SEDIMENT TRANSPORT FIELD DATA AND NUMERICAL MODELING STUDY TO SUPPORT DREDGE PIT INFILL RATE ESTIMATES

Atilla Bayram [1] Sean O'Neil [2] and Yang Zhang [3]

Site specific bedload and suspended sediment transport data collected at two test pit locations over a four-day period during April 2015 were analyzed to calibrate a numerical sediment transport model of Cook Inlet, AK. The field data campaign was designed to collect suspended load and bedload field measurements and was carried out in two phases. During Phase 1, both suspended load and bedload measurements were taken at approximately 55 ft water depth. The suspended sediment concentration was observed to be nearly uniform over the water column. Laboratory analysis showed the suspended sediment had an effective grain size of approximately 0.03 mm with ± 0.005 mm within a 95% confidence interval. During Phase 2, hydrodynamic, suspended load and bedload measurements were collected over four tidal cycles in the surfzone. A two-dimensional sediment transport model was developed to simulate sediment transport infill rates at the dredged areas of the Project site. The model was calibrated by comparing measured suspended load measurements made at two offshore locations. Calibration results showed that the suspended load transport rate, which is the dominant sediment transport regime in the area, can be predicted accurately at the project site. Based on the calibrated sediment transport model, preliminary annual sediment infill rates were estimated to lie between 1.1 to 1.6 ft/yr at offshore and nearshore locations, respectively, for the presently observed and measured conditions.

Keywords: suspended load; bedload; nearshore waves, surfzone sediment transport

INTRODUCTION

A sediment transport sampling and monitoring campaign was designed to collect a comprehensive set of field measurements to support a numerical sediment transport study that feeds into dredge infill rate estimates for a project located within Cook Inlet, Alaska, USA (see Figure 1, details of project are confidential). The specific scope of this study is to support the development of Marine Facilities comprising a Product Loading Facility (PLF) and a Material/Module Offloading Facility (MOF). It is well known that modeling of morphodynamics is not very accurate in the absence of accurate field measurements related to sediment transport processes. In the absence of such data the uncertainty margins are relatively large – up to 5 (van Rijn, 2006).

The purpose of the work entails building, and then stepwise refining and enhancing the numerical model, through comparison with sediment bedload and suspended load measurements. The main objective of the work is to collect flow velocity, bedload and suspended load sediment data which will be used to calibrate and validate the numerical sediment transport model. The measurements were made from mid- to late-2015. First, an offshore bedload and suspended sediment measurement campaign was conducted, followed by a nearshore bedload and suspended sediment measurement series, with a seabed-placed bedload grab samples made to better understand the nature of the bedload regime. Subsequently, the numerical sediment transport model was properly calibrated against the measurements, while further validation of the model will be carried our using dredged test pit monitoring data (i.e., bed level change over time) to be collected in near future. The model has been utilized after each measurement and monitoring episode, and the annual sediment infill rate near the project site assessed, at both the dredged test pits and the capital dredged areas as shown in Fig. 2.

FIELD DATA CAMPAIGN

A sediment transport monitoring program has been undertaken at offshore and nearshore locations near the project site during spring 2015. The field data campaign was designed to be carried out in two phases. The goal of Phase 1 was to collect the necessary field data to characterize offshore sediment transport. Phase 1 field study data were collected in open water from boat-mounted instruments for four days (21-Apr-15 to 24-Apr-15). The objective of Phase 2 was to collect the wave, current and sediment field data to characterize alongshore sediment transport. Phase 2 field work was shore-based and carried out on four days (31-Aug-15 and 28-Sep-15).

[1] Jacobs, 500 7th Ave. 17th Floor, New York, NY 10018, USA
[2] Jacobs, Sheikh Zayed Road, Trade Centre 1, 2nd Fl. City Tower 2, P.O. Box 360, Dubai, UAE
[3] Jacobs, 4350 W Cypress St., Tampa, FL 33607, USA

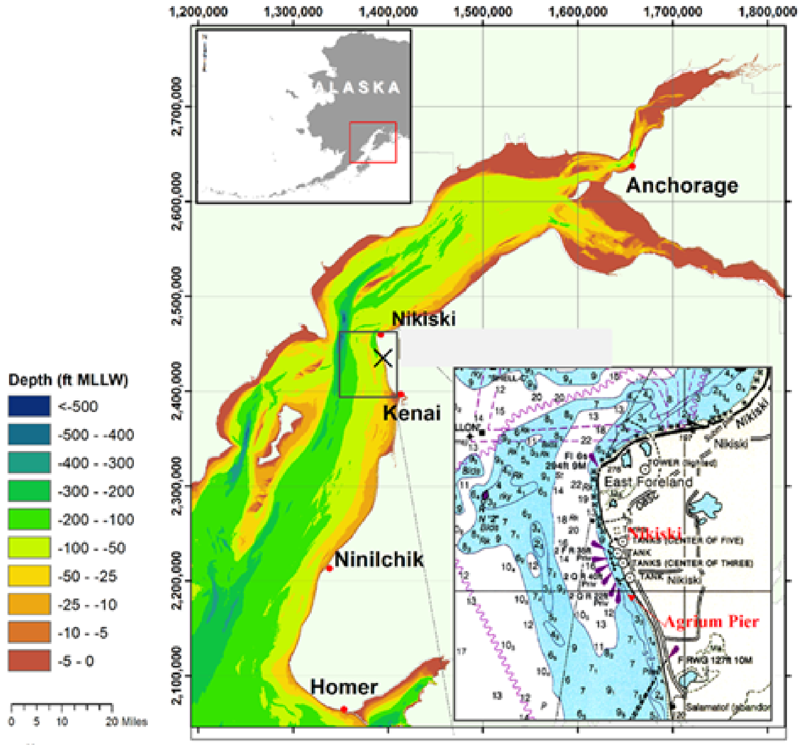

Figure 1. Cook Inlet Alaska, USA

Sediment Transport Sampling and Monitoring – Phase 1

Bedload and suspended load samplings were taken at 4 sites (Sites 11, 13, 14 and 19), as shown Fig. 2. Samples were taken at locations in the footprint of the offshore Test Pit (Sites 11, 14 and 13) in the first 3 days. Samples were also taken at Site 19, which is just seaward of the nearshore test pit, on the fourth day. A ship-attached, downward looking Acoustic Doppler Current Profiler (ADCP) was also deployed to collect the concurrent flow velocity data through the water column.

