

Field and Numerical Study of the Columbia River Mouth

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LONG-TERM GOALS

The overall goal is to improve the predictive capability and skill of Delft3D to simulate complex hydrodynamics in an inlet setting in which tides, river discharge, winds, waves, and bottom friction are all important.

OBJECTIVES

The main objectives of our effort are to measure and model from the inner-shelf to the Columbia River estuary: 1) the three-dimensional flow velocity distribution spatially and temporally during a range of conditions, 2) the tidal exchange of sediments, optics, salinity, and temperature, 3) the surface particle pathways, horizontal mixing, transport, and corresponding Lagrangian Coherent Structure (LCSs) as a function of tidal flow and stratification, 4) the sea-swell and infragravity wave-current interactions, 5) the spatial variability of bed sediment grain size and the concomitant bedform development to evaluate the spatial distribution of bottom friction required for model validation, and 6) the residual flow circulation associated with the forcing by waves, wind and density differences. In addition, our effort will utilize unique measurement platforms for collecting data in this harsh environment using autonomous and mobile platforms and new inexpensive tracking drifters.

APPROACH

USGS scientists and staff from the Pacific Coastal and Marine Science Center in Santa Cruz CA teamed with co-PIs Dr. Jamie MacMahan, Naval Postgraduate School and Dr. Ad Reniers, University of Miami, as well as Dr. Chris Sherwood, USGS Woods Hole to deploy instruments to measure

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hydrodynamics, map bathymetry, bedforms and seabed grain size, and deploy drifters around the Mouth of the Columbia River (MCR) during the spring freshet 2013. USGS is also working with Dr. Edwin Elias, Deltares to test Delft3D hydrodynamic and sediment transport model in MCR during high river discharge conditions.

WORK COMPLETED

The observations at the MCR consist of time-series measurements from instrumented tripods at three locations between May 9 and June 16, 2013 (Figure 1; Table 1). Each tripod was equipped with an upward-looking ADCP, a near-bed ADV, and a pressure sensor to measure hydrodynamics, a CTD and OBS to measure water properties near the bed, and fan- and pencil-beam sonars to measure bedform geometry (Table 2).

