical simulations at the calibration stage.
- Significant assumptions were made concerning the spatial variation of bottom sediment sizes; assumptions that have a strong influence on the model's predictions of morphology change.
- The model has difficulty simulating sediment transport and morphology change in areas that are intermittently submerged.
- Even the most advanced numerical model, such as the one employed in this study, can only provide a simplified and discretized representation of the many complex physical processes governing the hydrodynamics and sediment transport at a dynamic tidal inlet such as Shippagan Gully.

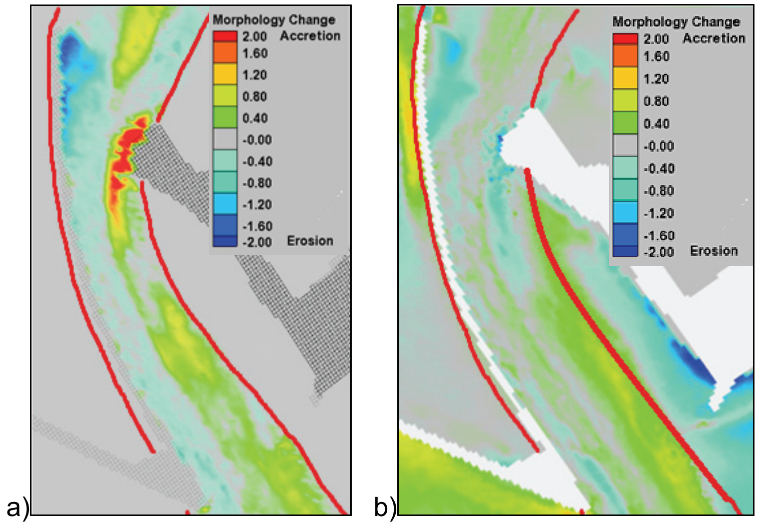

Figure 8. Measured and modelled change in seabed elevation from 2004-2010 (blue = erosion, green/yellow/red = deposition, grey = no change): a) measured; b) modelled

5 Numerical model results - coastal processes during storms

In this section we present numerical model results that highlight the coastal processes at the site under storm conditions, and demonstrate the response of Shippagan Gully inlet to storm forcing. Three different hypothetical storms were developed and simulated to investigate these aspects. One storm featured waves with significant wave height, H_s=4 m, and peak wave period, T_p=10 s, approaching from the east (waves propagating towards 270°); the second storm featured identical waves approaching from the southeast (towards 315°); while the third storm featured waves with H_s=3 m, T_p=10 s, approaching from the south (towards 360°). All three storms were assumed to generate a 1 m high surge (increase in mean sea level) and have a duration of 25 hrs. The assumed variation with time of water level, wave height and wave period for the easterly storm is shown in Figure 9. The other storms followed a similar pattern. To investigate the influence of storm surge, three other storms were synthesized and modelled in which the 1 m surge was excluded while all other storm properties remained unchanged.

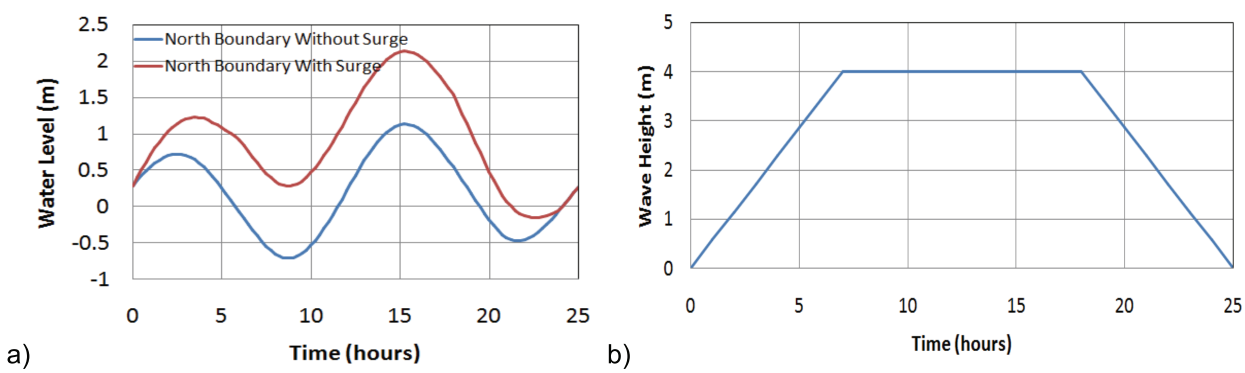

Figure 9. Assumed variation of a) water level, and b) wave height for hypothetical storms.