Vertical distribution of turbidity in the water column was sampled using an optical backscatter sensor (OBS 3A, Campbell Scientific). About 5 OBS turbidity casts per day were taken (a cast consisting of lowering the OBS through the water column and then retrieving it). Suspended sediment concentration measurements were also made by obtaining water samples via a pump system and later analyzing the samples in the laboratory. Using the concentration of suspended sediments from the sample to compare to the turbidity measured by optical backscatter sensors (OBS) located nearby to the water pump sampler, the OBS 3A was calibrated and a relationship between turbidity and suspended sediment concentration (SSC) was determined. Using the derived relationship, the turbidity data were converted to suspended sediment concentrations.

Fig. 3 shows the vertical distribution of suspended sediment concentration at different times for Sites 11, e.g., 5 casts on 21 to 22-Apr-15, Site 13, 5 casts on 23 to 24-Apr-15, 5 casts Taken at Site 14 on 22 to 23-Apr-15 and 5 casts taken at Site 19 on 22 to 23-Apr-15. The suspended sediment concentration shows distinctly uniform concentration profiles over the water column except close to surface for all samples. These measurements of the suspended sediment concentration by mass generally ranged from 2.0×10^{-4} lb./L to 2.45×10^{-3} lb./L.

Column settling experiments were performed on two samples to estimate the grain size distribution. The raw data indicated that the effective median grain size, D_{50} for the samples are 17 µm and 18.7 µm, respectively. In addition, a series of particle settling column experiments was performed on industrial sediment (AGSCO Silica size 325, sample N109) for which the D_{50} is reported to be approximately 14 µm. The effective settling velocity from the settling experiment of the AGSCO size 325 sediment was 17 µm, suggesting that the settling experiments are reasonably accurate with uncertainty in D_{50} within 20%.

A depth-integration of the product of suspended sediment concentration and velocity was used to calculate the suspended sediment transport rate for each cast (see Table 1). Bedload transport was measured using a 120 lb. Helley-Smith bedload sampler. The bedload sampler was attached to a cable and lowered to the bottom. The Helley-Smith bedload samplers were equipped with 0.25 mm nets which collected the larger solid bedload material greater than the net size but allowed water and finer material to pass through. They were also outfitted with a tilt sensor which allowed the operators to verify that the device was nearly horizontal (within 10° of horizontal) during the deployment. Measured bedload rates at offshore are summarized in Table 2.

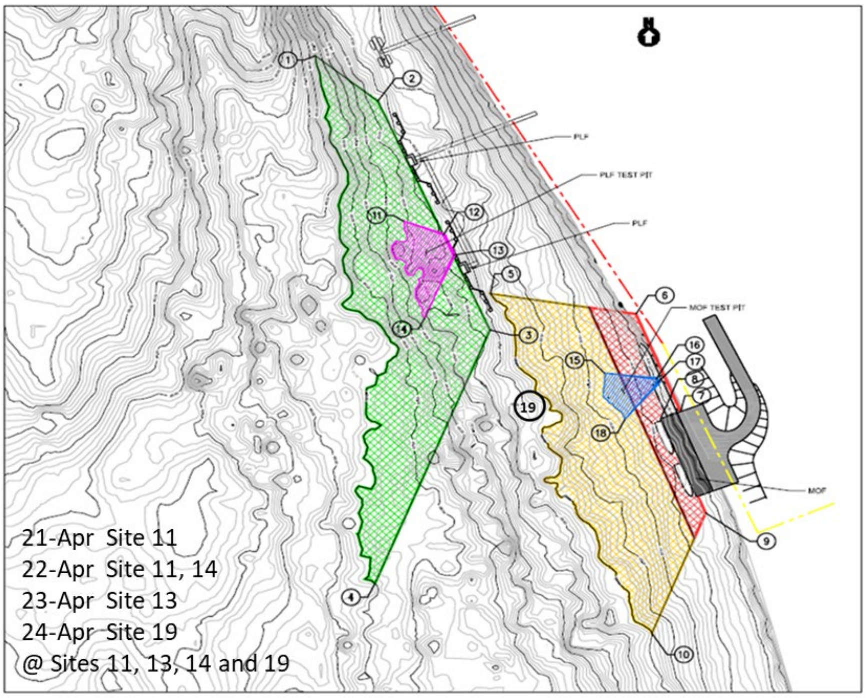

Figure 2. Location of field data collection points including dredging test pits (red and blue triangles)

The bedload sampler was deployed at 4 different Sites 11, 13, 14 and 19 (Fig. 2), and a total of 21 bedload samples were collected over the 4-day period from 21 to 24-Apr-15. Table 2 provides a summary of data including site number, the sample number, sample collection start time, sample collection period, mass of sample collected, rate of transport (lb./s) into the sampler, and the adjusted rate of transport (a calibration factor of 0.5 applied for particles in the 0.25 to 0.50 mm size range to account for the that many particles in this size range trapped by the sampler would actually be transported as suspended load, recommended by Emmett (1980).

Samples collected with the bedload sampler were tested at the laboratory. The averaged median grain size D_{50} value is found to be approximately 0.4 mm at Sites 11, 13 and 19, and 0.6 mm at Site 14 partially due to the large D_{50} for sample number 7, of which the bedload material is mostly large stones and pebbles.