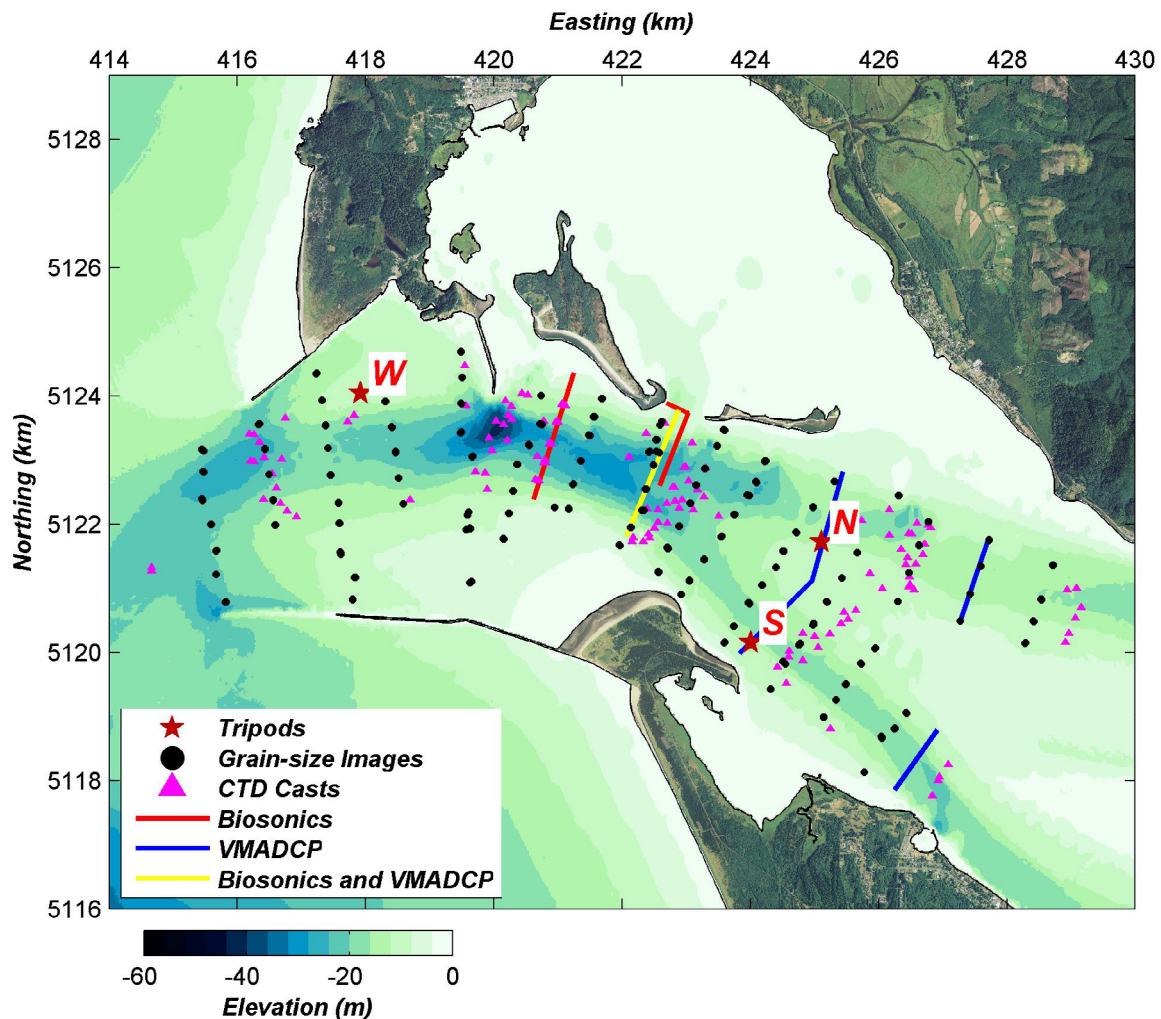


Figure 1. Map showing the locations of 3 instrumented tripods deployed at the MCR between May 9 and Jun 16, 2013, locations of “flying eyeball” seabed grain size images, CTD casts, Biosonics and vessel-mounted ADCP transects.

Digital images of the seabed were collected at 111 locations within the MCR using the “flying eyeball” (Rubin et al., 2007) from aboard the R/V *Parke Snavelly* (Figure 1). For each location, between 3 and 5 replicate images were collected and will later be analyzed to characterize grain-size distributions (Buscombe, 2008) of surface sediments throughout the MCR.

High-resolution acoustic backscatter data were collected within the water column along three transects within the MCR (Figure 1) using a Biosonics 420 kHz echosounder. The transects were navigated between 4 and 19 times under a variety of tide and flow conditions and the data will be used to delineate plume and shear fronts (eg. Nash and Moum, 2005) within the inlet.

Bathymetry and co-registered acoustic backscatter were collected throughout the MCR with a Systems Engineering & Assessment, Ltd. SWATHplus-M interferometric sidescan sonar system pole-mounted to the USGS survey vessel R/V *Parke Snavelly*. Positioning and orientation of the transducers were measured using an Applanix POS MV 320 and afterwards post-processed using Applanix POSPac MMS software. Continuous speed of sound measurements were collected using an Applied Micro Systems Micro SV mounted at the transducer and sound velocity profiles were collected regularly with a YSI CastAway CTD. The bathymetry and ancillary data were combined and rendered into a 5-m digital elevation model using Caris HIPS and SIPS (Figure 2). Final datum conversions from WGS84 Ellipsoid heights (Epoch 2013.54) into NAD83 (2011)/NAVD88 heights was done using the Proj4 library and then interpolation and application of the National Geodetic Survey Geoid12a offsets was done in Surfer. In total, more than 570 million soundings were collected along 1400 km of trackline.