The residual currents (net time-averaged currents) calculated for each storm are compared in Figure 10. The easterly storm (Figure 10a) forces a longshore current near the shore and over the ebb shoal flowing from NE to SW on both sides of the inlet. The strong ebb jet emerging from the inlet mouth is deflected towards the west in this case. For the southerly storm (Figure 10c) the longshore current on both sides of the inlet reverses and flows from SW to NE as expected. The strong ebb jet is deflected towards the east in this case, and the residual circulation on the ebb shoal is generally weaker and more variable. The southeasterly storm (Figure 10b) generates much weaker longshore currents than the other two storms.

The residual circulations on the ebb shoal are also rather mixed for the southeasterly storm, compared with the other storm directions. In all three cases, the residual currents within the inlet mouth are bi-directional; flowing strongly towards the Gulf of St. Lawrence on the west side of the inlet mouth parallel to the curved training wall, and flowing into the lagoon on the east side of the inlet mouth along the edge of the sand spit. This prominent clockwise circulation within the inlet mouth has likely contributed to the growth and elongation of the sand spit that has formed on the eastern side of the inlet mouth, which now threatens safe navigation through Shippagan Gully. These results show that the residual currents flowing in and out from the inlet mouth are weaker during storms from the east than during storms from the southeasterly or southerly directions.

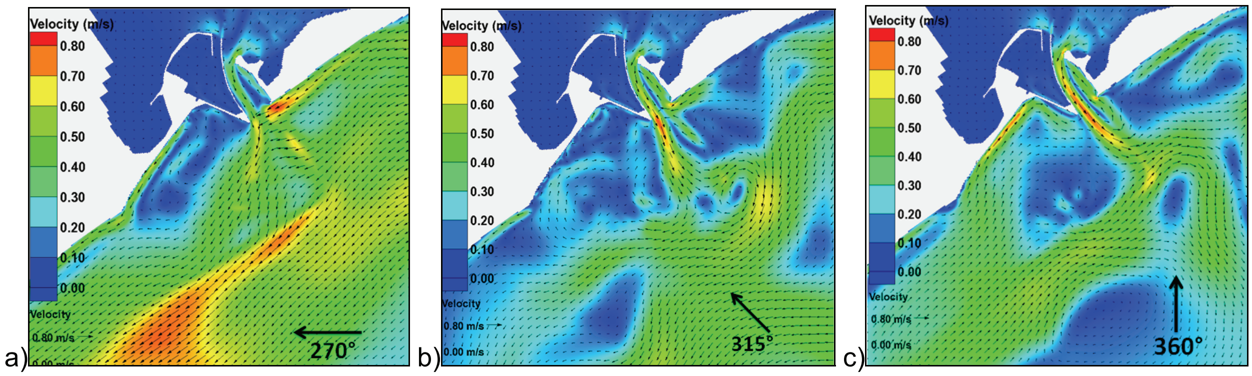

Figure 10. Residual currents due to storms from a) east, b) southeast and c) south direction (blue = weak current, red = strong current).

The changes in seabed elevation predicted by the model for each of the 25 hr storms are compared in Figure 11. The easterly storm (Figure 11a) deposits substantial volumes of sediment in the navigation channel just outside the inlet mouth, and lesser volumes within the inlet mouth itself. The southeasterly storm (Figure 11b) deposits less sediment near the entrance, but deposits more sediment within the inlet mouth, particularly along the eastern side of the navigation channel and between the channel and the edge of the sand spit. The southerly storm (Figure 11c) erodes the seabed just outside the inlet mouth while depositing substantial sediment volumes deep inside the inlet mouth, between the navigation channel and the sand spit. Erosion rather than deposition occurs outside the inlet mouth during the southerly storm. These results indicate that intense storms, particular those approaching from the southerly and southeasterly directions, are capable of depositing substantial volumes of sediment deep within the inlet mouth, and are likely to be at least partially responsible for the growth and elongation of the sand spit that presently constricts the navigation channel. Easterly storms can deposit sediments in the navigation channel just outside the inlet.