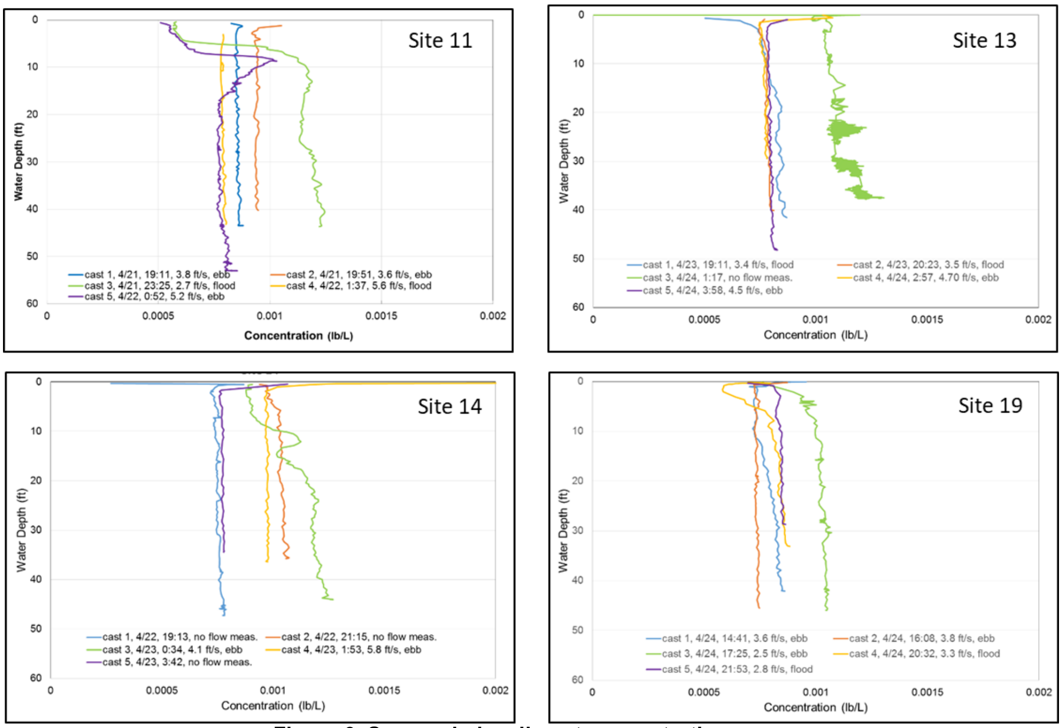

Figure 3. Suspended sediment concentrations

Table 1. Measured suspended load rates at offshore

Site	Cast No.	Tide	Velocity (ft/s)	Suspended Load ($yd^3/s/ft$)
Site 11	Cast 1	Ebb	3.77	8.74×10^{-4}
	Cast 2	Ebb	3.61	8.52×10^{-4}
	Cast 3	Flood	2.66	9.39×10^{-4}
	Cast 4	Flood	5.61	1.20×10^{-3}
	Cast 5	Ebb	5.22	1.10×10^{-3}
Site 13	Cast 1	Flood	3.41	7.15×10^{-4}
	Cast 2	Flood	3.48	6.74×10^{-4}
	Cast 3	N/R	N/R	N/R
	Cast 4	Ebb	4.69	4.97×10^{-1}
	Cast 5	Ebb	4.53	7.86×10^{-1}
Site 14	Cast 1	N/R	N/R	N/R
	Cast 2	N/R	N/R	N/R
	Cast 3	Ebb	4.13	9.23×10^{-1}
	Cast 4	Ebb	5.81	9.50×10^{-1}
	Cast 5	N/R	N/R	N/R
Site 19	Cast 1	Ebb	3.64	5.59×10^{-1}
	Cast 2	Ebb	3.81	5.86×10^{-1}
	Cast 3	Ebb	2.53	5.43×10^{-1}
	Cast 4	Flood	3.35	4.10×10^{-1}
	Cast 5	Flood	2.79	3.08×10^{-1}

Note: N/R not recorded

Table 2. Measured bedload rates at offshore

Site	Sample No	Sample collection start time	Time period of sampling (min)	Depth averaged current speed (ft/s)	Mass of sample collected (lb)	Rate of transport (into sampler)	Adjusted rate of transport (lb/s)
11	1	4/21/15 18:07	10	3.9	0.0121	2.02x10^{-05}	1.01x10^{-05}
11	2	4/21/15 18:53	15	3.9	0.0225	2.50x10^{-05}	1.25x10^{-05}
11	3	4/21/15 19:30	15	3.9	0.0049	5.39x10^{-06}	2.69x10^{-06}
11	4	4/21/15 23:37	20	3.0	0.0031	2.57x10^{-06}	1.29x10^{-06}
11	5	4/22/15 01:12	20	5.6	0.0220	1.84x10^{-05}	9.19x10^{-06}
11	6	N/R	N/R	N/R	0.0254	-	-
14	7	4/22/15 20:12	20	3.9	0.0776	6.47x10^{-05}	3.23x10^{-05}
14	8	4/22/15 20:43	20	3.6	0.0095	7.90.x10^{-06}	3.95x10^{-06}
14	9	4/23/15 00:37	20	3.6	0.0161	1.34x10^{-05}	6.71x10^{-06}
14	10	4/23/15 01:30	20	5.6	0.0833	6.96x10^{-05}	3.44x10^{-05}
14	11	4/22/15 03:20	20	4.6	0.0055	4.59x10^{-06}	2.30x10^{-06}
13	12	4/22/15 19:14	20	3.3	0.0882	7.35x10^{-05}	3.67x10^{-05}
13	13	4/23/15 20:01	20	3.3	0.0613	5.11x10^{-05}	2.55x10^{-05}
13	14	4/24/15 14:45	20	3.6	0.0606	5.05x10^{-05}	2.53x10^{-05}
13	15	4/22/15 03:00	20	4.9	N/R	-	-
13	16	4/23/15 04:01	20	4.3	0.3721	3.10x10^{-04}	1.55x10^{-04}
19	17	4/24/15 14:45	20	3.6	0.5388	4.49x10^{-04}	2.25x10^{-04}
19	18	4/24/15 15:45	20	3.9	N/R	-	-
19	19	4/23/15 17:01	20	3.0	0.0238	1.98x10^{-06}	9.92x10^{-06}
19	20	4/24/15 20:34	20	3.0	0.0057	4.78x10^{-06}	2.39x10^{-06}
19	21	4/24/15 21:30	20	3.3	0.3056	2.55x10^{-06}	1.27x10^{-04}

Note: N/R not recorded

Sediment Transport Sampling and Monitoring – Phase 2

To measure longshore sediment transport as a function of wave conditions in the surf zone, hydrodynamic and sediment transport data were collected over four tidal cycles. The field campaigns were shore-based, i.e., instruments were placed on the beach face at low tide, submerged as the tide came in, and exposed again for retrieval as the tide receded.

Suspended sediment concentration as a function of depth were measured using four optical backscatter sensors attached to a steel frame along with ADV’s on Quadropod 1 (Fig. 4). The OBS sensors were positioned at 5 in., 9.0 in., 15.5 in. and 19.5 in. above the seabed. A bilge pump was also attached to Quadropod 1 at 10 in. above the seabed to collect water/suspended sediment samples for the OBS calibration. A power cable and hose (or tubing) ran from the pump to the beach crest. The cable and hose were attached and weighted with lead weights. A 100-ft cable and hose assemble from Phase 1 was be used for this purpose.

Wave conditions were measured with horizontally oriented ADV on Quadropod 1 and a vertically-oriented ADV on Quadropod 2 (Fig. 4). The horizontal and vertical ADV’s were positioned approximately 45 ft and 70 ft seaward of beach crest. Due to rough weather conditions Quadropod 2 was taken out of water and replaced with Sontek Acoustic Doppler Profiler (ADP) mounted on barnacle.