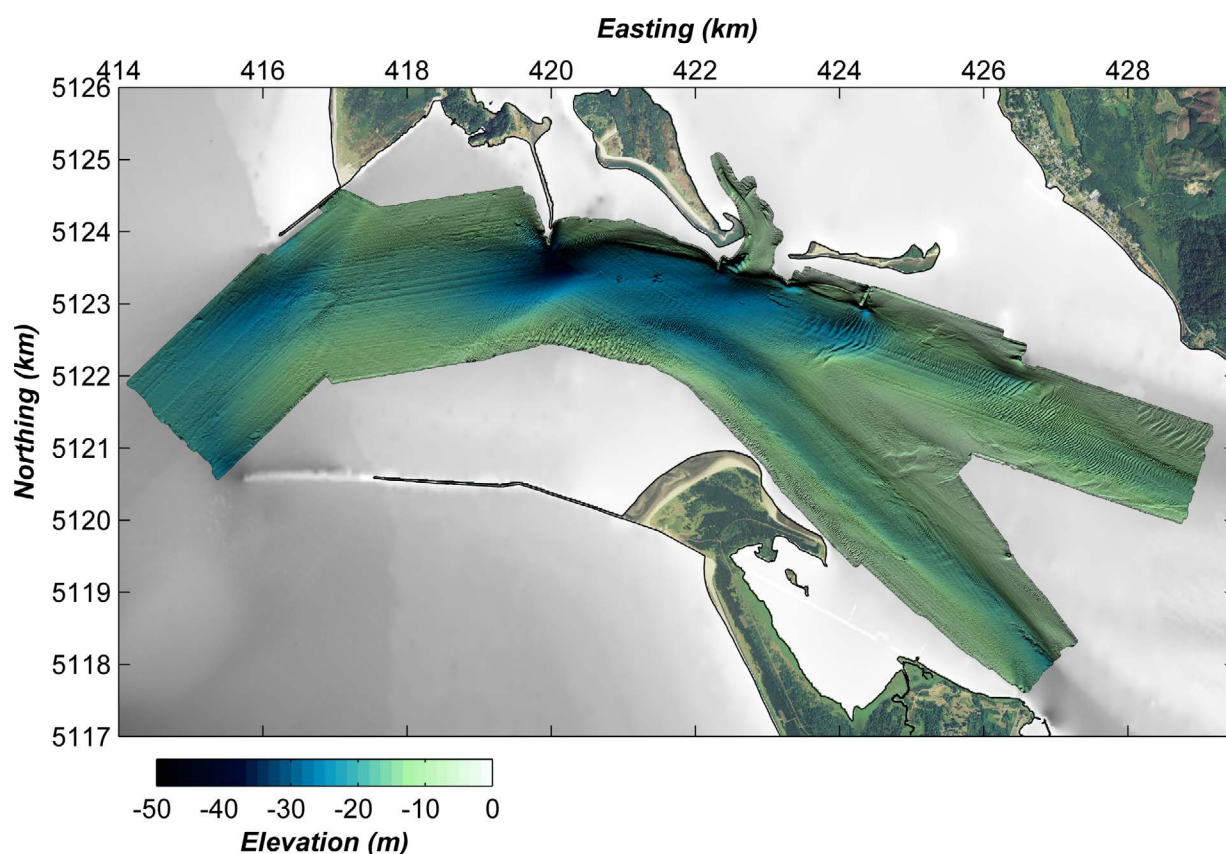


Figure 2. Map of 5-m DEM created from SWATHplus bathymetric data.

RESULTS

USGS successfully employed a robust open tripod frame with a dual recovery method on the three instrumented tripods. All instruments successfully collected data for the full duration of the deployment (except two of the sonars due to limited battery life) (Figures 3 and 4). In August 2005 these tripods were successfully deployed during low river discharge conditions and small waves at MCR. One of the goals of the present experiment was to test whether these frames could withstand the more energetic conditions of the spring freshet. Data from the instrumented tripods are presently being processed and checked for QA/QC.