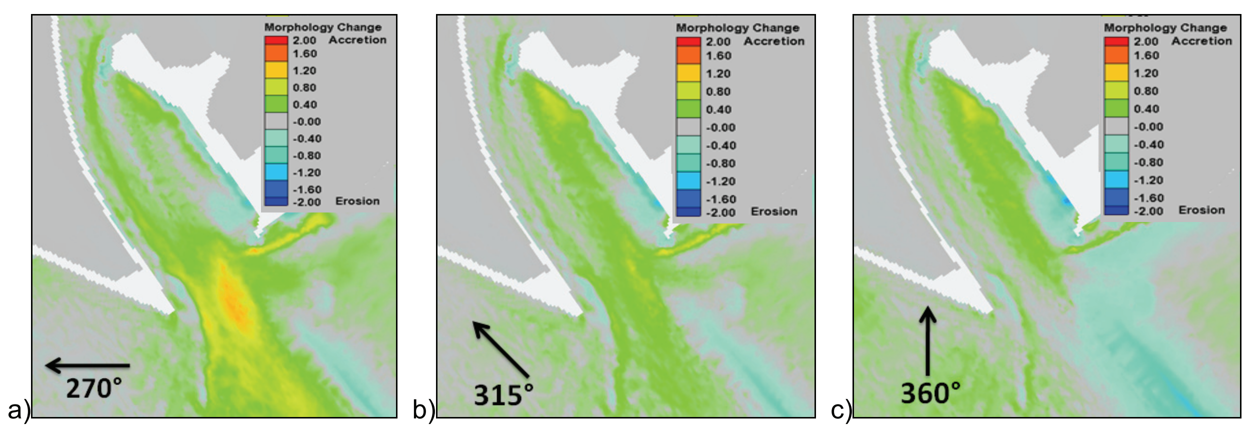

Figure 11. Modelled change in seabed elevation due to storms from a) east, b) southeast and c) south directions (blue = erosion, green/yellow = deposition, grey = no change).

The influence of storm surge on this depositional process can be seen in Figure 12, in which the modelled change in bed elevation for a 25 hr storm from the south, with and without 1 m surge, are compared. The surge is clearly responsible for increasing the volume of sediment deposited within the inlet mouth, and for depositing sediments deeper inside the inlet. The additional deposition is linked to an increase in the amount of wave energy that is able to penetrate into the inlet mouth when the water depths over the ebb shoal are increased. This additional wave energy mobilizes more sediment and reinforces the current running into the inlet along the edge of the sand spit; and both of these processes contribute to increased deposition deep within the inlet mouth.

a) b)

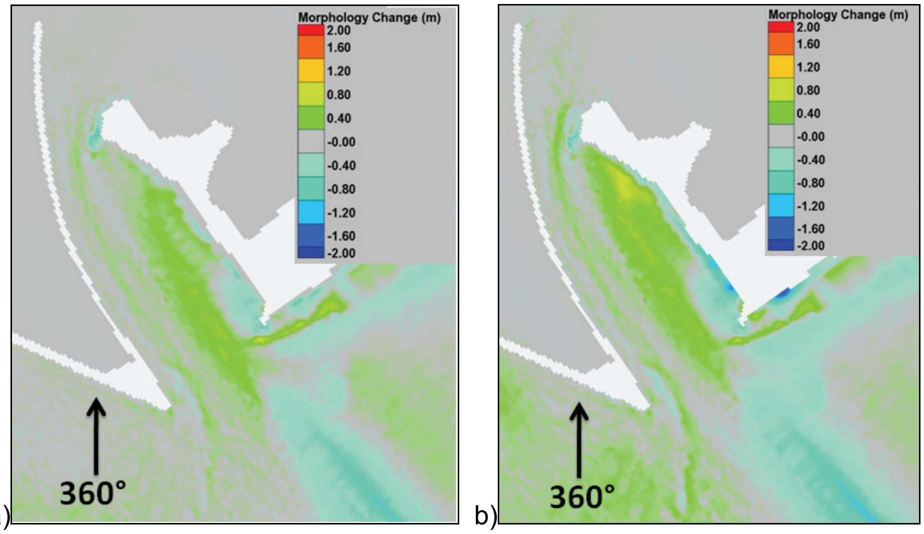

Figure 12. Influence of storm surge on morphology change for design storm from the south: a) without surge; b) with 1 m surge (blue = erosion, green/yellow = deposition, grey = no change).

6 Conclusions

A sophisticated numerical model based on the CMS modelling system has been developed to simulate coastal processes at the mouth of a highly dynamic tidal inlet located near Le Goulet, New Brunswick. Results from several field investigations were used to help calibrate and validate the hydrodynamic and sedimentary aspects of the new model. The calibrated model was then applied to investigate coastal processes at the inlet during storms and identify important sensitivities to storm properties such as surge and wave direction. Numerical results indicate that storms approaching from the south and southeast are capable of depositing significant sediment volumes within the inlet mouth, and are likely at least partially responsible for the growth of the sand spit presently constricting the navigation channel. The final goal of this work is to use the model to help assess the effectiveness of alternative engineering solutions for improving navigation safety at Shippagan Gully.

7 Acknowledgements

The authors wish to thank DFO for funding this study, Dr. Mahdi Razmaz from Hiroshima University, Japan, for assisting with the field work and processing of the ADCP data, Mr. Thierry Faure for assisting with the TELEMAC modelling, and Mr. Seth Logan for sharing his knowledge of the Phase 1 study. The support of the Natural Science and Engineering Council (NSERC) through its Discovery Grant is also acknowledged.

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