The vertical distribution of turbidity in the water column was sampled using two OBS sensors at Quadropod 1. The OBS turbidity casts were carried out at half-hour intervals. Suspended sediment concentration measurements were also made by obtaining water samples via the pump system (Fig. 4) and later analyzed in the laboratory. Using the concentration of suspended sediments from the sample turbidity measured by optical backscatter sensors (OBS) located nearby to the water pump sampler, the OBS was calibrated and relationship between OBS count and suspended sediment concentration (SSC) was determined. Suspended sediment concentration correlated well with turbidity measurements with a correlation coefficient of R^2=0.85 for the both samples.

Using the derived relationships, the turbidity data were converted into suspended sediment concentrations (SSC). Fig. 5 shows vertical distribution of suspended sediment concentration at half-hour intervals. The SSC shows nearly uniform concentration variation over the water column for all samples. These measurements of the suspended sediment concentration by mass generally ranged from 2.8 x 10^{-4} lb./L to 5.3 x 10^{-3} lb./L. Nearshore SSC showed similar profiles and similar order-of-magnitude transport rates as the offshore SSC measured during the Phase 1 study.

A depth-integration of the product of suspended sediment concentration and velocity was used to calculate the suspended sediment transport rate for each cast as listed in Table 3. Calculated suspended load rates are an order of magnitude smaller at nearshore locations compared with the offshore measurements.

Bedload transport was measured using two 120 lb. Halley-Smith bedload samplers. The bedload samplers were equipped with 65 µm mesh bags which collect the larger solid bedload material greater than the net size but allow water and finer material pass through. The bedload samplers were positioned approximately 35 ft and 65 ft seaward of beach crest.

A total of 8 bedload samples were collected over the 4-day period from 31-Aug-15 to 28-Sep-15. Table 4 provides a summary of data including collection date, sample ID, sample collection period, mass of sample collected, rate of transport ($ft^3/s/ft$) into the sampler. A calibration factor of 1.0 applied for particles in the 0.5 mm to 16 mm size range to account for the fact that many particles in this size range trapped by the sampler would actually be transported as suspended load, as recommended by Emmett (1980).

Bedload samples were analyzed for total mass and grain size distribution in the laboratory. The averaged median grain size D_{50} values is approximately 9.8 mm in the surfzone. Compared to the median grain size D_{50} values observed in the offshore samples during the Phase 1 campaign, the bedload comprises of mostly gravel and pebbles nearshore.

Table 3. Computed suspended sediment transport rates

Date	SSC-Integrated over depth (lb/ft^2)	Longshore current velocity (ft/s)	Suspended load (lb/ft/s)	Submerged suspended load ($ft^3/ft/s$)	Submerged suspended load ($yd^3/ft/s$)
09/21/15 10:00	2.22	0.30	0.66	0.000413	$1.53x10^{-05}$
09/21/15 10:30	6.65	0.39	2.62	0.001647	$6.10x10^{-05}$
09/21/15 11:00	8.64	0.49	4.25	0.002676	$9.91x10^{-05}$
09/21/15 11:30	7.52	0.36	2.71	0.001707	$6.32x10^{-05}$
09/21/15 12:00	4.26	0.16	0.70	0.000440	$1.63x10^{-05}$
09/21/15 12:30	2.59	0.36	0.94	0.000589	$2.18x10^{-05}$
09/21/15 13:00	2.62	0.72	1.89	0.001191	$4.41x10^{-05}$
09/21/15 13:30	1.60	0.52	0.84	0.000527	$1.95x10^{-05}$
09/28/15 17:00	7.06	0.27	1.92	0.001209	$4.48x10^{-05}$
09/28/15 17:30	11.85	0.23	2.72	0.001712	$6.34x10^{-05}$
09/28/15 18:00	11.86	0.34	4.09	0.002571	$9.52x10^{-05}$

Note: Rate by volume ($ft^3/ft/s$), Rate by mass/ρ_s(1-n), where n is the porosity of sand (=0.4)

Table 4. Computed bedload sediment transport rates

Date (mm-dd-yyyy)	Sample number	Total mass (lb)	Time period of sampling (min)	Bedload transport rate ($ft^3/ft/s$)	Bedload transport rate($yd^3/ft/s$)
08/31/2015	BL 1	4.79	60	$2.32x10^{-07}$	$8.59x10^{-09}$
08/31/2015	BL 2	23.08	60	$1.12x10^{-06}$	$4.14x10^{-08}$
09/21/2015	BL 1	27.79	60	$1.35x10^{-06}$	$4.98x10^{-08}$
09/21/2015	BL 2	7.62	60	$3.69x10^{-07}$	$1.36x10^{-08}$
09/25/2015	BL 3	14.08	60	$6.82x10^{-07}$	$2.52x10^{-08}$
09/25/2015	BL 2	61.73	20	$8.96x10^{-06}$	$3.32x10^{-07}$
09/28/2015	BL 1	103.62	25	$1.20x10^{-05}$	$4.46x10^{-07}$
09/28/2015	BL 2	27.99	60	$1.36x10^{-06}$	$5.02x10^{-08}$

Note: Rate by volume ($ft^3/ft/s$), Rate by mass/ρ_s(1-n), where n is the porosity of sand (=0.4)

SEDIMENT TRANSPORT MODELING

A numerical sediment transport model has been developed for the project area using the Sand Transport (ST) Flexible Mesh (FM) module of the MIKE21 model suite (MIKE by DHI, 2014a). The ST Module computes the transport of non-cohesive materials due to currents and waves. The model provides two options in computing sand transport: pure currents and combined current and waves. For the pure current option, the model computes the suspended load and bed load separately without considering the effect of waves. For the combined wave and current option, the model computes the total load without explicitly differentiating between the bed load and suspended load, and the sediment transport rates are found by linear interpolation in a sediment transport table.

The sediment transport table is generated using the MIKE21 Toolbox utility program 'Generation of Q3D Sediment Table (MIKE by DHI, 2014b), which calculates the sediment transport rates (total load consisting of bed load and suspended load) based on the various parameters describing the wave and current condition, including the ratio of wave height to water depth, sediment grain size and grading, and bed slope, etc. The expected range for each parameter and the associated increment interval are pre-defined and the look-up sediment transport table is prepared prior to the computations.