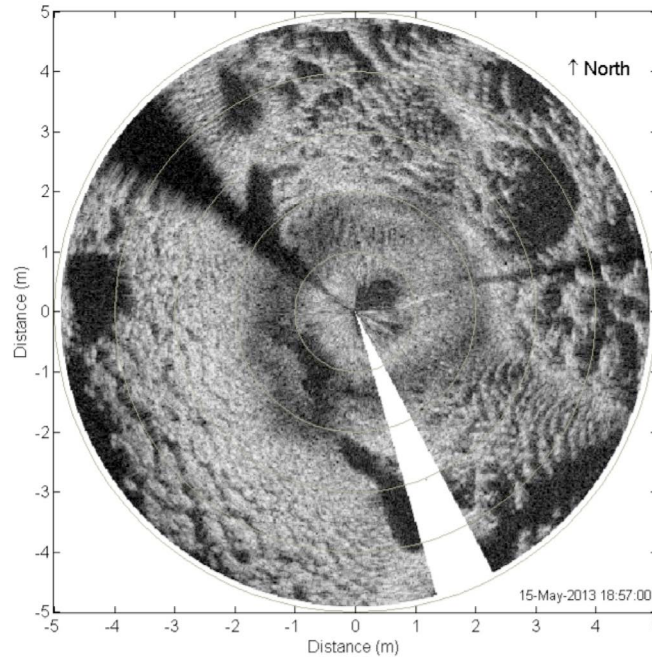


Figure 3. Seabed image from rotary sonar mounted on North tripod showing multiple three-dimensional bedform fields.

The SWATHplus successfully mapped bathymetry throughout the MCR characterizing large-scale inlet morphology as well as medium and large-scale bedforms. Important features including a deep hole adjacent to Jetty A, the shallow bar between the main jetties that induces wave shoaling, and a linear ledge along the north side of the channel were mapped in detail (Figure 2). Detailed seafloor mapping also characterized a variety of sand bedforms ranging in size from a few meters in wavelength to hundreds of meters.