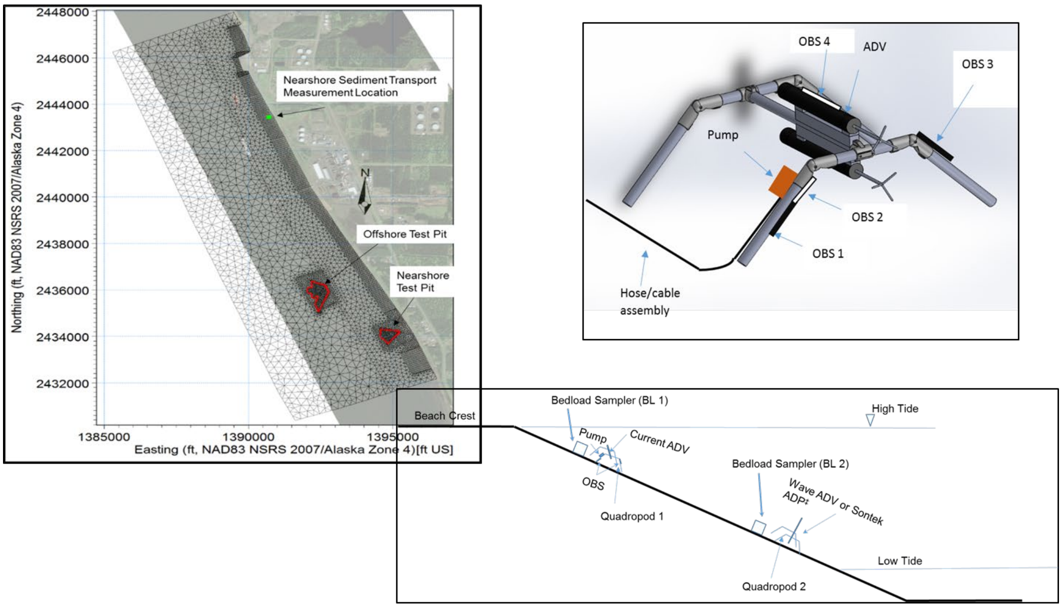

Figure 4. Suspended and bedload measurements location (top left), profile (bottom right) and instruments on Quadrapod 1 (top right)

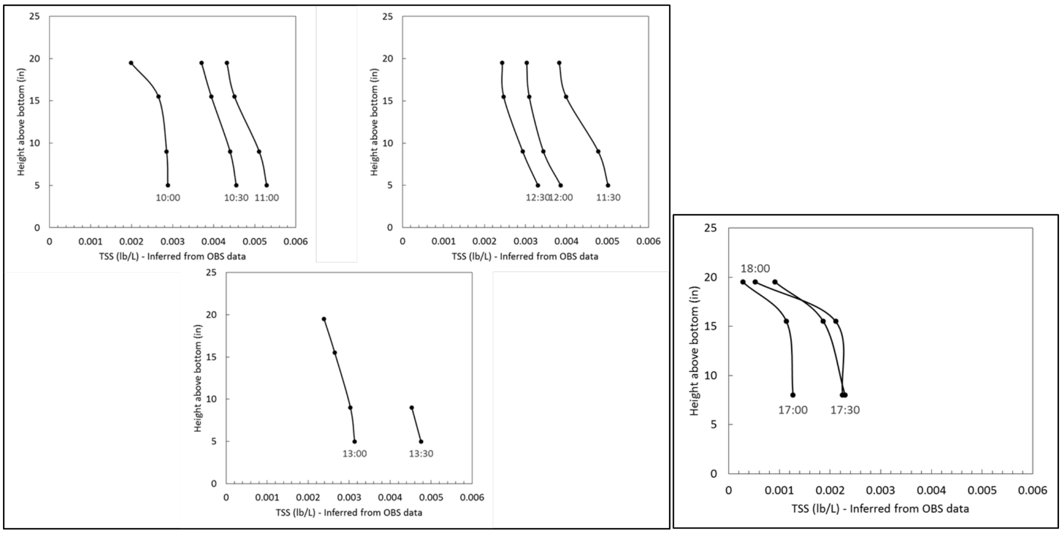

Figure 5. Suspended sediment concentrations at Quadrapod 1

The main objective of the modelling is to assess the sediment infill rate of a dredged area in the vicinity of the project site. The model will be driven by the wave and flow conditions from the calibrated, fully coupled wave and hydrodynamic model for the project area. The model was calibrated using measured bed load and suspended load transport measurements, and consequently will be further calibrated and validated using additional data to be measured during the dredged test pit monitoring program.

Model Mesh and Bathymetry

The sediment transport model domain covers an area approximately 45,000 ft in the alongshore direction by 15,000 ft in the cross-shore direction as shown Fig. 6. The model mesh, shown in Fig. 6, is gradually refined towards the project area, in particular with higher resolution used for the proposed nearshore structures (MOF and PLF) dredge areas, the shallow area (-30 ft MLLW) along the entire shoreline stretch covered by the model, and further refined for the two proposed test pits.

The bathymetric data near the project site wascollected during a recent high definition survey was used to develop model bathymetry. The bathymetric and topographic data are interpolated onto the model mesh, and the resulting model bathymetry is shown in Fig. 7.

Wave and current conditions used to drive the ST model are provided from the output of the fully coupled wave and hydrodynamic model. The coupled wave and hydrodynamic model is nested within the larger wave transformation model and hydrodynamic model that cover the entire Cook Inlet and the adjacent offshore areas. The coupled wave and hydrodynamic model are calibrated and validated against the measured wave and current data at the project site.

Measured vs. Modeled Suspended Load and Bed Load Transport

Fig. 8 shows modeled vs. measured suspended load transport rates. The model predicted the suspended load transport rates that are largely the same order as measured at Sites 11, 13 and 14. At Site 19 (offshore of the nearshore dredge test trench), the model underpredicted the measured suspended load transport rates by 3 to 5 times. For each site (except Site 19), very good agreement was observed for some of the casts, while for other casts the comparison is less good. This might be partially due to fact that 1) each cast the measured suspended load is essentially an instantaneous transport rate as the measurement period for each cast is on the order of one minute, while the time interval used in the ST model is hourly thus not sufficiently small; and 2) the inevitable discrepancies lies in currents between model and measurements as the modeled time period itself is an approximation. Overall, the modeled suspended loads compare reasonably well with the measured rates.

Since the nearshore field measurements were shore-based with instruments placed on the beach face at low tide, it thus requires a very fine mesh size to resolve nearshore area for the hydrodynamic and sediment transport modeling. Therefore, a revised model mesh is prepared by refining the nearshore area (surf zone and swash zone) with quadrilateral grids, as shown in Fig. 4. In the nearshore area, the quadrilateral meshes are approximately 80 ft in the alongshore direction, and 30 ft in the cross-shore direction for 500 ft wide section of surfzone.

The nearshore hydrodynamic and spectral wave model simulations using the revised model mesh were carried out for the period, 16 to 31-Sep-15. Water level, currents and wave conditions at the model boundaries were extracted from the larger Cook Inlet hydrodynamic model and spectral wave model.

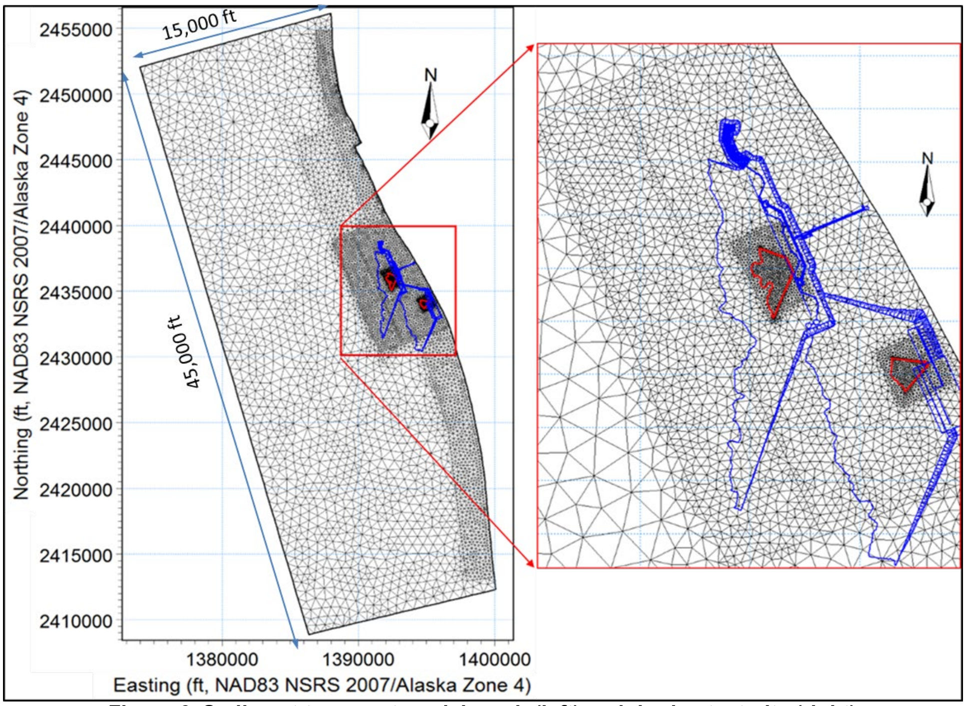

Figure 6. Sediment transport model mesh (left) and dredge test pits (right)

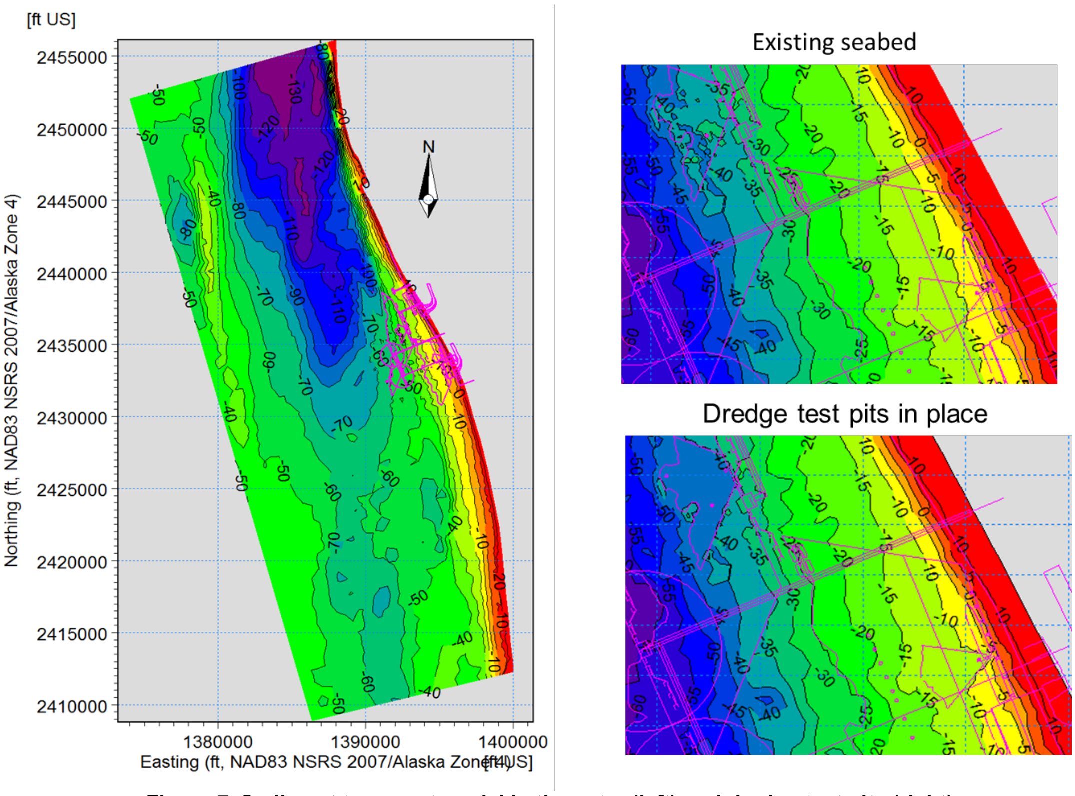

Figure 7. Sediment transport model bathymetry (left) and dredge test pits (right)