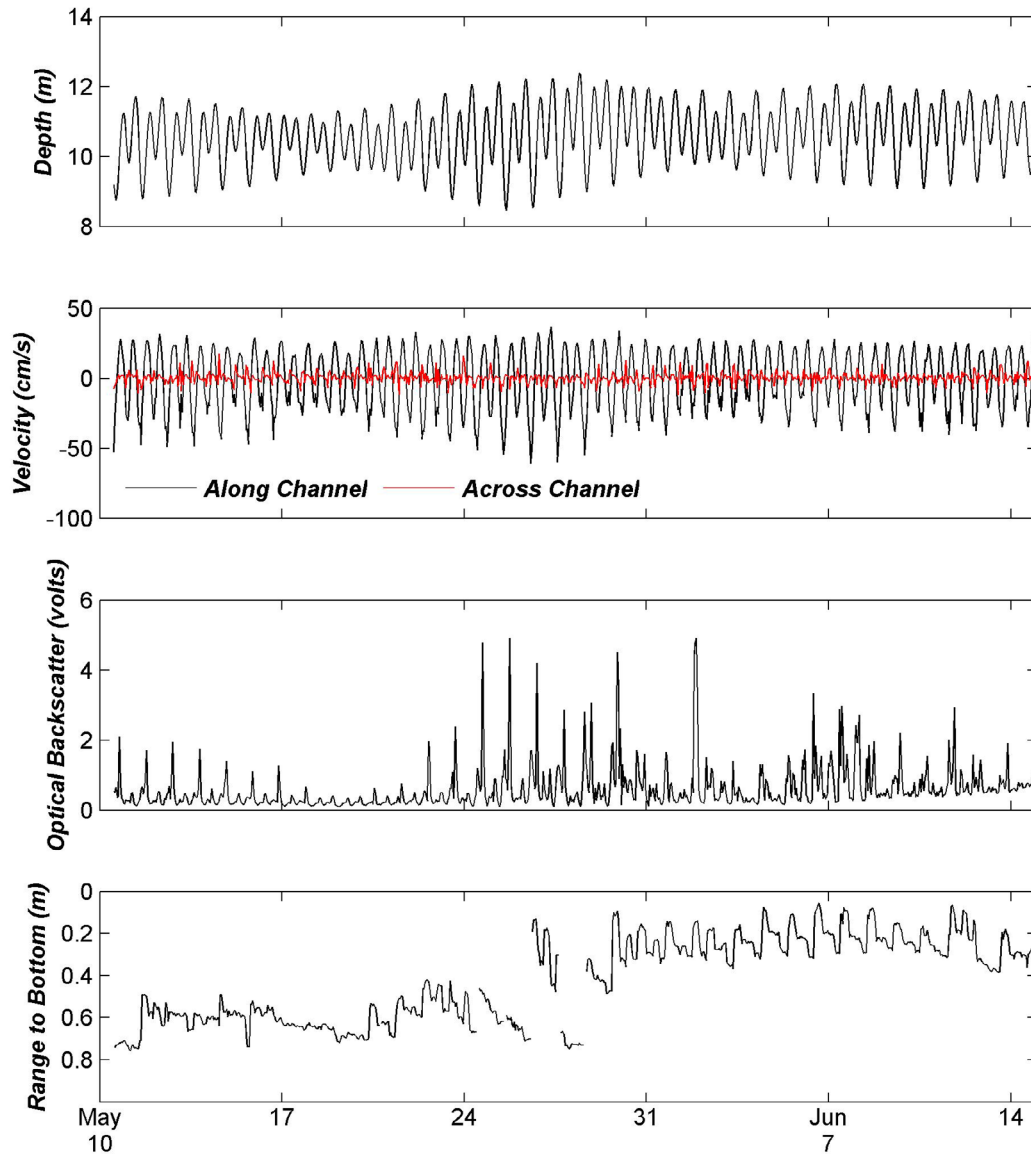


Figure 4. Time series from North Tripod of water depth, currents, optical backscatter, and range to the bottom from the ADV.

IMPACT/APPLICATIONS

The field measurements collected during the MCR freshet experiment will allow rigorous testing of the Delft3D hydrodynamic and sediment transport model. The model was successfully validated against low river discharge and small wave conditions during August 2005 by Elias et al. (2012). Conditions during the recent experiment were more energetic, with larger waves and higher river discharge. Testing and validating the model during these more energetic conditions will extend the range of applicability of this important model. In addition, the surface drifter deployments (see MacMahan and Reniers annual report) are a new and challenging data set to test the model's capacity to simulate shear and density fronts.

Detailed maps of bedforms observed in the new SWATHplus data will be used to test various bedform models as well as test various bottom roughness schemes in the Delft3D hydrodynamic and sediment transport model.

RELATED PROJECTS

None

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- Rubin, D.M., Chezar, H., Harney, J.N., Topping, D.J., Melis, T.S., Sherwood, C.R., 2007. Underwater microscope for measuring spatial and temporal changes in bed-sediment grain size. *Sedimentary Geology* 202: 402-408.

Table 1. Tripod locations, depths, and times of deployment and recovery

Location	Longitude (°E)	Latitude (°N)	Depth (m)	Deployed (GMT)		Recovered (GMT)	
				Date	Time	Date	Time
North Tripod	-123.97139	46.24498	11.2	9-May-13	16:35	15-Jun-13	20:37
West Tripod	-124.06505	46.26505	12.1	9-May-13	18:27	15-Jun-13	22:12
South Tripod	-123.98542	46.23073	13.0	9-May-13	19:51	16-Jun-13	1:47

Table 2. Instruments, sampling scheme, and data products from tripods deployed at the MCR

Instrument Type	Sampling Scheme	Quantity Measured
RDI ADCP	1 Hz Continuous Sampling	Velocity profiles from 2.9 m above bed to surface at 0.5-m resolution
Sontek ADV	22-min burst at 8 Hz every hour	Point measurement of velocity at 0.66 m above bed, range to bed from ADV sensor
OBS	22-min burst at 8 Hz every hour	Point measurement of optical backscatter at 0.67 m above bed
Pressure	22-min burst at 8 Hz every hour	Point measurement of velocity at 1.4 m above bed
RBR CTD	10-sec burst at 6 Hz every 5 min	Point measurement of temperature and salinity at 1.8 m above bed
Imagenex Fan Beam Sonar	1 scan every hour or every 3 hours	Side-scan imagery of bed forms
Imagenex Pencil Beam Sonar	1 scan every hour or every 3 hours	Profiles of bathymetry in vicinity of tripod