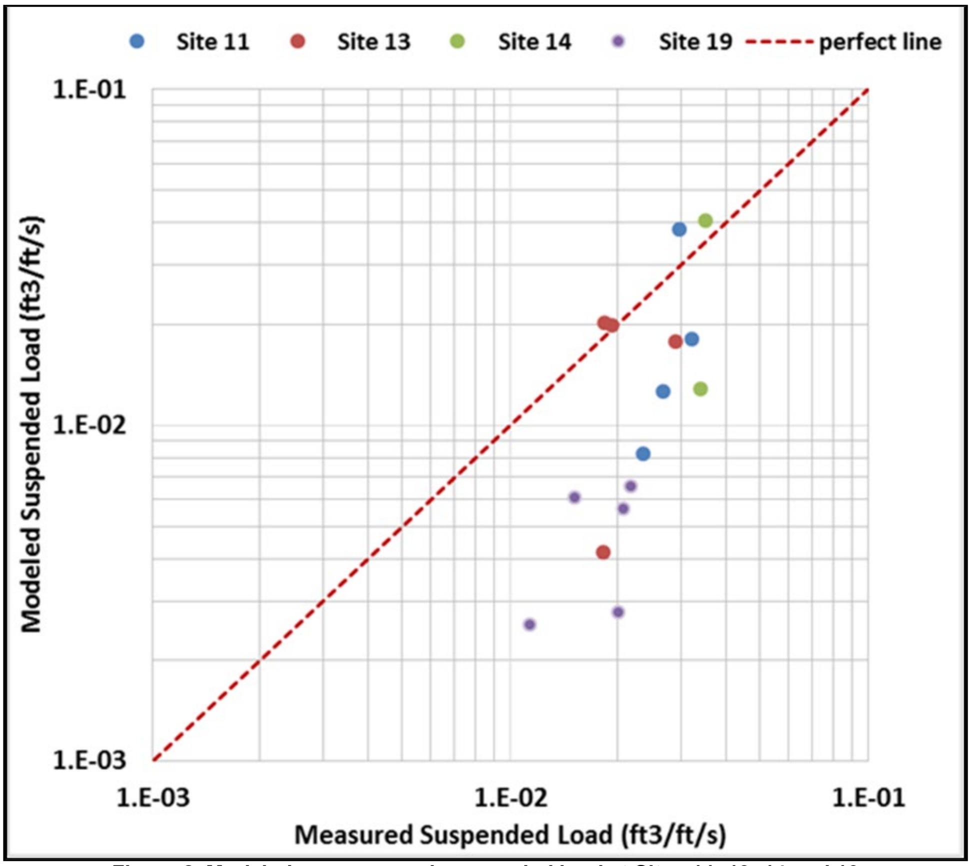

Figure 8. Modeled vs. measured suspended load at Sites 11, 13, 14 and 19

Modeled water level, current and waves were also compared with the measured currents at Quadropod 1 and measured water levels and waves at Quadropod 2 located on the beach face. The modeled water level in general shows good agreement with the measurements (Fig. 9). However, comparisons in current speed (Fig. 9) and wave conditions (Fig. 10) show a poor agreement. As for the currents, the model predicted current speeds vary from 0 to 3.0 ft/s, while the measured data suggest current speeds less than 1.0 ft/s. For waves, the model predicted significant wave height of over 4.0 ft during the storm occurring on 25-Sep-15 as shown in Fig. 10, while the measured wave height was less than 1.0 ft at the peak of the storm. Based on the field logbook, Quadropod 2 was replaced with Sontek Acoustic Doppler Profiler (ADP) mounted on a barnacle 25-Sep-15 due to rough waves in the surfzone. Moreover, the field notes document that the Sontek ADP was found buried by more than 12 in under the seabed and its mount filled with sediment. The field crew spent about two hours to salvage the instrument from its deployment location. Therefore, it is most likely that wave measurements reflected displacement of the barnacle on that day. The model under-predicted the wave height on 28-Sep-15 as compared with the measurements (Fig. 10).

These discrepancies between the model predictions and measurements are potentially due to 1) lack of the detailed bathymetry data for the nearshore area due to insufficient survey coverage in the site-specific bathymetry survey data used in model bathymetry; and 2) uncertainties in the accuracy and reliability of the measured waves and currents in the swash zone, as discussed above.Fig. 11 shows a time-series of the modeled total load transport rates in comparison with the measured rates on 21, 25 and 28-Sep 15. Overall, the model predicted total load transport rates reasonably well compared with the measured rates, except for the 21-Sep-15 measurement where the model under-predicted the total load. Both model and measurements showed that the total load on 25-Sep-15 are significantly higher than the other dates. This is due to a sizeable storm that occurred on that day as shown in Fig. 10. Model results with the D_{50} spatial-varying show some difference compared against the model using a constant D_{50} of 0.4mm, the latter predicted higher total load transport rates during non-storm periods, while predicted slightly smaller total load during the storm on 25-Sep-15.

Considering the complicated nature of the sediment movement in the surf zone and swash zone as well as uncertainties in the measurement data, comparison between model predictions and the nearshore sediment transport rate measurements is considered reasonable.

Based on calibrated sediment transport model, 3-month (Jul to Sep-14) simulations were carried out for the scenario with the two dredge test pits in place to estimate the sediment infill rates. The annual infill rate of the two dredge test pits was estimated by annualizing the 3-months simulation results. The results show that for the nearshore test pit, the annual infill rates vary between 1.6 ft/yr and 4.6 ft/yr, depending on the initial seabed sediment layer thickness. For the offshore test pit, the estimated annual infill rate ranges between 1.1 and 1.3 ft/yr.

Initially assuming the same 3.9 in. seabed sediment layer thickness used for the model calibration after the dredge test pits are excavated, the preliminary nearshore and offshore infill rates are 4.6 ft/yr and 1.1 ft/yr, respectively.

The predicted infill rate for the offshore test pit is likely to be accurate since the model was calibrated using data from the offshore area. The infill rate for the nearshore test pit should be considered preliminary and is likely to change once additional (nearshore) field data from sediment transport Phase 2 field campaign become available. The infill rate for the nearshore dredge test pit will be reevaluated after the model is further calibrated and refined.

CONCLUSIONS

There are well known uncertainties associated with sediment transport modeling due to the complicated nature of sediment movement as well as limitations in the modeling tools. Furthermore, the sediment transport model was initially calibrated based on the available information and data and is subject to change and further calibrations which will be carried out when additional data become available. Based on experience gained during the data collection and numerical modeling study findings, the following conclusions drawn as a lessons learned for future studies may carried out by others.

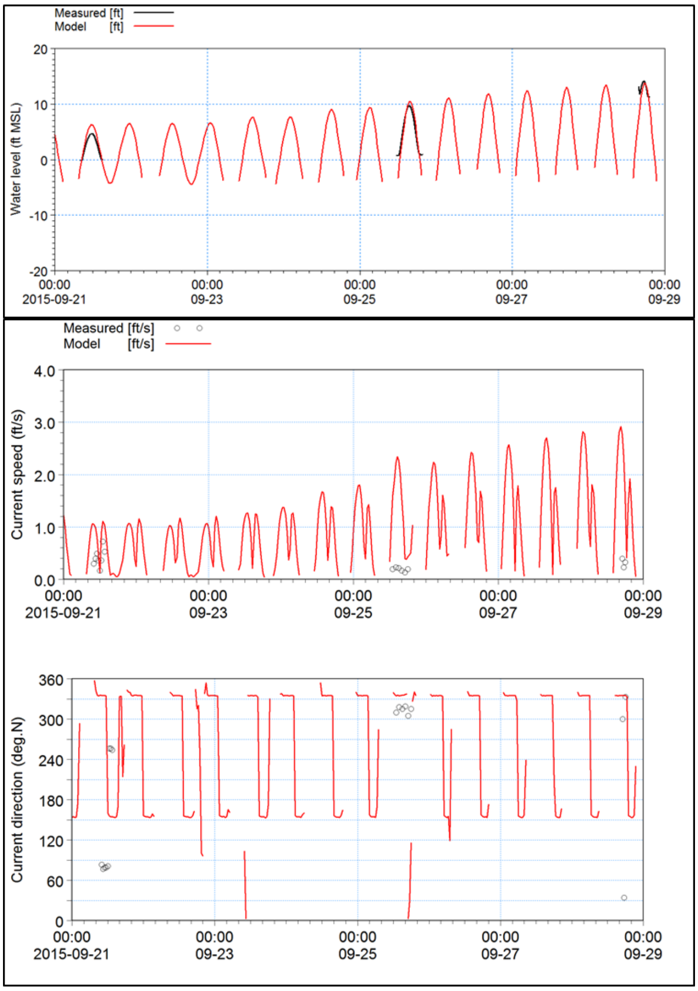

Figure 9. Modeled vs. measured water level (top), current speed (middle) and current direction (bottom) at Quadrapod 2

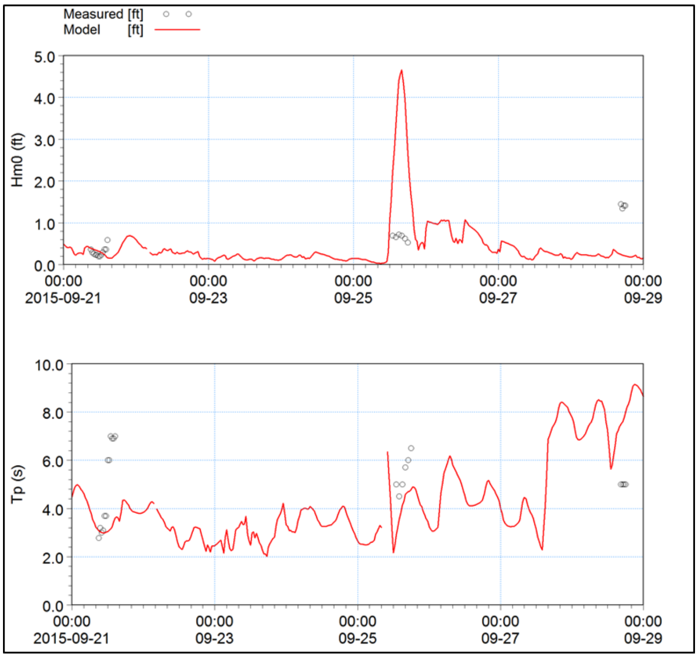

Figure 10. Modeled vs. measured wave height (top), peak wave period (bottom) at Quadrapod 2

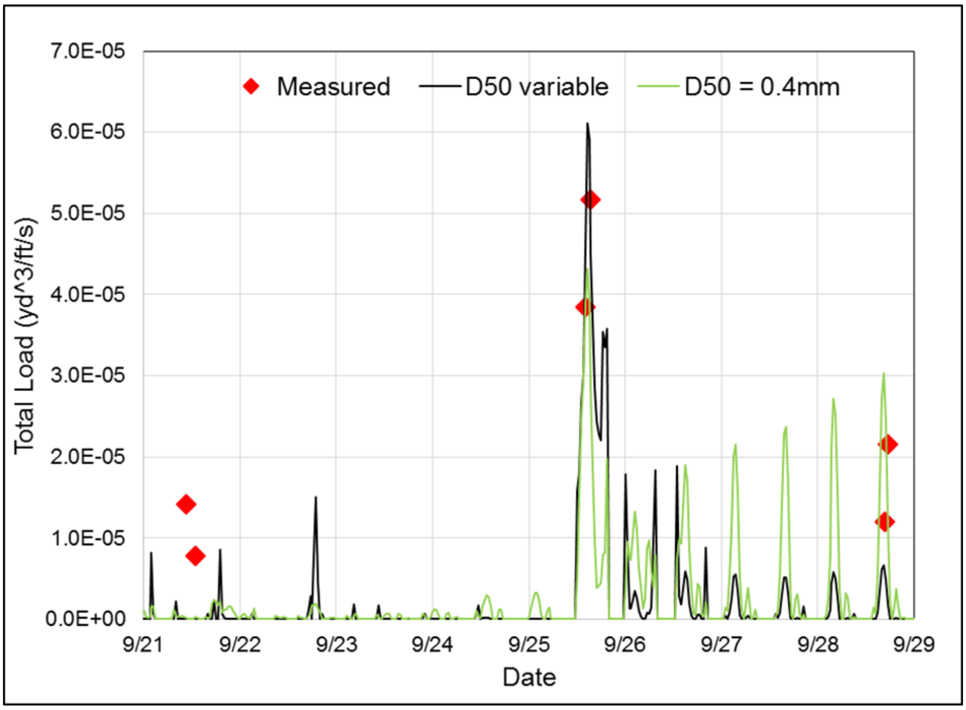

Figure 11. Modeled vs. measured nearshore total sediment transport rates

- Bedload materials collected from the first field sediment transport measurement (21 to 24-Apr-15) suggested that the median grain size D_{50} transported along the bed is approximately 0.4 mm at the measurement sites. A mesh size of 0.25 mm in the bedload samplers was used, and thus there is a possibility that a significant amount of material (finer than 0.25 mm) may have passed through the nets. As a result, it is not completely certain whether the derived D_{50} of 0.4mm is reliable. Planning for various bedload sampler net sizes prior to measurements should be considered to ensure the correct amount of bedload material is collected.
- Seabed features (i.e., spatial distribution of erodible/non-erodible seabed, sand layer thickness, etc.) in the project area is unknown. Thus, sediment size and sand layer thickness uniform over the entire model domain has been assumed in the simulations. Collection of site-specific borehole data or Vibrocores and seabed sediment grab sampled should be included to inform erodible sand layer thickness in the numerical model.
- The suspended sediment grain size is not an input parameter in the modeling software, thus the measured suspended sediment median grain size D_{50} was applied as the seabed grain size in order to achieve good agreement with measured suspended load.

The model was initially calibrated in terms of sediment transport rate, while the morphology module embedded in the sediment transport model tool, which calculates the bed level change, is not yet calibrated. Calibrations in this regard will be performed using the test pit monitoring data become available in the near future.

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